March 2 through June 8
2024



VIRGINIA STATE College of Agriculture

VIRGINIA STATE UNIVERSITY

Sustainable Urban Agriculture Certification Program







L. Githinji, M. Comer, T. Nartea, D. Pfeiffer, P. Johnson, Z. Mersha, L. Rutto, S. Gu, J. Dusci, N. Romano, & D. O'Brien © 2024

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https://www.ext.vsu.edu/urban-agriculture-certificate-program

Sustainable Urban Agriculture Certification Program

Module	Module Topic	Date / Time	Instructors
0	Program Orientation	March 2, 2024 9:00 AM – 3:30 PM	All the course instructors
1	General Principles of Urban Agriculture	March 9, 2024 9:00 AM – 10:30 AM	Dr. Leonard Githinji (lgithinji@vsu.edu)
2	Site Selection and planning, Ecosystem Services and Working with City Planners	March 9, 2024 10:30 AM – 12:00 PM	Dr. Marcus Comer (mcomer@vsu.edu)
3	Basic Botany, Physiology and Environmental Effects of Plant Growth	March 9, 2024 12:30 PM – 3:00 PM	Dr. Leonard Githinji (lgithinji@vsu.edu)
4	Urban Agriculture Entrepreneurship	March 16, 2024 9:00 AM – 11:30 AM	Dr. Theresa Nartea (tnartea@vsu.edu)
5	Weed Management	March 16, 2024 12:00 PM – 3:00 PM	Dr. Leonard Githinji (lgithinji@vsu.edu)
6	Sustainable Soil Management; Urban Soils and Brownfields	March 23, 2024 9:00 AM – 11:30 AM 12:00 PM – 3:00 PM	Dr. Leonard Githinji (lgithinji@vsu.edu)
7	Integrated Insect Pest Management	March 30, 2024 9:00 AM – 11:30 AM 12:00 PM – 3:00 PM	Dr. Doug Pfeiffer (dgpfeiff@vt.edu)
8	Business Principles for Urban Agriculture	April 6, 2024 9:00 AM – 11:30 AM	Dr. Theresa Nartea (tnartea@vsu.edu)
9	Permaculture	April 6, 2024 12:00 PM – 3:00 PM	Mr. Patrick Johnson (nanihva@gmail.com)
10	Plant Disease Management	April 13, 2024 9:00 AM – 11:30 AM 12:00 PM – 3:00 PM	Dr. Zelalem Mersha (zmersha@vsu.edu)
11	Plant Propagation and Nursery Management	April 20, 2024 9:00 AM – 11:30 AM 12:00 PM – 3:00 PM	Dr. Laban Rutto (lrutto@vsu.edu
12	Vegetable, Small Fruit and High Tunnel	April 27, 2024 9:00 AM – 11:30 AM 12:00 PM – 3:00 PM	Dr. Sanjun Gu (sgu@vsu.edu)
13	Hydroponic & Aquaponic Production Systems	May 4, 2024 9:00 AM – 11:30 AM	Mr. Joshua Dusci (jdusci@vsu.edu)
14	Urban Aquaculture	May 4, 2024 12:00 PM – 3:00 PM	Dr. Nicholas Romano (nromano@vsu.edu)
15	Urban Poultry	May 18, 2024 9:00 AM – 11:30 AM	Dr. Dahlia O'Brien (dobrien@vsu.edu)
16	Small Ruminants (Rabbits, Sheep, and Goats)	May 18, 2024 12:00 PM – 3:00 PM	Dr. Dahlia O'Brien (dobrien@vsu.edu)
17	Backyard Livestock Demonstration	June 8, 2024 9:00 AM– 3:00 PM	Dr. Dahlia O'Brien (dobrien@vsu.edu)

MODULE DESCRIPTION

Module 1: General Principles of Urban Agriculture
(Dr. Leonard Githinji, *Associate Prof., Extension Specialist, Sustainable and Urban Agriculture***)**

Participants will learn what urban agriculture is and why it is important. They will also explore some examples of urban agriculture operations including the Community Gardens, Small Urban Farms, Farmer's Markets, Home Vegetable Gardening, School Gardens, Roof Top Gardening, Community Supported Agriculture, and Farm to School. The concept of food desert, defined as geographic areas with limited access to affordable healthy food options will be discussed.

Module 2: Site Selection and Planning, Ecosystem Services and Working with City Planners
(Dr. Marcus Comer, *Associate Prof., Agriculture and Natural Resources*)

The student will learn about site planning, potential obstacles, Ecosystem Services, and how to work with city planners to avoid pitfalls. Class activities will include: Discussing site-related, government-related, procedure-related, and perception-related obstacles; Explaining Ecosystem Services and why it is important in urban agriculture; and Explaining the importance of working with city planners and effective approaches.

Module 3: Basic Botany, Physiology and Environmental Effects of Plant Growth
(Dr. Leonard Githinji, *Associate Prof., Extension Specialist, Sustainable and Urban Agriculture***)**

Participants will learn the basic botany including the lifecycle of flowering plants, the anatomy of vascular plants and how to identify a diverse range of plants. They will also learn about the various plants physiological processes and how the environmental factors effect plant growth. The knowledge gained will help the participants on how to better select their garden plants and manage the growing environment for successful production and higher yields.

Module 4: Urban Agriculture Entrepreneurship
(Dr. Theresa J. Nartea, *Associate Prof., Extension Specialist-Marketing & Agribusiness***)**

In this module, participants will learn about: 1) Planning production from a marketing viewpoint; 2) Identifying best-fit market outlet types; 3) Finding product pricing; and 4) Farm market regulations.

Module 5: Weed Management
(Dr. Leonard Githinji, *Associate Prof., Extension Specialist, Sustainable and Urban Agriculture***)**

Weeds are plants that are considered undesirable in a particular situation, or simply "plants in the wrong place". Economic losses due to weeds are encountered nearly everywhere weeds occur, especially for vegetables since only a few of them can compete with weeds. For this module participants will learn about the root cause of weeds; Weed seed banks and germination; Proactive weed management strategies; Reactive weed management; Weed-free by design; Weed control tools as well as integrated weed management.

Module 6: Sustainable Soil Management; Urban Soils and Brownfields
(Dr. Leonard Githinji, *Associate Prof., Extension Specialist, Sustainable and Urban Agriculture***)**

"Sustainable" is a word we see everywhere lately and whether the subject is energy, fishing or gardening, it generally means the ability to continue indefinitely without relying much on external inputs. The right

thing to do these days in your yard and garden is to practice the art and science of reusing and recycling organic waste materials, saving water and conserving energy. For this module participants will learn about the physical, chemical and biological soil characteristics, soil fertility, productivity, and management including composting. The concept of "brownfields" and their dangers including debris, dilapidated buildings and toxic chemicals will be discussed as well as well as their clean up and potential redevelopment into urban gardens or farms.

Module 7: Integrated Insect Pest Management
(Dr. Doug Pfeiffer, *Prof., Entomologist*)

Integrated pest management (IPM), also known as integrated pest control (IPC) is a broad-based approach that integrates practices for economic control of pests. IPM aims to suppress pest populations below the economic injury level (EIL). For this module, participants will learn about the definition of an insect pest; Principles of Insect Pest Management including: Prevention; Pest Identification and Monitoring; Tolerance Levels and Economic Thresholds; and Pest Control Methods. Online resources for chemical and biological control information will be presented.

Module 8: Business Principles for Urban Agriculture
(Dr. Theresa J. Nartea, *Associate Prof., Extension Specialist-Marketing & Agribusiness***)**

In this module, participants will learn how to: 1) Develop SMART business goals; 2) Develop a one-page business plan; 3) Use Veggie Compass and Livestock Compass Calculation Budget Spreadsheets; 4) Use small-scale enterprise budgets.

Module 9: Permaculture
(Mr. Patrick Johnson, *Certified Permaculturalist***)**

Permaculture is a system of agricultural and social design principles centered on simulating or directly utilizing the patterns and features observed in natural ecosystems. For this module, participants will learn how to design agricultural ecosystems that have the diversity, stability, and resilience of natural ecosystems. The instructor will share his personal experience on establishing and managing a permaculture system.

Module 10: Plant Disease Management
(Dr. Zelalem Mersha, *Associate Prof., Plant Pathology***)**

The goal of plant disease management is to reduce the economic and aesthetic damage caused by plant diseases. For this module, participants will learn about monitoring, diagnostics and integrated management of common diseases affecting vegetables and small fruits. Disease identification and monitoring will focus on common symptoms and signs of diseases in the field or in gardens. Participants will be introduced to clinics and other places where to seek help for disease identification. Integrated disease management options primarily target all non-chemical options that promote plant and soil health thus prevent diseases. Tolerance Levels and Economic Thresholds; Control Methods and Principles of integrated disease management will be covered in detail.

Module 11: Plant Propagation and Nursery Management
(Dr. Laban K. Rutto, *Prof., Horticulture***)**

Plant propagation is the process of creating new *plants* from a variety of sources: seeds, cuttings, bulbs and other *plant* parts. For this module we will cover the common plant propagation methods including starting plants from seed, and vegetative propagation methods including use of cuttings, slips, splits, and bulbs. Techniques including grafting, budding, layering, and tissue culture will also be discussed. The class will consist of classroom discussions coupled with demonstrations, and hands-on practice. While addressing plant propagation by seed, the instructor will provide in-depth coverage of seed treatment methods e.g. priming, coating, and pelleting, and as a bonus introduce the class to the recently acquired SATEC Concept 2000 seed coating and pelleting machine. Basic principles of media selection, climate control, and principles of nursery management will be covered while addressing the areas mentioned above.

Module 12: Vegetable, Small Fruit and High Tunnel
(Dr. Sanjun Gu, *Associate Prof. and Extension Specialist, Horticulture***)**

For this module, participants will learn about the following: Classification systems and identification of the major vegetables and small fruits; High tunnel basics; Cultivation and cropping systems; Field establishment and cultural practices; Postharvest and storage; and A tour to field and high tunnels with vegetable and small fruit crops.

Module 13 Hydroponic & Aquaponic Production Systems
(Mr. Joshua Dusci, Extension Associate, Climate *Smart***)**

For this module, participants will learn about indoor production systems including hydroponics and aquaponics. Emphasis will be placed on practical application of several management procedures; how to use logical and critical thinking to evaluate plant growth and development as related to these systems.

Module 14: Urban Aquaculture
(Dr. Nicholas Romano, *Associate Prof. and Extension Specialist, Aquaculture***)**

Aquaculture is the farming of aquatic organisms such as fish, crustaceans, mollusks and aquatic plants. For this module, best management practices for limited scale commercial or hobby scale aquaculture (water farming) of fish and shrimp will be discussed. Topics will include planning, facilities and equipment, safety, water quality and quantity, selection of crop, feeds and feeding, waste management, post-harvest handling and marketing. Solutions to seasonal production differences will be shown. Permits, if necessary, and possible regulations will also be discussed.

Module 15: Urban Poultry
(Dr. Dahlia O'Brien, *Prof., Small Ruminant Specialist***)**

For this module, participants will learn about backyard chicken rearing including breed selection, feeding, housing, sanitation, egg production and meat processing and handling. Hands-on exercise will include egg handling, cleaning and safe storage.

Module 16: Small Ruminants (Rabbits, Sheep, and Goat)
(Dr. Dahlia O'Brien, *Prof., Small Ruminant Specialist***)**

For this module, participants will learn about small ruminants (rabbits, sheep and goats): Zoning codes: determining which animals are allowed and under what conditions; Selection: learn how to select healthy animals to make your animal production more successful; Feeding: learn about the nutritional requirements and what you'll have to provide to meet these needs; Breeding and taking care of young stock – learn about the reproductive cycle, when and how to breed, gestation length, preparing for birthing, and caring for young stock; Housing and equipment – learn about shelter, supplies and/or equipment needed to handle and raise animals in your backyard; and Marketing: learn about how important it is to know who your customers are and how to explore local options to selling your products.

Module 17: Urban Livestock Hands-on Demonstration
(Dr. Dahlia O'Brien, *Prof., Small Ruminant Specialist*)

For this module, participants will be involved in a hands-on exercise on chickens, quails, and rabbits processing. Proper handling of these livestock species including the pre and post processing of meat products will be discussed in details.

Summary Description for Module 1

Title:	Module 1: General Principles of Urban Agriculture
Instructor:	Dr. Leonard Githinji, Associate Professor - Sustainable & Urban Agriculture
Prerequisites:	None
Students Must Bring:	A pen and writing materials
Time Duration:	1-1.5 hours
Learning Objective:	For this module, students will learn what urban agriculture is and why it is important. They will also explore some examples of urban agriculture operations including the Community Gardens, Urban Farms, Farmer's Markets, Home Vegetable Gardening, School Gardens, Rooftop Gardening, Community Supported Agriculture, and Farm to School. The students will also learn the concept of a food desert.
Instructor Media Needs:	Screen Projector Screen Pointer Computer
Class Materials and/or Supplies Needed:	Instructor provided-Printed copies of class notes with review questions at the end of the chapter (MSWord) PowerPoint slides (in electronic and/or printed format)
Class Activities:	1. Present basic information about urban agriculture (UA) 2. Explain how and why UA is important 3. Review various examples of UA systems 4. Review the concept of food desert as it relates to food security
Knowledge Gained:	Students will gain basic knowledge on the various urban agriculture systems.
Skills Gained:	Students will gain skills on some selected urban agriculture systems.
Abilities Gained:	Students will be able to develop a basic garden.
Exam Description:	A quiz will be administered at the end of the class. In addition, a take home exam based on the review questions will be given.

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General Principles of Urban Agriculture

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1. WHAT IS URBAN AGRICULTURE?

Urban agriculture (UA) is loosely defined as the growing of plants and the raising of animals for food and other uses within and around cities and towns, and include related activities such as the production and delivery of inputs, the processing and marketing of products, as well as the recycling of domestic waste into compost (Veenhuizen, R. , 2006).

According to Papanek *et al*. (2023), there is no standard definition of urban agriculture. Definitions depend on geographic region or field of practice. The team defines UA as the production, processing, distribution, and sale of food within urban, suburban, and peri-urban areas for commercial, non-commercial, hobby, educational, or nonprofit purposes. Their definition of the term "urban agriculture" includes activities beyond food production and thus, it could be understood to be equivalent to the term "urban food systems" (Papanek *et al*., 2023).

The UA activities are usually located within or on the fringe of a city and comprises a variety of production systems that range from small-scale subsistence production and processing at house-hold level to fully commercialized agriculture. It is generally characterized by closeness to markets, high competition for land, limited space, use of urban resources (such as organic solid wastes and wastewater), low degree of farmer organization, growing of mainly perishable products, and a high degree of specialization. By supplying perishable products such as vegetables, fresh milk and poultry products, urban agriculture to a large extent complements rural agriculture and increases the efficiency of national food systems. With its multiple functions, urban agriculture plays an important role in urban poverty alleviation and social inclusion, urban food security, urban waste management, and urban greening (Veenhuizen, R. , 2006).

Urban agriculture entails the production of food for personal consumption, education, donation, or sale and includes associated physical and organizational infrastructure, policies, and programs within urban and suburban environments.

The urban agriculture operations range from commercial farms in suburbs to rooftop gardens and beekeeping in built-out cities, urban agriculture exists in multiple forms and for multiple purposes. While it is a small component of the larger community based food system, urban agriculture is important to the overall health and resilience of communities and regions. It can contribute significantly to the development of social connections, capacity building, and

community empowerment in urban neighborhoods, most commonly through community gardening.

In addition, it offers links to community development practice as a viable means of workforce development, youth development, supplementing food budgets, and generating modest levels of revenue for urban farmers who sell their products. When combined with other efforts to improve access to healthy, affordable food, urban agriculture can become a valuable tool in promoting community food security, particularly in low-income, urban neighborhoods.



Fig. 1: An urban farm in Richmond, Virginia

Examples of Urban Agriculture

- Community Gardens
- Small Urban Farms
- Farmer's Markets
- Home Vegetable Gardens
- Hydroponic Gardening

- School Gardens
- Rooftop Vegetable Gardening
- Backyard Poultry
- Beekeeping
- Community Supported Agriculture
- Fish Farming
- Farm to School

2. WHY URBAN AGRICULTURE?

The rapid urbanization that is taking place goes together with a rapid increase in urban poverty and urban food insecurity. Most cities in the world have great difficulties in coping with this development and are unable to create sufficient formal employment opportunities for the poor. They also have increasing problems with the disposal of urban wastes and waste water and maintaining air and river water quality. Urban agriculture provides a complementary strategy to reduce urban poverty and food insecurity and enhance urban environmental management. It plays an important role in enhancing urban food security since the costs of supplying and distributing food to urban areas based on rural production and imports continue to increase, and do not satisfy the demand, especially of the poorer sectors of the population. Some of the reasons why many organizations are supporting urban agriculture are related to the following benefits of (intra- and peri-) urban agriculture:

Contributions to urban food security and nutrition

The contribution of urban agriculture to food security and healthy nutrition is probably its most important asset. Food production in the city is in many cases a response of the urban poor to inadequate, unreliable and irregular access to food, and the lack of purchasing power. Urban agriculture to a large extent complements rural agriculture and increases the efficiency of the national food system in that it provides products that rural agriculture cannot supply easily (e.g. perishable products, products that require rapid delivery upon harvest), that can substitute for food imports and can release rural lands for export production of commodities.

Economic impacts

Growing your own food saves household expenditures on food; low income families generally spend a substantial part of their income (50 – 70%) on food. Selling produce (fresh or processed) brings in cash.

Social impacts

Urban agriculture may function as an important strategy for poverty alleviation and social integration. The participants in the project may feel enriched by the possibility of working constructively, building their community, working together and in addition producing food and other products for consumption and for sale. In more developed cities, urban agriculture may be undertaken for the physical and/or psychological relaxation it provides, rather than just for food production. Also, urban and peri-urban farms may take on an important role in providing recreational opportunities for citizens (recreational routes, food buying and meals on the farm, visiting facilities) or having educational functions (bringing youth in contact with animals, teaching about ecology).

Contributions to urban ecology

Urban agriculture is part of the urban ecological system and can play an important role in the urban environmental management system. Firstly, a growing city will produce more and more wastewater and organic wastes. For most cities the disposal of wastes has become a serious problem. Urban agriculture can help to solve such problems by turning urban wastes into a productive resource. In many cities household waste can be converted to compost which can be used by urban farmers to reduce or eliminate the need to use chemical fertilizers. This is important as it minimizes the problems related to the contamination of groundwater. In addition, compost making initiatives can create employment and provide income for low income urban dwellers. The use of technologies such as hydroponics and drip irrigation substantially reduce wastewater. Secondly, urban agriculture may also positively impact upon the greening and cleaning of the city by turning derelict open spaces into green zones and maintaining buffer and reserve zones free of housing, with positive impacts on the micro-climate (shade, temperature, sequestration of CO2).

Degraded open spaces and vacant land are often used as informal waste dumpsites and are a source of crime and health problems. When such zones are turned into productive green spaces, not only an unhealthy situation is cleared, but also the neighbors will passively or actively enjoy the green area. Such activities may also enhance community self-esteem in the neighborhood and stimulate other actions for improving the community's livelihood.

Thirdly, urban agriculture and urban forestry contribute to disaster risk reduction and adaptation to climate change by reducing runoff, keeping floodplains free from construction, reducing urban temperatures, capturing dust and CO2, while growing fresh food close to consumers reduces energy spent in transport, cooling, processing and packaging, whilst productive reuse of urban organic wastes and wastewater (and the nutrients these contain) reduces methane emissions from landfills and energy use in fertilizer production.

3. SUSTAINABLE URBAN AGRICULTURE PRACTICES

Energy

-Energy inputs are found in every stage of agricultural production – from planting, applying fertilizers, to fueling equipment for tillage, and harvesting crops, to supplying electricity for animal housing facilities. This significant energy consumption has left urban farmers vulnerable

to high energy costs. However, energy efficiency. However, energy efficiency measures can help agricultural producers save energy without harming productivity. Urban farmers can enhance their operations with effective energy efficiency programs, such as educational training and incentives for energy efficiency improvements. - Sustainable Agriculture Research and Education Program (SARE), administered by the National Institute of Food and Agriculture, provides grants and educational materials on a broad range of sustainable agriculture topics as well as outreach to farmers on how to conserve energy.



Source: https://news.mit.edu/2012/programs-for-green-cities

-Conservation Stewardship Program (CSP) is part of the farm bill conservation title and administered by USDA's Natural Resources Conservation Service (NRCS). It provides technical and financial assistance to agricultural producers to promote resource conservation and enhancement of working farmland and encourages measures to achieve environmental stewardship goals for applicants' respective regions. -Environmental Quality Incentives Program (EQIP) is also administered by the NRCS and provides funding for agricultural producers to implement conservation practices for energy, soil and water.

-State, Local, and Private Programs and Organizations can contribute to promoting energy efficiency in the agricultural sector through initiatives such as Rural Electric Cooperatives (RECs). These are customer owned electric utilities that can target energy efficiency in rural areas, and companies that work specifically on agricultural energy efficiency like Ensave.

Water

There are several sustainable water practices including:

-Rain or storm water harvesting: This involves capturing rainwater and runoff for later use, decreasing the use of often expensive and energy intensive potable water. Rainwater Harvesting Rain provides water at no cost for various uses, including irrigation. A rooftop can provide an abundance of rainwater; rainwater capture presents great potential for water savings, preventing runoff and reducing the reliance on municipal water. There are four main components to rooftop rainwater harvesting systems: 1) a rooftop – the catchment area; 2) a gutter downspout to divert the water to storage; 3) rain barrels or cisterns to store the water; 4) a distribution method to redirect water from storage to the landscape. When it rains, the water that would otherwise run off into storm sewers is diverted into a cistern. A metal mesh is used to strain any debris that may get into the tanks. The clean rainwater can then be distributed by various mechanisms into the landscape via a simple hose, a drip irrigation system, channels, pumps, etc.

-Water Retention: High soil organic matter enhances its productivity and permeability, resulting in increased water infiltration and retention. Mulching and composting used to amend soil and the organic matter decomposes, providing a food source that boosts soil productivity and microorganism activity. Some of the organisms such as worms act as soil aerators and nutrient providers, by way of eating through the organic matter. Mulching decreases water evaporation resulting in greater ability of the soil to retain available moisture and diminishes the need to provide excess irrigation water.

-Drip Irrigation: Drip irrigation, also known as micro- and trickle-irrigation, is characterized by the slow and accurate application of water to plants. Drip systems are composed of a network of tubes and emitters that allow water to drip straight to plant roots at low volumes. Potential irrigation efficiencies for drip systems are relatively high, ranging from 88-90%. They also consume approximately half as much water as sprinklers. Micro-irrigation emits water at gallons per hour versus other watering systems that discharge water at gallons per minute. Continual maintenance is important to achieve maximum water efficiency. This method of irrigation reduces water loss from canopy interception, wind drift, and evaporation. Drip systems can be operated manually or with automatic scheduling controls.

Land Use Planning

Urban area is made up of competing and conflicting land uses and demands that have to be properly managed. This scenario is made worse by the fact that land is a finite resource and the demands on a particular piece of land are many and varied. There are several suggestions for enhancing urban land use:

- Brownfields redevelopment: Brownfields are properties that may have hazardous substances, pollutants or contaminants present. EPA's Brownfields Program provides grants and technical assistance to communities, states, tribes and others to assess, safely clean up and sustainably reuse these contaminated properties. Cleaning up and reinvesting in brownfields- protects human health and the environment, reduces blight, and takes development pressures off greenspaces and working lands.

- Buying locally produced goods and eating local foods that are in season helps reduce the transportation of foods (which generate an immense amount of pollution), while supporting the local community, economy and improving your health.
- Using organic fertilizers (such as compost and green manures) and pesticides in lieu of chemical fertilizers and pesticides can significantly reduce pollution.

- Recycling: Recycling of organic residues and reusing of containers can enhance the environment by reducing waste and encouraging a clean environment.

4. FOOD DESERTS

Food deserts can be described as geographic areas where residents' access to affordable, healthy food options (especially fresh fruits and vegetables) is restricted or nonexistent due to the absence of grocery stores within convenient traveling distance.

About 2.3 million people are reportedly living more than one mile away from a supermarket and do not own a car. In urban areas, access to public transportation may help residents overcome the difficulties posed by distance, but economic forces have driven grocery stores out of many cities in recent years, making them so few and far between that an individual's food shopping trip may require taking several buses or trains. In suburban and rural areas, public transportation is either very limited or unavailable, with supermarkets often many miles away from people's homes.

The other defining characteristic of food deserts is socio-economic: that is, they are most commonly found in communities of color and low-income areas (where many people don't have cars). Studies have found that wealthy districts have three times as many supermarkets as poor ones do, that white neighborhoods contain an average of four times as many supermarkets as predominantly black ones do, and that grocery stores in AfricanAmerican communities are usually smaller with less selection.

People's choices about what to eat are severely limited by the options available to them and what they can afford—and many food deserts contain an overabundance of fast food chains selling cheap "meat" and dairy-based foods that are high in fat, sugar and salt. Processed foods (such as snack cakes, chips and soda) typically sold by corner delis, convenience stores and liquor stores are usually just as unhealthy.

It is important to devote more attention to the food system, since it is paramount in the improvement of human settlements to better serve the needs of the people, and in incorporating linkages between various aspects such as physical, natural, housing, transportation, land use, and economic empowerment.

REVIEW QUESTIONS

1. What is urban agriculture?

2. What are the other activities included in urban agriculture besides the growing of plants and raising of animals?

3. List 10 examples of Urban Agriculture operations or practices.

4. Briefly discuss the importance or benefits of urban agriculture.

5. Define the term “Food Desert”.

6. What are some of the factors that limit food access in urban neighborhoods?

7. Explain the concept of “Food Miles”. How do food miles affect our environment?

8. How can urban agriculture promote community food security?

9. What is micro-farming?

10. Explain the similarities and differences among:

    i) hydroponics, ii) aquaponics and iii) aeroponics systems.

REFERENCES

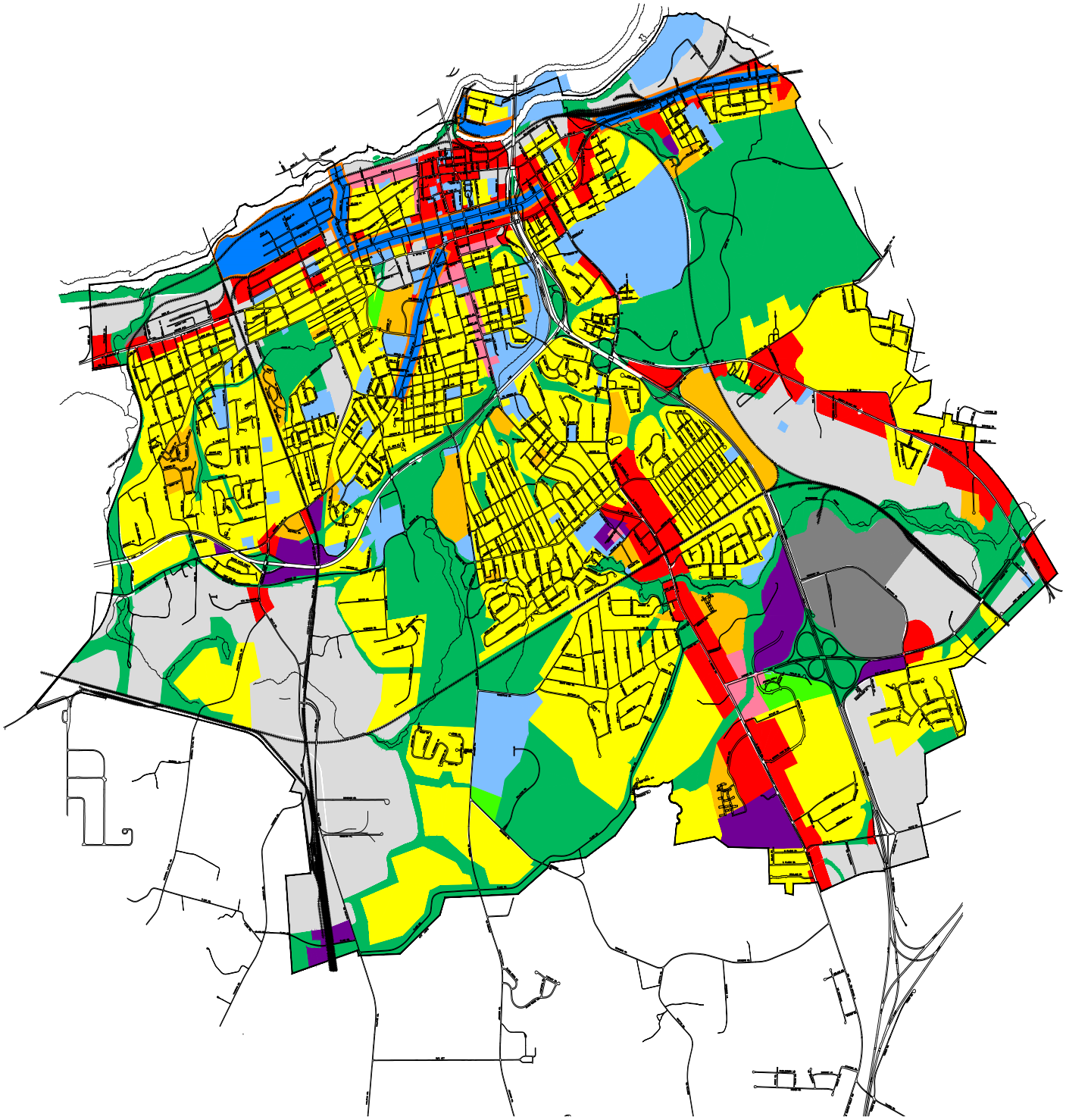
Papanek, a., Campbell, c.g. and Wooten, H (2023. What is Urban Agriculture? UF/IFAS Extension.https://edis.ifas.ufl.edu/publication/FY1519

van Veenhuizen, R. (2006). Cities Farming for the Future, Urban Agriculture for Green and Productive Cities. Edited by René van Veenhuizen. Published by RUAF Foundation, IDRC and IIRR. ISBN 1-930261-14-4.

Summary Description for Module 2

Title:	Module 2: Site Selection and planning, Ecosystem Services and working with city planners
Instructor:	Dr. Marcus Comer, Associate Professor – Agriculture & Natural Resources
Prerequisites:	None
Class Time:	10:30AM – 12:00PM
Learning Objective:	The student will learn about site planning, potential obstacles, Ecosystem Services, and how to work with city planners to avoid pitfalls.
Instructor Media Needs:	Screen Projector, Screen, Pointer, Computer Response clickers (instructor will provide)
Class Materials and/or Supplies Needed:	Instructor provided-Electronic copies of handouts PowerPoint slides (in electronic and/or printed format)
Class Activities:	1. Discuss Site-related, government-related, procedure related, and perception-related obstacles. 2. Explain Ecosystem Services and why it is important in UA. 3. Explain the importance of working with city planners and effective approaches.
Knowledge Gained:	Students will gain basic knowledge on the various ways to use Ecosystem Services in planning urban agriculture sites.
Skills Gained:	Students will gain skills on how to use Ecosystem services tools and effective approaches to work with city planners.
Abilities Gained:	Students will be able to calculate ecosystem services values for farm plans.
Exam Description:	An assessment will be administered at the end of the class.

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LEGEND

- LOW DENSITY RESIDENTIAL
- MEDIUM / HIGH DENSITY RESIDENTIAL
- MIXED COMMERCIAL / PROFESSIONAL
- COMMERCIAL
- LIGHT INDUSTRIAL/FLEXIBLE
- HEAVY INDUSTRIAL
- INSTITUTIONAL
- PUBLIC USES
- PARKS & OPEN SPACE
- MIXED USE (OFFICE, INSTITUTIONAL, COMMERCIAL, RESIDENTIAL)

- RTE. 36 (E. WASHINGTON STREET) DEVELOPMENT CORRIDOR EAST CITY LIMITS to E. BANK STREET
- WASHINGTON STREET DEVELOPMENT CORRIDOR CRATER ROAD to ADAMS STREET
- WASHINGTON STREET DEVELOPMENT CORRIDOR ADAMS STREET TO SOUTH STREET
- HALIFAX STREET DEVELOPMENT CORRIDOR W. WYTHE STREET to VIRGINIA AVENUE
- UNIVERSITY BOULEVARD / N. SOUTH STREET DEVELOPMENT CORRIDOR W. WASHINGTON STREET to APPOMATTOX RIVER
- POCAHONTAS ISLAND DEVELOPMENT DISTRICT
- BATTERSEA DEVELOPMENT DISTRICT

FUTURE LAND USE PLAN

CITY OF PETERSBURG, VIRGINIA

COMPREHENSIVE PLAN 2014



Seeding the City

Land Use Policies to Promote Urban Agriculture

nplan
NATIONAL POLICY & LEGAL ANALYSIS NETWORK
TO PREVENT CHILDHOOD OBESITY

ChangeLab Solutions
Law & policy innovation
for the common good.

Acknowledgements

Written by Heather Wooten, MCP (ChangeLab Solutions) and Amy Ackerman, JD (Consulting Attorney).

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Introduction

Communities around the country are looking to promote healthier eating by encouraging urban agriculture. "Urban agriculture" is an umbrella term encompassing a wide range of activities involving the raising, cultivation, processing, marketing, and distribution of food in urban areas.

In many communities, urban agriculture takes the form of backyard gardens and community gardens – places on public or private property where neighbors gather to cultivate vegetables and fruits, and even keep bees or raise poultry and small livestock. The food in community gardens is typically grown for the gardeners' own consumption or donation. Urban agriculture also encompasses urban farms (also called "market gardens" or "entrepreneurial agriculture") –enterprises, both for- and nonprofit, that grow produce on a larger or more intensive scale for sale.

Urban agriculture in its many forms benefits communities in many ways, promoting *health, environmental sustainability,* and *economic vitality.*

Increasing the amount of locally grown, minimally processed food promotes community health by expanding residents' access to fresh, nutritious food and decreasing hunger. Community gardeners eat significantly more fruits and vegetables than both home gardeners and nongardeners, and 56 percent of community gardeners met national recommendations to consume fruits and vegetables at least 5 times per day, compared with 37 percent of home gardeners and 25 percent of nongardeners.[1,2] Gardeners also eat a more balanced diet, consuming fewer sweets and sugar-sweetened beverages and a wider variety of vegetables.[3]

Definitions of Urban Agriculture Types

Throughout this toolkit, we use a number of terms to describe urban agriculture activities. These terms are not yet "terms of art" – in other words, different communities may use them to mean different things, and some communities use alternative terminology. Urban agriculture could be defined and classified into many categories (e.g., community gardens with sales versus those without, indoor urban farms versus outdoor, community gardens on institutional land versus those on public land). We've chosen to use the following terms for both simplicity and clarity, with the caveat that they should be used or modified as local circumstances dictate. More information on alternative definitions can be found in the model zoning code section of this toolkit.

Urban agriculture is an umbrella term that describes a range of food-growing practices, from backyard gardens to urban farms.

Home gardens are food-producing spaces on private, residential property (multifamily or single family) that are used primarily by the property's residents or guests. **Community gardens** are smaller-scale urban agriculture sites (often serving a neighborhood) where individuals and families grow food primarily for personal consumption or donation.

Urban farms are larger-scale, more intensive sites where food may be grown by an organization or private enterprise, and often include entrepreneurial opportunities such as growing food for sale.

While there is certainly some overlap between these categories, this framework is helpful for understanding both the purpose for and the needs of (in terms of land, people, and other resources) each type of activity.

Urban agriculture promotes environmental sustainability by reducing greenhouse gas emissions caused by transporting food over long distances. It could also increase food security by ensuring a local food source in the event of natural or man-made disasters that interrupt transportation networks.

Urban agriculture provides green space in urban areas and can provide ecological and environmental benefits, such as preventing storm water runoff. Furthermore, adding organic content, such as compost, leaf mulch, and

soil amendments to support plant growth improves both the quality of soil and its water capacity, so that less water is needed to support growth.[2] Local food promotion also may benefit local economies by providing jobs for local residents. Urban agriculture can boost property values,[4] promote community engagement, and be part of an effective crime-prevention strategy,[5] by activating underutilized community space, promoting community engagement, and increasing "eyes on the street" (a term coined by urbanist Jane Jacobs to describe the crime-prevention affect that neighbors and residents have when they are able to watch over space).[6]

[1] Litt et al. "The Influence of Social Involvement, Neighborhood Aesthetics, and Community Garden Participation on Fruit and Vegetable Consumption." *American Journal of Public Health,* 101(8): August 2011.

[2] Lee SH. "Community gardening benefits as perceived among Americanborn and immigrant gardeners in San Jose, California." 2002. Available at: http://nature.berkeley.edu/classes/es196/projects/2002final/Lee.S.pdf.

[3] *Id.*

[4] Been V and Voicu I. "The Effect of Community Gardens on Neighboring Property Values." *New York University School of Law and Economics Working Paper,* 2006. Available at: www.community-wealth.org/_pdfs/articles-publications/urban-ag/paper-been-voicu.pdf.

[5] Handlin L and Tranel M. "Planting Seeds; Growing Community." University of Missouri–St. Louis Public Policy Research Center. Available at: www.gatewaygreening.org/assets/pdf/WhitmireStudy_FullReport.pdf.

[6] Jacobs J. *The Death and Life of Great American Cities.* New York: Random House. ISBN 0-679-60047-7. 1961.

At the same time, if not implemented carefully, urban farming could have unwelcome effects. In densely populated cities, residents may not welcome the noise, smells, increased foot and vehicular traffic, and other potential effects. To be successful, urban agriculture must be cultivated in a way that promotes food production without creating a nuisance for surrounding property owners and users. In addition, it should follow safe agricultural practices to protect farmers and gardeners, neighboring residents, and city governments from harm or potential liability costs. With careful planning and zoning, urban agriculture can be successfully and seamlessly integrated into urban environments.

Communities can support, promote, and preserve urban agriculture through land use laws. Land use policies can assist in securing access to and ensuring the preservation of land for agricultural uses. Zoning regulations can ensure that agriculture occurs in suitable locations and under the proper conditions. But there is no one-size-fits-all urban agricultural land use policy. Urban areas vary in availability of land for agriculture, population density, soil suitability, and resident interest. This toolkit sets forth a framework and model language for urban agriculture land use policies that communities can tailor to their particular context and needs.



A Framework for Developing Urban Agriculture Land Use Policy

What Are Land Use Laws?

Regulating the use of land is fundamentally a local government function that takes place through planning zoning laws. Cities and counties derive their power to enact zoning regulations through either their state constitutions or their state enabling acts.[7] Local governments use zoning and other land use measures to regulate the growth and development of the city in an orderly manner.

Although state laws vary in the type of legal authority provide to local governments, most states allow local governments to adopt comprehensive plans (also called general, master, or community plans).[8] While plan requirements vary from state to state, they typically apply to all land within the jurisdiction of the local governmental entity.

Comprehensive plans establish long-term guidelines for the permissible land uses in the different areas of the community and guide future public and private development. Common issues addressed in comprehensive plans are land use, transportation and circulation, housing, park and recreation areas, and public facilities.[9]

Zoning is a regulatory mechanism by which a local government divides a community, such as a city or county, into distinct districts with different land use regulations. Simply stated, zoning determines what can and cannot be built, and what activities can and cannot take place, on any given parcel of land.

Local governments have considerable discretion when enacting zoning regulations. Governments enact zoning laws under their "police power" – the power of the government to regulate private conduct to protect and further the public's health, safety, or general welfare.[10] Courts generally defer to the government's judgment in determining whether or not a zoning regulation is legal. Because, by its nature, land use regulation cannot be done with scientific precision, courts presume zoning ordinances are valid and, provided there is a rational basis for different zoning treatment of similar lands, land uses, or land users, courts will generally uphold the regulations.[11]

Key Questions to Consider

To create an effective urban agriculture land use policy, and cities need to consider five key questions:

1. What form(s) of urban agriculture should the community allow?

Urban agriculture can range from backyard gardens to community and institutional gardens to commercial farms, and may be operated by a nonprofit or for-profit entity. It also may include farms that existed prior to they urban expansion and still operate within city limits. either require or Some communities may wish to allow all forms of agriculture; others may only want to permit them in some areas, or not at all. We encourage communities to plan for a range of possible forms of urban agriculture within the jurisdiction of the local governmental and to develop policies and regulations appropriate for each type. The model comprehensive plan language and zoning regulations included in this toolkit are within the community and guide future public and designed to allow communities to consider a range of urban agriculture activities and tailor their regulations to match the forms they wish to allow.



2. Where should different forms of urban agriculture occur?

Even cities that want to encourage all kinds of agriculture are unlikely to want all forms of the community. For example, farms may not be appropriate in a downtown commercial district. Communities need to consider both the availability of land and where different forms of urban agriculture will be most compatible. Conducting a land inventory or other comprehensive analysis of sites suitable for urban agriculture before developing zoning regulations may be helpful in answering this question.

3. Should urban agriculture be a "permitted" or "conditional" use?

Most cities have "use-based" zoning laws. Use-based codes divide the jurisdiction into distinct districts, such as residential, commercial, multi- or mixed-use, and industrial, and regulate the use and development of the land within the districts based on the designation.[12] Where a particular use of land, such as a community garden, is not included within a community's zoning code, it is vulnerable to being closed down as "illegal" or displaced by development that is expressly permitted in the zoning district.

Local governments can use their zoning ordinances either to permit urban agriculture as-of-right or use a discretionary process known as "conditional use" to impose certain standards and requirements.

Approved, Permitted, As-of-Right, or By Right Use

An "approved," "permitted," "as-of-right," or "by right" use is a use of property allowed "as a right" in the zoning code. If, for example, a community garden is included as an approved use of property in particular types of districts, community members may develop and maintain community gardens in those districts without obtaining a permit, finding, conditional use, or other government land use approval. (Note that occasionally jurisdictions require "change of use" or "establishing a use" permits when an allowed use changes, and that other, non–land use permits may be required.) The community may still place restrictions or regulations on that use but, provided that residents comply with those regulations, no land use approval is required. Kansas City, Mo., for example, allows community gardens in other zones as an approved use.[13]

Conditional Use

A "conditional" use is a use that is suitable to a zoning district but not necessarily to every location within that district. For example, urban farms may be appropriately zoned as-of-right in industrial areas, but communities may wish to make them conditional in residential zones. Conditional uses require the landowner to seek approval before using a particular piece of property in that particular manner. In communities where large-scale urban agriculture, on-site sales, or raising animals prompt practical or political concerns, conditional use gives planners and decision makers a tool to ensure that residents' issues are heard and addressed appropriately when an urban agriculture development is proposed. However, conditional use review can be a time-consuming and expensive process, and the costs associated (which may run into the thousands of dollars) are generally borne by the use permit applicant.

Cities can look for other ways to ensure compatibility and mitigate against possible conflicts, such as developing good operating standards (see "Model Zoning Ordinance for Urban Agriculture," page 20).

4. What operating standards should be placed on urban agriculture activities?

Cities need to consider how a particular agricultural activity should be carried out to ensure that the agricultural use is operating safely and does not infringe upon neighboring property owners. Zoning codes may place restrictions on operations of an activity (such as hours of operation, or whether on-site sales or animal rearing are allowed). Such operating standards can be imposed whether the activity is a permitted or conditional use. Providing concrete regulations to guide land use can ensure that operations will be carried out in a way that preserves and enhances the urban environment and is compatible with neighbors.

5. What activities related to urban agriculture should the community allow and what conditions should be placed on those activities? government's environmental department to see if they have record of the site. Second, if historical research reveals past uses that suggest the possibility of soil contamination, the EPA recommends soil testing and/or mitigation measures.[17]

Accessory or Incidental Use

An "accessory" or "incidental" use is a use that is dependent on or affiliated with the land's primary use. While practices vary, zoning codes often permit accessory uses with the main use, while a particular land use is permitted but accessory uses require express approval. For example, urban farmers may wish to sell or process produce at the farm site. Or they may wish to build a storage facility. Communities should consider what accessory uses will be allowed on these sites when drafting their zoning code.

Additional Considerations

Suitability of Property

Whether a parcel of land is suitable for agricultural use depends on factors such as access to water, sunlight, slope, and the soil type, quality, and contamination. Guidance on assessing the suitability of a parcel of land for a garden or farm is beyond the scope of this publication, but we list helpful resources in the "Resources" section (see p. 39).

Evaluating Sites for Contamination

One of the greatest concerns in establishing a garden or farm is the safety of the soil, due to environmental contaminants. The EPA's website offers a number of resources addressing soil testing and safety, including interim guidelines for urban agriculture.[14, 15] It suggests, in keeping with accepted commercial "due diligence" practice, a two-step approach (similar to the Phase I Environmental Site Assessment [ESA]).[16] First, it suggests researching the past uses of a site to help determine the potential for and type(s) of hazards.

Municipalities and urban farmers and gardeners may be concerned about the costs of these measures and enumerate staff capacity for evaluating test results and proposed remediation/mitigation plans. In addition, municipalities may be concerned about potential liability in the event of harm to garden users from exposure to contaminants. There is no standard answer to this issue, and many cities have not addressed it in their urban agriculture land use policies. Our model zoning ordinance includes options for soil testing requirements that range from submitting the results of a site evaluation and plan for remediation (if necessary), to requiring raised beds with non-contaminated soil and protections from soil dust, to conducting a Phase I ESA (see p. 25). In practical terms, any requirement to submit information prior to establishing an urban agriculture use is likely to go hand-in-hand with urban agriculture as a conditional, rather than permitted, use. Applicants would submit their findings as a component of the conditional use process.

Where historical industrial use, illegal dumping, or presence of fill or demolition debris suggests likely contamination, local governments may wish to seek EPA, state, or local brownfield grants or technical assistance to identify best practice measures needed to remove or reduce contaminants or exposures to identified or suspected hazards. Municipalities should partner with community-based nonprofit organizations, university extensions, or other local partners to educate gardeners and farmers on how to conduct and interpret soil testing and how to mitigate exposure to potential soil contamination that may be present. Historical

Farm Management Plans

research can include searching property records (title documents, deeds), looking at Sanborn fire insurance maps (available at local libraries), talking to people familiar with the site, and contacting your state or local

Under federal law, some types of agriculture, particularly those involving large agricultural operations, are required to submit management plans to ensure that their operations are not harming the environment. In King County, Wash., the King Conservation District

works with farmers to develop a farm management plan to improve farm productivity and reduce impacts on natural resources.

Seattle has applied the concept of farm management plans to urban farms. Requiring a farm management plan for larger farms or more intensive cultivation practices can assist in preventing adverse effects on the environment and neighbors. In Seattle, urban farms in residential zones must apply for a conditional use permit. The applicant must provide a proposed farm management plan that includes a site plan; the type and intended use of equipment; the type and use of pesticides or other agricultural chemicals to be used and frequency and duration of use; whether the farm will require drainage approval; a proposed sediment and soil erosion plan; and any required mitigation measures.[18]

Madison, Wis., has proposed an ordinance requiring urban farms to prepare a management plan if they intend to engage in animal husbandry, food processing, manure spreading, application of agricultural chemicals, use of heavy equipment, or anticipate off-street parking of more than 10 vehicles. The management plan must address how the applicant will manage these activities to avoid impacts on surrounding land uses and natural systems.

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[7] 8 McQuillin Mun. Corp. § 25.48 (3d ed. 2009).

[8] Breggin L and George S. "Planning for Biodiversity: Sources of Authority in State Land Use Laws." 22 (81-121): 88-91, 2003. *Virginia Environmental Law Journal,*

[9] *Id.*

[10] Ziegler E, Rathkopf A and Rathkopf D. 1 Rathkopf's The Law of Zoning and Planning § 1:2 (4th ed. 2009).

[11] Ziegler E, Rathkopf A and Rathkopf D. 1 Rathkopf's The Law of Zoning and Planning § 4:1 (4th ed. 2009).

[12] Another form of zoning that is becoming increasingly popular with smart growth advocates is "form-based zoning." While form-based zoning is broader in how it defines allowed uses, use definitions still apply. Most of the provisions here could be applied to form-based codes. For more information, see Section V of "How to Create and Implement Healthy General Plans." Available at: www.phlpnet.org/healthy planning/create_implement_gp.

[13] Kansas City, Mo. Zoning and Devel. Code Table 110-1, §88-312-02B (2010).

[14] *See* "Brownfields and Urban Agriculture: Interim Guidelines for Safe Gardening Practices," Summer 2011, available at: http://www.epa.gov/brownfields/urbanag/pdf/bf_urban_ag.pdf

[15] More information is available at: http://cluin.org/ecotools/urbangardens.cfm#subhead1

[16] A Phase I Environmental Site Assessment, also known as "All Appropriate Inquiries," is the process of conducting due diligence to determine prior uses and ownership of a property and assess conditions at the property that may be indicative of releases or threatened releases of hazardous substances at, on, in, or to the property. "EPA Brownfields Grants, CERCLA Liability, and All Appropriate Inquiries." EPA Publication No. 560-F-09-026. April 2009. Available at: www.epa.gov/brownfields/aai/cerclafs.pdf

[17][18] Seattle, WA. Municipal Code § 23.44.051(B)(1) (2010).*Id.*



Preserving Urban Agriculture

Many urban farmers and gardeners are concerned securing their plot of land over time. Some agriculture is developed as a temporary land particularly when a plot of land is available only short term. But usually, gardeners and farmers long-term use of the land, given the time, energy, and investment needed to improve soil quality for growing healthy plants. Preserving agricultural uses can be challenging, especially in densely populated cities where available land is scarce and where public private interests often compete for use of the land. we offer a brief discussion of some of the ways to agricultural uses (for more information, see the Resources section on page 39).

For more information on takings law, see "Limits on Government Power over Private Property: What Advocates and Government Officials Need to Know About Takings Law." Available at: www.nplan.org/nplan/ products/takings_survey.

Land tenure for urban agriculture is determined by land on a portion of the site. Applying open space both the right to possess or occupy the land – in the zoning protections to privately owned land requires present and the future – and the right to use the land for caution, since government cannot "take" property agriculture. There are a number of legal tools to ensure without providing adequate compensation. a gardener's right to occupy a plot of land: ownership, a property lease, or occupancy through a land trust or conservation easement. The right to use the land for urban agriculture occurs through zoning laws.

Depending on the form of occupancy and the zoning districts enhance the protection of land because once the district is requires a vote by the local hearing and a vote by the the citizens. laws, urban agriculture may have varying levels of protection. Least secure would be, for example, a community garden planted in a zoning district that does not allow for urban agricultural uses and whose gardeners have no right to occupy the land. That garden would be very vulnerable to displacement. A garden created in a zoning district that permits urban agriculture and whose gardeners have entered into with the owner to use the land as a garden the duration of the lease. Most a zoning district that whose owners are required to property for agriculture.

The greatest level of protection is not always possible desirable. And communities will always change; guarantee that urban agriculture will be permanently protected. Additionally, protection strategies may vary depending on the urban context (growing versus about shrinking cities; cities that wish to protect periurban urban or existing rural agriculture versus those establishing use, urban agriculture as a new use). Still, communities for a should be aware of the level of protection each strategy seek provides and apply them as appropriate.

Open Space Zoning Districts

Some cities preserve undeveloped property or recreation space by designating those areas as "protection districts" and or "overlay protection zones." Protection districts, such Here as open space districts, generally apply to publicly protect owned open and recreation spaces but can also apply to private land, where, for example, the community requires a development to contain open or undeveloped

Open space districts enhance the protection of land as open or green space, because once the district is established, a change of use requires a vote by the local legislative body (e.g., a public hearing and a vote by the city council) or, in some places, a vote by the citizens.

In contrast, changing property use from one allowed use to another *within* a district – for example, replacing a community garden with a residential development a lease in a residential district where both uses are allowed – would be protected for generally does not require public hearing or a policy protected would be a garden in permits urban agriculture and whose gardeners own the underlying property or Boston, for example, has enacted an ordinance creating allow continued use of the community garden open space subdistricts.[19] This ordinance allows community gardens to be designated as open space subdistricts to receive the same or protections as other open space uses.

no strategy individually or even in combination can

Land Banks

"Ground Rules: A Legal Toolkit for Community Gardens" provides legal resources for establishing community gardens by lease agreement. Available at: www.nplan.org/nplan/products/CommunityGardenToolkit.

Property ownership, while providing a high level of protection for urban agriculture, can be challenging especially when the cost of acquiring land is significant there isn't a willing seller of the property. Land banks and land trusts offer ownership strategies that can be well suited to urban agriculture. A land bank is a government entity that takes title to tax-delinquent, underutilized land – owned by government entities, individuals and other private entities, and nonprofit entities such as faith-based organizations, local colleges, universities, or hospitals – that could be used for a range of urban agriculture activities. transfers it back to private ownership with a clear title, so that the property can be put to productive (and tax-paying) use.[20] In January 2009, the Ohio legislature authorized a county-wide land bank to acquire tax-delinquent properties in Cuyahoga County, Ohio, which includes Cleveland and adjacent suburbs.[21] Cleveland hopes to acquire the vacant land and put some of it to use for agricultural purposes.[22] Columbus, Ohio, is also developing community gardens on land bank properties it has acquired.[23]

Conservation Easements and Land Trusts

A conservation easement is a right or interest in property that imposes restrictions or obligations on the property's owner or lessee to retain or protect natural, scenic, or open space values of the property and ensure its availability for agricultural, forest, recreational, or open space use. The land remains in existing ownership but the easement "runs with the title," ensuring that the protections remain in place regardless of who may own the land in the future. Troy Gardens, in Madison, Wis., is an example of a conservation easement established over property owned by the Madison Area Community Land Trust to protect land for use as a community garden.[24] The easement may be held by a governmental entity or by a qualified nonprofit entity, such as a land trust.

Land trusts are nonprofit entities that work to conserve land by assisting in land or conservation easement acquisition or by managing the land or easements. The Southside Community Land Trust in Providence, R.I., was established to purchase a blighted, vacant city lot and turn it into a community garden. Now, the trust manages a number of garden sites (some of which they own, others they lease) throughout Greater Providence.[25]

Leases on Public and Private Land

A lease is a contract where the owner of land gives another party the right to use and occupy the land in exchange for receiving a benefit (usually rent). The party's right to use the land lasts for the term of the lease (provided that no conditions of the lease are violated or "breached"). Many communities have a governmental entity that takes property, secures the property, and puts it to productive use for a limited time.

[19] Boston, Mass. Zoning Code § 33-8.

[20] LaCroix C. "Urban Agriculture and Other Green Uses: Remaking the Shrinking City." *Urban Lawyer,* 225(41): Spring 2010.

[21] *Id;* S.B. 353, 127th Gen. Assem., Reg. Sess. (Ohio 2007).

[22] *Id.*

[23] More information on the community garden program in Columbus is available at: http://development.columbus.gov/landredevelopment / content.aspx?id=40112.

[24] More information about Troy Gardens, including its conservation easement language, is available at: www.troygardens.net.

[25] More information about the Southside Community Land Trust is available at: http://southsideclt.org.

Other Laws Affecting Urban Agriculture

The model policies included in this toolkit address only one aspect of urban agriculture: where and under what conditions it may occur within a community. There are other legal and practical issues that affect urban agriculture that should be considered when implementing these model land use policies. Below, we provide a summary of some of the federal, state, and local laws that may affect urban agriculture.

The Americans with Disabilities Act

The Americans with Disabilities Act (ADA) prohibits discrimination against people with disabilities.[26] The ADA applies to all state and local governments and to private entities that are places of "public accommodation." The ADA requires all local government facilities to be accessible to people with disabilities. More specifically, any government facility built or altered after January 26, 1992, must be "readily accessible to and usable by" persons with disabilities. To meet this standard, buildings and facilities must be built in strict compliance with either the ADA Standards for Accessible Design or the Uniform Federal Accessibility Standards (UFAS).[27]

Community gardens and urban farms located on government property, operated through a government program, or open to the public generally are subject to some provisions of the ADA. However, neither the ADA Standards for Accessible Design nor the UFAS provide standards for urban agriculture, so there are no explicit federal design standards for local communities to follow to ensure compliance with the ADA.

Increasing numbers of communities have established community gardens to accommodate people with disabilities. The Palm Desert, Calif., community garden has 151 accessible gardening plots.[29] In June 2007, Somerville, Mass., opened a garden designed to be accessible for those with physical disabilities.[30] The Brookfield Farm in Amherst, Mass., is a community supported farm with an accessible garden.[31] The City of Cambridge, Mass., requires all newly established community gardens to contain a minimum of 5 percent, but not less than one, of the plots to have raised beds.[32]

Broadly, communities are interpreting accessibility to include:

- Accessible routes and entrances to the facility as established by the ADA Standards for Accessible Design or the UFAS.[33]
- Accessible routes of sufficient width so that physically wheelchair users can navigate between garden components (garden beds or plots).[34]
- Raised beds or plots about two feet high and 30 inches wide for disabled access from one side or 60 inches wide to be accessible from all sides, in at least some portion of the garden or in some gardens within a larger gardening program.[35]

Because gardening is a lifelong physical activity enjoyed by people of diverse ages and abilities, community gardens designed to be accessible for those with disabilities will likely also benefit children and seniors.

Pesticide and Other Environmental Laws[36]

A complex web of federal and state environmental laws and incentive programs regulate aspects of agriculture.

ADA requirements for playgrounds offer some for determining what an accessible requires. Among other requirements, entrance, accessible routes connecting certain "play components" (swings, spring riders, etc.), and sufficient maneuvering those components.[28]

Before including environmental or pesticide regulation in local land use laws, it is important to check with your local government attorney. We briefly describe a few of the most pertinent laws here.

Federal, and in some places state, laws regulate the use of pesticides. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) is the primary federal law controlling the regulation, sale, distribution, and use of

pesticides in the United States.[37] FIFRA requires the EPA to review and register pesticides for specified uses prohibits the use of any pesticide not registered also governs training and licensing pesticide applicators and a range of disposal requirements. In addition, Drug, and Cosmetic Act residue or tolerance or animal feed.[38] or use of any the state than allowed their

environmental practices in agriculture and other industries. The U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) is the federal by the EPA. It agency that works to conserve natural resources on private requirements for lands.[45] The NRCS manages many agricultural programs handling, storage, and to assist farmers in environmentally sound practices. under the Federal Food, Conservation districts, local units of government (FDCA), the EPA sets maximum established under state law, carry out natural resource levels for pesticides used in or on foods management programs at the local level. Conservation FIFRA allows a state to regulate the sale districts coordinate assistance from all available sources— federally registered pesticide, provided that public and private, local, state, and federal—in an effort does not impose less stringent requirements to develop locally driven solutions to natural resource under the federal law.[39] Some states have enacted concerns.[46] own laws regulating pesticides.[40]

A local government's ability to control pesticide use is generally limited.[41] FIFRA provides may regulate pesticides, but it does not specify governments may do so. In addition, some preempt (or prohibit) cities and counties regulating pesticides.[42] As a result, most urban will be prevented from imposing stricter their city than allowed by their consider when allowing larger-scale agricultural operations in densely populated areas.

The federal Coastal Zone Management Act (CZMA) Coastal Zone Act Reauthorization Amendments protects the natural, commercial, recreational, aesthetic resources of coastal and Great funding available to each of to control nonpoint runoff or snowmelt impervious

and workforce development boards to train residents living in or near a brownfield area to work in a range of environmental occupations. The EPA also funds the 35 states with coastal zone areas regional organizations to provide technical assistance to communities on brownfield issues and provides funding for the assessment and cleanup of sites.[49] surfaces such as roads, parking lots, and roofs. These states must develop state Coastal Nonpoint Pollution Control programs with enforceable policies. These state programs may require farmers or ranchers to implement particular management practices or apply for and obtain permits.[44]

Brownfields and Environmental Cleanup Laws

Federal and state laws also regulate the ability of public application or and private property owners to develop or reuse land that that states contains toxic or other harmful chemicals (including that local developing such sites as urban agriculture).[47] The EPA, states expressly under the Small Business Liability Relief and Brownfields from Revitalization Act, provides competitive funding to state, communities regional, local, and tribal governments to assess and pesticide standards within clean "brownfield" properties, defined as "real property, state – an issue that cities must the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant."[48] The EPA's brownfield program also provides competitive and the grants for job training to community-based organizations of 1990 ecological, and Lakes areas.[43] CZMA makes from cropland, pastures, barnyards, and In addition to funding, the Brownfields Act provides certain legal protections to landowners seeking to reuse brownfield sites. In order to receive the protections and be eligible for funding, as well as satisfy most commercial lender requirements, the property owner (including state and local certain governments) must conduct an "All Appropriate Inquiries,"

In addition to laws regulating the environment, some state governments offer many grants, loans, and other incentive programs to improve also known as a Phase I, Environmental Site Assessment (ESA). This assessment is the process of conducting due diligence to determine prior uses and ownership of a

property and to assess conditions at the property that may has a much more comprehensive guide, titled "Arkansas be indicative of releases or threatened releases of hazardous Direct Farm Business Guide." Before selling produce or substances at, on, in, or to the property.[50] food products, it is important to seek local guidance.

Right-to-Farm Laws

"Right-to-farm" laws seek to protect existing farms from lawsuits by neighboring property owners seeking To conduct their business, persons or entities that to curb agricultural activities. All 50 states have some run a business, including the selling of produce, must type of right-to-farm law.[51] As urban areas began to choose a business entity: sole proprietor, partnership, expand, existing farms were subject to lawsuits from new cooperative, for- or nonprofit corporation, or other type neighbors alleging that the agricultural activities were a allowed by their state. Produce sellers must follow state "nuisance," a legal term meaning a condition, activity, or law when forming their entity, which generally includes situation (such as a loud noise or foul odor) that interferes registering their entity with the Secretary of State or other with the use or enjoyment of property. States passed the comparable office. right-to-farm laws primarily as a means to protect existing farms from those nuisance lawsuits. In its most basic within their jurisdiction to obtain a business operating form, a right-to-farm law establishes that no agricultural license, which is essentially a requirement that the operation will be deemed a nuisance due to changed business register locally and pay a fee. circumstances in the area where it is located, so long as the operation is not conducted in a negligent or unlawful manner and was not a nuisance when it was begun.

Generally, a state's right-to-farm law should not impede development of a community's urban agriculture laws. But because in some states right-to-regulate farm management practices, they community's ability to regulate farm through their land use policies.[52] information, contact the National Agricultural the University of Arkansas School of Law (www.NationalAgLawCenter.org).

State and Local Laws Establishing and Regulating a Business Entity

Some municipalities require business entities located within their jurisdiction to obtain a business operating form, a license, which is essentially a requirement that the business register locally and pay a fee.

Federal, State, and Local Taxation Laws

Some sellers may need to register with the federal government and obtain a federal employer identification number. In many states, business entities, even nonprofit organizations, must obtain a sales and use tax permit (even when the products they are selling are not taxable) from the state's finance department or equivalent entity. Most entities must report earned income, and likely pay taxes on it, to the federal and state governments. Sellers may need to collect and pay state sales tax on the goods they sell.

Finally, those enterprises with employees must withhold and submit federal and state withholding taxes.

Laws Regulating Commercial Farms and Produce Sales

Urban farmers are often interested in selling their harvest or products made from food they've grown. Zoning laws regulate only whether sales may occur on a particular of property. Farmers, whether nonprofit or for-comply with other federal, state, or local they may sell their produce or food products. Compliance may include registering and obtaining various permits and licenses. Because these laws vary by locality, we can provide only a brief overview of the types of laws that likely apply. The National Agricultural Law Center

"Volunteers and Liability: The Federal Volunteer Protection Act" provides an overview of federal legal protections that shield volunteers from liability. Available at: www.nplan.org/nplan/products/volunteers-andliability-federal-vo.

Federal, State, and Local Employment and Volunteer Laws

Farms that employ workers are subject to federal, state, and sometimes local laws regulating employment conditions and safety, wages and benefits, unemployment insurance, and workers' compensation. Similarly, federal laws and state laws regulate the use of volunteer and child labor.

Federal and State Food Safety Laws

Federal laws regulate health and safety related to growing processing some agricultural products, primarily interstate, but many states apply those same standards to products grown in-state that may federal laws. Dairy products, eggs, and fish and animal operations are governed by additional federal and state regulations.

State laws also regulate the health and safety of retail food sales. Forty-nine of 50 states have retail food laws based on the FDA's model Food Code versions from 1993 or later.[53] Updated most recently in 2009, the model Food Code sets forth sanitation and food-handling requirements for restaurants, retail food stores, and operations.[54] Briefly, the model code definitions; sets sanitation standards for personnel, food operations, and equipment and facilities; and provides for food establishment plan review, permit issuance, inspection, and permit suspension.[55]

The model Food Code exempts from its provisions stands that sell only whole, uncut fresh fruits vegetables.[56] Many, but not all, states have included exemption in their retail food laws. In those states, fresh whole produce at produce stands are not required to obtain a food handler's license or permit, and are not subject to the other requirements under their food retail code. Those who make and sell products processed from fresh produce – even if sold at the produce stand generally must comply with the food code's safety requirements for food handling and preparation, which require undergoing training, obtaining a license, and preparing food in a commercial kitchen.

Animal Welfare and Control Laws

A number of cities regulate the keeping of farm animals animal welfare or control ordinance in the community and often specify the conditions that are required for lawful keeping of specified animals. Some codes require owners to obtain a permit and pay a fee to keep animals such as chickens or bees on their property. In addition to paying a fee, Minneapolis requires prospective bee or chicken keepers to obtain the written approval of 80 percent of the occupants of real estate located within 100 feet of the premises before Animal Care and Control will issue a permit.[57] The Seattle City Council approved an amendment to its code that allows residents to keep miniature goats as pets with a license similar to dog and cat owners.[58] Milwaukee has a detailed animal code regulating the keeping of chickens and bees, which specifies standards for coop construction, feeding, setbacks, and flyway barriers.[59]

State and Local Building Safety Laws

If farmers or gardeners erect structures, even sheds or food-processing other storage facilities, they need to adhere to state and local building code laws.

Medical Marijuana Laws

A number of states have laws approving the use and cultivation of marijuana (*cannabis sativa*) for medical use. Because the cultivation and sale of marijuana produce raises unique issues beyond the scope of other types of agriculture, communities may want to address marijuana cultivation separate from a general urban agriculture land use policy.

Local Composting Laws

A number of communities have laws addressing garden compost. Some, like San Francisco, require city – residents or businesses to separate out their garden and food waste for curbside removal. The trash collector is then required to remove the biowaste to a composting facility.[60] Others, like Minneapolis and Chicago, allow noncommercial backyard composting, but regulate it by limiting the type of waste allowed in composting and set requirements for the size and placement of composting containers on a property.[61] Chicago municipal code encourages composting by providing training and giving rebates to those who purchase composting bins.[62]

[26] 42 U.S.C. §§ 12101 *et. seq.* The U.S. Department of Justice, responsible enforcement of the ADA, has a website containing the statute, regulations, and many helpful technical assistance documents at: www.ada.gov.

[27] The ADA Standards for Accessible Design are located in 28 CFR pt. 36 app. A. The Uniform Federal Accessibility Standards (AFAS) are architectural design standards originally developed for facilities covered by the Architectural Barriers Act, a law that applies to buildings designed, built, altered, or leased by the federal government. State and local governments have the option to use the UFAS or the ADA Standards to meet their obligations under the ADA. "Americans with Disabilities Act: Questions and Answers," U.S. Equal Opportunity Commission, U.S. Department of Justice Civil Rights Division (Nov. 2007). Available at: www.ada.gov/q%26aeng02.htm.

[28] 36 C.F.R. Part 1191 Appendix A §§15.6 *et. seq.* Play Areas.

[29] More information on the Palm Desert community garden is available at: www.cityofpalmdesert.org/Index.aspx?page=422.

[30] More information on the Somerville garden is available at: www.somervillema.gov/section.cfm?org=consbd&page=233.

[31] More information is available at: www3.brookfieldfarm.org/accessibleGarden.html.

[32] City of Cambridge Community Garden Program Policy for City-gov/CityOfCambridge_Content/documents/2010-garden_ January 2009). Available at: www.cambridgema.

[33] The ADA requires all public facilities to have an entrance on an accessible route. 28 CFR pt. 36, app. A, §36 describes the design requirements for an accessible route. *See also* "Making Your Garden Accessible," Together 4 Health: Partners for Healthy Living (2008). Available at: www.together4health.ca/workgroups/community-gardens-waterloo-region/accessible-gardens.

[34] "Making Your Garden Accessible" *supra* note 28. The City of Palm Desert's community garden has raised plots that are four feet wide for easy maneuvering and gardening from either side of the plot. Information on how to build raised beds is available from the Dowling Community Garden in Minneapolis, Minn., at: www.dowlingcommunitygarden.org/pages/projects.htm# .

[35] Of the 345 federally recognized tribes with food service operations, as of February 2010, only 63 have adopted a tribal food code, 54 of which are based on the FDA Model Food code. (*Id.*)

[36] The Environmental Protection Agency is charged with enforcing federal laws protecting the environment. The EPA provides a summary of these federal laws in "Major Existing EPA Laws and Programs That Could Affect Agricultural Producers," Environmental Protection Agency Counselor Office of the Administrator (June 2007). Available at: www.epa.gov/agriculture/agmatrix.pdf.

[37] 7 U.S.C. § 136a *et seq.*

[38] 7 U.S.C. § 136a.

[39] 7 U.S.C. § 136v(a).

[40] *See, e.g.,* Cal. Food & Agric. Code §§ 12811 *et. seq.*

[41] 1 L. of Chemical Reg. and Hazardous Waste § 3 :90 (2011).

[42] *See, e.g.,* Cal. Food & Agric. Code § 11501.1.

[43] 16 U.S.C. § 1451.

[44] 16 U.S.C. § 1455.

[45] More information on the Natural Resources Conservation Service is available at: www.nrcs.usda.gov.

[46] More information on conservation districts is available at: www.nrcs.usda.gov/programs/rcd/pdf_files/RCD_2009_factsheet.pdf.

[47] The EPA also has laws and programs directed toward "Superfund" sites (abandoned hazardous waste sites).

[48] 42 U.S.C. 9601(39)(a).

[49] More information on the EPA's brownfield programs is available at: the www.epa.gov/brownfields/index.html.

[50] "EPA Brownfields Grants, CERCLA Liability, and All Appropriate Inquiries." EPA Publication No. 560-F-09-026. April 2009. Available at: www.epa.gov/brownfields/aai/cerclafs.pdf. For more information on Brownfields Redevelopment and Local Agriculture, see "How Does Your Garden Grow? Brownfields Redevelopment and Local Agriculture." EPA Publication No.560-F-09-024. March 2009. Available at: www.epa.gov/brownfields/success/local_ag.pdf. More information on "All Appropriate Inquiries" requirements is available at: www.epa.gov/brownfields/regneg.htm, and "All Appropriate Inquiries Final Rule," EPA Publication No. 560-F-05-240. November 2005. The standards and practices for conducting "All Appropriate Regulations" are set forth in regulations at 40 CFR Part 312.

[51] Centner T. "Governments and Unconstitutional Takings: When Do Right to Farm Laws Go Too Far?" 33 *Boston College Environmental Affairs Law Review,* 2005. Available at The National Agricultural Law Center at the University of Arkansas School of Law: www.NationalAgLawCenter.org.

[52] *See, e.g.,* Mich. C.L.A. § 286.474(c) (" . . . it is the express legislative intent that this act preempt any local ordinance, regulation, or resolution that purports to extend or revise in any manner the provisions of this act or generally accepted agricultural and management practices developed under this act").

[53] F.D.A. "Real Progress in Food Code Adoptions." Quarterly Report. December 31, 2010. Available at: www.fda.gov/food/foodsafety/retailfoodprotection/federalstatecooperativeprograms/ucm108156.htm. North Carolina has adopted a law based upon the 1976 model food service code. The District of Columbia, Puerto Rico, and the Virgin Islands have also adopted versions of the Food Code.

[54] F.D.A. Model Food Code, Preface § 3 (2009).

[55] F.D.A. Model Food Code § 1-103.10 (2009).

[56] F.D.A. Model Food Code § 1-202.10(B) Food Destablishement. (3)(b) Agricultural (2009).

[57] Minneapolis, MN Code of Ordinances. Title 4 §§ 70.10 (2011).

[58] Seattle, WA City Council Ordinance 122508, passed September 24, 2007. Seattle, Wash. Municipal Code § 23.42.052 (2010)

[59] Milwaukee, WI Common Council Ordinance 101416, passed May 24, 2011.

[60] San Francisco, Cal. Environment Code ch. 19.

[61] Title 12 Minneapolis, Minn. Muni. Code § 244.770; Chicago, Ill. Muni. Code § 7-28-715.

[62] More information on the Chicago Sustainable Backyard Program is available at: www.cityofchicago.org/city/en/depts/doe/provdrs/nat_res/svcs/how_can_i_get_a_rainbarrelorcompostbinrebateform.html.

Model Comprehensive Plan Language for Urban Agriculture

The following comprehensive plan language establishes a land use policy to promote urban agriculture as an important community feature. The language is designed to be tailored to the needs of an individual community. The local jurisdiction will need to determine where to add the language to its existing plan and/or include it during a comprehensive plan update, make other amendments as necessary for consistency, and follow the appropriate procedures for amending and adopting comprehensive plans. Language written in italics provides different options or explains the type of information that needs to be inserted in the blank spaces in the policy. "Comments" describe the provisions in more detail or provide additional information.

More information about comprehensive plans and healthy land use planning can be found in "How to Create and Implement Healthy General Plans." Available at: www.changelabsolutions.org/healthy-planning/create_implement_gp.

Goal 1: Protect existing and establish new urban agriculture sites, including home gardens, community gardens, and urban farms as important community resources that improve healthy food access and food literacy; build social connections; offer recreation, education, and economic development opportunities; and provide open space and a source of local food.

Objective 1a: Ensure that urban agriculture can flourish on public and private property, where appropriate, throughout the [*jurisdiction*].

Policies:

- [*The Planning Department/responsible entity*] will identify and eliminate any zoning, design, or other restrictions on home gardens and edible landscaping on residential properties, including [*single-family, multifamily, and residential mixed use*].
- Adopt zoning regulations that establish community gardens as a permitted use in appropriate locations. Community gardens are compatible with the [*insert names (e.g., Residential, Multifamily, Mixed Use, Open Space, Industrial, Public Facility)*] land use designations shown on the [*Comprehensive Plan land use map*].
- Adopt zoning regulations that establish urban farms as a conditional [*or permitted*] use in appropriate locations. Urban farms are compatible with the [*insert names (e.g., Commercial, Industrial)*] land use designations shown on the [*Comprehensive Plan land use map*].
- [*The Planning Department/responsible entity*] will identify existing and potential community garden sites on public property, including parks, recreation and senior centers, public easements and right-of-ways, and surplus property, and give high priority to community gardens in appropriate locations.
- [*The Planning Department/responsible entity*] will identify existing and potential urban farm sites within the community (including on private and public land), and remove regulatory barriers to developing urban farms where appropriate.
- In collaboration with relevant [*jurisdictional*] agencies as well as private and nonprofit stakeholders, develop an Urban Agriculture Plan for the [*jurisdiction*] that 1) identifies and inventories potential urban agriculture sites,

2) recommends policy and programmatic revisions as appropriate, and 3) sets forth specific actions to support and expand urban agriculture, including home gardens, community gardens, and urban farms.

COMMENT: The policy to develop an "Urban Agriculture Plan" might seem redundant given the other detailed policies presented here, but we offer this as an additional option for communities to consider as they update their comprehensive plans. Some jurisdictions may prefer to develop a topical plan (similar to an open space plan or pedestrian master plan) specifically focusing on urban agriculture, rather than tackle all the relevant policies and actions for urban agriculture in their comprehensive plan. For example, the City of Alameda, Calif., is currently developing an "Urban Farm and Garden Plan." However, the legal weight of policies not adopted as part of the comprehensive plan may be less than if they were included there. Communities should weigh the pros and cons of each option.

Objective 1b: Distribute urban agriculture resources equitably throughout the community.

Policies:

- [*The Planning Department/responsible entity*] will identify neighborhoods that are underserved by open space and healthy eating opportunities, including access to existing urban agriculture resources.

COMMENT: Communities should undertake an assessment of existing conditions relevant to urban agriculture, such as existing urban agriculture sites, parks, and open space, and nutrition-related health data, such as food insecurity. Such an assessment could be undertaken as part of the existing conditions analysis for a comprehensive plan or as a future action (including as part of an urban agriculture master plan). Understanding where needs are greatest will help direct public resources to be most beneficial. The lead or responsible implementing partner may be the planning department, or it may be another public or private partner, such as the local health department.

- Establish a standard for the creation and operation of one community garden of no less than [*one*] acre for every [*2,500*] households.

COMMENT: The standard presented here is based on Seattle's standard – one community garden per 2,500 households.[63] This standard matches closely the National Recreation and Park Association's widely used best practice standards for a neighborhood park or tot lot (1/2 acre per 2,500 households for a tot lot; 1 acre per 5,000 households for a neighborhood park[64]). Other options for standards could be distance-based (such as developing a community garden within one-quarter to one-half mile of all residences). Distance-based standards may not account for differences in residential density throughout a community, however, and communities that are more or less urban will need to assess which standard is appropriate for them.

- Identify development incentives, grants, and other sources of funding for developing new urban agriculture sites.

- Prioritize the development of new urban agriculture sites in low-income and underserved neighborhoods.

Goal 2: Maximize opportunities to incorporate urban agriculture into new development.

Objective 2a: Ensure that new development includes opportunities for urban agriculture, including rooftop and home gardens, community gardens, and urban farms, where appropriate.

Policies:

- Amend [*zoning and/or subdivision codes*] to encourage [*or require*] all new housing units [or multifamily housing units] to contain designated yard, rooftop, or other shared space for residents to garden.

- Amend [*zoning and/or building codes*] to encourage [*or require*] all [*or some, such as multifamily residential, commercial, institutional, or public*] new construction to incorporate green roofs and edible landscaping, and encourage the use of existing roof space for community gardening.

COMMENT: Communities should ensure that building codes address safety concerns, including appropriate fencing and added load weight, when permitting roof gardens.

- Community gardens shall count towards park and open space allocations required by [*reference state or local law requiring park or open space allocations for new subdivisions and multifamily development*].

> **COMMENT**: Some states require, or permit local governments to require, developers to dedicate land or pay fees (in lieu of dedicating land) for park and recreation purposes as a condition for approval of the development. For example, the Quimby Act is a California law that authorizes cities and counties to pass ordinances requiring developers to dedicate land or pay in lieu fees, or a combination of both, for park or recreational purposes as a condition to approving a tentative map application for the development.[65] The Quimby Act requires setting aside between three and five acres of the land to be developed for every 1,000 new residents generated by the proposed development.[66]

Goal 3: Promote urban agriculture through ongoing programming and partnerships.

Objective 3a: Establish partnerships and initiatives with public agencies and private and nonprofit groups that expand urban agriculture throughout the [jurisdiction].

Policies:

- Designate a Community Gardening Coordinator within the [*Parks and Recreation Department*] to support existing and assist in the creation of additional community gardens.

- The [*Community Gardening Coordinator/local food policy council*] will identify opportunities to increase support for community gardens and urban farms through partnerships with other governmental agencies and private institutions, including school district(s), neighborhood groups, senior centers, businesses, and civic and gardening organizations.

> **COMMENT**: Communities with active food policy councils may choose to identify the food policy council or its lead agency/organization as the implementing partner for several of these policies.

- The [*Community Gardening Coordinator*], in collaboration with relevant partners, will develop a streamlined process to apply for and access public land for urban agriculture through long-term leases on City-owned land.

- The [*jurisdiction*] will seek to secure additional urban agriculture sites through long-term leases or other mechanisms on land owned by nonprofit organizations and public or private institutions like universities, colleges, school districts, hospitals, and faith communities.

- Encourage local law enforcement agencies to recognize the risk of vandalism of and theft from community gardens and urban farms and provide appropriate surveillance and security.

- The [*Community Gardening Coordinator/local food policy council*], in collaboration with relevant partners, will identify additional regulatory or programmatic changes that could support the expansion of urban farms and community gardens as engines of local food system economic development and activity, such as establishing community kitchens, promoting shared use (or joint use) of school and community-based organizations' commercial kitchens, and conducting outreach on safe food-handling and sustainable-growing practices.

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[63] City of Seattle, Department of Planning and Development. *City of Seattle Comprehensive Plan, Urban Village Appendix.* 2005, p. UV-A5. Available at: the www.seattle.gov/DPD/cms/groups/pan/@pan/@plan/@proj/documents/Web_Informational/cos_004485.pdf.

[64] Lancaster R (ed). *Recreation, Park and Open Space Standards and Guidelines.* Ashburn, VA: National Recreation and Park Association. 1990; and see Mertes J and Hall J (eds). *Park, Recreation, Open Space and Greenway Guidelines. Ashburn*, VA: National Recreation and Park Association. 1996,

[65] Cal. Govt. Code § 66477 (West 2009).

[66] The formula to calculate a proposed development's requirement under Quimby Act is as follows:

(persons per household)* X (number of units in development) X (3 to 5 acres per 1,000 residents)**

* Estimates for "persons per household" can be found in the housing also element of a city or county's general plan or via the census website, available at: www.census.gov Tables D1.2, D1.3, D1.4, D1.5 and D1.6.

** Specific acreage requirements will be determined by local ordinance.

Model Zoning Ordinance for Urban Agriculture

The following section contains model language for communities to tailor and adopt as amendments to their existing zoning laws, or as part of a comprehensive zoning update. As noted above, cities vary considerably by size, density, availability of land, and demand for urban agricultural activities. There is no one-size-fits-all approach when it comes to zoning for urban agriculture, so we present a number of options in an à la carte fashion for communities to select as appropriate.

Language written in italics provides alternate options or explains the type of information that should be inserted in the blank spaces in the ordinance. "Comments" discuss alternatives, examples from different cities, or additional information. The local jurisdiction will need to determine where the ordinances would best fit within its existing code, make other amendments as necessary for consistency, and follow the appropriate procedures for amending the zoning law.

Definitions and Types of Uses

The way a community defines the different types of agriculture is extremely important because those definitions will guide decisions about what types of agriculture are appropriate in different areas within the community. "Urban agriculture" describes a spectrum of activities. We divide it into three major types of agricultural activities (home garden, community garden, and urban farm), but some communities may wish to subdivide it into more, or different, categories.

Key considerations are:

- The size of the land area;
- The location of the area;
- The number of users of the property (and possibly traffic generated by the activity); and
- The purpose of the operation (e.g., private or commercial).

Some communities may wish to distinguish between community gardens and urban farms by the nature of the activity and intensity of use (food grown for personal consumption or donation versus food grown for sale). Others will want to distinguish by the size of the operation. The advantage to providing multiple definitions is that it allows the jurisdiction the flexibility to apply appropriate standards and regulations to each type; for example, there is likely no need to require a conditional use permit for a small-scale neighborhood garden, but there may be important reasons for doing so with larger-scale gardens where food grown is sold on-site. Additionally, it allows the jurisdiction to designate specific zones where different types of activity may be allowed, allowed conditionally, or prohibited altogether. Make sure that the definitions are sufficiently distinct so that residents and officials are clear about the differences.

The key to promoting urban agriculture within a community is to eliminate unnecessary barriers while ensuring safe practices and adequate protection for gardeners, farmers and neighboring landowners.

USE DEFINITIONS

	Home Garden	**Community Garden**	**Urban Farm**
Definitions	A home garden shall mean the property of a single-family or multifamily residence used for the cultivation of fruits, vegetables, plants, flowers, or herbs by the residents of the property, guests of the property owner, or a gardening business hired by the property owner. ***Comment:*** *This definition is drafted specifically for residential properties. It is broad enough to include on-site gardens at home daycare sites or board and care homes, without permitting a home gardening business.* *Few communities place restrictions on the growing of produce in backyards. Some communities, however, restrict landscaping in front yards. In Sacramento, Calif., for example, residents were limited in the percentage of space they could use for cultivating fruits and vegetables in their front yards (but were successful in amending their zoning ordinance to eliminate that restriction).*[67]	A community garden shall mean privately or publicly owned land used for the cultivation of fruits, vegetables, plants, flowers, or herbs by multiple users. Community gardens may be divided into separate plots for cultivation by one or more individuals or may be farmed collectively by members of the group and may include common areas maintained or used by group members. ***Comment:*** *Community gardens may be cultivated on a wide variety of sites, including underutilized or vacant public or private property, schools, universities, hospitals, or private companies, and as a temporary or permanent use.*[68] *Community gardens may be used to fill different needs: a food source or recreation for individuals lacking access to home gardens, community building, education (such as school gardens), or to support an institution's food services (such as hospital or institutional gardens). This definition is broad enough to encompass all of these types of community gardens. Some communities may wish to expressly include institutional gardens in their definition of community gardens.*	An urban farm shall mean privately or publicly owned land used for the cultivation of fruits, vegetables, plants, flowers, or herbs, [and/ or for animal products, livestock production, or value increase] by an individual, organization, or business with the primary purpose of growing food for sale. ***Comment:*** *This definition is drafted to identify urban farms as commercial enterprises (including both for-profit and nonprofit), regardless of the type of land upon which they are sited and the type of entity operating the site (i.e., individual, private, or nonprofit corporation).* *From a land use perspective, a profitmaking enterprise is distinguished from the primarily non-commercial activities of home and community gardens by the scale of activities and intensity of use. Whether the farm is owned or operated by a for-profit or not-for-profit entity does not affect the actual use of property. Some communities, however, may wish to distinguish farms based on type of corporate structure. In that event, the community could subdivide the urban farm category into two categories (for-profit and nonprofit commercial enterprises.)*

USE DEFINITIONS

	Home Garden	Community Garden	Urban Farm

Alternative or Additional Definitions	*Describe property more specifically:* Home gardens include the front or backyard, rooftop, courtyard, balcony, windowsills, fence, and walls.		*Alternate terminology:* Market Gardens Commercial Gardens Small-Scale Entrepreneurial Agriculture ***Comment:*** *In some communities, state laws may limit "agricultural" uses in urban areas. For this reason as well as local preference or political palatably, communities have used other terms for urban farms. Cleveland uses the term "market garden," defined as "an area of land managed and maintained by an individual or group of individuals to grow and harvest food crops and/ or non-food, ornamental crops, such as flowers, to be sold for profit."*[69] *Nashville uses the terms "commercial community gardening" and "noncommercial community gardening" to distinguish between agriculturefor personal consumption and agriculture where the intent is growing food for sale.*[70] *Kansas City defines "Community Supported Agriculture" as "an area of land managed and maintained by an individual or group of individuals to grow and harvest food and/or horticultural products for shareholder consumption or for sale or donation."*[71]

	Home Garden	Community Garden	Urban Farm
Size Limits	[*No regulation*] ***Comment:*** *In many communities, there is likely no need to regulate home gardens, including size limits.*	Community gardens may consist of lot sizes of no more than [*number of square feet/acres*]. ***Comment:*** *Some communities may prefer to distinguish community gardens from urban farms by size limitations rather than by commercial and noncommercial activity.* *If the community is allowing sales on- or off-site at community gardens, it needs to make sure that the community garden can be distinguished from an urban farm. Some communities may wish to limit the size of community gardens to ensure they remain primarily noncommercial activity.* *In San Francisco's urban agriculture law, urban agriculture is divided into two categories: neighborhood agriculture and large-scale urban agriculture. "Neighborhood agriculture" is defined as an urban agricultural activity that is less than one acre in size, including backyard gardens, community gardens, community-supported agriculture, market gardens, and private farms, and allows limited sales and donation on the site of production.* *"Large-scale urban agriculture" is defined as a use of land for the production of horticultural crops that occurs on a site greater than one acre or on lots smaller than one acre but that do not meet the physical and operational standards for the neighborhood agriculture use.*[72] *Pittsburgh requires a minimum lot size of three acres for urban agriculture use.*[73]	Size limitations. ***Comment:*** *See comment on size limitations under "Community Gardens."*

USE DEFINITIONS			
	Home Garden	**Community Garden**	**Urban Farm**
Where Use Is Allowed	Home gardens are a permitted use in all residential districts. ***Comment:*** *To promote and protect urban agriculture, it is important to make sure home gardens are included in all residential districts, including multifamily and public housing.*	Community gardens are a permitted use in the following zones: residential, multifamily, mixed-use, open space, industrial, [*add other zoning districts*] subject to regulations. ***Comment:*** *To promote and protect urban agriculture, it is important to make sure community gardens are an allowed use in all appropriate districts. Provided the garden use is subject to adequate regulations, a community garden should need no additional land use authorization.*	Urban farms shall be a conditional use in [*residential*] districts and subject to regulations in all districts: ***Comment:*** *Communities may be comfortable with allowing all farms or smaller urban farms as a permitted use in certain districts, including residential.* *San Francisco's ordinance permits the Neighborhood Agriculture use, defined as an urban agricultural activity that is less than one acre in size, in nearly all zoning districts (subject to physical and operational standards) and requires conditional use authorization for urban industrial agriculture in residential districts.*[74]

Regulations of Uses

Setting forth the rules under which the property can be used for agricultural purposes ensures success. We offer proposed regulations that communities can use to develop their own policy. In some situations, these regulations can be part of a permitted or approved use; in other communities, these regulations could be part of a conditional use.

REGULATION OF USES/OPERATING STANDARDS

	Home Garden	Community Garden	Urban Farm
Compliance with All Laws	[*No regulation*]	All community gardens and their users must comply with all federal, state, and local laws and regulations relating to the operation, use, and enjoyment of the garden premises. Site users may not introduce heavy metals or other harmful contaminants to garden or farm sites. Site users may use pesticides only to the extent permitted by law. ***Comment:*** *Generally, municipalities are preempted from regulating pesticide use. Consult with your local government attorney before prohibiting all pesticide use.*	All urban farms and their owners, lessees, employees, volunteers, and visitors must comply with all federal, state, and local laws and regulations relating to the operation, use, and enjoyment of the farm premises. Site users may not use materials such as inappropriate fill that introduce heavy metals or other harmful contaminants to garden or farm sites. Site users may use pesticides only to the extent permitted by law. ***Comment:*** *See comment on pesticide use under "Community Gardens."*
Soil Testing	[*No regulation*] ***Comment:*** *Most communities will want to encourage all gardeners, including home gardeners, to test their soil for lead and other harmful contamination and to implement precautionary measures, particularly where children are gardening. Ensuring children are not ingesting soil and preventing soil dust is particularly important to prevent children's exposure to lead exposure. Municipalities should work with local gardening organizations, state university extensions, and others to help educate residents about soil safety and health. See the "Resources" section for more information on safe gardening practices.*	Prior to establishment, site users [*or municipal employees*] shall inquire into historical use of the property and undertake soil testing to measure nutrients, heavy metals, and any other harmful contaminants that may be present. The soil testing results and proposed remediation methodology (if needed) shall be provided to and kept on file with the City [*insert department name*] Department. ***Comment:*** *Soil safety is one of the most difficult issues facing municipalities when developing urban agriculture programs. Municipalities and advocates need to consider what requirements to impose before converting property into an agricultural use. The EPA's interim guidelines for safe gardening practices suggests that historical property assessments, soil testing for hazardous …*	Prior to establishment, site users shall inquire into historical use of the property and undertake soil testing to measure nutrients, heavy metals, and any other harmful contaminants that may be present. The soil testing results and proposed remediation methodology (if needed) shall be provided to and kept on file with the City [*insert department name*] Department. ***Comment:*** *See the comments on soil safety under "Community Gardens." The option above is an informal version of the Phase I ESA, suggested by the EPA.*

REGULATION OF USES/OPERATING STANDARDS

	Home Garden	Community Garden	Urban Farm
Soil Testing con't.	[*No regulation*]	***Comments continued:*** ***…*** *materials, and mitigation measures are all methods for determining site safety.*[75] *The language listed above, essentially a modified form of an ESA, is suggested by the EPA. Municipalities need to consider who should do the assessment – the municipality or site users – and who should interpret the testing results and determine what, if any, mitigation measures are required. Many municipalities lack staff with expertise in soil testing. Municipalities should consider partnering with local gardening organizations and universities.* *In practical terms, any requirement to submit information prior to establishing an urban agriculture use is likely to go hand-in-hand with urban agriculture as a conditional, rather than permitted, use. Applicants would submit their findings as a component of the conditional use process.*	***Continued:*** *Alternate soil testing requirement:* Site users must provide a Phase I Environmental Site Assessment (ESA). Any historical sources of contamination identified in the ESA must be tested to determine type and level of contamination; appropriate remediation procedures must be undertaken to ensure that soil is suitable for cultivation. ***Comment:*** *Alternatively, localities could require a Phase I ESA.*[76] *This is a potentially more resource-intensive requirement for the urban farm applicant. A Phase I ESA is a historical search of the property to determine if there are any past uses that could have caused contamination to the soil. To minimize costs, the municipality could conduct the assessment. Or, they could require those wishing to establish a new urban farm to have an assessment conducted.*

Operating Standards	[*No regulation*]	Site users must have an established set of operating rules addressing the governance structure of the garden, hours of operation, maintenance, and security requirements; must have a garden coordinator to perform the coordinating role for the management of the community gardens and to liaise with the City; and must assign garden plots in a fair and impartial manner according to the operating rules established for that garden. The name and telephone number of the garden coordinator [*or those of the leadership team members*] and a copy of the operating rules shall be kept on file with the City [*insert department name*] Department [*or the lead community garden nonprofit organization, as appropriate*].	Management plan required. Urban farms must prepare a management plan, to be reviewed as part of the conditional use process, to address how activities will be managed to avoid impacts on surrounding land uses and natural systems. The management plan must include: • A site plan, including lighting; • Operating hours; • A description of the type of equipment necessary or intended for use in each season and the frequency and duration of anticipated use;

REGULATION OF USES/OPERATING STANDARDS

	Home Garden	Community Garden	Urban Farm

Operating Standards con't.	[*No regulation*]	• The land shall be served by a water supply sufficient to support the cultivation practices used on the site. • The site must be designed and maintained so that water and fertilizer will not drain onto adjacent property. • All seed, fertilizer, and animal feed shall be stored in a sealed, rodentproof container [*and housed within an enclosed structure*]. • To the extent permitted under federal and state law, site users must use organic and sustainable growing practices. ***Comment:*** *To function effectively, a community garden must have established operating rules and a garden coordinator or leadership team.[77] In this ordinance, a municipality could 1) require that gardens have rules, as the model language does above; 2) provide a complete listing of rules; or 3) give authority for a particular city or county department or officer to establish community garden rules and require each community garden to adhere to those rules. A municipality could also choose to address some or all of the requirements for operating a community garden in this or an accompanying ordinance.* *As described more fully in the section on "Pesticide and Environmental Laws," pesticide use is regulated under federal and state law. A city may be prohibited from regulating pesticide use through local law. A city may be able to restrict or prohibit pesticide use in community gardens on its property in its proprietary capacity (as the property owner as opposed to as a regulator). Consult with your local government attorney.*	• Disclosure of any intent to spray or otherwise apply agricultural chemicals or pesticides, frequency and duration of application, and the plants, diseases, pests. or other purposes they are intended for; • Disclosure of the spreading of manure; • A proposed sediment and erosion control plan; • Disclosure of parking impacts related to the number of staff on-site during work hours, and the number of potential visitors regularly associated with the site; • A proposed composting and waste management plan. ***Comment:*** *Not all communities will want to require management plans. Communities could instead set forth standards regulating the above practices and impose them as regulations. Take care to ensure that any environmental or pesticide regulations are consistent with federal and state law and that composting, waste management, equipment use, and operating hours are addressed.*

REGULATION OF USES/OPERATING STANDARDS			
	Home Garden	**Community Garden**	**Urban Farm**
Compost and Waste Management	Compost materials shall be stored [*at least ____ feet from adjacent property*] and in a manner that is not visible from adjacent property (shielded from view by shrubbery or an enclosure), controls odor, prevents infestation, and minimizes runoff into waterways and onto adjacent properties.	Compost materials from the garden or gardeners shall be stored [*at least ___ feet from adjacent property*] and in a manner that is not visible from adjacent property (shielded from view by shrubbery or an enclosure), controls odor, prevents infestation, and minimizes runoff into waterways and onto adjacent properties. Waste shall be collected regularly by the municipality. Gardeners shall ensure that containers are placed in specified location to assist municipality in waste removal.	Composting and waste management must be managed according to the farm management plan.
Accessibility	[*No regulation*]	The garden must comply with Americans with Disabilities Act design standards for accessible entrance routes and accessible routes between different components of the garden and must follow universal design principles whenever possible. [*A minimum of ____ percent of the garden must contain raised beds that are designed for access by gardeners using wheelchairs or with other mobility impairments.*] ***Comment:*** *Communities are using different strategies to address the needs of gardeners with disabilities. The Palm Desert, Calif., community garden has an entire garden (151 plots) that is handicapped accessible; Cambridge, Mass., requires that all newly established community gardens have a minimum of 5 percent, but not less than one, raised bed plots. Communities should ensure that all residents have access to community gardens.*	The farm must comply with Americans with Disabilities Act design standards for accessible entrance routes and accessible routes between its different components and must follow universal design principles whenever possible.

REGULATION OF USES/OPERATING STANDARDS

	Home Garden	Community Garden	Urban Farm
Landscaping and Setback Requirements	***Comment:*** *Some communities have particular landscaping or setback requirements, such as limits on tree or plant heights, which may restrict the type of plants used in home gardens. Some restrictions serve important purposes such as fire safety; others are purely aesthetic. Communities should be sure to reconcile new urban agriculture provisions with existing landscaping requirements.* *Kansas City, Miss., prohibits row crops in the front yard of some residentially zoned and occupied property.*[78]	***Comment:*** *Some communities have particular landscaping or setback requirements and may want to require urban agriculture uses to blend with neighboring properties. Communities should consider existing requirements to determine their impact on the agricultural uses and whether the standards need adjusting.*	***Comment:*** *See comment under "Community Gardens."*

Incidental and Accessory Uses

As described above, an incidental or accessory use is a use that is dependent on or affiliated with the land's primary use. Zoning codes often enumerate accessory uses permitted with the main use. We list incidental uses below for communities to include and decide whether they may be permitted as part of the primary use or require express approval.

INCIDENTAL AND ACCESSORY USES			
	Home Garden	**Community Garden**	**Urban Farm**

Fencing	Fences are permitted as regulated in the underlying zoning district.	Fences are permitted as regulated in the underlying zoning district. *Alternative:* Fences shall not exceed [*eight feet*] in height, shall be at least [*50 percent*] open if they are taller than [*four feet*], and shall be constructed of wood, chain link, or ornamental metal. For any garden that is [*15,000 square feet in area or greater*] and is in a location that is subject to design review and approval by the [*City Planning Commission or Landmarks Commissio*n], no fence shall be installed without review by the [*City Planning Director, on behalf of the Commissio*n], so that best efforts are taken to ensure that the fence is compatible in appearance and placement with the character of nearby properties. ***Comment:*** *Municipalities usually have requirements regarding fences in their zoning or building codes. If the municipality has existing regulations, it may not need this provision, unless the preferred fencing for urban agriculture differs from existing law.* *In many urban areas, community gardeners prefer the security of locked gates to prevent vandalism and theft; in other areas, garden users might oppose fencing due to the cost and the desire to allow public access to gardens or portions of gardens.*	Fences are permitted as regulated in the underlying district. *Alternative*: Fences shall not exceed [*eight feet*] in height, shall be at least [*50 percent*] open if they are taller than [*four feet*], and shall be constructed of wood, chain link, or ornamental metal. For any garden that is [*15,000 square feet in area or greater*] and is in a location that is subject to design review and approval by the [*City Planning Commission or Landmarks Commission*], no fence shall be installed without review by the [*City Planning Director, on behalf of the Commission*], so that best efforts are taken to ensure that the fence is compatible in appearance and placement with the character of nearby properties. ***Comment:*** *Municipalities usually have requirements regarding fences in their zoning or building codes. If the municipality has existing regulations, it may not need this provision, unless the preferred fencing for urban agriculture differs from existing law.*

INCIDENTAL AND ACCESSORY USES

	Home Garden	**Community Garden**	**Urban Farm**

Structures	Structures are permitted as regulated in the underlying zoning district.	Definitions: A **greenhouse** shall mean a temporary or permanent structure typically made of, but not limited to, glass, plastic, or fiberglass in which plants are cultivated. A **hoophouse** shall mean a temporary or permanent structure typically made of, but not limited to, piping or other material covered with translucent plastic, constructed in a "half-round" or "hoop" shape, for the purposes of growing plants. A **cold frame** shall mean an unheated outdoor structure consisting of a wooden or concrete frame and a top of glass or clear plastic, used for protecting seedlings and plants from the cold. Only the following accessory uses and structures shall be permitted: [*sheds for storage of tools limited in size to [_____] or subject to the requirements of section ___*], greenhouses, hoophouses, and cold frames, in which plants are cultivated, benches, bike racks, raised/accessible planting beds, compost or waste bins, picnic tables, seasonal farm stands, fences, garden art, rain barrel systems, [*beehives, chicken coops, barbecue grills, outdoor ovens, and children's play areas*] shall be permitted. The combined area of all buildings or structures shall not exceed [*15 percent*] of the garden site lot areas.	Definitions: A **greenhouse** shall mean a temporary or permanent structure typically made of, but not limited to, glass, plastic, or fiberglass in which plants are cultivated. A **hoophouse** shall mean a temporary or permanent structure typically made of, but not limited to, piping or other material covered with translucent plastic, constructed in a "half-round" or "hoop" shape, for the purposes of growing plants. A **cold frame** shall mean an unheated outdoor structure consisting of a wooden or concrete frame and a top of glass or clear plastic, used for protecting seedlings and plants from the cold. Only the following accessory uses and structures shall be permitted: • Benches, bike racks, raised/accessible planting beds, compost bins, picnic tables, garden art, rain barrel systems, [*chicken coops, beehives, and children's play areas*]; • Greenhouses, hoophouses, cold frames, and similar structures used to extend the growing season; • Buildings, limited to tool sheds, shade pavilions, restroom facilities with composting toilets, planting preparation houses and [*barns*], in conformance with [*reference regulations or requirements relating to building and setback standards here*], [*provided that maximum lot coverage of all buildings, structures, and paved areas does not exceed* [*15 percent*] *of the farm lot area*].

INCIDENTAL AND ACCESSORY USES

	Home Garden	Community Garden	Urban Farm
Structures con't.		***Comment:*** *Some communities may wish to allow community gardeners to erect sheds for the storage of tools on garden sites. The municipality should make sure that any provision regarding sheds conforms to state and local building laws.*	• Roadside stand, farm stand: The stand may not be permanently affixed to the ground and must be readily removable in its entirety. • The maximum area of a roadside stand shall be *[300]* square feet in ground area. No more than one roadside stand is allowed on any one premise. • Off-street parking and walkways, in conformance with [*reference regulations or requirements related to parking and walkways here*]. ***Comment:*** *Erection of buildings or other structures is governed by state and local building laws. The municipality should make sure that any provision regarding structures conforms to other applicable laws (e.g., allowing annual or biannual sales as a fundraiser).*
Signage	No signage permitted.	Any signs shall comply with applicable [*City/County*] ordinances. *Alternative:* [*One*] unilluminated sign not exceeding [*six square feet or three feet in height*] in conformance with the regulations of [*reference other sign laws or requirements*]. ***Comment:*** *Sign requirements may raise First Amendment issues. Be sure to consult with your local government attorney on sign requirements.*	Any signs shall comply with applicable [C*ity/County*] ordinances. *Alternative:* Allowed [*one*] temporary, unilluminated sign not exceeding [*six square feet or three feet in height*] is permitted on-site, in conformance with the regulations of [*reference other sign laws or requirements*]. ***Comment:*** *See signage comment under "Community Garden."*

INCIDENTAL AND ACCESSORY USES			
	Home Garden	**Community Garden**	**Urban Farm**
Use of Produce/ Produce Sales	Produce shall be grown [*primarily*] for resident's use or donation [*only*]. *Alternative:* Food and/or horticultural products grown in the home garden may be used for personal consumption, and [*only whole, uncut, fresh foo*d] and/ or horticultural products grown in a home garden may be donated or sold on-site within a reasonable time of its harvest. The sales may only take place during [*add seasonal or time of day limitations on sales*]. ***Comment:*** *Some communities enable home gardeners in certain districts to sell homegrown produce from their homes. Kansas City, Miss., allows home growers to sell whole, uncut fresh food from May 15 through October 15.*[79] *Communities considering home sales should consider the following issues:* • *Whether commercial activity is compatible with the other uses in the district;* • *The potential for increased pedestrian and automobile traffic;* • *State food retail codes (which may require a food retail permit to sell produce or products made from produce).*	Produce shall be grown primarily for personal or shared use or donation [*or for sale*]. ***Comment:*** *One option is for communities to prohibit sale of community garden produce; another is to allow limited sales of community garden produce on- or off-site (e.g., allowing an annual sale as a fundraiser). If so, it is important to ensure that related laws are addressed (see comments under "Home Garden") and that the community garden is distinguishable from a commercial farm, if both definitions will be used in the code.*	Retail sales [*of plants and produce grown on-site or products that are processed off-site but made from products grown on-site*] and other public use of the farm may occur between [__] and [__] [*add hours*] every day of the week during [__] and [__] [*add months or seasons*]. ***Comment:*** *If needed to accommodate neighboring property owners, communities may want to limit sales according to growing seasons.*

Animals

Animals are an important part of agriculture, but can concerns about nuisances, including noise and in densely populated cities. Many existing laws related to the keeping of animals. Some are remnants of earlier common to keep a kitchen garden

Our model policy addresses beekeeping and chickens, the most common forms of urban livestock.[80] communities, such as Seattle, are including animals in their urban agriculture pigs, rabbits, and other poultry like only the land use considerations raising; that is, we address factors the land for raising animals negative impacts in the text animals, climate, do chickens.[89] not address all of the factors required for ensuring that animals are adequately tended and cared for. Similarly, we do not address the federal, state, or local laws that animal products. Municipalities interested in allowing home or with the other requirements relating to the inspection, commercial slaughtering should consult a local attorney licensing, and enforcement of animal welfare.

with expertise in this area.

Animal welfare is controlled primarily by state and law. (The federal Animal Welfare Act[82] applies in interstate or foreign commerce used in exhibitions, or as pets.[83] It does not apply animals, including poultry or livestock, used be used for food.[84]) All 50 states and the District of Columbia have animal cruelty laws that protect animals from unnecessary suffering or cruel mistreatment.[85] Although the state laws prohibit odors, particularly cruelty, they often do not set standards determining communities have appropriate care for farm animals. Some states and poultry and farm local governments do set standards for cats, dogs, and times, when it was other animals raised as pets.[86] and raise animals at home for food.

Two animal welfare organizations provide standards for humane farm animal care. Humane Farm Animal two of Care, a nonprofit charity dedicated to improving (Some the lives of farm animals by providing viable and a wide range of monitored standards for humane food production, has ordinances, such as established Humane Farm Animal Care standards.[87] geese.[81]) We address The Animal Welfare Institute has established Animal related to animal Welfare Approved standards for the care and keeping specific to the use of of animals. These standards are formulated for without causing nuisances or other large farming operations, but are helpful models for for neighboring property users. As noted municipalities to consider when drafting standards below, community regulations vary regarding of care.[88] The City of Vancouver has established due to factors such as environmental density, regulations regarding appropriate care of backyard political will, and types of natural predators. We

Before adopting land use laws related to animals, be sure to check state and local animal welfare and control control animal slaughtering or sales of animals or laws to ensure that the land use laws are compatible

Communities should be clear whether state or local animal control officers are responsible for enforcement of these laws and, if local enforcement is required, that local local officers have sufficient training in the care of these to animals animals. Finally, if state law permits, communities research, in should consider adopting local animal welfare standards to farm to ensure that farm animals within their jurisdictions or intended to are adequately and humanely cared for.

ANIMALS			
	Home Garden	**Community Garden**	**Urban Farm**

Beekeeping	Honeybee apiaries are a [*permitted accessory*] use to a home, subject to the following regulations: The apiary is properly registered pursuant to [*state law*]; Beekeeping practices are consistent with the standards of [*enter organization name here*]; The number of hives is limited to one per each [*24,000*] square feet of lot area; no beehive shall be kept on a lot smaller than 2,400 square feet in area; Hives are not located within 25 feet of any lot line except when situated eight feet or more above the grade immediately adjacent to the grade of the lot on which the hives are located or when situated less than eight feet above the adjacent existing lot grade and behind a solid fence or hedge six feet high. No beehive shall be kept in a front or side yard. The front of any beehive shall face away from the property line of the residential property closest to the beehive. ***Comment:*** *Many states regulate beekeeping; some require owners to register the number of colonies and location of each apiary.*[90] *Both Cleveland and Seattle allow beekeeping as a permitted use in residential districts, subject to certain regulations.*[91] *Seattle requires hives to be located more than 25 feet from any lot line except if the hive is situated eight feet or more above the grade immediately adjacent to the grade of the lot on which the hives are located or situated less than eight feet above the adjacent existing lot grade and behind a solid fence or hedge six feet high ...*	Honeybee apiaries are a [*permitted accessory*] use to community gardens, subject to the following regulations: The apiary is properly registered pursuant to [*state law*]; Beekeeping practices are consistent with the standards of [*enter organization name here*]; The number of hives is limited to one per each [*24,000*] square feet of lot area; no beehive shall be kept on lots smaller than 2,400 square feet in area; Hives are not located within 25 feet of any lot line except when situated eight feet or more above the grade immediately adjacent to the grade of the lot on which the hives are located or when situated less than eight feet above the adjacent existing lot grade and behind a solid fence or hedge six feet high. No beehive shall be kept in a front or side yard. The front of any beehive shall face away from the property line of the residential property closest to the beehive. ***Comment:*** *See comments under "Home Garden." Some communities may not be comfortable with allowing beekeeping as a permitted use in all community gardens. The community could require conditional use or allow beekeeping as a permitted use upon additional conditions, such as allowing the gardeners to vote annually on whether to allow an apiary on-site.*	Honeybee apiaries are a [*permitted accessory*] use to urban farms, subject to the following regulations: The apiary is properly registered pursuant to [*state law*]; Beekeeping practices are consistent with the standards of [*enter organization name here*]; The number of hives is limited to one per each [*24,000*] square feet of lot area; no beehive shall be kept on lots smaller than 2,400 square feet in area; Hives are not located within 25 feet of any lot line except when situated eight feet or more above the grade immediately adjacent to the grade of the lot on which the hives are located or when situated less than eight feet above the adjacent existing lot grade and behind a solid fence or hedge six feet high. No beehive shall be kept in a front or side yard. The front of any beehive shall face away from the property line of the residential property closest to the beehive. ***Comment:*** *See comments under "Home Garden."*

ANIMALS			
	Home Garden	**Community Garden**	**Urban Farm**
Beekeeping con't	***Comment con't: …****parallel to any lot line within 25 feet of a hive and extending at least 20 feet beyond the hive in both directions.*[92] *Several cities require minimum lot sizes for the keeping of colonies.* *Cleveland requires a minimum lot size of 2,400 square feet to host a hive.*[93] *Seattle allows for no more than four hives, each with only one swarm, on lots containing less than 10,000 square feet.*[94] *The City of Vancouver allows two hives on lots containing less than 10,000 square feet.*[95]		
Chickens	The keeping of hens is a [*permitted accessory*] use to a home garden, subject to the following regulations: The chicken owner is properly registered and licensed pursuant to [*state/local*] law; Animal care practices are consistent with the standards of [*enter reference to animal welfare laws or organization name here*]; There must be no less than [*10*] square feet allocated per chicken; The coops or cages housing the chickens may not be located in the front or side yard areas and shall not be located within [*five feet*] of the property line. The chickens, coops, and cages must be adequately maintained to control odor and prevent infestation. [*No more than [4] hens may be permitted per home garden*.] ***Comment:*** *Some communities permit the raising of hens in home gardens for personal use (i.e., no chicken or egg sales or slaughtering) as a permitted accessory use (i.e., without requiring any land use permits).*[96]	The keeping of hens is a [*permitted accessory*] use to a community garden, subject to the following regulations: The chicken owner(s) is properly registered and licensed pursuant to [*state/local*] law; There must be no less than [*10*] square feet allocated per chicken; The coops or cages housing the chickens may not be located in the front or side yard areas and shall not be located within [*five feet*] of the property line. The chickens, coops, and cages must be adequately maintained to control odor and prevent infestation. [*No more than [5] hens may be permitted per community garden*.] ***Comment:*** *See comments under "Home Garden." Like beekeeping, some communities will not want to permit the keeping of chickens in community gardens without further approvals.* *Allowing animals in community gardens presents the problem of oversight as gardeners may not attend to the garden every day.*	The keeping of hens is a [*permitted accessory*] use to an urban farm, subject to the following regulations: The chicken owner is properly registered and licensed pursuant to [*state/local*] law; There must be no less than [*10*] square feet allocated per chicken; The coops or cages housing the chickens may not be located in the front or side yard areas and shall not be located within [*five feet*] of the property line. The chickens, coops, and cages must be adequately maintained to control odor and prevent infestation. [*No more than [x] hens may be permitted per urban farm*.] ***Comment:*** *See comments under "Home Garden" and "Community Garden." Depending upon where the urban farms are located, communities may wish to permit additional hens and require fewer square feet per chicken and lesser setbacks from adjoining property.*

ANIMALS			
	Home Garden	**Community Garden**	**Urban Farm**

Chickens con't.	***Comment con't:*** *Regulations regarding the number of chickens permitted, the space allocation per bird, and the size or type of structure vary across cities; there is no gold standard as of yet.* *Factors such as climate, density of the environment, and the type or urban predators impact standards. One option is to limit the total number of birds per lot regardless of lot size, or to limit the number by virtue of lot size. Another option is to allow a certain number of birds as a permitted use and require a conditional use permit to exceed those standards.* *Some communities permit only hens and prohibit or limit the keeping of roosters due to concerns about noise and cockfighting operations. Some communities, including Cleveland and Seattle, allow a variety of domestic fowl.* *Cleveland requires a minimum of 100 square feet per animal (fowl and rabbits). It requires coops and cages to be located more than five feet from a side yard and 18 inches from a rear yard.*[97] *Seattle does not expressly address the amount of space per bird and allows up to 8 domestic fowl on any residential lot as a permitted accessory use. Structures housing domestic fowl must be located at least 10 feet from any structure that includes a dwelling unit on an adjacent lot.*[98] *Vancouver requires structures to be more than one meter from any property line.*[99] *It prohibits roosters and limits backyard hens to four per lot.*[100] *Animal Welfare Approved requires 1.8 square feet of indoor space and an additional 4.0 square feet of additional foraging area for a total of 5.8 square feet minimum space per chicken.*[101] *Animal slaughtering and sales and the sale of eggs are regulated by federal and, often, state law.*	***Comment con't:*** *Some cities only permit animals on property where there is residence, presumably to ensure that caretakers manage the animals regularly and are more easily identified and held accountable for nuisance or animal welfare violations.*	

[67] Sacramento, Calif. Zoning Code § 17.68.010(A)(1).

[68] For more information on establishing a community garden see PHLP's "Ground Rules: A Legal Toolkit for Community Gardens." Available at: www.nplan.org/nplan/products/CommunityGardenToolkit.

[69] Cleveland, Ohio Zoning Code § 336.02(b).

[70] Nashville, Tenn. Metropolitan Code §17.04.060.

[71] Kansas City, Mo. Zoning and Devel. Code § 88-312-02C.

[72] San Francisco, CA Planning Code § 102.35.

[73] Pittsburgh, Penn. Zoning Code § 911.04A2(a).

[74] San Francisco, CA Planning Code § 102.35.

[75] *See* "Brownfields and Urban Agriculture: Interim Guidelines for Safe Gardening Practices," Summer 2011, available at: http://www.epa.gov/ brownfields/urbanag/pdf/bf_urban_ag.pdf

[76] A Phase I Environmental Site Assessment, also known as "All Appropriate Inquiries," is the process of conducting due diligence to determine prior uses and ownership of a property and assess conditions at the property that may be indicative of releases or threatened releases of hazardous substances at, on, in, or to the property. "EPA Brownfields Grants, CERCLA Liability, and All Appropriate Inquiries." EPA Publication No. 560-F-09-026. April 2009. Available at: www.epa.gov/ brownfields/aai/cerclafs.pdf

For more information on brownfields redevelopment and local agriculture, see "How Does Your Garden Grow? Brownfields Redevelopment and Local Agriculture." EPA Publication No.560-F-09-024. March 2009. Available at: www.epa.gov/ brownfields/success/local_ag.pdf. More information on "All Appropriate Inquiries" requirements is available at: www.epa.gov/brownfields/ regneg.htm, and "All Appropriate Inquiries Final Rule," EPA Publication No. 560-F-05-240. November 2005. The standards and practices for conducting "All Appropriate Regulations" are set forth in regulations at 40 CFR Part 312.

[77] Model rules are included in PHLP's "Ground Rules, a Legal Toolkit for Community Gardens." Available at: www.nplan.org/nplan/products/ CommunityGardenToolkit

[78] Kansas City, Mo. Zoning and Devel. Code § 88-312-02A.

[79] Kansas City, Mo. Zoning and Devel. Code § 88-312-02A.

[80] Seattle and Cleveland address other types of farm animals and are a resource for municipalities interested in permitting other animals.

[81] Seattle, Wash. Municipal Code § 23.42.052.

[82] 7 U.S.C. §§ 2131 *et. seq.*

[83] *Id.*

[84] 7 U.S.C. § 2132(g).

[85] Ibrahim D."Anticruelty statute: A Study in Animal Welfare." *Journal of Animal Law & Ethics,* 175(1): 2006.

[86] *See, e.g.,* Nev. Rev. Statutes 574.210, providing standards for operators of cat and dog shelters, commercial operations, and retailers.

[87] More information on Humane Farm Animal Care standards is available at: www.certifiedhumane.org.

[88] More information on Animal Welfare Approved Standards is available at: www.animalwelfareapproved.org/standards.

[89] Vancouver, British Columbia, Can. Animal Control By-Law No. 9150, § 7.16 (2010). Available at: http://vancouver.ca/bylaws/9150c.PDF.

[90] *See, e.g.,* Cal. Food & Agric. Code § 29000 *et. seq.*

[91] Cleveland, Ohio Zoning Code Title VII §§ 337.23 (2010); Seattle, Wash. Municipal Code § 23.42.052 (2010).

[92] Seattle, Wash. Municipal Code § 23.42.052 (2010).

[93] Cleveland, Ohio Municipal Code § 347.02(d).

[94] *Id.*

[95] City of Vancouver. Canada Hobby Beekeeping Policies. 2007. Available at: http://vancouver.ca/commsvcs/BYLAWS/bulletin/H005.pdf.

[95] Animal slaughtering, sales, and the sales of eggs are regulated by federal and, often, state law.

[97] Cleveland, Ohio Muni. Code § 336A.06.

[98] Seattle, Wash. Muni. Code § 23.42.052(C).

[99] Vancouver, British Columbia, Can. Zoning and Develop. Bylaw No. 3571, § 10.18.2.

[100] Vancouver, British Columbia, Can. Animal Control Bylaw No. 9150; § 7.5(c).

[101] Animal Welfare Approved Standards for Laying Hens Standards 5.4.11; 8.1.1.

Resources

Accessible Design

Community Action Coalition for South Central Wisconsin, Inc.
www.cacscw.org/gardens/handbook/CommGardensFinal_UnivDesign.pdf

The Chicago Botanic Gardens Horticultural Therapy Services Program http://chicagobotanic.org/therapy

National Center of Physical Activity and Disability (NCPAD)
www.ncpad.org

Together 4 Health: Partners for Healthy Living
"Making Your Garden Accessible"
www.together4health.ca/workgroups/community-gardens-waterloo-region/accessiblegardens

Agricultural Law

Drake Law School Agricultural Law Center
www.law.drake.edu/academics/agLaw

University of Arkansas School of Law National Agricultural Law Center www.NationalAgLawCenter.org

Agricultural Product Sales and Commercial Farms

University of Arkansas School of Law National Agricultural Law Center
Arkansas Direct Farm Business Guide
www.nationalaglawcenter.org/assets/articles/tarr_directfarm.pdf

Animal Rearing

Animal Welfare Institute's Animal Welfare Approved Standards
www.animalwelfareapproved.org/standards

Humane Farm Animal Care's Humane Farm Care Standards
www.certifiedhumane.org

Environmental Laws and Agriculture

National Association of State Departments of Agriculture
"Federal Environmental Laws Affecting Agriculture"
www.nasda.org/nasda/nasda/foundation/state/Federal.pdf
Individual summaries of state environmental laws affecting agriculture are available at:
www.nasda.org/nasda/nasda/foundation/state/states.htm

Land Banks and Land Trusts

U.S. Department of Housing and Urban Development
"Revitalizing Foreclosed Properties with Land Banks"
www.huduser.org/portal/publications/affhsg/landbanks.htm
l

Land Trust Alliance
www.landtrustalliance.org

Land Use Laws and Urban Agriculture

American Planning Association
"Urban Agriculture: Growing Healthy, Sustainable Places"
www.planning.org/apastore/Search/Default.aspx?p=4146&a=1003 ***"Zoning for Urban Agriculture, Zoning Practice March 2010"*** www.planning.org/ZoningPractice

Safe Growing Practices

National Sustainable Agriculture Information Center
"An Illustrated Guide to Growing Safe Produce on Your Farm - IP382" http://attra.ncat.org/attra-pub/PDF/foodsafety.pdf

Site Suitability and Soil Testing

American Community Garden Association
"How Do I Pick a Site? Site Considerations and Analysis"
www.communitygarden.org/rebeltomato/roots/pick-a-site.php

American Planning Association
"Creating Community-Based Brownfields Redevelopment Strategies" www.planning.org/research/brownfields

Cornell Waste Management Institute, Department of Crop and Soil Sciences in the College of Agriculture and Life Sciences at Cornell University.
"Sources and Impacts of Contaminants in Soils"
"Guide to Soil Testing and Interpreting Results"
"Soil Contaminants and Best Practices for Healthy Gardens"
http://cwmi.css.cornell.edu/soilquality.htm

U.S. Department of Agriculture, Natural Resources Conservation Division *"Urban Soil Primer"*
www.soils.usda.gov/use/urban/downloads/primer(screen).pdf

U.S. Environmental Protection Agency
"Brownfields and Urban Agriculture: Interim Guidelines for Safe Gardening Practices"
www.epa.gov/brownfields/urbanag/pdf/bf_urban_ag.pdf
"EcoTools: Urban Gardens and Potentially Contaminated Land"
http://cluin.org/ecotools/urbangardens.cfm
"Steps to Create a Community Garden or Expand Urban Agriculture" www.epa.gov/brownfields/urbanag/steps.htm
"How Does Your Garden Grow? Brownfields Redevelopment and Local Agriculture"
www.epa.gov/brownfields/success/local_ag.pdf
"Urban Gardening Fact Sheet"
www.clu-in.org/s.focus/c/pub/i/1843/

Starting a Community Garden

American Community Garden Association
"Starting a Community Garden"
www.communitygarden.org/learn/starting-a-community-garden.php#sample

Public Health Law & Policy
"Ground Rules: A Legal Toolkit for Community Gardens"
www.nplan.org/nplan/products/CommunityGardenToolkit

University of Missouri Extension
"Community Garden Toolkit"

	http://extension.missouri.edu/publications/DisplayPub.aspx?P=MP906-6#Resources
	Starting an Urban Farm
	U.S. Partnership for Sustainable Communities *"Urban Farm Business Plan Handbook"* www.epa.gov/brownfields/urbanag/pdf/urban_farm_business_plan.pdf

nplan | NATIONAL POLICY & LEGAL ANALYSIS NETWORK TO PREVENT CHILDHOOD OBESITY

nplan.org

ChangeLab Solutions
Law & policy innovation for the common good.

changelabsolutions.org

Marcus Comer

Site Selection and planning, Ecosystem Services and working with city planners

Suggested reading

https://changelabsolutions.org/sites/default/files/Urban_Ag_SeedingTheCity_FINAL_%28CLS_20120530%29_20111021_0.pdf

Suggested items to bring to class

A copy of your municipalities comprehensive land use plan. The following link is an example:

https://petersburgva.gov/DocumentCenter/View/1848/Land-Use-09-11-2015-twk2?bidId=

Useful Resources:

https://www.usda.gov/sites/default/files/documents/urban-agriculture-toolkit.pdf

https://www.itreetools.org/tools **https://www.epa.gov/enviroatlas**

Summary Description for Module 3

Title:	Module 3: Basic Botany, Physiology and Environmental Effects of Plant Growth
Instructor:	Dr. Leonard Githinji, Associate Professor - Sustainable & Urban Agriculture
Prerequisites:	None
Class Time:	12:30PM – 3:00PM
Learning Objective:	The student will learn the basic science of plants including the life cycle of flowering plants, the anatomy of vascular plants and how to identify a diverse range of plants. They will also learn about the various plants' physiological processes and how the environmental factors affect plant growth.
Instructor Media Needs:	Screen Projector Screen Pointer Computer
Class Materials and/or Supplies Needed:	Instructor provided-Printed copies of class notes with review questions at the end of the chapter (MSWord) PowerPoint slides (in electronic and/or printed format)
Class Activities:	1. Present basic biology of the plant systems 2. Explain the life cycle of plants 3. Explain the various plant parts and their relative importance 4. Explore a diverse range of plans 5. Review the plant physiology and it's affected by the environmental factors
Knowledge Gained:	Students will gain knowledge on how to better select their garden plants and manage the growing environment for successful production and higher yields.
Skills Gained:	Students will gain skills on garden plants selection and their environmental management
Abilities Gained:	Students will be able to manipulate at least one environmental factor that affects plant growth
Exam Description:	A class quiz will be administered at the end of the class. In addition, a take home exam based on the review questions will be given.

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College of Agriculture
VIRGINIA STATE UNIVERSITY

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Basic Botany, Physiology and Environmental Effects on Plant Growth

Leonard Githinji, Ph.D.
Associate Professor and Extension Specialist for Sustainable and Urban Agriculture
Virginia State University; (804) 524-5962; lgithinji@vsu.edu

1. BASIC BOTANY

Angiosperms and Gymnosperms

Almost all of the plants used in horticultural production are **vascular plants**. These are plants that contain tissues which transport water and dissolved materials. The vascular system is analogous to the circulatory system in animals. A few of these plants, such as ferns, do not produce seed. They reproduce by **spores**. The vast majority of vascular plants produce true seed. These can be further divided into two large groups known as the **gymnosperms** and **angiosperms**. These two are similar in many ways: they make their own food through the process of photosynthesis; they have vascular systems to transport water, minerals and other materials; and they reproduce by seed. But they vary in some important ways. Gymnosperms do not have true flowers, and although they produce seeds, the seeds are not enclosed in fruits. Most of the gymnosperms we use in horticulture produce their seeds in cones. One examples is pine. Angiosperms produce flowers and develop fruits that contain seeds. This group can be further subdivided into **monocotyledons (monocots)** and **dicotyledons (dicots)**. Monocots and dicots differ in a number of ways:

-Monocots produce one cotyledon, or seed leaf, when they emerge from seeds while dicots produce two cotyledons;

-Monocot flower parts are generally in multiples of three while dicot flower parts are generally in multiples of four or five.
- Monocot leaves are long and narrow with parallel veins while dicots have variously shaped leaves with netted veins.

-The internal root, leaf, and stem structures vary significantly between monocots and dicots.

Life Cycle of Flowering Plants

Flowering plants can be classified by the number of growing seasons required to complete their life cycle. **Annuals** complete their entire life cycle from seed germination to seed production in one growing season, and then die. Examples include cucumber and tomato. Some annuals called winter annuals, germinate in fall, overwinter, produce seed in spring, and then die. Some that are perennial in their native tropical habitats may be used in colder regions as if they were annuals. **Biennials** are plants which start from seeds and produce vegetative structures and food storage organs the first season. During the first winter, the plant is vernalized, or stimulated to produce reproductive structures during the following growing season. In the

second season, flowers, fruit, and seeds develop to complete the life cycle, and the plant dies. Examples include carrots, beets, cabbage and onions. Plants which are botanically classified as biennials may, in some cases, complete their life cycle in only one growing season. This situation occurs when drought, variations in temperature, or other climatic conditions cause the plant to physiologically pass through the equivalent of two growing seasons, in a single growing season. This phenomenon is referred to as bolting. **Perennials** live for three or more years. Once they reach maturity, they generally produce flowers and seeds each year. Perennials are called herbaceous if their top dies back to the ground each winter and new stems grow from the roots each spring. Most of our flower garden perennials are herbaceous. Trees and shrubs are classified as woody perennials, since their top growth persists and develops woody tissue.

The Anatomy of the Vascular Plants

The anatomy of a plant can be divided into two groups, **vegetative parts** and **reproductive parts**. The vegetative parts include leaves, roots, leaf buds, and stems. Although they are not directly involved in sexual reproduction, they are often used in asexual or vegetative forms of reproduction, such as cuttings. Sexual reproductive parts are those involved in the production of seed: flower buds, flowers, fruits, and seeds.

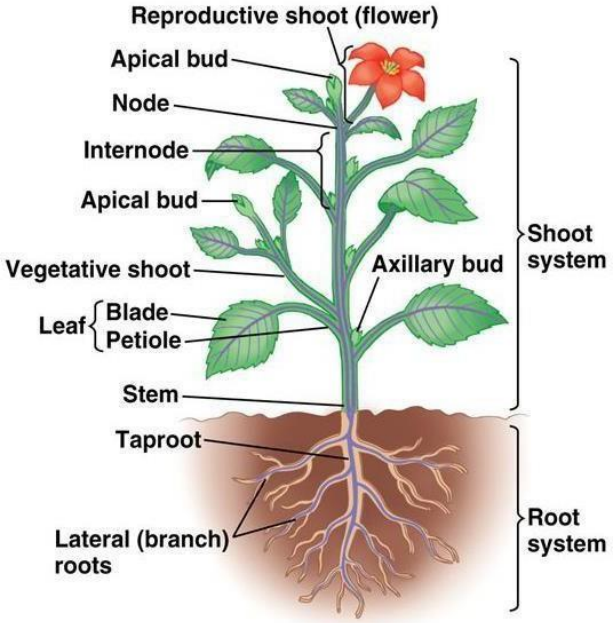


Fig. 1: The main parts of a plant
(Source: http://phsgirard.org)

Stems

Stems are structures which support buds and leaves and serve as conduits for carrying water, minerals and sugars. A stem can be differentiated from a root because all stems have **nodes** and **internodes**, while roots do not. A node is the region of stem where leaves are attached. The region between two nodes is called an internode. The length of an internode depends on many factors. Decreasing fertility can decrease internode length. Too little light can result in a long internode, creating a "spindly" plant. This situation is known as **etiolation**. Growth produced early in the season has the greatest internode length. Internode length decreases as the growing season nears its end. Vigorously growing plants tend to have greater internode lengths than less vigorous plants. Internode length varies with competition from surrounding stems or

developing fruit. If the energy for a stem has to be divided among three or four stems, or if the energy is diverted into fruit growth, internode length is shortened.

The three major internal parts of a stem are the **xylem**, **phloem**, and **cambium**. The xylem and phloem are the major components of a plant's **vascular system**. The vascular system transports food, water, and minerals and offers support for the plant. Xylem vessels conduct water and minerals, while phloem tubes conduct food. The vascular systems of **monocots** and **dicots** differ.

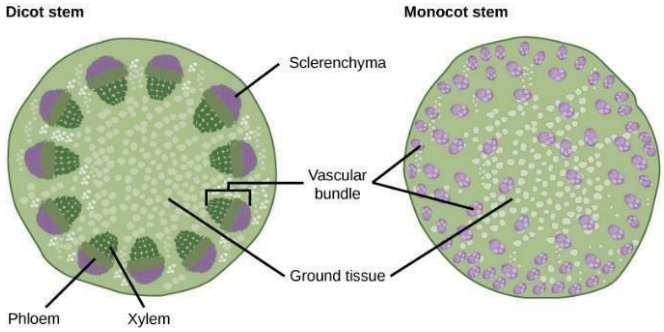


Fig. 2: The vascular system of a dicot vs monocot stem (Source: http://voer.edu.vn)

While both contain xylem and phloem, they are arranged differently. In the stem of a monocot, the xylem and phloem are paired into bundles; these bundles are dispersed throughout the stem. But in the stem of a dicot, the vascular system forms rings inside the stem. The ring of phloem is near the bark or external cover of the stem and is a component of the bark in mature stems. The xylem forms the inner ring; it is the sapwood and heartwood in woody plants. **The difference in the vascular system of the two groups is of practical interest to the horticulturist because certain herbicides are specific to either monocots or dicots. An example is 2, 4, -D, which only kills dicots**.

The cambium is a meristem, which is a site of cell division and active growth. It is located between the xylem and phloem inside the bark of a stem and is the tissue responsible for a stem's increase in girth, as it produces both the xylem and phloem tissues. Stems may be long, with great distances between leaves and buds (branches of trees, runners on strawberries), or compressed, with short distances between buds or leaves (fruit spurs, crowns of strawberry plants, dandelions). Stems can be above the ground like most stems with which we are familiar, or below the ground (potatoes, tulip bulbs). All stems must have buds or leaves present to be classified as stem tissue.

Modified Stems

Although typical stems are above-ground trunks and branches, there are modified stems which can be found above ground and below ground. The aboveground modified stems are crowns, stolons, and spurs, and the below-ground stems are bulbs, corms, rhizomes, and tubers.

A **crown** is a region of compressed stem tissue from which new shoots are produced, generally found near the surface of the soil. Crowns are compressed stems having leaves and flowers on short internodes.

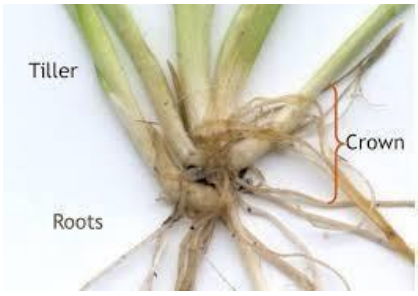


Fig. 3: A crown
(Source: blogs.oregonstate.edu)

A **spur** is a compressed fruiting branch. Spurs are short, stubby, side stems that arise from the main stem and are common on such fruit trees as pears, apples, and cherries, where they may bear fruit.

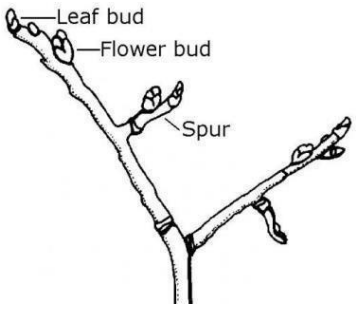


Fig. 4: A spur
(Source: content.ces.ncsu.edu/extension)

A **tuber** is an enlarged portion of an underground stem that store food for the plant. They have nodes that produce buds.

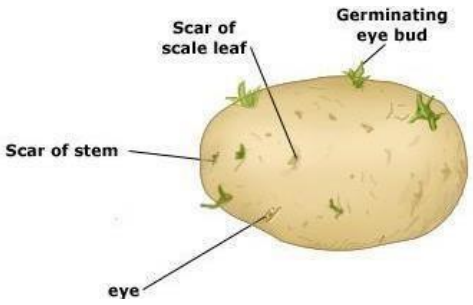


Fig. 5: A tuber
(Source: www.tutorvista.com)

A **rhizome** is a specialized stem which grows horizontally at or below the soil surface. They act as a storage organ and means of propagation like stolons.

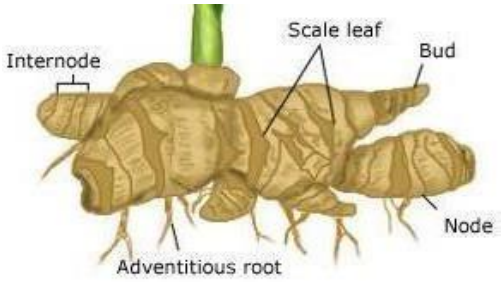


Fig. 6: A rhizome
(Source: www.tutorvista.com)

A **stolon** is a horizontal stem that is fleshy or semiwoody and lies along the top of the ground. A runner is a type of stolon. It is a specialized stem that grows on the soil surface and forms a new plant at one or more of its nodes. Strawberry runners are examples of stolons.

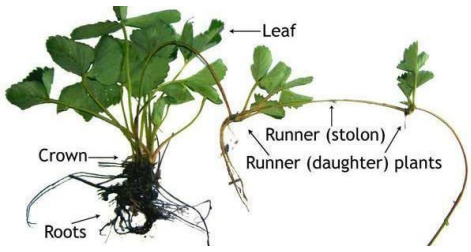


Fig. 7. A Stolon
Source: http://www.berrygardener.com)

A **corm** is a solid, swollen stem whose scales have been reduced to a dry, leaf like covering. They have shapes similar to bulbs, but do not contain fleshy scales.

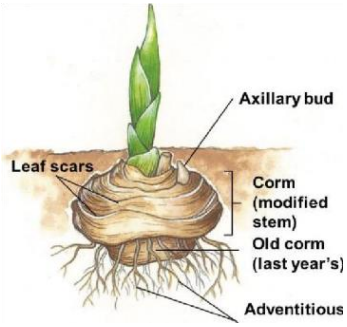


Fig. 8: A corm
(Source: slideplayer.com)

A **bulb** is a shortened, compressed, underground stems surrounded by fleshy scales (leaves) that envelop a central bud located at the tip of the stem are involved in the movement of water from the epidermis and in food storage.

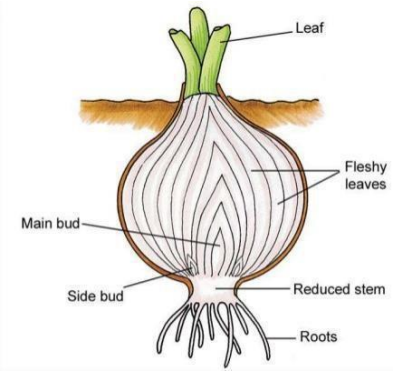


Fig. 9: A bulb
(Source: www.slideshare.net)

2.1.3.2. Leaves

Leaves are the **powerhouse of plants**. In most plants, leaves are the major site of food production for the plant. Structures within a leaf convert the energy in sunlight into chemical energy that the plant can use as food. **Chlorophyll** is the molecule in leaves that uses the energy in sunlight to turn water (H_2O) and carbon dioxide gas (CO_2) into sugar and oxygen gas (O_2). This process is called **photosynthesis**.

Structure of a leaf

Internal features: A leaf is made of many layers that are sandwiched between two layers of tough skin cells (called the **epidermis**). The epidermis also secretes a waxy substance called the **cuticle**. These layers protect the leaf from insects, bacteria, and other pests. Among the epidermal cells are pairs of sausage shaped **guard cells**. Each pair of guard cells forms a pore (called **stoma**; the plural is **stomata**).

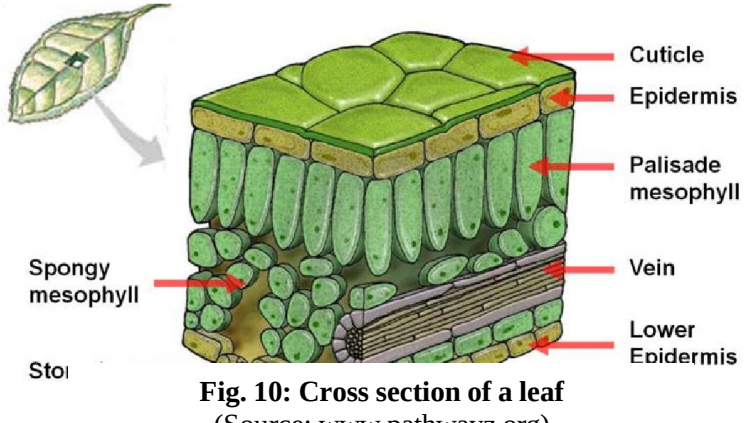


Fig. 10: Cross section of a leaf
(Source: www.pathwayz.org)

Gases enter and exit the leaf through the stomata. Most food production takes place in elongated cells called **palisade mesophyll**. Gas exchange occurs in the air spaces between the oddly-shaped cells of the **spongy mesophyll**. Veins support the leaf and are filled with vessels that transport food, water, and minerals to the plant.

External features: The external feature comprises of the **leaf blade**, **petiole** and **stipules**.

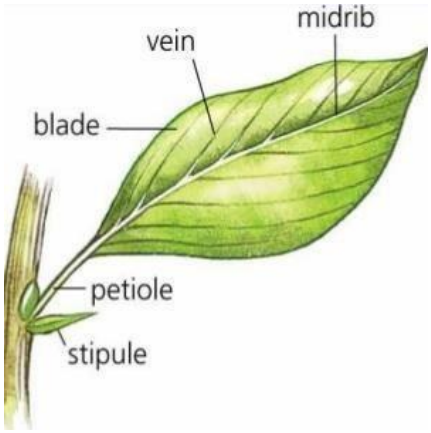


Fig. 11: External features of a leaf
(Source: www.slideshare.net)

The **blade** of a leaf is the expanded, thin structure on either side of the midrib. The blade is usually the largest and most conspicuous part of a leaf. The **petiole** is the stalk which supports the leaf blade. It varies in length and may be lacking entirely in some cases where the leaf blade is described as sessile or stalkless. The base of the petiole is attached to the stem at the node. The small angle formed between the petiole and the stem is called the leaf axil. An active or dormant bud or cluster of buds is usually located in the axil. The **stipule** is a modified leaf appendage located just below or sometimes attached to the leaf petiole. They are uncommon in monocots and usually occur in pairs in dicots.

Leaves as Food

The leaf blade is the principal edible part of several horticultural crops including chive, collard, dandelion, endive, kale, leaf lettuce, mustard, parsley, spinach, and Swiss chard. The edible part of leek, onion, and Florence fennel is a cluster of fleshy leaf bases. The petiole of the leaf is the edible product in celery and rhubarb. In plants like Brussels sprouts, cabbage, and head lettuce, the leaves form a large, naked bud and are the edible product.

2.1.3.3. Roots

A good understanding of plant root systems is essential in order to understand plant growth, flowering, and fruiting. The principal functions of roots are to absorb nutrients and moisture, to anchor the plant in the soil, to provide physical support for the stem, and to serve as food storage organs. In some plants they may be used as a means of propagation. The structure and growth habits of roots have a pronounced effect on the size and vigor of the plant, method of propagation, adaptation to certain soil types, and response to cultural practices and irrigation. The roots of certain vegetable crops are important as food. Roots typically originate from the lower portion of a plant or cutting. They possess a root cap, have no nodes and never bear leaves

or flowers directly. There are three major parts of a root. The **meristem** is at the tip and manufactures new cells. It is an area of cell division and growth. Behind it is the **zone of elongation**, in which cells increase in size through food and water absorption.

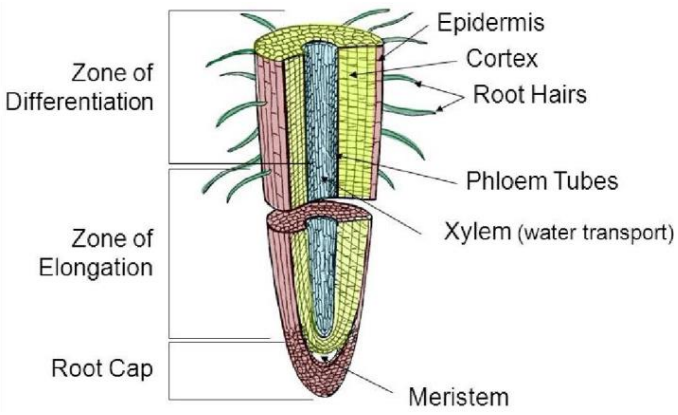


Fig. 12: Structure of a root
(Source: slideplayer.com)

By increasing in size, the cells in the zone of elongation push the root through the soil. The third major root part is the **zone of differentiation**, in which cells undergo changes in order to become specific tissues such as epidermis, cortex, or vascular tissue.

The epidermis is the outermost layer of cells surrounding the root. These cells are responsible for the absorption of water and minerals dissolved in water.
Cortex cells lie between the epidermis and the vascular tissue and may contain stored carbohydrates or other substances such as resins, latex, essential oils, and tannins. A layer of suberized (a fatty material in some cells), known as the **Casparian strips**, has regulatory effect on the types of minerals absorbed and transported by the roots to stems and leaves.

There are several kinds of root systems:

-A **primary root** that originates at the lower end of the embryo of a seedling plant.

-A **taproot** is formed when the primary root continues to elongate downward. This makes them difficult to transplant and necessitates planting only in deep, well-drained soil. The taproot of carrot, parsnip, and salsify is the principal edible part of these crops.

-A **lateral**, *or* **secondary root** is a side or branch root which arises from another root.

-A **fibrous root** system is one in which the primary root ceases to elongate, leading to the development of numerous lateral roots. These then branch repeatedly and form the feeding root system of the plant. A fibrous root is one which remains small in diameter because of a lack of significant cambial activity.

-The **enlarged root** is the edible portion of several vegetable crops. The sweet potato is a swollen root,

called a tuberous root, which serves as a food storage area for the plant.

Roots as Food

Some plants such as dahlia and the sweet potato produce underground storage organs called tuberous roots. They are true roots, not stems, and have neither
nodes nor internodes. Carrot, parsnip, salsify, and radish are elongated taproots.

Buds

A bud is an undeveloped shoot from which embryonic leaves or flower parts arise. The buds of trees and shrubs of the temperate zone typically develop a protective outer layer of small, leathery, bud scales.



Fig. 13: Flower buds (Source: www.waldeneffect.org)

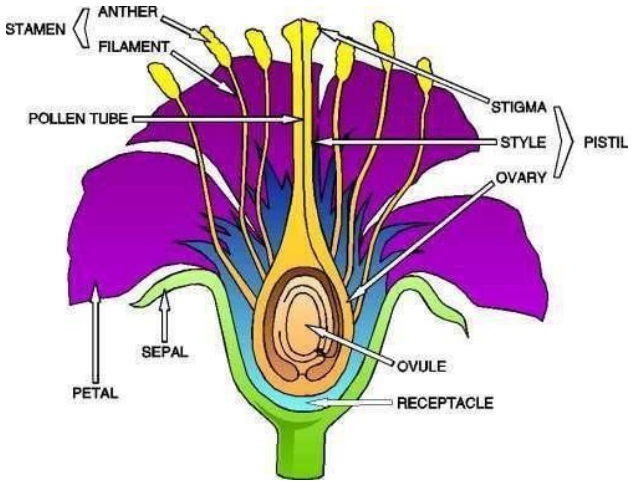
Annual plants and herbaceous perennials have naked buds in which the outer leaves are green and somewhat succulent. Buds of many plants require exposure to a certain number of days below a critical temperature before they resume growth in the spring. This time period varies for different plants. During rest, dormant buds can withstand very low temperatures, but after the rest period is satisfied, they become more susceptible to weather conditions and can be damaged easily by cold temperatures or frost.

Buds as Food

Enlarged buds or parts of buds form the edible portion of some horticultural crops. Cabbage and head lettuce are examples of unusually large terminal buds. Succulent axillary buds are the edible parts of

Brussels sprouts. In the case of globe artichoke, the fleshy basal portion of the bracts of the flower bud are eaten along with the solid stem portion of the bud. Broccoli is the most important horticultural plant in which edible flower buds are consumed (along with portions of the stem and small leaves).

Fig. 14: Parts of a flower



(Source: www.thinglink.com)

Flowers

The flowers are the sexually reproductive parts of a plant and involved in the production of seed. Both the male and the female reproductive parts of a plant are in the center of the flower.

The male, pollen producing part is called the **anther**, held aloft by a stalk called a **filament**. The entire male apparatus is called a **stamen.**

The female reproductive part of a plant, the stigma, sits on top of a **style**, or stalk, which leads to an **ovary** at the base. The entire female plant mechanism is called a **pistil**. In seed plants, the offspring can be packaged in a protective seed, which is used as an agent of dispersal.

Sepals are small green, leaflike structures on the base of the flower which protect the flower bud. The sepals collectively are called the calyx. **Petals** are highly colored portions of the flower. They may contain perfume as well as nectar glands. The petals collectively are called the corolla. The number of petals on a flower is often used in the identification of plant families and genera.

Flowers of dicots typically have sepals and/or petals in multiples of four or five. Monocots typically have these floral parts in multiples of three. If a flower has a stamen, pistils, petals, and sepals, it is called a **complete flower**. If one of these parts is missing, the flower is designated **incomplete flower**. If a flower contains functional stamens and pistils, it is called a **perfect flower**. (Stamen and pistils are considered the essential parts of a flower.) If either of the essential parts is lacking, the flower is **imperfect flower**.

Pistillate flowers are those which possess a functional pistil(s) but lack stamens. **Staminate flowers** contain stamens but no pistils. Because cross-fertilization combines different genetic material and producesstronger seed, **cross-pollinated plants are usually more successful than self-pollinated plants**. Consequently, more plants reproduce by cross-pollination than self-pollination.

Dioecious plants are those species in which the sexes are separated into staminate and pistillate plants. Most holly trees and pistachio trees are dioecious; therefore, to obtain berries, it is necessary to have female and male trees. **Monoecious** plants are those which have separate male and female flowers on the same plant. Corn plants and pecan trees are examples. Some plants bear only male flowers at the beginning of the growing season, but later develop flowers of both sexes; examples are cucumbers and squash.

Flowers and Plant Classification

Plants can be placed in a hierarchy based on how closely they are botanically related. This relatedness is based primarily on flower structures; this explains why flowers are so useful in identifying plants. We know many plants by common names, but in order to communicate with plant professionals around the world, we

use the scientific language of plant nomenclature. Each plant is identified by a unique botanical Latin name. The system of binomial nomenclature provides a double name for plants, called its genus and species. The first, or generic name, is followed by a descriptive, or specific, name.

Pollination and seed formation

Seeds are formed through **pollination** or the transfer of pollen from an anther to a stigma. This may occur by wind or by pollinators. Wind-pollinated flowers lack showy floral parts and nectar since they don't need to attract a pollinator. Flowers are brightly colored or patterned and contain a fragrance or nectar when they must attract insects, animals, or birds. In the process of searching for nectar these pollinators will transfer pollen from flower to flower. The stigma contains a chemical which stimulates the pollen, causing it to grow a long tube down through the style, to the ovules inside the ovary. After breaking through the ovule, the pollen grain releases two sperm nuclei: one combines with the female egg cell to form an embryo, and the other combines with polar nuclei in the embryo sac to form the endosperm (food storage tissue). This process is called double fertilization. If the fertilization process is successful, the embryo and endosperm and surrounding protective tissues develop into a seed. Some plants are self-fertile; that is, the pollen and ovules of a single plant can unite to form seeds containing viable embryos. Most plants, even those that are self-fertile, can be cross pollinated; this process combines genetic material from more than one plant, and produces stronger seed and more vigorous offspring.

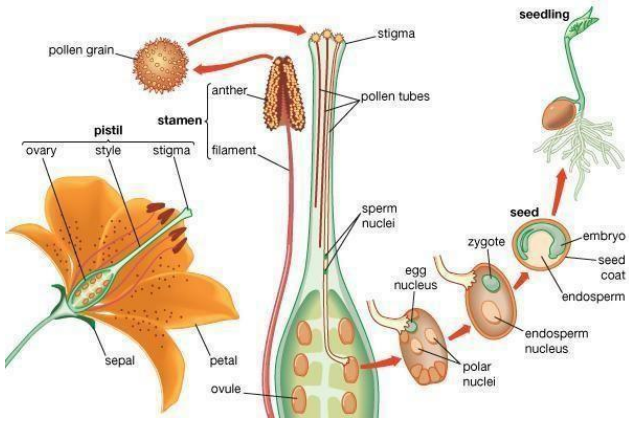


Fig. 15: Pollination and seed formation
(Source: http://byjus.com/biology/seed-formation/)

Consequently, more plants reproduce by crosspollination than self-pollination.

Types of inflorescences

Some plants bear only one flower per stem; these are called solitary flowers. Other plants produce an inflorescence, a term which refers to a cluster of flowers and how they are arranged on a floral stem. Some examples of inflorescences are spike, raceme, corymb, umbel, and head.

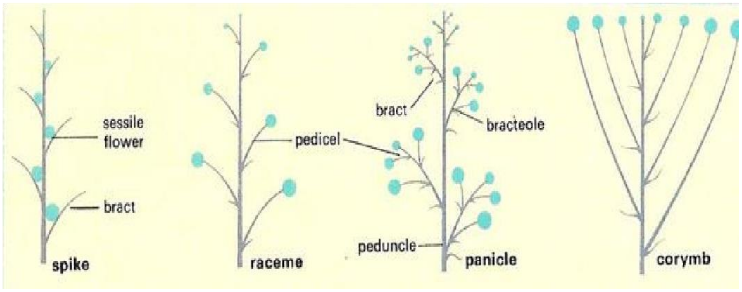


Fig. 16: Types of inflorescences
(Source: www.daviddarling.info/encyclopedia/I/inflorescence.html)

A **spike** has many stemless florets, each attached to an elongated flower stem; an example is gladiolus. A **raceme** is similar to a spike except the florets are on small stems (pedicels) attached to the central axis; an example is snapdragon. A **corymb**'s florets are on stalks, called pedicels, and are arranged at random along the peduncle in such a way that the florets create a flat, round top; an example is yarrow. An **umbel** is similar except that the pedicels all arise from one point on the peduncle; an example is dill. A head, or composite, inflorescence is composed of two distinct types of stemless florets. Usually, fertile disk florets crowd the central button and are surrounded by generally sterile, strap-like ray florets, often wrongly referred to as "petals".

Fruit

Fruit Botanically, the true fruit is the enlarged ovary around the newly developed seeds. But in practical horticulture, we often refer to fruits as the accessory tissues of the flower which develop around the true fruit.

Types of Fruit

Just as flowers are useful in identifying plants, fruits are also characteristic of specific plants. Fruits can be classified as simple fruits, aggregate fruits, or multiple fruits. Simple fruits are those which develop from a single ovary. These include cherries and peaches (called drupes), pears and apples (called pomes), and tomatoes (called berries). Tomatoes are a botanical fruit since they develop from the flower, as do squash, cucumbers, and eggplant. All of these fruits develop from a single ovary. Some types of simple fruit are dry, with papery, leathery or hard tissue. Examples are peanut (an example of a fruit type called legumes), poppy (typical of fruits called capsules), maple (a samara), and acorn (a true nut). Aggregate fruits, such as raspberries, come from a single flower which has many ovaries. The flower appears as a simple flower, with one corolla, one calyx, and one stem, but with many pistils (and therefore many ovaries). The ovaries are fertilized separately and independently. Incomplete pollination can produce misshapen fruit. Strawberry and blackberry are aggregate fruits born on an edible, enlarged receptacle, which is fused to the fruits and eaten as part of them. We sometimes call these "accessory" or "false" fruits, since the fleshy, juicy part is not the biological fruit, or ripened ovary itself. Multiple fruits are derived from a tight cluster of separate, independent flowers borne on a single structure. Each flower has its own calyx and corolla. Examples of multiple fruits are pineapple, fig and beet.

Parts of Fruit

The only parts of a fruit which are genetically representative of both the male and female flowers are the

seeds (mature ovules). The rest of the fruit arises from the maternal plant, and is therefore genetically identical to that female parent. This explains why a pumpkin can be cross-pollinated by a squash and still produce a predictable-tasting pumpkin, yet the seeds of that pumpkin will produce a new plant that is a hybrid between the pumpkin and the squash. A fruit as a whole is not a single solid product; it is divided into certain parts among itself. Generally, the parts of the fruits are divided into two fruit layers. These are:

- **Pericarp** which is comprised of: i) **Exocarp**, or the outermost layer consisting of only the epidermis; ii) **Mesocarp**, or middle layer, which varies in thickness; and iii) **Endocarp**, which shows considerable variation from one species to another. As an example, in the peach, the Exocarp is the skin, the Mesocarp is the fleshy part, and the endocarp is the stony pit. The seed, containing the embryo, is inside the pit.

- **Seed.** The seed, or matured ovule, has three parts. The **embryo** is a miniature plant in an arrested state of development. Most seeds contain a built-in food supply called the **endosperm** that can be made up of proteins, carbohydrates, or fats. The third part is the hard outer covering, called a **seed coat**, which protects the seed from disease and insects and prevents water from entering the seed.

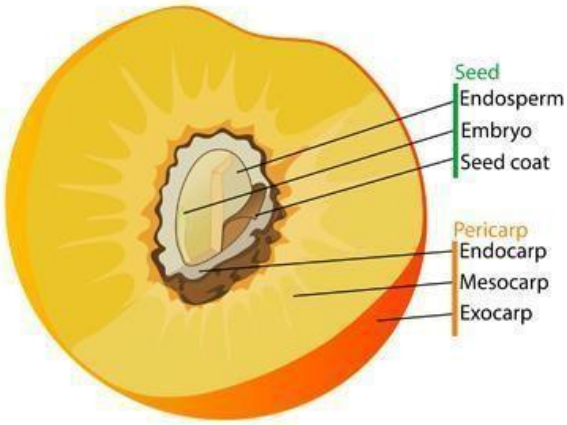


Fig. 17: Parts of a fruit
(Source: http://www.clemson.edu)

Germination Process

The process of germination begins when the seed absorbs water (**imbibition**) through the seed coat, and ends when the green plant begins **photosynthesis**. Successful germination requires the proper environmental conditions: favorable temperatures, correct light levels, and adequate moisture and aeration. The absorbed water activates hormones and enzymes which convert stored food into simpler food materials, and activate essential growth processes. The embryo begins to grow through cell division and enlargement, causing the young seedling to burst from the seed, sending its **radicle** downward to develop into a root system, and its **plumule** upward to develop into the stem and leaves. With uptake of water from the soil by the young root system and photosynthesis by the young green tissue, germination is complete. In many plants, the **cotyledons** (seed leaves) are the first structures to emerge above ground. Monocots have one cotyledon while dicots have two cotyledons. The cotyledons of many plants are similar, while their true leaves can vary greatly. There two distinct types of germination.

In **epigeal** germination, the cotyledons emerge and rise above ground level as the seedling grows. They may also serve a photosynthetic role in seedling development. Seedlings that develop this way quickly form a shoot and leaves, both of which perform photosynthesis to fuel further development.

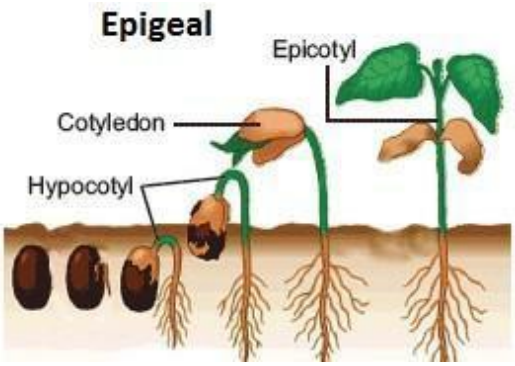


Fig. 18 a: Epigeal germination
(Source: http://www.plantscience4u.com/)

In **hypogeal** germination, the cotyledons emerge from the seed containing enough nutrients to fuel seed development and are not photosynthetic. These seeds are usually larger than epigeal seeds. As the seedling grows, its shoot rises above ground level, while the cotyledons remain below or at ground level.

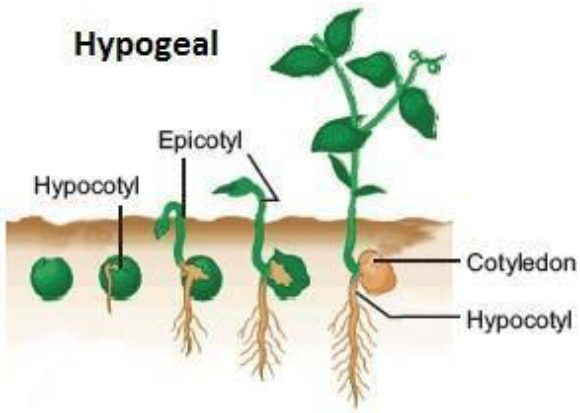


Fig. 18 b: Hypogeal germination
(Source: http://www.plantscience4u.com)

A summary of the differences between epigeal and hypogeal germination is given is Table 2.1 below:

Table 1: Epigeal versus Hypogeal germination

Epigeal germination (Example: Beans)	***Hypogeal germination (Example: Corn)***
Cotyledons/seed emerge out of the soil or above the soil	*Cotyledons/seed remain inside the soil or below the soil*
The cotyledons turn green (photosynthetic) acting as first leaves	*The cotyledons play no part in photosynthesis*

There is greater elongation of the hypocotyl	*There is greater elongation of the epipocotyl*
The terminal part of the hypocotyl is curved to protect the plumule from the friction of the soil	*The terminal part of the epicotyl is curved to protect the plumule from the friction of the soil*
Energy for growth is primarily derived from the cotyledon	*Energy for growth is primarily derived from the endosperm*

2. PHYSIOLOGY: PLANT GROWTH AND DEVELOPMENT

Three major plant functions that are essential for plant growth and development are **photosynthesis**, **respiration**, and **transpiration**.

Photosynthesis

One of the major differences between plants and animals is the ability of plants to internally manufacture or synthesize their own food. To carry out the process of photosynthesis, a plant requires **chlorophyll** (a green pigment in leaves and stems) within its tissue, energy from light, carbon dioxide from the air, and water from the soil. If any of these ingredients is lacking, photosynthesis cannot proceed. Photosynthesis literally means "to put together with light."

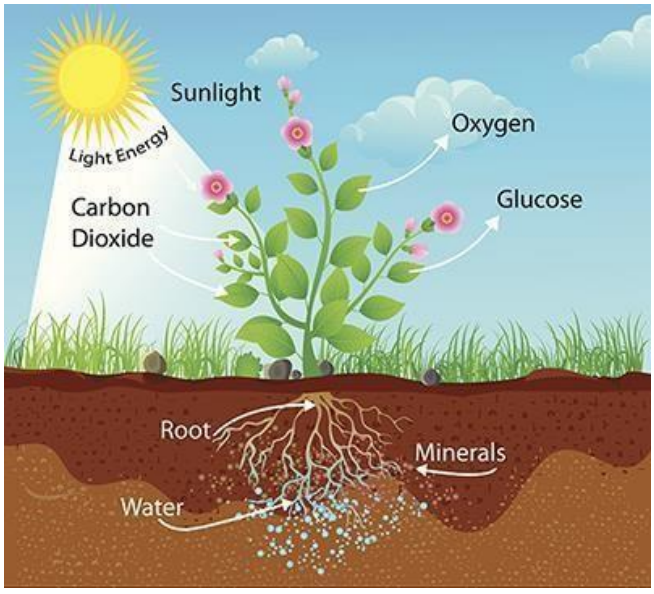


Fig. 19 : Photosynthesis
(Source: www.futuredirections.org.au)

In presence of photosynthetic light:

Carbon Dioxide + Water → Sugar + Oxygen + Water **[$6CO_2 + 12H_2O \rightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$]**

Plants store the energy from light first in simple sugars, such as glucose. This food may be converted back to water and carbon dioxide, releasing the stored energy through the process called **respiration**. This energy is required for all living processes and growth. Simple sugars can also be converted to more complex sugars and starches (carbohydrates) which may be transported to the stems and roots for use or storage, or they may be used as building blocks for other synthates, such as oils, pigments, proteins, and cell walls. Any green plant tissue can photosynthesize.

Chloroplasts in these cells contain the green pigment, chlorophyll, which traps the light energy. Leaves are the primary site of photosynthesis due to their special structure. The internal tissue (mesophyll) contains cells with abundant **chloroplasts** in an arrangement that promotes easy movement of water and air. The protective upper and lower epidermal layers of the leaf include many stomates that regulate movement of the gases involved in photosynthesis into and out of the leaf.

Photosynthesis is dependent on the availability of light. Generally, as sunlight increases in intensity, photosynthesis increases. This results in greater production. Many garden crops, such as tomatoes, respond best to maximum sunlight. Tomato production is greatly reduced as light intensities drop.
Only a few "greenhouse" tomatoes produce fruit when sunlight is minimal in late fall and early spring.

Water plays an important role in plants in several ways. First, it maintains a plant's turgor, or the firmness of plant tissue. **Turgor pressure** in a cell can be compared to air in an inflated balloon. Water pressure or turgor is needed by plant cells to maintain shape and ensure cell growth. Second, water is split into hydrogen and oxygen by the energy of the sun that is absorbed by the chlorophyll in plant leaves. This oxygen is released into the atmosphere while the hydrogen is used in carbohydrate synthesis. Third, water dissolves minerals from the soil and transports them up from the roots and throughout the plant, where they serve as raw materials in the development of new plant tissues. The soil surrounding plants must provide adequate water to be pulled into the plant by transpiration (evaporation of water from the leaves' stomates).

Photosynthesis also requires carbon dioxide (CO_2) which enters the plant through the stomates. Carbon and oxygen are used in the manufacture of carbohydrates. Carbon dioxide in the air is plentiful enough so that it does not limit plant growth outdoors. However, since carbon dioxide is consumed in making sugars and is not replenished by plants at a rapid rate, a tightly closed greenhouse in midwinter may not let in enough outside air to maintain an adequate carbon dioxide level. Under such conditions, production of roses, carnations, tomatoes, and many other crops can be increased by adding carbon dioxide to the growing area.

Temperature affects photosynthesis rates, which occurs at its highest rate in the temperature range 65 to 85° F and decreases when temperatures are above or below this range.

Respiration

Carbohydrates made during photosynthesis are of value to the plant when they are converted into energy through the process of **respiration**.

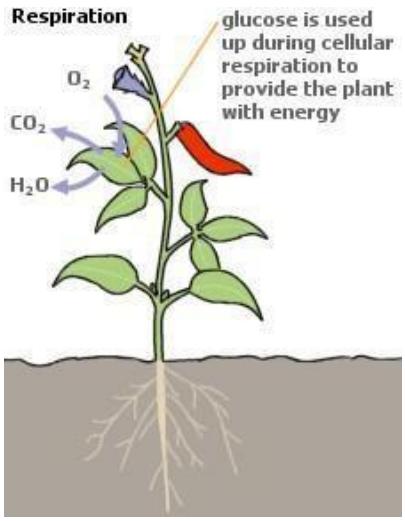


Fig. 20 : Respiration
(Source: lifeofplant.blogspot.com)

Respiration is similar to the burning of wood or coal to produce heat (energy).

$$C_6H_{12}O_6 + 6O_2 + 6H_2O \rightarrow 6CO_2 + 12H_2O + Energy$$

This equation is precisely the opposite of that used to illustrate photosynthesis, although more is involved than just reversing the reaction. However, it is appropriate to consider photosynthesis to be a building process, and respiration to be a breaking down process.

The differences and similarities between photosynthesis and respiration can be summarized in Table 2.2 below:

Table 2. Photosynthesis vs respiration

Photosynthesis	***Respiration***
Produces food	*Uses food for plant energy/growth*
Captures energy	*Releases energy*
Occurs only incells containing chloroplasts	*Occurs in all cells*
Releases oxygen	*Uses oxygen*
Uses and produces water	*Uses and produces water*
Uses carbon dioxide	*Produces carbon dioxide*
Rate is dependent on light	*Rate is independent of light*

Transpiration

Transpiration is the process by which a plant loses water, primarily through leaf stomates (or stomata). Transpiration is a necessary process that involves the use of about 90% of the water that enters the plant through the roots. The other 10% of the water is used in chemical reactions and in plant tissues.

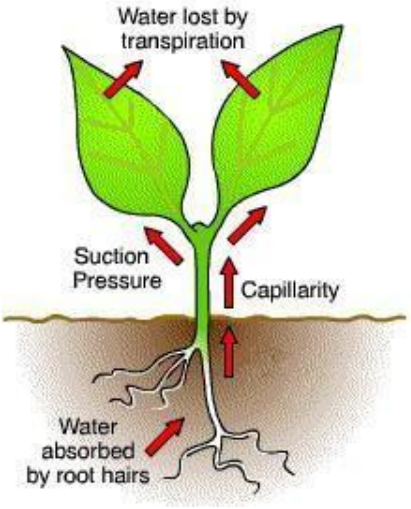


Fig. 21 : Transpiration process
(Source:http://wizznotes.com/biology/transport-inplants/transpiration)

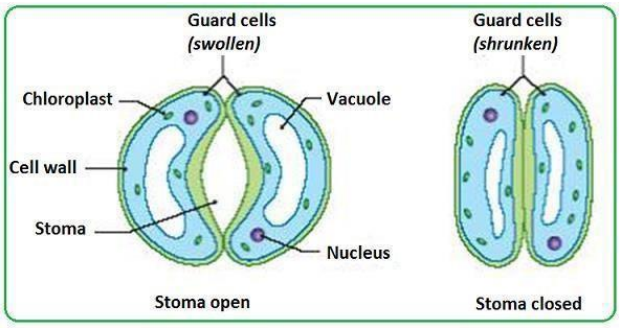


Fig. 22 : Opening and closing of stoma
(Source:http://hubpages.com/education/The-Crucial-Role-ofStomata-in-Plant-Transpiration-and-Photosynthesis)

Transpiration is necessary for mineral transport from the soil to the plant, for the cooling of the plant through evaporation, to move sugars and plant chemicals, and for the maintenance of turgor pressure. The water in a plant's xylem forms a continuous column. As water evaporates through leaf stomates, more water is drawn into plant roots.

Environmental Factors Affecting Transpiration

The amount of water lost from the plant depends on several environmental factors such as light, temperature, humidity and wind or air movement.

Light. Light, specifically light intensity, is probably the most obvious among the environmental factors affecting transpiration in plants. It has a controlling effect on the opening of the stoma through which

water primarily escapes in gaseous state. In general, transpiration rate is high during daytime, particularly when light is bright, than during night time. The opening of the stomata likewise enables the escape of water as water vapor in the process of stomatal transpiration. Except in CAM plants, the stomata are close at darkness between sunset to sunrise. In turn, photosynthesis decreases the concentration of CO_2 in the intercellular spaces within the leaf resulting to the opening of the stomata.

Relative Humidity. This environmental factor affects transpiration by regulating stomatal movement and atmospheric demand. At high RH, the stoma tends to close and thus limit the exit of water vapor from the plant. Further, high RH means that the water-potential gradient (also water vapor concentration and vapor pressure gradient) from plant to the atmosphere will be minimal compared to when RH is low. In addition, at high RH the atmosphere contains more water and has low atmospheric demand, meaning that it has limited capacity to absorb more water.

Temperature. The rate of transpiration is fastest when air temperature is between 75°F to 85°F. At these temperatures the stomatal apertures or opening are generally widest. In general, the stomata close at temperatures about 32°F and progressively increase in aperture up to about 85°F.

Soil Water. Where the supply of water from the soil is limiting, the rate of transpiration tends to slow down. This is more pronounced where other conditions, such as bright light and warm temperature, favor escape of water from the plant. In this case, water deficit within the plant may occur leading to the closing of the stomata which is manifested by wilting of leaves. Conversely, the entry of water into the guard cells opens the stoma. This allows the passage of water in the process of stomatal transpiration.

Wind. This environmental factor affects transpiration by removing that thin moist layer of air, called *boundary layer*, which lies next to the surface of a leaf. This moist air causes a lesser water potential gradient from the leaf resulting to reduced rate of transpiration. This layer also reduces light penetration into the leaf. But with wind, this boundary layer is replaced with drier air thus increasing water potential gradient and enhancing transpiration. However, strong wind may cause excessive loss of water from leaves leading to stomatal closure.

3. ENVIRONMENTAL EFFECT ON PLANT GROWTH

Temperature

Temperature is a measure of intensity of heat and it directly influences photosynthesis, respiration, cell wall permeability, nutrient and water absorption, transpiration, enzyme activity and protein coagulation. Temperature affects the productivity and growth of a plant depending upon whether the plant variety is a **warm-season** or **cool-season** crop. If temperatures are high and day length is long, cool-season crops such as broccoli and spinach will **bolt** rather than produce the desired flower. Temperatures that are too low or high for a warm-season crop will **prevent fruit set**.

Thermoperiod

Thermoperiod refers to daily temperature change. Plants produce maximum growth when exposed to a day temperature that is about 10 to 15° F higher than the night temperature. This allows the plant to photosynthesize and respire during an optimum daytime temperature and to curtail the rate of respiration during a cooler night.

Vernalization

The biennial crops and some cool season vegetables such as onion, carrot, cabbage, cauliflower and spinach initiates flower formation after the exposure to the low temperature. The duration of vernalization to initiate flowering declines as the temperature decreases, for example, at the same exposure duration, the radish flowers sooner at 41°F than at 50°F. If this cold requirement is not met then small, misshapen leaves and fruit will result. Many times fruit will not set. In low desert areas where these temperatures have not experienced low chill peach trees should be planted. Lilies need 6 weeks at 33°F before they will bloom.

Effects of high temperature

High temperatures cause increased respiration sometimes above the rate of photosynthesis. This means that the products of photosynthesis are being used more rapidly than they are being produced. For growth to occur photosynthesis must be greater than respiration. Heat injury caused by high temperature is expressed in the reduction of growth rate. Temperature above 85°F inhibit the germination of lettuce, celery and tuber formation in potato. The fruit set of solanaceous crops and legumes vegetables declines as the temperature exceeds 90°F. In tomato, under heat stress condition, cracks at the stems ends may occur and the fruits become puffy. Onion and radish become more pungent at high temperature condition. Heat injury is held due to starvation, toxicity or destruction of fruiting structure. At the temperature above 85°F, the stomata remains closed.

This may lead to stomatal closure and reduce rate of gaseous exchange leading to reduced photosynthesis and crop growth. Strong winds in association with rain can cause lodging, particularly at flowering in cereals. Provision of windbreaks in exposed areas can minimize the adverse effects of high wind speed Starvation results when net photosynthesis is zero. Toxicity may occur when the anaerobic respiration is initiated. The structural protein may be destroyed by a high temperature. The symptoms of heat injury are the appearance of dead areas in young stems in legumes and the leaves of onion, cabbage and lettuce. Temperatures that are too high for warm-season crops such as pepper or tomato can cause pollen to become inviable and not pollinate flowers. Adverse temperatures also cause stunted growth and poor quality. For example, the bitterness in lettuce is caused by high temperatures. Sometimes temperatures are used in connection with day length to manipulate the flowering of plants.

Chrysanthemums will flower for a longer period of time if daylight temperatures are 59°F. The Christmas cactus forms flowers as a result of short days and low temperatures.

Effects of low temperature

Low temperatures can result in poor growth. Photosynthesis slows at low temperatures. Since photosynthesis is slowed, growth is slowed and this results in lower yields. Temperatures alone also influence flowering. Daffodils are forced to flower by putting the bulbs in cold storage in October at 35° to 40°F. The cold temperatures allow the bulb to mature. The bulbs are transferred to the greenhouse in midwinter where growth begins. The flowers are then ready for cutting in 3 to 4 weeks. Plants can be classified as either hardy or non-hardy depending upon their ability to withstand cold temperatures. Winter injury can occur to non-hardy plants if temperatures are too low or if unseasonably low temperatures occur late in the spring or early in the fall. Winter injury may also occur because of desiccation (drying out). Wide variations in winter temperatures can cause premature bud break in some plants and consequent freezing damage. Late spring frost damage can ruin entire crops.

Solar radiation

This is the radiant energy from the sun, measured as a total amount (direct solar plus sky radiation) expressed in cal cm^{-2} min^{-1} measured by pyrheliometer. For photosynthesis, only visible part of the total

solar energy is of importance. Photosynthesis in green leaves use solar energy in wavelengths from 0.4 to 0.7 m often referred to as photosynthetically active radiation (PAR) or simply light. Radiant energy influences the protoplasm permeability, intake and loss of water, enzyme activity, respiration, photo-synthesis, flower initiation and ripening of fruits. Three aspects of light intensity (quantity), duration (day length) and quality (spectral distribution).

Precipitation

The essential requirement of water for plant growth can be visualized from the fact that it may constitute 70-95% of total fresh weight when it is actively growing. Precipitation is the major source of soil moisture for crop growth in dry regions during rainy season. A number of physiological processes in crop growth is affected due to water stress. Cell growth, cell wall and protein synthesis are adversely affected by the stress. Stomatal closure due to water stress restrict CO_2 intake leading to reduced photosynthesis. Precipitation also influences atmospheric humidity. High humidity can increase the risk of disease and pest outbreak. Plant roots need moist soil during the winter. When the soil is frozen the movement of water into the plant is severely restricted. On a windy winter day broad-leaved evergreens can become water deficient in a few minutes, turning the leaves or needles brown.

Wind

Wind greatly aids the spread of seeds (dispersal), pollen grains (pollination) and other materials. This can be a positive or a negative contribution to agriculture, depending on what kind of materials are being spread. On one hand, wind can help move beneficial seeds and pollens that support a healthy crop growth. On the other, wind can also spread contaminants such as pests, weeds, diseases, and chemicals that can harm harvests. Wind over the crop surface can also alter the onset of drought during dry periods due to water vapor loss through transpiration. Wind is also a major factor in soil erosion. Wind can carry away small bits of soil, reducing the overall soil fertility of the area. This can be particularly damaging to cropland, where the topsoil is particularly important for water retention, preventing runoff and promoting healthy crop growth. Wind erosion can also reduce levels of beneficial nutrients in the soil, leading to poor crop yields. It can also reduce the overall amount of water available to farmers, as it carries away moisture particles from the soil.

REVIEW QUESTIONS

1. What are **vascular plants**?
2. What is the role of plants' vascular system is analogous to the circulatory systems?
3. Give an example of a horticultural plant that produces spores instead of seed.
4. What are **gymnosperms** and **angiosperms** and how do they differ?
5. Differentiate between **monocotyledons (monocots)** and **dicotyledons (dicots)**.
6. Outline 4 ways in which monocots and dicots differ
7. What are the differences among annuals, biennials, and perennials?
8. What parts of a plant are considered vegetative and what parts are reproductive?
9. What are the three major internal parts of a stem?
10. How do the vascular systems of monocots and dicots differ?
11. Give an example of how the differences in the vascular systems of monocots and dicots can be used to our advantage in horticulture.
12. Briefly describe the various (seven) forms of modified stems.

15. List three kinds of modified stems that are above ground and three that are below-ground.
16. What part of the plant is described as the powerhouse?
17. What structures within a leaf plays the role of converting the solar energy in sunlight into chemical energy that the plant can use as food?
18. What is the name of the molecule in leaves that uses the energy in sunlight to turn water (H_2O) and carbon dioxide gas (CO_2) into sugar and oxygen gas (O_2)?
19. What is the name of the process described in # 16 above?
20. Gases enter and exit the leaf through the opening in leaves called_____.
21. Where does food production in plants take place?
22. Where does gas exchange in plants take place?
23. What is the name of the undeveloped shoot from which embryonic leaves or flower parts arise?
24. What are the three parts that comprises the external part of the leaf?

25. At what period would the flower buds withstand very low temperatures?

26. What are three major parts of a root?

27. What is the name of the layer of suberized material that regulates the minerals absorbed and transported by the roots to stems and leaves?

28. List the various kinds of root systems:

29. What is the difference between the pistillate and staminate flowers?

30. Explain the differences between:

-complete vs incomplete flower

-perfect vs imperfect flower

-monoecious vs dioecious plants

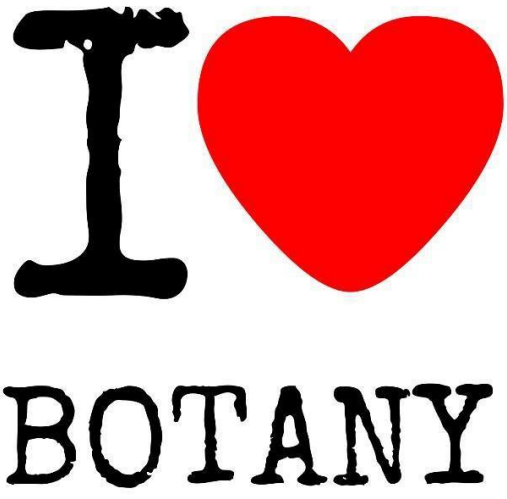
31. How would the petals of an insect-pollinated flower differ from than of a wind-pollinated flower?

30. Explain the terms:

-Photoperiod

-Thermoperiod

-Vernalization



Summary Description for Module 4

Title:	Module 4: Urban Agriculture Entrepreneurship
Instructor:	Dr. Theresa Nartea, Associate Professor, Extension Specialist-Marketing & Agribusiness
Prerequisites:	Working knowledge of Microsoft Word, Email
Class Time:	9:00AM – 11:30AM
Learning Objective:	For this module, first, you will learn how to plan your urban agriculture production using a marketing lens. Next, you will identify potential market outlets that best suit your personality. We will also touch upon product pricing and farm market regulations.
Instructor Media Needs:	Screen Projector Screen to Project upon Computer
Class Materials and/or Supplies Needed:	Instructor provided Worksheets Student provided Pen and Paper
Class Activities:	1. Present required information needed for understanding of entrepreneurship in Urban Agriculture 2. Demonstrate how to develop a plan to improve entrepreneurship in Urban Agriculture
Knowledge Gained:	Students will gain knowledge in how to develop an entrepreneurship plan in Urban Agriculture
Skills Gained:	Students will gain skills in preparing an Urban Agriculture entrepreneurship plan
Abilities Gained:	Students will be able to complete an Urban Agriculture entrepreneurship plan
Exam Description:	Email submission of file attachments (MSWord) of a completed 3-page summary of the information learned and how it may enhance their progress in Urban Agriculture.

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Determining Your Best

Farm Marketing Strategy



Dr. Theresa J. Nartea, State Program Leader-Food
Associate Professor & Extension Specialist
Marketing & Agribusiness

VSU College of Agriculture

Virginia Cooperative Extension
Virginia Tech • Virginia State University

VIRGINIA STATE UNIVERSITY

The VSU Small Farm Marketing and Business Program led by Dr. Theresa Nartea works directly with Virginia Cooperative Extension (VCE) county agents to provide science based educational curriculum and direct technical support in the following expertise areas:

- Local Food Systems Development
- Food Value Chains
- Food Hubs
- Direct to Consumer Marketing
- Collaborative Farm Marketing Ventures
- Value Added Enterprises
- Small Farmer Viability
- E-commerce, M-commerce, Social Media for Small Farmers

For more information and assistance with your small farm marketing needs, visit our website: https://www.ext.vsu.edu/marketing-agribusiness

VSU College of Agriculture

Virginia Cooperative Extension
Virginia Tech • Virginia State University

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Fig 1

Introduction



Virginia is an emerging farm marketplace both in a physical and virtual sense. If you're in the beginning stages of marketing your crops, you might be overwhelmed trying to determine which market types to pursue.

It can be a guessing game, and may lead to needless discouragement and at worst, financial ruin. However, if you take some time to identify your unique market strengths, you can develop your market strategy. This guide will help you understand your market options and determine which avenues you should pursue.



Fig 2

What does your personality say about which market types best suit you?

Picking a market type for your products involves more than just considering what you're selling, finances, and your farm operations. It's also important to choose a market type that suits your personal strengths. Some folks are more outgoing, while others might prefer a more "behind the scenes" approach to selling their products. On the next page, you'll complete a worksheet that will help you determine what market types are a potential good fit for your unique strengths.

How to complete this worksheet

There are two columns of statements. Look at each one and place the number “1” in the white box next to each statement that describes you. Leave the box blank for statements that you do not relate to. You can relate to both statements within a line, or neither, potentially. Trust your instincts and what you know about yourself.

	I can talk to anyone		I enjoy being by myself over being with people
	I enjoy being around people		I would rather someone else plan event activities
	I am a creative party planner		I tend to avoid parties or crowds
	I enjoy talking with customers		I prefer to talk to people I know over strangers
	I like to organize events such as parties		I feel most comfortable being alone
	I am thoughtful towards people’s feelings		I usually forget people’s names after I meet them
	People say I am fun to be around		People have mentioned I am a challenging person

Market Types

Look at your total score from the worksheet. Did you score higher in the left or right column? If you scored higher in the left column, you are likely better suited to "**direct to customer**" market types. If you scored higher in the right column, you are likely better suited to "**wholesale**" market types.

There are multiple market types within each of these larger categories. Today, farmers have more choices than ever for marketing their products. You might find that multiple markets within "**direct to customer**" or "**wholesale**" appeal to you, or that you should focus your efforts on one or two primary market avenues.

The next section provides a brief description of each type of market. If you want more assistance determining if a certain market is a good fit for you, check out the Market Tip Sheets. Each sheet describes one market in more detail and breaks down the advantages and considerations of each.



Direct to Customer Market Types

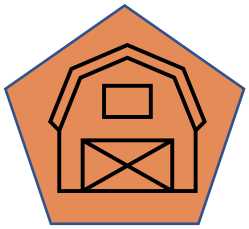
These methods of selling your products involve a connection between you, the grower, and your customer. Many of these market types involve a face-to-face interaction with the customer. If you scored higher in the left-hand column, these are probably the market types that will appeal most to you. The following are all direct to customer markets:

Agritourism	Pick Your Own	Farmer's Market
Roadside Stand	Community Supported Agriculture	Internet Sales
Restaurants		

Fig 3

Direct to Customer Market Types

Agritourism



Agritourism is a business model where people visit a working agricultural or horticultural operation. From farm tours to weddings, hay rides to hunting preserves, corn mazes to petting farms, agritourism allows you, the farmer, to profit from activities that reflect your farming or growing practices. Your customers will be people who want to enjoy a farm setting, learn about where their food comes from, or participate in a fun activity. According to the Census of Agriculture, agritourism income increased by 67% between 2007 and 2017, and more than doubled when you factor in direct sales of farm grown products.

Pick your own

One specific way to have an agritourism operation on your property is to have a "pick your own" model. This is when customers can pick or cut their own farm products where they grow. Popular crop choices include berries, tree fruit, pumpkins, sunflowers, and Christmas trees. This experience appeals to customers who want that connection to their food source, or a fun activity in a farm setting.



Fig 4

Direct to Customer Market Types


Fig 5

Farmer's market

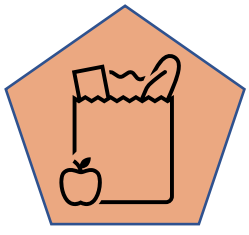
At a farmer's market, you are one of multiple vendors who set up a farm stand with your goods for sale. Most farmers markets have set timeframes and days of the week on which they occur throughout the market season. It's not just produce that's for sale – you'll find growers selling canned goods, apple cider, baked products, potted herbs, wines, and more.

Roadside stand



At a roadside stand, you or a cooperative of growers sell your products to customers driving by. Being located along routes with significant traffic is key, as is having a visually appealing stand that will compel potential customers to stop and have an enjoyable experience.

Community Supported Agriculture



A Community Supported Agriculture program, or CSA, fosters a farmer-customer connection throughout a season. A customer will pay up front for a share of the farm's products before each growing season, and then receives a weekly assortment of vegetables, fruits, and herbs, typically from a designated pick-up location. Certain farms run CSAs throughout the winter season, often with a reduced distribution schedule. CSA members assume some risk of crop loss, and CSA farmers can continue operations should products be lost.

Direct to Customer Market Types

Internet Sales

Though the internet may seem at odds with the traditional ethos of farming, many growers embrace the ability to sell their products through e-commerce. You'll need a consistent online presence, and a plan to find and market to your ideal customers. You could consider online orders for customers to pick up from designated locations, or, if your operation can accommodate, shipping to your customers.

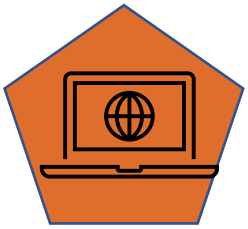




Fig 6

Restaurant

Farm to table restaurants are wildly popular. You could be the farmer that supplies local restaurants with your products! Restaurants are prepared to purchase large orders of produce. When making connections with owners, managers, and chefs, come prepared with an understanding of their business, ideas for recipes that could use your products, and information about your growing methods and product value.

Wholesale Market Types

In wholesale markets, your customers are the produce dealers, truckers, and food brokers that bridge the spatial gap between where the food is grown, and where it is consumed. If you scored higher in the right-hand column, you'll likely find that these markets appeal most to your personality.

Grocery Store	Institutional Market	Aggregator (Food hub)/ Cooperative
Produce Broker	Produce Packing Houses	Produce Distributor
Wholesale Buyer	 Fig. 7	

Wholesale Market Types

Grocery Store

One of the most common places people buy farm products is at the grocery store. While you may imagine it's only the largest corporations that can get a deal with a grocery store, independent farmers can market to smaller, independent grocery stores.



Institutional Market

An institutional market is a unit such as cafeteria in schools, hospitals, government buildings, universities, prisons, and other organizations. Many institutions have a growing interest in sourcing their produce locally and could be a good option for a medium to large-scale farm operation.



Aggregator (Food hub)/Cooperative



Fig 8

An aggregator is the combined business or cooperative of farmers that consolidates and then distributes products. This consolidation is key for ensuring steady supplies of fresh products to the end markets. This type of business model takes from pressure off you, the farmer, to be your own marketer, and frees up time to focus on farming. Sometimes, a cooperative can help with the purchase of packaging and marketing materials, reducing the cost for individual farmers.

Wholesale Market Types

Produce broker

A produce broker is an independent agent who negotiates food sales for growers. They work between the producer and the end buyer to place products in wholesale markets, retail stores, and other venues. A produce broker often works within their local geographic area, but this is not always the case.



Produce packing houses

Packing your produce, one of the final steps before selling through certain venues, can come with considerable expense in terms of purchasing specialized equipment, time, and personnel resources. A produce packing house has the existing infrastructure to take this pressure off the farmer, if your farm operation can produce and sell enough produce to make working with a packing house worth it.

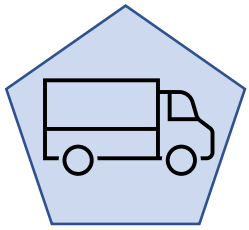


Fig 9

Wholesale Market Types

Produce distributor

Produce distributors move your product from your farm to customers. These supply chain intermediaries can purchase large quantities of products from you and increase your access to different markets. Using a produce distributor means you need the ability to fully prepare your products for the end customer as a part of your operation.



Wholesale buyer

Wholesale buyers purchase large quantities of product from the farmer, and then resell it directly to grocery stores, food co-ops, or natural food stores.



Fig 10

Activity – Determining Your Markets

Now that you've been introduced to the various kinds of markets, use your understanding of each market plus your understanding of your personality and place an "X" in the blank box to the left of each market type to indicate which markets fit your farm marketing personality.

Direct to Customer Market Types		Wholesale Market Types	
	Agritourism		Grocery Store
	Pick Your Own		Institutional Market
	Farmers Market		Aggregator (Food Hub)/Cooperative
	Roadside Stand		Produce Broker
	Community Supported Agriculture		Produce Packing Houses
	Internet Sales		Produce Distributor
	Restaurant		Wholesale Buyer

Market Ease of Entry

You now know which market types appeal to your personality, based on how you scored for both Direct to Customer and Wholesale Market Types. At this point, examine the chart below, which lists each market type in order of how easy it is to enter.

The easiest markets to enter are listed at the top of the chart. The most difficult markets to enter are at the bottom of the chart.

Easier to enter



Harder to enter

Direct to Customer Market Types	Wholesale Market Types
Roadside Stand	Aggregator (Food Hub)/Cooperative
Pick Your Own	Produce Broker
Internet Sales	Wholesale Buyer
Farmers Market	Produce Distributor
Restaurant	Produce Packing Houses
Community Supported Agriculture	Grocery Store
Agritourism	Institutional Market



Fig 11



Choosing Your Markets to Enter

Compare the markets that you find interesting with the ease on entry for each market. Do they align? Is there a middle ground for markets that you want to enter, and markets that will be feasible for you to start out with?

If you have established farm marketing practices currently and are looking for ways to expand your marketing, you may consider the ease of entry less than your interest and personality match.

Lastly, use the chart below and write down which markets you intend to enter, and when.

Example: 1. Aggregator/Cooperative *Enter by Fall of 2022*

I will enter these markets in the order below:

	Name of Market Type	Estimated Start Date
1		
2		
3		
4		
5		



Fig 12

Your Next Steps

You've completed the determining your farm market strategy guide! Now that you have an idea of which markets may be easiest and best for you to enter, you can use the **market tip sheets** to advise you on how to prepare to approach these different markets that fit you best.

The tips sheet describes each market type in more detail and provides more considerations for you as you take your next steps. Below is a curated list of helpful market resources.



Virginia Cooperative Extension

Virginia Cooperative Extension brings you the resources of Virginia's land-grant universities, Virginia Tech and Virginia State University, to solve problems facing Virginians every day. Agents and specialists form a network of educators whose classrooms are the communities, homes, and businesses across Virginia.

Find your answers on our website, https://www.ext.vsu.edu/

Need extra help with your farm marketing?

Step 1: Schedule an office or farm visit to determine your small farm marketing and business educational needs by contacting your local Virginia Cooperative Extension office, Agricultural and Natural Sciences (ANR) county agent: Find them at: http://www.ext.vt.edu/offices/.

Step 2: After your initial meeting with your VCE county agent, if it is determined additional educational assistance in small farm marketing and business is needed, please request your county agent to contact the program lead.

Sources

1. *United States Department of Agriculture*. List of Reports and Publications | 2017 Census of Agriculture | USDA/NASS. (n.d.). Retrieved November 12, 2021, from https://www.nass.usda.gov/Publications/AgCensus/2017/index.php.

2. *Figures 1 – 6, 11, 12.* Virginia State University. Retrieved from internal drive

3. *Figure 7* . Retrieved from Microsoft stock images

4. *Figure 8* - J. (2007) *Co-op. Northenden Road, Sale.* [photo]. Manchester, EN. Retrieved from flickr.com

5. *Figure* 9 - Retrieved from pxhere.com

6. *Figure 10* - Dunn, R. (2017). *Whole Foods Grocery "Buy Local and Support Small Farms"* [photo]. Ontario, CA. Retrieved from flickr.com

NCAT Marketing Tip Sheet Series

This publication contains 13 tip sheets, each of which describes a particular marketing channel and notes some of the considerations associated with that approach to marketing. Each tip sheet also provides additional resources about that marketing channel. These tip sheets are available to download from the ATTRA website as a packet, or individually.



— Contents —

1. Tips for Selling with Agritourism and "Pick-Your-Own"
2. Tips for Selling though CSAs Community Supported Agriculture
3. Tips for Selling at Farmers Markets
4. Tips for Selling at Roadside Stands
5. Tips for Selling on The Internet
6. Tips for Selling to Restaurants
7. Tips for Selling to Grocery Stores
8. Tips for Selling to Institutional Markets
9. Tips for Selling to Aggregators/Grower Marketing Coops
10. Tips for Selling to Produce Brokers
11. Tips for Selling to Produce Distributors
12. Tips for Selling to Produce Packing Houses
13. Tips for Selling to Wholesale Buyers at Terminal Markets

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USDA NIFA
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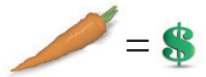
NCAT Marketing Tip Sheet Series

Tips for Selling with:
Agritourism and "Pick-Your-Own"

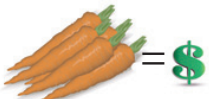
Agritourism combines agricultural sales with on-farm activities that involve the customers. These can include hayrides, mazes, pumpkin patches, farm tours, a bed and breakfast, or other endeavors.

"Pick-your-own" or "you-pick" operations allow customers to wander out into the fields or orchards to pick their own apples, berries, pumpkins, or other crops. Customers check in at the farmstand when finished and pay by weight or volume. This can be a fun activity, especially for kids, and can sometimes allow customers to get larger volumes at lower prices.

For this market you can expect:
- *Lower volume of product*
- *Higher prices per unit*







Advantages

✪ *key point*

- **Good way to attract customers willing to pay for an educational and engaging experience.**
- **Good way to diversify your farm business.**
- **Good way to advertise your farm and your other enterprises.**
- **Opportunity to educate the next generation about agriculture and rural communities.**
- **On-farm stores are an ideal venue to sell value-added products, such as jams, baked goods, etc.**



Photo: Tammy Hinman, NCAT

Considerations

- **You may have less privacy. People will be walking around your farm.**
- ✪ **You should be prepared to interact with a wide range of people.**
- **You will need to focus not just on production, but on creating an attractive and safe customer experience.**
- **You will need customer facilities, such as bathrooms and hand washing sinks.**
- **You may need additional insurance beyond a farm liability policy.**
- ✪ **Agritourism enterprises do best when located on a busy road or near a population center.**
- **In pick-your-own operations, farmers may be expected to offer a discounted price for high-value crops.**

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ATTRA

Agritourism Tips

✪ *key point*

✪ **Have "something to see, something to do, something to buy."**

- **Feature children's activities such as petting zoos, pumpkin picking, arts and crafts, or picking out a Christmas tree with the family.**
- **An internet presence can help advertise your operation, its location, what it has to offer, and times of operation.**
- **Provide adequate parking, restrooms, and signage.**
- **Consider hosting a festival focused on a particular farm product or activity, such as a lavender festival, harvest festival, planting celebration, etc.**
- **Check with your chamber of commerce or economic development office to connect to local or regional tourism promotion.**

✪ **Be prepared for folks who trip and fall, and absolutely carry at least $2 million in liability insurance.**

Key Questions to Ask Yourself

- **Do I like entertaining and having people at my farm?**
- **Can I keep my farm tidy and hazard free?**
- **Is my farm located on a road with enough traffic or close enough to a busy population center to generate customers?**
- **Can I put up sufficient signage to alert drivers and give them time and space to pull off the road?**
- **Do I have space for parking?**
- **What permits and extra insurance do I need?**

Agritourism Resources

- **ATTRA Publications**. Prices vary for individual publications, many are free. An inexpensive subscription to ATTRA will give you access to all 350+ publications and databases. ***www.attra.ncat.org***
  — ***Entertainment Farming and Agritourism: Business Management Guide*** (2004)
- **California Agritourism Directory** shows agritourism operations in the state, searchable by county. The directory provides detailed contact information and farmers can add their farms to the list. ***www.calagtour.org***
- **Local Harvest** website lists and describes all kinds of farms that sell direct to the public. Browsing here will give you a good sense of what farmers across the country are doing. The website currently has about 800 listings nationwide for Pick-Your-Own farms—mostly for small fruits. ***www.localharvest.org***
- **East Coast Agritourism** 2010 webinar series. ***www.ncsu.edu/tourismextension/programs/webinars.php***
- **National Agricultural Law Center** compiles information about specific agricultural and food law topics. ***www.nationalaglawcenter.org/readingrooms/agritourism*** and ***www.nationalaglawcenter.org/research***
- **UC Small Farm Program: Agritourism (2010)** website provides links to California case studies. ***http://sfp.ucdavis.edu/agritourism***
- **Agritourism: A Web-Based Resource for Farmers** is a network based at the University of Vermont that offers many links, webinars and nationwide research papers about agritourism, including *Agricultural Diversification and Agritourism: Critical Success Factors*. ***www.uvm.edu/tourismresearch/agritourism***
- **North American Farmers' Direct Marketing Association** promotes direct marketing, agritourism. ***www.nafdma.com***

This tip sheet was developed with assistance from Dina Izzo, Bludog Organic Produce Services.

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www.outreach.usda.gov/oasdfr

United States Department of Agriculture
National Institute of Food and Agriculture

Tips for Selling with: Agritourism and "Pick-Your-Own"
© 2012 National Center for Appropriate Technology—NCAT
By Marisa Alcorta, Rex Dufour and Tammy Hinman
Production: Karen Van Epen

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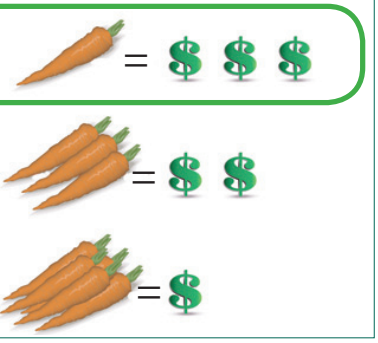
NCAT Marketing Tip Sheet Series

Tips for Selling through:
CSAs — Community Supported Agriculture

CSA is a system of direct marketing where consumers pay the farmer at the beginning of the growing season for a weekly box of fresh fruits and vegetables. A CSA "share" is harvested and delivered to customers over a period of several months. CSAs may include meat, grain, flowers, or value-added products such as bread or cheese, in addition to fresh produce.

A core philosophy of the CSA model is that customers (or "members") truly support their local CSA farm by sharing the risk each season. This means that even if there's a bad harvest, the members still pay the same amount for the season. Members are willing to do this to ensure that "their" farm survives over time as a healthy food source and connection to the land for the local community. A CSA farm has the opportunity to cultivate a very loyal customer base.

For this market you can expect:
- ***Lower volume of product***
- ***Higher prices per unit***



Advantages

✪ *key point*

- Customers pay up front, which generates operating capital.
- The major marketing push is completed before the season starts, leaving more time to farm during the growing season.
- CSAs can build loyal customers who may be willing to share the risks of farming. Farmers must earn that loyalty by growing high quality products.
- No standard pack or grading is required.



Serendipity Farm. Photo: www.serendipity-organic-farm.com

Considerations

- ✪ CSAs require thoughtful planning to maintain a continuous supply of crops.
- Packing is labor-intensive because of the wide variety in the weekly box.
- CSAs require an extensive post-harvest handling set-up for washing, sorting, packing, etc.

Tips

- Build community through efforts such as harvest parties, work days, and newsletters.
- Conduct annual surveys to get customer feedback on quality, variety and service.
- Consider collaborating with other CSA farms if you want to offer a wider selection.

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Key Questions to Ask Yourself about CSAs

✪ *key point*

- ✪ Timing and planning are critical in a CSA. How will I ensure consistent weekly harvests of a variety of vegetables and fruits for my CSA customers? See ATTRA's "Scheduling Vegetable Plantings for a Continuous Harvest."
- How many other CSA farms are in my area? Do they have waiting lists—unmet demand that I could tap into?
- Will I enjoy the social aspects of running a CSA, such as hosting festive gatherings or work days for members, writing newsletters to include in weekly boxes, and generally creating opportunities for people to get to know the farm?

ATTRA Publications

- Prices vary for individual publications, many are free. An inexpensive subscription to ATTRA will give you access to all 350+ publications and databases. ***www.attra.ncat.org***
  - — **Market Gardening: A Start-Up Guide** (2009)
  - — **Scheduling Vegetable Plantings for Continuous Harvest** (2008)
  - — **Season Extension Techniques for Market Gardeners** (2005)
  - — **Community Supported Agriculture** (2006)



Packing CSA boxes, Full Belly Farm, Guinda, Calif. Photo: Rex Dufour, NCAT

Books and Guides

- **Sharing the Harvest: A Citizen's Guide to Community Supported Agriculture** by Elizabeth Henderson with Robin Van En. Chelsea Green Publishing, 2nd edition, 2007. $35. This 300-page book provides valuable insight into making CSA a viable economic model as well as an excellent arrangement for farmers and food lovers alike. It provides information on starting a CSA and how to strengthen existing CSA operations.
- **Community Supported Agriculture**. University of Nebraska–Lincoln, Institute of Agriculture and Natural Resources, 2000. 4pp. ***www.ianrpubs.unl.edu/epublic/pages/index.jsp?what=publicationD&publicationId=11***
- **Community Supported Agriculture** by Matt Ernst and Tim Woods. University of Kentucky College of Agriculture, New Crops Opportunity Center. 3pp. ***www.uky.edu/Ag/NewCrops/marketing/csa.pdf***

CSA Software

- **Farmigo** is a computer software subscription service that provides recordkeeping and membership management. It costs 2% of gross sales from the CSA or farm. ***www.farmigo.com***
- **CSA Toolbox** is an online "toolbox" that offers programs to communicate with your customers, do your paperwork, handle your billing, and take payments. ***www.csatoolbox.com***
- **CSAware** is a customizable, user-friendly Community Supported Agriculture software from LocalHarvest.com designed for CSAs with lots of moving parts. The cost is 2% of sales. ***www.csaware.com***

Recursos en Español

- **La Agricultura Apoyado por la Comunidad (CSA)**: Una guía de entrenamiento para el ranchero de CSA nuevo o prospectivo. Producido por CSA-MI. ***www.csafarms.org/downloads/csa_manual_spanishpdf.pdf***

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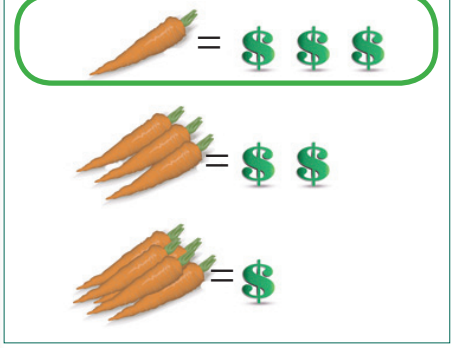
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NCAT Marketing Tip Sheet Series

Tips for Selling at:
Farmers Markets

Farmers markets are temporary retail establishments typically held outdoors, where farmers come to sell their produce at a specified place and time. Farmers markets are growing in popularity across the country and can be a good entry-level selling place for beginning farmers.

For this market you can expect:
- ***Lower volume of product***
- ***Higher prices per unit***



Advantages

- You may receive more money per unit, since you sell directly to customers.
- You generally have flexibility in the variety and volume of products you take to market.
- No standard pack or grade is required, but your produce should be good quality.
- Direct contact allows you to find out what your customers want.
- You have the opportunity to build a loyal customer base, including local chefs.

Considerations

- The volume of sales will vary with the popularity of the market. Think about how to incorporate deliveries to other outlets in the area to increase your sales and efficiency.
- Labor costs can be relatively high (time and travel to and from market, time away from the farm).
- If you sell at several farmers markets, schedules can be demanding.
- To sell at popular farmers markets, it helps to have unique products.
- Being successful requires positive interactions with the public.
- Most farmers markets have an application process and rules to participate. For example, in California you must register as a "certified grower" with the county agriculture commissioner before selling at a certified farmers market.



Photo: Rex Dufour, NCAT

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Tips for Selling at Farmers Markets

✪ *key point*

- ✪ **Have an attractive product mix and clear signs for your market stand.**
- **Ensure that you have a consistent supply of popular products.**
- **Consider providing samples of your product if local regulations permit.**
- **Set up a service system where customers do not have to wait too long in line.**
- **Invest in a scale that not only calculates weight but also gives you the sales price. A calculator that prints on a paper tape is another useful tool.**
- **Visit markets seasonally to figure out what's missing from your market that you could supply.**
- **Extend your season for popular products before or after the main season. This can increase your sales and attract new customers to your market stand.**

Key Questions to Ask Yourself

- ✪ **Do I enjoy working with the public? If not, can I hire someone friendly and competent for my booth?**
- **Where are the nearest farmers markets? Are they accepting new vendors?**
- ✪ **Do these farmers markets have enough customers to make it profitable for new vendors?**
- **What are the other vendors selling? What's my niche?**
- ✪ **How much time will I spend at the market? How early will my day start and end? Am I willing to do this each week?**
- **What is the application process for the farmers market? What are the rules? For example, can I sell products I have not grown?**

Resources

- **ATTRA Publications**
  Prices vary for individual publications. Many are free. An inexpensive subscription will give you access to all 350+ publications and databases. ***www.attra.ncat.org***
  - — **Scheduling Vegetable Plantings for Continuous Harvest** (2008)
  - — **Season Extension Techniques for Market Gardeners** (2005)
  - — **Postharvest Handling of Fruits and Vegetables** (2000)
- **Find a Farmers Market** by searching the USDA's online directory: ***http://apps.ams.usda.gov/FarmersMarkets***



Photo: Rex Dufour, NCAT

- **Growing For Market** magazine offers the free issue, "Selling at Farmers Markets:" ***www.growingformarket.com/categories/SellingAtFarmersMarkets***
- **Local Harvest website** is a nationwide directory of small farms, farmers markets, and other local food sources. The site helps consumers buy what they want directly from the farmers and ranchers who produce it. ***www.localharvest.org***

This tip sheet was developed with assistance from Dina Izzo, Bludog Organic Produce Services.

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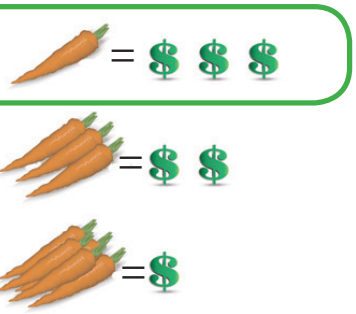
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Tips for Selling at: Farmers Markets
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By Marisa Alcorta, Rex Dufour and Tammy Hinman, NCAT
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Tips for Selling at:
Roadside Stands

Roadside stands are physical structures located on a farm or along a nearby road where farmers sell produce, meat, eggs, dairy, or other products from the farm. The stands can be as simple as a small open-sided display with payment on the honor system, or as elaborate as a small grocery store.

For this market you can expect:
- **Lower volume of product**
- **Higher price per unit**



key point

Advantages

- **You have potential for high profit margins because you sell directly to customers.**
- **You have low advertising costs, since you just need a few signs.**
- **You may have low overhead costs, depending on how elaborate the structure is. Some farm stands are very simple, even unstaffed, running on the honor system, where customers leave money in a secure container.**
- **You have no transport costs.**
- **No standard pack or grade is required.**

Considerations

- **Location is critical. Good locations have high traffic and high visibility, with proximity to other businesses, easy parking or turn-off lanes for customers, etc.**
- **Signs should be easy to see, giving drivers plenty of time to slow down and pull over to park.**
- **Make sure that local zoning ordinances allow roadside markets. Check with other roadside vendors about where to obtain permits.**
- **You could have high overhead expenses to develop, operate and staff the facility.**
- **If your roadside stand is large and includes products not grown on your farm, you may need commercial business insurance in addition to a comprehensive farm liability policy.**
- **The farm must be kept tidy, clean and hazard-free.**
- **You need to understand health regulations about selling processed or "value-added" products. Contact your state or local health departments for details.**

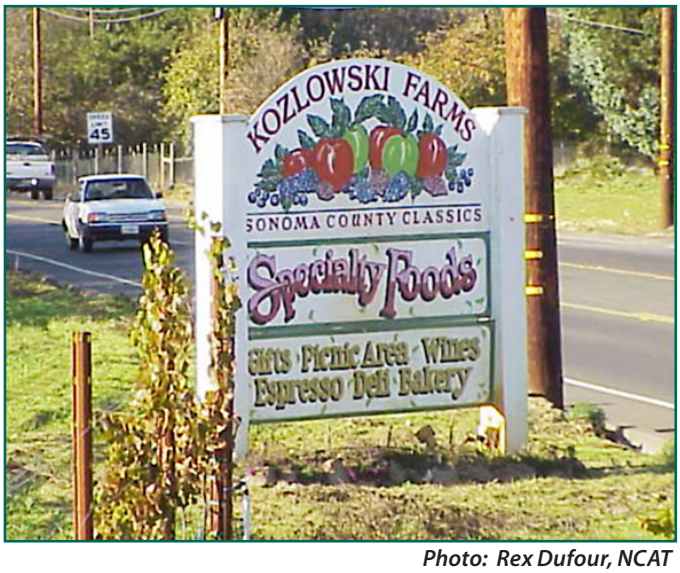


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Key Questions to Ask Yourself

✪ *key point*

- ✪ **Does my location get enough traffic to generate customers? Do I have space for parking? Can I put up sufficient signs to alert drivers and give them time and room to pull off the road?**
- **What hours and staffing would I need in order to run the stand effectively?**
- **What licenses, permits or zoning ordinances do I need to be aware of? Contact the state department of agriculture to find out.**

Resources

- **ATTRA Website.** Many relevant publications and resources are offered here, such as "Entertainment Farming and Agri-Tourism." Prices vary for individual publications. Many are free. An inexpensive subscription to ATTRA will give you access to all 350+ publications and databases. ***www.attra.ncat.org***

- **Developing a Roadside Farm Market** (2006). Agricultural Alternatives, Pennsylvania State University. 6 pp. This is a good overview of what farmers should consider when setting up a roadside stand. ***http://agalternatives.aers.psu.edu/Publications/roadside_farm.pdf***

- **Farmstand Regulations Expand Options.** University of California Small Farms program. This website provides updated, California-specific information about farmstand regulations. ***http://sfp.ucdavis.edu/agritourism/farmstands.html***

- **Roadside Stand Marketing of Fruits and Vegetables**. This 40-page publication offers a wealth of information about marketing considerations, the shopping habits of roadside-stand customers, pricing, store layout, marketing tactics, impulse buying, popular fresh products, etc. ***www.caed.uga.edu/publications/2002/pdf/CR-02-09.pdf***



Photo: Rex Dufour, NCAT

- **Roadside Markets, Stands, and Equipment**. Penn State offers these detailed design plans for four different sizes of roadside stands as well as a walk-in cooler. ***http://agmarketing.extension.psu.edu/Retail/PDFs/IP790-33.pdf***

- **The Legal Guide for Direct Farm Marketing** by Neil Hamilton. 1999. 235 pp spiralbound. $20.00 to $24.00. Before selling their products directly to consumers, all farmers should consider these important issues. Learn about legal considerations behind farmers' markets, business organization, contracts, food stamps, advertising and marketing, land use and property law, labor and employment, insurance and liability, food processing, and marketing meat, poultry, eggs, and dairy products.

- **Facilities for Roadside Markets**. Natural Resource, Agriculture and Education Service. 1992. 32 pp. $8.00. Valuable for persons considering a roadside market or looking to improve or expand a current one. Chapters cover site considerations (visibility and accessibility, utilities, drainage, zoning, and building ordinances); market layout (areas for sales, preparation, shipping and receiving); market structure and facilities (parking, lighting, fire protection, security). Includes illustrations and plans. ***www.nraes.org/nra_order.taf?_function=detail&pr_booknum=nraes-52***

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Tips for Selling at: Roadside Stands
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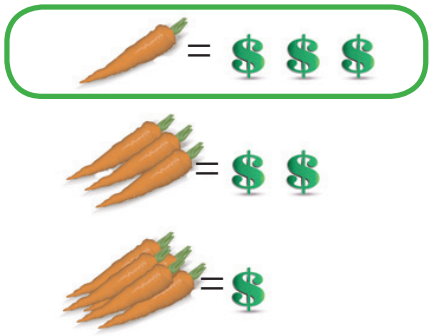
Tips for Selling on: The Internet

NCAT Marketing Tip Sheet Series

The Internet is a communication and marketing tool that can provide exposure to a large number of potential customers. The Internet can be used to advertise your farm with pictures and maps, take orders online, show product availability, keep in touch with your existing customers, and support other ways of selling, such as CSAs or farmers markets. Farmers can have an Internet presence through their own website or by using a website run by a third party.

For this market you can expect:

- **Lower volume of product**
- **Higher price per unit**



Advantages

✪ *key point*

- **You can let a lot of people know about your farm, its history, product line, and location.**
- **You save time marketing and selling, since your website or web presence is always available to customers.**
- **A basic website can be developed with minimal instruction.**
- **Third-party websites can be used to provide web presence with minimal investment of your time or resources.**

Considerations

- **There is less personal connection between customer and producer over the Internet.**
- ✪ **An Internet presence requires regular maintenance.**
- **The Internet can be used to take and process orders, but this requires a more sophisticated website than one that simply advertises your farm and products.**
- **Know your closest, least expensive, most reliable shipping options. Can they ship cold?**
- **Make sure you calculate the cost of all your packing materials into the cost of your products. Be aware of your customers' packing material preferences.**
- **Make sure you take into consideration how shipping is compensated. Is it included in the sale of goods, or do customers pay for shipping separately?**



The website of Full Belly Farm, Guinda, Calif. , gives details about their products, markets, CSA, staff, events, and more. www.fullbelly.com

Key Questions to Ask Yourself

- **What is my experience and comfort level with computers? If it is limited, who can help me with my computer and Internet work on a regular (weekly) or as-needed basis?**
- **How will I keep my site or web presence up to date in order to keep attracting customers to it?**
- **How much time will it take to maintain an electronic list of customers for e-newsletters and updates?**
- ✪ **How might Internet marketing fit with, and perhaps support, other marketing channels, such as CSA, agritourism and institutional markets?**

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Tips for Selling on the Internet

✪ *key point*

- ✪ **Outline your goals for your farm's Internet presence. This process will allow you to determine what resources (labor, expertise, software, hardware) you need to support these goals.**
- **Make your website easy to use and easy to find. Ask for feedback from friends and customers.**
- **Select a website address ("domain name") that is short, meaningful, easy to spell, and easy to remember.**
- ✪ **Diversify your marketing strategies. Don't rely on your website as your only marketing channel or tool for your business.**
- **Consider using Facebook and Twitter to connect with a large number of potential customers.**
- **Keep a blog and use other social media to keep customers interested in what is happening on your farm.**
- ✪ **Guide people to your site.**
  - **— Create and trade links to related websites.**
  - **— List your web address in Buy Fresh Buy Local and other farm guides.**
  - **— Use an e-newsletter that links to your website.**
  - **— Put your website and email address on all your farm's printed material.**
  - **— Sign up with websites that point to local produce such as *www.localharvest.org*.**

Resources

- **Buy Fresh Buy Local chapters** promote locally produced food. See a nearby chapter to find potential customers for your farm products and to learn more about local and Internet marketing. ***www.foodroutes.org***

- **Foodzie** helps small food producers and farmers across the U.S. reach new customers and connect directly to customers searching for foods and gifts. Cost of using this service is tied to product sales. ***www.foodzie.com***

- **Local Harvest** is a nationwide directory of small farms, farmers markets, and other local food sources. The site helps consumers buy what they want directly from the farmers and ranchers who produce it. ***www.localharvest.org***

- **CSAware** is a customizable, user-friendly Community Supported Agriculture software program. It allows your CSA members to sign up for your program online, let you know when they'll be out of town, and order any special items you offer. As the administrator, you can see and manage all of that information, set what goes into the boxes each week, manage your drop-off site information, email some or all of your members, print out harvest lists, box labels, and member sign-in sheets, and perform other functions. ***www.csaware.com***

- **Small Farm Central** was started by an ex-farmer who ran a CSA. The company provides, for a price, support to farmers to develop their own website as part of their marketing strategy. They offer a free trial as well as variable rates and levels of support service to help you develop and maintain your website. The site also provides member management services to CSAs and allows farmers to sell products on their website. ***www.smallfarmcentral.com***

- **Internet Marketing for Farmers.** ***http://king.wsu.edu/foodandfarms/documents/internetMrkt.pdf***

- **How to Direct Market Farm Products on the Internet** (a 50-page pdf download) is an excellent guide to developing internet marketing goals, doing research on internet consumers, setting up and marketing a website, and using the experience of a variety of farmers who use the internet to support their sales. Good resources section with links to relevant software, articles and publications. ***http://agmarketing.extension.psu.edu/retail/howdrctmrktoninternet.html***

This tip sheet was developed with assistance from Dina Izzo, Bludog Organic Produce Services.

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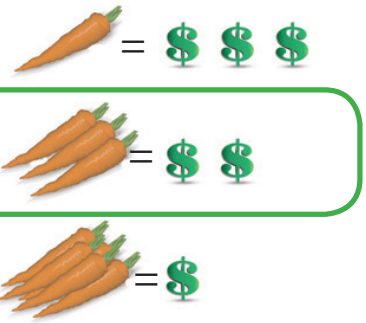
Tips for Selling to: Restaurants

NCAT Marketing Tip Sheet Series

Restaurants are businesses that provide full meals and drinks, and try to offer a unique atmosphere and menu for customers. Some restaurants, especially locally owned ones, now want to feature dishes using local produce. This presents a good marketing opportunity for farmers to sell to them directly.

For this market you can expect:

- *Low-to-medium volume of product*
- *Higher prices per unit*



Advantages

key point

- **Chefs value fresh, high-quality products.**

Considerations

- **Expect small order size and frequent delivery.**
- **Chefs value top quality produce.**
- **It's important to provide the buyer with a weekly availability list.**
- **Chefs may require a consistent supply of particular items.**

Tips

- **Be consistent. Chefs expect a product will be delivered if they put it on the menu.**
- Build a relationship with the entire staff. Chefs move frequently.
- **Chefs are on a tight schedule and generally require deliveries when they're not busy, such as before 10 a.m. or between 2 and 5 p.m.**
- Introduce new products by dropping off free samples with your regular deliveries.
- **Fax or email a list of available products for the chef to order from.**
- Use the chefs as your best source of market information. They may know what the next big thing is before you do.
- Know how the chef is using your product and be prepared to talk about other ways to use it.
- In the autumn, ask the chefs what products they want you to grow next season.
- **Ask about each restaurant's needs, including pack, size, variety, post-harvest preferences, new items, and how they would like to place orders (by fax, phone text message, or email).**



Photo: Tammy Hinman, NCAT.

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Key Questions to Ask Yourself

✪ *key point*

✪ **How far in advance do the chefs need to see an accurate schedule of product availability in order to allow them to plan their menus?**

- **What restaurants are the best fit for my product profile? Ethnic restaurants, specialty bakeries, high-end gourmet restaurants?**
- **What production, handling, storage, and delivery methods will I use to ensure the freshest and highest quality products to high-end chefs? Highlight these in outreach to chefs.**
- **How frequently and quickly am I able to deliver to restaurants? What are the chef's expectations about this?**

✪ **How do the restaurants want to communicate with me? Cell phone, email, text message, fax?**

Resources for Selling to Restaurants

- **ATTRA Publications**
  Prices vary for individual publications. Many are free. An inexpensive subscription to ATTRA will give you access to all 350+ publications and databases.
  www.attra.ncat.org
  - — **Selling to Restaurants** (2004)
  - — **New Markets for Your Crops** (2008) (also available in Spanish)
  - — **Scheduling Vegetable Plantings for Continuous Harvest** (2008)
  - — **Season Extension Techniques for Market Gardeners** (2005)
  - — **Postharvest Handling of Fruits and Vegetables** (2000)
  - — **Illustrated Guide to Growing Safe Produce on Your Farm: GAPs** (2011) (also available in Spanish)
- **Chefs Collaborative** works with chefs and the greater food community, including farmers, to celebrate local foods and foster a more sustainable food supply.
  www.chefscollaborative.org
- **Selling Directly to Restaurants and Grocery Stores**. Washington State Department of Agriculture. 2010.
  http://agr.wa.gov/Marketing/SmallFarm/DOCS/3-sellingDirectlyToRestaurantsAndGroceryStores.pdf



Photo: Markristo Farm.

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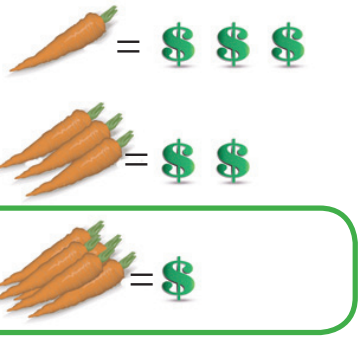
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Tips for Selling to: Grocery Stores

Grocery stores typically buy large volumes of fresh and processed foods as well as other household items, reselling their products to individual consumers. Grocery stores are appealing because they sell everything customers need at one convenient place. Depending on the size of the town, these stores may have more than one location. Very large grocery chains operate stores across broad regions of the country. Many grocery stores are now interested in selling products grown by local farmers.

For this market you can expect:

- ***Medium-to-high volume of product***
- ***Lower prices per unit***



Advantages

- **You may be able to sell larger volumes.**
- **The store may buy a range of products once you have introduced your first product.**
- **There is potential for a long-term relationship with the store, especially if you build a brand identity for your farm.**

Considerations

- **Liability insurance that covers claims of up to at least $1 million is required.**
- **The first sale may be difficult because grocery stores have a limited amount of shelf space, already have regular suppliers, and may prefer to buy from fewer suppliers.**
- **Payment generally occurs on a 15-to-30 day cycle.**
- **Standard packing and post-harvest practices are required. Produce should be delivered clean and cold.**
- **Grocery stores may require a PLU (Price Look-Up number) or UPC code (Universal Product Code, represented by a barcode).**
- **Some grocery stores may require a food safety plan.**



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Tips for Selling to Grocery Stores

✪ *key point*

✪ **Be professional, reliable, and on time when communicating and delivering products.**

- **Visit or call the store and ask for an appointment with the produce buyer before the season begins. Bring your crop plan or product list for the full season, and a price list. Show visuals for the upcoming crops — photos of trees in bloom, what the fruit looks like, testimonials, brix readings. If you have something to sample, bring it to show your quality and pack.**
- **Always bring two copies of an invoice, one for your customer and one for you. Both copies should be signed at the time of delivery, providing proof that quality and quantity are accurate.**
- **Build relationships with everyone who handles your product.**

✪ **Ask about and follow the store's expectations for pack, size, grade, or post-harvest practices.**

- **Communicate with buyers often throughout the course of the week to keep them updated on your product quality and quantity.**

✪ **Plan your plantings for continuous harvest and adequate volume to supply expected demand from store.**

- **Get the store's produce team enamored with your farm by educating them about your products. Give them samples to take home and maybe provide recipes.**
- **Offer to provide farm tours, pictures of your farm for display, and in-store demos of your products with recipes and descriptions.**

Key Questions to Ask Yourself

- **What products do local grocery stores want that I could supply, including specialty ethnic foods?**
- **Does a particular chain have an interest in purchasing locally?**
- **What is my plan to ensure a consistent supply of a few key products over a period of several weeks?**
- **Do I have a Good Agricultural Practices (GAPs) plan? Does this buyer require it?**

Resources

- **ATTRA Publications**. Prices vary for individual publications. Many are free. An inexpensive subscription to ATTRA will give you access to all 400+ publications and databases. ***www.attra.ncat.org***
  — **Sustainable Season Extension: Considerations for Design** (2011) — **Postharvest Handling of Fruits and Vegetables** (2000)
  Available in Spanish or English: — **Season Extension Techniques for Market Gardeners** (2005)
  — **Illustrated Guide to Growing Safe Produce on Your Farm: GAPs** (2011)
  — **Scheduling Vegetable Plantings for Continuous Harvest** (2008)
- **Selling Directly to Restaurants and Grocery Stores,** Washington State Department of Agriculture, 2010. ***http://agr.wa.gov/Marketing/SmallFarm/DOCS/3-sellingDirectlyToRestaurantsAndGroceryStores.pdf***
- **"A Guide for Farms Considering Selling in Grocery Stores"** and **"Is Selling to Grocery Stores Profitable for Farms or Processors?"** from the Local Fare website of the University of Wisconsin, Platteville. ***www.uwplatt.edu/cont_ed/LocalFare/links-resources.html***
- **See advertised prices of last week's produce** nationwide and by region at ***www.marketnews.usda.gov/portal/fv***
- **Price Look-up numbers (PLUs)**: a complete list is available at ***www.plucodes.com***
- **Rodale Institute Organic Price Report** shows prices of fruit, vegetables and grains for six different wholesale terminals across the U.S. ***www.rodaleinstitute.org/Organic-Price-Report***
- ***Wall Street Journal* article** explains why and how to obtain UPC codes, including costs and alternatives. ***http://guides.wsj.com/small-business/starting-a-business/how-to-get-upc-codes-for-your-products-2***

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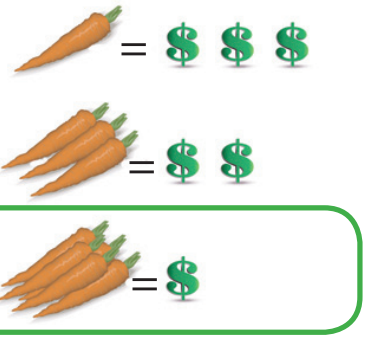
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Tips for Selling to:
Institutional Markets

NCAT Marketing Tip Sheet Series

Institutional markets are entities such as cafeterias in state and local government buildings, schools, universities, prisons, hospitals, or similar organizations. These institutions are becoming more interested in buying local food, which provides a new marketing opportunity for a medium to large-scale farm.

For this market you can expect:
- ***Larger volumes of product***
- ***Lower prices per unit***



key point

Advantages

- **You can sell large volumes of many products.**
- **There are many possible sales outlets, such as business cafeterias, schools, hospitals, prisons, day-care centers, senior centers, community colleges, and universities.**

Considerations

- **While you can sell a larger quantity, expect a lower price.**
- **Requires good communication between buyer and seller.**
- **Some institutions expect a more processed product.**
- **Liability insurance is required.**
- **Institutions usually pay within 30 days.**
- **The health department requires that vehicles delivering produce to institutions must remain at a certain temperature.**



Photo: Rex Dufour, NCAT.

Key Questions to Ask Yourself

- **Do I have liability insurance and a Good Agricultural Practices (GAPS) plan? Do these buyers require either of these items?**
- **How do these buyers want produce packed and delivered?**
- **What quantities do they need and how often?**
- **Do they need produce that has been pre-cut or lightly processed for easy use?**
- **What's the best way to communicate with these buyers about my product availability — fax, email, text message, phone?**
- **Is there a competitive bidding process for schools and other public institutions? What do I need to do to be considered?**

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Tips for Selling to Institutional Markets

✪ *key point*

- Research the institution. Find out who makes buying decisions.
- ✪ **Know what the buyer requires from you.**
  - **— Produce quality standards?**
  - **— Type of pack or size of product?**
  - **— Specific delivery times and number of deliveries per week?**
  - **— Liability insurance and for how much?**
  - **— A Good Agricultural Practices (GAPs) plan?**
- ✪ **Maintain consistent volumes and quality.**
- Work with local organizations such as universities, nonprofits, and Food Policy Councils to help reduce barriers for farmers selling to local institutions.
- Consider developing a Good Agricultural Practices (GAPs)/Food Safety Plan to allow easier access to these markets.
- Find out if the buyer will purchase imperfect, blemished or small produce for a lower price.

Resources

- **ATTRA Publications**
  Prices vary for individual publications, many are free. An inexpensive subscription to ATTRA will give you access to all 400+ publications and databases. ***www.attra.ncat.org***
  - — ***New Markets for Your Crops,*** 2008 (also available in Spanish and as a Spanish-language audio file)
  - — ***Illustrated Guide to Growing Safe Produce on Your Farm,*** 2010 (also available in Spanish)

- ***Selling to Institutions*** by Bill Wright, University of Wisconsin Cooperative Extension, Emerging Agricultural Markets Team, 2007. A 4-page PDF on how to get started and do well selling to institutions. ***www.uwex.edu/ces/agmarkets/publications/documents/A3811-19.pdf***

- ***Farm to Hospital: Supporting Local Agriculture and Improving Health Care.*** This 6-page brochure explains farm-to-hospital and why it's important, as well as how hospitals can improve their food, and how growers can approach institutions. ***www.foodsecurity.org/uploads/F2H_Brochure-Nov08.pdf***

- **Farm to College Website Resource List**. Useful for anyone interested in learning more about getting local produce into institutions. The lists are broken down by the intended audience such as farmers, food professionals, student organizers, etc. ***http://farmtocollege.org/resources***

- ***Community Food Security Liability & Food Safety*** (in English and Spanish). This short brochure summarizes some of the issues regarding food safety when selling to institutional markets. It gives the reader information on what to expect for insurance requirements and how to better protect your farm. ***www.foodsecurity.org/insurance.htm***

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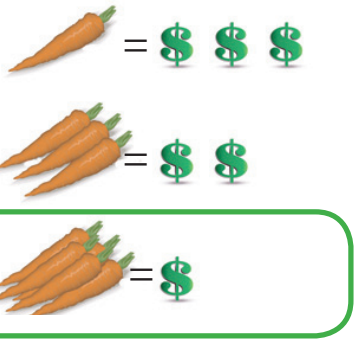
Tips for Selling to: Institutional Markets
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By Marisa Alcorta, Rex Dufour and Tammy Hinman
Production: Karen Van Epen
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NCAT Marketing Tip Sheet Series

Tips for Selling to:
Aggregators/Grower Marketing Coops

Aggregators are agricultural businesses or cooperatives of growers that consolidate and distribute agricultural products. They typically support regional growers of diverse sizes and experience, and sell products to local or regional markets. The consolidation of multiple farms' products can help supply fresh product for distributors and other wholesale customers and is not limited by grower size.

For this market you can expect:
- ***Higher volume of product***
- ***Lower prices per unit***



Advantages

- **In contrast with other wholesale markets, you can sell large or small quantities of product through this marketing channel.**
- **Your products may still retain your farm identity and may be marketed locally or regionally.**
- **Aggregators will often work with growers to provide on-farm technical support, harvest and pre-production planning to meet market projections.**
- **Aggregators often serve as the marketer and distributor, which allows the grower to focus more time on farming and may reduce the marketing and distribution costs of the individual grower.**
- **Aggregators and marketing co-ops can help buy packaging materials, labels and marketing materials through group purchasing, which can reduce the individual grower's materials costs.**



Transferring produce from the cooler for delivery to local schools in Davis, Calif. www.caff.org

Considerations

- **You can sell a larger quantity, but expect a lower price per unit.**
- **Growers are required to adhere to packing grades and standards.**
- **Growers may be required to adhere to Good Agricultural Practices and complete a food safety plan.**
- **If the aggregator is a co-op, growers will likely be required to attend meetings and participate in some capacity.**
- **There are often annual fees associated with a grower co-op.**



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Tips for Selling to Aggregators/Grower Marketing Coops

- **Aggregation on a local level is a fairly new concept. Look for grower recruitment meetings, or ask around to find out if one is located near you.** ✪ *key point*
- **BEFORE you begin production, call the aggregators to find out what products they are looking for.**
- ✪ **If you are starting a cooperative aggregation group, be sure you understand how the legal business structure of a cooperative works. Contact the USDA Rural Business Cooperative Service to help guide you through the process and possibly access federal funding: www.rurdev.usda.gov/rbs**

Key Questions to Ask Yourself

- **How will my membership with the aggregator or growers co-op align with my personal and business goals?**
- **Has this aggregator or co-op been successful or in business for more than a short period of time? Do they have a good reputation?**
- **If it's a co-op, what kind of time commitment is required? Am I willing to work with a group to help market our collective produce?**
- ✪ **Am I prepared to adhere to quality and other standards that are set by the group?**

Resources

- **ATTRA Publications**. Prices vary for individual publications. Many are free. An inexpensive subscription to ATTRA will give you access to all 350+ publications and databases. Phone 800-346-9140. ***www.attra.ncat.org***
  - —***Illustrated Guide to Growing Safe Produce on Your Farm: GAPs*** (2011) (English or Spanish)
  - —***Post-Harvest Handling for Fruits and Vegetables*** (2000) —***New Markets for Your Crops*** (2008) (English or Spanish)
  - —***ATTRA website's resources about Cooperative Development: https://attra.ncat.org/marketing.html#cooperatives***
- ***Collaborative Marketing: A Roadmap and Resource Guide for Farmers*** explains how to form a marketing coop, with many case examples of farmer marketing co-ops throughout the Midwest. 2008. King and DiGiacomo. University of Minnesota. ***www.extension.umn.edu/distribution/businessmanagement/DF7539.html***
- ***The Packer*** is a weekly newspaper covering fruit and vegetable news, produce shipping, distribution, packing, marketing, and trends in fresh produce in North America. ***www.thepacker.com***
- ***Rocky Mountain Farmers Union*** provides training and assistance to farmers who want to organize marketing cooperatives in New Mexico, Colorado, and Wyoming. Telephone 303-753-5800. ***www.rmfu.org/co-op***
- ***Scaling Up: Meeting the Demand For Local Food*** compares 11 aggregator models from across the country. To obtain a copy call toll-free 1-877-947-7827 or visit University of Wisconsin extension, ***www.learningstore.uwex.edu***
- **U.S. Agricultural Marketing Service (AMS) Fresh Fruit, Vegetable, Nut, and Specialty Crop Grade Standards** lists the quality standards for fruits, vegetables and nuts sold as commodities. ***http://tinyurl.com/ams-grade-standards***
- **USDA Rural Development, Business and Cooperative Programs** offer many publications about cooperatives as well as the bi-monthly *Rural Cooperatives* magazine. ***www.rurdev.usda.gov/rbs/pub/NEWPUB.htm***
- ***Wholesale Success: A Farmers Guide to Selling, Post Harvest Handling, and Packing Produce*** is a 255-page manual about the wholesale produce industry, with details on building relationships, food safety, grading standards, filling orders, record keeping, and billing. The manual includes harvesting, cooling, storing, and packing information for 103 different fruits and vegetables. Order online or call 708-763-9920. ***www.familyfarmed.org/wholesale-success***

This tip sheet was developed with assistance from Bob Corshen, Community Alliance with Family Farmers, and Karl Sutton, Mission Mountain Food Enterprise Center.

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Tips for Selling to:

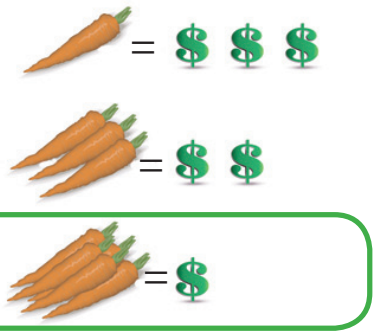
NCAT Marketing Tip Sheet Series

Produce Brokers

A produce broker is a salesperson who has access to any seller in the food chain, including packing houses, processors, agribusinesses, and mid- to large-scale farms. Typically they work with large-scale farms. A broker will help arrange the logistics of getting your product from your farm to their buyer, often taking commissions based on a percentage of the sale. Their success depends on their reputation and they spend years building relationships.

For this market you can expect:

- *Higher volume of product*
- *Lower prices per unit*



Advantages

key point

- **Brokers have relationships with many buyers and can arrange a sale more easily than the farmer can.**
- **Brokers generally have a better understanding of the market conditions and prices than the farmer does.**
- **Working with a broker allows you to focus on production, rather than sales.**
- **Brokers can arrange transportation, either from your farm or from a terminal market.**

Considerations

- **Brokers prefer to deal with larger volumes, but it is not a requirement.**
- **While you can sell a larger quantity, you should expect a lower price per unit.**
- **Research your broker and their reputation. Farmers can sign an agreeement with a broker that clearly delineates lines of fiscal responsibility.**
- **It is advantageous when working with brokers to have clear and concise agreements regarding volume throughout the season. Written agreements are helpful but not required.**
- **In order for a broker to sell your product, you will need to properly sort it for high quality, cool it, and store it.**



Photo: Rex Dufour, NCAT

Key Questions to Ask Yourself

- **Do you know others who have had good experiences with this broker?**
- **Do you have enough volume to still see a profit after paying a commission to a broker and selling at wholesale prices?**
- **Would you rather entrust someone else to sell your products so that you can focus only on production?**

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Tips for Selling to Produce Brokers

✪ *key points*

✪ **Check with other growers and get a sense of the broker's or the brokerage company's reputation before you work with them. You want someone with an excellent track record who comes highly recommended. You can check their credibility through their DUNS number (www.dnb.com) or through the Blue Book (www.producebluebook.com). There may be a fee for credit-check services.**

✪ **Written contracts are preferred, but not standard. However, it's always a good idea to have some type of written agreement with the broker outlining price, volume, time period, and whether the broker is purchasing the product from you or only negotiating a sale. These documents are critical to protecting both parties if anything goes wrong.**

Resources

- **ATTRA Publications**. Prices vary for individual publications. Many are free. An inexpensive subscription to ATTRA will give you access to all 400+ publications and databases. Phone 800-346-9140. ***www.attra.ncat.org***
  - — ***Illustrated Guide to Growing Safe Produce on Your Farm: GAPs*** (2011) (English & Spanish)
  - — ***Post-Harvest Handling for Fruits and Vegetables*** (2000) — ***New Markets for Your Crops*** (2008) (English & Spanish)
  - — **ATTRA website's Marketing, Business and Risk Management section: *www.attra.ncat.org/marketing.html***

- ***The Packer*** is a weekly newspaper covering fruit and vegetable news, produce shipping, distribution, packing, marketing, and trends in fresh produce in North America. ***www.thepacker.com***

- ***Wholesale Success: A Farmers Guide to Selling, Post Harvest Handling, and Packing Produce*** is a 255-page manual for the produce wholesale industry. It covers food safety, post-harvest handling, packing and grading standards, fulfilling orders, record keeping, billing, and building relationships. The manual includes harvesting, cooling, storing, and packing information for 103 different fruits and vegetables. Phone 708-763-9920. ***www.familyfarmed.org/wholesale-success***

- **AMS Fresh Fruit, Vegetable, Nut, and Specialty Crop Grade Standards** lists the U.S. Agricultural Marketing Service grade (quality) standards for each fruit, vegetable and nut sold as commodities. ***http://tinyurl.com/ams-grade-standards***

- ***Food Safety and Liability Insurance for Small-Scale and Limited Resource Farmers*** gives a brief overview of food safety and liability insurance. Published by the Community Food Security Coalition. ***www.foodsecurity.org/insurance.htm***

- **Como Proteger Su Negocio Agrícola y Producir Alimentos Seguros en Su Granja** is a Spanish audio version of the Food Safety and Liability Insurance brochure above. From the Community Food Security Coalition website, you can click on the link to listen to the mp3 version on your computer, or you can request a CD of this recording by contacting: ***publications@foodsecurity.org,*** **or (503) 954-2970.** ***www.foodsecurity.org/insurance.htm***

- **USDA Terminal Market Report** lists current wholesale prices online at ***http://tinyurl.com/3znaeuf***

- **Rodale Institute Organic Price Report** can be configured to show organic only or to compare organic and conventional wholesale prices at the current market rates. Prices of fruit, vegetables and grains are listed for six different wholesale terminals across the U.S. ***www.rodaleinstitute.org/Organic-Price-Report***

- **UC Davis Small Farm Program's Wholesale Market Resources** explain wholesale buyers and terminal markets: ***http://sfp.ucdavis.edu/pubs/sfnews/Archive/93052.htm*** and ***http://sfp.ucdavis.edu/pubs/sfnews/archive/92091.htm***

This tip sheet was developed with assistance from Dina Izzo, Bludog Organic Produce Services, and Bob Corshen, Community Alliance with Family Farmers.

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Tips for Selling to Produce Brokers
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Tips for Selling to: Produce Distributors

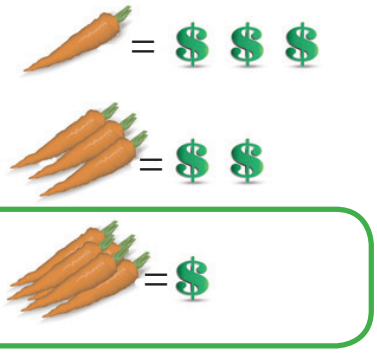
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Produce distributors are businesses that aggregate product and resell it in small or large quantities to their customers. Distributors may be an individual with a van or a company with a fleet of eighteen-wheelers. A distributor's primary relationship is purchasing directly from farmers, although distributors can also buy from brokers or packing houses.

Distributors sell to a range of customers, from individual restaurants to institutions such as hospitals and schools. Since local food has come into higher demand, some distributors have made the effort to focus their business on providing local produce to their customers.

For this market you can expect:

- ***Higher volume of product***
- ***Lower prices per unit***



Advantages

key point

- **Distributors can handle large volumes of product.**
- **Distributors can contract for a particular product for the whole season.**
- **Farm product identity could be retained in this wholesale market if the distributor focuses on local products.**

Considerations

- **While you can sell a larger quantity, expect a lower price per unit.**
- **Distributors typically pay in 30 days. You must determine how that will affect your cash flow.**
- **Distributors have USDA standard pack and grade requirements that you will need to follow, which include clean, new boxes.**
- **Selling to distributors requires a well organized invoicing and recordkeeping system.**



Earl's Organic Produce, San Francisco. Photo: Rex Dufour, NCAT.

Tips

- **Contact the distributor to see what products they are looking for as well as volume, price, pack and grade preferences, delivery or pickup schedule, and liability insurance and GAPs (Good Agricultural Practices) requirements.**
- **Ensure quality with proper cooling and post-harvest handling. Ask what requirements your buyer has.**
- **Consider specialty products that may bring a higher price, such as green garlic, squash blossoms, or pea tendrils that are variations on conventional items.**
- **When you deliver, always bring two copies of an invoice, one for your customer and one for you. Both should be signed at the time of delivery, providing proof that quality and quantity are accurate.**

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Key Questions to Ask Yourself about Selling to Produce Distributors

- **How do these buyers want produce packed and delivered? What quantities do they want, and how often?**
- **Do I have liability insurance or a GAPs plan? Do these buyers require either of these items, and how much coverage do I need to have?**

Resources

- **ATTRA Publications**. Prices vary for individual publications. Many are free. An inexpensive subscription to ATTRA will give you access to all 350+ publications and databases. Phone 800-346-9140. ***www.attra.ncat.org***
  - — ***Illustrated Guide to Growing Safe Produce on Your Farm: GAPs*** (2011) (English or Spanish)
  - — ***New Markets for Your Crops*** (2008) (English or Spanish)
  - — ***Scheduling Vegetable Plantings for Continuous Harvest*** (2008) (English or Spanish)
  - — ***Season Extension Techniques for Market Gardeners*** (2005) (English or Spanish)
- ***The Packer*** is a weekly newspaper covering fruit and vegetable news, produce shipping, distribution, packing, marketing, and trends in fresh produce in North America. An annual produce and availability merchandising guide has a list of buyers by commodity and their states and cities. ***www.thepacker.com***
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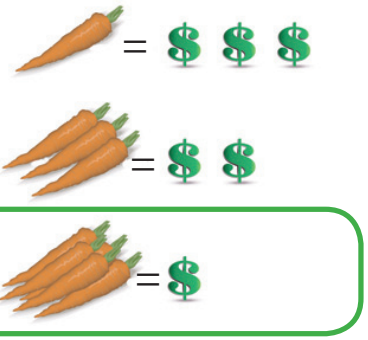
Tips for Selling to:
Produce Packing Houses

NCAT Marketing Tip Sheet Series

Produce packing houses are large-scale businesses that buy produce from growers through a contract and then re-sell it on the open market. They sell very large quantities. Packing houses can also own land, renting plots to farmers to grow specifically for them, and sometimes supplying seed, inputs and packaging. They have invested in equipment such as coolers and fumigators, so they have the ability to store large amounts of product.

Packing houses never own the product once they receive it, therefore the price the farmer receives is based on what it sells for at the end of the chain. Some packing houses are cooperatively owned by farmers.

For this market you can expect:
- ***Higher volume of product***
- ***Lower prices per unit***



Advantages

key point

- **Packing houses can provide land, seed, inputs, labor, and packaging.**
- **Working with a packing house allows farmers to focus on production rather than sales.**
- **Farmers don't have to invest in packing and washing equipment or storage facilities, because the packing house will provide those services for a fee.**

Considerations

- **Packing houses are considered by experts in the industry to be the most risky for farmers for many reasons. One potential problem is that the product goes through many hands, and the price a farmer gets at the end is based on the quality of the product, which may have had time to degrade.**
- **Some contracts with packing houses can limit participation in other market channels.**
- **Packing houses will quote you a price when you deliver the product, but it is not guaranteed. The farmer will get paid a percentage of the price the packing house receives for the sale.**
- **Some packing houses may sell seed, inputs and packaging at a marked-up price to farmers.**
- **Many farmers in this system are unable to reach a profit, since the costs of growing the product are often more than they receive after the packing house sells it.**



Packing bell peppers. www.ceriverside.ucdavis.edu

Key Questions to Ask Yourself

- **Am I comfortable with the risks (explained above) of selling my product to a packing house?**
- **Have I confirmed that other growers I know are making a profit and have a good relationship with this packing house?**
- **Am I able to understand the commitments I'm agreeing to, outlined in the contract I will sign? Have I found someone to translate it for me if necessary?**
- **Do I have a cushion of savings in case the money I owe the packing house is more than I will make from my sales?**

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Tips for Selling to Produce Packing Houses

✪ *key points*

- ✪ **Ask other farmers about the reputation of the packing house before you work with them.**
- ✪ **Packing houses always have a contract. Be sure that you understand it, keep a copy, and have someone translate it for you if necessary.**
- **If there is a concern about product quality, get a third-party quality inspection. For a fee you can have your produce inspected by the Agricultural Marketing Service (AMS) before you deliver it to the packing house. See the Resources section below.**
- ✪ **Request a written receipt when you drop off your product. Make sure the person who takes your boxes signs the receipt and prints their name legibly. A receipt should include what you sold, the weight or number of boxes, the date it was delivered, and the quality grade. Reconsider doing business with a packing house that will not give you a receipt.**
- **Depending on one market can be risky. Consider investigating other market channels. See other Marketing Tip Sheets in this series.**

Resources

- **ATTRA Publications**. Prices vary for individual publications. Many are free. An inexpensive subscription to ATTRA will give you access to all 350+ publications and databases. Phone 800-346-9140. ***www.attra.ncat.org***
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- **AMS Inspection Service** will inspect your produce and certify its grade of quality before you sell it. On their website, click on "Request an Inspection/Contact an Office" on the right column. ***http://tinyurl.com/ams-inspection-service***
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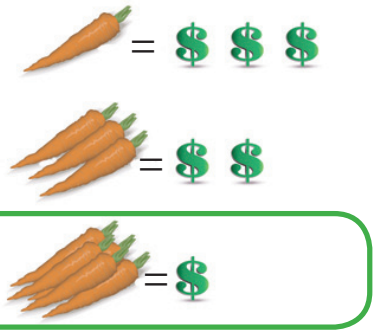
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Tips for Selling to:
Wholesale Buyers at Terminal Markets

NCAT Marketing Tip Sheet Series

Wholesale buyers are typically located in permanent stalls at a terminal market. Terminal markets are central sites, often in a metropolitan area, that serve as an assembly and trading place for agricultural commodities. Wholesale buyers will purchase products from farmers, brokers, or packing houses in large quantities, and resell it into the open marketplace. Prices of products, cooling considerations, and time of delivery are all negotiated before farmers bring their products to the docks.

For this market you can expect:
- *Higher volume of product*
- *Lower prices per unit*



Advantages

✪ *key point*

- Buyers can handle large deliveries of produce.
- Generally, pre-negotiated prices are more stable with wholesale buyers, however prices are not guaranteed.

Considerations

- You can sell a larger quantity, but expect a lower price per unit.
- ✪ **Wholesale buyers typically pay within 30 days. You must determine how this will affect your cash flow.**
- Farmers can set the price, but the buyer must agree to it. Farmers must have a good idea of what the going prices are in the wholesale market. See fifth Tip, next page.
- Farmers must meet packing and grading standards.
- ✪ **Consider your wholesale buyer's post-harvest requirements and whether product must be delivered in a refrigerated truck.**
- Selling to a wholesale buyer requires a well organized invoicing and recordkeeping system.

Key Questions to Ask Yourself

- How far away is the nearest terminal market?
- Do I want to put the effort into establishing relationships with the buyers? Would I rather go through a broker?
- How do the buyers at terminal markets want produce packed and delivered?
- How much volume is needed to supply wholesale buyers?
- ✪ **Do my profits cover the cost of production, gasoline and labor?**



Photo: Loading docks at a terminal market, www.oaklandnorth.net

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Tips for Selling to Wholesale Buyers at Terminal Markets

✪ *key points*

- ✪ **Visit a terminal market to get an idea of how it works and learn about the competition. To talk to a wholesale buyer and show them your produce, visit after 6 or 7 a.m. To see the market operating at busy times, visit around 3 or 4 a.m.**
- **Terminal markets are typically open from 11 p.m. to 12 noon. To sell a product, farmers must deliver to the terminal market late at night or very early in the morning. Most deliveries take place between 11 p.m. and 4 a.m. Buyers begin arriving at 5 a.m. to purchase products.**
- ✪ **Identify and contact wholesale buyers before you try to sell to them. Farmers can get higher prices through established relationships, for higher quality products, and for unique or specialty products in high demand.**
- **If this will be a regular market channel, plan to bring them product on a regular basis. Consistency and quality are keys to success in this market.**
- ✪ **Check the USDA Terminal Market Reports (available online at *http://tinyurl.com/3znaeuf)* for prices on your product before you try to negotiate with a wholesale buyer.**
- ✪ **Ensure high quality by using good pre-cooling and post-harvest practices.**
- ✪ **Don't use this channel if you have less than 50 to 100 boxes of each item. Wholesale buyers only purchase large quantities.**

Resources

- **ATTRA Publications**. Prices vary for individual publications. Many are free. An inexpensive subscription to ATTRA will give you access to all 350+ publications and databases. Phone 800-346-9140. ***www.attra.ncat.org***
  - — ***Illustrated Guide to Growing Safe Produce on Your Farm: GAPs*** (2011) (English & Spanish)
  - — ***Post-Harvest Handling for Fruits and Vegetables*** (2000)
  - — ***New Markets for Your Crops*** (2008) (English & Spanish)
  - — **ATTRA website's Marketing, Business and Risk Management section: *www.attra.ncat.org/marketing.html***
- ***The Packer*** is a weekly newspaper covering fruit and vegetable news, produce shipping, distribution, packing, marketing, and trends in fresh produce in North America. ***www.thepacker.com***
- ***Wholesale Success: A Farmers Guide to Selling, Post Harvest Handling, and Packing Produce*** is a 255-page manual for the produce wholesale industry. It covers food safety, post-harvest handling, packing and grading standards, fulfilling orders, record keeping, billing, and building relationships. The manual includes harvesting, cooling, storing, and packing information for 103 different fruits and vegetables. Phone 708-763-9920. ***www.familyfarmed.org/wholesale-success***
- **AMS Fresh Fruit, Vegetable, Nut, and Specialty Crop Grade Standards** lists the U.S. Agricultural Marketing Service grade (quality) standards for each fruit, vegetable and nut sold as commodities. ***http://tinyurl.com/ams-grade-standards***
- ***Food Safety and Liability Insurance for Small-Scale and Limited Resource Farmers*** gives a brief overview of food safety and liability insurance. (English & Spanish) ***www.foodsecurity.org/insurance.htm***
- **USDA Terminal Market Report** lists current wholesale prices online at ***http://tinyurl.com/3znaeuf***
- **Rodale Institute Organic Price Report** can be configured to show organic only or to compare organic and conventional wholesale prices at the current market rates. Prices of fruit, vegetables and grains are listed for six different wholesale terminals across the U.S. ***www.rodaleinstitute.org/Organic-Price-Report***
- **UC Davis Small Farm Program Wholesale Market Resources** explain wholesale buyers and terminal markets: ***http://sfp.ucdavis.edu/pubs/sfnews/Archive/93052.htm*** and ***http://sfp.ucdavis.edu/pubs/sfnews/archive/92091.htm***

This tip sheet was developed with the assistance of Dina Izzo, Bludog Organic Produce Services, and Bob Corshen, Community Alliance with Family Farmers.

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www.outreach.usda.gov/oasdfr



United States Department of Agriculture
National Institute of Food and Agriculture

Tips for Selling to Wholesale Buyers at Terminal Markets
© 2012 National Center for Appropriate Technology—NCAT
By Marisa Alcorta, Rex Dufour and Tammy Hinman
Production: Karen Van Epen
Find this on the Internet at *www.attra.ncat.org/marketing.html*
IP 432, Slot 432, Version 122612

Pricing your Products for Profit



Dr. Theresa J. Nartea, State Program Leader-Food
Associate Professor & Extension Specialist
Marketing & Agribusiness

VSU College of Agriculture
Virginia Cooperative Extension
Virginia Tech • Virginia State University

Pricing your products for profit

Determining the price of your agricultural products is critical for business success. Prices are determined by supply (both seasonal and weather related), demand, and location. Prices vary widely and should be adjusted regularly to reflect market conditions. Many online resources are available to help you determine state, regional, and national wholesale and retail prices for a wide range of farm products.

Retail Market Prices

USDA Weekly Retail Report



USDA

Agricultural Marketing Service

Specialty Crops Market News Division

National Retail Report - Specialty Crops

Websites: www.marketnews.usda.gov/mnp/fv-home **and** http://www.ams.usda.gov/mnreports/fvwretail.pdf **and** http://www.ams.usda.gov/mnreports/wa_lo100.txt

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Advertised Prices for Specialty Crops at Major Retail Supermarket Outlets ending during the period of 07/10 to 07/22[1,2]

Sweet Summer Deals

This week retailers used creative advertising to put produce in shoppers carts and to leave money in their pockets. Deals were offered on all the seasonal favorites like cherries, apricots, plums, corn, asparagus, and soft squashes. Melons, berries, and grapes continued to be popular. New and heirloom varieties of tree fruit were touted by several retailers. Tangerines, clementines, and apple juice appeared with other back-to-school favorites. Many stores had sections for school supplies.

Total ad numbers this week were 341,688, about steady from last weeks 344,093. Ad numbers this week were 13% higher than for the same week last year, when many retailers withheld weekly specials due to the Covid-19 pandemic. The total number of ads broken out by commodity groups: fruit 194,763 (57% of all ads), onions and potatoes 18,534 (5%), vegetables 124,994 (37%), herbs 1,260, ornamentals 988, and hemp 1,149. The number of ads for organic produce was 62,369, 18% of total ads.

The following are the prices of major advertised items (3,000 plus stores) this week, compared to the same week last year. Significant increases in price for fruit this week included strawberries (organic 25%, conventional 10%), and white seedless grapes at 12%. Significant decreases included only white nectarines at 10%. There were no significant changes in price for onions and potatoes this week. Significant increases in vegetable prices this week included only organic grape tomatoes at 15%. Significant decreases included asparagus at 17%, yellow squash at 14%, bell peppers (yellow and orange at 11%, red at 10%), zucchini at 11%, and on-the-vine tomatoes at 10%.

For more detailed information on organic and locally grown produce visit the National Retail--Local and Organic Report at: http://www.ams.usda.gov/mnreports/wa_lo100.txt

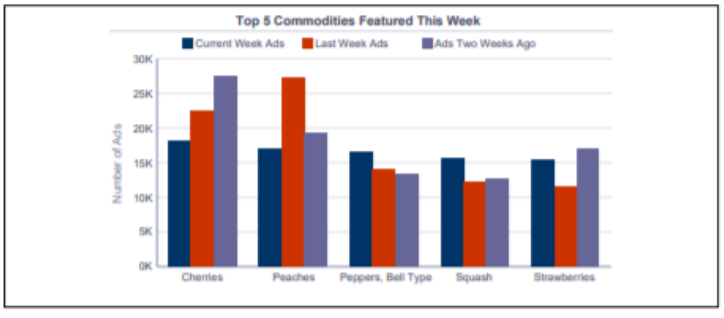


Figure 1

Figure 1

This is a compilation of surveys of over 400 retailers, representing over 30,300 individual stores. USDA National Retail Report for Specialty Crops database promotes their products with online weekly advertising. This database updates weekly on Fridays. Below are highlights of the USDA National Retail Report for Specialty Crops:

This weekly report can be found at: http://www.ams.usda.gov/mnreports/fvwretail.pdf

Retail Market Prices

USDA Weekly Retail Report

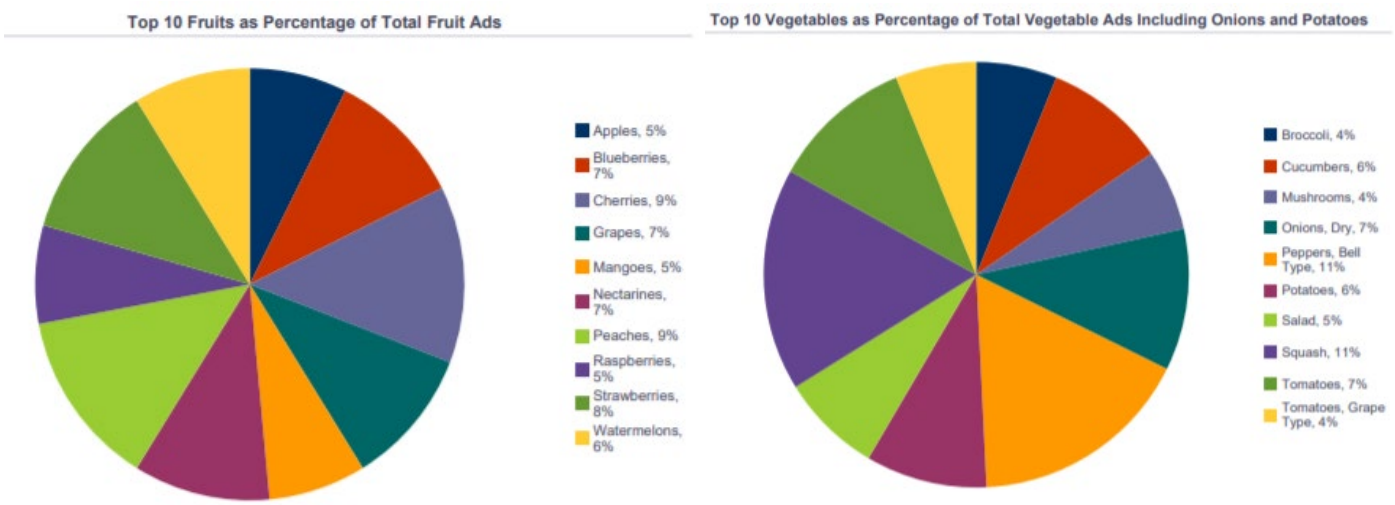


Figure 2

Figure 2. The USDA Weekly Retail Report has information about seasonal fluctuations of produce availability in relation to store promotions. These charts can assist you in deciding how to price your products. For example, these two charts represent the week's top 10 selling fruits and vegetables as a percentage of retail market advertisements.

Virginia Farmers' Markets

Participating farmer's market managers submit produce pricing to the Virginia Department of Agriculture and Consumer Services. The VDACS then compiles the information into a monthly report, available online at:



http://www.vdacs.virginia.gov/markets-and-finance-market-news-fruits-and-vegetables-virginia-retail-farmers-markets.shtml

Retail Market Prices

Virginia Farmers' Markets

Birdhouse Market
1507 Grayland Avenue
Richmond, VA 23220
804.404.3817
Tuesdays 3 to 6:30 p.m. (May-Nov)
www.birdhousefarmersmarket.org/

Vegetables	
Beets	3.00 bunch
	3.50 organic bunch
Broccoli	4.00-6.00 organic head
Celery	3.00 head
Chicory	3.00 organic head
Cucumbers	2.25 organic lb
Fava Beans	5.50 organic lb
Greens	2.50-3.00 bunch
	3.50-4.00 organic bunch
Lettuce	1.50 head
	2.50 organic head
Napa Cabbage	3.50-5.00 organic head
Onions	2.50 bunch
	3.00-3.50 organic bunch
Peas	4.00 organic pt
Radishes	3.00 bunch
	3.00 organic bunch
Spinach	4.50 organic bunch
Turnips	3.00 bunch
	3.50 organic bunch
Fruits & Berries	
Cherries	4.00 1/2 lb-7.00 lb
Strawberries	6.00 qt
Meat	
Chicken	
Whole	4.75-5.50 lb
Thigh/Leg	7.00 lb
Breast	14.00 lb
Other Cuts	6.50-12.00 lb
Duck	
Whole	6.50 lb
Legs	13.00 lb
Breast	20.00 lb
Other Cuts	4.00 lb
Other	
Eggs	5.00 dz
Garlic Scapes	3.00-5.00 organic bunch
Herbs	2.00-3.00 bunch
	2.50 organic bunch
Honey	12.00 lb

Figure 3

Figure 3. Example price list from VDACS website

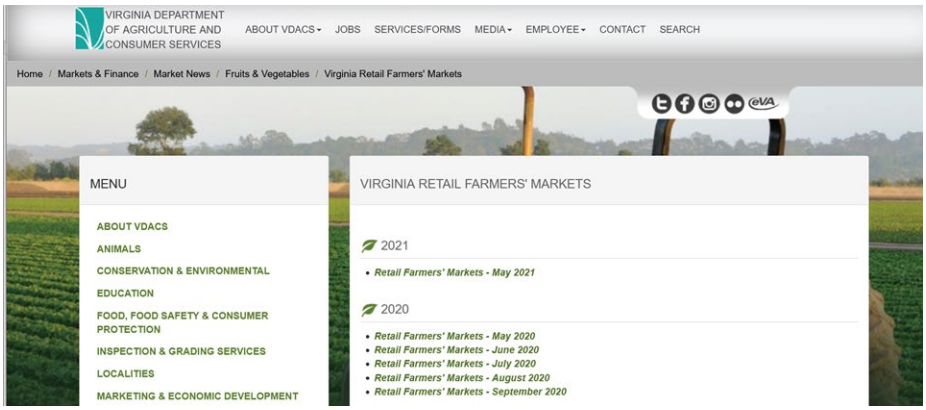


Figure 4

Figure 4. Homepage of the Virginia Department of Agriculture and Consumer Services, which has helpful resources to help you price your produce.

Park Slope Food Coop, New York

This food coop lists unique specialty crops. Find their pricing recommendations at: http://www.foodcoop.com/produce

Retail Market Prices

USDA Market News - Local and Organic Prices

The USDA releases a national retail report of local and organic foods, sourced from advertised prices for all regions at major retail supermarkets. This report is updated weekly. Check out this report at: https://www.ams.usda.gov/mnreports/wa_lo100.txt

All USDA Retail Crop Reports

In addition to the Local and Organic Prices report, the USDA releases weekly reports for retail activity for beef, chicken, dairy, eggs, lamb/veal, conventional vs organic foods, pork, specialty crops, and turkey.

Visit USDA's Crop Reports home page: https://www.ams.usda.gov/market-news/retail

Wholesale Market Prices

USDA Wholesale Market Price Reports

You can see price reports for wholesale prices on USDA's website. You can check by commodity, (fruit, onions & potatoes, vegetables, herbs, nuts, ornamentals, or honey), or by report type (terminal market, international market, shipping point, movement, retail, daily movement, or truck rate).

https://www.ams.usda.gov/market-news/fruits-vegetables

Other Resources

If the above reports don't have what you're looking for, USDA, has a tool to co create your own custom report: https://www. marketnews.usda.gov/mnp/fv-home

FOOD SERVICE VENDORS

Those who prepare food on site at a Farmer's Market

Food Service Vendors, except those offering for sale primarily packaged food products or samples of such products not subject to Virginia Department of Health (VDH) inspection, must obtain a VDH food establishment permit. The local health department issues these permits and inspects food service vendors. Vendors who do not hold a food establishment or mobile food establishment permit need to apply to the local health department for a temporary food establishment permit and submit the applicable fee at least 10 days prior to operation.

Food Service Vendors must have:

1) An on-site warewashing set up that includes three basins: one each for washing, rinsing, and sanitizing. The appropriate strength of sanitizing solution should be used and confirmed with the appropriate sanitizer test strips. Wares should be cleaned and sanitized after use with raw animal foods and before use with ready-to-eat foods, including raw fruits and vegetables, or if they have been contaminated.

2) An on-site handwashing station is also required. Hands must be washed frequently including before beginning food preparation or putting on gloves; and after eating, drinking, smoking, using the restroom, handling raw animal foods, or whenever the hands may have been contaminated. Avoid bare-hand contact with ready-to-eat foods by using gloves, tongs, deli paper, etc. Don't work if you are sick.

3) Overhead protection for vendor operation is required (tent, canopy, awning, table umbrella, permanent structure, etc.). Food preparation must occur on smooth cleanable surfaces such as tables. Slicing must be done on cutting boards. Use wrapping or other effective barriers to protect from customer handling. Stored food should be in a clean, dry location, at least 6 inches off the ground.

TCS foods ** must be kept hot, at 135°F or higher, or cold, at 41°F or lower. Use a calibrated metal stem thermometer to ensure you are meeting the required temperatures. Ice should be drained frequently at an approved dump site.

***Time and Temperature Controlled for Safety (TCS) Foods: Please see important note in bottom right of previous page.*

VDH, VDACS & VCE CONTACTS FOR MORE INFORMATION

Your local agency contact	Name	Address	Phone number	e-mail
Virginia Cooperative Extension				
Virginia Department of Health Inspector				
Virginia Department of Agriculture and Consumer Services inspector				

Virginia Tech Food Innovations Program*:
Food Product Testing Services

Website:
http://ext.vt.edu/food-health/food-innovations.html

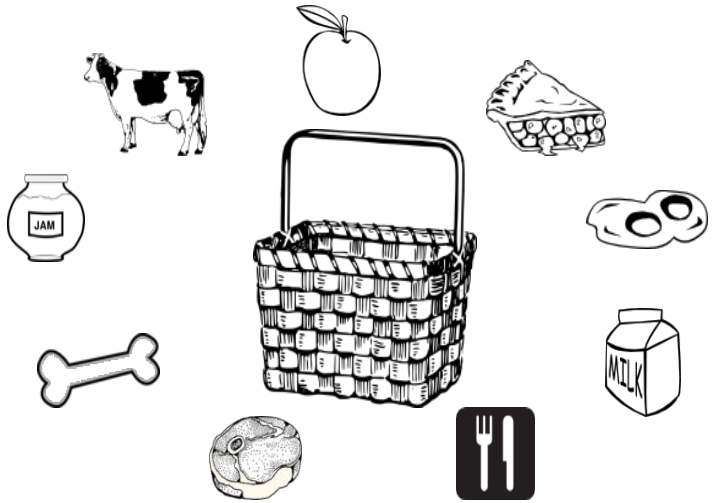
Farmers' Market Resources:
Virginia Grown:
www.vdacs.virginia.gov/vagrown/frmsmkt-farmvend.shtml

Virginia Farmers' Market Association:
http://www.vafma.org/

*please fill out the "Ask a Question" or "Request an evaluation form" for the quickest response!

Virginia Cooperative Extension
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www.ext.vt.edu

GOING TO MARKET



A Guide to Selling Raw, Processed and Prepared Food Products from Your Home, at Farmers' Markets, Stores & Roadside Stands

Do I need to get inspected? By whom?

On the following pages Farm Market & Food Service Vendors will find the answers to these questions, which vary depending on the type of food product and preparation process used. The contact information for permitting and/or inspection requirements is on the back page.

By Renee Boyer, Associate Professor, Extension Specialist & Joell Eifert, Director of Food Innovations Center, Food Science & Technology Department, Virginia Tech

** Acknowledgements go to Cathryn Kloetzli, Former Horticulture Extension agent & Rachel Wallace, Summer Intern 2012 for originally creating this publication*

2018 Virginia Tech ANR-46NP (FST-273NP)

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FARM MARKET VENDORS : Inspected by VDACS unless vendor prepared food and samples at the market (see food service vendor)

VDACS INSPECTION REQUIRED

MEAT



All meat that is to be sold must be slaughtered at a USDA/state-inspected facility.

The VDACS Office of Meat and Poultry Services (OMPS) provides free inspections for amenable species (cattle, hogs, sheep, goats, chickens, turkeys, ducks, geese, guineas, ratites and squabs).

EXEMPTIONS

- 1,000 Bird Exemption
- 20,000 Bird Exemption
- Custom Exemption: with permit from OMPS, allows businesses to slaughter animals, only for their owners consumption, without an inspector present.

LABELING

- Product Name
- Net Weight
- List of Ingredients
- Name/address of Responsible Party
- Inspection Legend (plant number that did the work)
- Safe Handling Statement

For Custom Exemption: "NOT FOR SALE"; 20,000 Bird Poultry Exemption Label, if applicable.

AT MARKET

Keep products at 41°F or lower

DAIRY



All dairy products to be sold must be inspected. Sale of raw milk is prohibited.

Sale of cheese made from raw milk must be aged at least sixty days above 35 degrees. Contact the VDACS Office of Dairy & Foods.

LABELING

- Product Name
- Net Weight
- Ingredient Statement
- Name & Address of Manufacturer/ Distributor
- Sell-by date

AT MARKET

Keep frozen products frozen and other products at 41°F or lower. If storing products on ice, drain often.

Products offered as samples should be prepped on-site or in your VDACS approved facility.

Un-refrigerated samples may be left out for tasting no more than 4 hours (any leftovers then cannot be re-cooled or used again, they must be thrown away).

Please keep your most recent VDACS inspection reports on hand with you at the market.

VDACS INSPECTION REQUIRED: UNLESS EXEMPTION CONDITIONS BELOW ARE MET

ACIDIFIED CANNED FOODS *



Acidified low-acid foods (pickled products, salsa, pumpkin/sweet potato butter, barbeque sauces, chow-chow, relishes, hot pepper jelly, hot sauces, garlic in oil, etc.) must achieve a pH of 4.6 or lower (verified by an electronic pH meter you purchase). Low-acid canned foods are not permitted to be made in the home.

Completion of 'Better Process Control School' course and process approval by a processing authority strongly advised (Virginia Tech Food Innovations Program: Food Testing Services).

Must not exceed $3,000 in total annual gross sales for all acidified products produced.

LABELING

The standard label must contain:

- Product name
- Net weight
- Ingredient statement
- Name & address of manufacturer/distributor/packer
- Nutritional labeling (exemptions apply)
- List of allergens
- NOT FOR RESALE – PROCESSED AND PREPARED WITHOUT STATE INSPECTION

You must also have a label displaying the name, physical address and telephone number of the person preparing the food product and the date the food product was processed.

All acidified foods must have a unique identifying code visible to the naked eye.

BAKED GOODS, JAMS AND … *



Includes jams and jellies (no low-acid ingredients), candies, dried fruits/herbs/seasonings/ mixes, (un)coated nuts, (flavored) vinegars, popcorn (balls), cotton candy, dried pasta, roasted coffee, dried tea, cereals, trail mixes and granola and baked goods that don't require time or temperature control.

LABELING

The standard label must contain:

- Product name
- Net weight
- Ingredient statement
- Name & address of manufacturer/distributor/packer
- Nutritional labeling (exemptions apply)
- List of allergens
- NOT FOR RESALE – PROCESSED AND PREPARED WITHOUT STATE INSPECTION

You must also have a label displaying the name, physical address and telephone number of the person preparing the food product and the date the food product was processed.

AT MARKET

Cover baked goods to protect them from environmental contaminants, such as flies and dirt.

If providing samples, prepare them at your VDACS approved and inspected facility prior to arriving at the market. Cut baked goods into pieces at your inspected facility, place them on a tray, insert a toothpick into each piece, and keep the tray covered in food safe wrapping, such as plastic wrap.

HONEY



Those who process & prepare honey in their private residence from hives they own, who sell less than 250 gallons of honey a year, & who do not process or sell other food products (except as noted here) are exempt from inspection.

Infused honey products are not exempted.

LABELING

The standard label must contain:

- Product name
- Net weight
- Ingredient statement
- Name & address of manufacturer/distributor/packer
- Nutritional labeling (exemptions apply)
- PROCESSED AND PREPARED WITHOUT STATE INSPECTION. WARNING: Do Not Feed Honey to Infants Under One Year Old

EGGS



Exempt from Virginia Egg Law and do not need inspection if selling less than 150 dozen of your own eggs per week or less than 60 dozen of another producer's eggs per week.

LABELING

- Product Name (term "fresh eggs" can only be used if product meets requirement for Grade A or higher)
- Safe Handling Instructions
- Name & Address of Packer
- Grade (AA, A, B) or "Ungraded" if not inspected

AT MARKET

Eggs must be clean and held at 45°F or lower at all times.

Note: Reusing egg cartons runs the risk of contamination; consider asking patrons to bring their own

PRODUCE



If you grow and sell fresh produce, and make < $25,000 in annual sales (3 yr. avg), you are not covered under the Produce Safety Rule and do not need to be inspected. Growers that make >$25,000 may fall under the PSR and may need to be inspected. Sprouts, hydroponic operations and farm raised mushrooms are considered produce regulated by the PSR. (not covered if <$25K). Wild mushrooms require VDACS food safety applications harvesting and retail sales.

AT MARKET

Most fruits and vegetables only require basic coverage for protection from outside contamination, but since, for example, cut melon, cut leafy greens and cut tomatoes are a TCS Food** (see note below), they must be held at 41F or lower. This applies to samples as well.

VDACS LICENSE REQUIRED

PET TREATS



Home/facility inspection by VDACS not required, but it is suggested to contact your local health department for any local inspection requirements.

You must obtain licensing and permitting through VDACS. Product registration may also be required.

LABELING

1. Product Name
2. Intended Species
3. Quantity Statement
4. Guaranteed Analysis
5. Ingredient Statement

Name and Address of Manufacturer/Distributor

AT MARKET

Can be sold either pre-packaged or in a bulk, self-serve style.

*** Exemptions: Apply to ACIDIFIED CANNED FOODS and BAKED GOODS, JAMS AND …':**
Must be produced in a private home. Must be sold at farmers markets, from the private home where product is manufactured or to an individual for their own consumption. These products cannot be sold to other businesses (ie. grocery stores), for resale, on the internet or across state lines.

You do not have to pay the $40 annual fee to VDACS, although you are still required to comply with all applicable laws and regulations (outlined here).

****Time and Temperature Controlled for Safety (TCS) Foods** require temperature control because they are capable of supporting the growth of various infectious microorganisms or toxins. These foods include meats, dairy products, eggs, mushrooms, cut melons, cut tomatoes, cut leafy greens, and heat-treated plant food such as cooked rice, beans, and vegetables.

Let's "Farmer" It Out! VSU-SFOP-LRVBFRP Learning Series

Dr. Theresa J. Nartea, Associate Professor-Extension Specialist (Marketing & Agribusiness)
Email: tnartea@vsu.edu Phone: 804-524-5491

Grower Question: What should I grow?

Step 1. Let's do some "Market Research!

What is Selling Near Your Farm?

HINT: See Handout "Retail Farmers' Markets
https://www.vdacs.virginia.gov/markets-and-finance-market-news-fruits-and-vegetables-virginia-retail-farmers-markets.shtml

Now, write in the table below: The TOP FIVE (5) crops you'd like to grow this year:

Table 1.

#	Crop Name	Retail Price *$*	Quantity *(bunch, lb, pt. qt., etc.)*	#1 Reason you Picked Crop *(Write Below)*
1				
2				
3				
4				
5				

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Step 2. Let's do more Market Research!

What are the HOT CROPS customers are looking for?

HINT: See Handout: WHAT'S HOT-Culinary Forecast *https://restaurant.org/research-and-media/research/research-reports/whats-hot-food-beverage-trends*

Now, as you go through the handout, make note of any vegetables, fruits, and herbs that are mentioned or pictured, and the page number you found the item, below:

Table 2.

Crop Item Name	Page Number where you saw Crop

REFLECTION TIME



Do any of the HOT CROPS (Table 2.) match the crops you wanted to grow (Table 1.)?

Where can you find recipes by typing in the ingredient?

Try: https://www.allrecipes.com
https://www.supercook.com
https://www.tasteofhome.com
https://www.specialtyproduce.com
https://www.americastestkitchen.com/cooksillustrated

Step 3. How Much Will You Harvest?

Go back to your completed Table 1., and refer to the **Handout named "Yield Expectations for Mixed Stand, Small-Scale Agriculture."** *https://studylib.net/doc/18745496/yield-expectations-for-mixed-stand--small-scale*

Consider this applied research publication states:

> *As a General Guideline,*
> *a Yield Expectation of*
> ***0.5 lb/square foot****
> *is a realistic value for*
> *Mixed Stand, Small-Scale Agriculture*

To fill out the table below:

Table 3.

#	**Crop Name** From Table 1.	**Retail Price** From Table 1.	**Estimated Yield** *(bunch, lb, .)*	**Number of 100-Foot Rows** *(you will plant)*
1				
2				
3				
4				
5				

Step 4. How Will My Field Rows Be Arranged?

In the space below, draw out a simple map of your greenhouse floor. Write in the Length and Width (in feet). Write in how long your rows will be (try 100-foot rows). How many rows? What about the space between rows? Make sure to have room for storage, trash, turning equipment around, etc.



Step 5. Go Home and Think About What You Learned.

What other information do you need? Write your Thoughts, below:

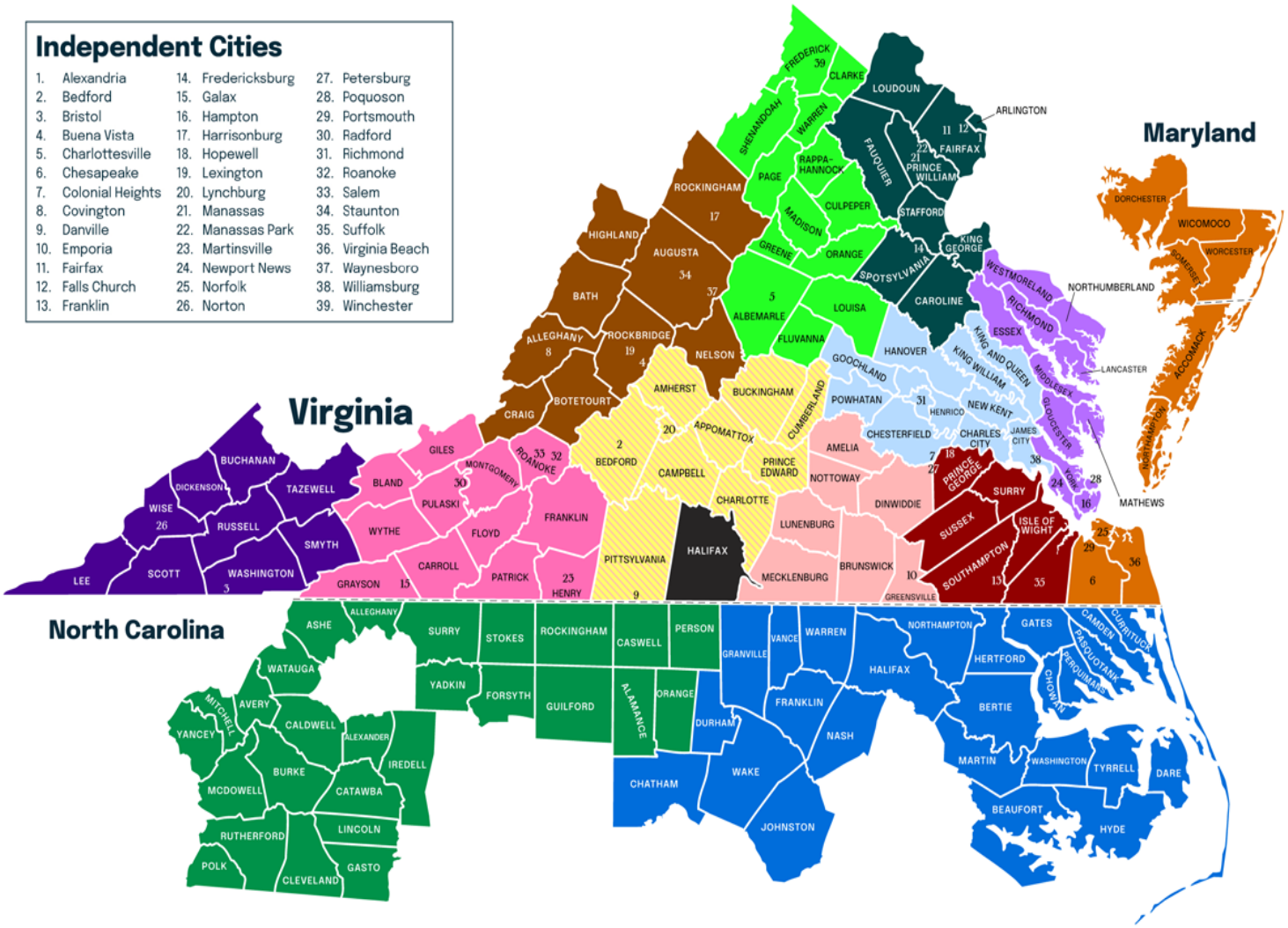
Step 6. How do I contact my VSU-SFOP Program Assistant?

See Handout: Contact our Program Assistants.
https://www.ext.vsu.edu/s/SFOP-Regional-Map-2024.pdf

Be sure to make an appointment with your SFOP-Program Assistant to go over your ideas!

Write your SFOP PA contact information below, and after you have thought about what you learned in this activity, give them a call to visit with you!

Contact Our Program Assistants



Regional Program Assistants*

Michael Carter Sr.	804-481-1163	mcarter@vsu.edu
Ben Dukes	804-731-7916	bdukes@vsu.edu
Leonard Elam	804-894-3095	lelam@vsu.edu
Marilyn Estes	804-481-0485	mestes@vsu.edu
Mandy Fletcher	804-892-0108	afletcher@vsu.edu
Derrick Gooden	804-586-5352	dgooden@vsu.edu
James Gibson	804-720-6826	jegibson@vsu.edu
Vacant	804-524-3292	
Forrest Hobbs	804-524-3292	fhobbs@vsu.edu
Brent Noell	804-892-0140	bnoell@vsu.edu
Cliff Somerville	804-892-4581	csomerville@vsu.edu
Roland Terrell	804-892-4612	rterrell@vsu.edu

State Program Assistants

Frederick Custis | 804-894-0218 | fcustis@vsu.edu
Agriculture Management Coordinator

Derrick Cladd | 804-892-4489 | dcladd@vsu.edu
Beginning Farmers

James Edwards | 804-720-2588 | jtedwards@vsu.edu
Military Veteran, AgrAbility

Barry Harris | 804-720-6367 | bdharris@vsu.edu
Conservation Practices

Tammy Holler | 804-229-2730 | tholler@vsu.edu
Nutrient Management

Wanda Johnson | 434-632-9701 | wjohnson@vsu.edu
Community Gardens, Food Services

Grace Summers | 804-712-0093 | gsummers@vsu.edu
NRCS, SFOP High Tech Tunnel

Small Farm Outreach Program Office hours: Monday–Thursday, 8 am–5 pm, Friday, 8 am–noon. 95% of SFOP is out in the field.

*If you have any difficulty figuring out which region is yours, please call 804-524-3292 for clarification.

How to complete this worksheet

There are two columns of statements. Look at each one and place the number “1” in the white box next to each statement that describes you. Leave the box blank for statements that you do not relate to. You can relate to both statements within a line, or neither, potentially. Trust your instincts and what you know about yourself.

	I can talk to anyone		I enjoy being by myself over being with people
	I enjoy being around people		I would rather someone else plan event activities
	I am a creative party planner		I tend to avoid parties or crowds
	I enjoy talking with customers		I prefer to talk to people I know over strangers
	I like to organize events such as parties		I feel most comfortable being alone
	I am thoughtful towards people’s feelings		I usually forget people’s names after I meet them
	People say I am fun to be around		People have mentioned I am a challenging person

Activity – Determining Your Markets

Now that you've been introduced to the various kinds of markets, use your understanding of each market plus your understanding of your personality and place an "X" in the blank box to the left of each market type to indicate which markets fit your farm marketing personality.

Direct to Customer Market Types		Wholesale Market Types	
	Agritourism		Grocery Store
	Pick Your Own		Institutional Market
	Farmers Market		Aggregator (Food Hub)/Cooperative
	Roadside Stand		Produce Broker
	Community Supported Agriculture		Produce Packing Houses
	Internet Sales		Produce Distributor
	Restaurant		Wholesale Buyer

Market Ease of Entry

You now know which market types appeal to your personality, based on how you scored for both Direct to Customer and Wholesale Market Types. At this point, examine the chart below, which lists each market type in order of how easy it is to enter.

The easiest markets to enter are listed at the top of the chart. The most difficult markets to enter are at the bottom of the chart.

Easier to enter



Harder to enter

Direct to Customer Market Types	Wholesale Market Types
Roadside Stand	Aggregator (Food Hub)/Cooperative
Pick Your Own	Produce Broker
Internet Sales	Wholesale Buyer
Farmers Market	Produce Distributor
Restaurant	Produce Packing Houses
Community Supported Agriculture	Grocery Store
Agritourism	Institutional Market



Fig 11



Choosing Your Markets to Enter

Compare the markets that you find interesting with the ease on entry for each market. Do they align? Is there a middle ground for markets that you want to enter, and markets that will be feasible for you to start out with?

If you have established farm marketing practices currently and are looking for ways to expand your marketing, you may consider the ease of entry less than your interest and personality match.

Lastly, use the chart below and write down which markets you intend to enter, and when.

Example: 1. Aggregator/Cooperative *Enter by Fall of 2022*

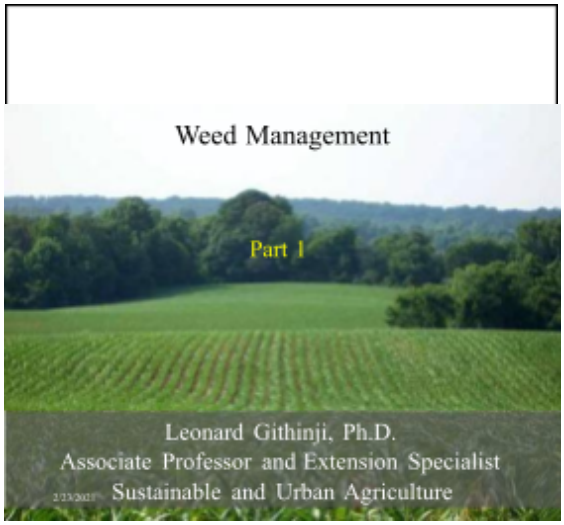
I will enter these markets in the order below:

	Name of Market Type	Estimated Start Date
1		
2		
3		
4		
5		

Summary Description for Module 5

Title:	Module 5: Principles of Weed Management
Instructor:	Dr. Leonard Githinji, Associate Professor - Sustainable & Urban Agriculture
	Not Applicable
Class Time:	12:00PM – 3:00PM
Learning Objective:	Following completion of Module 5, students will learn the principles of weed science including what makes a plant a weed, how weeds compete with crops, the various types of weeds, and the basic methods of weed control. Outside of the traditional classroom setting, students will participate in a field walk in which the students will be introduced to weeds common to Virginia. Students are required to submit a completed weed profile to the Module 5 instructor.
Instructor Media Needs:	Screen Projector Screen to project upon Computer
Class Materials and/or Supplies Needed:	Instructor provided- lecture handouts for note taking
Class Activities:	1. Introduce students to the discipline of weed science 2. Discuss how weeds compete with crops 3. Identify the different types of weeds 4. Present basic methods of weed control 5. Field walk; Identify weeds *in situ*
Knowledge Gained:	Students will learn the fundamentals of weed science
Skills Gained:	Students will gain skills in weed identification and weed management
Abilities Gained:	Students will be able to identify commonly found weeds and employ tactic for control
Exam Description:	Email submission of completed weed profile by the due date.

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What is Weed Science?

discipline that investigates the
ogy and ecology of weeds and how
to manage these plant species for
betterment of mankind.

2/23/2021



What is a Weed?

2/23/2021









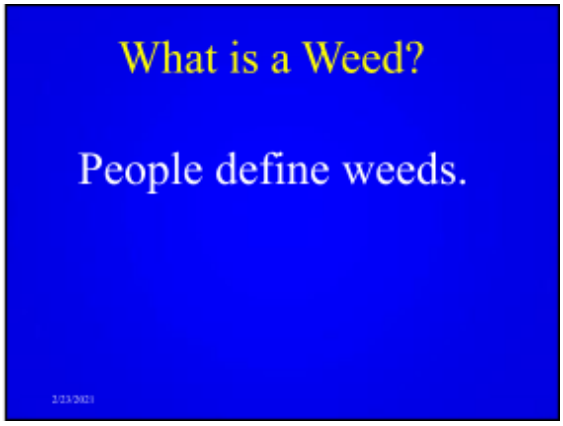











What is a Weed?
People define weeds.



What is a Weed?

Simplistic definitions:

- A plant out of place
- A plant growing where it is wanted















What is a Weed?

Simplistic definitions do not give the real story:

- A plant out of place
- A plant growing where it is not wanted









Characteristics of Weedy Plants

1. Able to colonize disturbed environments; rapid population establishment
2. High reproductive capacity (sometimes multiple methods)
3. Short time to reproduction
4. Germination and reproduction over a range of environmental conditions
5. Seed dormancy; discontinuous germination, seed longevity
6. Presence of vegetative reproductive structures
7. Adaptations for spread (propagule dispersion)
8. Ability to compete well with crops

Losses Caused by Weeds

I. Direct losses

II. Indirect losses

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What is a Weed?

- Weed Science Society of America definition:

  any plant that is objectionable or interferes with the activities or welfare of man.

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Losses Caused by Weeds

I. Direct losses in crops

A. Reduced crop yield

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How Do Weeds Reduce Yield?

I. Competition

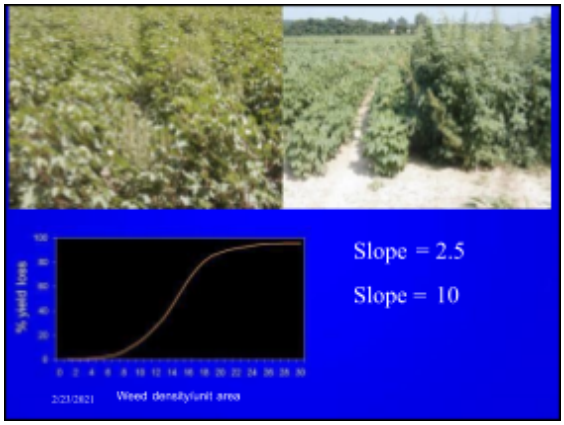
- Finite amount of resources.
- Competition occurs when combined resource demands of crop and weeds exceed available supply.
- Resources used by weeds are unavailable to crop.
- Weeds compete with crops for
  - light
  - Water
  - Nutrients
  - possibly essential gasses or space

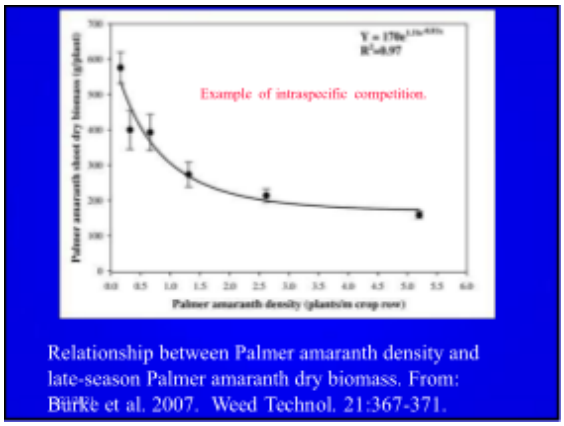
Weeds are undesirable because they cause some type of loss or other problem

How Do Weeds Reduce Yield?

I. Competition

- Competition occurs when combined resource demands of crop and weeds exceed available supply.
- Resources used by weeds are unavailable to crop.
- A few weeds do not cause measurable yield loss.
- As weed density increases, amount of resources used by weeds increase.
- Reach a point where resources become limiting to crop; crop is adversely affected. This is the basis of economic thresholds.





Relationship between Palmer amaranth density and late-season Palmer amaranth dry biomass. From: Burke et al. 2007. Weed Technol. 21:367-371.

Interspecific competition: competition between two or more species

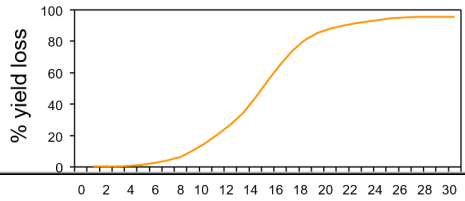
Intraspecific competition: competition within the same species

How Do Weeds Reduce Yield?

II. Allelopathy

- Release of an organic chemical by one plant that adversely affects the growth and development of surrounding plants

Crop yield loss as affected by weed density. Theoretical example.



Weed density/unit area

How Do Weeds Reduce Yield?

II. Allelopathy

- Release of an organic chemical by one plant that adversely affects the growth and development of surrounding plants
- Root exudates or leaf leachates from living weeds
- Release of volatile compounds
- Compounds released from dead weeds as they decay in the soil

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Allelopathy may be useful in weed management systems

1. Allelochemicals in cover crops

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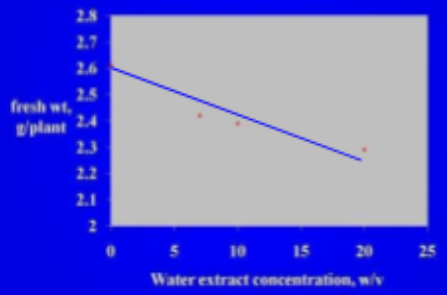


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Effect of water extracts of johnsongrass rhizomes on soybean growth. Lolas, 1979.



Allelopathy may be useful in weed management systems

1. Allelochemicals in cover crops
2. Allelopathic potential of crops may be genetically controlled. Breed/select for cultivars with greater allelopathic potential.

Weed Interference:

collective effects of competition and allelopathy

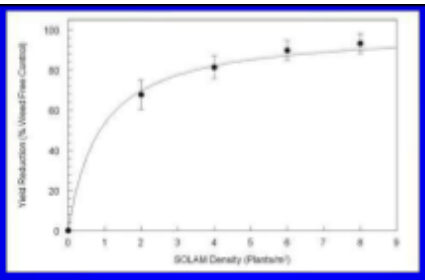
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Examples of weed interference



Extent of weed interference depends upon:

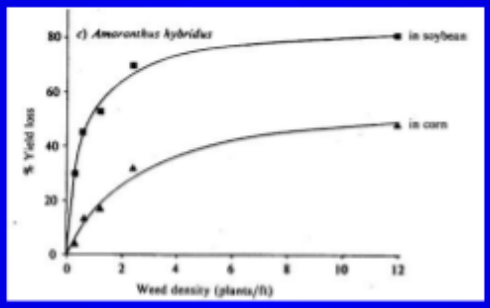
- Crop species
- Crops vary in their competitiveness with weeds
- Within a crop species, agronomic practices, crop genetics, and environment can affect amount of interference
- Weed species and density
- Weed species vary in their competitiveness
- Higher densities exert more influence
- Time and duration of weed presence in crop's crop life cycle



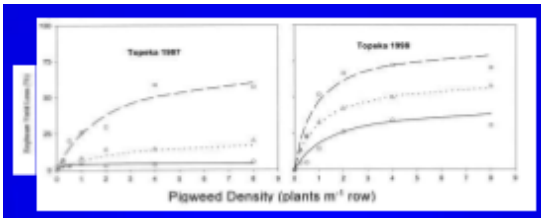
Watermelon yield reduction as affected by season-long interference at different American black nightshade (SOLAM) densities. From: Gilbert et al., 2008. Weed Technol. 22:186-189.

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Example of effect of crop species on interference



Source: Cousens 1985



□ Palmer amaranth
△ Redroot pigweed
○ Livid amaranth

Soybean yield loss as affected by density of three *Amaranthus* species. From: Bensch et al. 2003. Weed Sci. 51:37-43.

Crops do not need to be weed free all season to avoid yield losses

- If good weed control is obtained early in the season, crops lerate weeds emerging at some point later in the season.
- Crops can tolerate weeds for a short period early in the n, assuming they are effectively controlled thereafter.

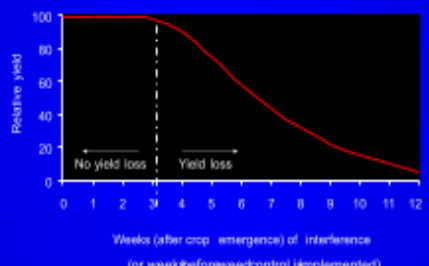
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Crops do not need to be weed-free all season to avoid yield losses

- If good weed control is obtained early in the season, crops can tolerate weeds emerging at some point later in the season.

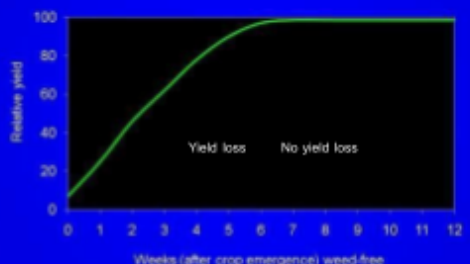
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Hypothetical yield of crop as affected by length of early season weed interference (critical time of removal)



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Hypothetical yield of crop as affected by length of early season weed control (Critical weed-free requirement)



Crops do not need to be weed free all season to avoid yield losses

- Crops can tolerate weeds for a short period early in the n, assuming they are effectively controlled thereafter.
- If good weed control is obtained early in the season, crops lerate weeds emerging at some point later in the season.

✔ ere is a critical period of weed control, or a time when weeds be controlled. When is it?

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Hypothetical example of critical period of weed control.



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Crop competition with weeds can be an important component of a weed management program.

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Effect or row orientation on competition:

ow orientation may affect light interception by crops, but aries with latitude and with the seasonal tilt of the earth in n to the sun. Near the equator, a north-south row ation gives the greatest light absorption for most of the At higher latitudes (up to 55°), absorption is highest in -south crops in summer and east–west crops for the rest year.

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Utilizing crop competition as a weed management tool

Any practice that leads to more a uniform stand of h crop plants that grow off rapidly (get ahead of weeds) w weed suppression.

- Narrow rows
- Denser crop stands
- More equidistant crop spacing
- Good fertility, pH, nematode control, seedling diseas control

Losses Caused by Weeds

I. Direct losses in crops
   A. Yield loss
   B. Reduced Harvesting Efficiency

- 2/23/2021
- 2/23M/202O1 wing height (turf)

Weeds may reduce harvesting efficiency

1. Delayed start of harvest
2. Slower harvest speed
3. Increased harvesting losses
4. Wear and tear on equipment

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Losses Caused by Weeds

I. Direct losses in crops
   A. Yield loss
   B. Reduced Harvesting Efficiency
   C. Reduced Quality of Harvested Crop

Weeds may reduce quality of harvested crop

1. Foreign matter dockage

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Weeds may reduce quality of harvested crop

1. Foreign matter dockage
2. Off-flavors in products made from crop
3. Crop rejected due to toxic weeds
4. Increased moisture content
5. Loss of quality due to delayed harvest

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Losses Caused by Weeds

II. Indirect losses in crops

A. Increased Crop Production Costs

1. Cost of herbicides & application costs (equipment and labor)
2. Other control costs, such as cultivation & additional land prep
3. Management time

Losses Caused by Weeds

II. Indirect losses in crops

B. Damage to crop

1. Herbicide damage to target crop
2. Herbicide damage to other crops due to drift or carryover
3. Mechanical damage
4. Moisture loss from cultivation
5. Enhance other pest problems

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III. Other types of losses by weeds

A. Health hazards to humans, livestock

1. Poisons
   a. Dermal
   b. Internal
2. Allergins

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Losses Caused by Weeds

II. Indirect losses in crops

C. Limited rotational choices

1. Weeds can determine which crops can and cannot be planted due to necessary management strategies.
2. Herbicide program necessary to control weeds in one crop may dictate crops which can and cannot be planted next year.

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Losses Caused by Weeds

II. Indirect losses in crops

D. Weeds may be alternate hosts for other pests

Horsenettle	--	TMV
Johnsongrass	--	MCDV
Sicklepod	--	SCN



III. Other types of losses by weeds

B. Sanitation concerns, such as cover and breeding sites for rodents and snakes





III. Other types of losses by weeds

C. Safety issues

Example: obstruction of traffic signs



II. Other types of losses by weeds

D. Problems in water use

1. Impede flow in drainage and irrigation canals
2. Utilize water intended for irrigation
3. Impede river navigation
4. Interfere with recreational uses of water and aesthetic value of water
5. Fish kills

III. Other types of losses by weeds

E. Aesthetics

Lawns, ornamentals, golf courses

F. Utility of recreational turf





Other Types of Losses Caused by Weeds

G. Maintenance of non-crop areas

roadsides, utility rights-of-way,

electrical substations, farmsteads



III. Other types of losses by weeds

H. Reduced property value



Invasive Weeds

- An invasive weed is one which is introduced, by human activities, into an area where it did not previously occur naturally, becomes capable of establishing a breeding population in the new location without further human intervention, and spreads rapidly throughout the new area.



Invasive Weeds

- Spread rapidly, dominate the habitat
- Cause adverse environmental impacts
  - Destroy wildlife habitat
  - Displace threatened or endangered species
  - Reduce plant or animal diversity
  - Disrupt waterfowl flight patterns, nesting sites
  - Interfere with agricultural production
  - Natural disasters (such as fires)

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Noxious Weeds

- Federal Noxious Weed Act of 1974
- Defined a noxious weed as “any living stage of a parasitic or other plant of a kind which is of foreign origin, is new to or not widely prevalent in the U.S., and can directly or indirectly injure crops, other useful plants, livestock, poultry or other interests of agriculture, including irrigations, navigation, fish and wildlife resources, or the public health.”
- Act gave Sec. of Ag. authority to designated plants as noxious weeds and to enforce associated regulations.
  - Federal noxious weed list presented in your notes.

Invasive Weeds

- Spread rapidly, dominate the habitat
- Cause adverse environmental impacts
  - Economic impacts
    - Reduce crop, pasture, forestry production
    - Reduce property values
    - Reduce recreation value of land (or water)
    - Interfere with irrigation
    - Treatment costs

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Examples of Invasive Weeds

- Johnsongrass
- Japanese stiltgrass
- Kudzu
- Multiflora rose
- Hydrilla
- Water hyacinth
- Tropical spiderwort












Questions?

Principles of Weed Science

Part 2

Basic Weed Biology

Leonard Githinji, Ph.D.
Associate Professor and Extension Specialist
Sustainable and Urban Agriculture

Weed Catergorization

2. By life cycle
   a. Herbacious: non-woody aerial stems that usually die down each year
   b. Woody: woody aerial stems that persist from year to year

Weed Categorization

1. By habitat
2. By life cycle
3. By morphology
4. By anthropocentric values

Weed Catergorization

2. By life cycle
   a. Herbacious
      1. Annuals
      2. Biennials
      3. Perennials
   b. Woody - all are perennial

Weed Catergorization

1. By habitat
   a. Terrestrial
   b. Aquatic

Annual Weeds

Complete life cycle in one growing season

Summer annuals: complete life cycle during period from spring to fall

Winter annuals: complete life cycle during period from fall to spring

Biennial Weeds

- Require 2 growing seasons to complete life cycle
- Seed germinate in spring, summer, or fall of the first year and rosette is formed. Plants overwinter as rosette with a thick storage root.
- After vernalization, the plants flower and produce seed in the summer of the second year and die that fall.

Perennial Weeds

Produce vegetative structures (or propagules) that allow them to live for more than two years without having to reproduce from seed



Perennial Weeds

A. Simple perennials
B. Creeping perennials

Biennial Weeds

Seldom a problem in conventionally tilled systems.

Perennial Weeds

Simple perennials: overwinter by means of a vegetative structure, such as a perennial root with a crown, but reproduce new plants almost entirely by seed. Do not spread by means of vegetative structures.



Weed Catergorization

3. By morphology
   a. Monocots
   b. Dicots

Perennial Weeds

Creeping perennials: can overwinter and produce new plants from vegetative reproductive structures. Most can also reproduce from seed.

Monocots

- Seedlings bear only one cotyledon (seed leaf)
- Parallel leaf venation (in most cases)
- Includes following botanical families:

Terrestrial weeds	Aquatic weeds
Gramineae	Typhaceae
Cyperaceae	Najadaceae
Juncaceae	Lemnaceae
Liliaceae	Alismaceae
Commelinaceae	Pontederiaceae
Dioscoreaceae	

Some of our most troublesome weeds are creeping perennials

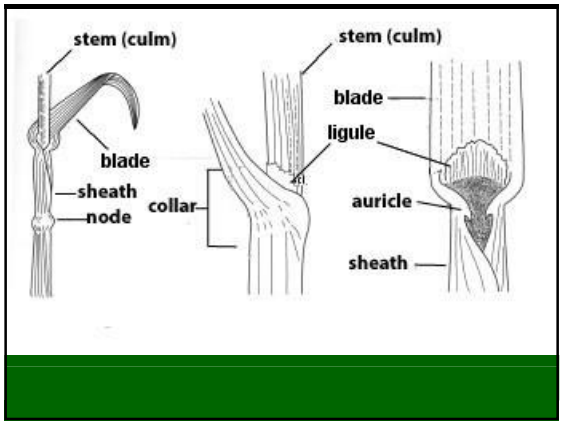
Examples:

- common bermudagrass
- johnsongrass
- yellow and purple nutsedge

Grasses vs Sedges

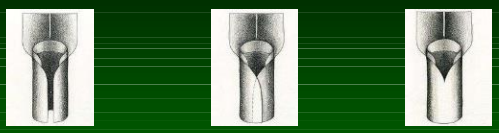
Grasses:
- Usually have a ligule
- Sometimes have an auricle
- Sheath usually split around stem
- Hollow internodes

Sedges:
- Lack ligules and auricles
- Sheath continuous around stem
- Stem triangular in cross section, solid internodes



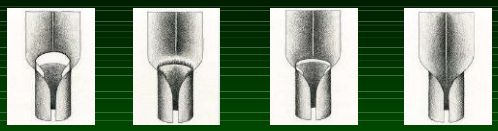
Leaf sheaths

Split Overlapping Fused

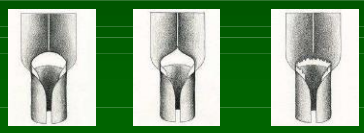


Types of ligules

Membraneous Fringe of hairs Truncate Absent



Rounded Tapered Scalloped or toothed

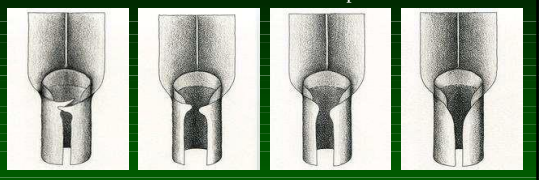


Dicots

- Seedlings bear two cotyledons
- Net-like leaf venation
- Commonly called broadleaves
- Numerous botanical families with "weedy" species

Auricles

Claw-like Rounded Not fully developed Absent



Weed Propagation

1. Sexual
2. Asexual

Methods of Weed Propagation

A. Sexual Reproduction:

1. Flowers and pollination, seed production
2. Weedy species prolific seed producers
3. Annuals, biennials, simple perennials reproduce entirely this way
4. Creeping perennials may also reproduce sexually

Rhizome vs Root

Rhizome: Rhizome has nodes, internodes, and scale leaves

Root: Roots do not have nodes or leaves

Methods of Weed Propagation

B. Asexual Reproduction:

1. New plants develop from vegetative reproductive structures
2. Flowering and seed production not involved
3. Confined to creeping perennials



Vegetative Propagules

A. Rhizome:

Horizontal, underground stem which roots and develops new shoots at the nodes



Vegetative Propagules

B. Stolon:

Above-ground stem that grows flat on the ground, roots and develops new shoots at the nodes





Vegetative Propagules

C. Tuber:

Enlarged terminal portion of a rhizome which acts as a storage organ.

Has axillary buds.





Vegetative Propagules

D. Bulb:

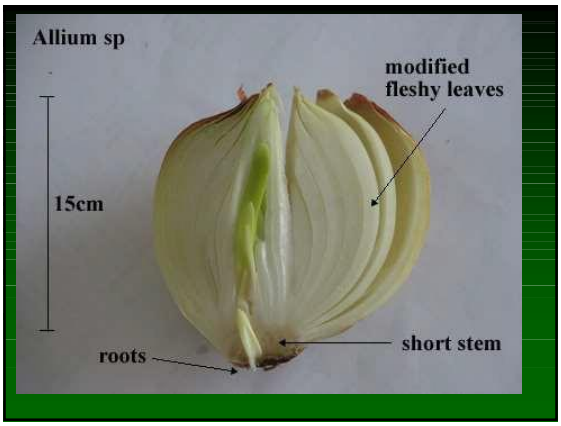
Underground modified storage organ consisting of a short, fleshy, usually vertical stem axis and fleshy scale leaves

Thick, fleshy scale leaves enclose a bud











Vegetative Propagules

E. Creeping Roots:

Deep, horizonital roots modified for food storage and vegetative reproduction

Weed Seed Dispersal

A. Natural mechanisms

1. Wind

a. Seed blown by wind

i. Some species have adaptations on seed to aid in wind dispersal

b. Whole plant moved by wind





Methods of Weed Dissemination

Shields, E.J., J.T. Dauer, M.J. VanGessel, and G. Neuman. 2006. Horseweed (*Conyza canadensis*) seed collected in the planetary boundary layer. Weed Sci. 54:1063-1067.

Altitude (ft)	Seeds found (#/1000 m^3)*
230	3.3
460	1.7

* Approximately 33 by 33 by 33 ft

Weed Seed Dispersal

A. Natural mechanisms
   1. Wind
   2. Water
      a. Water runoff and erosion
      b. Streams and flooding

Artificial Seed Dispersal

Resulting from man's activities

Weed Seed Dispersal

A. Natural mechanisms
   1. Wind
   2. Water
   3. Animals
      a. Mucilaginous seed coats
      b. Hooks, barbs
      c. Pass through digestive track

Artificial Seed Dispersal

1. Movement on equipment

Weed Seed Dispersal

A. Natural mechanisms
   1. Wind
   2. Water
   3. Animals
   4. Forceful dehiscence

Artificial Seed Dispersal

1. Movement on equipment

2. Movement in crop seed
   Weed seeds that mimic the crop in shape or size are more difficult to separate from crop seed

Seed Laws

1. Enacted to prevent movement of weed seed in crop seed.
2. Federal Seed Act of 1939
3. Federal Noxious Weed Act of 1974
4. Plant Protection Act of 2000
5. North Carolina Seed Law of 1963

Artificial Seed Dispersal

1. Movement on equipment
2. Movement in crop seed
3. Movement in livestock feed, hay, manure
4. Others, such as moving soil for construction and landscaping, use of weedy plants in floral arrangements, use of weedy plants in water gardens, movement of aquatic weeds on boat propellers, etc.

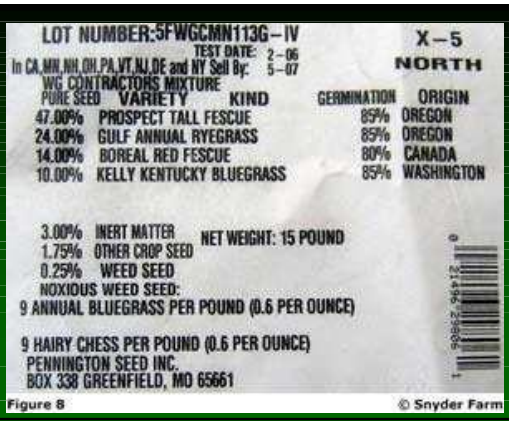


Figure 8 © Snyder Farm

Vegetative Propagule Dispersal

A. Natural mechanisms
   1. Encroachment, short distance
      a. single yellow nutsedge plant can lead to 150 tubers and infested area 6 ft diameter in one year
      b. single johnsongrass plant can lead to 200+ ft of rhizomes per year and infested area 10-12 ft diameter
B. Artificial mechanisms

Artificial Seed Dispersal

1. Movement on equipment
2. Movement in crop seed
3. Movement in livestock feed, hay and straw, manure

Vegetative Propagule Dispersal

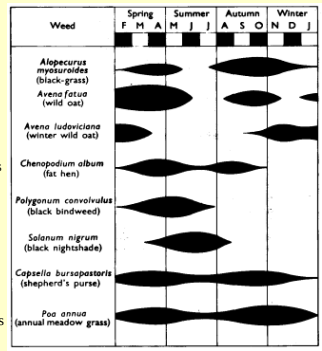
A. Natural mechanisms
B. Artificial mechanisms
   1. Man's activities; physical movement
   2. Short or long distance
   3. Examples: movement on and by equipment; movement in construction and landscaping; movement in nursery stock

Germination and Dormancy

Weed Emergence Periodicity

c. lambsquarters

annual bluegrass



Source: Roberts et al. 1968, as modified by Hill 1977

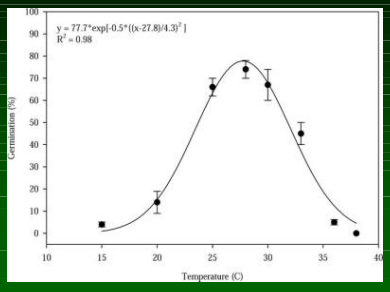
External Factors Regulating Seed Germination

1. Water
2. Oxygen
3. Temperature
   a. Max, minimum, optimum; varies by species
   b. Explains periodicity of germination

External Factors Regulating Seed Germination

1. Water
2. Oxygen
3. Temperature
   a. Max, minimum, optimum; varies by species
   b. Explains periodicity of germination
4. Light (required by some species)
5. Chemical germination stimulate from host plant for parasitic weeds

Effect of constant temperature on cumulative germination of doveweed over 14 days. Wilson et al., 2006.



Enforced Dormancy (quiescence)

- Seed capable of germination (not dormant) but does not germinate because environmental conditions not suitable
- Survival mechanism

Dormancy

- Inactive state in which seed will not germinate even though environmental conditions are favorable.
- Due to factors internal to the seed.
- Survival mechanism; ensures reservoir of ungerminated but viable seed for future years

Mechanisms of Dormancy

1. Impermeable seed coat
2. Hard seed coat
3. Immature embryo
4. Hormonal balance - Must have a critical level of "germination-promoting" hormones; "germination-inhibiting" hormones must drop below critical level. After-ripening requirement in some species associated with formation of germination-promoting hormones. Annual grasses.

Germination inhibitors may be leached out of seed.

Mechanisms of Dormancy

1. Impermeable seed coat - seed coat will not allow water or oxygen to enter seed; velvetleaf
2. Hard seed coat - seed coat is permeable to water but too strong to be broken by force of swelling; restricts imbibition of adequate water; pigweed species

---

Dormancy due to above two factors can be overcome by damage to seed coat, such as by abrasion from tillage or attack by soil micro-organisms. Alternate wetting and drying may also break dormancy due to hard seed coat.

Beale's Study

- Buried seed of 20 species
- Extracted seed at various time intervals, checked germination

Mechanisms of Dormancy

1. Impermeable seed coat
2. Hard seed coat
3. Immature embryo - seed shed before embryo is fully developed. Embryo continues development after seed shed. Smartweed species.

Beale's Study

After 40 years, some seed of the following still viable:

redroot pigweed	prostrate pigweed
common ragweed	black mustard
Virginia pepperweed	eveningprimrose
broadleaf plantain	common purslane
curly dock	

Beale's Study

After 80 years, some seed of the following still viable:

- eveningprimrose
- curly dock
- common mullein

Implications of Dormancy

- In agricultural systems, dormancy shorter than in burial studies
- Allowing weeds to go to seed ensures problems for years to come
- It is job security for a weed scientist

Questions???

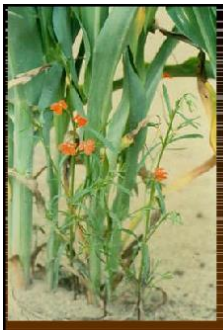


Principles of Weed Science

Part 3

Methods of Weed Control

Leonard Githinji, Ph.D.
Associate Professor and Extension Specialist
Sustainable and Urban Agriculture



Witchweed (*Striga asiatica*)

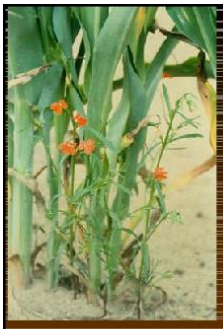
- Parasitic on grass crops and weeds

Food crops	Forages	Weeds
Corn	Millets	Crabgrass
Barley	Orchardgrass	Goosegrass
Oats	Sudangrass	Crowfootgrass
Rye	Ky bluegrass	Johnsongrass
Rice	Switchgrass	Barnyardgrass
Sugarcane	Others	Others
Sorghum		

Methods of Control

A. Eradication

- Complete kill or removal of a weed species from a defined geographical area; includes elimination of ungerminated seed and vegetative propagules
- Infers that the weed will not reappear unless introduced into the area.
- The ideal of weed control but rarely achieved



Witchweed (*Striga asiatica*)

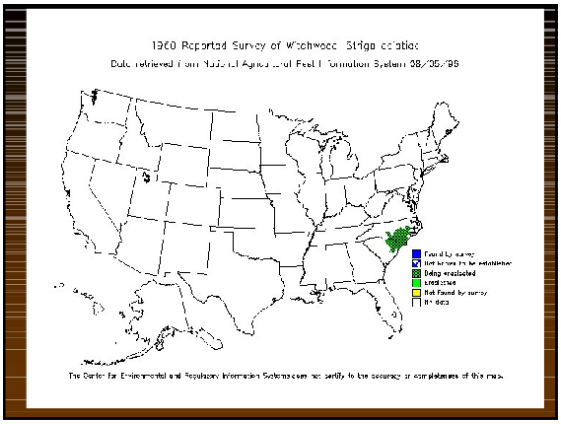
- Parasitic on grass crops and weeds
- Native to Africa and Asia, particularly problematic in sub-Saharan Africa and India.
- Still considered greatest biological constraint to cultivation of cereal crops in sub-Saharan Africa.
- Hemiparasitic: has chlorophyll and can fix CO_2, depends on host for water and nutrients.
- Requires chemical signal from host to germinate. Attaches to host roots via haustoria. Has roots but non-functional.

Why is Eradication of Weeds Not Common?

1. Very difficult, very expensive
2. Obstacles to eradication:
   - prolific seed production
   - long life of seed
   - numerous methods of dispersal
   - difficulty of avoiding reinfestation
3. Practical only in cases where there is a small isolated area and the weed is a serious threat.
   Examples: witchweed, itchgrass, bengal dayflower (tropical spiderwort).

Witchweed Eradication

- Found in US (NC) in 1955
- Initially found in 39 counties in NC and SC; 425,000 acres
- Source of introduction never established
- If reached Corn Belt, lose estimated at 10% of crop
- Congress allocated funding for eradication in 1957; USDA-APHIS responsible for eradication program.



If we can't eradicate weeds, what can we do?

We manage them.

Witchweed Eradication Methodology

Three phases:

1. Survey to find and map infestations
2. Containment (quarantines to prevent human spread to non-infested areas)
3. Control (stop seed production; destroy seed already in soil)
   - Herbicides (phenoxies and diphenylethers)
   - Fumigation (methyl bromide)
   - Suicidal germination (ethylene)

Weed Management

Limiting weed population to a level that will not cause economic damage or other loss of value

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   - prolific seed production
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   - numerous methods of dispersal
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3. Practical only in cases where there is a small isolated area and the weed is a serious threat.

How Do We Manage Weeds?

What methods are at our disposal?

Weed Control Methods

A. Prevention

steps taken to prevent introduction, establishment, and/or spread of a specified weed species into an area not currently infested with that species

Examples of Prevention

1. Use of weed-free crop seed
2. Clean equipment before moving from infested to non-infested fields
3. Weed-free irrigation water

Examples of Prevention

1. Use of weed-free crop seed

Survey in Kansas in 1984 showed that weed seed were present in up to 39% of grower-saved wheat seed.

Survey in Victoria, Australia in 1996-97 showed >15 weed seed/kg wheat seed in 36% of grower-saved seed.

State and national seed laws focused on preventing weed spread via crop seeds

Examples of Prevention

1. Use of weed-free crop seed
2. Clean equipment before moving from infested to non-infested fields
3. Weed-free irrigation water
4. Avoid hay, livestock feed, or manure containing seed of species currently not on farm

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Examples of Prevention

1. Use of weed-free crop seed
2. Clean equipment before moving from infested to non-infested fields
3. Weed-free irrigation water
4. Avoid hay, livestock feed, or manure containing seed of species currently not on farm
5. Preventing introduced weeds from going to seed; preventing seed production on field borders
6. Caution in buying used equipment

Weed Control Methods

B. Mechanical Control

Use of a tool or machine

to remove weeds (includes hand weeding)



Weed Control Methods

B. Mechanical Control

1. Hand removal
   a. Limited use in agronomic crops; too expensive (exception is Palmer amaranth in southern US
   b. More use in high-value crops
   c. Widely used in developing countries



Weed Control Methods

B. Mechanical Control

1. Hand removal

Is it ever feasible in turf?

Weed Control Methods

B. Mechanical Control
   1. Hand removal
   2. Tillage
      - Primary (seed bed preparation)
      - Secondary (in-crop cultivation)



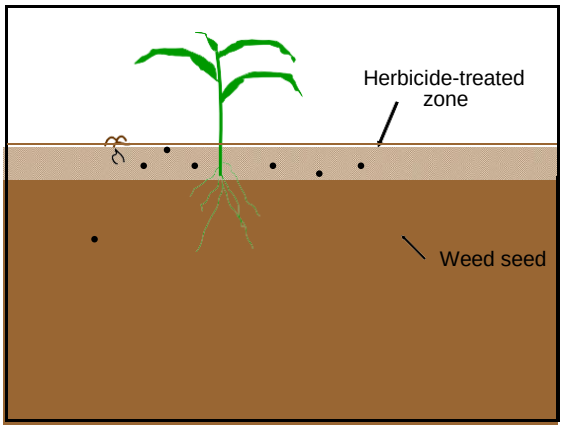
Primary Tillage



Cultivation

1. Works best on hot, dry soils
2. Cultivate shallow to avoid crop root damage, and to avoid bringing up untreated soil from below the herbicide-treated zone





Problems with Cultivation

1. May not be effective on weeds in crop row
2. Weather may prevent timely use
3. May promote weed germination
4. Depletes soil moisture
5. Can cause physical damage to crop
6. May enhance disease problems; especially a problem in peanuts



Weed Control Methods

B. Mechanical Control
   1. Hand removal
   2. Tillage
   3. Mowing

Mowing for Weed Control

1. More effective on tall-growing weeds.
2. More effective on broadleaves than than grasses; grasses have protected growing point.
3. For perennials, most effective when food reserves (stored carbohydrates) are low, which is usually near bud time.

Mowing for Weed Control

1. More effective on tall-growing weeds.
2. More effective on broadleaves than than grasses; grasses have protected growing point.

Carbohydrate content in rhizomes



Carbohydrate content in rhizomes





Weed Control Methods

B. Mechanical Control
1. Hand removal
2. Tillage
3. Mowing
4. Mulching

Weed Control Methods

B. Mechanical Control
1. Hand removal
2. Tillage
3. Mowing
4. Mulching
5. Burning, heat

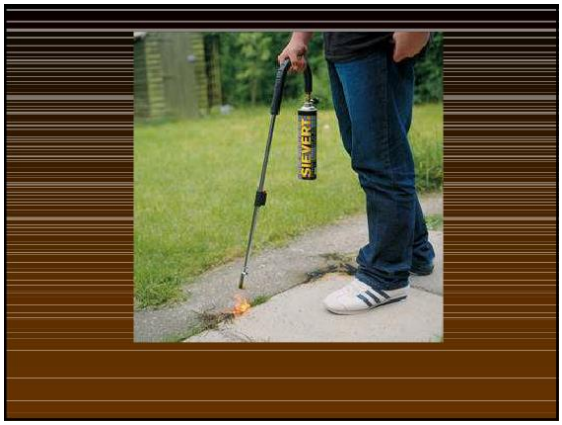
Mulching

- **Goal is to exclude light**
- **Black plastic, sawdust, wood chips, paper, straw, grass clippings, etc.**
- **Used in vegetable crops, ornamentals, home gardens, etc.**
- **Cost of disposing of non-biodegradable materials**
- **Not practical in agronomic crops**
  (except cover crop residue)

Burning for Weed Control

1. Flaming
   a. Once used on railroads
   b. Flame cultivation in crops







Burning for Weed Control

1. Flaming
   a. Once used on railroads
   b. Flame cultivation
   c. Flaming sidewalk cracks
   d. Steaming sidewalk cracks
2. Steam sterilization

Burning for Weed Control

1. Flaming
   a. Once used on railroads
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Burning for Weed Control

1. Flaming
   a. Once used on railroads
   b. Flame cultivation
   c. Flaming sidewalk cracks
   d. Steaming sidewalk cracks
2. Steam sterilization
3. Burning off wheat fields

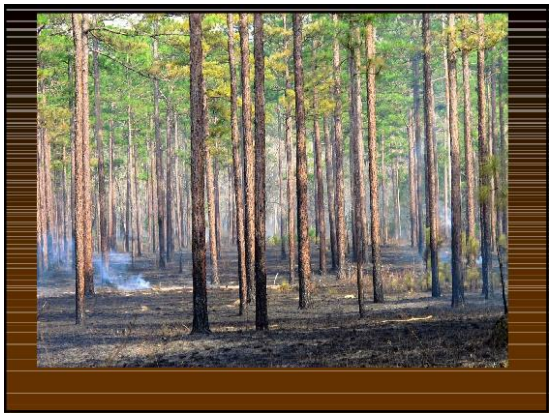
Burning/Heat for Weed Control

1. Flaming
   a. Once used on railroads
   b. Flame cultivation
   c. Flaming sidewalk cracks
   d. Steaming sidewalk cracks
2. Steam sterilization
3. Burning off wheat fields
4. Soil solarization





Soil solarization



Weed Control Methods

C. Cultural Control

practices that make conditions more favorable for crop, less favorable for weeds

Weed Control Methods

C. Cultural Control

1. Crop competition
2. Crop rotation
3. Cover crops
4. Water management

Effect of Row Spacing on Weed Management

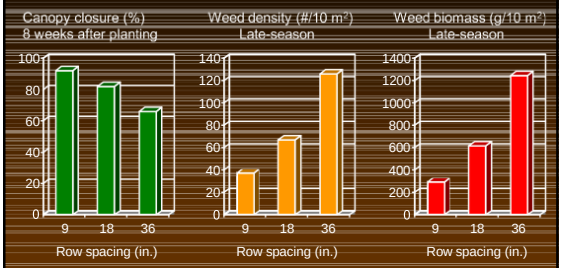
- Narrow rows have little effect on initial weed emergence
- Narrow rows give quicker canopy closure (i.e., shade), and shade impacts later weed emergence

Using Crop Competition for Weed Control

Anything to give crop an edge over weeds, to get crop ahead of weeds, to promote shading by the crop

- Good seed, good seedbed, seeding rate, uniform stands
- Fertilization and liming
- Disease and nematode control
- Early season insect control
- Cultivar selection

Effect of soybean row spacing on weed resurgence following POST application of non-residual herbicide.



Yelverton and Coble, 1991.

Using Crop Competition for Weed Control

Anything to give crop the edge over weeds, to get crop ahead of weeds, to promote shading by the crop

- Good seed, good seedbed, seeding rate, uniform stands
- Fertilization and liming
- Disease and nematode control
- Early season insect control
- Cultivar selection
- **NARROW ROWS**

Weed Control Methods

C. Cultural Control

1. Crop competition
2. Crop rotation
3. Cover crops
4. Water management

Crop Rotation as a Weed Control Tool

- Good overall practice; results in healthier crops which in turn compete better with weeds

Impact of Crop Rotation on Chemical Weed Control

- Crop rotation allows herbicide rotation
  - Broader spectrum, better long-term control
  - Helps avoid weed population shifts

Crop Rotation as a Weed Control Tool

- Good overall practice; results in healthier crops which in turn compete better with weeds
- Given weeds tend to be associated with given crops; rotation breaks that cycle

Weed Population Shift

- Change in species composition of a weed population over time
- Occurs in response to management practices, especially herbicide use

Crop Rotation as a Weed Control Tool

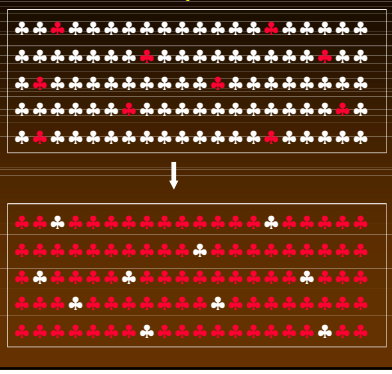
- Good overall practice; results in healthier crops which in turn compete better with weeds
- Given weeds tend to be associated with given crops; rotation breaks that cycle
- CROP ROTATION HAS MAJOR IMPACT ON CHEMICAL CONTROL

Weed Population Shift



If a particular herbicide controls ♣ very well, but gives poor control of ♣, what happens over time if that herbicide is used annually?

Weed Population Shift





Examples of Weed Population Shifts

- Fall panicum after extensive use of atrazine
- Broadleaf signalgrass after extensive use of Lasso
- Prickly sida after extensive use of Classic
- Morningglory and dayflower after extensive use of glyphosate in RR crops

Impact of Crop Rotation on Chemical Weed Control

Crop rotation allows herbicide rotation

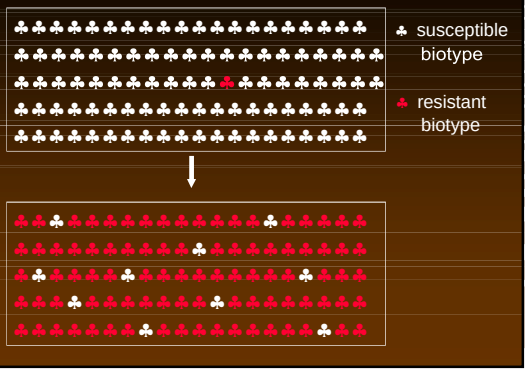
- Broader spectrum, better long-term control
- Helps avoid weed population shifts
- Helps avoid herbicide resistance

Weed Population Shifts Due To:

- Herbicide programs
- Tillage practices

(example: perennials in continuous no-till)

Weed Resistance

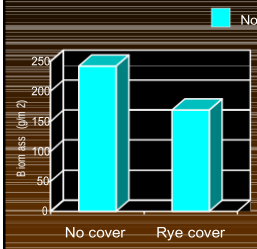


Weed Control Methods

C. Cultural Control

1. Crop competition
2. Crop rotation
3. Cover crops
4. Water management

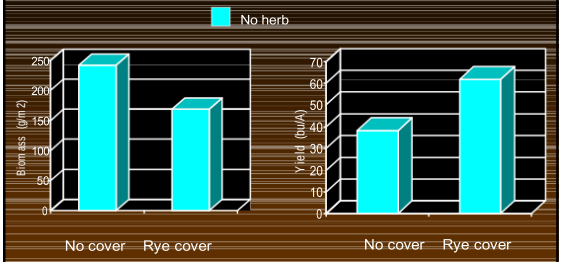
Effect of rye cover crop and herbicides on late-season weed biomass and grain yield of no-till corn.



Yenish, Worsham, York, 1996



Effect of rye cover crop and herbicides on late-season weed biomass and grain yield of no-till corn.



Yenish, Worsham, York, 1996

Cover Crops as a Weed Management Tool

- Small grains most common; some legumes also used
- Usually killed before planting crop of interest
- "Chokes" out weeds before planting crop of interest
- After cover crop killed, residue can exclude light, provide physical barrier, release allelochemicals

Weed Control Methods

C. Cultural Control

1. Crop competition
2. Crop rotation
3. Cover crops
4. Water management

Water Management as a Weed Control Tool

- Flooding in rice; weeds deprived of oxygen
- Water deprivation on weeds
- Timely irrigation may make crop more competitive

Weed Control Methods

D. Biological Control

- Use of living organism to control weeds
- Examples: insects, fungi, animals such as geese, sheep, hogs, fish



Harrington Seed Destructor



Weed Control Methods

D. Biological Control

use of living organism to control weeds

Pathogens as Biocontrol Agents

1. Classical approach

   initial inoculation with self-sustaining pathogenic fungi

2. Mycoherbicide approach

   annual application of pathogenic fungi

Mycoherbicides

- Typically applied as foliar sprays
- Shelf life can be problem
- Use of fungicides on crop limits use of mycoherbicides
- May require specific environmental conditions
- Species specific; what do you do about other weed species in field?

Problems with Biological Control in Intensively Managed Areas

1. Narrow spectrum of control
2. Do not work fast enough to avoid early season weed competition
3. Difficult for biocontrol agent to survive in typical cropping systems
4. Require special handling; poor shelf life
5. Not compatible with other components of pest management required for profitable production

Weed Control Methods

D. Biological Control

- Use of living organism to control weeds
- Examples: insects, fungi, animals such as geese, sheep, hogs, fish
- Control agent must not harm crops and other beneficial organisms
- Fits best in non-intensive systems

Weed Control Methods

E. Chemical Control

use of herbicides to control weeds

Reality of Biological Control

- May fit well in low-input systems, such as rangeland, or in certain situations such as grass carp in ponds
- Generally not practical in typical, intensively managed cropping systems; not a replacement for herbicides

Herbicide Nomenclature

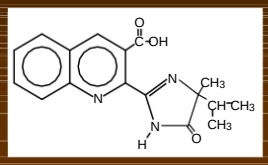
- Trade name
- Common name
- Chemical name

Example of Herbicide Nomenclature

Trade name: Scepter (agronomic crops)
Image (turf)

Common name: imazaquin

Chemical name: 2-[4,5-dihydro-4-methyl -4(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl}-3-quinolinecarboxylic acid



Broad Categories of Herbicides

A. Selective

B. Non-selective



Selective vs. Non-Selective Herbicides

- Selective: kills some species but not others;
  kills weeds, not the crop
- Non-Selective: kills or severely injures most species

Categories of Herbicides

(terminology)

Selectivity is usually rate dependent.

Selective herbicides can be made non-selective by increasing the rate.

Example:

Diuron can be applied preemergence to cotton at 1 to 2 lb a.i. (selective control)

Diuron can be applied at 5 to 15 lb a.i. in non-cropland areas for total vegetation control (non-selective)

Selectivity

- Through genetic engineering, a gene normally not present in a crop can be introduced. This gene can confer resistance to a herbicide that ordinarily would be non-selective on the crop.
- Example: Roundup Ready® crops

Systemic Herbicides

- translocated (moved) within plant
- coverage less critical than for contacts (coverage is always important)
- usually exhibit chronic effects -- kill slowly
- more effective on perennials than contacts
- can be selective or non-selective

Broad Categories of Herbicides

A. Contacts

B. Systemics

Broad Categories of Herbicides

A. Residual

B. Non-residual

Contact Herbicides

- very little translocation within the plant
- destroy only that plant tissue touched by chemical
- good spray coverage essential
- usually exhibit acute effects -- kill rapidly
- effective on annuals, usually ineffective on perennials
- can be selective or non-selective

Residual Herbicide

- Herbicide continues to have activity on weeds for some period of time after application
- Length of time it remains active depends primarily on the chemistry, and secondarily on the rate
- Preemergence or postemergence
- Selective or non-selective

Non-residual Herbicide

- Herbicide has activity only on weeds emerged at the time of application
- Postemergence (to weeds) only
- Can be selective or non-selective

Soil Sterilant

- Chemical applied to soil or soil plus foliage that controls essentially all vegetation for a given period of time
- Length of control varies, depending on chemistry and rate
- Total vegetation control (TVC)
- Nonselective

Questions?

Principles of Weed Science

Part 4

Weed Identification

Leonard Githinji, Ph.D.
Associate Professor and Extension Specialist
Sustainable and Urban Agriculture



Palmer amaranth
Amaranthus palmeri



Identifying characteristics:

- Similar appearance to smooth pigweed.
- Cotyledons: Long narrow
- Petioles on leaves are much longer than other pigweeds. As long as leaf.
- Leaves: glossy in appearance
- Male and female organs are found on separate plants.
- The male flower head is very tall and feels smooth, whereas the female floral stalk is tall and bristly to the touch.

smooth pigweed
Amaranthus hybridus





Identifying characteristics:

- Stems: erect and slender.
- Upper stem is densely hairy and the hairs are short.
- Leaves: simple, alternate, oval to egg-shaped, green above, light green or magneta below
- Leaves: hairy but not as rough as redroot pigweed

Palmer amaranth
Amaranthus palmeri









smooth pigweed
Amaranthus hybridus









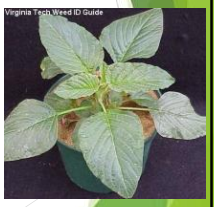


redroot pigweed
Amaranthus retroflexus



Characteristics

- Hypocotyls often without hair and often reddish
- Cotyledons narrow with lower surface reddish
- 1st leaves alternate, ovate in shape, and with distinct notch at tip.
- Leaves: ovate, with petioles about half the length of leaves
- Leaves look like fabric, not glossy, roughly hairy
- Stem: can reach 6.5 ft tall
- Seed: small, round, glossy, black
- Seedhead: dense and compact, much shorter than Palmer amaranth.



Common Lambsquarters
Chenopodium album



- Leaves: Alternate, light green, rounded, triangular, 1 1/4 to 10 inches long and on a long petiole
- Identifying Characteristics: Cotyledons and seedling leaves have a mealy gray cast. Cotyledons of common lambsquarters and Redroot Pigweed (Amaranthus retroflexus) are similar, however redroot pigweed cotyledons have a prominent midvein while lambsquarter cotyledons do not.









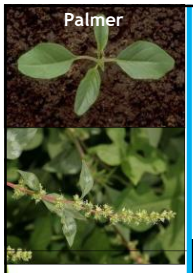
common lambsquarters
Chenopodium album

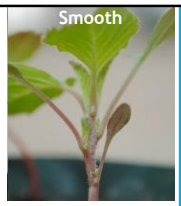


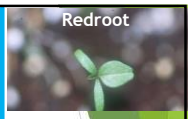




















Common Ragweed
Ambrosia artemisiifolia



Identifying Characteristics:

- **Seedling: Stems below cotyledons (hypocotyls) are green, usually spotted with purple.**
- **Cotyledons are round to oblong, purple underneath. Young leaves opposite, becoming alternate with age, dense pubescence over entire leaf surface.**
- **Fruit: Woody achene, yellowish- to reddish-brown, 3-4 mm long and 1.8-2.5 mm wide, 1-2 mm central protuberance surrounded by 4-7 shorter projections. Resembles a crown.**
- **Cotyledons with purple underside. Fruit an achene resembling a queen's crown**



Common Ragweed
Ambrosia artemisiifolia





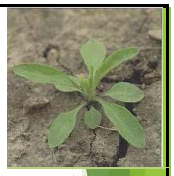
common cocklebur
Xanthium strumarium



Identifying Characteristics:

- **Leaves: Three prominent main veins are evident on upper surface. Leaves are triangular to ovate, pubescent, long petiolated (5-15 cm), and irregularly lobed. First leaves are opposite, subsequent leaves are alternate.**
- **Fruit: Elliptic to egg-shaped two-chambered bur, 1-3.5 cm long, covered with hooked prickles. Two prickles that are longer and wider than the remaining prickles project from the tip of the bur.**
- **Relatively large, waxy lanceolate cotyledons. Stems with maroon to black stem lesions. Characteristic prickly bur fruit.**

horseweed
Conyza canadensis



Identifying Characteristics:

- **Leaves: The mature plant has leaves that are entirely without petioles (sessile).**
- **Leaves are 4 inches long, 10 mm wide, alternate, linear, entire or more often toothed, crowded along the stem, and hairy. Leaves become progressively smaller up the stem.**
- **Erect plants with mature leaves that are entirely without petioles.**
- **When mature, this weed is easily identifiable. However, in the rosette stage of growth, horseweed might resemble other weeds that have this rosette habit, such as Shepherd's-Purse or Virginia Pepperweed.**



common cocklebur
Xanthium strumarium







horseweed
Conyza canadensis



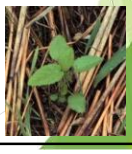




Prickly sida
Sida spinosa

- Weed Description: A summer annual with yellow flowers and very small spines at the base of each leaf and branch. This weed is one of the ten most common and troublesome weeds in peanuts, cotton, and soybeans in most of the southern states.
- Leaves: Arranged alternately along the stem, approximately 3/4 to 2 inches long, and inconspicuously hairy. Leaves are oval to lanceolate in outline with toothed margins. Leaves occur on petioles that are 1/2 to 1 1/4 inches long and have small spines (stipules) that are 5 to 8 mm long at the base of each leaf petiole.





prickly sida
Sida spinosa





velvetleaf
Abutilon theophrasti



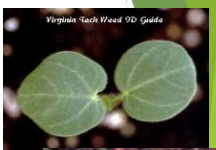


- **<u>Identifying Characteristics</u>:**
- Leaves feel like velvet, have a rounded heart shape.
- One rounded and one heart-shaped cotyledon.
- True leaves with densely hairy and velvety.
- Stem has many small hairs as well.

spurred Anoda
Anoda cristata

<u>Characteristics</u>

- Alternate, triangular-shaped leaves, coarsely toothed
- Can reach 3.5 foot tall
- Hypocotyl green with hairs
- One round and one heart-shaped cotyledon
- Leaves: hairy, triangular, coarsely toothed
- Stipules at base of leaves, resembling spurs
- Stems: hairy
- Flower: between petiole and stem, light blue to lavender
- Fruit: capsule with 10-20 segments with kidney shaped seed





velvetleaf
Abutilon theophrasti



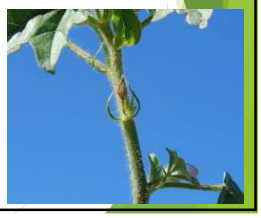








spurred Anoda
Anoda cristata



sicklepod
Senna obtusifolia





<u>Identifying Characteristics</u>:

- **Seedling: Cotyledons are rounded, much more so than the subsequent egg-shaped leaflets. Distinctive veins (3-5) also occur on the cotyledons.**
- **Stems: Erect, branched, and without hairs (glabrous).**
- **Leaves: Arranged alternately up the stem, and consist of 4-6 leaflets that are arranged oppositely from one another (pinnately compound). The basal pair of leaflets smallest, terminal pair largest. Individual leaflets are egg-shaped, with the broadest end above the middle (obovate), 1-3.5 inches long, 0.5-1 inch wide.**



horsenettle
Solanum carolinense





Identifying Characteristics:

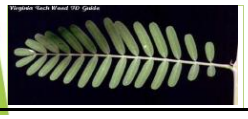
- Leaves: Simple, elliptic-oblong to oval, alternate, petioled, 2.5-4.5 inches long and covered on both surfaces with star-shaped hairs.
- Leaves also emit a potato odor when crushed, and contain prominent prickles (6-12 mm long) on the midvein and petiole.
- Stems and leaves with prickles and star-shaped hairs. Horsenettle might be confused with other solanaceous species like groundcherries
- However, groundcherries do not have prickles on the stems and leaves and have papery membranes enclosing their berries.

hemp sesbania
Sesbania herbacea

Identifying Characteristics

- Cotyledons: spoon-shaped, 1st leaf is simple
- Leaves: 20-70 leaflets, pinnately compound
- Fruit: long slender curved pod, tipped with small beak
- Flowers: yellow





horsenettle
Solanum carolinense







hemp sesbania









Pennsylvania smartweed
Polygonum pensylvanicum





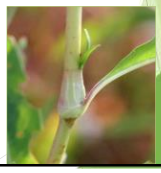
Identifying characteristics:

- Summer annual.
- Stems smooth, swollen at nodes, branching, reddish to purple, one to four feet tall.
- Leaves smooth, pointed, alternate with OCREA surrounding stem.
- Flowers pink on short spike.
- Seed smooth, shiny black.
- Found in wastelands, cultivated fields, ditches.
- Sometimes there is a purple watermark on the leaves.
- Taproot.



Pennsylvania smartweed
Polygonum pensylvanicum



Eclipta
Eclipta prostrata

- Weed Description: A prostrate or erect summer annual to 2 feet in height found in the southern, lower midwest, and east coast states.
- Mature Plant: Leaves are opposite, elliptic to lanceolate either without petioles or with a short petiole, slightly thickened, approximately 1 1/4 to 5 inches long and up to 1 1/4 inches wide, with short, appressed hairs on both surfaces. Leaf margins have widely spaced teeth. Stems initially green, becoming reddish brown, freely branched, and capable of rooting at the nodes.





ladysthumb
Polygonum persicaria

Identifying characteristics:

- Cotyledons are long and tapered leaves have a reddish brown to purple blotch near middle (usually).
- Smooth except for distinct nodes which have a hairy ocrea.
- Flowers are purplish white.
- Its name comes from the purple blotch in the center of the leaf which looks like a lady's thumb print.




Eclipta





ladysthumb
Polygonum persicaria





Common Purslane
Portulaca oleracea

- Prostrate, fleshy, succulent summer annual
- Cotyledons oblong, succulent and without hairs
- Young leaves opposite with each succeeding pair 90 from the preceding pair. Young leaves maroon or maroon-tinted on lower surface.
- Leaves: Alternate or opposite, 1/4 to 1 1/4 inches long, rounded at apex and narrowed to the base (spatulate). Leaves are thick, succulent and fleshy, with smooth margins.
- Stems: Succulent, smooth, prostrate, much-branched, purplish-red or green, 4 to 20 inches long and without hairs.



Common Purslane
Portulaca oleracea

- Flowers: Yellow in color with 5 petals, 5-10 mm wide, that open only when sunny. Flowers are found alone in the leaf axils or clustered at the ends of the branches.
- Identifying Characteristics: Prostrate growth habit in combination with the fleshy, succulent nature of this weed helps to distinguish it from most other plants

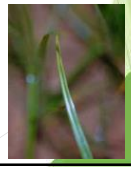




Yellow nutsedge
Cyperus esculentus

- Weed Description: A perennial from rhizomes and tubers that may reach 2 1/2 feet in height. The stems are 3-sided and triangular in cross section and the leaves are yellow to green in color with a distinct ridge.
- Leaves: Yellow to green in color and have a distinctly shiny appearance. Leaves are 5 to 8 mm wide and have a distinct ridge along the midvein. Leaves are produced in groups of 3 from the base of the plant. Leaves are without hairs (glabrous) and no auricles or ligules are present. The leaves of yellow nutsedge taper gradually to a sharp point.





Pink purslane
Portulaca pilosa



Identifying Characteristics:

- Summer annual
- Can reach 8 inches in height
- Low growing and spreading
- Thick fleshy leaves
- Alternate leaves: 1 inch long, linear/oblong in shape with point at the end
- Pink flowers with five petals
- Distinct long white hairs near petiole
- Typical of dry, sandy areas

Purple Nutsedge
Cyperus rotundus

- Leaves: Dark green in color and have a distinctly shiny appearance. Leaves are 5 to 8 mm wide and have a distinct ridge along the midvein. Leaves are produced in groups of 3 from the base of the plant. Leaves are without hairs (glaucus) and no auricles or ligules are present. The leaves of purple nutsedge taper abruptly to a sharp point, unlike the gradual taper of yellow nutsedge leaves.



Pink purslane
Portulaca pilosa







Purple and Yellow nutsedge





wild radish
Raphanus raphanistrum

Characteristics

- Winter annual
- Cotyledons: heart-shaped on petioles
- 1st leaf: hairy, lobed, with toothed margin
- Leaves: develop as a basal rosette of highly lobed leaves
- Basal leaves: elliptic and occur on petioles
- Stem leaves: alterante, lanceolate in outline, toothed margins, and without petioles
- All leaves covered with stiff hairs
- Flowers: distinct small yellow flowers with 4 petals

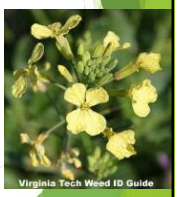












wild mustard
Brassica kaber





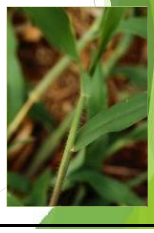
- Mature plant: Flowering stems are erect, stiff hairs on lower portions, leaves alternate and roughly hairy.
- Lower leaves are deep, jagged, irregularly lobed, upper leaves become progressively smaller.
- Flowers: small, have four yellow petals. Form fruit capsules (siliques)
- Seedlings: Cotyledons are kidney-shaped or heart shaped, with a distinct indentation at the cotyledon tip.

large crabgrass
Digitaria sanguinalis



Identifying Characteristics:

- Seedling: Sheaths and blades usually densely hairy, with a jagged membranous ligule.
- Hairs on the blade and sheath are at a 90° angle to the plant surface.
- Seedlings are upright, leaves are rolled in the bud, and the first leaf blade is lanceolate to linear.
- Densely hairy leaf and sheath and relatively large membranous ligule.
- Leaves and sheaths may turn dark red or maroon with age.
- Flowers: Seed head composed of 4-6 branches (spikes) at the top of stems, each 4-18 cm long.
- Spikelets are elliptic and **in two**



wild mustard
Brassica kaber





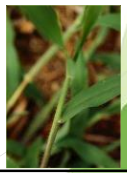


large crabgrass
Digitaria sanguinalis









goosegrass
Eleusine indica



Identifying Characteristics:

- **Leaves: Leaf blades are 2-14 inches long, 3-8 mm wide, without hairs or only sparsely hairy, and folded along the midvein.**
- **The ligule is 1-2 mm long, fringed, uneven, and membranous. Sheaths are flattened, whitish at the base, and sparsely hairy in the collar region.**
- **Flattened stems with a distinctive white or silver center.**
- **Plants often appear compressed to the soil, as if they have been repeatedly stepped on.**

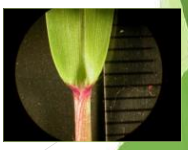


fall panicum
Panicum dichotomiflorum









goosegrass
Eleusine indica









Texas millet
Urochloa texana





Identifying Characteristics:

A summer annual with relatively wide leaves that are covered with soft minute hairs on both surfaces.

Texas panicum is very similar in appearance and growth habit to Broadleaf Signalgrass (*Brachiaria platyphylla*). However, broadleaf signalgrass has hairs only along the leaf margins unlike Texas panicum.

Additionally, the two can be distinguished in the seedling stage by the lack of hairs on the leaves of broadleaf signalgrass compared to the small velvety hairs on both leaf surfaces of Texas panicum.

Texas panicum seedlings also very closely resemble Large Crabgrass (*Digitaria sanguinalis*) in appearance. Once ligules become noticeable, however, the two can be readily distinguished from one another. Large crabgrass has a relatively tall membranous ligule with jagged edges while

Texas panicum has a ligule that is membranous at the base but fringed with hairs on the top.

fall panicum
Panicum dichotomiflorum





Identifying Characteristics:

- A primary identifying characteristic of this grass weed is the 'zigzagged' growth pattern it takes on due to bending at the nodes.
- Seedlings have many hairs on the lower surface of the leaf blades.
- Leaves are rolled in the shoot, the ligule is a fringe of hairs to 2 mm in length, and auricles are absent.
- Leaf blades have a conspicuous midvein and are smooth above but sometimes slightly hairy near the leaf tip or leaf base.
- The lower leaf surfaces of mature plants are without hairs (glaucus

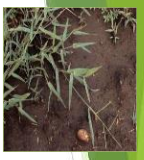
Texas millet
Urochloa texana







broadleaf signalgrass
Brachiaria platyphylla



Identifying Characteristics:

- **Seedling: Leaf sheaths often maroon-tinged and hairy throughout.**
- **Leaf blades are without hairs, except for those that occur on the margins.**
- **Leaf blades may also be maroon-tinged, with a fringed membranous ligule**
- **The relatively broad and short leaves of this grass weed make it easily distinguishable from other grasses.**
- **Additionally, the lack of hairs on leaf blades, rooting stem nodes, and flattened spikelets aide in identification.**



Johnsongrass
Sorghum halepense

Identifying Characteristics:

- **Leaves: Rolled in the shoot, without auricles, with a prominent white midvein. Leaf blades are usually without hairs however some hairs may be present at the base of the leaf blade.**
- **The ligules are membranous, and often toothed at the top. With maturity, some ligules may develop a fringe of hairs in the upper portion of the ligule, and remain membranous towards the base.**
- **Johnsongrass is often mistaken with Barnyardgrass and/or Fall Panicum prior to seedhead formation.**
- **However, johnsongrass has a membranous ligule unlike that of fall panicum or barnyardgrass and johnsongrass seedlings do not have hairs on the lower leaf surface like those of fall panicum.**





Crowfootgrass
Dactyloctenium aegyptium





Identifying Characteristics:

- **Leaves: Blades are 2-30 cm long, 2-9 mm wide, without hairs or less often having long, stiff hairs.**
- **Leaf margins have evenly spaced hairs that point outward.**
- **The ligule is membranous to 1.0 mm long and fringed with hairs (0.8 mm long). Sheaths are without hairs.**
- **Entire plant is most often found without hair, except for the hairs that extend outward from the margins and those found on the ligule.**
- **Seed head resembles a crow's foot.**

Johnsongrass
Sorghum halepense









Crowfootgrass
Dactyloctenium aegyptium









giant foxtail
Setaria faberi



Identifying Characteristics:

- **Leaves: Leaf blades may reach 16 inches in length and 15 to 25 mm in width, and are generally covered with many small hairs on the upper leaf surface, except near the leaf base.**
- **Auricles are absent and the ligule is a fringe of hairs reaching 3 mm in length.**
- **Characteristic foxtail-like seedhead that droops when mature**
- **Giant foxtail may be identified by the presence of many short hairs on the upper surface of the leaf blades, unlike the other foxtails.**
- **Additionally, giant foxtail is generally larger and has a nodding seedhead, unlike the other foxtails.**



giant foxtail
Setaria faberi






yellow foxtail
Setaria glauca



Identifying Characteristics:

- Characteristic foxtail-like seedhead that appears yellow when mature and leaves with long silky hairs at the base only, which helps to distinguish this weed from both Giant Foxtail (*Setaria faberi*) and Green Foxtail (*Setaria viridis*).
- Giant foxtail has many short hairs on the upper surfaces of the leaf blades, unlike yellow foxtail which only has a few long, silky hairs near the leaf base.
- Similarly, green foxtail has no hairs on the leaf blades or at the leaf bases.
- Seedling: Leaves are rolled in the bud, leaf sheaths are without hairs, but the leaf blades have long silky hairs on the upper surface near the leaf base (shown in picture on left).
- The ligule is a fringe of hairs approximately 1/2 mm long, often very difficult to see with the naked eye.

green foxtail
Setaria viridis




Identifying Characteristics:

- Seedling: Leaves are rolled in the bud, leaf sheaths and blades without hairs, but the leaf sheaths often have slightly hairy margins.
- The ligule is a row of hairs approximately 1/2 mm long,.
- The leaf sheath is closed and is without hairs, except along the margin near the mouth.
- Characteristic foxtail-like seedhead and leaves with no hairs, which helps to distinguish this weed from both Giant Foxtail (*Setaria faberi*) and Yellow Foxtail (*Setaria glauca*).

yellow foxtail
Setaria glauca








green foxtail
Setaria viridis





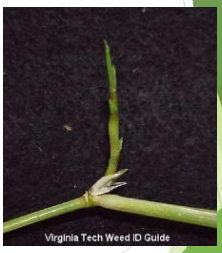

Bermudagrass
Poaceae: *Cynodon dactylon*

- Has rhizomes and stolons that root at the nodes
- Ligule is a fringe of hairs
- Leaves are sparsely hairy above, margins are rough
- Hairy collar region




Bermudagrass
Poaceae: *Cynodon dactylon*





Summary Description for Module 6

Title:	Module 6: Sustainable Soil Management; Urban Soils and Brownfields
Instructor:	Dr. Leonard Githinji, Associate Professor - Sustainable & Urban Agriculture
Prerequisites:	None
Class Time:	9:00AM – 11:30PM & 12:00PM – 3:00PM
Learning Objective:	The student will learn the various sustainable soil management techniques. They will learn about the physical, chemical and biological characteristics of soil and their management for soil fertility and productivity. The concept of "brownfields" and their dangers in urban environments will be discussed.
Instructor Media Needs:	Screen Projector Screen Pointer Computer
Class Materials and/or Supplies Needed:	Instructor provided-Printed copies of class notes with review questions at the end of the chapter (MSWord) PowerPoint slides (in electronic and/or printed format)
Class Activities:	1. Present information on sustainable soil management practices 2. Discuss the various soil physical, chemical and biological characteristics affecting crop production 3. Explore the principle of soil health, fertility, and soil productivity 4. Demonstrate how to do a soil test and how to interpret the results 5. Discuss the concept of "brownfields" and their management.
Knowledge Gained:	Students will gain knowledge on the various soil management techniques
Skills Gained:	Students will gain in-depth skills on methods of enhancing soil health
Abilities Gained:	Students will be able to: i) collect soil samples for soil testing and how to interpret the results; ii) build their own compost pile
Exam Description:	A class quiz will be administered at the end of the class. In addition, a take home exam based on the review questions will be given.

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Sustainable Soil Management;

Urban Soils and Brownfields

Leonard Githinji, Ph.D.
Assistant Professor and Extension Specialist for Sustainable and Urban Agriculture
Virginia State University; (804) 524-5962; lgithinji@vsu.edu

SOIL MANAGEMENT PRINCIPLES

There are several elements that impacts on soil, determining its successful management for crop production:

1. Physical properties of Soil

A. Soil profile

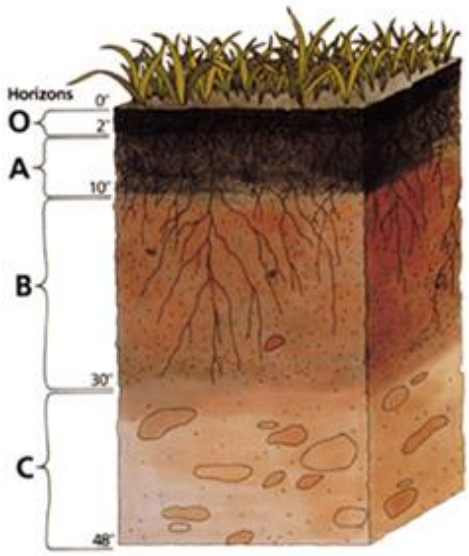


Figure 1: Soil profile

Soil profile refers to the arrangement of soil into **soil horizons**. These horizons are identified by their color and physical characteristics. Other differences include pore size and chemical composition, but they can't be examined without laboratory testing. The horizons are based on the dominant soil forming process occurring in that layer. The Master Horizons or major classifications of soil horizons include:

- O – decomposing plant material.
- A – organic material mixed with minerals.
- B – accumulation of silicate clay, iron, aluminum, carbonates, and or gypsum
- C – has not been much affected by soil formation, may look like the bedrock
- R – Unweathered bedrock.

B. Soil Composition

The basic components of soil are minerals, organic matter, water and air. The typical soil consists of approximately:

- 45% mineral
- 5% organic matter

} Soil Solids

- 20-30% water
- 20-30% air

} Soil Pores

These percentages are only generalizations at best. In reality, the soil is very complex and dynamic. The composition of the soil can fluctuate on a daily basis, depending on numerous factors such as water supply, cultivation practices, and/or soil type.

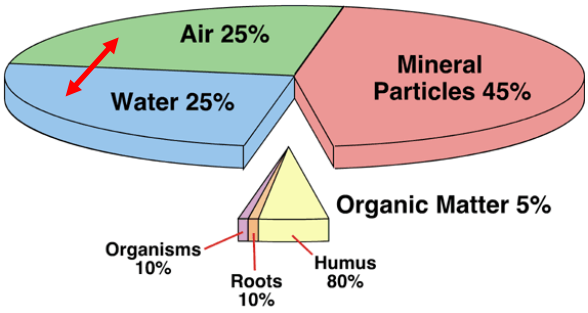


Figure 2: Soil composition

i) Soil Air: The percentage by volume of soil occupied by air under field conditions or at a given suction has been suggested as a measure of soil aeration status. Just like humans, plants need air, both above ground for photosynthesis and in the soil as well. Air in the soil holds atmospheric nitrogen that can be converted into a usable form for plants. Soil oxygen is also crucial to the survival of soil organisms that benefit plants. Good soil provides just the right space between its particles to hold air that plants will use. Silty and heavy clay soils have small particles that are close together. These dense soils have little air. Sandy soils have the opposite problem; their particles are too big and spaced out. The excessive amount of air in sandy soil leads to rapid decomposition of organic matter. Adding organic matter, especially compost, will help balance the air supply.

ii) Soil water: The capacity of soil to hold water is very important. Soil texture, structure and depth determine its moisture retention capacity to meet the crop needs. All forms of life, including plants and soil organisms, need water, but not too much or too little. Healthy soil should be about 25% water. In soils with too much pore space (sandy soils), water quickly drains through and cannot be used by plants.

iii) Soil mineral component: Capacity of the soil to supply essential plant nutrient elements has profound influence on crop production. Soil analysis provides estimates of the levels of available nutrients for determining the suitability of a soil for a particular crop and in formulating more precisely the fertilizer requirements. The inherent capacity of soil to supply amount of adequate nutrients to plants in balanced form is known as soil fertility while soil productivity is the capacity of soil to yield crops per unit area.

iv) Soil Organic matter: Soil organic matter (SOM) is the component of soil consisting of plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by soil organisms. Organic matter can be sub-divided into humus, roots, and living organisms. The most important component of organic matter is humus. This is the biochemical substance that makes the upper layers of the soil become dark. It is colored dark brown to black. Humus provides soil with a number of very important benefits:

- It enhances a soil's ability to hold and store moisture;
- It enhances retention of nutrients from the soil profile;
- It improves soil structure which is necessary for plant growth.

C. Soil texture

Soil texture refers to the relative amounts of sand, silt and clay the soil holds.

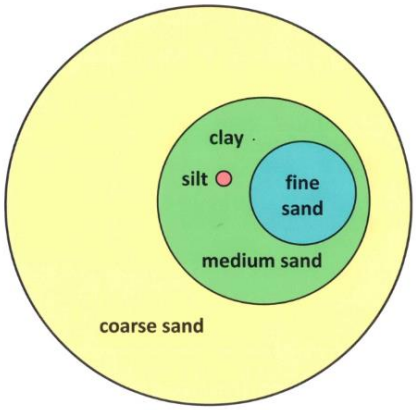


Figure 3: Comparative size of the soil particles

Soil texture is determined through laboratory analysis by Pipette method or Hydrometer methods. However, it can be estimated in the field using the "feel method", where we estimate the amount of sand, silt, and clay.

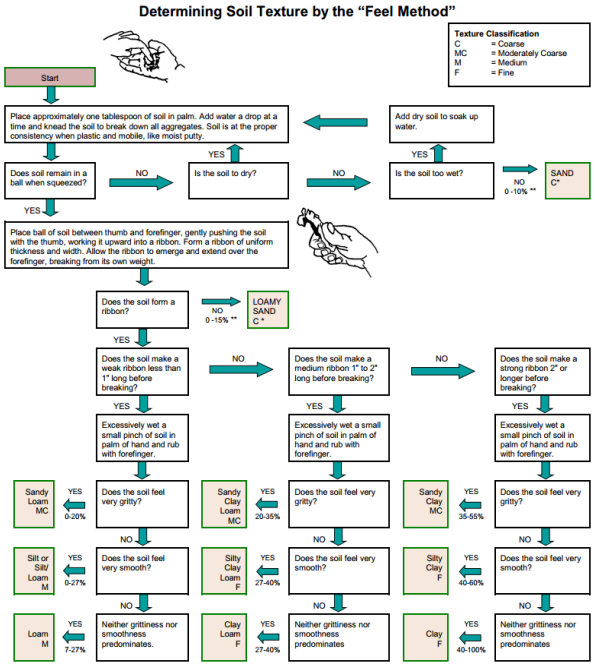


Figure 4: Soil Texture by "feel' method

USDA Soil Textural Classes

The United States Department of Agriculture (USDA) has defined several soil textural classes based on the relative proportions of the various soil separates (sand, silt, and clay). We use the texture triangle to determine the textural class. There are 12 different soil textural classes:

Clay	Silt	Silt loam
Sandy clay	Silty clay loam	Sand
Clay loam	Sandy clay loam	Loamy sand
Silty clay	Sandy loam	Loam

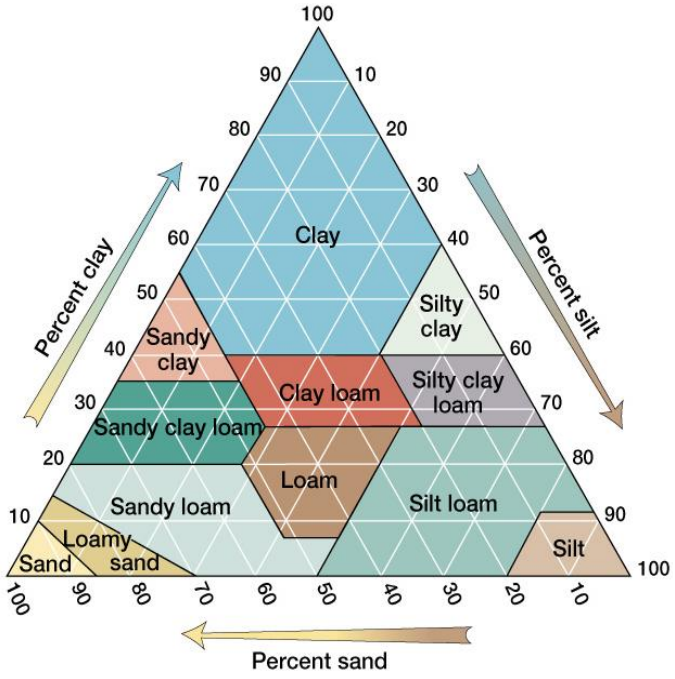


Figure 5: Soil textural triangle

Example: A soil with 40% silt, 30% sand and 30% clay would be <u>clay loam</u>.

<u>Importance of the soil texture</u>

- Soil texture influences soil's drainage characteristics and the risk of erosion.
- Plant roots have a hard time growing in fine-textured soil.
- Sandy soils tend to be nutrient-poor since water and nutrients rapidly drain through the large spaces between the particles of sand.
- Sandy soils tend to be low in beneficial microbes and organic matter that plants need
- Heavy clay soils are quite dense, do not drain well and tend to be hard and crack when dry.

- Because there isn't much space between the clay particles, there usually isn't much air pores.

D. Soil structure

Soil structure refers to the arrangement of soil separates into soil aggregates. Sand, silt, clay, and organic-matter particles in a soil combine with one another to form larger particles of various shapes and sizes. These larger particles, or clusters, are often referred to as aggregates.

The arrangement of the soil particles into aggregates of various sizes and shapes is soil structure. Aggregates that occur naturally in the soil are called peds, whereas clumps of soil caused by tillage are called clods.

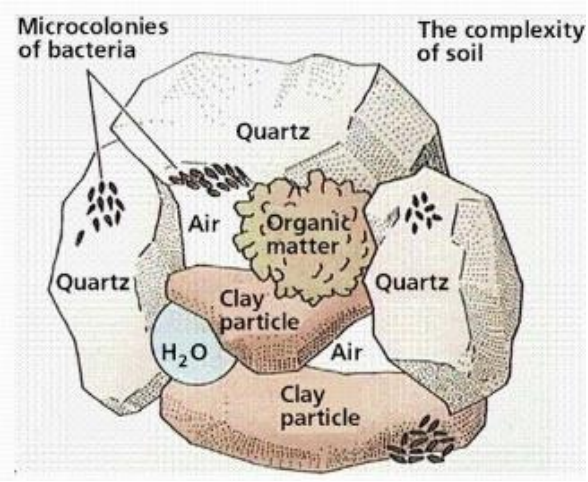


Figure 6: Soil aggregate

Ways in which aggregates are created include:

- freezing and thawing;
- wetting and drying;
- fungal activity; and
- the surrounding of the soil by plant roots that separate the clumps.
- water and air flow

Types of soil structure

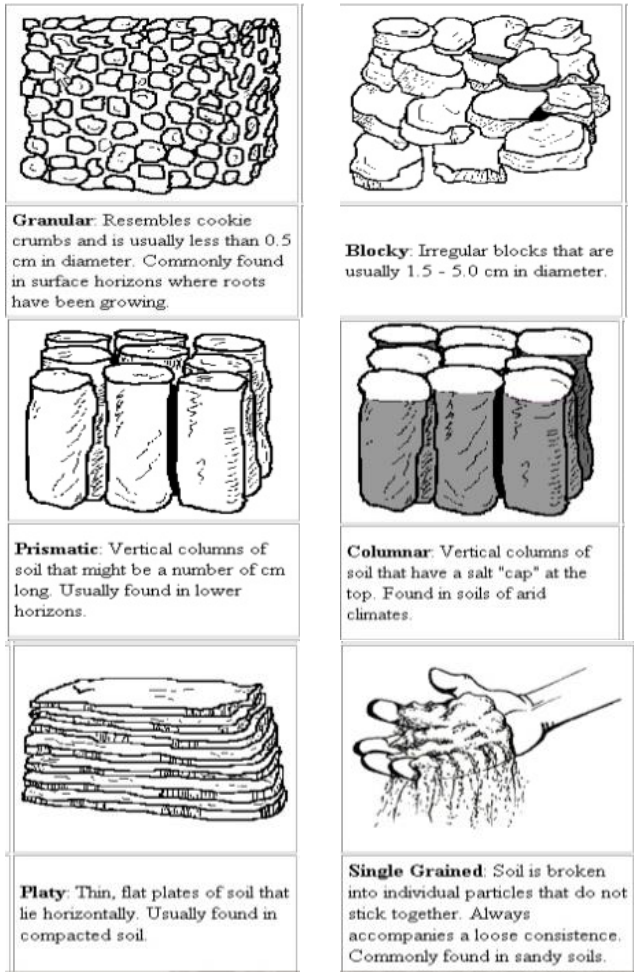


Figure 7: Types of soil structure

The importance of soil structure

- Well-structured soils allow water and air movement and healthy root development.

- Without structure, soils will suffer from anaerobism, waterlogging and nutrient lock-up and, ultimately, plants will die.

- Silty soils are dense and do not drain well. They are more fertile than either sandy or clay soils.

- It provides space for:

    - roots
    - germinating seeds
    - soil fauna (macro and micro)

- It affects farming operations:

    - trafficability of machinery
    - ease of cultivation
    - response of the soil to tillage

- It affects the impact of land use on the environment:

    - amount of run-off and erosion
    - amount of nutrients lost in drainage, run-off and/or erosion from the soil
    - amount of pollutants lost from farms in erosion, run-off and/or drainage.

An example of a well-structured soil is shown in figure 6 while a poorly-structured soil is shown in figure 7.



Figure 6: A well-structured soil



Figure 7: A poorly-structured soil

E. Bulk density

Bulk density is the proportion of the weight of a soil relative to its volume. It is expressed as a unit of weight per volume, and is commonly measured in units of grams per cubic centimeters (g/cc).

Bulk density is an indicator of the amount of pore space available within individual soil horizons, as it is inversely proportional to pore space:

$$Pore\ space = 1 - \frac{bulk\ density}{particle\ density}\frac{g/cc}{g/cc}$$

Pore space = 1 – bulk density/particle density

For example, at a bulk density of 1.60 g/cc, pore space equals 0.40 or 40%. At a bulk density of 1.06 g/cc, pore space equals 0.60 or 60%.

The addition of even a small percentage of organic soil material to a mineral soil can affect the bulk density of that soil. Compare the two soil samples:

Soil “A”: 100% mineral soil material; bulk density = 1.33 g/cc

Soil "B": 95% mineral soil material and 5% organic soil material; bulk density = 1.26 g/cc

The difference in bulk density relates to a difference in "particle density" of mineral soil material versus organic soil material. The average particle density of mineral soil material is 2.65 g/cc, which approximates the density of quartz. Conversely, the average particle density of organic soil material is 1.25 g/cc. Organic soil material weighs less than mineral soil material, so it will lower the bulk density of a mineral soil when added, as it reduces the overall weight of the soil.

As a rule, higher the bulk density, more compact the soil and smaller the amount of pore space. This situation restricts the plant growth due to its influence on root as well as shoot growth. High bulk densities inhibit the emergence of seedlings, increase mechanical resistance to root penetration and decrease the O_2 supply to root in the garden beds. Avoid using heavy equipment that can compact the soil. Avoid working the soil if it is very wet to reduce compaction.

2. Soil Moisture and Plant Growth

i) Water permeability

Permeability is the ability of the soil to transmit water and air. Pore size, texture, structure and the presence of impervious layers such as clay pan determines the permeability of a soil. Clayey soils with platy structures have very low permeability. Permeability is measured in terms of permeability rate or coefficient of permeability (cm per hour, cm per day, cm per sec.). Permeability rate or coefficient of permeability is determined in the laboratory by measuring the rate of flow of water from a constant head of water through a column of soil at specific moisture content and other conditions. It is determined in the field by digging a hole of approximately 30 cm diameter, smearing the sides of the hole with heavy wet clay or lining with plastic sheet and measuring the rate of infiltration of water by filling the hole repeatedly with water and noting the time it takes for the water level to go down by a specific depth.

ii) Soil water status: Content and potential

The state of water in soil is described in terms of the amount of water and the energy associated with the forces which hold the water in the soil.

The amount of water defined by water content and the energy state of the water is the water potential. Plant growth, soil temperature, chemical transport, and ground water recharge are all dependent on the state of water in the soil.

While there is a unique relationship between water content and water potential for a particular soil, these physical properties describe the state of the water in soil in distinctly different manners. It is important to understand the distinction when choosing a soil water measuring instrument.

Soil water content is expressed on a gravimetric or volumetric basis.

Gravimetric water content (θ_g) is the mass of water per mass of dry soil. It is measured by weighing a soil sample (m_{wet}), drying the sample to remove the water, and then weighing the dried soil (m_{dry}).

$$\theta_g = \frac{m_{water}}{m_{dry}} = \frac{m_{wet} - m_{dry}}{m_{dry}}$$

Volumetric water content (θ_v) is the volume of liquid water per volume of soil. Volume is the ratio of mass to density (ρ) which gives:

$$\theta_v = \frac{V_{water}}{V_{soil}} = \frac{\theta_g * \rho_{bulk}}{\rho_{water}}$$

Example: A sample of known volume was weighed before and after oven drying at 105°C for 24 hours. Data for this is shown below: Calculate the gravimetric water content (θ_g), bulk density (ρ_{bulk}) and volumetric water content (θ_v).

m_{wet}	94 g
m_{dry}	78 g
Sample volume	60 cm^3

$$\theta_g = \frac{m_{water}}{m_{dry}} = \frac{94\ g - 78\ g}{78\ g} = 0.205\ g/g$$

$$\rho_{bulk} = \frac{m_{dry}}{V_{soil}} = \frac{78\ g}{60\ cm^3} = 1.3\ g/cm^3$$

$$\theta_v = \frac{\theta_g * \rho_{bulk}}{\rho_{water}} = \frac{\frac{0.205g}{g} * 1.3\ g/cm^3}{1.0 g/cm^3}$$

$$= 0.267 cm^3/cm^3$$

Soil bulk density (ρ_{bulk}) is the ratio of soil dry mass to sample volume. The density of water is close to 1 and often ignored.

$$\rho_{bulk} = \frac{m_{dry}}{V_{soil}}$$

Another useful property, soil porosity (ε), is related to soil bulk density as shown by the following expression:

$$\varepsilon = 1 - \frac{\rho_{bulk}}{\rho_{particle}}$$

The term $\rho_{particle}$ is the density of the soil solid fraction and is approximated by the value 2.65 g/cm^3.

Soil water potential: Available water

Available water capacity is the amount of water that a soil can store that is available for use by plants. It is the water held between **field capacity** and the **wilting point**.

Field capacity is the water retained in a freely drained soil about 2 days after thorough wetting.

The wilting point is the water content at which plants wilt irreversibly.

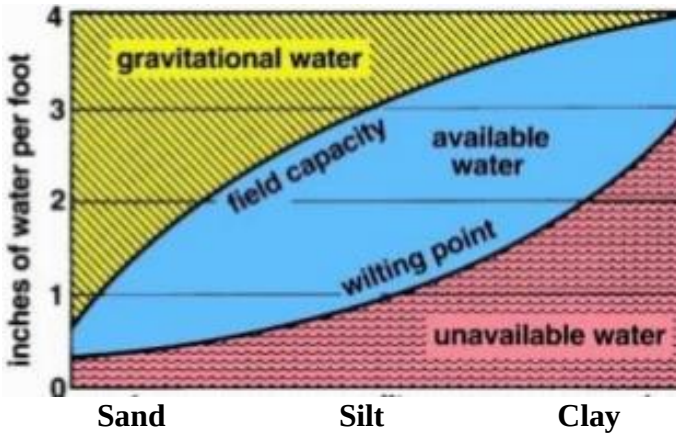


Figure 8: Available water in soil

2. Chemical properties of the Soil

i) Nutrients and soil fertility

There are 17 **essential elements** or nutrients needed for plant growth. Three essential nutrients, namely: Carbon (C), Hydrogen (H), and Oxygen (O_2) are taken up from atmosphere and water. The other 14 essential nutrients are taken up from the soil, and are usually grouped as primary nutrients, secondary nutrients, and micronutrients.

- Macronutrients:
  - C, H, O

- N, P, K (Primary nutrients)
- Ca, Mg, S (Secondary nutrients)
- Micronutrients:
    - B, Cl, Cu, Fe, Mn, Mo, Ni, Zn

Table 1: Essential plant nutrients

ESSENTIAL PLANT NUTRIENTS			
Element	Chemical symbol by crop plants	Chemical forms absorbed	Source
carbon	C	CO_2	air
hydrogen	H	H_2O	water
oxygen	O	O_2, H_2O	air, water
PRIMARY NUTRIENTS			
nitrogen	N	NO_3^-, NH_4^+	soil solids*
potassium	K	K^+	soil solids
phosphorus	P	$H_2PO_4^-$, HPO_4^{2-}, PO_4^{3-}	soil solids
SECONDARY NUTRIENTS			
calcium	Ca	Ca^{2+}	soil solids
magnesium	Mg	Mg^{2+}	soil solids
sulfur	S	SO_4^{2-}	soil solids
MICRONUTRIENTS†			
boron	B	BO_3^{3-}	soil solids
chlorine	Cl	Cl^-	soil solids
copper	Cu	Cu^+, Cu^{2+}	soil solids
iron	Fe	Fe^{3+}	soil solids
manganese	Mn	Mn^{2+}	soil solids
molybdenum	Mo	MoO_4^{2-}	soil solids
nickel	Ni	Ni^{2+}	soil solids
zinc	Zn	Zn^{2+}	soil solids

The *primary nutrients* are commonly found in blended fertilizers such as 10-10-10, or equivalent grades. Primary nutrients are utilized in the largest amounts by crops, and therefore, are applied at higher rates than secondary nutrients and micronutrients.

The s*econdary nutrients* are required in smaller amounts than the primary nutrients. The major source for supplementing the soil with calcium and magnesium is dolomitic lime (Ag-lime), although these nutrients are also available from a variety of fertilizer sources. Sulfur is available in fertilizers such as potassium and magnesium sulfate, gypsum (calcium sulfate), and elemental sulfur.

The *Micronutrients* are required in even smaller amounts than secondary nutrients. They are available in manganese, zinc and copper sulfates, oxides, oxy-sulfates and chelates, as well as in boric acid and ammonium molybdate.

ii) Soil pH

pH is a measure of acidity or alkalinity of a solution that is a number on a scale on which a value of 7 represents neutrality and lower numbers indicate increasing acidity and higher numbers increasing alkalinity. **Each unit of change represents a tenfold change in acidity or alkalinity**.

pH is defined as the negative logarithm of hydrogen-ion concentration or hydrogen-ion activity in gram equivalents per liter of the solution.

Soil pH levels can be critical to your plant's ability to absorb nutrients. Most minerals and nutrients are best available to plants in soils with a pH of between 6.5-6.8.

If your soil is acidic (low pH, at or below 6.0) or alkaline (high pH, above 7.0) it doesn't matter how rich it is in nutrients, the plants won't be able to absorb them.

pH is usually included in a soil test, or you can buy a pH Meter and determine the acid-alkaline balance of your soil on your own.

The best time to get the soil tested is in the spring or fall when it is most stable. This is also the best time to add any soil amendments or organic fertilizer should your soil fall short of minerals or nutrients.

How does pH affect the soil?

Soil pH affects available or unavailable of nutrients. - Most plants thrive in slightly acidic soil because that pH affords them good access to all nutrients.

Soil pH also influences soil-dwelling organisms, whose well-being, in turn, affects soil conditions and plant health. The slightly acidic conditions enjoyed by most plants are also what earthworms like, as do microorganisms that convert nitrogen into forms that plants can use.

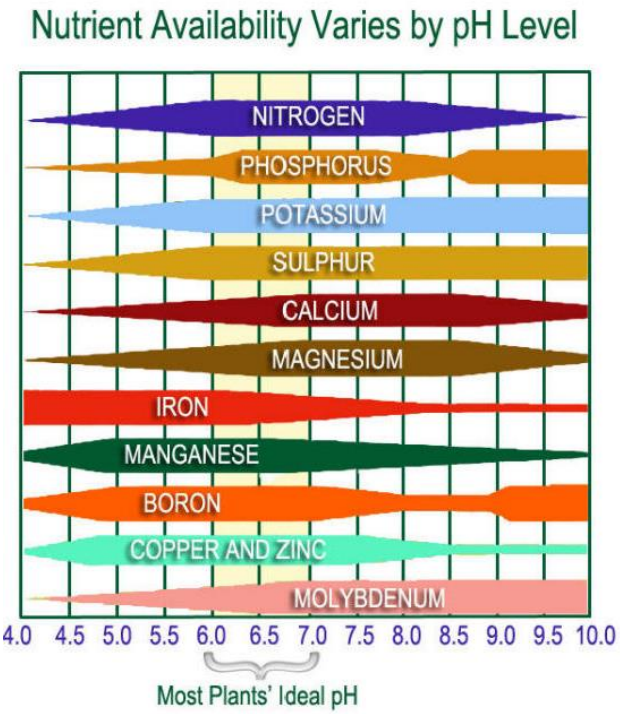


Figure 9: Effect of pH on nutrients availability

Effect of low pH:

-Too low a pH level can render the plant nutrient manganese available at toxic levels.

-A pH level that is too low also liberates aluminum—not a plant nutrient—in amounts that can stunt root growth and interfere with a plant's uptake of nutrients.

-Acid soils with high Fe, Al, and Mn decrease the availability of phosphorus.

-Availability of Mo declines with decrease in pH.

Effect of high pH:

-At a high pH level, the plant nutrient molybdenum becomes available in toxic amounts.

-Iron deficiency: Yellowing between the veins of young leaves maybe an indication an iron deficiency, a condition arising not from a lack of iron in the soil but from insufficient soil acidity to put iron into a form that a plant can absorb.

3. Biological properties of the Soil

-A healthy organism population is essential to healthy soil.
-These little critters make nutrients available to plants and bind soil particles into aggregates that make the soil loose and fluffy.
-Soil organisms include earthworms, nematodes, springtails, bacteria, fungi, protozoa, mites and many others.
-Some of these organisms (ex. earthworms) can be purchased and added to the soil, but unless the environment is suitable for them, they will languish.
-It is better to create an ideal habitat by providing the food (organic matter), air and water they need and let them thrive on their own.

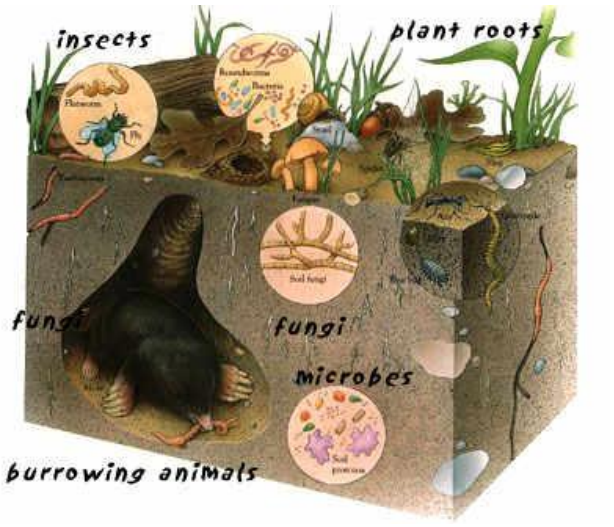


Figure 10: Soil macro and microorganisms

4. Sustainable soil management practices

The best strategy sustainable soil management is to build soil organic matter. Soil organic matter (SOM) is a small portion of soil solid phase. SOM consists of plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by soil organisms.

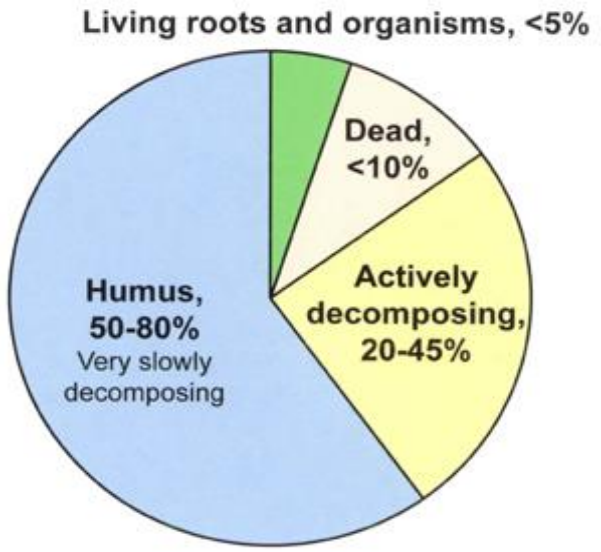


Figure 11: Soil organic matter fraction

- slowly releasing nitrogen, phosphorus, and sulfur over time, which plants then use for growth and development.
- retaining nutrients due to its negative surface charge.

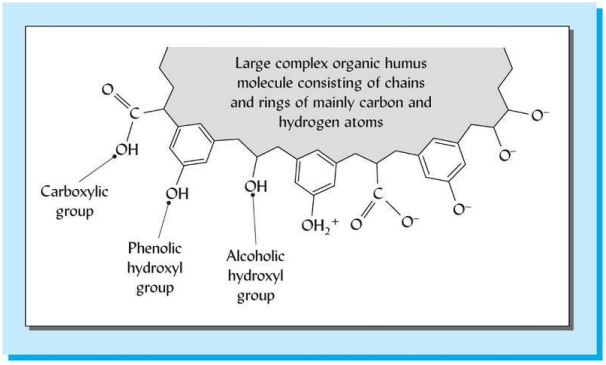


Figure 13: Humus colloid

Humus

Humus is the stabilized organic matter. It's the pool of SOM that has the longest lasting benefits. It's a mix of tiny solid particles and soluble compounds that are too chemically complex to be used by most organisms including:

- sugars
- gums and resins
- proteins
- fats, waxes and lignin.

Humus plays an important role in improving the physical and chemical properties of soil by:

- buffering the soil pH so it remains stable for plant roots.
- binding metals in soil, preventing metal toxicities.
- enhancing soil structure by binding small mineral particles together into larger aggregates creating large soil pores for improved air and water movement.
- improving water retention and release to plants, or plant available water.

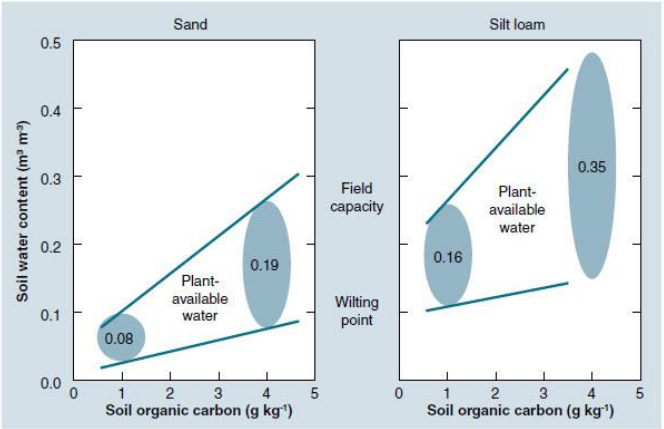


Figure 12 Water retention upon adding humus

Management of soil organic matter

A. Mineralization and immobilization

Mineralization of organic matter involves conversion of organically bound N and S (plant unavailable) to inorganic N (NH_4^+ and NO_3^-) and S (SO_4^{2-}) that plant roots can absorb. It enables plant growth and therefore crop production because, as consequence of the mineralization process, readily available nutrients are released.

Immobilization is the opposite of mineralization. It involves conversion of an element from an inorganic to organic form by microorganisms. If a particular nutrient is limiting to microbial metabolism, nutrients liberated by mineralization or nutrients available from other soil pools will be taken up and retained by the microbial biomass rendering these nutrients unavailable for plant uptake. Thus, under conditions of nutrient limitation, the microorganisms compete with plants for nutrient made available from mineralization, chemical weathering, and atmospheric deposition.

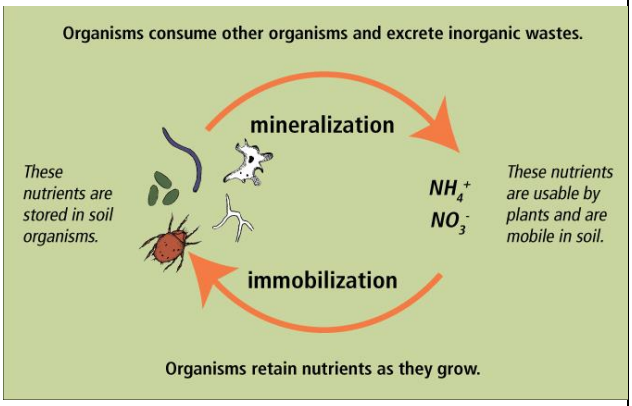


Figure 13: Mineralization vs immobilization

The amount of nutrient made available for plant uptake is termed net mineralization which is equal to gross mineralization minus immobilization.

B. Carbon-to-nitrogen ratio (C:N ratio)

All organic matter is made up of substantial amounts of carbon (C) combined with lesser amounts of nitrogen (N).

The balance of these two elements in an organism is called the carbon-to-nitrogen ratio (C:N ratio).

To acquire the carbon and nitrogen a soil microorganism needs to stay alive it needs a diet with a C:N ratio near 24:1.

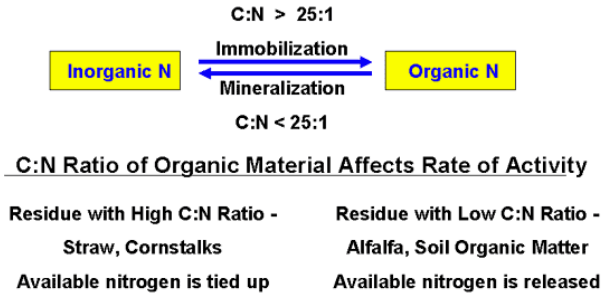


Table 2: Carbon-to-Nitrogen Ratios (Browns)

Estimated Carbon-to-Nitrogen Ratios	
Browns = High Carbon	**C:N**
Ashes, wood	25:1
Cardboard, shredded	350:1
Corn stalks	75:1
Fruit waste	35:1
Leaves	60:1
Newspaper, shredded	175:1
Peanut shells	35:1
Pine needles	80:1
Sawdust	325:1
Straw	75:1
Wood chips	400:1

Table 3: Carbon-to-Nitrogen Ratios (Greens)

Estimated Carbon-to-Nitrogen Ratios	
Greens = High Nitrogen	**C:N**
Alfalfa	25:1
Clover	23:1
Coffee grounds	20:1
Food waste	20:1
Garden waste	30:1
Grass clippings	20:1
Hay	25:1
Manures	15:1
Seaweed	19:1
Vegetable scraps	25:1
Weeds	30:1

For best performance, the compost pile, the composting microorganisms, require the correct proportion of carbon for energy and nitrogen for protein production.

If the C:N ratio is too high (excess carbon), decomposition slows down. If the C:N ratio is too low (excess nitrogen) you will end up with a stinky pile

The materials containing high amounts of carbon are considered "browns" (Table 2) and materials containing high amounts of nitrogen are considered "greens." (Table 3).

5. Strategies for increasing soil organic matter (humus)

i) Composting

Adding organic matter in the form of compost and aged manure, or using mulch or growing cover crops (green manures), is the best way to prepare soil for planting. Adding chemical fertilizers will replenish only certain nutrients and do nothing for maintaining good, friable soil. Organic matter will help supply everything your plants need. Adding compost will improve almost any soil. The texture of silty and clay soils, not to mention their nutrient levels, are radically improved from initially having the compost mixed in. All soils get better with annual applications on top.

Organic compost can be purchased by the bag or by the yard, or you can make it yourself at home. Compost and other organic materials hold soil particles together in aggregates and help to retain moisture. They also absorb and store nutrients that are then available to plants, and compost is a food source for beneficial microorganisms. Making your own compost can be as easy as piling brown layers (straw, leaves), and green layers (grass clippings, livestock manure, food waste) on top of one another. Keep the pile moist and turn it often. If a pile is too messy, or you are concerned about rodents and other animals getting into your pile, there are all kinds of composters and bins available.

ii) Fertilizer

Dry or liquid fertilizer can add nutrients to the soil that might not get there any other way. Organic garden fertilizers work a little slower than their synthetic counterparts, but they release their nutrients over a longer time frame. Additionally synthetic fertilizers are bad for the environment and can make

the soil worse in the long run as beneficial microorganisms are killed off.

Organic dry fertilizers are mixed into the soil according to the directions on the label and then watered. They work more slowly than liquid fertilizers, but last longer. Fertilizer blends contain different amounts of nitrogen, phosphorous and potassium. The ratio is listed on the label (for example 5-10-5).

Liquid fertilizers are sprayed directly on the plant foliage or onto the soil. Popular organic liquid fertilizers include fish emulsion and seaweed blends. Compost teas are another liquid fertilizer that is easy to make and takes advantage of the compost you have piling up in the yard.

If you are using a foliar spray, be sure to wet the underside of the leaves. This is where the stomata, the microscopic openings that take in gases, are located. As they open to let in carbon dioxide and release moisture, they will quickly absorb the fertilizer. Read the labels of the liquid fertilizer you choose as some could burn crops and should be applied only to soil.

iii) Mulching

Organic (straw, hay, grass clippings, shredded bark) cover the soil and insulate it from extreme heat and cold. Mulches reduce water loss through evaporation and deter the growth of weeds. They break down slowly, enriching the soil with organic matter. Inorganic mulches (pebbles, gravel, black plastic, landscape fabrics) will prevent rapid evaporation and keep weeds down just as an organic mulch does. Unlike organic mulches, they do not need to be replaced every year and will not attract insects and rodents.

However, inorganic mulches do not benefit the soil by breaking down and adding organic matter which improves soil structure and nutrient content. If you're looking to improve your soil structure, use a clean, seed-free, high-quality garden mulch.

iv) Cover Crops

Cover crops are a temporary planting, usually sown in the fall, which help protect the soil from wind and erosion and add valuable organic material. They also establish a dense root structure that can have a positive effect on soil texture. Cover crops also suppress weeds, deter insects and disease and help fix nitrogen. When the crops are turned into the soil, they become green manure.

Cover crops are planted at the end of the growing season (winter cover crops) or during part of the growing season itself (summer cover crops). Rye and alfalfa are common winter cover crops. Legumes such as cowpeas, soybeans, annual sweetclover or velvet beans may be grown as summer green manure crops to add nitrogen along with organic matter. Non-legumes such as sorghum-sudangrass, millet, forage sorghum, or buckwheat are grown to provide biomass, smother weeds, and improve soil tilth.

Choose a legume crop for the added benefit of nitrogen fixation. After you have harvested your summer crops, add compost and any other amendments (such as lime) that you have determined your soil needs. Disperse the cover crop seeds and rake lightly. If you grow vegetables into the fall, plant cover crops seeds in between the rows a month or less before you expect to harvest. Don't let your cover crops go to seed or they may prove invasive. When spring comes around, till the crop into the soil 2-3 weeks

REVIEW QUESTIONS

1. List the 5 soil forming factors

2. a) What is a soil profile?

b) List any three soil horizon symbols.

3. What is the importance of soil aeration?

4. a) What is soil texture?

b) How does soil texture affect crop production?

c) If a soil has 20% silt and 30% clay, what will be its textural class?

5. a) What is soil structure?

b) Why is the soil structure important for crop production?

6. Define the term soil bulk density?

b) How does the soil bulk density affect crop production?

7. What is the difference between gravimetric and volumetric water content?

8. Differentiate between the following:

-Primary vs Secondary nutrients

-Macronutrients vs Micronutrients

9. a) How does pH affect the relative availability of macronutrients and micronutrients in the soil?

b) What pH range will most minerals and nutrients are best available?

c) If a soil has a hydrogen concentration of 0.000001 mol/L, what will be its pH?

10. What parameter is defined as the difference between the field capacity and the permanent wilting point?

11. Briefly discuss the role humus (organic matter) plays in the soil.

12. a) Define the terms mineralization and immobilization.

b) How does the C:N ratio affect mineralization and immobilization of plant nutrients?

c) What would be the ideal C: N ratio for a soil?

13. List any 4 ways you can build your soil organic matter.

14. List 3 examples of a cover crop.

15. What is a catch crop?

Summary Description for Module 7

Title:	Module 7: Integrated Insect Pest Management
Instructor:	Dr. Douglas G. Pfeiffer, Professor of Entomology
Prerequisites:	Working knowledge of Microsoft Word and Microsoft Excel
Class Time:	9:00AM – 11:30AM & 12:00PM – 3:00PM
Learning Objective:	After completing Module 6, the student learner understands the main groups of arthropods affecting crops in urban settings (pest insects, mites, beneficial predators and parasitoids, and pollinators. They understand the strengths and shortcomings of chemical and biological control. The students will develop means to know when a control action is justified. The students will know where to go for free, current on-line pest management information from objective sources.
Instructor Media Needs:	Screen Projector Screen to Project upon Computer
Class Materials and/or Supplies Needed:	Student provided-Computer with Microsoft Office software, and either Adobe Reader or Adobe Acrobat, or other software that can open PDF files. Dissecting microscopes with lamps, ideally one per person, at least 1 for every 2 people.
Class Activities:	1. Presentation of general arthropod categories relevant to urban gardening 2. Review of pests affecting main crop groupings (cole crops, solanaceous crops, etc.) 3. Review of VCE Pest Management Guide series and related extension resources 4. Who you gonna call? Bug Busters: Your extension support network 5. Exercise in insect identification
Knowledge Gained:	Students will gain knowledge in how to develop an urban farm pest management plan
Skills Gained:	Students will learn to identify pests, find their local extension contacts, and where to go for current extension recommendations.
Abilities Gained:	Students will be able to identify common crop pests, determine if control is needed, alternative control measures, if and what chemical control action is needed, and where to go for additional help.
Exam Description:	Students will be presented with actual specimens and relevant situational information, and will be asked the identity of the pest, what kind of injury it causes, and will provide a recommended action. The students will be asked to provide the contact information for an appropriate extension resources person.

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Sustainable Urban Agriculture Program

Insect Pest Management

Doug Pfeiffer
Dept. of Entomology Virginia Tech

dgpfeiff@vt.edu



Class activities:

Presentation of general arthropod categories relevant to urban gardening

Review of pests affecting main crop groupings (cole crops, solanaceous crops, etc.)

Review of VCE Pest Management Guide series and related extension resources

Who ya gonna call? Bug Busters: Your extension support network

Exercise in insect identification

Class activities:

Presentation of general arthropod categories relevant to urban gardening and general pest management

Review of pests affecting main crop groupings (cole crops, solanaceous crops, etc.)

Review of VCE Pest Management Guide series and related extension resources

Who ya gonna call? Bug Busters: Your extension support network

Exercise in insect identification

Principles of Insect Control

- Type of damage
- Part of host damaged
- Identify pest species
- Causes of outbreak
- Seasonal abundance
- Host ability to withstand damage
- Identify natural enemies
- Choice of control tactics
- Economics of pest control
- Environmental impact

Insect Pest Management

- *Integrated* - Select from list of appropriate tools:
  - Biological
  - Host plant resistance
  - Physical
  - Cultural
  - Regulatory
  - Chemical
- Goal is management of insect pest problems

Pest Management Tactics

- A. **Preventive Control**
- Environmental
- Host plant resistance
- Legal & Regulatory

Regulatory Control Programs

- Eradication
- Containment
- Suppression

Regulatory Control Programs

- Containment



B: **Remedial Control**

- Mechanical
- Physical
- Genetic
- Behavioral
- Cultural
- Hormonal
- Biological
- Chemical

} More later!

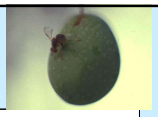
MECHANICAL CONTROL

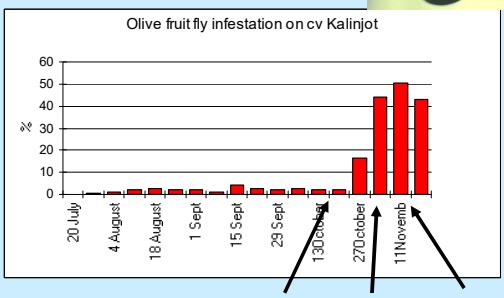
- Hand-picking
- Barriers - Exclusion
- Protective Packaging
- Collection devices
- Trapping
- Brushing
- Sweeping
- Jarring & shaking

PHYSICAL CONTROL

- Temperature extremes
  - Flaming
  - Freezing
- Humidity
  - Low humidity
- Electromagnetic Energy

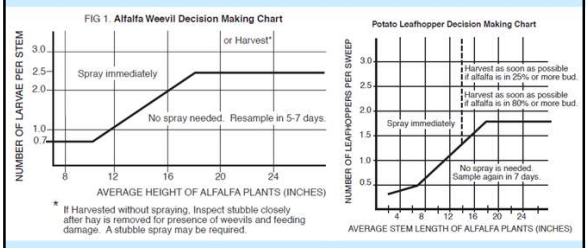
Cultural Control





Oil rating by harvest date: **Extra virgin** **Extra virgin** **Virgin**

Cultural Control



INTEGRATED PEST MANAGEMENT [IPM]

- **Reduction of pest problems to an acceptable level by use of combination of methods** selected on the basis of pest biology that are ecologically and economically sound.

Pest Management Concepts

- Economic Injury Level
- Economic Threshold

Economic Injury Level (**EIL**)

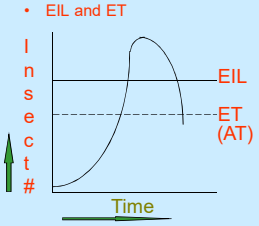
- **The pest density (level of insects) where the cost of injury = the cost of control**
- Remember this definition!
- Point of Economic loss

Economic Threshold (ET)

- **Pest density at which action is taken to prevent pest pop. from reaching EIL**
- Time for Action

Thresholds and Insect density

- EIL and ET



Important definitions

- Direct pest
- Indirect pest
- Secondary pest

Types of Injury:

Indirect injury
Direct injury
Insect-vectored diseases

Impact on acceptable pest levels?
Key vs secondary pest?

Types of Injury:

What type does Japanese beetle cause?



Time out for taxa:

Aphididae

◆aphids



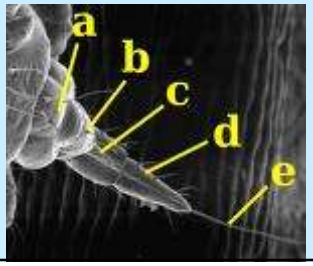
Aphididae

Soft-bodied, pear-shaped
Usually long antennae
Have cornicles



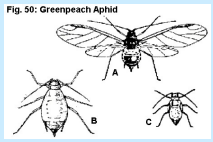
Aphididae

Piercing-sucking mouthparts
Phloem feeders



Aphididae

Alternation of generations:
- Winged vs wingless (alate vs apterous)
- Live birth vs egg-laying
  - (Asexual vs sexual)



Aphididae

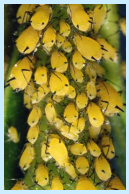
Alternation of generations:
- Winged vs wingless (alate vs apterous)
- Live birth vs egg-laying
  - (Asexual vs sexual)





Aphididae

Often dense colonies



Aphididae

Sources of injury:
- Weaken plant, loss of phloem sap
- Honeydew and sooty mold
- Virus transmission
- Toxic saliva

Biological Control often important with aphids

- 1. Syrphidae
- 2. Coccinellidae
- 3. Cecidomyiidae
- 4. Chrysopidae
- 5. Anthocoridae









Parasitic wasps, incl. Aphelinidae



Aphididae

Sometimes protected by ants



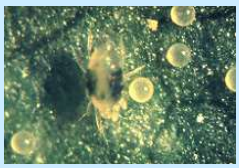
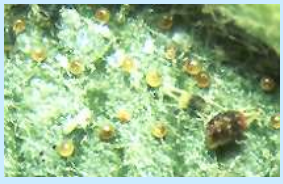

Time out for taxa:

Spider mites

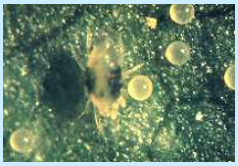
◆Tetranychidae




Spider mites

Spider mites







Spider mites



Insect Morphology

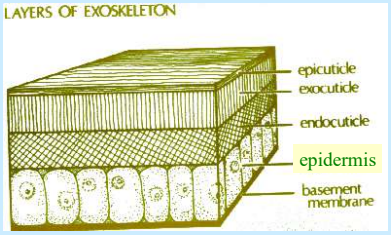
Insect Morphology

- **External Morphology**
- **Internal Systems**
- **Will be important for insect id, and understanding biology**
- **Will be important to understand basis for control measures (will emphasize relevant systems)**

External Insect Morphology

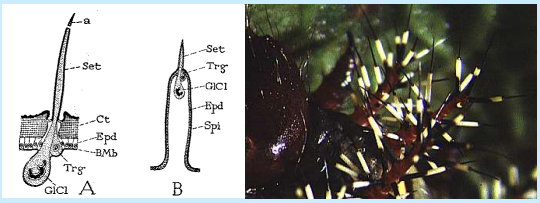
- **Exoskeleton**
- **Head**
- **Antennae**
- **Thorax**
- **Leg**
- **Wing**

Exoskeleton

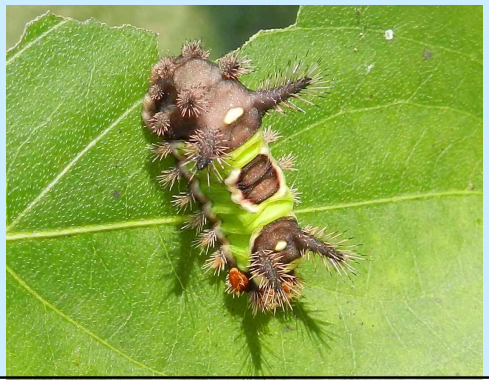


Spurs, spines

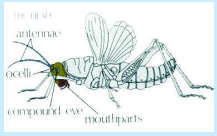
- Spine is separated by groove, may be movable (A)
- Spur is an outgrowth of cuticle (B)
- May be combined

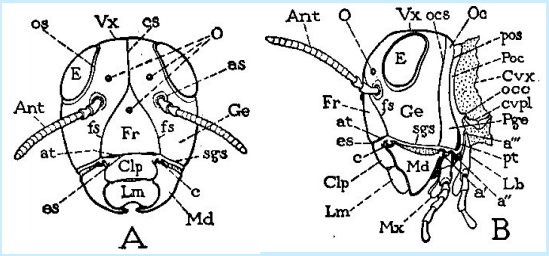


Saddleback Caterpillar

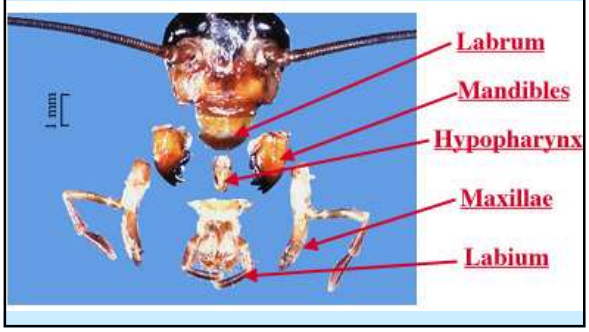


Head





Chewing Mouthparts



Sucking Mouthparts

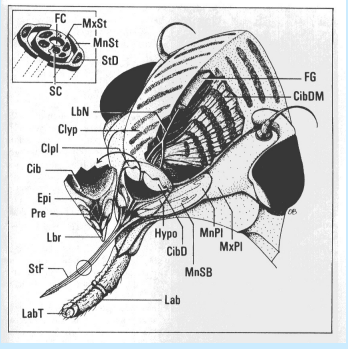
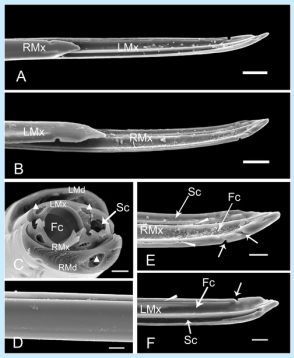


Fig 11. SEM of maxillary stylets of female *Lycorma delicatula*.



Hao Y, Dietrich CH, Dai W (2016) Structure and Sensilla of the Mouthparts of the Spotted Lanternfly Lycorma delicatula (Hemiptera: Fulgoromorpha: Fulgoridae), a Polyphagous Invasive Planthopper. PLOS ONE 11(6): e0156640. doi:10.1371/journal.pone.0156640
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0156640

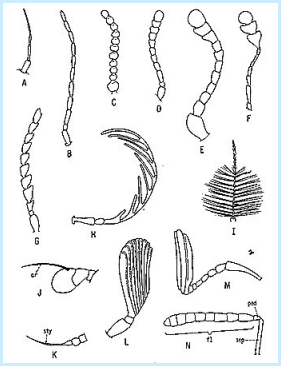
Sucking Mouthparts

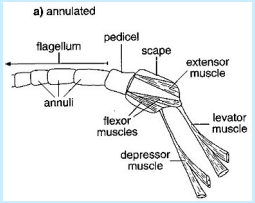
Grasshopper chewing mouthparts

Green stink bug feeding on raspberry

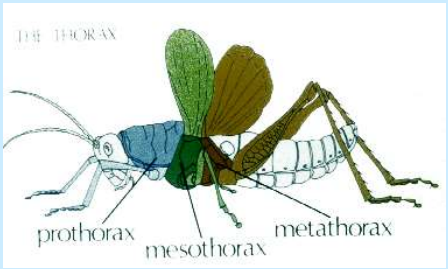
Mosquito feeding

Antennae

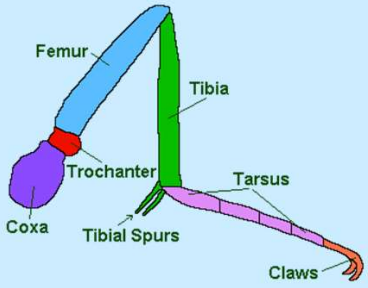




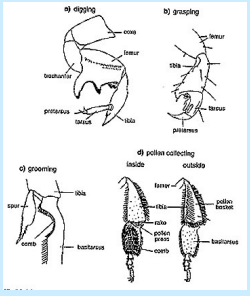
Thorax



The Insect Leg



Modified Legs





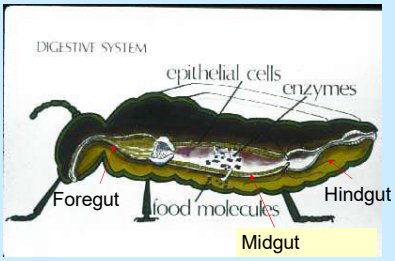
Wings



Internal systems:

- **Excretory system**
- **Digestive system**
- **Excretory system**
- **Respiratory system**
- **Muscular system**
- **Circulatory system**
- **Nervous system**
- **Reproductive system**

Digestive system



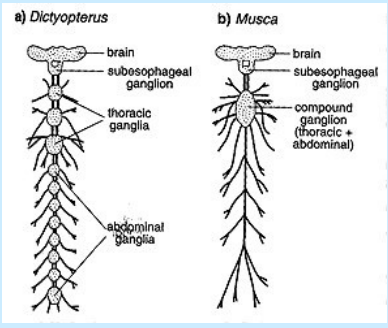
What a waste!

Terminology:

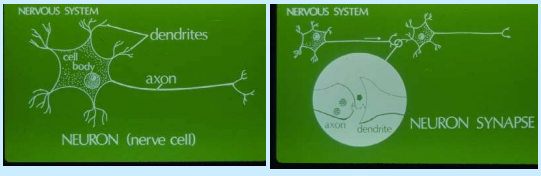
Solid insect waste = frass

Liquid digestive waste in plant feeders = honeydew

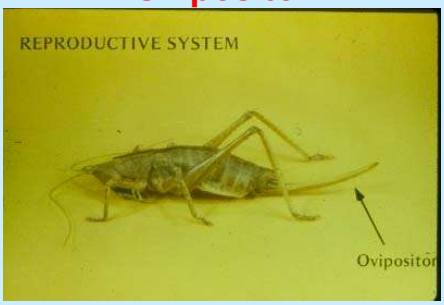
Ganglia in VNC



Neuron



Ovipositor



Time out for taxa:

Chrysomelidae/Coccinellidae

- Leaf beetles
- Lady beetles





Chrysomelidae

- Leaf beetle adults and larvae phytophagous
- Large family, 1400 N. Am. spp



Chrysomelidae

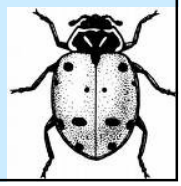
May be round in outline, may be elongate
May be dark, may be brightly colored
How to tell from lady beetles?



Chrysomelidae

Antennae filiform in chrysomelids, capitate in coccinellids
Tarsal formula apparently 3-3-3 in coccinellids
Chrysomelids are 5-5-5, but pseudotetramerous (look like 5-5-4)





Coccinellidae

- Large family, 400 N. Am. Spp.
- Mainly predatory as both adults and larvae





Coccinellidae


Coleomegilla maculata


Hippodamia convergens


Adalia bipunctata


Coccinella novemnotata


Coccinella septempunctata


Harmonia axyridis

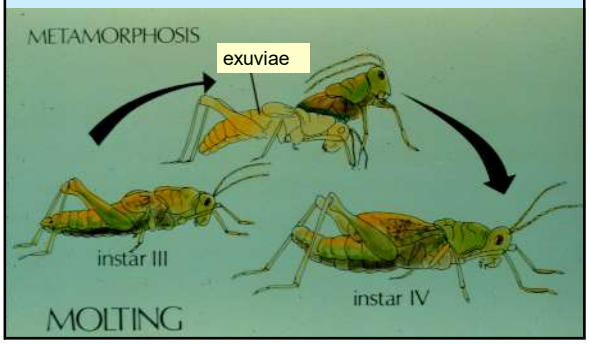
Coccinellidae

Multicolored Asian Lady Beetle,
Harmonia axyridis (Pallas)

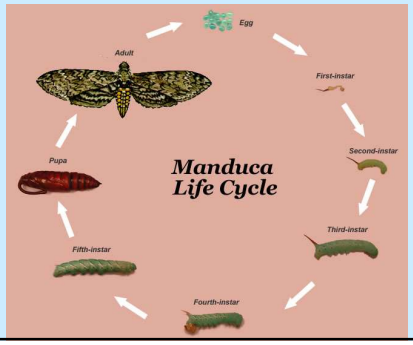



Insect Taxonomy

In order to grow, insects must undergo **metamorphosis** – molting, exuviae
Here – Gradual metamorphosis



Complete Metamorphosis



Wisc.

Pterygote orders with gradual metamorphosis

- **Orthoptera** – grasshoppers, etc.
- **Hemiptera**
  - **Heteroptera** – true bugs
  - **Homoptera (Auchenorrhyncha, Sternorrhyncha)** – leafhoppers, aphids, scales, etc.
- **Thysanoptera** - thrips

Pterygote orders with complete metamorphosis

- **Coleoptera** – beetles
- **Neuroptera** – lacewings
- **Diptera** - flies
- **Lepidoptera** – butterflies, moths
- **Hymenoptera** – wasps, bees, ants

Important families of Orthoptera

- **Orthoptera**: Acrididae, Tettigoniidae, Gryllidae (grasshoppers, katydids, crickets)



Hemiptera

- **Hemiptera**: Bugs
- Gradual metamorphosis
- Piercing-sucking mouthparts
- Heteroptera – half wings, hemelytra
- Homoptera:
  - Auchenorrhyncha
  - Sternorrhyncha

Important families of Hemiptera: Heteroptera

- **Hemiptera**: Miridae, Pentatomidae, Tingidae, Reduviidae, Anthocoridae (plant bugs, stink bugs, lace bugs, assassin bugs, pirate bugs)



Important families of Hemiptera: Homoptera

- **Homoptera** - Auchenorrhyncha: Cicadellidae, Cicadidae (leafhoppers, cicadas)



Important families of Homoptera

- **Homoptera** - Sternorrhyncha: Aphididae, Aleyrodidae, Diaspididae, Coccidae, Psyllidae (aphids, whiteflies, armored scales, soft scales, psyllids)







Thysanoptera

- **Thysanoptera:** thrips
- Gradual metamorphosis – but with "pupa"!
- Feathery wings
- Rasping mouthparts



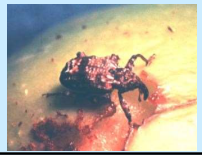

Coleoptera

- **Coleoptera**: beetles
- Complete metamorphosis
- Chewing mouthparts
- Hardened front wings - elytra

Important families of beetles

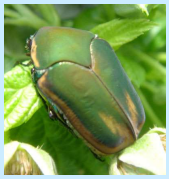
- **Coleoptera**: Chrysomelidae, Scarabaeidae, Curculionidae (leaf beetles, scarabs or white grubs, weevils)

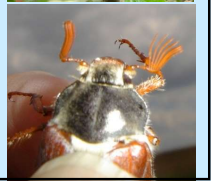




Scarabaeidae – scarabs, white grubs

- **Coleoptera**: Scarabaeidae

Important families of beetles

- **Coleoptera**: Cerambycidae, Buprestidae (longhorned beetles, metallic wood-boring beetles)




Lepidoptera

- **Lepidoptera**: Butterflies and moths
- Complete metamorphosis
- Chewing mouthparts as larvae, siphoning mouthparts as adults
- Scale-covered wings

Important families of leps

- **Lepidoptera**: Pieridae, Sphingidae, Noctuidae, Sesiidae, Pyralidae/Crambidae, Tortricidae








Hymenoptera

- **Hymenoptera**: Tenthredinidae, Formicidae, Vespidae, Apidae
- Complete metamorphosis
- Chewing mouthparts
- Primitive: sawflies
- Advanced: bees, wasps, ants

Important families of hymenops

- **Hymenoptera**: Tenthredinidae, Formicidae, Vespidae, Apidae (sawflies, ants, paper wasps, bees)






Diptera

- **Diptera**: Flies
- Complete metamorphosis
- Mouthparts various: chewing, piercing-sucking, sponging
- Primitive: mosquitoes, black flies, gall midges, fungus gnats
- Middle: horse flies, deer flies
- Advanced: house flies, shore flies, face fly, horn fly, stable fly, tsetse

Important families of Diptera

- **Culicidae**
- **Tabanidae**
- **Muscidae**





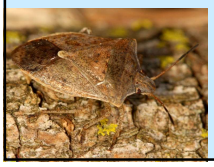

Proper taxonomy is critical to IPM

- Must identify pest correctly to determine appropriate control
- Must be able to evaluate exotic species
- Must be able to find appropriate natural enemies

Time out for taxa:

Stink bugs

- ◆Pentatomidae, ca. 250 spp in N. Am.
- ◆Thoracic glands give off defensive scent
- ◆Characteristic broad, flat shape
- ◆Large scutellum



Harlequin Bug

- Pest of cole crops (cabbage, broccoli, turnip, collards, etc.)
- Brightly colored – harlequin = clown
- Black-and-white keg-shaped eggs
- 2-4 generations



Spined Soldier Bug

- *Podisus maculiventris*
- Predatory stink bug
- 1 generation in north, 2 in south
- Generalist predator



Brown Marmorated Stink Bug

- *Halyomorpha halys* Stål

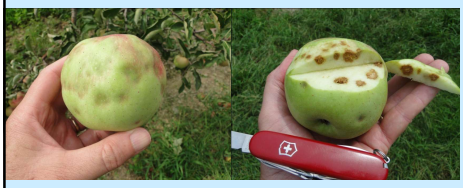


Brown Marmorated Stink Bug

- Native to China, Japan, Korea
- Introduced around Allentown PA in 1996
- Found in Virginia 2004
- Probably one, poss 2 generations for us (4-6 in subtropical parts of China)
- In China, feeds on apple, peach, fig, mulberry, persimmon, citrus, weeds, soybean
- 300 hosts
- In fall, seek shelter in houses
- Note color on antennae



Brown Marmorated Stink Bug



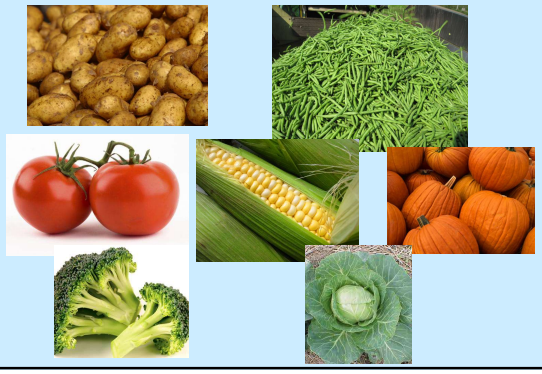


Crop Pests: Vegetables

Vegetables

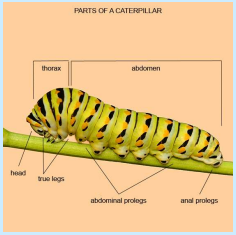
- Over 200 different plant species
- Leaves
- Stems
- Roots and tubers
- Flowers
- Pods
- Fruit

Major vegetable crops in Virginia



Lepidoptera

- Larvae (caterpillars)
- Chewing leaves and boring into plants

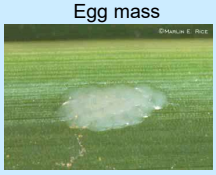


European Corn Borer
Lepidoptera: Crambidae

Adults



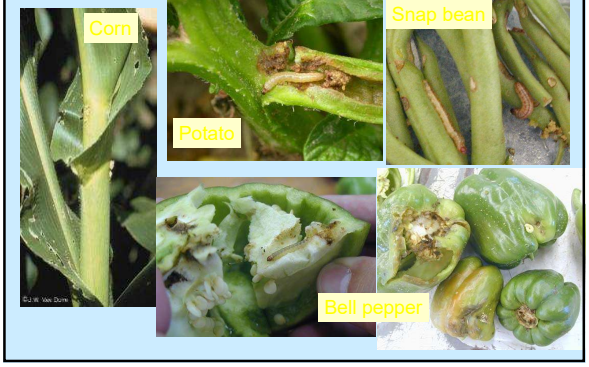
Egg mass



Larva



European corn borer



European corn borer IPM

- Transgenic Bt sweet corn
- Biological control
- Chemical control

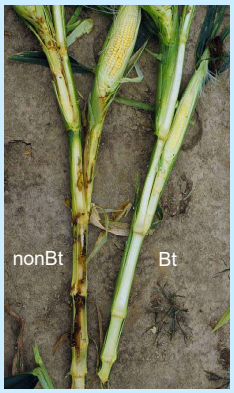
Bt transgenic sweet corn

- Several hybrids commercially available (Syngenta Seeds among other companies)
- Protect ears against lepidopterous larvae and stalks against borers
- Very effective – provide 80-90% control



nonBt Bt

- 100% prevention of whorl and stalk damage due to European corn borer



Biological Control: *Trichogramma*

- Hymenoptera: Trichogrammatidae
- Very tiny (0.2 - 1.5mm) parasitic wasps
- Lepidopteran egg parasitoids
- Generalists



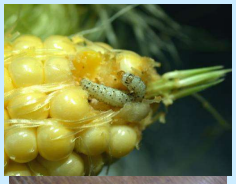
Corn earworm Lepidoptera: Noctuidae)

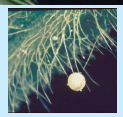




Corn earworm





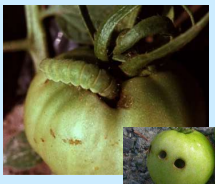




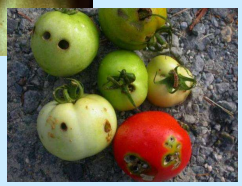




Corn earworm damages many different vegetables









Corn earworm IPM

- Monitor moth activity with pheromone traps or Black light traps
- Transgenic sweet corn
- Chemical control

Lepidopteran Pest Complex attacking crucifer crops

- Diamondback moth
- Cabbage looper
- Imported cabbageworm
- (several other species)



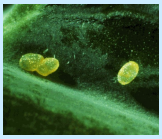
Diamondback Moth

Plutella xylostella

Lepidoptera: Plutellidae

- Adult moths overwinter in crop residue
- Multiple generations/yr
- Eggs laid on leaves of host plant





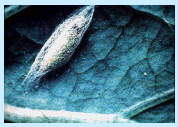
Diamondback Moth Life History

- Small larvae make window-like feeding scars, larvae wiggle violently when disturbed





- Larvae complete development in 10 - 30 days and spin loose silk cocoons on host leaves
- Windowpane injury



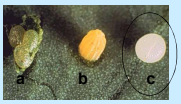
Cabbage Looper

Trichoplusia ni

Lepidoptera: Noctuidae

- Overwinters as a pupa in loose silk cocoon on host
- Multiple generations/yr
- Moths oviposit on leaves of host plant





a = DBM eggs

b = ICW egg

c = CL egg

Cabbage Looper Life Cycle

- Larvae have 5 instars and complete development in 2 - 4 weeks
- Larvae move with characteristic looping gait, 1 in. long and voracious feeders when mature





Imported Cabbageworm

Pieris(Artogeia) rapae

Lepidoptera: Pieridae

- **Overwinters as a chrysalis**
- **multiple generations/yr**
- **Adults are white butterflies**
- **Eggs deposited on leaves**







a = DBM eggs

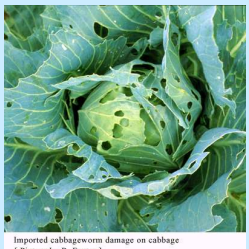
b = ICW egg

c = CL egg

Imported Cabbageworm Life Cycle

- Larvae have 5 instars and complete development in about 2 weeks
- they are 1 in. long, green, and velvety, voracious feeders





Imported cabbageworm damage on cabbage
[Picture by R. Foster]

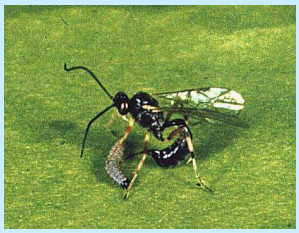
Lepidopteran Pest Management in Cole Crops

- ET = Treatment justified if ≥ 20% small plants or ≥ 5% mature plants infested with any pest larvae
- Chemical control
  - Small larvae easier to control than large larvae
  - Use of a spreader-sticker is essential for cole crops
  - DBM hardest to control due to resistance
  - Bt and other narrow spectrum insecticides are effective
- Biological control – many effective parasitoids – should be preserved
- Cultural control – get rid of old leaves left behind after harvesting

Biological Control of DBM: *Diadegma insulare*

Hymenoptera: Ichneumonidae

- Up to 70% of DBM larvae are parasitized each yr





Healthy diamondback moth pupa (top); parasitized pupae (middle, bottom). **J.Ogrodnick**

Hymenopterous Parasitoids of ICW









Apanteles glomeratus ***Pteromalus sp.***

Hornworms Lepidoptera: Sphingidae





What are these white cotton balls?



Squash vine borer Lepidoptera: Sesiidae





Beetle Pests of vegetables





Colorado potato beetle



CPB Management

- Crop rotation is best 1st line defense:
  - CPB not capable of flight until temperature approaches 80º F;
  - colonize nearby fields by walking
  - Feed on potatoes, tomatoes, eggplant, horse nettle
- Chemical control
  - Serious insecticide resistance problems
  - Systemic insecticides applied at-planting
  - Rescue foliar treatments



Biological Control of CPB



Podisus maculiventris



Perillus bioculatus
(red and white color morphs)



Coleomegilla maculata



Edovum puttleri
(Exotic egg parasitoid)

Cucumber Beetles

Striped cucumber beetle
Acalymma vittatum



Spotted cucumber beetle
Diabrotica undecimpunctata howardi



Cucumber beetle

- 2 - 3 generations annually
- overwinter as adults in woods, weeds, etc.
- in spring, adults aggregate at the edges of cucurbit fields
- eggs laid in soil, larvae feed on roots

Cucumber beetle aggregation

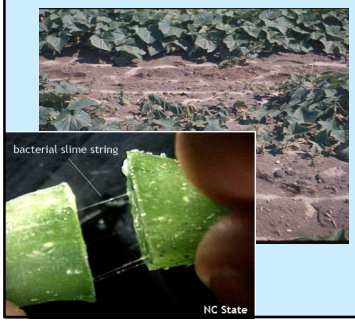


Cucumber beetle damage

- Leaf feeding (can completely defoliate and kill young seedlings)
- Minor root pruning by larvae
- Also may scar the surface of fruit by feeding



Transmit Bacterial Wilt Pathogen (*Erwinia tracheiphila*)



- young seedlings most susceptible
- cucumber and muskmelons most susceptible

Management/Control

- Resistant varieties - Plant bacterial wilt-resistant varieties or varieties less preferred by cucumber beetles
- Trap crops – Beetles will aggregate on early-planted preferred (high cucurbitacin-level) crops
- Chemical control – systemic insecticides can be applied to seed or at-planting as a preventative; or foliar sprays can be applied after beetles aggregate

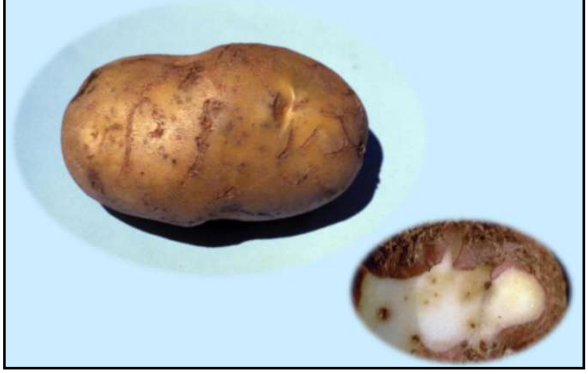
What caused this injury?



Flea beetles (several species)



Tuber injury from flea beetle larvae



Bean leaf beetle



Bean leaf beetle



Mexican bean beetle





Biocontrol of MBB

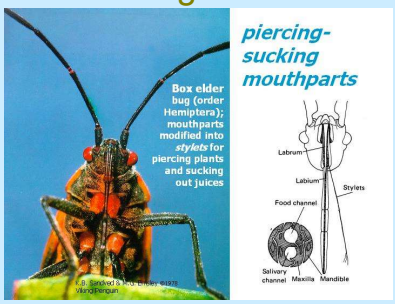




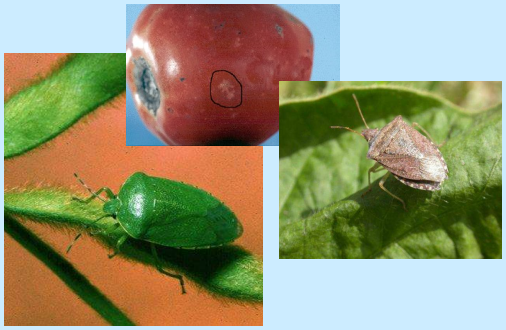


- MBB adults and larvae eat the undersides of bean leaves causing lacing of the foliage.
- *Pediobius foveolatus* is a small beneficial wasp that will seek out and destroy Mexican bean beetle larvae.
- Imported from India, this non-overwintering wasp can suppress MBB to non-damaging levels.
- The MD Plant Protection Section has raised this effective biological control agent since the late 1970's to control MBB on commercial soybean acreage in Maryland.

Sucking insect pests of vegetables



Stink bugs



What is this insect pest?





Brown Marmorated Stink bug






Life cycle of BMSB






Stink bug management

- Chemical control
- Trap cropping opportunities
- Biological control – egg parasitoids




Trissolcus basalis

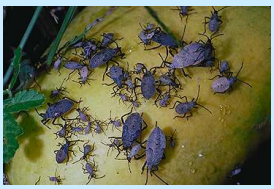
(Hymenoptera: Scelionidae)

Stink bug egg parasitoids




Trissolcus grandis

Squash bug
Hemiptera: Coreidae


Leaffooted bug
Hemiptera: Coreidae





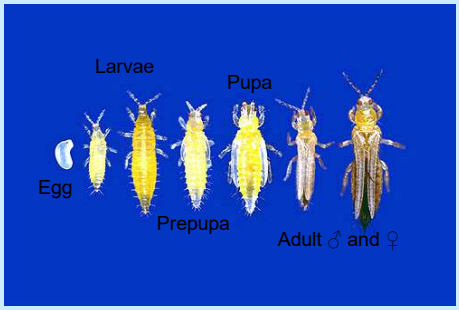
Thrips







Thrips life cycle



Major thrips species in Virginia

- Eastern flower thrips, *Frankliniella tritici*
  - accounts for 90% of species in tomato
  - found in blossoms, injures fruit
  - does not vector TSWV



- Tobacco thrips, *F. fusca*
  - primarily a leaf feeder
  - vectors TSWV





Thrips larva

Western flower thrips, *F. occidentalis*

- Major greenhouse pest
- Not found in Virginia tomatoes in 3-yr survey from 1999-2001 (Nault & Speese)
- In 2002, a few WFT (<3%) in tomato
- Species is a major vector of TSWV
- Very difficult to control





Leaf feeding



Thrips feeding on blossoms



Thrips damage to tomato



Dimpling





Gold flecking



Tomato Spotted Wilt Virus







TSWV





T

Thrips management

- Biological control
- Chemical control
- Aluminated silver plastic mulch

Minute pirate bugs

- *Orius*





Nymphs and adult stage



Orius insidiosus
• *Insidious flower bug*
• nymphs & adults feed on:
Mites, thrips, aphids, leafhoppers, and eggs & young larvae of leps

Potato Leafhopper
Empoasca fabae
Hemiptera: Cicadellidae





Potato leafhopper adult (R) and nymphs
[Picture by Michigan State University]



Potato leafhopper damage (hopperburn) on potato
[Picture by University of Wisconsin]

What are these pests?



Green peach aphids



Alate (winged) adult

Apterous (wingless) colony



Aphids

- wide variety of host plants
- can attain high densities on young plants
- undersides of leaves
- suck plant sap, reduce vigor, cause wilting
- Honeydew secretions & sooty mold problems
- Most important vectors of plant viruses

Thorough spray coverage beneath leaves is important when foliar sprays are used.





Pumpkin insecticide trial – Painter, VA (Kuhar data)

Treatment	Rate/acre	Melon Aphids/ 2 leaves on 12 July
Platinum 2SC	8 fl oz drench	1.0 c
Admire 2F	24 fl oz drench	9.5 c
Asana XL	9.6 fl oz foliar	200.0 a
Danitol 2.4EC	10.7 fl oz foliar	223.0 a
Danitol 2.4EC	16 fl oz foliar	500.8 a
UTC		146.0 ab









Important natural enemies



What is this?



Aphidiid – aphid parasitoid

- Wasp parasitoids of Aphids



can parasitize up to 90% of aphid population



Neonicotinoid insecticides

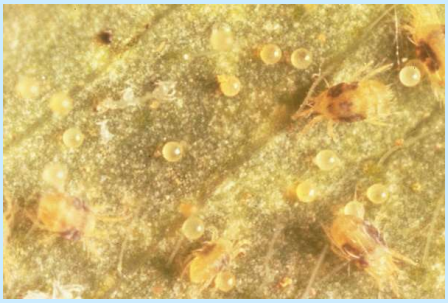
- Soil Applied: (Admire Pro, Platinum, Venom, Belay (generic imidacloprid 2F formulations)
  New Durivo (combo product = Platinum + Coragen)
- Foliar Sprays: (Actara, Assail 30G, Venom, Belay)



What caused this injury?



Twospotted spider mites



Spider mite damage

- mites suck sap from plant cells on the underside of leaves
- characteristic white speckles can be seen from the upper leaf surface.
- as mite numbers increase these white speckles will increase in number, the leaf will take on a bleached appearance and die.



Spider mite Management:

- Mite infestations generally begin around field borders and grassy areas. Mowing grassy areas surrounding fields drives mites onto the crop.
- Mite outbreaks usually occur under hot, dry conditions. Adequate rain generally will keep populations below threshold.
- ET = 10-15% of leaves are infested early in the season, or 50% of leaves late in the season.
- Use of carbamates and pyrethroids may flare mite populations.

Time out for taxa:

Cicadellidae/Delphacidae/Fulgoridae Membracidae/Cercopidae

◆Cicadellidae - leafhoppers









Cicadellidae/Delphacidae/Fulgoridae Membracidae/Cercopidae

◆Cicadellidae – leafhoppers (Jassidae in some Old World countries)

◆Usually elongate triangular, short setaceous antennae

◆Very large family – 2500 N. Am. Spp.

◆Overwinter as either egg or adult, depending on species.

◆Many pest species

◆All plant types



Cicadellidae/Delphacidae/Fulgoridae Membracidae/Cercopidae

- Mesophyll feeders
- Phloem feeders
- Xylem feeders



Cicadellidae/Delphacidae/Fulgoridae Membracidae/Cercopidae

- Xylem feeders – Sharpshooters



Eject large amounts of water/honeydew
Apply brochosomes to wings, later apply to eggs

Cicadellidae/Delphacidae/Fulgoridae/ Membracidae/Cercopidae

- Cercopidae – froghoppers, spittlebugs



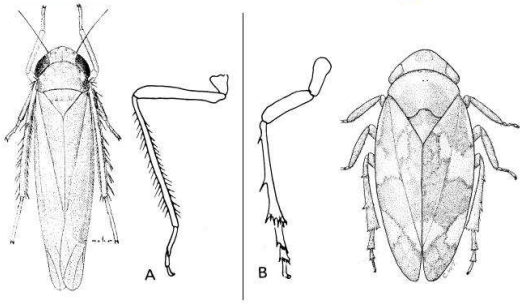
Cicadellidae/Delphacidae/Fulgoridae/ Membracidae/Cercopidae

- Cercopidae – froghoppers, spittlebugs
- Usually brown or gray
- Resemble leafhoppers, but broader; have stout spines on hind tibiae (unlike leafhoppers



For comparison . . .

Cicadellidae **vs** **Cercopidae**



Cicadellidae/Delphacidae/Fulgoridae Membracidae/Cercopidae

- Delphacidae and Fulgoridae – planthoppers (Fulgoroidea)
- Only a few stout spines on hind tibiae
- Antennae arise below compound eyes

Cicadellidae/Delphacidae/Fulgoridae Membracidae/Cercopidae

- Delphacidae – planthoppers
- Largest family of planthoppers
- Have a large flattened spur at tip of hind tibiae





Rice brown planthopper

Cicadellidae/Delphacidae/Fulgoridae/ Membracidae/Cercopidae

- Membracidae – treehoppers
- Have pronotum that covers head, often projecting backwards in unusual shape
- Few economically important



Membracidae



Cicadellidae/Delphacidae/Fulgoridae/ Membracidae/Cercopidae

- Fulgoridae – planthoppers
- Some tropical species have enlarged head
- Reticulated anal area of hind wings





Spotted lanternfly, *Lycorma deliculata*



Pfeiffer

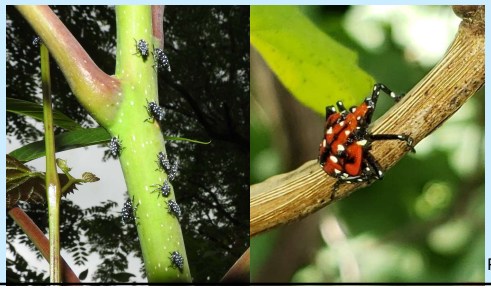
Spotted lanternfly, *Lycorma deliculata*



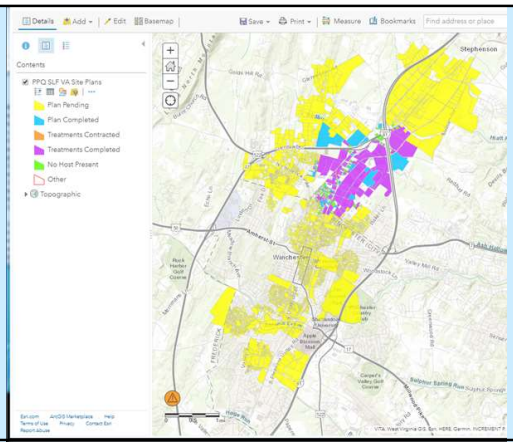
Pfeiffer

Spotted lanternfly, *Lycorma deliculata*

- Nymphs black with white spots in instars 1-3, then red with black spots later in instar 4.



Pfeiffer



Spotted lanternfly, *Lycorma deliculata*

- Fact sheet
  - http://www.pubs.ext.vt.edu/ENTO/ENTO-180/ENTO-180.html
- Recorded presentation
  - http://www.virginiafruit.ento.vt.edu/PresenterExtensionTalks/SLFPreparednessSymposium/index



USDA

Resources and Reporting

- http://www.virginiafruit.ento.vt.edu/SLF.html
- If found in Virginia, please notify:
  - Doug Pfeiffer, Dept. of Entomology dgpfeiff@vt.edu
  - Eric Day, Insect Identification Laboratory, idlab@vt.edu
- https://ask.extension.org/groups/1981/ask

Crop Pests: Tree Fruits

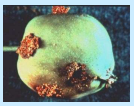
A. Pest Classification

1. Pests causing direct vs. indirect damage
2. Key vs. secondary pests

- **B. Pests Causing Direct Injury in apple**
  - **1. codling moth, *Cydia pomonella* (L.)****
  - **2. oriental fruit moth, *Grapholita molesta* (Busck)****
  - **3. plum curculio, *Conotrachelus nenuphar* (Herbst)****
  - **4. apple maggot, *Rhagoletis pomonella* (Walsh)****
  - 5. leafrollers
    - a. variegated leafroller & tufted apple bud moth, *Platynota flavedana* (Clemens), *P. ideausalis* Walker
    - b. redbanded leafroller, *Argyrotaenia velutinana* (Walker)
  - 6. San Jose scale, *Quadraspidiotus perniciosus* (Comstock)
  - **7. Catfacing insects (various species)**
    - a. tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois)
    - b. stink bugs**

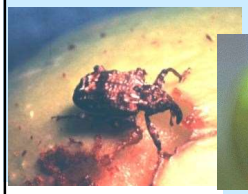
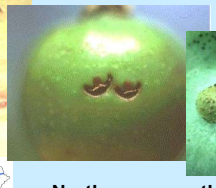
- **B. Pests Causing Direct Injury in apple**
  - 1. codling moth, Tortricidae
  - 2. oriental fruit moth, Tortricidae






•This complex is an increasing problem
•Especially severe in processing apple industry (**An important point**)

- **B. Pests Causing Direct Injury in apple**
  - 3. plum curculio, Curculionidae



Northern vs southern strains

Early season pest, or export problem?

- **B. Pests Causing Direct Injury in apple**
  - 4. apple maggot, Tephritidae

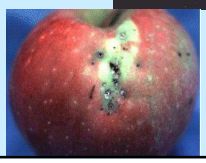





Key apple pest in northeastern states

- **B. Pests Causing Direct Injury in apple**
  - 5. leafrollers - Tortricidae
    - a. tufted apple bud moth & variegated leafroller
    - b. redbanded leafroller




- **B. Pests Causing Direct Injury in apple**
  - 6. San Jose scale, Diaspididae







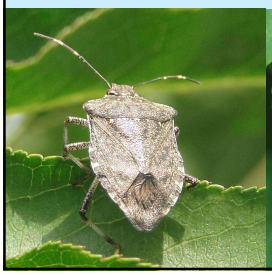
- **B. Pests Causing Direct Injury in apple**
  - 7. Catfacing insects (various species)
    - a. tarnished plant bug, Miridae
    - b. stink bugs, Pentatomidae





Dimpling in apple
Catfacing in peach and nectarine

- **B. Pests Causing Direct Injury in apple**
  - 7. Catfacing insects (various species)
    - b. stink bugs, Pentatomidae
    - Brown marmorated stink bug, *Halyomorpha halys*




- **B. Pests Causing Direct Injury in apple**
  - 7. Catfacing insects (various species)
    - b. stink bugs, Pentatomidae
    - Brown marmorated stink bug




II. Pests Causing Indirect Injury

- **A. Aphids**
- 1. **apple and spirea aphids**, ***Aphis pomi*** **DeGeer, *A. spiraecola* Patch****
- **2. rosy apple aphid, *Dysaphis plantaginea* (Passerini)****
- 3. apple grain aphid, *Rhopalosiphum fitchii* (Sanderson)
- **4. woolly apple aphid, *Eriosoma lanigerum* (Hausmann)**
- **5. Green peach aphid, *Myzus persicae* Sulzer**

First four on apple, last on peach

•Candidates for biological control?
•Complicated in species that are disease vectors, or have toxic saliva

Rosy apple aphid




- **B. Mites**
- **1. European red mite, *Panonychus ulmi* (Koch) (Tetranychidae)****
- **2. twospotted spider mite, *Tetranychus urticae* Koch(Tetranychidae)****
- 3. apple rust mite, *Aculus schlechtendali* (Nalepa), peach silver mite, *Aculus cornutus* (Banks) (Eriophyidae)

•Note: spider mite host ranges
•Overwintering site
•Intensity of feeding injury
•Tendency to develop resistance!!



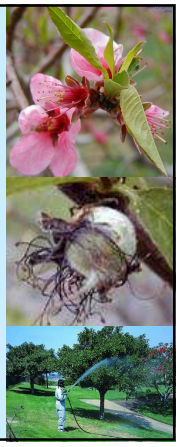
II. Chemical Control

- A. General use patterns on apple
  - Dormant or delayed dormant
  - Quarter-inch green
  - Half inch green
  - Tight cluster
  - Pink
  - Bloom
  - Petal fall
  - Cover sprays (6-8)
- B. General use patterns on peach
- C. Variations on pattern



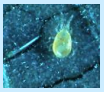
II. Chemical Control

- A. General use patterns on apple
- B. General use patterns on peach
  - Dormant
  - Bloom
  - Petal fall
  - Shuck split
  - Shuck fall
  - Cover sprays (4-5)
  - Borer sprays
- C. Variations on pattern



IV. Biological Control

- **A. Mites**
- 1. *Stethorus punctum* (LeConte)
- 2. Phytoseiid mites (e.g. *Neoseiulus (=Amblyseius) fallacis* (Garman)
- **B. Aphids**
- 1. Syrphidae
- 2. Coccinellidae
- 3. Cecidomyiidae
- 4. Chrysopidae
- 5. Anthocoridae







Crop Pests:
Small Fruits

Grape Berry Moth, *Paralobesia viteana*


Rufus Isaacs, MSU

- Formely *Endopiza*
- Key pest in eastern U.S. vineyards
- 3-5 generations annually
- NY threshold 2% injured clusters
- mid summer 2000 in VA:
  - 19, 27, 58, 79, 83, 95% injured clusters **(Avg. 60.2%)**



GBM injury

- Exterior feeders initially
- Enter and tunnel beneath berry surface
- Red spot on surface of berry
- Larva in rotted berry

GBM Control

- Insecticides
  - Imidan
  - Danitol
  - Bt
  - methoxyfenozide (Intrepid)
  - spinosad (Entrust)
  - spinetoram (Delegate)
  - indoxacarb (Avaunt)
  - Botanicals?

- **B. Pests Causing Indirect Injury to Grape**
  - 1. Japanese beetle, *Popillia japonica* (Newman)



Life History of GRB

- Lay eggs on vine trunks and on weeds.
- First instar larvae hatch, drop to ground
- Enter soil, begin feeding on grape roots
- Live in soil for two years



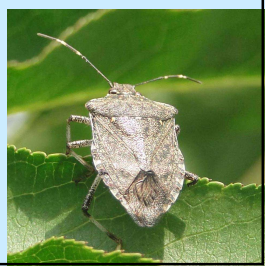
- **B. Pests Causing Direct Injury to Caneberries**
  - 2. Tarnished Plant Bug, *Lygus lineolaris* (Palisot de Beauvois)



3. Stink Bugs (Hemiptera: Pentatomidae)







Stylets insert between drupelets with *Euschistus, Acrosternum*



Laura Maxey - VT

- **B. Pests Causing Indirect Injury to Caneberries**
  - Raspberry crown borer *Pennisetia marginata* (Harris) (Sesiidae)
  - Rednecked cane borer *Agrilus ruficollis* (F.) (Buprestidae)
  - Raspberry cane borer *Oberea bimaculata* (Olivier) (Cerambycidae)





Wash. St. Univ. Col. St. Univ.

- **B. Pests Causing Indirect Injury to Caneberries**
  - Raspberry crown borer *Pennisetia marginata* (Harris) (Sesiidae)
  - Rednecked cane borer *Agrilus ruficollis* (F.) (Buprestidae)
  - Raspberry cane borer *Oberea bimaculata* (Olivier) (Cerambycidae)





Rednecked Cane Borer

- **Young larvae are restricted to the cambium, circling the cane 3-4 times in a close spiral, girdling the primocane, and producing gall-like swellings.**





UGA photos

Rednecked Cane Borer

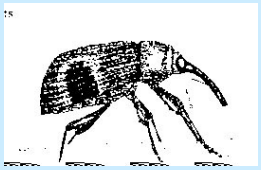
- **Cultural control: Remove galled canes in dormant season or early spring.**
- **This is most effective if nearby wild hosts are eliminated, and also more effective in open settings (wild brambles in nearby woods provide a source of wild beetles).**

- **B. Pests Causing Indirect Injury to Caneberries**
  - Raspberry crown borer *Pennisetia marginata* (Harris) (Sesiidae)
  - Rednecked cane borer *Agrilus ruficollis* (F.) (Buprestidae)
  - Raspberry cane borer *Oberea bimaculata* (Olivier) (Cerambycidae)



Strawberry Bud Weevil (aka Clipper)

- A small reddish-brown weevil





The strawberry weevil (enlarged about 8 times) is present during the flowering and bud formation period.

Tarnished Plant Bug

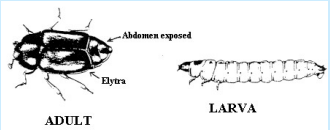




"apical seediness"

Strawberry Sap Beetle

- In ripe and over-ripe fruit
- Harvest completely
- Bait buckets of over-ripe fruit
- Brigade, diazinon
- Observe PHI



Blueberry Insects



- Cranberry Fruitworm, *Acrobasis vaccinii* Riley





- Cherry Fruitworm, *Grapholita packardii* Zeller





Blueberry Maggot, *Rhagoletis mendax* Curran



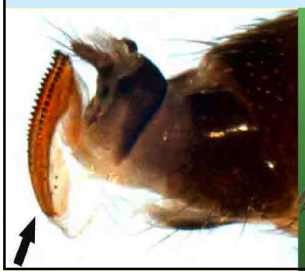


NCSU, USDA

Spotted wing drosophila



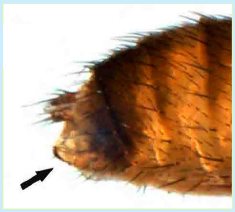
- Arrived in Va 2011





SWD Identification: Female

Other *Drosophila*



Blunt ovipositor cannot pierce skin of healthy fruit

Female: No spot on wing

SWD *D. suzukii*



Saw-like, serrated ovipositor with two even rows of teeth

SWD Larvae in Fruit



Cherry



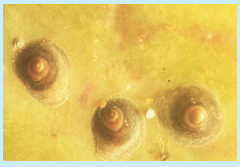
Strawberry

Damage is difficult to see until larvae are almost mature

Time out for taxa:

Scales

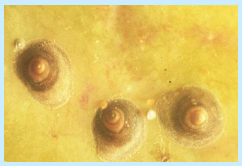
- Armored scales: Diaspididae
- Soft scales: Coccidae





Armored scales

- San Jose scale
- Euonymus scale
- Oystershell scale







Injury from armored scales

- Cover bark, loss of nutrients, vigor
- Decline of plant, death
- Contamination of fruit





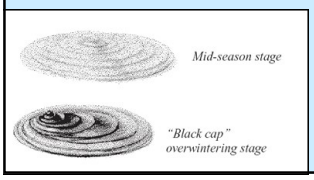
Life cycle of armored scales

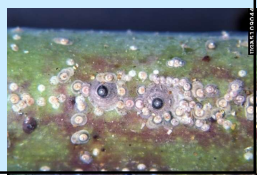
- Crawlers



Life cycle of armored scales

- Crawlers
- Nymphs and adults under scale covering





Life cycle of armored scales

- Crawlers
- Nymphs and adults under scale covering
- Males fly to females
- Females produce new crawlers



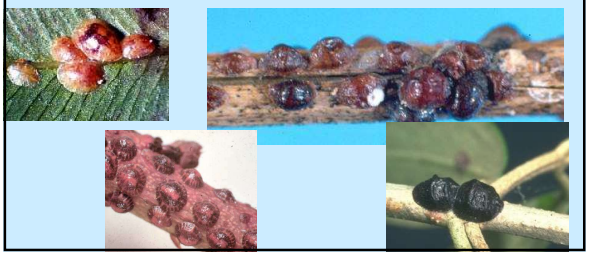
Soft scales

- More rounded, dome-shaped
- The actual insect, not a scale covering



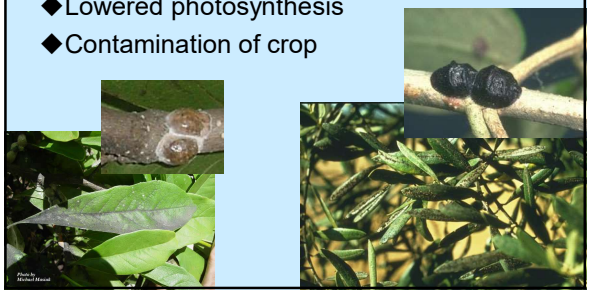
Soft scales

- Brown soft scale
- European fruit lecanium
- Terrapin scale
- Mediterranean black scale



Injury from soft scales

- Honeydew production, sooty mold
- Lowered photosynthesis
- Contamination of crop



Chemical Control

Chemical Control and Environmental Impact

- Heavy reliance of chemical control in recent decades



For every problem, there's a solution!

Most Insecticides are:

- Synthetic organic chemicals
- Contact poisons
- Highly insoluble in water
- Formulated into usable products

LD_{50} Values (mg/kg)

- IMPORTANT MEASURE OF TOXICITY!
- LD_{50} - dosage producing 50% mortality
- LC_{50} - concentration producing 50% mortality

LD_{50} Values (mg/kg)

- LD_{50} - Risk rankings — Label Warning Words
- High toxicity – 1-50 (Danger)
- Moderate – 51-500 (Warning)
- Slight – 501-5000 (Caution)
- Low - >5000 (Caution)

- MSDS (Lannate versus Delegate)
- Label (Lannate versus Delegate)

CDMS

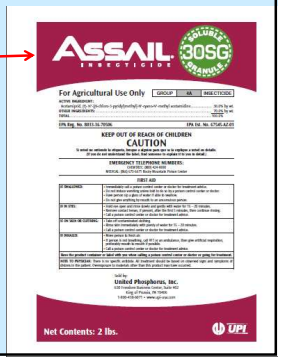
- CDMS web site source of labels
- http://www.cdms.net/Label-Database

Two important documents for pesticide users:

- **Label** – a legal agreement between three parties
  - EPA
  - Manufacturer
  - User
- **Material Safety Data Sheet** (MSDS)
- Both are available in CDMS web site:
- http://www.cdms.net/Label-Database

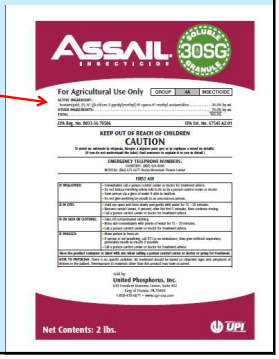
The Pesticide Label:

- Trade name
- Common name
- Formulation
- Manufacturer
- Resistance Class



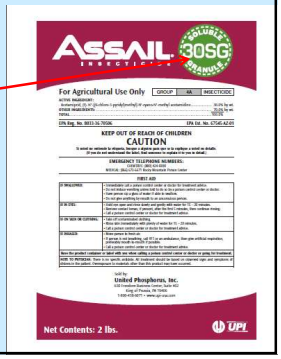
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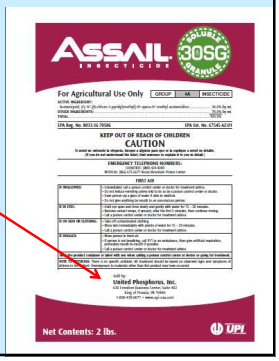
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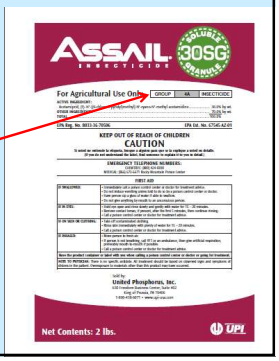
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The Pesticide Label:

- Trade name
- Common name
- Formulation
- Manufacturer
- Resistance Class



The Pesticide Label:

- Restricted Entry Interval
- PPE

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE) and restricted-entry intervals. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 12 hours.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, is coveralls, waterproof gloves and shoes plus socks.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal.

The Pesticide Label:

- Restricted Entry Interval
- PPE

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STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal.

The Pesticide Label:

- Crop use
- Use restrictions
- Days to harvest

GRAPES AND OTHER CLIMBING VINE SMALL FRUITS (EXCEPT FUZZY KIWIFRUIT) (within Crop Sub-Group 13-07F)

SPRAY VOLUME FOR GRAPES AND OTHER CLIMBING VINE SMALL FRUITS (EXCEPT FUZZY KIWIFRUIT) (within Crop Sub-Group 13-07F): Apply in a minimum finished spray volume of 5 gallons per acre by air or 20 gallons per acre by ground. Ground applications are recommended for optimal control.

SITE	PEST	DOSAGE PER ACRE: POUNDS ACTIVE	DOSAGE PER ACRE: OUNCES ASSAIL 30 SG INSECTICIDE	SPECIFIC DIRECTIONS
GRAPES AND OTHER CLIMBING VINE SMALL FRUITS (EXCEPT FUZZY KIWIFRUIT) (within Crop Sub-Group 13-07F) Amur river grape, gooseberry, hardy kiwifruit, Maypop, schisandra berry, and cushaws, varieties, and/or hybrids of these.	Leafhoppers including grape leafhopper and variegated leafhopper Grape cane girdler Glassywinged sharpshooter Aphids Mealybug (Citrips, Obscure) Western Grapeleaf Skeletonizer EAST of Rocky Mountains Only Phylloxera (aerial form only) Banded Grape Bug Rose Chafer Japanese Beetle	0.047	2.5	Begin applications when treatment thresholds have been reached. Thorough coverage is important to obtain optimum control. For Mealybug control, apply ASSAIL 30 SG insecticide as crawlers/nymphs become active. The addition of a spreader, methylated seed oil or crop oil will enhance control. For Western grapeleaf skeletonizer, apply ASSAIL 30 SG insecticide as larvae are observed feeding on leaves. Apply sufficient water to provide thorough coverage of all surfaces. For Japanese Beetle: Adult beetles will stop feeding after application and mortality will occur within a few days.

RESTRICTIONS AND PRECAUTIONS: Grapes and Other Climbing Vine Small Fruits (Except Fuzzy Kiwifruit) (within Crop Sub-Group 13-07F)

- Do not make more than 2 applications per season.
- Do not apply more than once every 14 days.
- Do not apply less than 7 days before harvest (PHI = 7 days).
- Do not exceed a total of 0.1 lb. active ingredient (5.3 ozs. product) per acre per growing season.

The Pesticide Label:

- Crop use
- Use restrictions
- Days to harvest

GRAPES AND OTHER CLIMBING VINE SMALL FRUITS (EXCEPT FUZZY KIWIFRUIT) (within Crop Sub-Group 13-07F)

SPRAY VOLUME FOR GRAPES AND OTHER CLIMBING VINE SMALL FRUITS (EXCEPT FUZZY KIWIFRUIT) (within Crop Sub-Group 13-07F): Apply in a minimum finished spray volume of 5 gallons per acre by air or 20 gallons per acre by ground. Ground applications are recommended for optimal control.

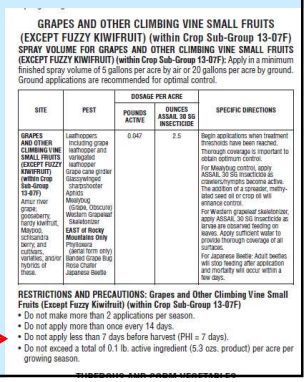
SITE	PEST	DOSAGE PER ACRE: POUNDS ACTIVE	DOSAGE PER ACRE: OUNCES ASSAIL 30 SG INSECTICIDE	SPECIFIC DIRECTIONS
GRAPES AND OTHER CLIMBING VINE SMALL FRUITS (EXCEPT FUZZY KIWIFRUIT) (within Crop Sub-Group 13-07F) Amur river grape, gooseberry, hardy kiwifruit, Maypop, schisandra berry, and cushaws, varieties, and/or hybrids of these.	Leafhoppers including grape leafhopper and variegated leafhopper Grape cane girdler Glassywinged sharpshooter Aphids Mealybug (Citrips, Obscure) Western Grapeleaf Skeletonizer EAST of Rocky Mountains Only Phylloxera (aerial form only) Banded Grape Bug Rose Chafer Japanese Beetle	0.047	2.5	Begin applications when treatment thresholds have been reached. Thorough coverage is important to obtain optimum control. For Mealybug control, apply ASSAIL 30 SG insecticide as crawlers/nymphs become active. The addition of a spreader, methylated seed oil or crop oil will enhance control. For Western grapeleaf skeletonizer, apply ASSAIL 30 SG insecticide as larvae are observed feeding on leaves. Apply sufficient water to provide thorough coverage of all surfaces. For Japanese Beetle: Adult beetles will stop feeding after application and mortality will occur within a few days.

RESTRICTIONS AND PRECAUTIONS: Grapes and Other Climbing Vine Small Fruits (Except Fuzzy Kiwifruit) (within Crop Sub-Group 13-07F)

- Do not make more than 2 applications per season.
- Do not apply more than once every 14 days.
- Do not apply less than 7 days before harvest (PHI = 7 days).
- Do not exceed a total of 0.1 lb. active ingredient (5.3 ozs. product) per acre per growing season.

The Pesticide Label:

- Crop use
- Use restrictions
- Days to harvest



GRAPES AND OTHER CLIMBING VINE SMALL FRUITS (EXCEPT FUZZY KIWIFRUIT) (within Crop Sub-Group 13-07F)

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Safety Data Sheet - SDS:

- Must be in possession
- Product & Company identification
- Hazards identification
- First aid
- Fire-fighting measures
- Accidental release measures
- Handling and storage
- Exposure control/Personal protection
- Toxicological information
- Ecological information

Toxicity:

- Acute: Immediate toxicity, resulting from a single dose
- Chronic: long term toxicity, sublethal, resulting from repeated doses, or long term effects from single dose

Chemical Groups of Insecticides

- Mode of action classes – about 30 for insecticides!
- IRAC
  - http://www.irac-online.org/documents/moa-classification/
  - http://www.frac.info/

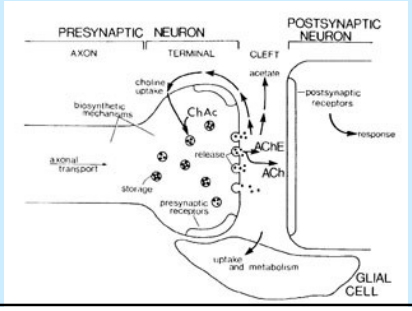
Chemical Groups of Insecticides

- Organophosphates } Inhibit cholinesterase
- Carbamates }
- DDT & Cyclodienes – axonic poisons
- Botanical insecticides
- Pyrethroids
- Neonicotinoids (chloronicotinyls)
- Insect growth regulators
- New compounds

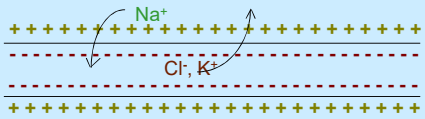
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- **Pyrethroids**
- **Neonicotinoids (chloronicotinyls)**
- **Insect growth regulators**
- New compounds

Nerve cells communicate with each other and with other tissues through **synapses**, specialized areas where the membranes of two cells are close together



Nerve axon



Modes of action of Insecticides

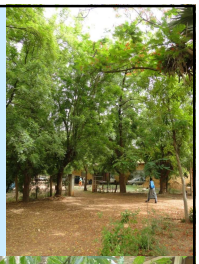
- Act at synapse
  - OPs (1B) (Imidan, malathion)
  - Carbamates (1A) (Sevin)
  - Neonicotinoids (4) (imidacloprid, acetamiprid, etc)
- Act on axon
  - DDT & Cyclodienes (2, 3) – gone but not forgotten!
  - Pyrethroids (3)
- **Insect growth regulators**
- New compounds

Botanical Insecticides

- Neem
- Pyrethrum
- Nicotine
- Rotenone
- Sabadilla
- Ryania
- Limonene

Neem

- *Azadirachta indica* oil
- Active ingredient - azadirachtin
- Insecticidal, fungicidal, bactericidal properties
- Insect growth regulator properties
- Repellant





Mode of action

- Disrupts molting by inhibiting biosynthesis or metabolism of ecdysone
- Marketed as
  - Azatin: insect growth regulator
  - Margosan-O: stomach/contact insecticide for greenhouse/ornamental pests
  - Aza-Direct
  - Trilogy/Neemix

Pyrethrum

- Extracted from flowers of a chrysanthemum grown in Kenya, Africa, Ecuador, South America
- Oral LD_{50} 1,500
- One of oldest household insecticides
- Dried flower heads used as louse powder to control body lice

Pyrethrins - Properties

- Naturally present in flowering plants - chrysanthemums
- Very rapid knockdown activity
- Natural compounds costly
- photosensitive, unstable
- safe to mammals

Synthetic pyrethrins (Pyrethroids)

- 1st gen. – allethrin (Pynamin)
- 2nd gen. - resmethrin, tetramethrin, bioallethrin, phenothrin
- 3rd gen. – esfenvalerate (Asana), permethrin (Ambush, Pounce, Perm-UP)
- 4th gen. - cypermethrin, fenpropathrin (Danitol), bifenthrin (Brigade, Capture, Bifenture), deltamethrin (Battalion)
- 5th gen. - lambda-cyhalothrin (Warrior), gamma-cyhalothrin (Proaxis), zeta-cypermethrin (Mustang Max)

Properties of Pyrethroids

- Photo stable
- Low volatility
- Highly insecticidal, but less knockdown capability
- Low mammalian toxicity
- High fish toxicity, also natural enemies
- No synergist needed

Synthetic nicotine? (Neonicotinoids)

- Imidacloprid first one on the market

Neonicotinoids

- Aka chloronicotinyls
- Long-term systemic action
- Translocated in xylem, highly hydrophilic
- Acetyl choline receptor antagonists
- Aphids, leafminers, leafhoppers
- Bee, bird toxicity

Neonicotinoids (cont.)

- imidacloprid (Admire Pro, Pasada, Merit)
- thiamethoxam (Actara)
- acetamiprid (Assail) **
- thiacloprid (Calypso) **
- clothianidin (Belay)
- All effective on many sucking insects; latter two more broad spectrum, internal caterpillars
- Problems with hormoligosis, predators

Synthetic ryania? (Anthranilamides)

- chlorantraniliprole (rynaxypyr) (Altacor, Coragen)
- cyantraniliprole (cyazypyr)

Anthranilamides

- rynaxypyr (Altacor, Coragen)
- Highly effective, highly selective
- Acts at ryanodine receptors in muscles, more so in insects than mammals

oxadiazines

- indoxacarb (Avaunt)
- Sodium channel blockers
- Mostly for Lepidoptera e.g. CM, OFM, some others (plum curculio, AM)

Particle film technology

- Kaolin (Surround)
- Effective on a range of insects and diseases
- Psyllids, leafhoppers, PC, AM, JB
- OMRI approved
- Disadvantage – rate
  - 25-50 lb/A
  - White residue

Avermectins

- macrocyclic lactones
- antibiotic – wide target range
- fermentation products of *Streptomyces avermitilis* , a soil fungus (actinomycete family)
- abamectin (Agri-Mek, Abba, Temprano)
- emamectin benzoate (Proclaim)

Mode of action

- acts @ GABA (gamma-amino butyric acid) site
- blocks neurotransmitter GABA at neuromuscular junction in mites and insects
- nerves incapable of firing, similar to cyclodienes
- broad spectrum - insects, mites, helminths
- have to be ingested
- extremely active – effective at low concentration
- local systemic qualities

Spinosyns

- Based on a soil actinomycete
- spinosad (Entrust – OMRI)
- spinetoram (Delegate, Radiant)
- Effective on Lepidoptera, thrips
- Acetyl choline modulators, activates receptors

Insect Growth Regulators

- Not a mode of action in itself!
- Four main modes of action
  - Ecdysone mimics
  - Prevent production of ecdysone
  - Juvenile hormone mimics
  - Chitin biosynthesis inhibitor

Molt-Accelerating Compounds

- MAC - active against lep larvae
- tebufenozide (Confirm) - 1st Reduced Risk Insecticide
- methoxyfenozide (Intrepid) - more effective
- halofenozide (Mach 2)

MACs

- ecdysone agonists - force premature molt
- timing more important
- very selective
- Why not active against other insects (which also use ecdysone)?

Ecdysone is really a family of compounds

Juvenile Hormone mimics

- pyriproxyfen (Esteem) – effective against aphids, leafminers, scales, codling moth (suppression of OBLR)

Chitin Biosynthesis Inhibitors

- Prevents proper formation of new cuticle
- diflubenzuron (Dimilin) – broad spectrum
- buprofezin (Centaur) – Homoptera
- novaluron (Rimon) - Lepidoptera

Premixes

- Leverage 360 – beta cyfluthrin & imidacloprid
- Voliam Flexi – chlorantraniliprole & thiamethoxam
- Voliam Xpress – chlorantraniliprole & lambda-cyfluthrin
- Endigo – thiamethoxam & lambda-cyfluthrin
- Agri-Flex – thiamethoxam & abamectin

- Rationale?
- Impacts?
  - Seasonal use rates
  - Unneeded insecticide application?

Advantages of Chemical use

- Effective
- Immediate impact
- Range of toxicity on large # organisms

Disadvantages of Chemicals

- Induction of secondary pests,
- Resistance,
- Environmental contamination,
- Harmful to workers,
- Residues in food

Pesticides in Food

- Both parent compounds and metabolites may be found on food
- This is recognized in establishment of ADIs
- Most removed by washing, varies with cmpd
- Public perception of risk?
- Relative risk of residues versus poor diet, microbial contamination?

Formulations

- Products in **soluble packets** should be added first. Some compounds in other formulations may hinder the ability of the packet to dissolve.
- **Wettable powder** products should be added next, followed by **flowables**.
- Next, the **emulsifiable concentrates** are added, followed by **oils**

Time out for taxa:

Curculionidae

- ◆Snout beetles
- ◆Largest family of beetles
- ◆3000 N Am species in 500 genera
- ◆Most have a well developed snout
- ◆Geniculate antennae arising halfway down snout
- ◆All are plant feeders



Curculionidae





Curculionidae



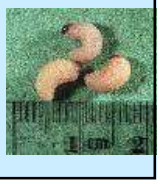




Curculionidae

◆Larvae are legless





Curculionidae

- Alfalfa weevil





Scolytinae

- One of the few subfamilies with no snout
- Cylindrical
- Important forest pests
- Often involved in symbioses with fungi



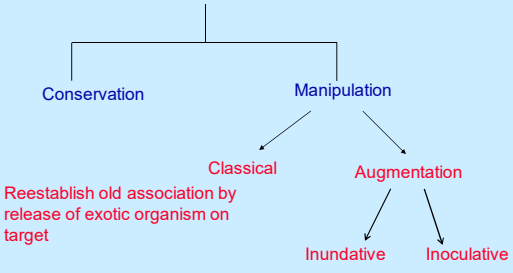


Biological Control

Natural enemies act by:

- Directly killing host
- Indirectly through
  - antagonistic effects
    - sterilization of host
    - reducing reproduction of host
    - reducing competitive ability of host

- Basic approaches in Biological control

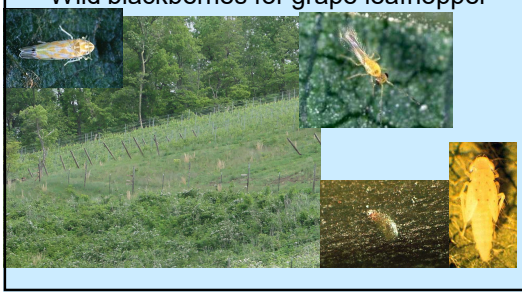


Cases of Conservation of Natural Enemies

- **Physiological selectivity**
  - Selective materials – toxicity tables for orchard use
    - Pests versus predators?
- **Ecological selectivity**
  - Reduced dosages – methomyl, leafrollers
  - Limited treatment area – alternate row spraying
  - Limited treatment time – prebloom sprays of pyrethroids

Cases of Conservation: Environmental manipulation

- Nesting sites for *Polistes*
- Wild blackberries for grape leafhopper



Cases of Classical Biological Control

- Ash whitefly, *Siphoninus phillyreae*
  - Found in California in 1988
  - Infested many ornamental trees, high numbers
  - Aphelinid *Encarsia inaron* introduced from Israel and Italy



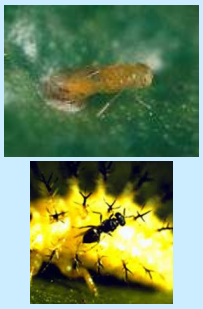
Cases of Augmentation: Inundative release

- *Trichogramma* sold for inundative release for ECB in Europe, China

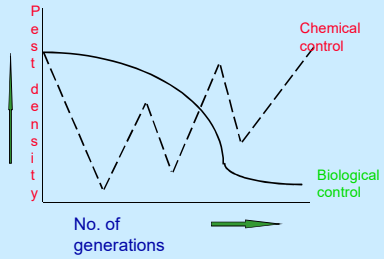


Cases of Augmentation: Inoculative release

- *Aphytis* released for California red scale
- In eastern US, *Pediobius foveolatus* imported from India, released against Mexican bean beetle



Biological vs. Chemical Control



Desirable Qualities of Biological Control Agents

- Host Specific
- Adaptable
- Effective
- Searching ability
- Synchronized with host life cycle
- High reproduction
- Dispersal
- Free from hyperparasites
- Reciprocal D-D relationship

Advantages of Biological Control

- Multiply and increase in numbers
- Permanent once established
- Target seeking ability
- Selectivity
- No undesirable side-effects
- Safe to user

Disadvantages of Biological Control

- Slow in achieving results
- Complex
- Special handling and use
- Often not spectacular -- partial success
- Not all pests suitable for biological control

Cole Crop Pests



Parasitized Cabbage Looper



Need to be careful …

- *Cactoblastis cactorum*, cactus moth now considered an invasive species
- *Harmonia axyridis*, multicolored Asian lady beetle



Predators: Coccinellids (lady beetles)



Predators: Carabids (ground beetles)

- Generalist predators, but…
- Some variation on prey
- Some species can be ag pests



Predators Syrphids (hover flies)





Predators: Predatory bugs

Predatory stink bugs



Minute pirate bugs







Mullein bug

Predators: Lacewings

- Both adults and larvae predatory (usually)
- Some reared commercially

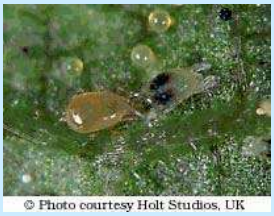






Predators: Predatory mites (e.g. Phytoseiidae)





© Photo courtesy Holt Studios, UK

Parasitoids: Wasps - Egg parasites

- *Trichogramma*





- Mymarids



Parasitoids: Wasps - Egg parasites

- Scelionidae (now in Platygastridae) – stink bug specialists
- *Trissolcus japonicus*

Parasitoid of BMSB – Status in US?

https://www.youtube.com/watch?v=rbdXiiM538I



Parasitoids: Wasps - TPB parasites

- Braconid



Parasitoids: Wasps - Scale parasites

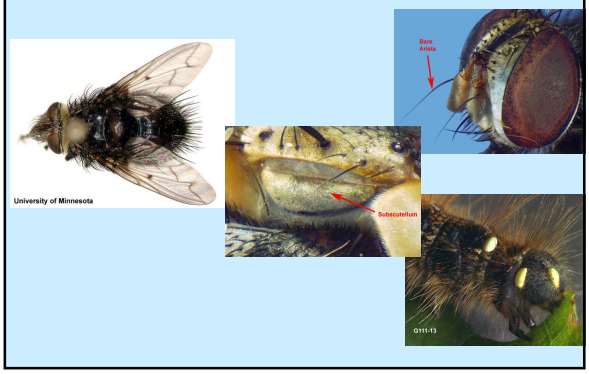
- *Metaphycus*



Parasitoids: Aphid parasites



Parasitoids: Tachinids



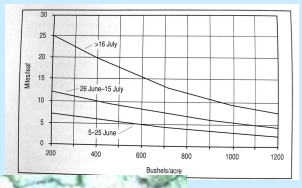
Parasitoids: Tachinids

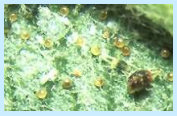


Istocheta aldrichi (Mesnil)



Integrating Biological and Chemical Control with Action Thresholds





European red mite



If ERM above AT, then *Stethorus*/3 min should be greater than 2.5 times ERM/leaf

Stethorus punctum

Commercial Sources of BC Agents

- **Green Methods** (Nottingham, NH)
  - (http://greenmethods.com/site/)
- **Koppert Biological Systems**
  - (http://www.koppert.com) (Netherlands)
  - (http://www.koppertonline.com) (Romulus MI)
- **IPM Laboratories** (Locke, NY)
  - (http://www.ipmlabs.com/)
- **Arbico Organics**
  - (http://www.arbico-organics.com/)
- **Certis** (Microbials)
  - (http://www.certisusa.com)
- **BASF** (Entomopathogenic Nematodes)
  - (http://betterplants.basf.us/products/nemasys-l-bio-insecticide.html)

Time out for taxa:

Reduviidae

- Assassin bugs
- Kissing bugs, ambush bugs
- Mostly predatory, some parasites of vertebrates
- About 160 N. American spp.



Reduviidae

- Variable in size and shape
- 4-segmented antennae
- Short, stout beak
- Elongate head with transverse groove behind head



Reduviidae

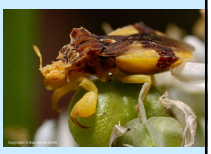
Kissing bugs transmit Chagas disease
Protozoan *Trypanosoma cruzi*.



Reduviidae

Ambush bugs are small, stout-bodied hemipterans, with enlarged front femora, all predaceous. What is the family?

Reduviidae (no longer the Phymatidae; are now Phymatinae).



Reduviidae



Who ya' gonna call?



Who ya' gonna call?

Virginia Cooperative Extension
Virginia Tech • Virginia State University
www.ext.vt.edu

Who ya' gonna call?

- Identify specimen yourself?
- County agent
- Insect ID lab
- Systemic Entomology Laboratory (SEL) at USDA Beltsville

USEFUL WEB LINKS

- Local Virginia Cooperative Extension Offices (VCE)
  http://ext.vt.edu/offices.html
- VCE Fact Sheets and Control Recommendations
  - Fact Sheets
    - Vegetables and Fruit Crops
  - Home Grounds and Animals
    - Vegetable Recommendations
    - Fruit Recommendations
- https://biocontrol.entomology.cornell.edu/index.php

Chemical Control Information

- General Information on Pesticides
  - http://www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/456/456-018/section1-reg-basic.pdf
- CDMS Pesticide Labels and Safety Data Sheets
  - http://www.cdms.net/Label-Database
- Toxicity to predators
  - http://www.virginiafruit.ento.vt.edu/SprayGuide/PredTox.html
- Toxicity to bees
  - http://www.virginiafruit.ento.vt.edu/beetox.html
  - http://www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/456/456-017/Section-1a_Protecting_Honeybees.pdf
- Modes of Action (IRAC)
  - http://www.irac-online.org/documents/moa-classification/?ext=pdf

Questions?

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PULL HERE TO OPEN

RESTRICTED USE PESTICIDE

DUE TO TOXICITY TO FISH, MAMMALS, AND AQUATIC ORGANISMS.

FOR RETAIL SALE TO AND USE ONLY BY CERTIFIED APPLICATORS OR PERSONS UNDER THEIR DIRECT SUPERVISION, AND ONLY FOR THOSE USES COVERED BY THE CERTIFIED APPLICATOR'S CERTIFICATION.

Not for sale, sale into, distribution and/or use in Nassau and Suffolk counties of New York State

ABAMECTIN | GROUP 6 | INSECTICIDES

CYANTRANILIPROLE | GROUP 28 | INSECTICIDES

Minecto® Pro

syngenta®

Insecticide/Miticide

Active Ingredient:	
Cyantraniliprole*	12.70%
Abamectin**	2.68%
Other Ingredients:	84.62%
Total:	100.00%

Minecto® Pro is formulated as a suspension concentrate and contains 1.13 lb cyantraniliprole and 0.24 lb abamectin per gallon.

* CAS No. 736994-63-1
** CAS No. 71751-41-2

KEEP OUT OF REACH OF CHILDREN.

WARNING/AVISO

Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand the label, find someone to explain it to you in detail.)

See additional precautionary statements and directions for use inside booklet.

EPA Reg. No. 100-1592
EPA Est. No. 100-NE-001

Product of the USA
Formulated in the USA

SCP 1592A-L1B 0718
4096042

3 qt 24 fl oz
(120 fl oz)
Net Contents

®

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2.2 Personal Protective Equipment (PPE)
2.3 Environmental Hazards

DIRECTIONS FOR USE

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1.0 FIRST AID

FIRST AID	
If swallowed	• Call poison control center or doctor immediately for treatment advice. • Have a person sip a glass of water if able to swallow. • Do not induce vomiting unless told to do so by a poison control center or doctor. • Do not give anything by mouth to an unconscious person.
In inhaled	• Move person to fresh air. • If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth, if possible. • Call a poison control center or doctor for further treatment advice.
If on skin or clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.
If in eyes	• Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center or doctor for treatment advice.
NOTE TO PHYSICIAN Early signs of intoxication include dilation of pupils, muscular incoordination, and muscular tremors. Toxicity following accidental ingestion of this product can be minimized by early administration of chemical adsorbents (e.g., activated charcoal). If toxicity from exposure has progressed to cause severe vomiting, the extent of resultant fluid and electrolyte imbalance should be gauged. Appropriate supportive parenteral fluid replacement therapy should be given, along with other required supportive measures (such as maintenance of blood pressure levels and proper respiratory functionality) as indicated by clinical signs, symptoms, and measurements. In severe cases, observations should continue for at least several days until clinical condition is stable and normal. Because abamectin, one of the active ingredients in this formulation, is believed to enhance GABA activity in animals, it is probably wise to avoid drugs that enhance GABA activity (barbiturates, benzodiazepines, valproic acid) in patients with potentially toxic abamectin exposure.	
Have the product container or label with you when calling a poison control center or doctor, or going for treatment.	
HOT LINE NUMBER For 24-Hour Medical Emergency Assistance (Human or Animal) Or Chemical Emergency Assistance (Spill, Leak, Fire or Accident), Call **1-800-888-8372**	

2.0 PRECAUTIONARY STATEMENTS

2.1 Hazards to Human and Domestic Animals

WARNING/AVISO

May be fatal if swallowed. Harmful if inhaled. Harmful if absorbed through the skin. Causes moderate eye irritation. Avoid breathing vapor or spray mist. Avoid contact with skin, eyes, or clothing.

Attention: This product contains a chemical known to the State of California to cause birth defects or other reproductive harm.

2.2 Personal Protective Equipment (PPE)

Mixers, loaders, applicators, and other handlers must wear:

- Long-sleeved shirt
- Long pants
- Shoes and socks
- Chemical-resistant gloves made of: barrier laminate, butyl rubber ≥ 14 mils, nitrile rubber ≥ 14 mils, neoprene rubber ≥ 14 mils, polyvinyl chloride (PVC) ≥ 14 mils or Viton® ≥ 14 mils

2.2.1 USER SAFETY REQUIREMENTS

Discard clothing and other absorbent materials that have been drenched or heavily contaminated with this product's concentrate. DO NOT reuse them. Follow the manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables exist, use detergent and hot water. Keep and wash PPE separately from other laundry.

2.2.2 USER SAFETY RECOMMENDATIONS

Users should:

- Wash hands before eating, drinking, chewing gum, using tobacco, or using the toilet.
- Remove clothing/PPE immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

2.2.3 ENGINEERING CONTROL STATEMENTS

When handlers use closed systems, enclosed cabs, or aircraft in a manner that meets the requirements listed in the Worker Protection Standard (WPS) for agricultural pesticides (40 CFR 170.240(d)(4-6)), the handler PPE requirements may be reduced or modified as specified in the WPS.

2.3 Environmental Hazards

This pesticide is toxic to fish, aquatic invertebrates, oysters, and wildlife. For terrestrial uses: Do not apply directly to water, or to areas where surface water is present, or to intertidal areas below the mean high water mark. Do not apply when weather conditions favor drift from target areas. Drift and runoff may be hazardous to aquatic organisms in water adjacent to use sites. Do not contaminate water when disposing of equipment washwater or rinsate.

This product is highly toxic to bees exposed to direct treatment on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops or weeds while bees are foraging in or adjacent to the treatment area.

Use of this product may pose a risk to threatened and endangered species of fish, amphibians, crustaceans (including fresh water shrimp), and insects. All use of this product in the state of California should comply with the recommendations of the California Endangered Species Project. Before using this product in California, consult with your county agriculture commissioner to determine use limitations that apply in your area.

2.3.1 SURFACE WATER ADVISORY

This product may impact surface water quality due to runoff of rain water. This is especially true for poorly draining soils and soils with shallow ground water. This product is classified as having high potential for reaching both surface water and aquatic sediment via runoff for several weeks to months after application. A level, well-maintained vegetative buffer strip between areas to which this product is applied and surface water features such as ponds, streams, and springs will reduce the potential loading of cyantraniliprole and abamectin from runoff water and sediment. Runoff of this product will be reduced by avoiding applications when rainfall is forecast to occur within 48 hours.

2.3.2 GROUND WATER ADVISORY

One of the active ingredients in this product, cyantraniliprole, has properties and characteristics associated with chemicals detected in groundwater. Cyantraniliprole may leach into ground water if used in areas where soils are permeable, particularly where the water table is shallow.

PROTECTION OF POLLINATORS



APPLICATION RESTRICTIONS EXIST FOR THIS PRODUCT BECAUSE OF RISK TO BEES AND OTHER INSECT POLLINATORS. FOLLOW APPLICATION RESTRICTIONS FOUND IN THE DIRECTIONS FOR USE TO PROTECT POLLINATORS.

Look for the bee hazard icon  in the Directions for Use for each application site for specific use restrictions and instructions to protect bees and other insect pollinators.

This product can kill bees and other insect pollinators.

Bees and other insect pollinators will forage on plants when they flower, shed pollen, or produce nectar.

Bees and other insect pollinators can be exposed to this pesticide from:

- Direct contact during foliar applications, or contact with residues on plant surfaces after foliar applications
- Ingestion of residues in nectar and pollen when the pesticide is applied as a seed treatment, soil, tree injection, as well as foliar applications.

When Using This Product Take Steps To:

- Minimize exposure of this product to bees and other insect pollinators when they are foraging on pollinator attractive plants around the application site.
- Minimize drift of this product on to beehives or to off-site pollinator attractive habitat. Drift of this product onto beehives or off-site to pollinator attractive habitat can result in bee kills.

Information on protecting bees and other insect pollinators may be found at the Pesticide Environmental Stewardship website at: http://pesticidestewardship.org/PollinatorProtection/Pages/default.aspx.

Pesticide incidents (for example, bee kills) should immediately be reported to the state/tribal lead agency. For contact information for your state, go to: www.aapco.org/officials.html. Pesticide incidents should also be reported to the National Pesticide Information Center at: www.npic.orst.edu or directly to EPA at: beekill@epa.gov

DIRECTIONS FOR USE

RESTRICTED USE PESTICIDE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulation.

See individual crops for specific pollinator protection application restrictions. If none exist under the specific crop, for foliar applications, follow these application directions for crops that are contracted to have pollinator services or for food/feed crops & commercially grown ornamentals that are attractive to pollinators.



FOR CROPS UNDER CONTRACTED POLLINATION SERVICES

Do not apply this product while bees are foraging. Do not apply this product until flowering is complete and all petals have fallen unless the following condition has been met:

If an application must be made when managed bees are at the treatment site, the beekeeper providing the pollination services must be notified no less than 48 hours prior to the time of the planned application so that the bees can be removed, covered or otherwise protected prior to spraying.



FOR FOOD/FEED CROPS AND COMMERCIALLY GROWN ORNAMENTALS NOT UNDER CONTRACT FOR POLLINATION SERVICES BUT WHICH ARE ATTRACTIVE TO POLLINATORS

Do not apply this product while bees are foraging. Do not apply this product until flowering is complete and all petals have fallen unless one of the following conditions is met:

- **The application is made to the target site after sunset.**
- **The application is made to the target site when temperatures are below 55°F.**
- **The application is made in accordance with a government-initiated public health response.**
- **The application is made in accordance with an active state-administered apiary registry program where beekeepers are notified no less than 48 hours prior to the time of the planned application so that the bees can be removed, covered or otherwise protected prior to spraying.**
- **The application is made due to an imminent threat of significant crop loss, and a documented determination consistent with an IPM plan or predetermined economic threshold is met. Every effort should be made to notify beekeepers no less than 48 hours prior to the time of the planned application so that the bees can be removed, covered or otherwise protected prior to spraying.**

Minecto Pro must be used only in accordance with instructions on this label, in a supplemental label or in state-specific 24C labeling. Always read the entire label, including the Conditions of Sale and Limitation of Warranty and Liability.

FAILURE TO FOLLOW DIRECTIONS AND PRECAUTIONS ON THIS LABEL MAY RESULT IN CROP INJURY, POOR PEST CONTROL, OR ILLEGAL RESIDUES.

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on the label about personal protective equipment (PPE), and restricted-entry interval, and notification to workers (as applicable). The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard (WPS).

Do not enter or allow worker entry into treated areas during the restricted-entry interval (REI) of 12 hours.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, is:

- Coveralls
- Shoes and socks
- Chemical-resistant gloves made of: barrier laminate, butyl rubber ≥ 14 mils, nitrile rubber ≥ 14 mils, neoprene rubber ≥ 14 mils, polyvinyl chloride (PVC) ≥ 14 mils or Viton® ≥ 14 mils

3.0 PRODUCT INFORMATION

Minecto Pro is a suspension concentrate that can be mixed with water and applied as a foliar spray to control a broad spectrum of insects and mites, as listed on this label. It is specially formulated for optimal performance by foliar application on the target crops.

3.0.1 MODE OF ACTION

Minecto Pro contains two active ingredients, cyantraniliprole and abamectin. Cyantraniliprole is a member of the anthranilic diamide class of insecticides with a novel mode of action on insect ryanodine receptors. Abamectin is a member of the avermectin class of miticide/insecticide with a unique agonist mode of action on the neurotransmitter gamma-aminobutyric acid (GABA).

Although Minecto Pro has some contact activity, it is most effective through ingestion of plant material. After exposure to Minecto Pro, affected insects and mites will rapidly stop feeding, become paralyzed, and typically die within 1- 3 days, reducing both direct damage and the transmission of some arthropod-vectored plant diseases. Minecto Pro has preventative activity but low curative activity for sucking pests.

3.0.2 PEST SUPPRESSION

Suppression can mean either inconsistent control (good to poor) or consistent control at a level below that generally considered acceptable for commercial control.

3.0.3 CROP TOLERANCE

Not all crops within a crop group, and not all varieties, cultivars, or hybrids of crops, have been individually tested for crop safety. It is not possible to evaluate for crop safety all applications of Minecto Pro on all crops within a crop group, on all varieties, cultivars, or hybrids of those crops, or under all environmental conditions and growing circumstances. To test for crop safety, apply the product in accordance with the label instructions to a small area of the target crop to ensure that a phytotoxic response will not occur, especially where the application is a new use of the product by the applicator. Refer to **Section 4.4.2** for information regarding crop safety of tank mixtures.

3.1 Integrated Pest Management (IPM)

Syngenta supports the use of Integrated Pest Management (IPM) programs to control pests. This product may be used as part of an IPM program, which can include biological, cultural, and genetic practices aimed at preventing economic pest damage. IPM principles and practices include field scouting or other detection methods, correct target pest identification, population monitoring, rotation of insecticides with different modes-of action, and treating when target pest populations reach locally determined action thresholds. Consult your state cooperative extension service, professional consultants, or other qualified authorities to determine appropriate action treatment threshold levels for treating specific pest/crop or site systems in your area.

3.2 Resistance Management

ABAMECTIN	**GROUP**	**6**	**INSECTICIDES**
CYANTRANILIPROLE	**GROUP**	**28**	**INSECTICIDES**

For resistance management, please note that Minecto Pro contains both a Group 28 (cyantraniliprole) insecticide and Group 6 (abamectin) miticide/insecticide. Any insect/mite population may contain individuals naturally resistant to Minecto Pro and other Group 28 insecticides or Group 6 miticides/insecticides. The resistant individuals may dominate the insect/mite population if these insecticides/miticides are used repeatedly in the same fields. Appropriate resistance-management strategies should be followed.

To delay insecticide/miticide resistance, take the following steps:

- Rotate the use of Minecto Pro or other Group 28 or Group 6 miticides/insecticides within a growing season, or among growing seasons, with different groups that control the same pests.

- Use tank mixtures with insecticides/miticides from a different group that are equally effective on the target pest when such use is permitted. Do not rely on the same mixture repeatedly for the same pest population. Consider any known cross-resistance issues (for the targeted pests) between the individual components of a mixture. In addition, consider the following recommendations provided by the Insecticide Resistance Action Committee (IRAC):
    - Individual insecticides selected for use in mixtures should be highly effective and be applied at the rates at which they are individually registered for use against the target species.
    - Mixtures with components having the same IRAC mode of action classification are not recommended for insect resistance management.
    - When using mixtures, consider any known cross-resistance issues between the individual components for the targeted pest(s).
    - Mixtures become less effective if resistance is already developing to one or both active ingredients, but they may still provide pest management benefits.
    - The insect resistance management benefits of an insecticide mixture are greatest if the two components have similar periods of residual insecticidal activity. Mixtures of insecticides with unequal periods of residual insecticide activity may offer an insect resistance management benefit only for the period where both insecticides are active.
- Adopt an integrated pest management program for insecticide/miticide use that includes scouting, uses historical information related to pesticide use, crop rotation, record keeping, and which considers cultural, biological and other chemical control practices.
- Monitor after application for unexpected target pest survival. If the level of survival suggests the presence of resistance, consult with your local university specialist or certified pest control advisor.
- Contact your local extension specialist or certified crop advisors for any additional pesticide resistance-management and/or IPM recommendations for the specific site and pest problems in your area.
- For further information or to report suspected resistance contact your local Syngenta representative.

3.2.1 MAINTAINING SUSCEPTIBILITY TO THESE CLASSES OF CHEMISTRY

- Avoid using Group 28 or Group 6 miticides/insecticides exclusively for season-long control of insect or mite species with more than one generation per crop season.
- For insect or mite species with successive or overlapping generations, apply Minecto Pro or other Group 28 or Group 6 miticides/insecticides using a “treatment window” approach. A treatment window is a period of time as defined by the stage of crop development and/or the biology of the pests of concern. Within the treatment window, depending on the length of residual activity, there may either be single or consecutive applications (seed treatment, soil, foliar, unless otherwise stated) of the Group 28 or Group 6 miticides/insecticides. Do not exceed the maximum Minecto Pro allowed per year.
- Following a treatment window of Group 28 or Group 6 miticides/insecticides, rotate to a treatment window of effective products with a different mode of action before making additional applications of Group 28 or Group 6 miticides/insecticides.
- A treatment window rotation, along with other IPM practices for the crop and use area, is considered an effective strategy for preventing or delaying a pest’s ability to develop resistance to these classes of chemistry.
- If resistance is suspected, do not reapply Minecto Pro or other Group 28 or Group 6 miticides/insecticides.

3.2.2 OTHER SOURCES FOR INFORMATION ON INSECT OR MITE RESISTANCE MANAGEMENT

- Contact your local extension specialist, certified crop advisor and/or product manufacturer for additional insect resistance management recommendations.
- Visit the Insecticide Resistance Action Committee (IRAC) on the web at: http://www.irac-online.org/.

4.0 APPLICATION DIRECTIONS

4.1 Methods of Application

Foliar applications of Minecto Pro are permitted by ground, air or chemigation as specified in **Section 7.0**, unless otherwise restricted in **Section 6.1**

4.2 Application Equipment

Minecto Pro may be applied by foliar ground or aerial application equipment, except as otherwise directed in **Section 7.0** or **Section 6.1**.

4.2.1 SHIELDED SPRAYERS

- Shielding the boom or individual nozzles can reduce the effects of wind.
- However, it is the responsibility of the applicator to verify that the shields are minimizing drift potential and not interfering with uniform deposition of the product.

4.2.2 AIR-ASSISTED (AIR-BLAST) FIELD CROP SPRAYERS

- Air-assisted field crop sprayers carry droplets to the target via a downward-directed air stream. Some may reduce the potential for drift, but if a sprayer is unsuitable for the application and/or set up improperly, high drift potential can result.
- It is the responsibility of the applicator to determine that a sprayer is suitable for the intended application, that it is configured properly, and that drift potential has been minimized.
- **Note:** Air-assisted field sprayers can affect product performance by affecting spray coverage and canopy penetration. Read the specific crop use and application equipment instructions to determine if an air-assisted field crop sprayer can be used.

4.2.3 SPRAY TANK CLEAN-OUT

- Prior to application, start with clean, well maintained application equipment. Immediately following application, thoroughly clean all spray equipment to reduce the risk of forming hardened deposits which might become difficult to remove.
- Drain application equipment. Thoroughly rinse and flush all application equipment with clean water.
- Clean all other associated equipment. Take all necessary safety precautions when cleaning equipment. Do not clean near wells, water sources or desirable vegetation.
- Dispose of waste rinse water in accordance with local regulations.

4.3 Application Volume and Spray Coverage

See **Section 7.0** for additional application volume information.

- Thorough spray coverage is essential for good insect and mite control.
- Use sufficient water carrier to obtain thorough, uniform coverage.
- The highest labeled rate for a specified pest may be needed when aerial applications are made.

4.4 Mixing Directions

- It is the pesticide user's responsibility to ensure that all products are registered for the intended use. Read and follow the applicable restrictions and limitations and directions for use on all product labels involved in tank mixing. Users must follow the most restrictive directions for use and precautionary statements of each product in the tank mixture.
- Refer to **Section 4.4.5** for instructions on the use of adjuvants with this product.
- If the pH of the spray tank after all products have been added and mixed is above pH 8, adjust to a range of pH 5-8 using a registered acidifying agent.
- If the spray tank pH is 8 or less no adjustment of the spray tank pH is necessary.
- Do not store the spray mixture overnight in the spray tank.

4.4.1 MINECTO PRO ALONE

1. Fill clean spray tank 1/4 - 1/2 full of water.
2. Add Minecto Pro directly to the spray tank.
3. Mix thoroughly to fully disperse the insecticide/miticide. Once dispersed, continuous agitation is required.
4. Use mechanical or hydraulic means; do not use air agitation.
5. Observe the most restrictive of the labeling limitations and precautions of all products used in mixtures.

4.4.2 TANK-MIX PRECAUTIONS

- This product may be mixed with pesticide products labeled for use on crops on this label in accordance with the most restrictive of label limitations and precautions.
- Do not exceed labeled dosage rates.
- This product cannot be mixed with any product containing a label prohibition against such mixing.

Crop Safety of Tank Mixtures

- Except for known potential problems noted below, the crop safety of Minecto Pro in tank mix with many common insecticides, fungicides, nutritionals, and adjuvants has been found to be acceptable. However, the safety of all potential tank mixes on all crops may not have been tested. Before applying any tank mixture not specifically recommended on this label, the safety to the target crop should be confirmed.
- Tank mixes of Minecto Pro with some of the following products may result in adverse crop response.
  - Products formulated as emulsifiable concentrates (EC)
  - Strobilurin fungicides, for example Cabrio® and Quadris® brands
  - Copper and sulfur-based fungicides
  - Chlorothalonil-based fungicide formulations, for example Bravo Weather Stik® and the fungicides Tanos®, Rally®, Manzate® brands, and captan-containing products
- Some of the following materials when applied individually, sequentially, or in tank mixtures may solubilize the plant cuticle, facilitate penetration into plant tissues, and increase the potential for crop injury.
  - Oils
  - Surfactants
  - Adjuvants
  - Nutritionals
  - Pesticide formulations
- The application of strobilurin fungicides in a short time sequence (i.e., seven days or less between applications) before or after Minecto Pro may also result in adverse crop response.
- Applying Minecto Pro with any product that produces adverse crop response in a tank mixture, specifically including, but not limited to, those listed above, may also cause adverse crop response when applied in a short time sequence. Such uses should be tested as described below before broad application is made.
- Crop varieties can differ in their responsiveness to tank mixtures, and environmental conditions can have an influence on product performance and crop response. It is not possible to test Minecto Pro alone or with all possible tank-mix combinations and sequences on all varieties under all environmental conditions.
- When considering the use of a tank mixture on a labeled crop without prior experience, or which is not specifically described on Minecto Pro product labeling or in other Syngenta product use instructions, or when applying the aforementioned products in close sequence with Minecto Pro, it is important to check crop safety first.
- To test for crop safety, prepare a small volume of the intended tank mixture or sequence, apply it to an area of the target crop as directed by both this and the tank mix partner product labels, and observe the treated crop to ensure that a phytotoxic response does not occur.
- Use of Minecto Pro in any tank mixture or sequence of applications that is not specifically described on Minecto Pro product labeling, or in other Syngenta product use instructions, could potentially result in crop injury.
- To the extent allowed by applicable law, Syngenta will not be responsible for any crop injury arising from the use of a tank mixture or sequence of applications that is not specifically described on Minecto Pro product labeling or in other Syngenta product use instructions.

Physical Compatibility of Tank Mixtures

- Minecto Pro has been tested and shown to have broad physical compatibility with many commonly used pesticides, spray adjuvants, and nutritional products. However, since it is not possible to test all potential mixtures, it is recommended that the user conduct a jar test for physical compatibility (**Section 4.4.3**) of all components of the proposed mixture using proper concentrations of each mixture component.
- Avoid mixtures of several materials and very concentrated spray mixtures.

4.4.3 TANK-MIX COMPATIBILITY TEST

Minecto Pro is physically compatible with many commonly used fungicides, herbicides, insecticides, biological control products, liquid fertilizers, non-ionic surfactants, crop oils, methylated seed oils and drift control additives. However, since the formulations of products change, it is important to test the physical compatibility of desired tank mixes and check for undesirable physical effects, including settling out or flocculation.

A jar compatibility test is recommended prior to tank mixing with other pesticides and/or adjuvants/additives, in order to ensure the compatibility of Minecto Pro with other tank-mixed pesticide, adjuvant or fertilizer partners. The recommended procedure for conducting jar tank-mix compatibility tests is as follows:

Compatibility Test: Since pesticides, adjuvants and fertilizers can vary in quality, always **check tank-mix compatibility with tank-mixed partners each time before use.** Be especially careful when using **complete** suspension or fluid fertilizers as carriers, as serious compatibility problems are more likely to occur with these products. Commercial application equipment may improve tank-mix compatibility in some instances. The following test assumes a spray volume of 25 gallons/A. For other spray volumes, make appropriate changes in the components. Check tank-mix compatibility using this procedure:

1. Add 1 pt of carrier (either the water or liquid fertilizer to be used in the spray operation) to each of two clear 1-qt jars with tight lids.
2. To **one** of the jars, add 1/4 teaspoon or 1.2 ml of a commercially available tank-mix compatibility agent approved for this use (1/4 teaspoon is equivalent to 2 pt/100 gallons of spray). Invert the jar, shake or stir gently to ensure thorough mixing.
3. To **both** jars, add the appropriate amount of each tank-mix partner. If more than one tank-mix partner is to be used, add them separately with dry formulations (wettable powders or water dispersible granules) first, followed by liquid flowables, capsule suspensions, emulsifiable concentrates and finally adjuvants. After each addition, invert the jar, shake or stir gently to thoroughly mix. The appropriate amount of each tank-mix partner for this test, is as follows:

   Dry formulations: For each pound to be applied per acre, add 1.5 level teaspoons to each jar.

   Liquid formulations: For each pint to be applied per acre, add 1/2 teaspoon or 2.5 milliliters to each jar.
4. After adding all ingredients, put lids on and tighten, then invert each jar 10 times to fully mix. Let the mixtures stand for 15-30 minutes and then assess by looking for separation, large flakes, precipitates, gels, heavy oily film on the jar, or other signs of incompatibility. Determine if a compatibility agent is needed in the spray mixture by comparing the two jars. If either mixture separates, but can be remixed readily, the mixture can be sprayed as long as good agitation is used. If the mixtures are incompatible, test the following methods of improving compatibility: (A) slurry dry formulations in water before addition, or (B) add the compatibility agent directly into liquid formulations, before addition to the tank-mixture. If these procedures are followed but incompatibility is still observed, do not use the tank-mixture.

4.4.4 MINECTO PRO IN TANK MIXTURES

Add different formulation types in the sequence indicated below, unless otherwise specified by manufacturer directions for use or by local experience. Allow time for complete mixing and dispersion after addition or each product.

1. Water-soluble bag (WSB)
2. Water-soluble granules (SG)
3. Water-dispersible granules (WG, XP, DF)
4. Wettable powders (WP)
5. Minecto Pro and other water-based suspension concentrates (SC)
6. Water-soluble concentrates (SL)
7. Suspoemulsions (SE)
8. Oil-based suspension concentrates (OD)
9. Emulsifiable concentrates (EC)
10. Surfactants, oils, adjuvants
11. Soluble fertilizers
12. Drift retardants

4.4.5 SPRAY ADDITIVES

- To avoid illegal crop residues, Minecto Pro **must always** be mixed with a non-phytotoxic, non-ionic activator type wetting, spreading and/or penetrating spray adjuvant or horticultural oil (not a dormant oil) and applied as specified in **Section 7.0** for each crop on this label.

- Non-ionic activator type wetting, spreading and/or penetrating spray adjuvants include:
  - Non-ionic surfactants (NIS) with at least 75% surface active agent
  - Crop oil concentrates (COC)
  - Vegetable oil concentrates (VOC)
  - Methylated seed/vegetable oils (MSO)
  - Organosilicones (OS) with at least 15% emulsifiers/surfactants
  - Blends of these non-ionic activator type spray adjuvants.
- Since spray adjuvants alone are known to cause phytotoxicity to certain crops under certain environmental conditions, **do not** use Minecto Pro on a spray-adjuvant-sensitive crop unless the spray adjuvant supplier can confirm a known non-phytotoxic labeled use rate for the intended spray adjuvant on the target crop.
- Spray adjuvants must be compatible with Minecto Pro and must be used at concentrations specified on the **spray adjuvant product label** directions for use for the targeted crop unless more specific directions are provided in the **Section 7.0** for individual crops on this label.
- **Do not use binder or sticker type adjuvants because these type adjuvants may reduce translaminar movement of the active ingredient into the plant, and can result in reduced efficacy.**
- Syngenta recommends the use of a Chemical Producers and Distributors Association (CPDA) certified spray adjuvant.

4.5 Application through Irrigation Systems (Chemigation)

4.5.1 CHEMIGATION PRECAUTIONS

- Apply this product at rates and timings described in Section 7.0.
- Apply this product only through overhead sprinkler irrigation systems including center pivot, lateral move, end tow, side (wheel) roll, traveler, big gun, solid set, or hand move irrigation systems. Do not apply this product through any other type of irrigation system.
- Never put Minecto Pro into a dry tank or other mixing equipment without first adding water. See Section 4.4 for more information.
- Inject Minecto Pro downstream from any water filtration system.
- The irrigation system used must provide uniform water distribution. Crop injury, lack of effectiveness, or illegal pesticide residues in the crop can result from non-uniform distribution of treated water.
- End guns must be turned off during application if they irrigate nontarget areas or if they do not provide uniform application and coverage.
- Nozzles in the immediate area of wells, control panels, chemical supply tanks, and system safety devices are to be plugged to prevent contamination of these areas.
- Do not apply when system connections or fittings leak or when nozzles do not provide uniform distribution.
- Do not allow irrigation water to collect or run-off during chemigation application.
- Do not apply when wind speeds favor drift beyond the area intended.
- Apply in 0.1-0.20 inches/acre. Excessive water may reduce efficacy.
- Ensure the irrigation system is calibrated to uniformly distribute the chemigation application to the crop. If you have questions about calibration, you should contact State Extension Service specialists, equipment manufacturers, or other experts.
- Do not connect an irrigation system (including greenhouse systems) used for pesticide application to a public water system, unless the pesticide label-prescribed safety devices for public water systems are in place.
- A person knowledgeable of the chemigation system and responsible for its operation, or under the supervision of the responsible person, shall shut the system down and make necessary adjustments should the need arise.
- Wear the personal protective equipment as defined in Section 2.2 for applicators and other handlers when making adjustments or repairs on the chemigation system with Minecto Pro in the irrigation water.

4.5.2 OPERATING INSTRUCTIONS FOR CHEMIGATION

1. The system must contain a functional check-valve, vacuum relief valve, and low pressure drain appropriately located on the irrigation pipeline to prevent water-source contamination from backflow.
2. The pesticide injection pipeline must contain a functional, automatic, quick-closing check-valve to prevent the flow of fluid back toward the injection pump.

3. The pesticide injection pipeline must also contain a functional, normally closed, solenoid-operated valve located on the intake side of the injection pump and connected to the system interlock to prevent fluid from being withdrawn from the supply tank when the irrigation system is either automatically or manually shut down.
4. The system must contain functional interlocking controls to automatically shut off the pesticide injection pump when the water pump motor stops.
5. The irrigation line or water pump must include a functional pressure switch which will stop the water pump motor when the water pressure decreases to the point where pesticide distribution is adversely affected.
6. Systems must use a metering pump, such as a positive displacement injection pump (e.g., diaphragm pump), effectively designed and constructed of materials that are compatible with pesticides and capable of being fitted with a system interlock.

4.5.3 SPECIFIC INSTRUCTIONS FOR PUBLIC WATER SYSTEMS

1. Do not apply Minecto Pro through an irrigation system connected to public water system unless the pesticide label prescribed safety devices for public water systems are in place. Public water system means a system for the provision to the public of piped water for human consumption if such system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year.
2. Chemigation systems connected to public water systems must contain a functional, reduced-pressure zone, back-flow preventer (RPZ) or the functional equivalent in the water supply line upstream from the point of pesticide introduction. As an option to the RPZ, the water from the public water system should be discharged into a reservoir tank prior to pesticide introduction. There shall be a complete physical break (air gap) between the outlet end of the fill pipe and the top or overflow rim of the reservoir tank of at least twice the inside diameter of the fill pipe.
3. The pesticide injection pipeline must contain a functional, automatic, quick-closing check valve to prevent the flow of fluid back toward the injection pump.
4. The pesticide injection pipeline must contain a functional, normally closed, solenoid-operated valve located on the intake side of the injection pump and connected to the system interlock to prevent fluid from being withdrawn from the supply tank when the irrigation system is either automatically or manually shut down.
5. The system must contain functional interlocking controls to automatically shut off the pesticide injection pump when the water pump motor stops, or in cases where there is no water pump, when the water pressure decreases to the point where pesticide distribution is adversely affected.
6. Systems must use a metering pump, such as a positive displacement injection pump (e.g., diaphragm pump) effectively designed and constructed of materials that are compatible with pesticides and capable of being fitted with a system interlock.
7. Do not apply when wind speed favors drift beyond the area intended for treatment.

4.5.4 APPLICATION DIRECTIONS FOR IRRIGATION SYSTEMS

1. Apply Minecto Pro in sufficient water and of sufficient duration to ensure the specified rate is applied evenly to the entire treated area.
2. A pesticide tank is recommended for the application of Minecto Pro in chemigation systems.
3. Thoroughly clean the injection system and tank of any fertilizer or chemical residues using a standard clean out procedure. Dispose of any residues in accordance with State and Federal laws. Consult your owner's manual or your local equipment dealer for cleanout procedures for your injection system
4. With the mix tank 1/4 to 1/2 full with water and the agitator running, measure the required amount of Minecto Pro and add it to the tank. Then add additional water to bring the total pesticide mixture up to the desired volume for application.
5. Continue agitation throughout the application. Use mechanical or hydraulic agitation. Do not use air for agitation.
6. Injection should occur at a point in the main irrigation water flow to ensure proper mixing with the irrigation water.
7. For continuously moving systems inject the solution containing Minecto Pro into the irrigation water line continually and uniformly throughout the irrigation cycle.
8. For continuously moving systems the maximum recommended water volume for overhead chemigation application is 0.1 acre inches of water.
9. For overhead sprinkler irrigation systems that are stationary, add the solution containing Minecto Pro to the irrigation water line and apply in a maximum water volume of 0.20 acre inches of water.

10. Calibrate the irrigation system and injector before applying Minecto Pro. Calibrate the injection pump while the system is running using the expected irrigation rate.
11. Start the water pump and sprinkler and let the system achieve the desired pressure and speed before starting the injector.
12. Start the injector and calibrate the injection system. This is necessary to deliver the desired product rate per acre in a uniform manner.
13. When the application is finished, allow the entire irrigation and injector system to be thoroughly flushed clean before stopping the system.
14. Thoroughly clean the injection system and tank of any fertilizer or chemical residues using a standard clean out procedure. Dispose of any residues in accordance with State and Federal laws.

5.0 ROTATIONAL CROP RESTRICTIONS

The following crops may be planted at the specified interval following application of Minecto Pro:

There is no plant back restriction for conversion of a treated field or for making a new or replacement planting into established orchards or fields of Bushberries (Crop Subgroup 13-07B); Citrus (Crop Group 10-10); Pome Fruits (Crop Group 11-10); Stone Fruits (Crop Group 12); Low Growing Berries (Crop Subgroup 13-07G); or Tree Nuts (Crop Group 14-12).

Crop, Crop Group, or Subgroup	**Plant-back Restriction (in Days) following Last Application of Minecto Pro**
Brassica Leafy Vegetables (Crop Group 5)	0
Bulb Vegetables (Crop Group 3-07)	
Corn (Field, Pop, Seed and Sweet)	
Cotton	
Cucurbit Vegetables (Crop Group 9)	
Fruiting Vegetables (Crop Group 8-10)	
Leafy Vegetables (except Brassica) (Crop Group 4)	
Leaves of Root and Tuber Vegetables (Crop Group 2)	
Legume Vegetables (Crop Groups 6 and 7)	
Low Growing Berries (Crop Subgroup 13-07H)	
Oilseeds (Crop Group 20)	
Peanuts	
Root and Tuber Vegetables (Crop Subgroups 1B and 1C)	
Tobacco	
Cereal Grains (Crop Group 15)	30
Forage, Fodder, and Straw of Cereal Grains (Crop Group 16)	
Grass Forage, Fodder and Hay (Crop Group 17)	
Non-grass Animal Feeds (forage, fodder, straw, and hay) (Crop Group 18)	
Sugar beets	
All other crops not listed	12 months

6.0 RESTRICTIONS AND PRECAUTIONS

See **Section 7.0** for crop-specific restrictions and precautions.

6.1 Use Restrictions

- To avoid illegal residues the product must be mixed with a non-ionic activator type wetting, spreading, and/or penetrating spray adjuvant or horticultural oil (not a dormant oil). The spray adjuvant must be approved for use on the intended target crop.
- **DO NOT** treat plants grown for transplanting. Minecto Pro is not for use in nurseries, plant propagation houses, or greenhouses by commercial transplant producers on plants being grown for transplanting.
- **DO NOT** use on crops grown to harvest in greenhouses unless specified in the crop use section of this label.
- **DO NOT** apply Minecto Pro to the soil or through drip irrigation systems as doing so may damage the plant root system.
- **DO NOT** use in residential areas or residential landscapes.
- **DO NOT** apply Minecto Pro through any type of irrigation system (chemigation) to any crop except for bulb onions, green onions and potatoes.
- **DO NOT** apply a total of more than 0.4 lb ai per acre per calendar year including all application types (seed treatment, soil, foliar) of cyantraniliprole-containing products unless otherwise stated for a specific crop.
- **DO NOT** apply Minecto Pro with aircraft in New York State.

6.2 Spray Drift Precautions

The interaction of many equipment- and weather-related factors determines the potential for spray drift. The applicator is responsible for considering all these factors when making application decisions. Avoiding spray drift is the responsibility of the applicator.

6.2.1 VEGETATIVE BUFFER STRIP

- **DO NOT** make ground applications within 25 ft or aerial application within 150 ft of lakes, rivers, reservoirs, permanent streams, marshes, natural ponds, estuaries or coastal areas. Do not cultivate within 25 ft of these aquatic areas to allow growth of a vegetative filter strip.

6.2.2 IMPORTANCE OF DROPLET SIZE

- The most effective drift management strategy is to apply the largest droplets which are consistent with pest control objectives.
- The presence of sensitive species nearby, the environmental conditions, and pest pressure may affect how an applicator balances drift control and coverage.
- Applying larger droplets reduces drift potential, but will not prevent drift if applications are made improperly or under unfavorable environmental conditions.
- A droplet size classification system describes the range of droplet sizes produced by spray nozzles. The American Society of Agricultural and Biological Engineers (ASABE) provide a Standard that describes droplet size spectrum categories defined by a number of reference nozzles (fine, coarse, etc.). Droplet spectra resulting from the use of a specific nozzle may also be described in terms of volume mean diameter (VMD). Coarser droplet size spectra have larger VMD's and lower drift potential.

6.2.3 AERIAL APPLICATION SPRAY DRIFT MANAGEMENT

- **Nozzle Type –** Solid-stream or other low-drift nozzles produce the coarsest droplet spectra.
- **Number of Nozzles –** Using the minimum number of nozzles with the highest flow rate that provide uniform coverage will produce a coarser droplet spectrum.
- **Nozzle Orientation –** Orienting nozzles in a manner that minimizes the effects of air shear will produce the coarsest droplet spectra. For some nozzles such as solid stream, pointing the nozzles straight back parallel to the airstream will produce a coarser droplet spectrum than other orientations.
- **Pressure –** Selecting the pressure that produces the coarsest droplet spectrum for a particular nozzle and airspeed reduces spray drift potential. For some nozzle types such as solid streams, lower pressures can produce finer droplet spectra and increase drift potential.

- **Boom Length –** Using shorter booms decreases drift potential. Boom lengths are expressed as a percentage of an aircraft's wingspan or a helicopter's rotor blade diameter. Shorter boom length and proper positioning can minimize drift caused by wingtip or rotor vortices.
- **Application Height –** Applications made at the lowest height that are consistent with pest control objectives and the safe operation of the aircraft will reduce the potential for spray drift.

6.2.4 GROUND APPLICATION SPRAY DRIFT MANAGEMENT

- **Nozzle Type –** Select a nozzle type that is designed for the intended application. With most nozzle types, narrower spray angles produce larger droplets. The use of low-drift nozzles will reduce drift potential.
- **Pressure –** The lowest spray pressures recommended for the nozzle produce the largest droplets. Higher pressure reduces droplet size and does not improve canopy penetration. When higher flow rates are needed, using a higher-capacity nozzle instead of increasing pressure results in the coarsest droplet spectra.
- **Flow Rate/Orifice Size –** Using the highest flow rate nozzles (largest orifice) that are consistent with pest control objectives reduces the potential for spray drift. Nozzles with higher rated flows produce coarser droplet spectra.
- **Application Height –** Applications made at the lowest height consistent with pest control objectives, and that allow the applicator to keep the boom level with the application site and minimize bounce, will reduce the exposure of spray droplets to evaporation and wind, and reduce spray drift potential.

6.2.5 WIND

- Drift potential is lowest when applications are made in light to gentle sustained winds (2-10 mph), which are blowing in a constant direction.
- Many factors, including droplet size and equipment type also determine drift potential at any given wind speed.
- AVOID GUSTY OR WINDLESS CONDITIONS.
- Local terrain can also influence wind patterns.
- Every applicator is expected to be familiar with local wind patterns and how they affect spray drift.

6.2.6 TEMPERATURE AND HUMIDITY

- Setting up equipment to produce larger droplets to compensate for droplet evaporation can reduce spray drift potential.
- Droplet evaporation is most severe when conditions are both hot and dry.

6.2.7 SURFACE TEMPERATURE INVERSIONS

- Drift potential is high during a surface temperature inversion. Surface inversions restrict vertical air mixing, which may cause small suspended droplets to remain close to the ground and move laterally in a concentrated cloud.
- Surface inversions are characterized by increasing temperature with altitude and are common on nights with limited cloud cover and light to no wind. They begin to form as the sun sets and often continue into the morning.
- Mist or fog may indicate the presence of an inversion in humid areas. Inversions may also be identified by producing smoke and observing its behavior. Smoke that remains close to the ground or moves laterally in a concentrated cloud under low wind conditions indicates a surface inversion. Smoke that moves upward and rapidly dissipates indicates good vertical air mixing.

6.2.8 SENSITIVE AREAS

- Making applications when there is a sustained wind moving away from adjacent sensitive areas (e.g., residential areas, bodies of water, known habitat for threatened or endangered species, non-target crops) is an effective way to minimize the effect of spray drift.

6.2.9 DRIFT CONTROL ADDITIVES

- Using product compatible drift control additives can reduce drift potential.
- When a drift control additive is used, read and carefully observe cautionary statements and all other information on the additive's label.
- If using an additive that increases viscosity, ensure that the nozzles and other application equipment will function properly with a viscous spray solution.
- Preferred drift control additives have been certified by the Council of Producers and Distributors of Agrotechnology.

7.0 CROP USE DIRECTIONS

7.1 Bean, Dry and Succulent

Crops (Including cultivars, varieties, and/or hybrids of these)

Broad bean (fava bean)
Chickpea (garbanzo bean)

***Lupinus* spp.**
- Grain lupin
- Sweet lupin
- White lupin
- White sweet lupin

***Phaseolus* spp.**
- Kidney bean
- Lima bean
- Navy bean
- Pinto bean
- Snap bean
- Wax bean

***Vigna* spp.**
- Asparagus bean
- Blackeyed pea
- Cowpea*
- Crowder pea
- Mung bean
- Southern pea

Target Pest	Rate (fl oz/A)	Application Timing	Use Directions
Corn earworm European corn borer Leafminers Spider mites	7.5 – 10.0	Time applications to the most susceptible insect or mite pest stage at locally determined action thresholds, before populations reach damaging levels. For best results when targeting control of sucking pests, begin applications when populations first appear. For **spider mites and leafminer** control, apply when spider mites or adult leafminer flies are first observed and repeat application, as needed to maintain control within constraints of a sound resistance management program.	When pest populations are high, use the highest rate allowed for that pest. Apply this product diluted in a minimum volume of 10 gal/A by ground or 5 gal/A by air. Under conditions such as high pest populations, dense foliage, or adverse application conditions (such as high temperatures), use a greater volume of water to ensure adequate coverage. For best control, apply Minecto Pro with ground application equipment. With aerial application, the resulting level and duration of control could be less than with ground application.
Whitefly **Suppression:** Potato leafhopper Thrips (foliage-feeding only)	10.0		

Resistance Management:
- Do not make more than 2 sequential applications of Minecto Pro or any other foliarly applied abamectin-containing product.

Precautions:
- Applications of Minecto Pro to certain species of the commodities in this crop group may result in adverse crop response. Affected plants outgrow the effects in most cases. If the risk of adverse crop response to Minecto Pro cannot be accepted, do not apply it to legume vegetables
- The crop safety of Minecto Pro in tank mixture has not been evaluated on these crops. When using Minecto Pro alone or in tank mixtures in bean crops, it is recommended that a small area be tested to demonstrate safety before using in large areas. See Section 4.4.2 for more information.

USE RESTRICTIONS
1) Refer to **Section 6.1** for additional product use restrictions. 2) **Adjuvant Requirement:** To avoid illegal residues, Minecto Pro must be mixed with a non-ionic activator type wetting, spreading and/or penetrating spray adjuvant as instructed in Section 4.4.5. Do not use binder or sticker type adjuvants. 3) **Maximum Single Application Rate:** 10.0 fl oz/A/application (0.088 lb ai/A of cyantraniliprole and 0.019 lb ai/A of abamectin) a. If a concurrent foliar application of another product is made, do not exceed a total of 0.133 lb ai/A of any foliar-applied cyantraniliprole-containing products or 0.019 lb ai/A of any foliar-applied abamectin-containing products. 4) **Minimum Application Interval:** 6 days 5) **Maximum Annual Rate:** 20.0 fl oz/A/calendar year (0.18 lb ai/A of cyantraniliprole and 0.038 lb ai/A of abamectin) a. **Do not** apply more than 0.40 lb ai/A/calendar year of cyantraniliprole-containing products including all application types (seed treatment, soil, foliar). b. **Do not** apply more than 0.056 lb ai/A/calendar year of abamectin-containing products including all application types (seed treatment, soil, foliar). 6) *For use on cowpeas that are grown for dry seed. **DO NOT** allow livestock to graze cowpea for and **DO NOT** harvest cowpea forage or hay for use as livestock feed. 7) **Pre-Harvest Interval (PHI):** 7 days

7.2 Citrus Fruit, Crop Group 10-10

Crops (Including cultivars, varieties, and/or hybrids of these)		
Australian desert lime	Lemon	Satsuma mandarin
Australian finger lime	Lime	Sweet lime
Australian round lime	Mediterranean mandarin	Tachibana orange
Brown River finger lime	Mount White lime	Tahiti lime
Calamondin	New Guinea wild lime	Tangelo
Citron	Orange, sour	Tangerine (mandarin)
Citrus hybrids	Orange, sweet	Tangor
Grapefruit	Pummelo	Trifoliate orange
Japanese summer grapefruit	Russell River lime	Uniq fruit
Kumquat		

continued…

7.2 Citrus Fruit, Crop Group 10-10 *(continued)*

Target Pest	Rate (fl oz/A)	Application Timing	Use Directions
Citrus leafminer Citrus rust mite	8.0 – 12.0	Time applications to the most susceptible insect or mite pest stage at locally determined action thresholds, before populations reach damaging levels. For best results when targeting control of sucking pests, begin applications when populations first appear. For **Asian citrus psyllid** control, apply to protect newly expanding foliage flush during the spring, summer or fall. For **mite** control, apply when mites first appear during spring, summer, or fall. For **citrus bud mite** control, time the spray at "bud swell" for best results. For **citrus leafminer** control, apply to protect new growth during spring, summer, or fall. For **citrus thrips** control, application will only control the current generation and must be correctly timed. Apply when economic thresholds have been reached (after egg hatch has begun – preferably early to mid-hatch).	With aerial application, the resulting level and duration of control of **Asian citrus psyllid** and **citrus leafminer** could be reduced compared to ground application. When applying by air, use the higher end of the rate range (11.0-12.0 fl oz/A). Apply this product diluted in a minimum volume of 10 gal/A by air. When pest populations are high, use the highest rate allowed for that pest. Thorough coverage is essential to obtain best results. Select a spray volume appropriate for the size of trees and density of foliage. Apply this product diluted in a minimum volume of 30 gal/A by ground application. Under conditions such as high pest populations, dense foliage, or adverse application conditions (such as high temperatures), use a greater volume of water to ensure adequate coverage.
Asian citrus psyllid Broad mite Citrus bud mite Citrus thrips Cotton aphid Twospotted spider mite	10.0 - 12.0		

Resistance Management:
- Do not make more than 2 sequential applications of Minecto Pro.
- Do not apply in citrus nurseries.

USE RESTRICTIONS
1) Refer to **Section 6.1** for additional product use restrictions. 2) **Adjuvant Requirement:** To avoid illegal residues, Minecto Pro must be mixed with a spray adjuvant as instructed in **Section 4.4.5**. It is recommended for best results that a minimum of 0.20% horticultural spray oil (not a dormant oil) be used in the spray mixture or not less than 1.0 gal horticultural spray oil/A. Do not use binder or sticker type adjuvants. 3) **Maximum Single Application Rate:** 12.0 fl oz/A/application (0.106 lb ai/A of cyantraniliprole and 0.023 lb ai of abamectin) a. If a concurrent foliar application of another product is made, do not exceed a total of 0.133 lb ai/A of any foliar-applied cyantraniliprole-containing products or 0.023 lb ai/A of any foliar-applied abamectin-containing products. 4) **Minimum Application Interval:** 30 days 5) **Maximum Annual Rate:** 24.0 fl oz/A/calendar year (0.21 lb ai/A of cyantraniliprole and 0.044 lb ai of abamectin) a. **Do not** apply more than 0.40 lb ai/A/calendar year of cyantraniliprole-containing products including all application types (seed treatment, soil, foliar). b. **Do not** apply more than 0.047 lb ai/A/calendar year of abamectin-containing products including all application types (seed treatment, soil, foliar). 6) **Aerial application** is permitted **only** for control of citrus leafminer and Asian citrus psyllid. For all other pests, apply only by ground application. 7) **DO NOT** allow livestock to graze in treated citrus groves. 8) Application is not permitted from onset of flowering until after petal fall is complete. 9) **Pre-Harvest Interval (PHI):** 7 days

7.3 Cotton

Crops (including all cultivars, varieties, and/or hybrids)			
Cotton			
Target Pest	**Rate (fl oz/A)**	**Application Timing**	**Use Directions**
Beet armyworm Carmine spider mite Cotton bollworm Fall armyworm Pacific spider mite Saltmarsh caterpillar Southern armyworm Strawberry spider mite Tobacco budworm Twospotted spider mite Western yellowstriped armyworm	6.0 – 10.0	Time applications to the most susceptible insect or mite pest stage at locally determined action thresholds, before populations reach damaging levels. For best results when targeting control of sucking pests, begin applications when populations first appear. For **mite** control, apply when mites first appear. Repeat application, if needed, to maintain control. For **thrips** suppression, begin making applications when populations are low. If populations are higher, use an effective thrips knockdown product before spraying with Minecto Pro.	When pest populations are high, use the highest rate allowed for that pest. Apply this product, by ground or air, diluted in a minimum volume of 5 gal/A. For best control of **spider mites**, apply with ground application equipment. With aerial application, spray coverage and the resulting level and duration of control of mites may be less than with ground application. For **Heliothine** control (cotton bollworm and/or tobacco budworm), make the first application at rates of 8.0-10.0 fl oz/A. Subsequent applications may be at rates of 6.0-10.0 fl oz/A, depending on pressure. For **thrips** suppression, use the highest rate listed. Use as part of an effective thrips control program. Rotate with products with different modes of action.
Cabbage looper Soybean looper Whitefly **Suppression:** Thrips (foliage-feeding only)	10.0		
Resistance Management: • Do not make more than 2 sequential applications of Minecto Pro.			

continued…

7.3 Cotton *(continued)*

Precaution:

- Application to seedling cotton may result in crop response. Affected plants outgrow the effects in most cases. If the risk of crop response cannot be accepted, do not apply to seedling cotton.

USE RESTRICTIONS

1) Refer to **Section 6.1** for additional product use restrictions.
2) **Adjuvant Requirement:** To avoid illegal residues, Minecto Pro must be mixed with a non-ionic activator type wetting, spreading and/or penetrating spray adjuvant as instructed in **Section 4.4.5**. Do not use binder or sticker type adjuvants.
3) **Maximum Single Application Rate:** 10.0 fl oz/A/application (0.088 lb ai/A of cyantraniliprole and 0.019 lb ai/A of abamectin)
   a. If a concurrent foliar application of another product is made, do not exceed a total of 0.133 lb ai/A of any foliar-applied cyantraniliprole-containing products or 0.019 lb ai/A of any foliar-applied abamectin-containing products.
4) **Minimum Application Interval:** 21 days
5) **Maximum Annual Rate:** 20.0 fl oz/A/calendar year (0.18 lb ai/A of cyantraniliprole and 0.038 lb ai/A of abamectin)
   a. **Do not** apply more than 0.4 lb ai/A/calendar year of cyantraniliprole-containing products including all application types (seed treatment, soil, foliar).
   b. **Do not** apply more than 0.038 lb ai/A/calendar year of abamectin-containing products including all application types (seed treatment, soil, foliar).
6) **DO NOT** feed or allow livestock to graze treated cotton.
7) **Pre-harvest Interval (PHI):** 20 days

7.4 Cucurbit Vegetables, Crop Group 9

Crops (including all cultivars, varieties, and/or hybrids of these)

Chayote (fruit)
Chinese waxgourd (Chinese preserving melon)
Citron melon
Cucumber
Gherkin
Gourd, edible
- Hyotan
- Cucuzza
- Hechima
- Chinese okra

***Momordica* spp.**
- Balsam apple
- Balsam pear
- Bitter melon
- Chinese cucumber

Muskmelon
- Cantaloupe
- Casaba
- Crenshaw melon
- Golden pershaw melon
- Honeydew melon
- Honey balls
- Mango melon
- Persian melon
- Pineapple melon
- Santa Claus melon
- Snake melon
- True cantaloupe

Pumpkin

Squash, summer
- Crookneck squash
- Scallop squash
- Straightneck squash
- Vegetable marrow
- Zucchini

Squash, winter
- Acorn squash
- Butternut squash
- Calabaza
- Hubbard squash
- Spaghetti squash

Watermelon

<table>
<tr><th>Target Pest</th><th>Rate
(fl oz/A)</th><th>Application Timing</th><th>Use Directions</th></tr>
<tr><td>Beet armyworm
Liriomyza leafminers
Melonworm
Pickleworm
Spider mites
Western yellowstriped armyworm</td><td>5.5 - 10.0</td><td rowspan="3">Time applications to the most susceptible insect or mite pest stage at locally determined action thresholds, before populations reach damaging levels. For best results when targeting control of sucking pests, begin applications when populations first appear.

For spider mites and leafminer control, apply when spider mites or adult leafminer flies are first observed and repeat application, as needed to maintain control within constraints of a sound resistance management program.

Apply foliarly soon after emergence or transplant to control whiteflies which may vector the cucurbit yellow stunting disorder virus. This will help to suppress and slow the expression of the virus in cucurbit vegetables.

For thrips suppression, begin making applications when populations are low. Use as part of an effective thrips control program. Rotate with products of different modes of action. If populations are above threshold, use an effective thrips knockdown product before spraying with Minecto Pro.</td><td rowspan="3">When pest populations are high, use the highest rate allowed for that pest.

Apply this product diluted in a minimum volume of 20 gal/A by ground or 5 gal/A by air.

Under conditions such as high pest populations, dense foliage, or adverse application conditions (such as high temperatures), use a greater volume of water to ensure adequate coverage.

For best control, apply Minecto Pro with ground application equipment. With aerial application, the resulting level and duration of control could be less than with ground application.</td></tr>
<tr><td>Cabbage looper</td><td>7.5 - 10.0</td></tr>
<tr><td>Cotton/melon aphid
Green peach aphid
Whitefly

<u>Suppression:</u>
Flea beetle
Thrips (foliage-feeding only)</td><td>10.0</td></tr>
</table>

Resistance Management:

- Do not make more than 2 sequential applications of Minecto Pro.

USE RESTRICTIONS

1) Refer to **Section 6.1** for additional product use restrictions.
2) **Adjuvant Requirement:** To avoid illegal residues, Minecto Pro must be mixed with a non-ionic activator type wetting, spreading and/or penetrating spray adjuvant as instructed in **Section 4.4.5**. Do not use binder or sticker type adjuvants.
3) **Maximum Single Application Rate:** 10.0 fl oz/A/application (0.088 lb ai/A of cyantraniliprole and 0.019 lb ai/A of abamectin)
   - If a concurrent foliar application of another product is made, do not exceed a total of 0.133 lb ai/A of any foliar-applied cyantraniliprole-containing products or 0.019 lb ai/A of any foliar-applied abamectin-containing products.
4) **Minimum Application Interval:** 7 days
5) **Maximum Annual Rate:** 20.0 fl oz/A/calendar year (0.18 lb ai/A of cyantraniliprole and 0.038 lb ai/A of abamectin)
   a. **Do not** apply more than 0.4 lb ai/A/calendar year of cyantraniliprole-containing products including all application types (seed treatment, soil, foliar).
   b. **Do not** apply more than 0.056 lb ai/A/calendar year of abamectin-containing products including all application types (seed treatment, soil, foliar).
6) **Pre-harvest Interval (PHI):** 7 days

7.5 Fruiting Vegetables, Crop Group 8-10

Crops (including all cultivars, varieties, and/or hybrids of these)		
African eggplant	Goji berry	Nonbell pepper
Bush tomato	Groundcherry	Roselle
Bell pepper	Martynia	Scarlet eggplant
Cocona	Naranjilla	Sunberry
Currant tomato	Okra	Tomatillo
Eggplant	Pea eggplant	Tomato
Garden huckleberry	Pepino	Tree tomato

Target Pest	Rate (fl oz/A)	Application Timing	Use Directions
Beet armyworm Broad mite Colorado potato beetle European corn borer Fall armyworm *Liriomyza* leafminers Southern armyworm Spider mites *Thrips palmi* Tomato fruitworm Tomato hornworm Tomato psyllid Tomato russet mite Western yellowstriped armyworm	5.5 - 10.0	Time applications to the most susceptible insect or mite pest stage at locally determined action thresholds, before populations reach damaging levels. For best results when targeting control of sucking pests, begin applications when populations first appear. For **broad, russet and spider mite** control, apply when mites first appear. For ***Thrips palmi*** control, apply when thrips are first observed. For **tomato pinworm** control, application can be made from the time moth activity is detected up to, but no later than, the time when newly emerged larvae are present.	**All crops except commercially grown greenhouse tomato:** When pest populations are high, use the highest rate allowed for that pest. Apply this product diluted in a minimum volume of 20 gal/A by ground or 5 gal/A by air. Under conditions such as high pest populations, dense foliage, or adverse application conditions (such as high temperatures), use a greater volume of water to ensure adequate coverage. For best control, apply Minecto Pro with ground application equipment. With aerial application, the resulting level and duration of control could be less than with ground application.
Loopers	7.5- 10.0		
Green peach aphid Potato aphid Tomato pinworm Whitefly **Suppression:** Pepper weevil Thrips (foliage-feeding only)	10.0		

Target Pest	Rate (fl oz/A)	Application Timing	Use Directions
Commercially grown greenhouse tomato only: *Liriomyza* leafminers Spider mites *Thrips palmi* Tomato psyllid Tomato russet mite	5.5 - 10.0	For **pepper weevil and thrips** suppression, begin making applications when populations are low. Use as part of an effective control program. Rotate with products of different modes of action. For **thrips**, if populations are above threshold, use an effective thrips knockdown product before spraying Minecto Pro. Apply foliarly soon after emergence or transplant to control **thrips** which may vector the **tomato spotted wilt virus**. This will help to suppress and slow the expression of the virus in fruiting vegetables. Apply foliarly soon after emergence or transplant to control **whiteflies** which may vector the **tomato yellow leaf curl virus**. This will help to suppress and slow the expression of the virus in fruiting vegetables.	**Commercially grown greenhouse tomato only:** When pest populations are high, use the highest rate allowed for that pest. Apply by ground only Thorough coverage is essential to obtain best results. Select a spray volume appropriate for the size of plants and density of foliage but do not apply diluted product in a volume less than 20 gal/A. Under conditions such as high pest populations, dense foliage, or adverse application conditions (such as high temperatures), use a greater volume of water to ensure adequate coverage.
Commercially grown greenhouse tomato only: Tomato pinworm Whitefly **Suppression:** Thrips (foliage-feeding only)	10.0		

Resistance Management:

- Do not make more than 2 sequential applications of Minecto Pro.

USE RESTRICTIONS

1) Refer to **Section 6.1** for additional product use restrictions.
2) **Adjuvant Requirement:** To avoid illegal residues, Minecto Pro must be mixed with a non-ionic activator type wetting, spreading and/or penetrating spray adjuvant as instructed in **Section 4.4.5**. Do not use binder or sticker type adjuvants.
3) **Maximum Single Application Rate:** 10.0 fl oz/A/application (0.088 lb ai/A of cyantraniliprole and 0.019 lb ai/A of abamectin)
   a. If a concurrent foliar application of another product is made, do not exceed a total of 0.133 lb ai/A of any foliar-applied cyantraniliprole-containing products or 0.019 lb ai/A of any foliar-applied abamectin-containing products.
4) **Minimum Application Interval:** 7 days
5) **Maximum Annual Rate:** 20.0 fl oz/A/calendar year (0.18 lb ai/A of cyantraniliprole and 0.038 lb ai/A of abamectin)
   a. **Do not** apply more than 0.4 lb ai/A/calendar year of cyantraniliprole-containing products including all application types (seed treatment, soil, foliar).
   b. **Do not** apply more than 0.056 lb ai/A/calendar year of abamectin-containing products including all application types (seed treatment, soil, foliar).
6) **Not for use in commercially grown greenhouse tomatoes in New York State.**
7) **Pre-harvest Interval (PHI):**
   a. 1 day commercially grown greenhouse tomatoes.
   b. 7 days all other crops.

7.6 Leafy Vegetables (Except Brassica), Crop Group 4 (Except Spinach)

Crops (including all cultivars, varieties, and/or hybrids of these)

Amaranth (leafy amaranth, Chinese spinach, tampala)	Corn salad	Parsley
Arugula (Roquette)	Cress, garden	Purslane, garden
Cardoon	Cress, upland (yellow rocket, winter cress)	Purslane, winter
Celery	Dandelion	Radicchio (red chicory)
Celery, Chinese	Dock (sorrel)	Rhubarb
Celtuce	Endive (escarole)	Swiss Chard
Chervil	Fennel, Florence (finochio)	
Chrysanthemum, edible-leaved	Lettuce, head and leaf	
Chrysanthemum, garland	Orach	

Target Pest	Rate (fl oz/A)	Application Timing	Use Directions
Beet armyworm Carmine spider mite Corn earworm Diamondback moth Fall armyworm *Liriomyza* leafminers Twospotted spider mite Western yellowstriped armyworm	5.5 - 10.0	Time applications to the most susceptible insect or mite pest stage at locally determined action thresholds, before populations reach damaging levels. For best results when targeting control of sucking pests, begin applications when populations first appear. For **spider mite and leafminer** control, apply when spider mites or adult leafminer flies are first observed and repeat application as needed to maintain control. For **thrips** suppression, begin making applications when populations are low. Use as part of an effective thrips control program. Rotate with products of different modes of action. If populations are above threshold, use an effective thrips knockdown product before spraying with Minecto Pro.	When pest populations are high, use the highest rate allowed for that pest. Apply this product diluted in a minimum volume of 20 gal/A by ground or 5 gal/A by air. Under conditions such as high pest populations, dense foliage, or adverse application conditions (such as high temperatures), use a greater volume of water to ensure adequate coverage. For best control, apply Minecto Pro with ground application equipment. With aerial application, the resulting level and duration of control could be less than with ground application.
Cabbage looper	7.5 – 10.0		
Green peach aphid Whitefly **Suppression:** Thrips (foliage feeding only)	10.0		

Resistance Management:

- Do not make more than 2 sequential applications of Minecto Pro.
- **Diamondback Moth:**
  - Do not apply Minecto Pro or other foliar-applied cyantraniliprole-containing products more than twice to any generation of diamondback moth within any 30-day period.
  - After the second application of Minecto Pro for diamondback moth, rotate to another effective insecticide with a different mode of action (i.e. a non-Group 28 insecticide).
  - Application to the next generation of diamondback moth must be with another effective insecticide with a different mode of action (i.e. a non-Group 28 insecticide).
  - Do not make more than 6 total applications per calendar year of any cyantraniliprole-containing products for control of diamondback moth at the same farm location.

USE RESTRICTIONS
1) Refer to **Section 6.1** for additional product use restrictions. 2) **Adjuvant Requirement:** To avoid illegal residues, Minecto Pro must be mixed with a non-ionic activator type wetting, spreading and/or penetrating spray adjuvant as instructed in **Section 4.4.5**. Do not use binder or sticker type adjuvants. 3) **Maximum Single Application Rate:** 10.0 fl oz/A/application (0.088 lb ai/A of cyantraniliprole and 0.019 lb ai/A of abamectin) a. If a concurrent foliar application of another product is made, do not exceed a total of 0.133 lb ai/A of any foliar-applied cyantraniliprole-containing products or 0.019 lb ai/A of any foliar-applied abamectin-containing products. 4) **Minimum Application Interval:** 7 days 5) **Maximum Annual Rate:** 20.0 fl oz/A/calendar year (0.18 lb ai/A of cyantraniliprole and 0.038 lb ai/A of abamectin) a. **Do not** apply more than 0.4 lb ai/A/calendar year of cyantraniliprole-containing products including all application types (seed treatment, soil, foliar). b. **Do not** apply more than 0.056 lb ai/A/calendar year of abamectin-containing products including all application types (seed treatment, soil, foliar). 6) **Pre-harvest Interval (PHI):** 7 days

7.7 Onion, Bulb, Crop Subgroup 3-07A

Crops (including all cultivars, varieties, and/or hybrids of these)			
Daylily, bulb Garlic, bulb Garlic, great-headed, bulb Garlic, serpent, bulb		Lily, bulb Onion, bulb Onion, Chinese, bulb	Onion, pearl Onion, potato, bulb Shallot, bulb
Target Pest	**Rate (fl oz/A)**	**Application Timing**	**Use Directions**
Liriomyza leafminers Thrips (foliage-feeding only)	7.0 – 10.0	For **leafminer** control, apply when adult leafminer flies are first observed and repeat application as needed. For **thrips** control, apply as part of a thrips management program. Begin making applications when populations are low (1-3 thrips/plant). Repeat application as needed. If populations are high, use an effective thrips knockdown product before spraying Minecto Pro.	For best control of thrips, use 10.0 fl oz/A. Apply this product diluted in a minimum volume of 20 gal/A by ground or 5 gal/A by air. Under conditions such as high pest populations, dense foliage, or adverse application conditions (such as high temperatures), use a greater volume of water to ensure adequate coverage. Minecto Pro may be applied through overhead chemigation systems for suppression of thrips. See section 4.5 for more information. For best control apply Minecto Pro with ground application equipment. With aerial or chemigation application, the resulting level and duration of control could be less than with ground application.
Resistance Management: • Do not make more than 2 sequential applications of Minecto Pro.			
Precaution: • Do not use Minecto Pro as a rescue treatment for thrips control.			

continued…

7.7 Onion, Bulb, Crop Subgroup 3-07A *(continued)*

USE RESTRICTIONS
1) Refer to **Section 6.1** for additional product use restrictions. 2) **Adjuvant Requirement:** To avoid illegal residues, Minecto Pro must be mixed with a non-ionic activator type wetting, spreading and/or penetrating spray adjuvant as instructed in **Section 4.4.5**. Do not use binder or sticker type adjuvants. 3) **Maximum Single Application Rate:** 10.0 fl oz/A/application (0.088 lb ai/A of cyantraniliprole and 0.019 lb ai/A of abamectin). a. If a concurrent foliar application of another product is made, do not exceed a total of 0.133 lb ai/A of any foliar-applied cyantraniliprole-containing products or 0.019 lb ai/A of any foliar-applied abamectin-containing products. 4) **Minimum Application Interval:** 7 days 5) **Maximum Annual Rate:** 20.0 fl oz/A/calendar year (0.18 lb ai/A cyantraniliprole and 0.038 lb ai/A of abamectin). a. **Do not** apply more than 0.4 lb ai/A/calendar year of cyantraniliprole-containing products including all application types (seed treatment, soil, foliar). b. **Do not** apply more than 0.056 lb ai/A/calendar year of abamectin-containing products including all application types (seed treatment, soil, foliar). 6) **Pre-harvest Interval (PHI):** 30 days

7.8 Onion, Green, Crop Subgroup 3-07B

Crops (including all cultivars, varieties, and/or hybrids of these)		
Chive, fresh leaves	Lady's leek	Onion, green
Chive, Chinese, fresh leaves	Leek	Onion, macrostem
Elegans hosta	Leek, wild	Onion, tree, tops
Fritillaria, leaves	Onion, Beltsville bunching	Onion, Welsh, tops
Kurrat	Onion, fresh	Shallot, fresh leaves

Target Pest	Rate (fl oz/A)	Application Timing	Use Directions
Liriomyza leafminers Thrips (foliage-feeding only)	7.0 – 10.0	For **leafminer** control, apply when adult leafminer flies are first observed and repeat application as needed. For **thrips** control, apply as part of a thrips management program. Begin making applications when populations are low (1-3 thrips/plant). Repeat application as needed. If populations are high, use an effective thrips knockdown product before spraying Minecto Pro.	For best control of **thrips**, use 10.0 fl oz/A. Apply this product diluted in a minimum volume of 20 gal/A by ground or 5 gal/A by air. Under conditions such as high pest populations, dense foliage, or adverse application conditions (such as high temperatures), use a greater volume of water to ensure adequate coverage. Minecto Pro may be applied through overhead chemigation systems for suppression of thrips. See section 4.5 for more information. For best control apply Minecto Pro with ground application equipment. With aerial or chemigation application, the resulting level and duration of control could be less than with ground application.

Resistance Management:
- Do not make more than 2 sequential applications of Minecto Pro.

Precaution:
- Do not use Minecto Pro as a rescue treatment for thrips control.

USE RESTRICTIONS

1) Refer to **Section 6.1** for additional product use restrictions.
2) **Adjuvant Requirement:** To avoid illegal residues, Minecto Pro must be mixed with a non-ionic activator type wetting, spreading and/or penetrating spray adjuvant as instructed in **Section 4.4.5**. Do not use binder or sticker type adjuvants.
3) **Maximum Single Application Rate:** 10.0 fl oz/A/application (0.088 lb ai/A of cyantraniliprole and 0.019 lb ai/A of abamectin).
   a. If a concurrent foliar application of another product is made, do not exceed a total of 0.133 lb ai/A of any foliar-applied cyantraniliprole-containing products or 0.019 lb ai/A of any foliar-applied abamectin-containing products.
4) **Minimum Application Interval:** 7 days
5) **Maximum Annual Rate:** 20.0 fl oz/A/calendar year (0.18 lb ai/A cyantraniliprole and 0.038 lb ai/A of abamectin).
   a. **Do not** apply more than 0.4 lb ai/A/calendar year of cyantraniliprole-containing products including all application types (seed treatment, soil, foliar).
   b. **Do not** apply more than 0.076 lb ai/A/calendar year of abamectin-containing products including all application types (seed treatment, soil, foliar).
6) **DO NOT** apply with aircraft in New York State and California.
7) **Pre-harvest Interval (PHI):** 7 days

7.9 Pome Fruit, Crop Group 11-10

Crops (including all cultivars, varieties, and/or hybrids of these)		
Apple	Mayhaw	Quince
Azarole	Medlar	Quince, Chinese
Crabapple	Pear	Quince, Japanese
Loquat	Pear, Asian	Tejocote

continued…

7.9 Pome Fruit, Crop Group 11-10 *(continued)*

Target Pest	Rate (fl oz/A)	Application Timing	Use Directions
Codling moth European apple sawfly European red mite Green fruitworm McDaniel spider mite Obliquebanded leafroller Oriental fruit moth Pear rust mite Redbanded leafroller Spotted tentiform leafminer Tufted apple budmoth Twospotted spider mite Variegated leafroller White apple leaf hopper Yellow mite	8.0 – 12.0	Time applications to the most susceptible insect or mite pest stage at locally determined action thresholds, before populations reach damaging levels. For best results when targeting control of sucking pests, begin applications when populations first appear. For **spider mite** control, apply when spider mite or insect thresholds are reached. Make a second application, if needed, to maintain control. For **apple maggot** suppression, begin making applications when pest populations are at or below threshold. Use as part of an effective control program. Rotate with products of different modes of action. If populations are above threshold, use an effective knockdown product before spraying with Minecto Pro. For **thrips** control, apply as part of a thrips management program. Begin making applications when populations are low (1-3 thrips/plant). Repeat application as needed. If populations are high, use an effective thrips knockdown product before spraying Minecto Pro. For best results, start applications for **rosy apple aphid** at green tip to early pink timing.	When pest populations are high, use the highest rate allowed for that pest. Apply by ground only. Thorough coverage is essential to obtain best results. Select a spray volume appropriate for the size of trees and density of foliage but do not apply diluted product in a volume less than 40 gal/A. For **apple maggot** suppression, use 12.0 fl oz/A for best results.
Pear psylla Plum curculio Rosy apple aphid **Suppression :** Apple maggot Thrips (foliage feeding only)	10.0 – 12.0		
Resistance Management: • Do not make more than 2 sequential applications of Minecto Pro.			

USE RESTRICTIONS
1) Refer to **Section 6.1** for additional product use restrictions. 2) **Adjuvant Requirement:** To avoid illegal residues, Minecto Pro must be mixed with a spray adjuvant as instructed in **Section 4.4.5**. Horticultural spray oil (not dormant oil) is recommended. Do not use binder or sticker type adjuvants. 3) **Maximum Single Application Rate:** 12.0 fl oz/A/application (0.106 lb ai/A of cyantraniliprole and 0.023 lb ai/A of abamectin) a. If a concurrent foliar application of another product is made, do not exceed a total of 0.133 lb ai/A of any foliar-applied cyantraniliprole-containing products or 0.023 lb ai/A of any foliar-applied abamectin-containing products. 4) **Minimum Application Interval:** 21 days 5) **Maximum Annual Rate:** 24.0 fl oz/A/calendar year (0.21 lb ai/A of cyantraniliprole and 0.044 lb ai/A of abamectin) a. **Do not** apply more than 0.4 lb ai/A/calendar year of cyantraniliprole-containing products including all application types (seed treatment, soil, foliar). b. **Do not** apply more than 0.047 lb ai/A/calendar year of abamectin-containing products including all application types (seed treatment, soil, foliar). 6) **DO NOT** apply by air. 7) **DO NOT** allow livestock to graze in treated orchards. 8) Application is not permitted from onset of flowering until after petal fall is complete. 9) **Pre-harvest Interval (PHI):** 28 days

7.10 Stone Fruit, Crop Group 12

Crops (including all cultivars, varieties, and/or hybrids of these)			
Apricot Cherry, sweet Cherry, tart Nectarine		Peach Plum Plum, Chickasaw Plum, Damson	Plum, Japanese Plumcot Prune (fresh)
Target Pest	**Rate (fl oz/A)**	**Application Timing**	**Use Directions**
Cherry fruit fly Codling moth European red mite Obliquebanded leafroller Oriental fruit moth Pacific spider mite Peach twig borer Omnivorous leafroller Tufted apple budmoth Twospotted spider mite	8.0 – 12.0	Time applications to the most susceptible insect or mite pest stage at locally determined action thresholds, before populations reach damaging levels. For best results when targeting control of sucking pests, begin applications when populations first appear. For **spider mite** control, apply when spider mites first appear. Make a second application, if needed, to maintain control. For **peach twig borer** control, application may be made throughout the growing season. For April-May applications to the summer generation, make applications at peak moth flight (timed at or before peak egg lay).	When pest populations are high, use the highest rate allowed for that pest. Apply by ground only. Thorough coverage is essential to obtain best results. Select a spray volume appropriate for the size of trees and density of foliage but do not apply diluted product in a volume less than 40 gal/A. For **peach twig borer** control, use higher rates for dormant applications and lower rates for delayed dormant applications. Use 12.0 fl oz/A for best results. For **peach twig borer** control in the April-May applications to the summer generation period, higher rates in the labeled rate range may be needed for higher infestation levels and large, dense foliage trees.
Spotted wing *Drosophila* Black cherry aphid Japanese beetle Plum curculio	10.0 – 12.0		
Resistance Management: • Do not make more than 2 sequential applications of Minecto Pro.			

continued...

7.10 Stone Fruit, Crop Group 12 *(continued)*

Precautions:

- Tank mixes with organosilicone adjuvants at rates of 0.03% v/v or lower on sweet or tart cherries should not result in crop response on cherry fruit or leaves. However, it is impossible to test all conditions and varieties. Therefore, it is recommended that a small area be tested to demonstrate safety to fruit and leaves before using in large areas.

USE RESTRICTIONS

1) Refer to **Section 6.1** for additional product use restrictions.
2) **Adjuvant Requirement:** To avoid illegal residues, Minecto Pro must be mixed with a non-ionic activator type wetting, spreading and/or penetrating spray adjuvant or with a horticultural spray oil (not a dormant oil) as instructed in **Section 4.4.5**. Do not use binder or sticker type adjuvants.
3) **Maximum Single Application Rate:** 12.0 fl oz/A/application (0.106 lb ai/A of cyantraniliprole and 0.023 lb ai/A of abamectin)
   a. If a concurrent foliar application of another product is made, do not exceed a total of 0.133 lb ai/A of any foliar-applied cyantraniliprole-containing products or 0.023 lb ai/A of any foliar-applied abamectin-containing products.
4) **Minimum Application Interval:** 21 days
5) **Maximum Annual Rate:** 24.0 fl oz/A/calendar year (0.21 lb ai/A of cyantraniliprole and 0.044 lb ai/A of abamectin)
   a. **Do not** apply more than 0.4 lb ai/A/calendar year of cyantraniliprole-containing products including all application types (seed treatment, soil, foliar).
   b. **Do not** apply more than 0.047 lb ai/A/calendar year of abamectin-containing products including all application types (seed treatment, soil, foliar).
6) **DO NOT** apply by air.
7) **DO NOT** allow livestock to graze in treated orchards.
8) Application is not permitted from onset of flowering until after petal fall is complete.
9) **Pre-harvest Interval (PHI):** 21 days

7.11 Strawberry

Crops (including all cultivars, varieties, and/or hybrids of these)

Strawberry

Target Pest	Rate (fl oz/A)	Application Timing	Use Directions
Carmine spider mite Spotted wing drosophila Strawberry spider mite Twospotted spider mite **Suppression:** Cyclamen mite Thrips (foliage-feeding only)	10.0	Time applications to the most susceptible insect or mite pest stage at locally determined action thresholds, before populations reach damaging levels. For best results when targeting control of sucking pests, begin applications when populations first appear.	Apply by ground only. Thorough coverage is essential to obtain best results. Select a spray volume and nozzle placement to ensure maximum coverage of tops and undersides of leaves. Do not apply diluted product in less than 50 gal/A with conventional ground application equipment. When using electro-static sprayers do not apply diluted product in less than 10 gal/A For **cyclamen mite** control, apply in sufficient water volume to obtain good coverage into the crown of the plant. For **spider mite** control, make 2 sequential applications 7-10 days apart when mites first appear. Repeat this application sequence no sooner than 21 days after the second application, if needed, to maintain control.

Resistance Management:
- Do not make more than 2 sequential applications of Minecto Pro.
- For management of thrips use Minecto Pro in conjunction with an effective thrips management system.
- For resistance management purposes, DO NOT use in strawberry nurseries.

Precautions:
- Not all varieties of strawberries have been tested for crop safety with Minecto Pro alone or in tank mixture. It is recommended that a small area be tested to demonstrate safety before using in large areas. See Section 4.4.2 for more information.

USE RESTRICTIONS

1) Refer to **Section 6.1** for additional product use restrictions.
2) **Adjuvant Requirement:** To avoid illegal residues, Minecto Pro must be mixed with a non-ionic activator type wetting, spreading and/or penetrating spray adjuvant as instructed in **Section 4.4.5**. Do not use binder or sticker type adjuvants.
3) **Maximum Single Application Rate:** 10.0 fl oz/A/application (0.088 lb ai/A of cyantraniliprole and 0.019 lb ai/A of abamectin).
   a. If a concurrent foliar application of another product is made, do not exceed a total of 0.133 lb ai/A of any foliar-applied cyantraniliprole-containing products or 0.019 lb ai/A of any foliar-applied abamectin-containing products.
4) **Minimum Application Interval:** 7 days; wait 21 days after the second application before repeating application.
5) **Maximum Annual Rate:** 40.0 fl oz/A/calendar year (0.35 lb ai/A of cyantraniliprole and 0.075 lb ai/A of abamectin)
   a. **Do not** apply more than 0.4 lb ai/A/calendar year of cyantraniliprole-containing products including all application types (seed treatment, soil, foliar).
   b. **Do not** apply more than 0.075 lb ai/A/calendar year of abamectin-containing products including all application types (seed treatment, soil, foliar).
6) **DO NOT** apply by air.
7) **Pre-harvest Interval (PHI):** 3 days

7.12 Tree Nuts, Crop Group 14-12

Crops (including all cultivars, varieties, and/or hybrids of these)

African nut-tree	Coconut	Okari nut
Almond	Coquito nut	Pachira nut
Beech nut	Dika nut	Peach palm nut
Brazil nut	Ginkgo	Pecan
Brazilian pine	Guiana chestnut	Pequi
Bunya	Hazelnut (filbert)	Pili nut
Bur oak	Heartnut	Pine nut
Butternut	Hickory nut	Pistachio
Cajou nut	Japanese horse-chestnut	Sapucaia nut
Candlenut	Macadamia nut	Tropical almond
Cashew	Mongongo nut	Walnut, black
Chestnut	Monkey-pot	Walnut, English
Chinquapin	Monkey puzzle nut	Yellowhorn

continued...

7.12 Tree Nuts, Crop Group 14-12 *(continued)*

Target Pest	Rate (fl oz/A)	Application Timing	Use Directions
Codling moth European red mite Hickory shuckworm Obliquebanded leafroller Oriental fruit moth Pacific spider mite Peach twig borer Pecan nut casebearer Strawberry spider mite Twospotted spider mite	8.0 – 12.0	Time applications to the most susceptible insect or mite pest stage at locally determined action thresholds, before populations reach damaging levels. For best results when targeting control of sucking pests, begin applications when populations first appear. For **spider mite** control, apply when spider mites first appear. Residual spider mite control is greater from spray deposits on newer leaves compared to older leaves. Make a second application, if needed, to maintain control.	When pest populations are high, use the highest rate allowed for that pest. Apply by ground only. Select a spray volume appropriate for the size of trees and density of foliage but do not apply diluted product in a volume less than 40 gal/A. For **codling moth (walnut)** control, use higher rates and higher water volumes to achieve thorough coverage. For **peach twig borer** control in the April-May applications to the summer generation, higher rates in the labeled rate range may be needed for higher infestation levels and large, dense foliage trees. For **navel orangeworm** control, depending on infestation levels, use of higher rates in the labeled rate range and multiple applications may be needed.
Navel orangeworm Walnut aphid	10.0 – 12.0	For **codling moth (walnut)** control, make initial application at or before peak egg lay for targeted generation. Depending on level of infestation reapply 21 days later as needed. For **peach twig borer** control, application may be made throughout the growing season. For spring application to overwintering generation: Make applications at late dormant (just prior to bud break) to early bloom. For April-May applications to the summer generation: Make applications at peak moth flight (timed at or before peak egg lay). For **navel orangeworm** control, applications can be made during the "May spray" or "Hull split" application timing. For applications made at "Hull split" timing, make an application at 1-2% hull-split timing.	

Resistance Management:
- Do not make more than 2 sequential applications of Minecto Pro.

USE RESTRICTIONS
1) Refer to **Section 6.1** for additional product use restrictions. 2) **Adjuvant Requirement:** To avoid illegal residues, Minecto Pro must be mixed with a spray adjuvant as instructed in **Section 4.4.5**. Horticultural spray oil (not a dormant oil) is recommended. Do not use binder or sticker type adjuvants. 3) **Maximum Single Application Rate:** 12.0 fl oz/A/application (0.106 lb ai/A of cyantraniliprole and 0.023 lb ai/A of abamectin) a. If a concurrent foliar application of another product is made, do not exceed a total of 0.133 lb ai/A of any foliar-applied cyantraniliprole-containing products or 0.023 lb ai/A of any foliar-applied abamectin-containing products. 4) **Minimum Application Interval:** 21 days 5) **Maximum Annual Rate:** 24.0 fl oz/A/calendar year (0.21 lb ai/A of cyantraniliprole and 0.044lb ai/A of abamectin) a. **Do not** apply more than 0.4 lb ai/A/calendar year of cyantraniliprole-containing products including all application types (seed treatment, soil, foliar). b. **Do not** apply more than 0.047 lb ai/A/calendar year of abamectin-containing products including all application types (seed treatment, soil, foliar). 6) **DO NOT** apply by air. 7) **DO NOT** allow livestock to graze in treated orchards. 8) Application is not permitted from onset of flowering until after petal fall is complete. 9) **Pre-harvest Interval (PHI):** 21 days

7.13 Tuberous and Corm Vegetables, Crop Subgroup 1C

Crops (including all cultivars, varieties, and/or hybrids of these)		
Arracacha	Chayote (root)	Sweet potato
Arrowroot	Chufa	Tanier
Artichoke, Chinese	Dasheen	Turmeric
Artichoke, Jerusalem	Ginger	Yam bean
Canna, edible	Leren	Yam, true
Cassava, bitter and sweet	Potato	

continued...

7.13 Tuberous and Corm Vegetables, Crop Subgroup 1C *(continued)*

Target Pest	Rate (fl oz/A)	Application Timing	Use Directions
Beet armyworm Colorado potato beetle European corn borer Liriomyza leafminers Potato tuberworm Spider mites Yellowstriped armyworm	5.5 – 10.0	Time applications to the most susceptible insect or mite pest stage at locally determined action thresholds, before populations reach damaging levels. For best results when targeting control of sucking pests, begin applications when populations first appear. For **Colorado potato beetle** control, make the first application after approximately 50% of the egg masses have hatched and early instar larvae are present. If two applications are needed, limit them to a single Colorado potato beetle generation per crop. For ***Liriomyza* leafminer** control, make the first application when adult flies are first observed. Repeat applications as needed to maintain control. For **spider mite** control, make the first application when mites first appear. Repeat application as needed to maintain control. For **potato tuberworm** control, begin application when field scouting indicates the presence of tuberworm adults and/or larvae. Potato tuberworm often has overlapping generations, so repeat application may be needed based on scouting. Avoid treating successive generations with the same mode of action. Begin application when populations are low to control **potato psyllid** which may vector **zebra chip disease**. This will help to suppress the expression of the disease symptoms. For **potato aphid and potato flea beetle** suppression, use as part of an effective control program. Rotate with products with different modes of action.	When pest populations are high, use the highest rate allowed for that pest. Apply this product diluted in a minimum volume of 20 gal/A by ground or 5 gal/A by air. Under conditions such as high pest populations, dense foliage, or adverse application conditions (such as high temperatures), use a greater volume of water to ensure adequate coverage. Thorough coverage of the crop canopy is essential for optimum results. For best control of mites, apply with ground application equipment. With aerial or chemigation application, the resulting level and duration of control could be less than with ground application. For **potato tuberworm** control, apply at rates of 5.5 – 10.0 fl oz/A. See the **Precaution** below for further guidance. For **potato psyllid** control, use a rate of 10 fl oz/A. to help suppress **zebra chip disease**. Minecto Pro may be applied through overhead chemigation systems in potatoes only. See section 4.5 for more information. For best control apply Minecto Pro with ground application equipment. With aerial or chemigation application, the resulting level and duration of control could be less than with ground application.
Cabbage looper	7.5 – 10.0		
Green peach aphid Potato psyllid **Suppression:** Potato aphid Potato flea beetle Thrips (foliage feeding only)	10.0		

Resistance Management:

- Do not make more than 2 sequential applications of Minecto Pro.
- **Colorado Potato Beetle:**
  - Do not apply Minecto Pro more than twice to a generation of Colorado potato beetle or within any 30-day period.
  - Application(s) to the next generation of Colorado potato beetle must be with an effective product with a different mode of action.
  - Do not apply Minecto Pro for Colorado potato beetle control if any cyantraniliprole-containing product was used at-plant either as a soil or seed piece application.

Precaution:

- **Potato Tuberworm control:** It is important to protect the crop just prior to harvest when foliage starts to senesce. Use the higher rate (10.0 fl oz/A) when tuberworm pressure is high. Failure to adequately control potato tuberworm larvae prior to crop senescence or vine kill increases the risk of tuber damage. Foliar sprays alone, by air or ground, may not provide adequate control of the larvae in the mid to lower crop canopy. For best results, add methylated seed oil (MSO) adjuvant at 1% volume to volume. For chemigation applications, apply in 0.1 to 0.2 acre inches of water and add MSO at 12-16 fl oz/A.
- Spider mite control may be greatly reduced when Minecto Pro is applied through chemigation.

USE RESTRICTIONS

1) Refer to **Section 6.1** for additional product use restrictions.
2) **Adjuvant Requirement:** To avoid illegal residues, Minecto Pro must be mixed with a non-ionic activator type wetting, spreading and/or penetrating spray adjuvant as instructed in **Section 4.4.5**. Do not use binder or sticker type adjuvants.
3) **Maximum Single Application Rate:** 10.0 fl oz/A/application (0.088 lb ai/A of cyantraniliprole and 0.019 lb ai/A of abamectin)
   a. If a concurrent foliar application of another product is made, do not exceed a total of 0.133 lb ai/A of any foliar-applied cyantraniliprole-containing products or 0.019 lb ai/A of any foliar-applied abamectin-containing products.
4) **Minimum Application Interval:** 7 days
5) **Maximum Annual Rate:** 20.0 fl oz/A/calendar year (0.18 lb ai/A of cyantraniliprole and 0.038 lb ai/A of abamectin)
   a. **Do not** apply more than 0.4 lb ai/A/calendar year of cyantraniliprole-containing products including all application types (seed treatment, soil, foliar).
   b. **Do not** apply more than 0.056 lb ai/A/calendar year of abamectin-containing products including all application types (seed treatment, soil, foliar).
6) **DO NOT** feed or allow livestock to graze treated foliage.
7) **Pre-harvest Interval (PHI):** 14 days

8.0 STORAGE AND DISPOSAL

STORAGE AND DISPOSAL

Do not contaminate water, food, or feed by storage or disposal.

Pesticide Storage

Keep container closed when not in use. Always store pesticides in the original container only, away from other pesticides, food, pet food, feed, seed, fertilizers, and veterinary supplies. If a leaky container must be contained within another, mark the outer container to identify the contents. Storage areas must be locked and secure from vandalism, with precautionary signs posted. The storage area must be dry, well-lit, and well-ventilated. Keep pesticide storage areas clean. Clean up any spills promptly. Protect pesticide containers from extreme heat and cold. Store herbicides, insecticides and fungicides in separate areas within the storage unit. Place liquid formulations on lower shelves and dry formulations above. Maintaining a spill kit and fire extinguisher on hand and having emergency phone numbers posted will allow you to be prepared for emergencies. If spill cleanup PPE is stored nearby, but outside the pesticide storage area, it will be accessible when needed.

Pesticide Disposal

Wastes resulting from the use of this product must be disposed of on site or at an approved waste disposal facility.

continued...

8.0 STORAGE AND DISPOSAL *(continued)*

Container Handling [less than or equal to 5 gallons]

Non-refillable container. Do not reuse or refill this container. Triple rinse container (or equivalent) promptly after emptying. Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container 1/4 full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times. Then offer for recycling if available or puncture and dispose of in a sanitary landfill, or by incineration, or by other procedures approved by state and local authorities.

Container Handling [greater than 5 gallons]

Non-refillable container. Do not reuse or refill this container. Triple rinse container (or equivalent) promptly after emptying. Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank. Fill the container 1/4 full with water. Recap and tighten closures. Tip container on its side and roll it back and forth, ensuring at least one complete revolution, for 30 seconds. Stand the container on its end and tip it back and forth several times. Turn the container over onto its other end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Repeat this procedure two more times. Then offer for recycling if available or puncture and dispose of in a sanitary landfill, or by incineration, or by other procedures approved by state and local authorities.

Container Handling [greater than 5 gallons]

Refillable container. Refill this container with pesticide only. Do not reuse this container for any other purpose. Cleaning the container before final disposal is the responsibility of the person refilling. To clean container before final disposal, empty the remaining contents from this container into application equipment or mix tank. Fill the container about 10 percent full with water. Agitate vigorously or recirculate water with the pump for 2 minutes. Pour or pump rinsate into application equipment or rinsate collection system. Repeat this rinsing procedure two more times. Then offer for recycling if available or puncture and dispose of in a sanitary landfill, or by incineration, or by procedures approved by state and local authorities.

CONTAINER IS NOT SAFE FOR FOOD, FEED, OR DRINKING WATER.

9.0 CONDITIONS OF SALE AND LIMITATION OF WARRANTY AND LIABILITY

NOTICE: Read the entire Directions for Use and Conditions of Sale and Limitation of Warranty and Liability before buying or using this product. If the terms are not acceptable, return the product at once, unopened, and the purchase price will be refunded.

The Directions for Use of this product must be followed carefully. It is impossible to eliminate all risks inherently associated with the use of this product. Crop injury, ineffectiveness or other unintended consequences may result because of such factors as manner of use or application, weather or crop conditions, presence of other materials or other influencing factors in the use of the product, which are beyond the control of SYNGENTA CROP PROTECTION, LLC or Seller. To the extent permitted by applicable law, Buyer and User agree to hold SYNGENTA and Seller harmless for any claims relating to such factors.

SYNGENTA warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes stated in the Directions for Use, subject to the inherent risks referred to above, when used in accordance with directions under normal use conditions. To the extent permitted by applicable law: (1) this warranty does not extend to the use of the product contrary to label instructions or under conditions not reasonably foreseeable to or beyond the control of Seller or SYNGENTA, and (2) Buyer and User assume the risk of any such use. TO THE EXTENT PERMITTED BY APPLICABLE LAW, SYNGENTA MAKES NO WARRANTIES OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE NOR ANY OTHER EXPRESS OR IMPLIED WARRANTY EXCEPT AS WARRANTED BY THIS LABEL.

To the extent permitted by applicable law, in no event shall SYNGENTA be liable for any incidental, consequential or special damages resulting from the use or handling of this product. **TO THE EXTENT PERMITTED BY APPLICABLE LAW, THE EXCLUSIVE REMEDY OF THE USER OR BUYER, AND THE EXCLUSIVE LIABILITY OF SYNGENTA AND SELLER FOR ANY AND ALL CLAIMS, LOSSES, INJURIES OR DAMAGES (INCLUDING CLAIMS BASED ON BREACH OF WARRANTY, CONTRACT, NEGLIGENCE, TORT, STRICT LIABILITY OR OTHERWISE) RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT, SHALL BE THE RETURN OF THE PURCHASE PRICE OF THE PRODUCT OR, AT THE ELECTION OF SYNGENTA OR SELLER, THE REPLACEMENT OF THE PRODUCT.**

SYNGENTA and Seller offer this product, and Buyer and User accept it, subject to the foregoing Conditions of Sale and Limitation of Warranty and Liability, which may not be modified except by written agreement signed by a duly authorized representative of SYNGENTA.

10.0 APPENDIX

10.1 Minecto Pro Use Summary Table

IMPORTANT: The table below is a summary of the Crop Use Directions for Minecto Pro. However, it is important for the user to read and follow the complete instructions contained within this label.

Crop or Crop Group or Subgroup, with examples	Maximum Minecto Pro Rate per Application (fl oz/A)	Minimum Application Interval (days)	Pre-Harvest Interval - PHI (days)	Maximum Minecto Pro Rate per Year (fl oz/A)
Bean, Dry and Succulent, chickpea, snap bean	10.0	6	7	20.0
Citrus Fruit, orange, lemon, grapefruit	12.0	30	7	24.0
Cotton	10.0	21	20	20.0
Cucurbit Vegetables cucumber, squash	10.0	7	7	20.0
Fruiting Vegetables tomato, bell pepper	10.0	7	7	20.0
Leafy Vegetables celery, lettuce	10.0	7	7	20.0
Onion, Bulb	10.0	7	30	20.0
Pome Fruit apple, pear	12.0	21	28	24.0
Stone Fruit apricot, peach	12.0	21	21	24.0
Strawberry	10.0	7	3	40.0
Tree Nuts almond, pecan	12.0	21	21	24.0
Tuberous and Corm Vegetables potato, ginger	10.0	7	14	20.0

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the SYNGENTA Logo and the PURPOSE ICON
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Cabrio® is a trademark of BASF Corporation.

Tanos® is a trademark of E. I. DuPont.

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Manzate® is a trademark of United Phosphorous, Inc.

Viton® is a trademark of E.I. DuPont De Nemours & Co, Inc.

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For non-emergency (e.g. current product information), call
Syngenta Crop Protection at 1-800-334-9481.

Manufactured for:
Syngenta Crop Protection, LLC
P.O. Box 18300
Greensboro, North Carolina 27419-8300

SCP 1592A-L1B 0718
4096042

RESTRICTED USE PESTICIDE

DUE TO TOXICITY TO FISH, MAMMALS, AND AQUATIC ORGANISMS.

FOR RETAIL SALE TO AND USE ONLY BY CERTIFIED APPLICATORS OR PERSONS UNDER THEIR DIRECT SUPERVISION, AND ONLY FOR THOSE USES COVERED BY THE CERTIFIED APPLICATOR'S CERTIFICATION.

Not for sale, sale into, distribution and/or use in Nassau and Suffolk counties of New York State

ABAMECTIN	GROUP	6	INSECTICIDES
CYANTRANILIPROLE	GROUP	28	INSECTICIDES

Minecto® Pro

Insecticide/ Miticide

Active Ingredient:	
Cyantraniliprole*	12.70%
Abamectin**	2.68%
Other Ingredients:	84.62%
Total:	100.00%

Minecto® Pro is formulated as a suspension concentrate and contains 1.13 lb cyantraniliprole and 0.24 lb abamectin per gallon.

* CAS No. 736994-63-1
** CAS No. 71751-41-2

See additional precautionary statements and directions for use inside booklet.

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. Refer to supplemental labeling under "Agricultural Use Requirements" in the Directions for Use section for information about this standard.

EPA Reg. No. 100-1592
EPA Est. No. 100-NE-001

SCP 1592A-L1B 0718
4096042

3 qt 24 fl oz
(120 fl oz)
Net Contents

KEEP OUT OF REACH OF CHILDREN.

WARNING/AVISO

Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand the label, find someone to explain it to you in detail.)

FIRST AID

If swallowed: Call poison control center or doctor immediately for treatment advice. Have a person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a poison control center or doctor. Do not give anything by mouth to an unconscious person. **In inhaled:** Move person to fresh air. If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth, if possible. Call a poison control center or doctor for further treatment advice. **If on skin or clothing:** Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice. **If in eyes:** Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.

NOTE TO PHYSICIAN: Early signs of intoxication include dilation of pupils, muscular incoordination, and muscular tremors. Toxicity following accidental ingestion of this product can be minimized by early administration of chemical adsorbents (e.g., activated charcoal).

If toxicity from exposure has progressed to cause severe vomiting, the extent of resultant fluid and electrolyte imbalance should be gauged. Appropriate supportive parenteral fluid replacement therapy should be given, along with other required supportive measures (such as maintenance of blood pressure levels and proper respiratory functionality) as indicated by clinical signs, symptoms, and measurements.

In severe cases, observations should continue for at least several days until clinical condition is stable and normal. Because abamectin, one of the active ingredients in this formulation, is believed to enhance GABA activity in animals, it is probably wise to avoid drugs that enhance GABA activity (barbiturates, benzodiazepines, valproic acid) in patients with potentially toxic abamectin exposure.

Have the product container or label with you when calling a poison control center or doctor, or going for treatment.

HOT LINE NUMBER: For 24-Hour Medical Emergency Assistance (Human or Animal) Or Chemical Emergency Assistance (Spill, Leak, Fire or Accident), Call **1-800-888-8372**.

syngenta®

PRECAUTIONARY STATEMENTS

Hazards to Human and Domestic Animals

WARNING/AVISO

May be fatal if swallowed. Harmful if inhaled. Harmful if absorbed through the skin. Causes moderate eye irritation. Avoid breathing vapor or spray mist. Avoid contact with skin, eyes, or clothing.

Attention: This product contains a chemical known to the State of California to cause birth defects or other reproductive harm.

Environmental Hazards

This pesticide is toxic to fish, aquatic invertebrates, oysters, and wildlife. For terrestrial uses: Do not apply directly to water, or to areas where surface water is present, or to intertidal areas below the mean high water mark. Do not apply when weather conditions favor drift from target areas. Drift and runoff may be hazardous to aquatic organisms in water adjacent to use sites. Do not contaminate water when disposing of equipment washwater or rinsate.

This product is highly toxic to bees exposed to direct treatment on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops or weeds while bees are foraging in or adjacent to the treatment area.

Use of this product may pose a risk to threatened and endangered species of fish, amphibians, crustaceans (including fresh water shrimp), and insects. All use of this product in the state of California should comply with the recommendations of the California Endangered Species Project. Before using this product in California, consult with your county agriculture commissioner to determine use limitations that apply in your area.

SURFACE WATER ADVISORY

This product may impact surface water quality due to runoff of rain water. This is especially true for poorly draining soils and soils with shallow ground water. This product is classified as having high potential for reaching both surface water and aquatic sediment via runoff for several weeks to months after application. A level, well-maintained vegetative buffer strip between areas to which this product is applied and surface water features such as ponds, streams, and springs will reduce the potential loading of cyantraniliprole and abamectin from runoff water and sediment. Runoff of this product will be reduced by avoiding applications when rainfall is forecast to occur within 48 hours.

GROUND WATER ADVISORY

One of the active ingredients in this product, cyantraniliprole, has properties and characteristics associated with chemicals detected in groundwater. Cyantraniliprole may leach into ground water if used in areas where soils are permeable, particularly where the water table is shallow.

STORAGE AND DISPOSAL

Do not contaminate water, food, or feed by storage or disposal.

Pesticide Storage

Keep container closed when not in use. Always store pesticides in the original container only, away from other pesticides, food, pet food, feed, seed, fertilizers, and veterinary supplies. If a leaky container must be contained within another, mark the outer container to identify the contents. Storage areas must be locked and secure from vandalism, with precautionary signs posted. The storage area must be dry, well-lit, and well-ventilated. Keep pesticide storage areas clean. Clean up any spills promptly. Protect pesticide containers from extreme heat and cold. Store herbicides, insecticides and fungicides in separate areas within the storage unit. Place liquid formulations on lower shelves and dry formulations above. Maintaining a spill kit and fire extinguisher on hand and having emergency phone numbers posted will allow you to be prepared for emergencies. If spill cleanup PPE is stored nearby, but outside the pesticide storage area, it will be accessible when needed.

Pesticide Disposal

Wastes resulting from the use of this product must be disposed of on site or at an approved waste disposal facility.

Container Handling

Non-refillable container. Do not reuse or refill this container. Triple rinse container (or equivalent) promptly after emptying. Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank. Fill the container 1/4 full with water. Recap and tighten closures. Tip container on its side and roll it back and forth, ensuring at least one complete revolution, for 30 seconds. Stand the container on its end and tip it back and forth several times. Turn the container over onto its other end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Repeat this procedure two more times. Then offer for recycling if available or puncture and dispose of in a sanitary landfill, or by incineration, or by other procedures approved by state and local authorities.

CONTAINER IS NOT SAFE FOR FOOD, FEED, OR DRINKING WATER.

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For non-emergency (e.g. current product information), call Syngenta Crop Protection at 1-800-334-9481.

Manufactured for:
Syngenta Crop Protection, LLC
P.O. Box 18300
Greensboro, North Carolina 27419-8300

SCP 1592A-L2C 0718 4097431

(01) 0 07 02941 59019 9

GROUP	3A	INSECTICIDE

VALENT®

MGK

PyGanic®

Crop Protection EC 5.0II

OMRI LISTED For Organic Use

FOR ORGANIC PRODUCTION

- Provides rapid knockdown and kill of listed plant pests
- For use on growing crops
- Can be used on day of harvest

ACTIVE INGREDIENT:

Pyrethrins	5.00%
OTHER INGREDIENTS:	95.00%
	100.00%

This product contains 0.41 lbs. of Pyrethrins per gallon.

EPA Reg. No. 1021-1772
EPA Est. No. 1021-MN-2

KEEP OUT OF REACH OF CHILDREN

CAUTION/PRECAUCIÓN

Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle.
(If you do not understand the label, find someone to explain it to you in detail.)

FIRST AID

If swallowed:	Call a poison control center or doctor immediately for treatment advice. Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by the poison control center or doctor. Do not give anything by mouth to an unconscious person.
If in eyes:	Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.
If on skin or clothing:	Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice.

(continued)

FIRST AID (continued)
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-888-740-8712 for emergency medical treatment information.

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

CAUTION

Harmful if absorbed through skin. Harmful if swallowed. Causes moderate eye irritation. Wash hands thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco or using the toilet. Avoid contact with skin, eyes or clothing. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Wear long-sleeved shirt and long pants, socks, shoes, and chemical-resistant gloves.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Some materials that are chemical-resistant to this product are made of any waterproof material. If you want more options, follow the instructions for category E on an EPA chemical-resistance category selection chart.

Mixers, loaders, applicators, and other handlers must wear the following:
– long-sleeved shirt,
– long pants,
– shoes and socks, and
– chemical-resistant gloves.

In addition to the above PPE, applicators using handheld foggers in an enclosed area must wear:
- A particulate respirator with any N, R, or P filter with NIOSH approval prefix TC-84A, or
- A NIOSH-approved gas mask with a canister filter with NIOSH approval prefix TC-14G, or
- A NIOSH-approved powered air purifying respirator with HE filter with NIOSH approval prefix TC-21C.

Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables exist, use detergent and hot water. Keep and wash PPE separately from other laundry.

Discard clothing and other absorbent materials that have been drenched or heavily contaminated with the product's concentrate. Do not reuse them.

When handlers use aircraft in a manner that meets the requirements listed in the Worker Protection Standard (WPS) for agricultural pesticides 40 CFR 170.240 (d) (4-6), the handler PPE requirements may be reduced or modified as specified in the WPS.

SPECIMEN

USER SAFETY RECOMMENDATIONS:
Users should wash hands before eating, drinking, chewing gum, using tobacco or using the toilet.

Users should remove clothing/PPE immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.

Users should remove PPE immediately after handling this product. As soon as possible, wash thoroughly and change into clean clothing.

ENVIRONMENTAL HAZARDS

This product is toxic to aquatic organisms, including fish and invertebrates. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. This product may contaminate water through runoff. This product has a potential for runoff for several weeks after application. Poorly draining soils and soils with shallow water tables are more prone to produce runoff that contains this product. This product is highly toxic to bees exposed to direct treatment on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops or weeds while bees are foraging in the treatment area. Do not apply directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwaters or rinsate.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or Tribe, consult the agency for pesticide regulation.

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR, Part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE), and restricted-entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the restricted-entry interval (REI) of 12 hours.

PPE required for early entry to treated areas (that is permitted under Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water), is:

- Long-sleeved shirt and long pants;
- Chemical-resistant gloves, such as Barrier Laminate, Nitrile Rubber, Neoprene Rubber or Viton;
- Shoes plus socks.

NON-AGRICULTURAL USE REQUIREMENTS

The requirements in this box apply to uses of this product that are NOT within the scope of the Worker Protection Standard for agricultural pesticides (40 CFR, Part 170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries, or greenhouses.

Do not enter or allow others to enter until vapors, mists, and aerosols have dispersed, and the treated area has been thoroughly ventilated.

Do not enter or allow others to enter until sprays have dried.

INDOOR AREAS for use in and around:
Greenhouses

OUTDOOR AREAS for use in and around:
Nurseries
Outdoor Growing Crops

TO KILL THE FOLLOWING INSECTS:

Angoumois Grain Moths
Ants (excluding fire and Pharaoh ants)
Aphids
Apple Maggots
Armored Scales
Armyworms
Artichoke Plume Moths
Asian Citrus Psyllids
Asparagus Beetles
Bagworms
Bean Beetles
Beet Armyworms
Beetles
Bermudagrass Mirids
Billbugs
Blister Beetles
Blow Flies
Boll Weevils
Boxelder Bugs
Branch and Twig Borers
Cabbage Loopers
Cabbage Maggots
Cadelles
Cankerworms
Carrot Weevils
Caterpillars
Chalcids
Cheese Skippers
Cherry Fruit Flies
Cigarette Beetles
Clover Mites
Clover Weevils
Cockroaches
Codling Moths
Colorado Potato Beetles
Confused Flour Beetles
Corn Earworms
Crane Flies
Crickets
Cross-striped Cabbageworms
Cucumber Beetles
12-spotted Cucumber Beetles
Dark Mealworms
Darkling Beetles (lesser mealworms)
Diamondback Larvae and Moths
Driedfruit Beetles
Drugstore Beetles
Earwigs
Eastern Tent Caterpillars
Elm Leaf Beetles
Eriophyid Mites
European Pine Tip Moths
Fireworms
Flea Beetles
Fleas
Forest Tent Caterpillars
Fruit Flies
Fruittree Leafrollers
Fruitworms
Fungus Gnats
Garden Symphylan
Glassy-winged Sharpshooters
Gnats
Grain Mites
Grapeleaf Skeletonizers
Grape Leafhoppers
Grape Mealybugs
Grasshoppers
Greenbugs
Green Fruitworms
Green Peach Aphids
Greenhouse Thrips
Gypsy Moths (adults & larvae)
Harlequin Bugs
Heliothis spp.
Horn Flies
Hornworms
House Flies
Imported Cabbageworms
Indian Meal Moths
Japanese Beetles
Katydids
Lace Bugs
Leaffooted Plant Bugs
Leafhoppers
Leafminers
Leafrollers
Leaftiers
Loopers
Lygus
Maggots
Mealybugs
Mediterranean Flour Moths
Mexican Bean Beetles
Midges
Millipedes
Mites
Mole Crickets
Moths
Mushroom Flies
Navel Orangeworms
Olive Fruit Flies
Onion Maggots
Orange Tortrix
Pacific Flatheaded Borers
Pear Psyllids
Pepper Weevils
Pink Bollworms
Potato Leafhoppers
Potato Tuberworms
Poultry Lice
Proba Bugs
Psyllids
Red Flour Beetles
Rice Weevils
Saltmarsh Caterpillars
Sawtoothed Grain Beetles
Scales
Sharpshooters
Sheep "Tick" or Ked
Shore Flies
Shothole Borers
Silverfish
Skippers
Small Flying Moths
Soft Scales
Southern Chinch Bugs
Sowbugs
Spider Beetles
Springtails
Squash Bugs
Stable Flies
Stink Bugs
Tarnished Plant Bugs
Thrips
Ticks
Tobacco Moths
Tomato Budworms
Tomato Bugs
Tomato Fruitworms
Tomato Hornworms
Tomato Pinworms
Tomato Russet Mites
Tussock Moths
Vine Mealybugs
Vinegar Flies
Webworms
Weevils
Western Yellowstriped Armyworms
Whiteflies
Yellow Mealworms

PRECAUTIONS AND RESTRICTIONS

Do not apply this product in a way that will contact workers or other persons, either directly or through drift.

Only protected handlers may be in the area during application.

Not for use in outdoor metered release devices.

Keep unprotected persons out of treated areas until sprays have dried.

Allow spray to dry before allowing adults, children or pets on treated areas.

Do not wet plants to the point of runoff or drip.

Do not apply more than 10 times per season.

Do not reapply within 3 days except under extreme pest pressure.

In case of extreme pest pressure, do not reapply within 24 hours.

For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulation.

Not for use in outdoor residential misting systems.

Do not apply when food, feed, and/or water is present.

Not for indoor use except in greenhouses.

Spray Drift Management for Agricultural Crops
Avoiding spray drift at the application site is the responsibility of the applicator and the grower. The interactions of many equipment and weather-related factors determine the potential for spray drift. The applicator and the grower are responsible for considering all these factors when making decisions.

Do not apply at wind speeds greater than 10 mph at the application site.

Do not make any type of application into temperature inversions.

Apply as a medium or coarser spray (ASABE standard 572).

Additional Requirements for Aerial Applications:
Do not release spray at a height greater than 10 feet above the ground or crop canopy.

The boom length must not exceed 75% of the wingspan or 90% of the rotor blade diameter.

Aerial applicators must consider flight speed and nozzle orientation in determining droplet size.

When applications are made with a cross-wind, the swath will be displaced downwind. The applicator must compensate for this displacement at the downwind edge of the application area by adjusting the path of the aircraft upwind.

Additional requirements for ground applications:
Do not release spray at a height greater than 4 feet above the ground or crop canopy.

Additional requirements for airblast applications:
Direct sprays into the canopy.

Turn off outward pointing nozzles at row ends and when spraying outer rows.

PESTICIDE RESISTANCE MANAGEMENT
PyGanic® Crop Protection EC 5.0$_{II}$ contains a Group 3A insecticide. Insect biotypes with acquired resistance to Group 3A may eventually dominate the insect population if Group 3A insecticides are used repeatedly in the same field or in successive years as the primary method of control for targeted species. This may result in partial or total loss of control of those species by PyGanic Crop Protection EC 5.0$_{II}$ or other Group 3A insecticides.

To delay insecticide resistance consider:

- Avoiding the consecutive use of PyGanic Crop Protection EC 5.0$_{II}$ or other Group 3A insecticides that have a similar target site of action, on the same insect species.
- Using tank mixtures or premixes with insecticides from a different target site of action Group as long as the involved products are all registered for the same use and have different sites of action.
- Basing insecticide use on a comprehensive IPM program.
- Monitoring treated insect population for loss of field efficacy.
- Contacting your local extension specialist, certified crop advisors, and/or manufacturer for insecticide resistance management and/or IPM recommendations for the specific site and resistance pest problems.

USE DIRECTIONS

IMPORTANT: It is recommended that the final spray mix be buffered to a pH of 5.5-7.0. Outside of this range pyrethrins can degrade and the product will lose effectiveness.

To avoid possible harm to honey bees and other beneficial insects, it is advisable to apply when the nontarget insects are least active.

Pyrethrins degrade rapidly in sunlight. To ensure the best performance, coverage is key. Use spray equipment that will provide the best coverage and direct contact with as many insects as possible.

Kills only at time of application. Listed insect pests must be directly contacted to be effective.

TANK MIX: This product may be tank mixed with other insecticides, acaricides, fungicides, adjuvants, and wetting agents. This application should conform to accepted use precautions and directions for both products. Tank mix applications must be made in accordance with the more restrictive of label limitations and precautions. No label application rates may be exceeded. This product cannot be mixed with any product with label prohibitions against such mixing.

Prior to tank mixing, a compatibility test should be conducted using the proper proportions of products

and water to ensure the physical compatibility of the mixture.

IMPORTANT NOTE: Plant safety is an important consideration when using insecticides in a greenhouse. However, it is not possible to evaluate the phytotoxicity of PyGanic Crop Protection EC 5.0$_{II}$ on numerous plant varieties that may react differently to insecticides in different growth stages or under varying environmental conditions. Before making widespread applications of PyGanic Crop Protection EC 5.0$_{II}$ or tank mix combinations, treat a limited number of plants and observe for phytotoxicity over a 10-day period.

DIRECTIONS FOR APPLICATION THROUGH IRRIGATION SYSTEMS (CHEMIGATION):
Apply this product only through sprinkler (including center pivot, lateral move, end tow, side (wheel) roll, traveler, big gun, solid set, or hand move) irrigation systems. Do not apply this product through any other type of irrigation system.

Crop injury, lack of effectiveness, or illegal pesticide residues in the crop can result from non-uniform distribution of treated water.

If you have questions about calibration, you should contact State Extension Service specialists, equipment manufacturers or other experts.

Do not connect an irrigation system (including greenhouse systems) used for pesticide application to a public water system unless the pesticide label-prescribed safety devices for public water systems are in place.

A person knowledgeable of the chemigation system and responsible for the operation or under the supervision of the responsible person, shall shut the system down and make necessary adjustments should the need arise.

The system must contain a functional check valve, vacuum relief valve, and low-pressure drain appropriately located on the irrigation pipeline to prevent water source contamination from backflow. The pesticide injection pipeline must contain a functional, automatic, quick-closing check valve to prevent the flow of fluid back toward the injection pump. The pesticide injection pipeline must also contain a functional normally closed, solenoid-operated valve located on the intake side of the injection pump and connected to the system interlock to prevent fluid from being withdrawn from the supply tank when the irrigation system is either automatically or manually shut down. The system must contain functional interlocking controls to automatically shut off the pesticide injection pump when the pump motor stops. The irrigation line or water pump must include a functional pressure valve, which will stop the water pump motor when the water pressure decreases to the point where pesticide distribution is adversely affected.

System must be a metering pump, such as a positive displacement injection pump (e.g., diaphragm pump) effectively designed and constructed of materials that are compatible with pesticides and capable of being fitted with a system interlock.

Do not apply when wind speed favors drift beyond the area intended for treatment.

Constant agitation must be maintained in the chemical supply tank during the entire period of insecticide application. Greater accuracy in calibration and distribution will be achieved by injecting a larger volume of more dilute suspension per unit of time.

SOIL DRENCH DIRECTIONS FOR USE IN GREENHOUSES: For a standard drench rate add 0.375 fl. oz. of PyGanic Crop Protection EC 5.0$_{II}$ to 5 gallons of water and apply as a soil drench to 1,000 sq. ft., of soil or non-soil media to kill soil-borne insect larvae (e.g. Fungus Gnats). Apply for sufficient duration so as to distribute the application rate evenly to the entire treated area. Do not exceed the maximum application rate of 0.375 fl. oz. of PyGanic Crop Protection EC 5.0$_{II}$ per 1,000 sq. ft. To drench the soil, additional water may be applied to the area, being careful not to apply to runoff.

GROWING CROPS (OUTDOORS AND IN GREENHOUSES AND NURSERIES):
Apply 4.5 to 15.61 fl. oz. per acre by ground equipment in sufficient water for thorough coverage. This product may be applied by air at the rate of 4.5 to 15.61 fl. oz. per acre in a minimum of 2 gallons of water per acre for field crops and in a minimum of 10 gallons of water per acre for orchard crops. Mix only enough for immediate use. Spraying should begin when insects first appear. Do not wait until plants are heavily infested. Repeat as needed but not more than once daily.

PyGanic Crop Protection EC 5.0$_{II}$ may be used on most crops because its active ingredient is exempt from tolerances when applied to growing crops. The crop-grouping scheme used on this label was devised by the Environmental Protection Agency to expedite minor use pesticide registration. Each crop grouping on this label contains the phrase "including, but not limited to," and then lists a number of crops in each group. This wording allows the use of PyGanic Crop Protection EC 5.0$_{II}$ on crops that may not be specifically listed on this label (providing that the group to which the crop belongs is listed).

Maximum application rates:
Field and Orchard – 0.05 lbs. ai/acre or 15.61 fl. oz. of PyGanic Crop Protection EC 5.0II per acre (0.0012 lb. ai/1,000 sq. ft.)
Greenhouse space sprays – 0.0014 lbs. ai/acre.

ROOT AND TUBER VEGETABLES: Including: Arracacha, Arrowroot, Purple Arrowroot, Japanese Artichoke, Jerusalem Artichoke, Garden Beets, Sugar Beets, Edible Burdock, Edible Canna, Carrots, Cassava (bitter or sweet), Celeriac (Celery root), Chayote (root), Chervil (turnip rooted), Chicory, Chufa, Dasheen, Ginger, Ginseng, Horseradish, Leren, Pars-

ley (Turnip-rooted), Parsnip, Potato, Radish, Japanese Radish (Daikon), Rutabaga, Salsify, Black Salsify, Spanish Salsify, Sweet Potato, Tanier, Turmeric, Turnip, Yam (true), Yam Beans.

LEAVES OF ROOT AND TUBER VEGETABLES: Including: Garden Beet, Sugar Beet, Edible Burdock, Carrot, Cassava (bitter or sweet), Celeriac (Celery root), Chervil (Turnip-rooted), Chicory, Dasheen (Taro), Parsnip, Radish, Japanese Radish (Daikon), Rutabaga, Black Salsify, Sweet Potato, Tanier, Turnip, Yam (true).

BULB VEGETABLES: Including: Garlic, Great-headed Garlic, Leek, Onion (bulb and green) Welsh, Shallot.

LEAFY VEGETABLES: Including: Amaranth (Leafy Amaranth, Chinese Spinach, Tampala), Arugula, Cardoon, Celery, Chinese Celery, Celtuce, Chervil, Corn Salad, Chrysanthemum (edible-leaved), Chrysanthemum (garland), Cress (garden, water), Upland Cress (Yellow Rocket, Winter Cress), Dandelion, Dock (Sorrel), Endive (Escarole), Fennel (Florence), Lettuce (head and leafy), Orach, Parsley, Purslane (garden & winter), Radicchio, Rhubarb, Spinach, Fine Spinach (Malabar, Ceylon), Spinach (New Zealand), Swiss Chard.

BRASSICA (COLE) LEAFY VEGETABLES: Including: Broccoli, Chinese Broccoli (Gai Lan), Broccoli Raab (Rapini), Brussels Sprouts, Cabbage, Chinese Cabbage (Bok Choy), Chinese Cabbage (Napa), Chinese Mustard Cabbage (Gai Choy), Cauliflower, Cavallo Broccoli, Collards, Kale, Kohlrabi, Mizuna, Mustard Greens, Mustard Spinach, Rape Greens.

LEGUME VEGETABLES (SUCCULENT OR DRIED): Including: Adzuki Beans, Field Beans, Kidney Beans, Lima Beans, Moth Beans, Mung Beans, Navy Beans, Pinto Beans, Rice Beans, Runner Beans, Snap Beans, Tepary Beans, Urd Beans, Wax Beans, Asparagus Beans, Blackeyed Peas, Catjang, Chinese Long Beans, Cowpeas, Crowder Peas, Southern Peas, Yardlong Beans, Broad Beans, (Fava Beans), Chick Peas (Garbanzo Beans), Guar, Jack Beans (Sword Bean), Lablab Beans (Hyacinth Bean), Lentils, Peas (Garden Peas, Field Peas, Sugar Snap Peas, English Peas, Snow Peas), Pigeon Peas, Soybeans, Sweet Lupin Beans, White Lupin Beans, White Sweet Lupin, Sword Beans.

FOLIAGE OF LEGUME VEGETABLES: Including: Plant part of any legume vegetable included in the legume vegetable group that will be used as animal feed including any variety of Beans, Field Peas, Soybeans.

FRUITING VEGETABLES: Including: Eggplant, Ground Cherry, Okra, Pepinos, Peppers (Bell Peppers, Chili Peppers, Cooking Peppers, Pimentos, Sweet Peppers), Tomatillos, Tomatoes.

CUCURBIT VEGETABLES: Including: Balsam Apple, Balsam Pear (Bitter Melon), Chayote (fruit), Chinese Wax Gourd (Chinese Preserving Melon), Chinese Cucumber, Citron Melon, Cucumber, Gherkin, Edible Gourds, Melons (including hybrids, Cantaloupe, Casaba, Golden Pershaw Melon, Crenshaw, Honeydew Melons, Honey Balls, Mango Melon, Muskmelon, Persian Melon, Pineapple Melon, Santa Claus Melon, Snake Melon), Pumpkin, Squash (summer & winter), Watermelon (including hybrids).

CITRUS FRUITS: Including: Calamondin, Citrus Citron, Citrus Hybrids, Grapefruit, Kumquats, Lemons, Limes, Mandarin (Tangerine), Orange (sweet & sour), Pummelo, Satsuma Mandarin, (*Citrus* spp. includes Chironja, Tangelos, Tangors).

POME FRUITS: Including: Apple, Crab Apple, Loquat, Mayhaw, Pear, Oriental Pear, Quince.

STONE FRUITS: Including: Apricot, Cherry (sweet & sour), Nectarine, Peach, Plum, Prune, Chickasaw Plum, Damson Plum, Japanese Plum, Plumcot.

SMALL FRUITS AND BERRIES: Including: Blackberry, Blueberry, Cranberry, Currant, Dewberry, Elderberry, Gooseberry, Grape, Huckleberry, Loganberry, Olallieberry, Raspberry (black & red), Strawberry, Youngberry.

TREE NUTS: Including: Almond, Beech Nut, Brazil Nut, Butternut, Cashew, Chestnut, Chinquapin, Filbert (Hazelnut), Hickory Nut, Macadamia Nut (Bush Nut), Pecan, Pistachio, Walnut, Black and English (Persian).

ORIENTAL VEGETABLES: Including: Acerola, Atemoya, Balsam Pear (bitter melon), Carambola, Japanese Artichoke, Chinese Broccoli (Gai Lan), Chinese Cabbage (Bok Choy, Napa), Chinese Mustard Cabbage (Gai Choy), Dasheen, Ginger, Ginseng, Chinese Longbeans, Mung Beans, Citron Melon, Japanese Radish (Daikon), Chinese Spinach, Chinese Waxgourd, Cilantro, Citron Melon, Rambutan, Water Chestnut.

SUBTROPICAL FRUITS: Including: Avocado, Banana, Carob, Barbados Cherry, Cherimoya, Dates, Durian (Jackfruit), Feijoa, Figs, Guava, Kiwifruit, Lychee, Mango, Papaya, Passion Fruit, Persimmon, Pineapple, Pomegranate.

CEREAL GRAINS: Including: Barley, Buckwheat, Corn (sweet and field), Millet, Proso, Oats, Pearl Millet, Popcorn, Rice, Rye, Sorghum (Milo), Teosinte, Triticale, Wheat, Wild Rice.

FORAGE, FODDER AND STRAW OF CEREAL GRAINS: Including: Barley, Buckwheat, Corn (sweet and field), Millet, Proso, Oats, Pearl, Popcorn, Rice, Rye, Sorghum (Milo), Teosinte, Triticale, Wheat, Wild Rice.

GRASSES FOR SEED, FORAGE, FODDER AND HAY: Including: Any grass, Gramineal family (green or cured) except Sugarcane and those listed in the cereal grains group, Pasture and Range Grasses, Grasses grown for hay and silage, Bermudagrass, Bluegrass, Bromegrass, Fescue, Oat Hay, Orchard Grass, Forage Sorghum, Sudan Grass, Timothy.

NON-GRASS ANIMAL FEEDS: Including: Alfalfa, Velvet Beans, Clover, Kudzu, Lespedeza, Lupine, Sainfoin, Trefoil, Crown Vetch, Milk Vetch.

HERBS AND SPICES: Including: Allspice, Angelica,

Anise (Anise seed), Star Anise, Annatto (seed), Balm (Lemon balm), Basil, Borage, Burnet, Caper Buds, Caraway, Black Caraway, Cardamom, Cassia Bark, Cassia Buds, Catnip, Celery Seed, Chamomile, Chervil (dried), Chicory, Chive, Chinese Chive, Cinnamon, Clary, Clove Buds, Coriander (Cilantro or Chinese Parsley leaf), Coriander (Cilantro seed), Costmary, Culantro (leaf), Culantro (seed), Cumin, Curry (leaf), Dill (Dill Weed), Dill (seed), Fennel (common), Florence Fennel (seed), Fenugreek, Grains of Paradise, Horehound, Hyssop, Juniper Berry, Lavender, Lemongrass, Lovage (leaf), Lovage (seed), Mace, Marigold, Marjoram (includes sweet or annual Marjoram, Wild Marjoram or Oregano, and Pot Marjoram), Mustard (seed), Nasturtium, Nutmeg, Oregano, Mint, Paprika, Parsley (dried), Pennyroyal, Black Pepper, White Pepper, Poppy (seed), Rosemary, Rue, Saffron, Sage, Summer and Winter Savory, Sweet Bay (Bay leaf), Tansy, Tarragon, Thyme, Vanilla, Wintergreen, Woodruff, Wormwood.

ADDITIONAL CROPS: Including: Artichoke, Asparagus, Avocado, Coffee, Cotton, Hops, Jojoba, Mushroom, Okra, Olives, Peanuts, Pineapple, Rice, Safflowers, Sesame, Sugarcane, Sunflower, Tea.

TO KILL ANTS (EXCLUDING FIRE AND PHARAOH ANTS) ON ORCHARD FLOORS AND VINEYARD FLOORS: Apply as a broadcast spray to the entire orchard or vineyard floor using ground spray equipment at 5 to 17 fl. oz. per acre in 25 or more gallons of water. For best results use the high rate for heavy infestations and the lower rate for light infestations.

Do not apply where weed growth or other obstructions would impede uniform coverage of the orchard or vineyard floor. Mow or chemically control weeds before the application. Foliar applications of PyGanic Crop Protection EC 5.0$_{II}$ may be made in addition to the orchard floor treatment.

USE ON GREENHOUSE, ORNAMENTAL FLOWER AND FOLIAGE PLANTS: Combine 16 to 32 fl. oz. with 100 gallons of water for applications with conventional sprayers or 1/4 - 1/2 of a fl. oz. per gallon of water for applications with handheld or backpack sprayers. Apply the diluted product at the rate of 3 gallons/1,000 sq. ft.

Do not exceed maximum application rate of .0036 lbs. ai/1,000 sq. ft. or 1.18 fl. oz. of PyGanic Crop Protection EC 5.0$_{II}$/1,000 sq. ft.

Do not apply more than 1 time per day.

FOR USE IN VEGETABLE AND TRUCK GARDENS: For commercial production of listed crops to kill listed insects dilute 1/4 to 1/2 fl. oz. of PyGanic Crop Protection EC 5.0$_{II}$ per gallon of water. Apply diluted solution with all types of agricultural sprayers, including compressed air sprayers or pump driven sprayers.

STORAGE AND DISPOSAL

Do not contaminate water, food, or feed by storage or disposal.

PESTICIDE STORAGE: Keep this product in its tightly closed original container, when not in use. Store in a cool, dry (preferably locked) area that is inaccessible to children and animals.

PESTICIDE DISPOSAL: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

CONTAINER DISPOSAL: Non-refillable container. Do not reuse or refill this container.

Triple rinse container (or equivalent) promptly after emptying.

Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container 1/4 full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times. Offer for recycling if available or reconditioning if appropriate, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities.

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Manufactured for:
MGK
8810 Tenth Avenue North
Minneapolis, MN 55427
Rev. 0617-1018

Information contained in this booklet is accurate at the time of printing. Since product testing is a continuous process, please read and follow the directions on the product label for the most current directions and precautionary statements.

Always check with your state to verify state registration status or call 800-6-VALENT (682-5368).

VALENT®

For state registration and/or supplemental labels, please call.

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Specimen Label

CORTEVA™
agriscience

Radiant® SC

INSECTICIDE

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For control or suppression of lepidopterous larvae (worms, caterpillars), dipterous leafminers, thrips, and certain psyllids in asparagus, *Brassica* (cole) crops, bulb vegetables, cereal grains (except rice, millet and sorghum), corn (field, sweet, popcorn, and seed corn), cotton, cucurbits, fruiting vegetables (tomato, peppers, and eggplant), globe artichoke, grain amaranth, herbs, leafy vegetables, leaves of legume vegetables, leaves of root and tuber vegetables, legume vegetables (succulent and dried beans and peas), okra, peanut, peppermint, pineapple, quinoa, root and tuber vegetables, soybean, spearmint, spices (except black pepper), strawberry, teosinte, turnip greens, and watercress.

Group	5	INSECTICIDE

Active Ingredient:
spinetoram (a mixture of spinetoram-J and spinetoram-L) 11.7%
Other Ingredients..... .88.3%
Total..... 100.0%

Contains 1 lb of active ingredient per gallon (120 g ai/liter)

Precautionary Statements

Hazards to Humans and Domestic Animals

EPA Reg. No. 62719-545

Keep Out of Reach of Children

CAUTION

Causes Moderate Eye Irritation

Avoid contact with eyes or clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, or using tobacco.

Personal Protective Equipment (PPE)

Applicators and other handlers must wear:
- Long-sleeved shirt and long pants
- Shoes plus socks

Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

User Safety Recommendations

Users should:
- Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet.

First Aid

If in eyes: Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.

First Aid (Cont.)

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-800-992-5994 for emergency medical treatment information.

Environmental Hazards

This product is toxic to bees exposed to treatment during the 3 hours following treatment. Do not apply this pesticide to blooming, pollen-shedding or nectar-producing parts of plants if bees may forage on the plants during this time period. This product is toxic to aquatic invertebrates. Do not apply directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwaters. Do not apply where runoff is likely to occur. Do not apply when weather conditions favor drift from treated areas. Drift and runoff from treated areas may be hazardous to aquatic organisms in neighboring areas. Apply this product only as specified on the label.

Directions for Use

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.
Read all Directions for Use carefully before applying.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your state or tribe, consult the state or tribal agency responsible for pesticide regulation.

Agricultural Use Requirements

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment, restricted entry interval, and notification to workers (as applicable). The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 4 hours.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, is:
- Coveralls
- Chemical-resistant gloves made of any waterproof material
- Shoes plus socks

Storage and Disposal

Do not contaminate water, food or feed by storage or disposal.
Pesticide Storage: Store in original container only. In case of leak or spill, contain material with absorbent materials and dispose as waste.
Pesticide Disposal: Wastes resulting from the use of this product must be disposed of on site or at an approved waste disposal facility.

Nonrefillable rigid containers 5 gallons or less:
Container Handling: Nonrefillable container. Do not reuse or refill this container.
Triple rinse or pressure rinse container (or equivalent) promptly after emptying. **Triple rinse** as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container 1/4 full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times. **Pressure rinse** as follows: Empty the remaining contents into application equipment or a mix tank and continue to drain for 10 seconds after the flow begins to drip. Hold container upside down over application equipment or mix tank and continue to drain for 10 seconds after the flow begins to drip. Hold container upside down over application equipment or mix tank or collect rinsate for later use or disposal. Insert pressure rinsing nozzle in the side of the container, and rinse at about 40 psi for at least 30 seconds. Drain for 10 seconds after the flow begins to drip. Then offer for recycling if available or puncture and dispose of in a sanitary landfill, or by incineration, or by other procedures allowed by state and local authorities.

Refillable rigid containers larger than 5 gal:
Container Handling: Refillable container. Refill this container with pesticide only. Do not reuse this container for any other purpose.

Storage and Disposal (Cont.)

Cleaning the container before final disposal is the responsibility of the person disposing of the container. Cleaning before refilling is the responsiiblity of the refiller. To clean the container before final disposal, empty the remaining contents from this container into application equipment or a mix tank. Fill the container about 10% full with water and, if possible, spray all sides while adding water. If practical, agitate vigorously or recirculate water with the pump for two minutes. Pour or pump rinsate into application equipment or rinsate collection system. Repeat this rinsing procedure two more times. Then offer for recycling if available or puncture and dispose of in a sanitary landfill, or by incineration, or by other procedures allowed by state and local authorities.

Nonrefillable rigid containers larger than 5 gal:
Container Handling: Nonrefillable container. Do not reuse or refill this container.
Triple rinse or pressure rinse container (or equivalent) promptly after emptying. **Triple rinse** as follows: Empty the remaining contents into application equipment or a mix tank. Fill the container 1/4 full with water. Replace and tighten closures. Tip container on its side and roll it back and forth, ensuring at least one com[plete revolution, for 30 seconds. Stand the container on its end and tip it back and forth several times. Turn the container over onto its other end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Repeat this procedure two more times. **Pressure rinse** as follows: Empty the remaining contents into application equipment or a mix tank and continue to drain for 10 seconds after the flow begins to drip. Hold container upside down over application equipment or mix tank and continue to drain for 10 seconds after the flow begins to drip. Hold container upside down over application equipment or mix tank or collect rinsate for later use or disposal. Insert pressure rinsing nozzle in the side of the container, and rinse at about 40 psi for at least 30 seconds. Drain for 10 seconds after the flow begins to drip. Then offer for recycling if available or puncture and dispose of in a sanitary landfill, or by incineration, or by other procedures allowed by state and local authorities.

Product Information

Radiant™ SC insecticide is used for control or suppression of many foliage feeding pests including lepidopterous larvae (worms or caterpillars), thrips, Colorado potato beetles, dipterous leafminers, and certain psyllids infesting labeled crops. This product's active ingredient, spinetoram, is derived from the fermentation of *Saccharopolyspora spinosa*, a naturally occurring soil organism. Mix the suspension concentrate of Radiant SC with water and apply as a foliar spray with aerial or ground equipment suitable for conventional insecticide spraying.

Product Use Precautions

Integrated Pest Management (IPM) Programs
Radiant SC is recommended for IPM programs in labeled crops. Apply Radiant SC when field scouting indicates target pest densities have reached the economic threshold, i.e., the point at which the insect population must be reduced to avoid economic losses beyond the cost of control. Other than reducing the target pest species as a food source, Radiant SC does not have a significant impact on certain parasitic insects or the natural predaceous arthropod complex in treated crops, including big-eyed bugs, ladybird beetles, flower bugs, lacewings, minute pirate bugs, damsel bugs, assassin bugs, or spiders. The feeding activities of these beneficials will aid in natural control of other insects and reduce the likelihood of secondary pest outbreaks. If Radiant SC is tank mixed with any insecticide that reduces its selectivity in preserving beneficial predatory insects, the full benefit of Radiant SC in an IPM program may be reduced.

Insecticide Resistance Management (IRM)
Radiant SC contains spinetoram, a Group 5 insecticide. Insect/mite biotypes with acquired resistance to Group 5 insecticides may eventually dominate the insect/mite population if Group 5 insecticides are used repeatedly in the same field or area, or in successive years as the primary method of control for targeted species. This may result in partial or total loss of control of those species by Radiant SC or other Group 5 insecticides. Currently, only spinetoram and spinosad active ingredients are classified as Group 5 insecticides. These two insecticide active ingredients share a common mode of action and must not be rotated with each other for control of pests listed on this label. Spinetoram and spinosad may be rotated with all other labeled insecticide active ingredients.

To delay development of insecticide resistance, the following practices are recommended:

- Carefully follow the specific label guidelines within the Use Direction sections of this label, especially in regard to IRM recommendations.
- Avoid use of the same active ingredient or mode of action (same insecticide group) on consecutive generations of insects. However, multiple applications to reduce a single generation are acceptable. Treat the next generation with a different active ingredient that has a different mode of action, or use no treatment for the next generation.
- Avoid using less than labeled rates of any insecticide when applied alone or in tank mixtures.
- Applications should be targeted against early insect developmental stages whenever possible.
- Base insecticide use on comprehensive IPM programs including crop rotations.
- Monitor treated insect populations in the field for loss of effectiveness.
- Contact your local extension specialist, certified crop advisor, and/or manufacturer for insecticide resistance management and/or IPM recommendations for the specific site and resistant pest problem.
- For further information or to report suspected resistance, contact your local Dow AgroSciences by calling 800-258-3033.

Mixing Directions

Always shake well before use. Avoid freezing.

Application Rate Chart for Crop Uses

Application Rate of Radiant SC (fl oz/acre)	Active Ingredient Equivalent (lb ai/acre)
12	0.0938
11	0.0859
10	0.0781
9.5	0.0742
9	0.0703
8.5	0.0664
8	0.0625
7.5	0.0586
7	0.0547
6.5	0.0508
6	0.0469
5.5	0.0430
5	0.0391
4.5	0.0352
4	0.0313
3.5	0.0273
3	0.0234
2.5	0.0195
2	0.0156

Radiant SC - Alone: Fill the spray tank with water to about 1/2 of the required spray volume. Start agitation and add the required amount of Radiant SC. Continue agitation while mixing and filling the spray tank to the required spray volume. Maintain sufficient agitation during application to ensure uniformity of the spray mix. Do not allow water or spray mixture to back-siphon into the water source.

Radiant SC - Tank Mix: When tank mixing Radiant SC with other materials, a compatibility test (jar test) using relative proportions of the tank mix ingredients should be conducted prior to mixing ingredients in the spray tank. If foliar fertilizers are used, the jar test should be repeated with each batch of fertilizer utilizing the mixing water source. Vigorous, continuous agitation during mixing, filling and throughout application is required for all tank mixes. Sparger pipe agitators generally provide the most effective agitation in spray tanks. To prevent foaming in the spray tank, avoid stirring or splashing air into the spray mixture.

Mixing Order for Tank Mixes: Fill the spray tank with water to 1/4 to 1/3 of the required spray volume. Start agitation. Add different formulation types in the order indicated below, allowing time for complete dispersion and mixing after addition of each product. Allow extra dispersion and mixing time for dry flowable products.

Add different formulation types in the following order:
1. Water dispersible granules
2. Wettable powders
3. Radiant SC and other aqueous suspensions

Maintain agitation and fill spray tank to 3/4 of total spray volume. Then add:
4. Emulsifiable concentrates and water-based solutions
5. Spray adjuvants, surfactants, and oils
6. Foliar fertilizers

Finish filling the spray tank. Maintain continuous agitation during mixing, final filling and throughout application. If spraying and agitation must be stopped before the spray tank is empty, the materials may settle to the bottom. Settled materials must be re-suspended before spraying is resumed. A sparger agitator is particularly useful for this purpose.

Premixing: Dry and flowable formulations may be premixed with water (slurried) and added to the spray tank through a 20 to 35 mesh screen. This procedure assures good initial dispersion of these formulation types.

Spray Tank pH: A spray tank pH between 5.0 and 9.0 is suggested to achieve maximum performance of Radiant SC. If the water source is outside of this pH range, or tank mixing other pesticides, adjuvants, or foliar nutrients will cause the pH to fall outside this range, consider adjusting the spray tank pH to be between 5.0 and 9.0 before adding Radiant SC. To do this, add all other tank mix components first, then check the spray tank pH and adjust if desired, and then add Radiant SC. If you require additional information on how to adjust spray tank pH, contact your Dow AgroSciences representative.

Use of Adjuvants: Adjuvants may be used to improve control of dipterous and lepidopterous leafminers, and thrips in situations where achieving uniform plant coverage is difficult such as a closed crop canopy, or dense foliage), or penetration into waxy leaf surfaces is required.

- Use only adjuvant products labeled for agricultural use and follow the manufacturer's label directions. A nominal concentration of 1 to 2 quarts per 100 gallons (0.25 to 0.5% v/v) is generally sufficient.
- For dipterous leafminers and thrips, emulsified crop oils or methylated crop oil plus organosilicone combination products are recommended.
- For lepidopterous leafminers, thrips, and psyllids, citrus oils or horticultural oils may improve control.
- When using adjuvants, always conduct a jar test to determine the compatibility of the various components in the spray mixture. Crop safety should be evaluated in a small area of the crop whenever there is a significant change in spray mixture ingredients or source of water for the spray mixture.
- Do not use diesel fuel or pure mineral oil.
- When an adjuvant is to be used with this product, Dow AgroSciences recommends the use of a Chemical Producers and Distributors Association certified adjuvant.

Application Directions

Do not apply Radiant SC in greenhouses or other enclosed structures used for growing crops.

Proper application techniques help ensure thorough spray coverage and correct dosage for optimum insect control. The following directions are provided for ground and aerial application of Radiant SC. Attention should be given to sprayer speed and calibration, wind speed, and foliar canopy density to ensure adequate spray coverage.

Wind Direction and Speed
Only apply this product if the wind direction favors on-target deposition. Do not apply when the wind velocity exceeds 15 mph. Wind speed must be measured adjacent to the application site on the upwind side, immediately prior to application.

Temperature Inversion
Do not make aerial or ground applications into temperature inversions. Inversions are characterized by stable air and increasing temperatures with height above the ground. Mist or fog may indicate the presence of an inversion in humid areas. The applicator may detect the presence of an inversion by producing smoke and observing a smoke layer near the ground surface.

Droplet Size
Use only medium or coarser spray nozzles (for ground and non-ULV aerial application) according to ASABE Standard S-572 definition for standard nozzles. In conditions of low humidity and high temperatures, applicators should use a coarser droplet size. Exceptions may be indicated for specific crop groups.

Ground Row Crop Application
Use calibrated power-operated ground spray equipment capable of providing uniform coverage of the target crop. Orient the boom and nozzles to obtain uniform crop coverage. A minimum of 5 to 10 gallons per acre should be utilized, increasing volume with crop size and/or pest pressure. Use hollow cone, twin jet flat fan nozzles or other atomizer suitable for insecticide spraying to provide a fine to coarse spray quality (per ASABE S-572, see nozzle catalogs). Under certain conditions, drop nozzles may be required to obtain complete coverage of plant surfaces. Follow manufacturer's specifications for ideal nozzle spacing and spray pressure. Minimize boom height to optimize uniformity of coverage and optimize deposition (on-target deposition) to reduce drift.

Groundboom Application
For groundboom applications, apply using a nozzle height of no more than 4 feet above the ground or crop canopy. For ground boom and airblast applications, turn off outward pointing nozzles at row ends and when spraying the outer two rows. To minimize spray loss over the top of the crop canopy, spray must be directed into the canopy. Calibrate airblast application equipment and operate in a manner that achieves full displacement of the air within the crop canopy with air containing spray droplets.

Aerial Application
Apply in spray volume of 3 to 5 gallons or more per acre. Nozzle configuration should provide a medium to fine droplet size per ASABE S-572 standard (see USDA-ARS or NAAA handbook). Guidance for ASABE S-572 nozzle configuration can be found at the following web site: http://apmru.usda.gov/downloads/downloads.htm. Boom length must be less than 75% of wing or 85% of rotor span and swath adjustment (offset) to compensate for crosswinds. Observe minimum safe application height (maximum 12 feet for agricultural canopies). Use GPS equipment, swath markers or flagging to ensure proper application to the target area. Configure the boom nozzle used (e.g., at NAAA/ Operation Safe Fly-In) for both crosswind and near parallel winds. If application is made parallel to the wind direction, adjust swath width downward. Use swath adjustment (offset) to compensate for crosswinds. Do not apply under completely calm wind conditions. It is best to apply when wind speed is between 2 to 10 mph. Under conditions of low humidity and high temperatures, adjust spray volume and droplet size upward to compensate for evaporation of spray droplets.

Additional Requirements for Aerial Applications: Mount the spray boom on the aircraft to minimize drift caused by wingtip or rotor vortices. Use the minimum practical boom length and do not exceed 75% of the wing span or 80% rotor diameter. Flight speed and nozzle orientation must be considered in determining droplet size. Spray must be released at the lowest height consistent with the pest control and flight safety. Do not release spray at a height greater than 10 feet above the crop canopy unless a greater height is required for aircraft safety. When applications are made with a cross-wind, the swath will be displaced downwind. The applicator must compensate for this displacement at the downwind edge of the application area by adjusting the path of the aircraft upwind.

Chemigation Application
Radiant SC may be applied through properly equipped chemigation systems for insect control in corn, and potatoes. Follow use directions for these crops in the Uses section of this label. Do not apply Radiant SC by chemigation to other labeled crops except as specified in Dow AgroSciences supplemental labeling or product bulletins.

Directions for Sprinkler Chemigation: Apply this product only through sprinkler irrigation systems including: center pivot, lateral move, end tow, side (wheel) roll, traveler, solid set, or hand move. Do not apply this product through any other type of irrigation system. Sprinkler systems that deliver a low coefficient of uniformity such as certain water drive units are not recommended.

For continuously moving systems, the mixture containing Radiant SC must be injected continuously and uniformly into the irrigation water line as the sprinkler is moving. If continuously moving irrigation equipment is used, apply in no more than 0.25 inch of water. For irrigation systems that do not move during operation, apply in no more than 0.25 inch of irrigation immediately before the end of the irrigation cycle.

Chemigation Equipment Preparation: The following use directions are to be followed when this product is applied through irrigation systems. Thoroughly clean the chemigation system and tank of any fertilizer or chemical residues, and dispose of the residues according to state and federal laws. Flush the injection system with soap or a cleaning agent and water. Determine the amount of Radiant SC needed to cover the desired acreage. Mix according to instructions in the Mixing Directions section above using a dilution concentrate matching your injector system requirements. Continually agitate the mixture during mixing and application.

Chemigation Equipment Calibration: In order to calibrate the irrigation system and injector to apply the mixture containing Radiant SC, determine the following: 1) Calculate the number of acres irrigated by the system; 2) Calculate the amount of product required and premix. 3) Determine the irrigation rate and determine the number of minutes for the system to cover the intended treatment area; 4) Calculate the total gallons of insecticide mixture needed to cover the desired acreage. Divide the total gallons of insecticide mixture needed by the number of minutes (minus time to flush out) to cover the treatment area. This value equals the gallons per minute output that the injector or eductor must deliver. Convert the gallons per minute to milliliters or ounces per minute if needed. 5) Calibrate the injector pump with the system in operation at the desired irrigation rate. It is suggested that the injector pump/system be calibrated at least twice before operation, and the system should be monitored during operation.

Chemigation Equipment Requirements:
- The system must contain an air gap, an approved backflow prevention device, a functional check valve, vacuum relief valve (including inspection port), and low-pressure drain appropriately located on the irrigation pipeline to prevent water source contamination from back flow. Refer to the American Society of Agricultural Engineer's Engineering Practice 409 for more information or state specific regulations.
- The pesticide injection pipeline must contain a functional, automatic, quick-closing check valve to prevent the flow of fluid back toward the injection pump.
- The pesticide injection pipeline must also contain a functional normally closed, solenoid-operated valve located on the intake side of the injection pump and connected to the system interlock to prevent fluid from being withdrawn from the supply tank when the irrigation system is either automatically or manually shut down.
- The system must contain functional interlocking controls to automatically shut off the pesticide injection when the water pump motor stops.
- The irrigation line or water pump must include a functional pressure switch which will stop the water pump motor when the water pressure decreases to the point where pesticide distribution is adversely affected.
- Systems must use a metering pump, such as a positive displacement injection pump (e.g., diaphragm pump) effectively designed and constructed of materials that are compatible with pesticides and capable of being fitted with a system interlock.
- To insure uniform mixing of the insecticide in the water line, inject the mixture in the center of the pipe diameter or just ahead of an elbow or tee in the irrigation line so that the turbulence created at those points will assist in mixing. The injection point must be located after all back-flow prevention devices on the water line.
- The tank holding the insecticide mixture should be free of rust, fertilizer, sediment, and foreign material, and equipped with an in-line strainer situated between the tank and the injector point.

Chemigation Operation: Start the water pump and irrigation system, and let the system achieve the desired pressure and speed before starting the injector. Check for leaks and uniformity and make repairs before any chemigation takes place. Start the injection system and calibrate according to manufacturer's specifications. This procedure is necessary to deliver the desired rate per acre in a uniform manner. When the application is finished, allow the entire irrigation and injector system to be thoroughly flushed clean before stopping the system.

Chemigation Precautions:
- Crop injury, lack of effectiveness or illegal pesticide residues in the crop can result from non-uniform distribution of treated water.
- If you have questions about calibration, contact state extension service specialists, equipment manufacturers or other experts.
- Public water system means a system for the provision to the public of piped water for human consumption if such system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year.
- A person knowledgeable of the chemigation system and responsible for its operation, or under the supervision of the responsible person, shall operate the system and make necessary adjustments should the need arise and continuously monitor the injection.

Chemigation Restrictions:
- Chemigation systems connected to public water systems must contain a functional, reduced-pressure zone, back flow preventer (RPZ) or the functional equivalent in the water supply line upstream from the point of pesticide introduction. As an option to the RPZ, the water from the public water system shoud be discharged into a reservoir tank prior to pesticide introduction. There shall be a complete physical break (air gap) between the flow outlet end of the fill pipe and the top or overflow rim of the reservoir tank of at least twice the inside diameter of the fill pipe.
- The pesticide injection pipeline must contain a functional, automatic, quick-closing check valve to prevent the flow of fluid back toward the injection.
- The pesticide injection pipeline must contain a functional, normally closed, solenoid-operated valve located on the intake side of the injection pump and connected to the system interlock to prevent fluid from being withdrawn from the supply tank when the irrigation system is either automatically or manually shut down.
- The system must contain functional interlocking controls to automatically shut off the pesticide injection pump when the water pump motor stops, or in cases where there is no water pump, when the water pressure decreases to the point where pesticide distribution is adversely affected.
- Systems must use a metering pump, such as a positive displacement injection pump (e.g., diaphragm pump) effectively designed and constructed of materials that are compatible with pesticides and capable of being fitted with a system interlock.
- Do not connect an irrigation system used for pesticide application (including greenhouse systems) to a public water system unless the pesticide label-prescribed safety devices for public water systems are in place with current certification. Specific local regulations may apply and must be followed.
- Do not apply when wind speed favors drift beyond the area intended for treatment. End guns must be turned off during the application, if they irrigate nontarget areas.
- Do not allow irrigation water to collect or runoff and pose a hazard to livestock, wells, or adjoining crops.
- Do not enter treated area during the reentry interval specified in the Agricultural Use Requirements section of this label unless required PPE is worn.
- Do not apply through sprinkler systems that deliver a low coefficient of uniformity such as certain water drive units.

Rotational Crop Restrictions
Only a crop approved for spinetoram use (Delegate WG or Radiant SC) may be immediately rotated to a treated field. All other crops may be rotated 30 days following last application.

Uses

Asparagus
(Post Harvest Protection of Ferns Only)

Pest and Application Rates:

Pest	Radiant SC (fl oz/acre)
asparagus beetle	4 – 8

Application Timing: For determining when to treat, scout with enough regularity to monitor the population size of the labeled pest. Make applications **only to asparagus ferns**. Treat when pests appear, targeting eggs at hatch or small larvae. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor or your state agricultural experiment station for any additional local use recommendations for your area.

Application Rate: Apply Radiant SC as a foliar spray at the rate specified to control asparagus beetle in asparagus ferns. Use a higher rate in the rate range for heavy infestations or advanced growth stages of the beetle. Heavy infestations may require repeat applications, but follow resistance management guidelines.

Resistance Management: Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. Consult your local Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area.

Restrictions:
- **Preharvest Interval:** This use is only for asparagus ferns; do not apply within 60 days of spear harvest.
- Do not apply more than a total of 24 fl oz of Radiant SC (0.188 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than three applications per year.
- **Minimum Treatment Interval:** Do not make applications less than 4 days apart.

Berry, Low Growing Berry (Subgroup 13-07G)[1] except cranberry and lowbush berry
[1]Bearberry; bilberry; cloudberry; lingonberry; muntries; partridgeberry; strawberry; cultivars, varieties, and/or hybrids of these.

Pests and Application Rates:

Pests	Radiant SC (fl oz/acre)
armyworms[1] leafrollers light brown apple moth spotted wing drosophila thrips[2]	6 – 10

[1]With the exception of yellowstriped armyworm and western yellowstriped armyworm.
[2]Control of thrips may be improved with the addition of an adjuvant to the spray mixture. See Use of Adjuvants section under Mixing Directions.

Application Timing: Treat when pests appear, targeting eggs at hatch or small larvae. For thrips, a 3- to 4-day re-treatment schedule may be necessary if there is heavy pest pressure or if the pest population is increasing rapidly. For control of all other pests, a 5- to 7-day re-treatment schedule may be necessary if the crop is growing rapidly or if there is heavy pest pressure. Consult your Dow AgroSciences representative, extension service specialist, certified crop advisor or your state agricultural experiment station for any additional local use recommendations for your area.

Application Rate: Apply as a foliar spray at the rate specified to control target pests. Use a higher rate in the range for larger larvae or moderate to severe pest infestations.

Resistance Management: Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. For thrips, if additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least two applications. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area.

Restrictions:
- **Preharvest Interval:** Do not apply within 1 day of harvest.
- Do not apply more than a total of 30 fl oz of Radiant SC (0.2343 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than three applications per calendar year. See Resistance Management regarding number of applications for specific pests.
- **Minimum Treatment Interval**: Do not make applications less than 3 days apart for thrips, nor less than 4 days apart for all other listed pests.

Brassica (Cole) Leafy Vegetables (Crop Group 5)[1]

[1]*Brassica* (cole) leafy vegetables (crop group 5) broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cavalo, Chinese broccoli, Chinese cabbage (bok choy), Chinese cabbage (napa), Chinese mustard cabbage (gai choy), collards, kale, kohlrabi, mizuna, mustard greens, mustard spinach, rape greens

In the state of Georgia, do not apply Radiant SC to broccoli raab, Chinese cabbage (bok choy), collards, kale, mizuna, mustard greens, mustard spinach, rape greens

Pests and Application Rates:

Pests	Radiant SC (fl oz/acre)
armyworms[1] cabbage looper[2] diamondback moth[2] imported cabbageworm[2] light brown apple moth cabbage root maggot (suppression)	5 – 10
dipterous leafminers, *Liriomyza* spp[2] thrips[2]	6 – 10
Hawaiian beet webworm	7 - 10

[1]With the exception of yellowstriped armyworm and western yellowstriped armyworm.
[2]Control of lepidopterous larvae, leafminers, and thrips may be improved with the addition of an adjuvant to the spray mixture. See Use of Adjuvants section under Mixing Directions.

Application Timing (except cabbage root maggot): Treat when pests appear, targeting eggs at hatch or small larvae. For all listed pests, heavy infestations may require repeat applications, but follow resistance management guidelines. Consult your Dow AgroSciences representative, extension service specialist, certified crop advisor or your state agricultural experiment station for any additional local use recommendations for your area.

Application Rate (except cabbage root maggot): Apply Radiant SC as a foliar spray at the rate specified to control target pest. Use a higher rate in the rate range for heavy infestations or advanced growth stages of target pests.

Resistance Management (except cabage root maggot): Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. For **diamondback moth and thrips**, if additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least two applications. Do not make more than three applications of Group 5 insecticides for thrips in a season. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area. Make treatment decisions for the entire farm and consider area wide programs if other growers are in close proximity. Do not make more than six applications of Radiant SC per calendar year for diamondback moth over an entire farm (an area of abutting or nearby fields).

Specific Use Direction for cabbage root maggot:
For **cabbage root maggot suppression**, apply Radiant SC at 5 to 10 fl oz/acre. For 20-inch plant row spacing, i.e. two plant lines per 40 inch bed, apply Radiant SC at 0.19 to 0.38 fl oz per 1000 linear feet of plant row. For 30-inch plant row spacing, apply Radiant SC at 0.29 to 0.57 fl oz per 100 linear feet of plant row. Use proportional amounts for other row spacings, but do not exceed 10 fl oz per acre of Radiant SC per application. Application volume of at least 100 gallons of water per acre is recommended. Performance may be reduced at lower application volumes. Optimum application timing is based on field scouting. Begin applications when adult activity is observed in or near the field.

For direct seeded crops, an application should be made when the crop has developed to about the second true leaf stage and a second application should be made two to three weeks later. Direct the spray in a narrow band at the base of the plants and on the adjacent soil. The recommended width of the spray band is four inches.

For transplanted crops, an application should be made immediately after transplanting and a second application should be made two to three weeks later. Application to a narrow band of soil within 24 hours before transplanting is permitted, provided that the transplants are placed accurately within the band of treated soil and there is minimal disturbance of the treated soil during transplanting.

A third application may be needed under high cabbage root maggot pest pressure conditions, such as when there is a large amount of debris from a previous brassica crop or when adjacent brassica fields are being harvested. For optimum control, direct the spray in a narrow band at the base of the plants.

Do not make more than three applications of Group 5 insecticides (spinetoram and spinosad) per crop cycle for cabbage maggot suppression.

Restrictions:
- **Preharvest Interval:** Do not apply within 1 day of harvest.
- Do not apply more than a total of 34 fl oz of Radiant SC (0.266 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than six applications per calendar year. See Resistance Management regarding number of applications for specific pests.
- **Minimum Treatment Interval:** Do not make applications less than 4 days apart.
- Do not apply to seedling cole crops grown for transplant within a greenhouse, shade house, or field plot.

Bulb Vegetables (Subgroups 3-07A & 3-07B)[1]

[1]Chive, fresh leaves; chive, Chinese, fresh leaves; daylily, bulb; elegans hosta; fritillaria, bulb; fritillaria, leaves; garlic, bulb; garlic, great-headed, bulb; garlic, serpent, bulb; kurrat; lady's leek; leek; leek, wild; lily, bulb; onion, bulb; onion, Chinese, bulb; onion, Beltsville bunching; onion, fresh; onion, green; onion, macrostem; onion, pearl; onion, potato, bulb; onion, tree, tops; onion, Welsh, tops; shallot, bulb; shallot, fresh leaves; cultivars, varieties, and/or hybrids of these.

Pests and Application Rates:

Pests	Radiant SC (fl oz/acre)
armyworms[1,2] European corn borer[2] loopers[2]	5 – 10
dipterous leafminers[2] flea beetles (suppression) thrips[2]	6 – 10

[1]With the exception of yellowstriped armyworm and western yellowstriped armyworm.
[2]Control of lepidopterous larvae, leafminers, and thrips may be improved with the addition of an adjuvant to the spray mixture. See Use of Adjuvants under Mixing Directions. Control of thrips requires thorough coverage of the crop. Coverage can be increased by using higher spray pressure and dual directed nozzles.

Application Timing: For determining when to treat, scout with enough regularity to monitor the population size of each of the labeled pests. Treat when pests appear, targeting eggs at hatch or small larvae. Consult your Dow AgroSciences representative, extension specialist, certified crop

advisor or your state agricultural experiment station for any additional local use recommendations for your area.

Application Rate: Apply Radiant SC as a foliar spray at the rate specified to control target pests. Use a higher rate in the rate range for larger larvae or heavier infestations.

Resistance Management: Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. For thrips, if additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least two applications. Do not make more than three applications of Group 5 insecticides for thrips in a season. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area.

Restrictions:
- **Preharvest Interval:** Do not apply within 1 day of harvest.
- Do not apply more than a total of 30 fl oz of Radiant SC (0.234 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than five applications per calendar year. See Resistance Management regarding number of applications for specific pests.
- **Minimum Treatment Interval:** Do not make applications less than 4 days apart.

Cereal Grains (Except Rice, Millet and Sorghum) and Grain Amaranth

Cereal grains including barley, buckwheat, milo, oats, rye, triticale, wheat

Pests and Application Rates:

Pests	Radiant SC (fl oz/acre)
cereal leaf beetle	2 – 6
armyworms[1] corn earworm (headworm) grasshoppers (suppression) southwestern corn borer webworms	3 – 6

[1]With the exception of yellowstriped armyworm and western yellowstriped armyworm.

Application Timing: Scout for **armyworms** with enough regularity to monitor egg laying and egg hatch and treat when thresholds are reached. Time applications of Radiant SC to coincide with peak egg hatch and/or small larval stage of each generation.

Application Rate: Apply Radiant SC as a foliar spray at the rate specified for the target pest. Use a higher rate in the rate range for heavy infestations, advanced growth stages of target pests, or difficult spray coverage situations.

Resistance Management: Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area.

Restrictions:
- **Preharvest Interval:** Do not apply within 21 days of grain or straw harvest or within 3 days of forage, fodder, or hay harvest.
- Do not apply more than a total of 18 fl oz of Radiant SC (0.141 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than three applications per calendar year.
- **Minimum Treatment Interval:** Do not make applications less than 4 days apart.

Corn (Field, Sweet, Popcorn, Seed Corn) and Teosinte

Pests and Application Rates:

Pests	Radiant SC (fl oz/acre)
armyworms[1] corn earworm, *Helicoverpa zea* European corn borer southwestern corn borer western bean cutworm	3 – 6

[1]With the exception of yellowstriped armyworm and western yellowstriped armyworm.

Application Timing: Scout for corn borers and armyworms with enough regularity to monitor egg laying and egg hatch. Time applications of Radiant SC to coincide with peak egg hatch of each generation. For corn earworm control and armyworms, a 2-day re-treatment schedule may be necessary at silking. For control of all other pests, a 5- to 7-day re-treatment schedule may be necessary if the crop is growing rapidly or if there is heavy pest pressure.

Application Rate: Apply Radiant SC as a foliar spray at the rate specified to control target pests. Use a higher rate in the rate range for heavy infestations or advanced growth stages of target pests.

Spray Delivery: For control of **first generation European corn borer** and **armyworms**, apply broadcast or as a directed spray into the leaf whorls. For control of **corn earworm,** apply broadcast or direct spray to ear zone. Use sufficient spray volume and nozzle pressure to ensure thorough wetting of the silks.

Chemigation: Radiant SC may be applied to corn by chemigation at labeled rates. Refer to the Chemigation Application section.

Resistance Management: Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area.

Restrictions:

Sweet Corn
- **Preharvest Interval:** Do not apply within 1 day of ear harvest or 3 days of forage or fodder harvest.
- Do not apply more than a total of 36 fl oz of Radiant SC (0.281 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than six applications per calendar year.
- **Minimum Treatment Interval:** For corn earworm at silking, do not make applications less than 2 days apart. For all other pests and timings, do not make applications less than 4 days apart.

Popcorn and Seed Corn
- **Preharvest Interval:**

Seed Corn: Do not apply within 1 day of grain harvest or 3 days of forage or fodder harvest.
Popcorn: Do not apply within 28 days of grain harvest or 3 days of forage or fodder harvest.
- Do not apply more than a total of 36 fl oz of Radiant SC (0.281 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than six applications per calendar year.
- **Minimum Treatment Interval:** For corn earworm at silking, do not make applications less than 2 days apart. For all other pests and timings, do not make applications less than 4 days apart.

Field Corn and Teosinte
- **Preharvest Interval:** Do not apply within 28 days of grain harvest or within 3 days of fodder or forage harvest.
- Do not apply more than a total of 16 fl oz of Radiant SC (0.125 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than three applications per calendar year.
- **Minimum Treatment Interval:** For corn earworm at silking, do not make applications less than 2 days apart. For all other pests and timings, do not make applications less than 4 days apart.

Cottonseed (Subgroup 20-C)[1]

[1]Cottonseed; cultivars, varieties, and/or hybrids of these.

Pests and Application Rates:

Pests	Radiant SC (fl oz/acre)
cotton bollworm (pre-bloom) cotton leafperforator European corn borer tobacco budworm	2.8 – 8
armyworm[1] cotton bollworm (post-bloom) dipterous leafminers[2] loopers saltmarsh caterpillar thrips[2]	4.25 – 8

[1]With the exception of yellowstriped armyworm and western yellowstriped armyworm.
[2]Control of lepidopterous larvae, leafminers and thrips may be improved with the addition of an adjuvant to the spray mixture. See Use of Adjuvants section under Mixing Directions.

Application Timing: For **cotton bollworm,** use a lower rate in the rate range at pre-bloom timings and a higher rate in the rate range at post-bloom timings. For **tobacco budworm** and/or **cotton bollworm**, scout fields twice per week and apply Radiant SC when the majority of the population is within blackhead egg stage to 1/8-inch larval length. The following table illustrates the size of development of worms in relation to age and stage of development (instar) as a guide to timing treatments for optimum control:

Age (Days)	Average Size (Inch)	Instar
Hatch	1/16	1st
3	1/4	2nd
5	1/2	3rd
8	7/8	4th
10	1	5th

Note: A scouting schedule of only once per week is risky since hatching worms will have grown to 3rd instar before the next scouting observation has determined the need to spray.

Beet Armyworm: Economic thresholds vary with local conditions and sampling methods. The following is an example of one such method: apply Radiant SC when field scouting reveals three occurrences or more of egg hatch or larval feeding per 100 feet of row.

Loopers: Economic thresholds vary with local conditions and sampling methods. The following is an example of one such method: apply Radiant SC when field scouting reveals 4 larvae per 1 foot of row or 25% defoliation.

Application Rate: Use a higher rate of Radiant SC in the rate range and higher spray volume when one or more of the following is true: tobacco budworms or bollworms are more than 1/4 inch in length; target pest population is 2X above state threshold level; or foliage canopy is tall/dense and worms are present in the lower part of the canopy. Heavy infestations may require repeat applications, but follow resistance management guidelines.

Resistance Management: Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. Do not make more than three applications of Group 5 insecticides for thrips in a season. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area.

Restrictions:
- **Preharvest Interval:** Do not apply within 28 days of harvest.
- Do not apply more than a total of 34 fl oz of Radiant SC (0.266 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than six applications per calendar year. See Resistance Management regarding number of applications for specific pests.
- **Minimum Treatment Interval:** Do not make applications less than 4 days apart.

Cucurbit Vegetables (Crop Group 9)[1]

[1]Cucurbit vegetables (crop group 9) cucumber, edible gourds, muskmelons (cantaloupe, honeydew, etc.), pumpkin, summer squash, watermelon, winter squash

Pests and Application Rates:

Pests	Radiant SC (fl oz/acre)
armyworms[1] cabbage looper melonworm pickleworm rindworms	5 – 10
dipterous leafminers[2] thrips[2]	6 – 10

[1]With the exception of yellowstriped armyworm and western yellowstriped armyworm.
[2]Control of lepidopterous larvae, leafminers and thrips may be improved with the addition of an adjuvant to the spray mixture. See Use of Adjuvants section under Mixing Directions.

Application Timing: Treat when pests appear, targeting eggs at hatch or small larvae. Heavy infestations may require repeat applications, but follow resistance management guidelines. Consult your Dow AgroSciences representative, extension service specialist, certified crop advisor or your state agricultural experiment station for any additional local use recommendations for your area.

Application Rate: Apply Radiant SC as a foliar spray at the rate specified to control target pests. Use a higher rate in the rate range for heavy infestations or advanced growth stages of target pests.

Resistance Management: Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. Do not make more than three applications of Group 5 insecticides for thrips in a season. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area

Restrictions:
- **Preharvest Interval:** Do not apply within 3 days of harvest for all cucurbit crops except cucumbers. Do not apply within 1 day of harvest for cucumbers.
- Do not apply more than a total of 34 fl oz of Radiant SC (0.266 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than six applications per year. See Resistance Management regarding number of applications for specific pests.
- **Minimum Treatment Interval:** Do not make applications less than 4 days apart.

Herbs (Subgroup 19A)[1]

[1]Herbs (subgroup 19A) angelica, balm, basil, borage, burnet, chamomile, catnip, chervil (dried), chive, chive (Chinese), clary, culantro (leaf), coriander (leaf), costmary, curry (leaf), dillweed, horehound, hyssop, lavender, lemongrass, lovage (leaf), marigold, marjoram, nasturtium, parsley (dried), pennyroyal, rosemary, rue, sage, savory (summer and winter), sweet bay, tansy, tarragon, thyme, wintergreen, woodruff, wormwood

Pests and Application Rates:

Pests	Radiant SC (fl oz/acre)
armyworms[1] light brown apple moth loopers thrips[2]	5 – 8

[1]With the exception of yellowstriped armyworm and western yellowstriped armyworm.
[2]Control of thrips may be improved with the addition of an adjuvant to the spray mixture. See Use of Adjuvants section under Mixing Directions.

Application Timing: For determining when to treat, scout with enough regularity to monitor the population size of each of the labeled pests. Treat when pests appear, targeting eggs at hatch or small larvae. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor or your state agricultural experiment station for any additional local use recommendations for your area.

Application Rate: Apply Radiant SC as a foliar spray at the rate specified to control target pests. Use a higher rate in the rate range for larger larvae or high infestations and/or larger plant volume. Heavy infestations may require repeat applications, but follow resistance management guidelines.

Resistance Management: Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. Do not make more than three applications of Group 5 insecticides for thrips in a season. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area.

Restrictions:
- **Preharvest Interval:** Do not apply within 1 day of harvest.
- Do not apply more than a total of 39 fl oz of Radiant SC (0.305 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than five applications per year. See Resistance Management regarding number of applications for specific pests.
- **Minimum Treatment Interval**: Do not make applications less than 4 days apart.

Leafy Vegetables (Except *Brassica*) (Crop Group 4)[1], Leaves of Root and Tuber Vegetables (Crop Group 2)[2] and Leaves of Legume Vegetables (Crop Group 7A)[3], Turnip Greens, and Watercress

[1]Leafy vegetables (except *Brassica*) (crop group 4) amaranth, arugula, cardoon, celery, celtuce, chervil, Chinese celery, Chinese spinach, corn salad, dandelion, dock, edible-leaved chrysanthemum, endive (escarole), Florence fennel, garden cress, garden purslane, garland chrysanthemum, head lettuce, leaf lettuce, leafy amaranth, New Zealand spinach, orach, parsley, radicchio (red chicory), rhubarb, spinach, Swiss chard, tampala, upland cress, vine spinach, winter cress, winter purslane, yellow rocket

[2]Leaves of root and tuber vegetables (crop group 2) bitter cassava, black salsify, carrot, celeriac (celery root), chicory, dasheen (taro), edible burdock, garden beet, oriental radish (daikon), parsnip, radish, rutabaga, sugar beet, sweet cassava, sweet potato, tanier, true yam, turnip, turnip-rooted chervil

[3]Leaves of legume vegetables (crop group 7A) any cultivar of bean and field pea (except soybean)

Pests and Application Rates:

Pests	Radiant SC (fl oz/acre)
armyworms[1] cabbage looper corn earworm, *Helicoverpa zea* diamondback moth imported cabbageworm light brown apple moth	5 – 10
dipterous leafminers, *Liriomyza* spp[2] thrips[2]	6 – 10

[1]With the exception of yellowstriped armyworm and western yellowstriped armyworm.

[2]Control of leafminers and thrips may be improved with the addition of an adjuvant to the spray mixture. See Use of Adjuvants section under Mixing Directions.

Application Timing: Scout at least weekly and consider the impact of both pests and beneficials. Treat when economic thresholds are exceeded, targeting eggs at hatch or small larvae. Heavy infestations may require repeat applications, but follow resistance management guidelines. Consult your Dow AgroSciences representative, extension service specialist, certified crop advisor or your state agricultural experiment station for any additional local use recommendations for your area.

Application Rate: Apply Radiant SC as a foliar spray at the rate specified to control target pests. Use a higher rate in the rate range for heavy infestations or advanced growth stages of target pests.

Resistance Management: Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. Do not make more than three applications of Group 5 insecticides for thrips in a season. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area.

Restrictions:

- **Preharvest Interval:**

Leafy vegetables (including watercress): Do not apply within 1 day of harvest.

Leaves of root, tuber and legume vegetables: Do not apply within 3 days of harvest. **Note:** Root, tuber and legume vegetables treated as described may only be harvested for the foliage, not for the root, tuber, bean or pea.

- Do not apply more than a total of 34 fl oz of Radiant SC (0.266 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications**: Do not make more than six applications per year. See Resistance Management regarding number of applications for specific pests.
- **Minimum Treatment Interval**:

Leafy vegetables (including watercress): Do not make applications less than 4 days apart.

Leaves of root, tuber and legume vegetables: Do not make applications less than 7 days apart.

- Do not apply to seedling leafy crops grown for transplant within a greenhouse, shade house, or outdoor transplant bed.

Legume Vegetables (Succulent and Dried Beans and Peas) (Crop Group 6)[1]

[1]Legume vegetables (succulent and dried beans and peas) (crop group 6) adzuki bean, blackeyed pea, chickpea, cowpea, crowder pea, edible-pod pea, English pea, fava bean, field bean, field pea, garbanzo bean, garden pea, green pea, kidney bean, lentil, lima bean, lupins, mungbean, navy bean, pigeon pea, pinto bean, runner bean, snap bean, snow pea, sugar snap pea, tepary bean, wax bean, yardlong bean

Pests and Application Rates:

Pests	Radiant SC (fl oz/acre)
European corn borer (eggs & larvae)	3 – 8
armyworms[1] corn earworm, *Helicoverpa zea* light brown apple moth loopers	4 – 8
dipterous leafminers, *Liriomyza* spp[2] thrips[2]	5 – 8

[1]With the exception of yellowstriped armyworm and western yellowstriped armyworm.

[2]Control of leafminers and thrips may be improved with the addition of an adjuvant to the spray mixture. See Use of Adjuvants section under Mixing Directions.

Application Timing: For determining when to treat, scout with enough regularity to monitor the population size of each of the labeled pests. Heavy infestations may require repeat applications, but follow resistance management guidelines. Treat when pests appear, targeting eggs at hatch or small larvae. For **European corn borer**, treat when moth flights first appear and use the lower end of the rate range to control eggs and larvae every three days before they enter the plant. Consult your Dow AgroSciences representative, extension service specialist, certified crop advisor or your state agricultural experiment station for any additional recommendations for your area.

Application Rate: Apply Radiant SC as a foliar spray at the rate specified to control target pests. Use a higher rate in the rate range for heavy infestations or advanced growth stages of target pests.

Resistance Management: Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. Do not make more than three applications of Group 5 insecticides for thrips in a season. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area

Restrictions:

- **Maximum Number of Applications:** Do not make more than six applications per year. See Resistance Management regarding number of applications for specific pests.
- **Minimum Treatment Interval**: For European corn borer, do not make applications less than 3 days apart. For all other pests, do not make applications less than 4 days apart.

Succulent Beans and Peas:

- **Preharvest Interval:** Do not apply within 3 days of harvest.
- Do not apply more than a total of 28 fl oz of Radiant SC (0.219 lb ai spinetoram) per acre per year.

Dried Beans and Peas:

- **Preharvest Interval:** Do not apply within 28 days of harvest.
- Do not apply more than a total of 12 fl oz of Radiant SC (0.094 lb ai spinetoram) per acre per year.

Peanut

Pests and Application Rates:

Pests	Radiant SC (fl oz/acre)
armyworms[1] cabbage looper corn earworm European corn borer green cloverleaf worm red-necked peanut worm saltmarsh caterpillar soybean looper velvetbean caterpillar	3 – 8

[1]With the exception of yellowstriped armyworm and western yellowstriped armyworm.

Application Timing: Regularly monitor the population size of each of the labeled pests. Treat when pests appear, targeting eggs at hatch or small larvae. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor or your state agricultural experiment station for any additional local use recommendations for your area.

Application Rate: Use a higher rate of Radiant SC in the rate range for larger larvae or moderate to severe infestations and/or larger plant volume.

Resistance Management: Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area.

Restrictions:
- **Preharvest Interval:** Do not apply within 3 days of nut, forage or hay harvest.
- Do not apply more than a total of 24 fl oz of Radiant SC (0.188 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than three applications per calendar year.
- **Minimum Treatment Interval:** Do not make applications less than 7 days apart.
- **Grazing Restriction**: Do not allow grazing of peanut hay

Peppermint and Spearmint

Pests and Application Rates:

Pests	Radiant SC (fl oz/acre)
armyworms cutworms dipterous leafminers[1] light brown apple moth loopers thrips (suppression)[1]	4 – 12

[1]Control of leafminers and suppression of thrips may be improved with the addition of an adjuvant to the spray mixture. See Use of Adjuvants section under Mixing Directions. If thorough coverage is desired, then high pressure (>70 psi) directed sprays with dual directed nozzles can assist leaf penetration.

Application Timing: For determining when to treat, scout with enough regularity to monitor the population size of each of the labeled pests. Treat when pests appear, targeting eggs at hatch or small larvae. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor or your state agricultural experiment station for any additional local use recommendations for your area.

Application Rate: Apply Radiant SC as a foliar spray at the rate specified to control target pests. Heavy infestations may require repeat applications, but follow resistance management guidelines. Use a higher rate in the rate range for larger larvae or heavier infestations.

Resistance Management: Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. Do not make more than three applications of Group 5 insecticides for thrips in a season. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area.

Restrictions:
- **Preharvest Interval:** Do not apply within 7 days of harvest.
- Do not apply more than a total of 39 fl oz of Radiant SC (0.305 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than four applications per year. See Resistance Management regarding number of applications for specific pests.
- **Minimum Treatment Interval:** Do not make applications less than 4 days apart.

Pineapple
(For Use in Hawaii Only)

Pests and Application Rates:

Pests	Radiant SC (fl oz/acre)
lepidopterous larvae (suppression) such as: armyworms banana moth fruit borer caterpillar, *Thecia basilides* gummosos, *Batrachedra commosae* pineapple caterpillar pink cornworm sugarcane bud moth	4 - 8

Application Timing: For determining when to treat, scout with enough regularity to monitor the population size of each of the labeled pests. Treat when pests appear, targeting eggs at hatch or small larvae. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor or your state agricultural experiment station for any additional local use recommendations for your area.

Application Rate: Apply as a foliar spray at the rate specified to control target pests. Heavy infestations may require repeat applications, but follow resistance management guidelines.

Resistance Management: Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area.

Restrictions:
- **Preharvest Interval:** Do not apply within 7 days of harvest.
- Do not apply more than a total of 39 fl oz of Radiant SC (0.305 lb ai spinetoram) per acre per year
- **Maximum Number of Applications:** Do not make more than six applications per calendar year.
- **Minimium Treatment Interval:** Do not make applications less than 7 days apart.

Quinoa

Pests and Application Rates:

Insect Suppression Only

Pests	Radiant SC (fl oz/acre)
armyworms[1] loopers leafminers[2]	3 - 6
thrips[2] cutworms	6

[1]With the exception of yellowstriped armyworm and western yellowstriped armyworm.
[2]Control of leafminers and thrips may be improved with the addition of an adjuvant to the spray mixture. See Use of Adjuvants under Mixing Directions.

Application Timing: Scout weekly throughout the season to monitor and track populations of **leafminers** and **thrips** to determine when economic thresholds are exceeded. Scout weekly throughout the season to monitor and track pest and beneficial populations. For tracking **lepidopterous larvae**, scout with enough regularity to monitor the population size of each of the labeled pests. Treat when economic thresholds are exceeded, targeting eggs at hatch or small larvae. Heavy infestations may require repeat applications, but follow resistance management guidelines. Consult your Dow AgroSciences representative, extension service specialist, certified crop advisor or your state agricultural experiment station for any additional local use recommendations for your area.

Application Rate: Apply Radiant SC as a foliar spray at the rate specified to control target pest. Use a higher rate in the rate range for heavy infestations or advanced growth stages of target pests.

Resistance Management: Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. For thrips, if additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least two applications. Do not make more than three applications of Group 5 insecticides for thrips in a season. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area. Make treatment decisions for the entire farm and consider area wide programs if other growers are in close proximity.

Restrictions:

- **Preharvest Interval:** Do not apply within 21 days of harvest.
- Do not apply more than a total of 18 fl oz of Radiant SC (0.141 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than three applications per calendar year. See Resistance Management regarding number of applications for specific pests.
- **Minimum Treatment Interval:** Do not make applications less than 4 days apart.

Root and Tuber Vegetables (Crop Group 1)[1] and Globe Artichoke

[1]Root and tuber vegetables (crop group 1) arracacha, arrowroot, bitter cassava, black salsify, carrot, celeriac, chayote root, chicory, Chinese artichoke, chufa, dasheen, edible burdock, edible canna, garden beet, ginger, ginseng, horseradish, Jerusalem artichoke, leren, oriental radish, parsnip, potato, radish, rutabaga, salsify, skirret, Spanish salsify, sugar beet, sweet cassava, sweet potato, tanier, true yam, tumeric, turnip, turnip-rooted chervil, turnip-rooted parsley, yam bean

Pests and Application Rates:

Pests	Radiant SC (fl oz/acre)
Colorado potato beetle	4.5 – 8
armyworms[1] artichoke plume moth dipterous leafminers, *Liriomyza* spp[2] European corn borer flea beetles (suppression) light brown apple moth loopers potato psyllid (suppression)[2] thrips[2]	6 – 8

[1]With the exception of yellowstriped armyworm and western yellowstriped armyworm.

[2]Control of leafminers, psyllids, and thrips may be improved with the addition of an adjuvant to the spray mixture. See Use of Adjuvants section under Mixing Directions.

Application Timing: For determining when to treat, scout with enough regularity to monitor the population size of each of the labeled pests. Treat when pests appear, targeting eggs at hatch or small larvae. Consult your Dow AgroSciences representative, extension service specialist, certified crop advisor or your state agricultural experiment station for any additional local use recommendations for your area.

Application Rate: Apply Radiant SC as a foliar spray at the rate specified to control target pests. Use a higher rate in the rate range for heavy infestations or advanced growth stages of target pests. Heavy infestations may require repeat applications, but follow resistance management guidelines.

Chemigation: Radiant SC may be applied to potatoes by chemigation at labeled rates. Refer to the Chemigation Application section.

Resistance Management: Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. Do not apply Group 5 insecticides to consecutive generations of Colorado potato beetle and do not make more than two applications of Group 5 insecticides per single generation of Colorado potato beetle. Do not make more than three applications of Group 5 insecticides for thrips in a season. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area.

Restrictions:

Garden beet and sugar beet:

- **Preharvest Interval:** Do not apply within 7 days of harvest.
- Do not apply more than a total of 32 fl oz of Radiant SC (0.250 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than four applications per calendar year. See Resistance Management regarding number of applications for specific pests.
- **Minimum Treatment Interval**: Do not make applications less than 7 days apart.

Black salsify, carrot, chicory, ginseng, horseradish, parsnip, salsify, skirret, Spanish salsify, turnip-rooted chervil, turnip-rooted parsley:

- **Preharvest Interval:** Do not apply within 3 days of harvest.
- Do not apply more than a total of 28 fl oz of Radiant SC (0.219 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than four applications per calendar year. See Resistance Management regarding number of applications for specific pests.
- **Minimum Treatment Interval**: Do not make applications less than 4 days apart.

Arracacha, arrowroot, bitter cassava, chayote root, Chinese artichoke, chufa, dasheen, edible canna, ginger, Jerusalem artichoke, leren, potato, sweet cassava, sweet potato, tanier, true yam, turmeric, yam bean:

- **Preharvest Interval:** Do not apply within 7 days of harvest.
- Do not apply more than a total of 32 fl oz of Radiant SC (0.250 lb spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than four applications per calendar year. See Resistance Management regarding number of applications for specific pests.
- **Minimum Treatment Interval**: Do not make applications less than 7 days apart.

Globe Artichoke:

- **Preharvest Interval:** Do not apply within 2 days of harvest.
- Do not apply more than a total of 32 fl oz of Radiant SC (0.250 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than four applications per calendar year. See Resistance Management regarding number of applications for specific pests.
- **Minimum Treatment Interval**: Do not make applications less than 7 days apart.

Celeriac, edible burdock, oriental radish, radish, rutabaga, turnip and other root vegetables not specifically listed:

- **Preharvest Interval:** Do not apply within 3 days of harvest.
- Do not apply more than a total of 24 fl oz of Radiant SC (0.188 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than three applications per calendar year.
- **Minimum Treatment Interval:** Do not make applications less than 4 days apart.

Soybean

Pests and Application Rates:

Pests	Radiant SC (fl oz/acre)
armyworms[1] cabbage looper corn earworm (podworm) green cloverworm saltmarsh caterpillar soybean looper true armyworm velvetbean caterpillar	2 – 4

[1]With the exception of yellowstriped armyworm and western yellowstriped armyworm.

Application Timing: Treat when field counts or crop injury indicates damaging pest populations are present or developing. Time applications to treat small larvae and use sufficient spray volume to ensure good coverage.

Application Rate: Use a higher rate in the rate range for heavy infestations and/or difficult spray coverage situations.

Resistance Management: Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area.

Restrictions:
- **Preharvest Interval**: Do not apply within 28 days of harvest.
- Do not apply more than a total of 14 fl oz of Radiant SC (0.109 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than four applications per calendar year.
- **Minimum Treatment Interval**: Do not make applications less than 4 days apart.

Spices (Except Black Pepper) (Subgroup 19B)[1]

[1]Spices (except black pepper) (subgroup 19B) allspice, anise (seed), annatto (seed), black caraway, caper (buds), caraway, cardamom, cassia (buds), celery (seed), cinnamon, clove (buds), common fennel, coriander (seed), culantro (seed), cumin, dill (seed), Florence fennel (seed), fenugreek, grains of paradise, juniper (berry), lovage (seed), mace, mustard (seed), nutmeg, poppy (seed), saffron, star anise, vanilla, white pepper

Pests and Application Rates:

Pests	Radiant SC (fl oz/acre)
dipterous leafminers[1] (suppression) lepidopterous larvae thrips (suppression)[1]	5 - 8

[1]Suppression of leafminers and thrips may be improved with the addition of an adjuvant to the spray mixture. See Use of Adjuvants under Mixing Directions.

Application Timing: For determining when to treat, scout with enough regularity to monitor the population size of each of the labeled pests. Treat when pests appear, targeting eggs at hatch or small larvae. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor or your state agricultural experiment station for any additional local use recommendations for your area.

Application Rate: Apply as a foliar spray at the rate specified to control target pests. Use a higher rate in the rate range for heavy infestations or advanced growth stages of target pests. Heavy infestations may require repeat applications, but follow resistance management guidelines.

Resistance Management: Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. Do not make more than three applications of Group 5 insecticides for thrips in a season. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area.

Restrictions:
- **Preharvest Interval**: Do not apply within 14 days of harvest.
- Do not apply more than a total of 39 fl oz of Radiant SC (0.305 lb ai spinetoram) per acre per year.
- **Maximum Number of Applications:** Do not make more than five applications per calendar year. See Resistance Management regarding number of applications for specific pests.
- **Minimum Treatment Interval:** Do not make applications less than 10 days apart.

Vegetable, Fruiting (Crop Group 8-10))[1] and Okra

[1]African eggplant; Bush tomato; Cocona; Currant tomato; Eggplant; Garden huckleberry; Goji berry; Groundcherry; Martynia; Naranjilla; Okra; Pea eggplant; Pepino Pepper, bell; Pepper, nonbell; Roselle; Scarlet eggplant; Sunberry; Tomatillo; Tomato; Tree tomato; Cultivars, varieties and/or hybrids of these

Pests and Application Rates:

Pests	Radiant SC (fl oz/acre)
armyworms[1] Colorado potato beetle European corn borer hornworms light brown apple moth loopers tomato fruitworm, *Helicoverpa zea* tomato pinworm	5 – 10
dipterous leafminers, *Liriomyza* spp[2] flower thrips[2] pepper weevil (suppression) *Thrips palmi*[2]	6 – 10

[1]With the exception of yellowstriped armyworm and western yellowstriped armyworm.
[2]Control of leafminers and thrips may be improved with the addition of an adjuvant to the spray mixture. See Use of Adjuvants section under Mixing Directions.

Application Timing: Scout weekly throughout the season to monitor populations of **leafminers** and **thrips** to determine when economic thresholds are exceeded. Scout weekly throughout the season to monitor beneficial populations. For **lepidopterous larvae**, scout with enough regularity to monitor the population size of each of the labeled pests. Time applications of Radiant SC to coincide with peak egg hatch in species without overlapping generations.

Application Rate: Apply Radiant SC as a foliar spray at the rate specified to control target pests. Use a higher rate in the rate range for heavy infestations or advanced growth stages of target pests.

Resistance Management: Do not make more than two consecutive applications of Group 5 insecticides (spinetoram and spinosad). If additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least one application. For **thrips**, if additional treatments are required after two consecutive applications of Group 5 insecticides, rotate to another class of effective insecticides for at least two applications. Do not make more than three applications of Group 5 insecticides for thrips in a season. Consult your Dow AgroSciences representative, extension specialist, certified crop advisor, or state agricultural experiment station for information on alternative effective products to use in your area. Do not apply Group 5 insecticides to consecutive generations of Colorado potato beetle and do not make more than two applications per single generation of Colorado potato beetle.

Restrictions:
- **Preharvest Interval:** Do not apply within 1 day of harvest.
- Do not apply more than a total of 34 fl oz of Radiant SC (0.266 lb ai spinetoram) per acre per calendar year.
- **Maximum Number of Applications:** Do not make more than six applications per calendar year. See Resistance Management regarding number of applications for specific pests.
- **Minimum Re-Treatment Interval:** Do not make applications less than 4 days apart.
- Do not apply to seedling fruiting vegetables and okra grown for transplant within a greenhouse, shade house, or outdoor transplant bed.

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Summary Description for Module 8

Title:	Module 8: Business Principles of Urban Agriculture
Instructor:	Dr. Theresa Nartea, Associate Professor, Extension Specialist-Marketing & Agribusiness
Prerequisites:	Working knowledge of Microsoft Word and Microsoft Excel
Class Time:	9:00 AM – 11:30 AM
Learning Objective:	After completing Module 8, the student learner will learn the types of essential information needed in order to develop a comprehensive urban farm business plan. The student learner will be provided instruction on utilizing provided computer-based worksheets to develop their personal urban farm business plan.
Instructor Media Needs:	Screen Projector Screen to Project upon Computer
Class Materials and/or Supplies Needed:	Instructor provided-Urban Farm Business Plan Worksheets (MS Excel, MSWord) Student provided-Computer with MS Excel and MSWord software
Class Activities:	1. Present required information needed for an urban farm business plan 2. Explain how to use provided Urban Farm Business Plan worksheets 3. Demonstrate how to input data into the Urban Farm Business Plan using computer
Knowledge Gained:	Students will gain knowledge in how to develop an urban farm business plan
Skills Gained:	Students will gain skills in preparing a personal urban farm business plan
Abilities Gained:	Students will be able to complete personal urban farm business plan
Exam Description:	Email submission of file attachments (MS Excel, MSWord) of a completed personal urban farm business plan.

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S.M.A.R.T. Goal and One Page Business Plan for Start-Ups

Dr. Theresa J. Nartea, Associate Professor-Extension Specialist (Marketing & Agribusiness)

Email: tnartea@vsu.edu Phone: 804-524-5491

Use this worksheet to develop your effective ***Specific, Measurable, Attainable, Relevant and Time-Based*** goals. Make it your goal to be S.M.A.R.T. in all you do!

Example with steps to writing an effective S.M.A.R.T. Goal

STEP 1: Start with a general goal: "I want to start a food business"

STEP 2: Now fill in the S.M.A.R.T. goal items

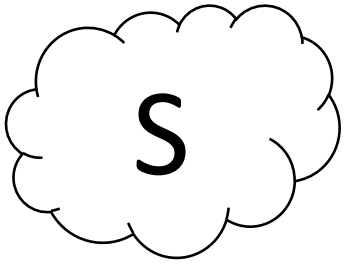
- **SPECIFIC:** I will sell homemade herbal kale teas online at https://www.etsy.com.
- **MEASURABLE:** My weekly sales target is to sell a minimum of 10 tea boxes per week for $12.00 per one-12 count box.
- **ATTAINABLE:** I will set up my online store at https://www.etsy.com with an initial inventory of 50 tea boxes to sell. I will promote my business and build customer relationships through social media and conducting local tasting events.
- **RELEVANT:** Selling homemade herbal kale teas using herbs and kale I grow will allow me to earn money and provide a healthy tea product to my customers.
- **TIME-BASED:** My online store at https://www.etsy.com/ will be ready within eight weeks, and I will have an inventory of 50 tea boxes to sell one week prior to my online store launch.

STEP 3: Combine all the S.M.A.R.T. goal items into one effective statement

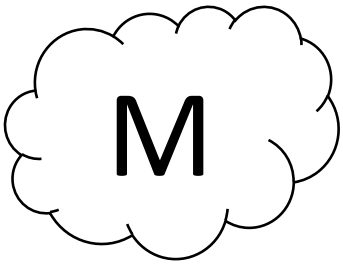
Within two months, I will set up my online store to sell homemade herbal kale teas online at https://www.etsy.com which will allow me to earn money and provide a healthy tea product to my customers. Within seven weeks, I will have an inventory of 50 tea boxes to sell and I aim to sell a minimum of ten tea boxes per week for $12.00 each to earn at least $120.00 per week by promoting my product and building customer relationships through social media and conducting local tasting events.

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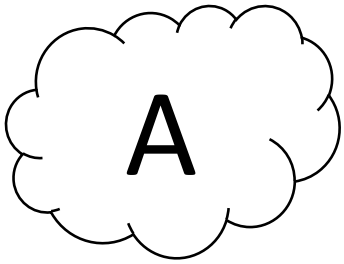
Write your own S.M.A.R.T. Goal using the boxes below:



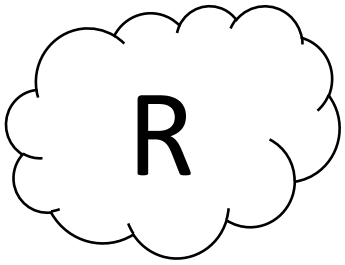
What **SPECIFIC** goal do I want to achieve?



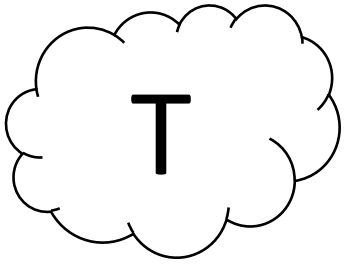
How will I **MEASURE** progress towards my specific goal?



Is my specific, measurable goal **ATTAINABLE**? Do I have what I need to make it possible? *(See page 4, Start-up costs example)*



Is my specific, measurable, attainable goal **RELEVANT** to me? Why do I want to do this goal?



By what **TIME** will I complete my specific, measurable, attainable and relevant goal?

Combine all your S.M.A.R.T. Goal items into one statement.

Write your complete statement below:

SPECIAL TIPS: Be sure to share your S.M.A.R.T. Goal with others to improve it. Don't forget to celebrate when you accomplish your S.M.A.R.T. Goal. Keep up your success by writing new S.M.A.R.T. Goals as you move forward in your business and life journey.

Startup costs — Joe's Pizza Place

This worksheet is set up for a fictional business, Joe's Pizza Place. Use it to get started calculating the startup costs for your own business. Change expense categories or add new ones to fit your business. Enter one-time and monthly expenses in the appropriate columns. Your estimations should go into the Budget column, and the exact amount spent should go into the Actual column. Total funds required is the total estimated amount you need to start your company.

One-time expenses	Budget	Actual
Rent		
Security deposit	1,200.00	
First month's rent	1,200.00	
First month's utilities (including phone and Internet)	250.00	
Improvement costs		
Kitchen improvements	800.00	
Tables and furniture	1,500.00	
Utensils, dishes, and kitchen and bar equipment	350.00	
Inventory		
Food	1,250.00	
Beverage	700.00	
Alcohol	900.00	
Miscellaneous		
Licenses and permits	150.00	
Legal fees	300.00	
Signage	550.00	
Technology	300.00	
Software	400.00	
Total funds required	9,850.00	0.00

Monthly expenses	Budget	Actual
Rent		
Monthly rent	1,200.00	
Property insurance	300.00	
Utilities	250.00	
Employees		
Payroll	3,000.00	
Payroll taxes	1,250.00	
Health insurance	650.00	
Professional services		
Accounting	200.00	
Legal	250.00	
Consultants	200.00	
Other	50.00	
Supplies		
Office supplies	150.00	
Operating supplies	200.00	
Marketing		
Digital advertising	350.00	
Promotional materials	400.00	
Miscellaneous		
Liability insurance	400.00	
Repairs and maintenance	200.00	
Organizational dues	75.00	
Total monthly expenses	9,125.00	0.00

Total funds required	18,975.00

U.S. Small Business Administration. (2017). *Startup costs – Joe's Pizza Place.* Retrieved from https://www.sba.gov/sites/default/files/2017-07/Startup%20Costs%20Worksheet.pdf

PLAN Template #1

<table>
<tr>
<td colspan="2">PROBLEM
What are the top 1-3 frustrating problems your audience faces every day?
What problems are they already paying to solve?</td>
<td rowspan="2">ELEVATOR PITCH
In one powerful sentence, combine your audience, problem, solution, and differentiator.

For example: “I help <audience> with <problem> by <solution>. Unlike <competitors>, I <differentiator>”.</td>
<td colspan="2">SOLUTION
What does the perfect solution to your audience’s problem look like?
How will you solve the problem your audience has for them?
What are the benefits your audience will get from your solution?</td>
</tr>
<tr>
<td>AUDIENCE
Who is your ideal customer?
How old are they?
Where do they live?
What do they do?
What do they care deeply about?
What are their future goals or aspirations?</td>
<td>CHANNELS
Where does your ideal customer hang out? Online? Offline?
What social media networks do they use frequently?
What kinds of things do they share most often? Least often?
How often will you communicate with your mailing list?
What kinds of content will you send to your mailing list subscribers?</td>
<td>COSTS
What will it cost to build and sell your solution?
Are these costs monthly? Yearly? One-time?
Do you need additional contractors or employees to build the solution?
Do you need to pay yourself for household expenses, rent, etc?
Is the cost of running your business more than the revenue?</td>
<td>REVENUE
What will you sell to your audience that solves their problem?
How much will you charge for it?</td>
</tr>
<tr>
<td colspan="2">COMPETITORS
What are 3-5 competing businesses you can find that serve the same audience?
What do they do well? What do they do badly?</td>
<td>DIFFERENTIATOR
What’s different or unique about your solution?
How will you stand out from your competitors?
What puts you ahead of the pack?</td>
<td colspan="2">PERSONAL FIT
Does this business feel like you?
Is it the kind of lifestyle and responsibility you want?
Will you get tired of it, or do you get energized thinking about it?</td>
<td>BUSINESS BOOSTERS
What unfair advantages do you have over the competition?
Do you have existing relationships you can leverage?
How is your solution not easily copied?</td>
</tr>
</table>

Elliot, C. (2019). *What you need to create a simple one page business plan.* Retrieved from https://www.listenmoneymatters.com/one-page-business-plan-template

PLAN Template #2

One Page Business Plan

What is your Vision for the business?	What does the market for your product look like?
What problem will your business solve?	How will your customer learn about your business?
Do you have experience in this business?	Do you have enough money? How much will you invest?
What product or service will you offer or sell?	What are your biggest challenges?
Who will buy it; that is, who are your target customers?	What is your solution to the challenges?
How will you get paid? (Cash, Check, Credit card, other)	I am successful if I have achieved the following goal:
How will you deliver your product/service to the customer?	What are your financial objectives? What income do you expect?
Who is your competition? (name 3 competitors)	What are your milestones & timelines for starting your business?
Do you have a particular advantage? (e.g., product difficult to copy)	Describe in 25 words or less the nature of your business.

U.S. Small Business Administration. (2019). *Write your business plan*. Retrieved from https://www.sba.gov/business-guide/plan-your-business/write-your-business-plan

CREATE YOUR PLAN *In the space below, write your one page business plan by adapting either template #1 or #2*

Virginia Cooperative Extension
Virginia Tech • Virginia State University
www.ext.vt.edu

A Promising Whole Farm Profit Management Tool for Market Farmers: Veggie Compass

T. J. Nartea, Associate Professor, Extension Specialist-Marketing & Agribusiness tnartea@vsu.edu

Introduction

Small market farmers in Virginia may sell in different market outlets and may not know which of their markets is most profitable for their operation. Although there are many available software programs to assist them in determining their most profitable market outlets, the majority are not free, or developed specifically for the unique record keeping challenges of small market farmers. To address this issue, University of Wisconsin-Madison researchers at the Center for Integrated Agriculture Systems have developed the Veggie Compass profit management tool available at: http://www.veggiecompass.com

Target Audience

Small farm extension agents may improve the economic viability of their small farm clientele by developing hands-on training workshops on how to use Veggie Compass to assess market profitability of specific crops sold across different market outlets. As a result of participating in a hands-on training, small farmers may benefit from raised awareness of the types of recordkeeping necessary for operating a profitable farm business, as well as learning how to use records to increase business profitability.

Available Educational Video Series



Virginia farmer Ellen Polishuk of Potomac Vegetable Farms (pictured left) provides valuable personal insight from a small farmer's viewpoint as she hosts the eight (8) video series. She goes step by step on how to use Veggie Compass to assist farmers in understanding potential factors that may influence their profitability. The videos guide farmers in developing an awareness and understanding of Veggie Compass and how to incorporate this management tool into a profitable farm operation.

Accessing Online Veggie Compass Video Series

The series is designed to be viewed in order. However, they do not all need to be viewed at one time.

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Veggie Compass Video Descriptions



Video #1: Introduction to Tutorial Series: https://vimeo.com/93177660
Farmer Ellen explains what Veggie Compass can and can't do for you. (10:03 mins)



Video #2: Expenses Input Introduction: https://vimeo.com/93177661
Farmer Ellen goes over the Expenses Input sheet. She shares relevant information to farmers to consider before adding their own data. (10:50 mins)



Video #3: Expenses Input in Action: https://vimeo.com/93177663
Farmer Ellen uses her real farm data to demonstrate how to use the Expenses Input sheet. (13:30 mins)



Video #4: Sales Input: https://vimeo.com/93177664
Farmer Ellen uses her real farm data to demonstrate how to use the Sales Input sheet. (15:24 mins)



Video #5: Production Input: https://vimeo.com/93177665
Farmer Ellen uses her real farm data to demonstrate how to use the Production Input sheet. (16:54 mins)



Video #6: Cost of Production by Crop: https://vimeo.com/93183249
Farmer Ellen demonstrates how the Veggie Compass data she entered on the first three sheets provides important information about the true costs of each crop. (7:13 mins)



Video #7: Sales Output: https://vimeo.com/93183250
Farmer Ellen demonstrates how the Veggie Compass data she entered on the first three sheets yields information on sales by crop and market channel. (12:09 mins)



Video #8: Profit and Loss: https://vimeo.com/93183251
Farmer Ellen provides a "big picture," view in summarizing how Veggie Compass informs about profits/losses for each market channels and the whole farm. (13:48 mins)

Additional Suggestions

Before watching videos, download the Veggie Compass Example at: http://www.ssawg.org/s/VEGGIE-COMPASS-SAMPLE-April-2014.xls by doing so, you will be able to get a better feel of how to use the program in real time, as it is explained by Farmer Ellen during the various videos.

Be sure to return to the Veggie Compass webpage http://www.veggiecompass.com before each growing season to check for any new updates: http://www.veggiecompass.com/tools/

In companion with Veggie Compass, using Google Forms to create is recordkeeping forms may be helpful: https://www.youtube.com/watch?v=6AXO9vnoJns&feature=youtu.be

In 2019, Livestock Compass is available for evaluating livestock enterprises: http://www.veggiecompass.com/livestock-compass-is-now-available/

For additional related resources, go to: http://tinyurl.com/2019VSUBudgetClass-Nartea

Let's "Farmer" It Out! VSU-SFOP-LRVBFRP Learning Series: ENTERPRISE BUDGETS

Nartea, T., Dukes, B., Gooden, D., VSU-SFOP 2024

Participant Question:

Where can I find small-scale enterprise budgets?

Step 1. Obtain research-based calculation spreadsheets:

Let's go to: https://www.uky.edu/ccd/tools/budgets (See Figure 1)

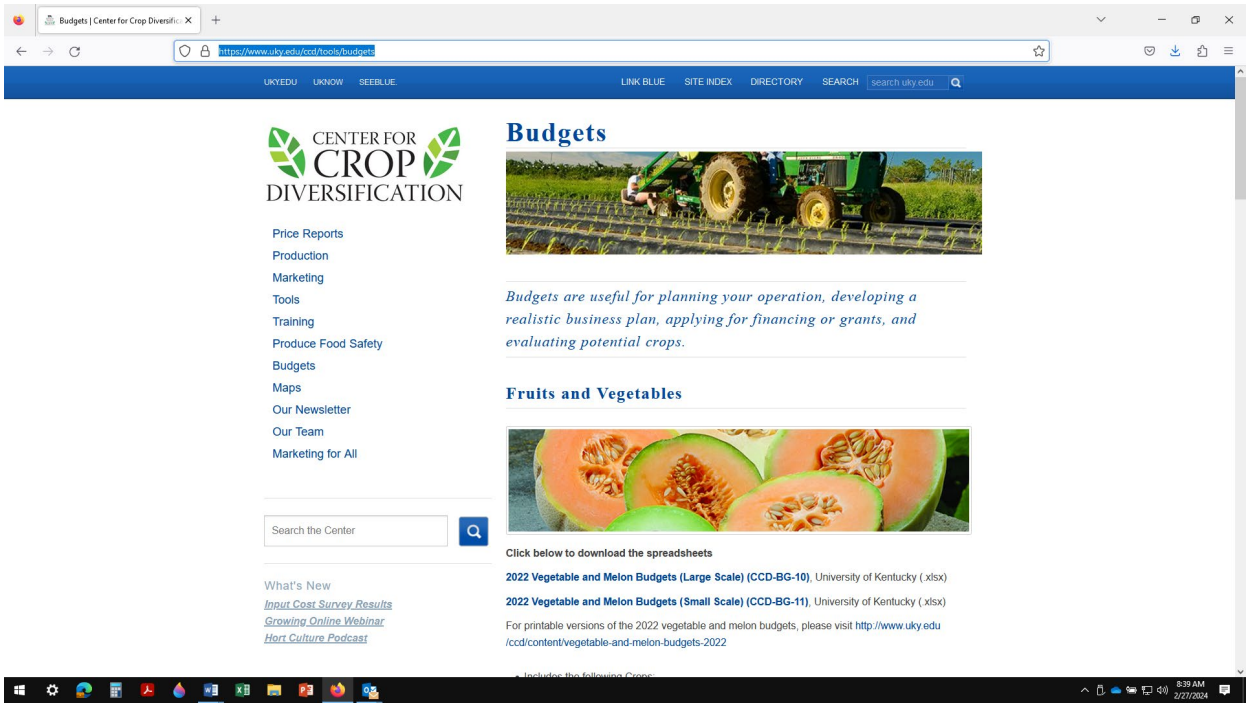


Figure 1. Screen Capture of Center for Crop Diversification Webpage

Download Small-Scale Spreadsheet at:

https://www.uky.edu/ccd/sites/www.uky.edu.ccd/files/2022vegmelonsmallscale.xlsx

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Step 2. Obtain research-based small-scale budget publications:

Let's go to: https://ncfarmschool.ces.ncsu.edu/small-scale-budgets (See Figure 2)

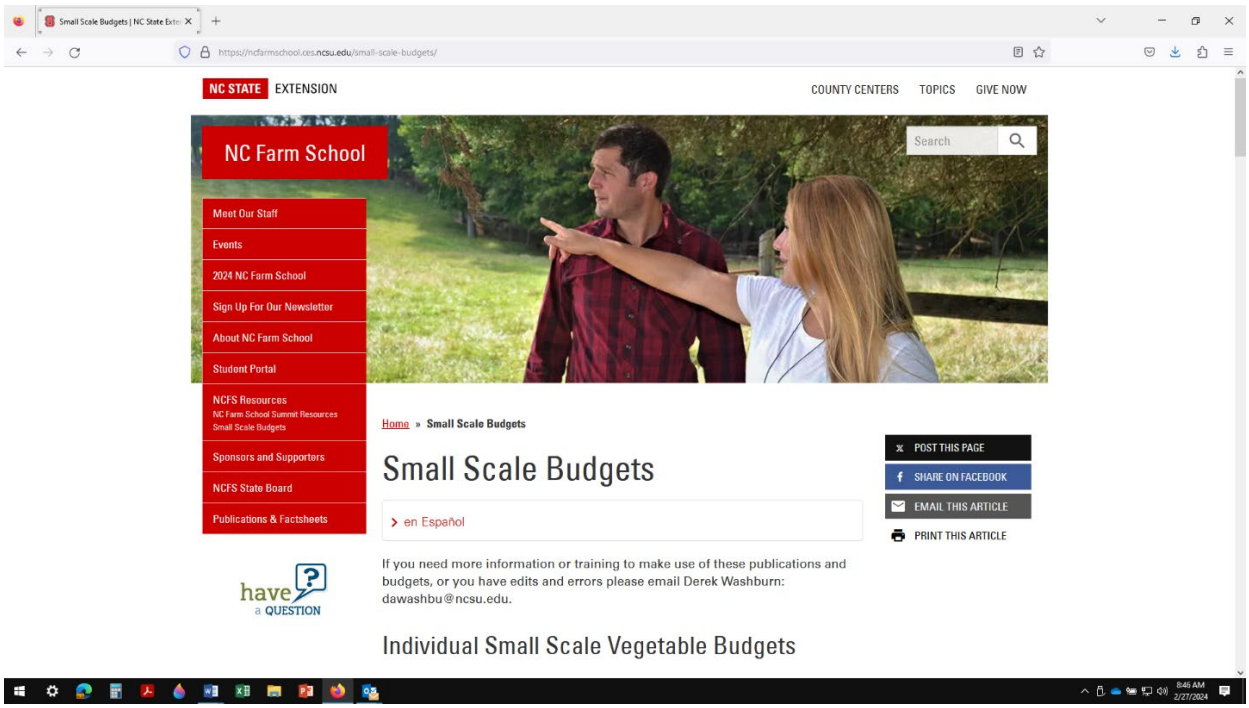


Figure 2. Screen Capture of NC Farm School Webpage

From the NC Farm School webpage, you can download the following helpful enterprise budget written publications:

Market Garden Start-Up and Cost Considerations: https://ncfarmschool.ces.ncsu.edu/wp-content/uploads/2022/03/AG_sible_071221-1-1.pdf

Pasture Poultry Start-Up and Cost Considerations: https://ncfarmschool.ces.ncsu.edu/wp-content/uploads/2022/03/AG_sible_071221-4.pdf

Pastured Pork Start-Up and Cost Considerations: https://ncfarmschool.ces.ncsu.edu/wp-content/uploads/2022/03/AG_sible_071221.pdf

Sheep & Goat Start-Up and Cost Considerations: https://ncfarmschool.ces.ncsu.edu/wp-content/uploads/2022/03/AG_sible_071221-3.pdf

Agritourism Start-Up and Return Considerations: https://ncfarmschool.ces.ncsu.edu/wp-content/uploads/2022/03/AG_sible_071221-2.pdf

Partnership *for* Sustainable Communities






Urban Farm Business Plan Handbook

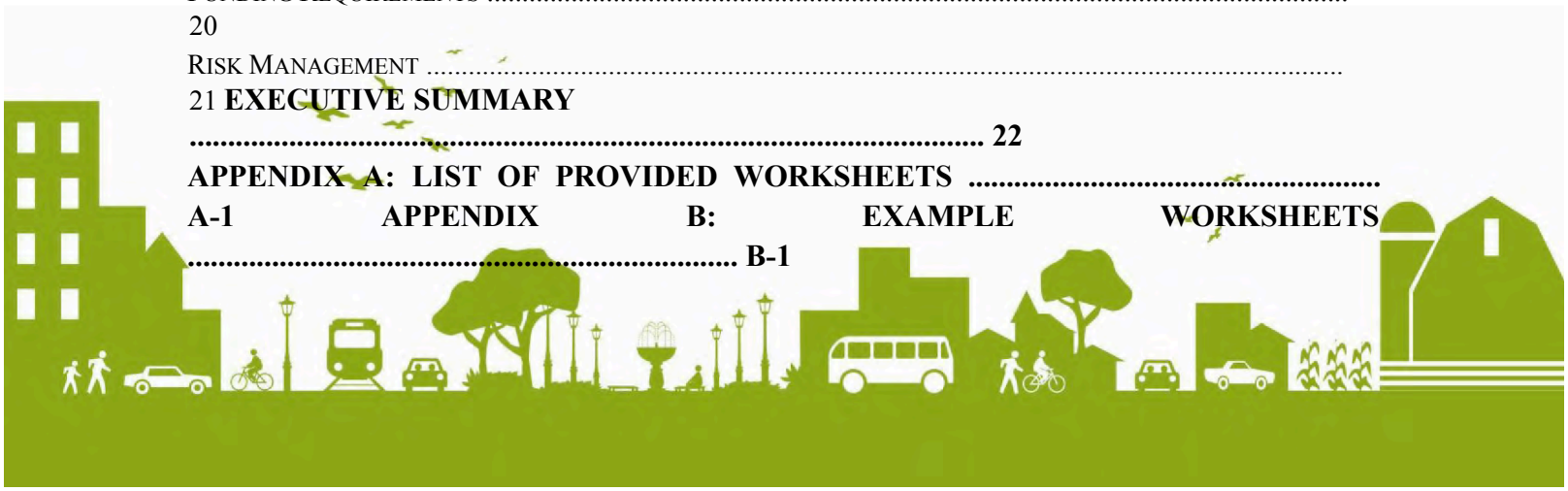


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Introduction

As communities look for sustainable reuses for brownfield and other abandoned properties and opportunities to provide healthier food choices to the community, interest in establishing community gardens and other forms of farming has been growing in urban areas. Urban farms, however, present unique challenges that are different from conventional agricultural development.

Developed land often has a history of uses that may have affected the quality of the soil (e.g., environmental contamination, building debris and other fill material unfit for plant growth) that may require substantial site preparation (e.g., environmental cleanup, demolition, or placement of topsoil) or special growing techniques (e.g., raised growing beds, vertical gardens). Urban farms typically need to address security issues for the crops, buildings and tools. In many cases, urban farm development and operating practices will have to account for the proximity of residential and/or commercial neighbors and the compatibility of the farm operations with these neighbors. In addition, the success of an urban farm may depend on a diversity of products as opposed to a single crop and volunteer labor to support the start-up and initial operations.

As urban farming moves towards income-earning or foodproducing activities, it is important to develop a plan for the start-up and operation of the business regardless of whether it is intended to be a for-profit business or a non-profit business. A business plan provides a road map that not only serves as an internal planning tool, but can be used to provide information to external stakeholders important to the successful start up and operation of the business such as investors and funding sources. It is used to map out the strategies for the start up and operation of a business and to track progress of that business against its goals.

What is an Urban Farm?

An urban farm is a part of a local food system where food is cultivated and produced within an urban area and marketed to consumers within that urban area. Urban farming can also include animal husbandry (e.g., breeding and raising livestock), beekeeping, aquaculture (e.g., fish farming), aquaponics (e.g., integrating fish farming and agriculture), and non-food products such as producing seeds, cultivating seedlings, and growing flowers. It can be characterized in terms of the geographic proximity of a producer to the consumer, sustainable production and distribution practices.

Urban farms can take a variety of forms including non-profit gardens and forprofit businesses. They can provide jobs, job training, and health education, and they can contribute to better nutrition and health for the community by providing locally grown, fresh produce and other products. In addition, urban farms can also contribute to the revitalization of abandoned or underutilized urban land, social and economic benefits to urban communities, and beneficial impacts on the urban landscape.

Through EPA's Office of Brownfields and Land Revitalization and the Partnership for Sustainable Communities, technical assistance was provided to support the development of a business plan for an urban farm in Toledo. The technical assistance was intended to support the Toledo Community Development Corporation (CDC) in achieving its vision to reuse a two-plus-acre former industrial site as an economically viable and accessible source of fresh locally grown fruits and vegetables, jobs and job training, and education on growing and preserving fresh produce and improved health through better diet for the community.

The project resulted in the development of two products that will be used in Toledo, but also have wider application to brownfield and other communities working on land revitalization across the country that are seeking alternative sustainable reuses that can improve access to fresh and healthy food, and related food shed economics and market conditions in local areas:

- Urban Farm Business Plan Handbook.
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Urban Farm Business Plan Worksheets.

How Should The Handbook and the Worksheets Be Used?

The **Urban Farm Business Plan Handbook** (this document) provides guidance for developing a business plan for the startup and operation of an urban farm.[1] It focuses on food and non-food related cultivated agriculture. The information provided is applicable regardless of whether the farm is to be operated as a non-profit or for-profit business.

More specifically, it describes what information should be collected, evaluated, and presented in each section of the business plan. The Handbook is designed to be used side-by-side with the accompanying Urban Farm Business Plan Worksheets. As the Handbook describes each section of the business plan, there are references to worksheets that should be filled out in order to fully develop that section of the business plan. A list of all of the provided worksheets is in Appendix A. The handbook also includes example worksheets to help users understand how to fill in the worksheets, in Appendix B. While the example worksheets do not represent a complete set of worksheets and include hypothetical information, they do provide a useful example of the level of detail and background research required to develop a business plan. Blank worksheets can be found in the Urban Farm Business Plan Worksheet files, described below.

The **Urban Farm Business Plan Worksheets** provides a framework in which to compile and organize the information needed to draft a business plan. There are two files that comprise the Worksheets:

1. Urban Farm Business Plan Worksheet.doc (Microsoft (MS) Word®). This file contains blank worksheets that when completed will provide the information needed to write a business plan. Worksheets 1-16, 18-22, and 28-29 are contained in this file. A list of all worksheets and in which file they are located is provided in Appendix A.

2. Urban Farm Business Plan Worksheet.xls (Microsoft (MS) Excel®). This file contains spreadsheets with formulas to help calculate expenditures and revenue. Worksheets 17 and 23-27 are contained in this file. A list of all worksheets and in which file they are located is provided in Appendix A.

The information presented in the following sections of this handbook is intended to be representative of the information needed for the development of a business plan; however, the specific goals and plans for any individual farm may require more or less information be provided for their particular plan.

The Urban Farm Business Plan Handbook and Worksheets are available on EPA's urban agriculture website: www.epa.gov/brownfields/urbanag/.

[1] This handbook has been prepared for informational purposes only. Vita Nuova has relied upon outside sources for information and data presented in this report. Although all best efforts were used to confirm the information and data presented in this report and to complete this report, no representation or warranties are made as to the timeliness, accuracy or completeness of the information contained herein or that the actual results will conform to any projections or recommendations contained herein. All areas are approximate. Any reliance upon this material shall be without any liability or obligation on the part of Vita Nuova LLC, SRA International, or the U.S. EPA.

Before Beginning the Urban Farm Business Plan

Before beginning the development of your business plan, think about the primary reasons for starting an urban farm. Documenting your reasons for starting the farm will help you focus the business plan and identify the issues, the resources and the expertise that will be needed to develop the business plan. Finally, think about the values that you bring to the business and the values that are important to the success of the business.

Consider the following questions:

- Do you have crop growing or farm experience that will assist in your farm operations or will you need to secure that expertise elsewhere?
- Will you be involved with food production, animal husbandry, aquaculture, aquaponics, or nonfood products or some combination of products?
- Do you have a property for your urban farm or are you in the process of selecting a location?
- Are you developing the farm as a community-based, non-profit business that will involve community members in the operation?
- Are you developing the farm as a for-profit business and income source?
- Are you developing the farm as a family-run business and source of income?
- Is there a particular expertise or product that you want to commercialize?
- Are you creating the farm to provide produce for another business, such as an institution or restaurant?
- Who will be part of your planning team?
- Do you have the expertise to develop marketing, operating, human resource, and financial strategies necessary for the business plan or to help in the start up of the business?
- Are you going to need expertise to address environmental and cleanup issues that may be associated with an urban property you intend to farm?
- Do you need to hire expertise to develop the strategies, conduct surveys, or plan the development?
- Do you need financial resources to obtain this expertise?
- Is there an economic motivation for this farm?
- Are you hoping to generate a profit, break-even, or will the farm require a source of charitable income?
- Is the farm to be community-focused?
- To what extent are environmental issues related to the operation of the farm a consideration, such as organic fertilizers and resource use?

Use ***Worksheet # 1 (Before You Begin)*** to document your reasons, expertise and resource needs.[2]

[2] Please refer to Appendix A: Worksheet Summary List to identify the file in which each worksheet is contained.

Using the Urban Farm Business Plan Handbook

The business plan is divided into six sections:

- Executive Summary.
- Overview.
- Organization and Management.
- Marketing Strategy.
- Operating Strategy.
- Financial Strategy.

The following sections in this handbook address each of these sections of the business plan. In addition, blank worksheets are provided in the Urban Farm Business Plan Worksheets (available on EPA's urban agriculture website (www.epa.gov/brownfields/urbanag) to help identify the information typically required under the topics discussed in that section and to document the information needed to develop the business plan. Example worksheets with information filled in are provided in Appendix B.

The sections in the handbook are provided in the order in which they should appear in the final business plan, with the exception of the Executive Summary section which is developed last but should appear first in the final business plan. The development of the business plan will not necessarily follow this order, depending on the information readily available for each urban farm project. It is important to note that the development of a business plan may require access to the appropriate expertise to adequately develop the information necessary to address the topics contained in the business plan.

To begin developing a business plan, define your vision, mission, and goals of the business as discussed in the Overview section of this handbook. The vision, mission, and goal statements provide the conceptual outline for the urban farm business. These statements should be considered draft or preliminary and subject to change as the completion of the remaining sections of the business plan may suggest changes to these statements are appropriate. Next define the organization and management structure for the farm as discussed in the Organization and Management section of this handbook.

Based on the vision, mission, and goals, discuss your understanding of the market and potential products of the farm. In many cases, a marketing study may need to be conducted to identify the potential markets and products most appropriate for the farm. Using the information about the market, the marketing strategy is defined as discussed in the Marketing Strategy section of this handbook.

Building on the marketing strategy, the next step is to define the operations and human resources necessary to achieve the marketing strategy. The information about the operation of the farm is used to develop the operating strategy as discussed in the section of this handbook.

Finally, the executive summary section is developed to summarize the key concepts of the business plan as discussed in the Financial Strategy section of this handbook.

Overview

The overview introduces the reader to the business plan, provides your vision and mission for the farm, and summarizes your goals for the farm. The overview is divided into four sections:

- Introduction.
- Vision Statement.
- Mission Statement.
- Goals.



Santa Fe Farmer's Market, Santa Fe, New Mexico

Introduction

The introduction describes the purpose of the business plan and the key issues addressed by the plan. It provides the reader with an understanding of what information is contained in the business plan and a general description of the plan development process.

Consider the following questions:

- Is the business plan an internal organizing tool, a tool for communicating outside the proposed business, or a combination of both?
- Is there information that is missing or unable to be identified at this stage of the planning
- process?
- Who are the members of your business planning team?
- Who was involved in the planning process?
- What is the planned size of the company and is future growth anticipated?

What is the time frame considered in the business plan? (At minimum, the plan should consider a 5-year time frame.)

- Is it to be a for-profit or non-profit business?
- Are there potential risks for the start up of this business?

Use ***Worksheet # 2 (Introduction)*** to document the information to include in the introduction.

Vision Statement

The vision statement is an inspirational statement that describes your vision for the future of the farm and how your values will be incorporated into the farm. It focuses on the future and provides a direction for the farm and the community in which it operates. It provides clear decision-making criteria.

Consider the following questions:

- What economic, environmental, or community values are important to the success of the farm?
- In a general sense, what products or services do you expect to provide?
-
-

How will the community benefit from these products or services? How will operating practices enhance the environment?

Use ***Worksheet # 3 (Vision)*** to document the information to include in the vision statement.

Mission Statement

The mission statement is a simple statement that communicates the fundamental purpose and expectations for the farm to its customers and others outside of the business. It is a set of guiding principles that describes the overall goals of the business and serves as a benchmark. It incorporates meaningful and measurable criteria addressing concepts such as values of the business, public image, the target market, products or services, the geographic extent of the business, and expectations of growth and profitability. It provides an understanding of what the business aspires to be and what the business will be known for in the future.

Use ***Worksheet # 4 (Mission)*** to document the information to include in the mission statement.

Goals

The goals describe what is to be achieved by the business in the future. Goals can be expressed in terms of time, such as short-term and long-term goals. For a start-up business, short-term goals may be focused on the startup of the business and achieving a certain level of production income. Long-term goals can reflect plans for growth. Goals address potential products, what the farm will look like, who will be involved in operations, and your expectations from the business. The goals reflect what you would like to achieve and when you would like to achieve them. They do not identify how this will be accomplished. Clearly identified goals can motivate, help to mitigate conflict, and direct limited resources.

Use ***Worksheet # 5 (Goals)*** to document the information to include in the goal discussion.

Organization and Management

Describe the ownership structure of the business and how the business will be organized and managed. If you decide to create a corporation, a non-profit, a limited liability company, or a partnership, you will need to register your business with the state. Check with your state's requirements for organizing a business and registering your business name. In addition, you will need to register your business with the IRS and state and local revenue agencies and receive a tax identification number or permit.

Consider the following questions:

- What will be the legal structure of your organization (e.g., sole proprietorship, partnership, limited liability company, corporation, non-profit, cooperative)?
- How will the business management be organized?
- Will there be a single farm manager to oversee all business operations or multiple managers to oversee various business segments (e.g., marketing, operations, finance, human resources)? Where a multiple manager structure is anticipated, a simple organization chart may be useful to explain the organization.
- Who will be the principal or key managers who will run the business?
- What unique skills do they bring to the business and what will be their duties and
- responsibilities?
- Will there be an overseeing board or board of directors?

  What will be the composition of such a board and what, if any, role will members of the board take in the business?
- How will the principals, key managers, or board members be compensated?
- Are there any administrative expenses associated with the management or oversight of this business?

Use ***Worksheet # 6 (Organization and Management)*** to document information about the organization and management of your business.

Marketing Strategy



Barn, Lynchburg Grows! Lynchburg, Virginia

Defining a strategy for marketing and sales is the most important part of your business plan. If a market does not exist or if a workable approach for getting your product to the market has not been identified, you will not meet your goals or expectations. The development of your marketing strategy will require an understanding of the market, including the demand for your product, the potential customers, and the potential competitors. In developing a marketing strategy, you need to convince yourself, as well as the reader of the business plan, that there is a viable market for your product. The marketing strategy is divided into seven sections:

- Introduction.
- Market.
- Product.
- Distribution.
- Competition.
- Promotion.

Introduction

The introduction to the marketing section summarizes for the reader:

- The potential customers for the farm (Market).
- The products that will be produced and sold (Products).
- Where and how the products will be made available to the customers (Distribution).
- The competitors (Competition).
- How the customers will be made aware of the farm and its products (Promotion).

It should also describe the approach that was taken in developing the marketing strategy.

Market

The market section provides an analysis of the market to identify your potential customers or target market. To identify your potential customers, you will first need to have a general understanding of the environment in which your business will operate. Describe the economic factors, such as inflation, unemployment, interest rates, and income that affect a potential customer's purchasing power and spending patterns. Income, for example, will affect a consumer's ability to purchase and the price you

will be able to charge for your product. Discuss the demographic factors that describe your potential customers. Demographics provide information on the size, location, age, income, and other statistics about potential consumers. Discuss the social and cultural factors that will influence or impact your business. Social and cultural factors refer to the basic values, perceptions, preferences, and behaviors of your potential customers. They could include preferences on the types of crops to be grown, the ease of purchase of the product, perceptions of organic versus chemical-based production, and impact on the immediate neighborhood. Finally, discuss any voids in the market that your farm will fill.

Consider the following questions:

- What are the significant regulatory requirements that need to be addressed or that will impact your business?
- Who are your potential customers (e.g., households, commercial businesses)?
- Where are your customers located (i.e., within easy transportation or long distances)?
- How likely are they to buy your product (is the project unique or of superior quality)?
- Is there a particular crop that you will grow that is not easily accessible to the consumer?
- Is fresh, organically grown produce easily accessible to the consumer?

Use ***Worksheet # 7 (Market Analysis)*** to document information to include in the market section.

Customers

Considering the market analysis, describe the customers that your farm will target and how your offerings will meet their needs. Where appropriate, divide the larger target market into submarkets (market segments), such as direct marketing to individual households or business-to-business marketing. Identify the market segments to be targeted. Describe the size and geographic location of each market segment. For example, distance from the business, number of households, commercial establishments or institutional establishments, and likely purchase volume. Discuss the specific characteristics or demographics that define the target customers in each segment, such as age, gender, and income. Discuss the attributes of the market segment related to personality, values, attitudes, interests, or lifestyles. Describe the specific needs and preferences of the market segment that the farm will target.

Consider the following questions:

- Are there trends and/or market conditions that were considered for each market segment?
- Is there a specific product that will appeal to the market segment?
- What motivates buying decisions in each market segment?
- What evidence is there that potential customers in each market segment want the product?

Use ***Worksheet # 8 (Market Segments)*** to document information about the customers and market segments. Complete a worksheet for each market segment.

Product

Using information developed in the market analysis about the customer values, needs, and preferences, describe the products to be offered and how they will compete in the target market. This could be a list of specific products (collard greens) or a list of general classes of products (greens). Product offerings

should also include the seasonal availability of the products. Describe the specific characteristics of the product that meet the needs of the target market. For example, the market segment desires fresh, organically grown produce from local suppliers or the specific product is not available in the current market. Discuss why the products offered to each market segment are unique. Attributes such as locally grown, organically produced, and price serve to differentiate a product and make it unique. Finally, describe why the business is different from its competitors. Attributes such as being a local employer, accessibility to customers, and partnerships with local businesses help to describe the uniqueness of your business.

Consider the following questions:

- What products will be offered?
- What is the product availability (seasonal offerings)?
- Why would a customer prefer your product to a competitor's?
- What differentiates your product in the target market?
- How does your product differ from that of your competitor's?
- What are the strengths and weaknesses of the product?

Use ***Worksheet # 9 (Product)*** to document information about your product. Complete a worksheet for each market segment.

DISTRIBUTION

Getting your product to the market will be a critical component of your marketing strategy. Perishable products will need to be delivered or sold to customers within a short period of time after harvest or stored. The quality of crops and customer perception will depend on the quality and freshness of your product. Describe how your product will get to each market segment. Discuss the handling of the product from harvest to sale to the customers in each market segment including any options for storage of the product prior to sale.

Consider the following questions:

- Are products to be packaged for distribution (salad mixes), secondary products (salsa or preserves), or distributed in bulk crates or bushels?
- Are products going to be stored for later distribution?
- Will product be distributed direct from the harvest to the customer?
- How will your product be sold?
- Will the distribution be through direct marketing, such as community supported agriculture, farmers' markets, home delivery services, Internet sales, pick-your-own, or will the products be marketed through an intermediary distributor (e.g., retailers, wholesalers, brokers, or cooperatives)?
- How will product quality be maintained during storage and distribution?
- Why was a particular method of distribution selected for a market segment?
- Are there seasonal issues that will affect the supply of product to a market segment or the distribution of the product to a market segment?
- What will you do with product that is not sold or delivered?

Use ***Worksheet # 10 (Distribution)*** to document information about your approach to storage and distribution. Complete a worksheet for each market segment.

SALES

Using information developed in the market analysis about the average product consumption, geographic location, and customer attributes, needs, and preferences, develop simple sales projections for each market segment. Since various crops may be seasonal, describe when and how long product will be available for each market segment. For example, products may be available for a market segment all year or only on a seasonal basis.

Pricing

To develop your sales projections, consider the prevailing prices for the products to be sold and your strategy for pricing these products. Describe the pricing strategy for each market segment and how your strategy compares with the competition. Finally, discuss why the selected pricing strategy will be effective in the market segment.

Consider the following questions:

- What are the prevailing market prices for similar products?
- What is the sensitivity of demand to price?
- Will customers be willing to pay higher prices for your offering?
- How will the product be priced for each market segment? Will pricing be based on what your competitors are charging, on the cost of producing the crop plus a percentage for profit, on a price determined by a market study, or some other form of pricing strategy? Is there evidence that the target market segment will accept the price?

Use ***Worksheet # 11 (Pricing)*** to document information about your approach to pricing. Complete a worksheet for each market segment.

Sales Volume

Estimate the potential volume of sales for each market segment. This discussion will require an estimate for each market segment of the number of potential customers in your planned market area and the number (or percentage) of these potential customers that will be needed to sustain the anticipated volume of product. The potential sales volume will be the product of the potential number of customers times the potential volume for each customer. Describe any assumptions that were made about the market segment and volume estimates. Identify any research that was conducted or used to develop information about each market segment.

Use ***Worksheet # 12 (Sales Volume)*** to document information about potential sales volumes. Complete a worksheet for each market segment.

COMPETITION

Describe the competition for each market segment and how the business will be positioned to compete in each market segment. Summarize the products they provide, the characteristics of their products, and pricing for their products. Discuss the advantages your business will have over your competitors in each market segment. Discuss the disadvantages your business will have to the competitors in each market segment. Discuss how your business will distinguish itself from competitors. Finally, discuss whether competitors are expected to respond to your entry into the market and how quickly and effectively the competitors may be able to respond.

Consider the following questions:

- Who are the competitors for each product segment?
- Is your product of a higher quality, better meets the needs of the consumer, or is more
- accessible?
- Are your competitors established in the market?
- Do they offer a greater variety of products?
- Will your pricing be competitive with your competitors?
- Will product distribution be an issue?
- Why will customers switch to or select this business over a competitor?

Will your business provide higher quality product, greater variety, better service, lower prices?

Use ***Worksheet # 13 (Competition)*** to document information about competitors. Complete a worksheet for each market segment.

PROMOTION

Discuss how you will gain access to the market segments and distribution channels. Describe how you will communicate your message about the product or business. Discuss what you want to communicate to your customers. Discuss how much you expect to spend on advertising and communication.

Consider the following questions:

- How will potential customers find out about your product?
- What approaches will be used to promote your farm and its products?
- Will you advertise the product, the business or company image, or both?
- Will you contact potential customers directly or use display ads in magazines or newspapers, mailings, flyers, catalogues, Internet, social media, programs promoting locally grown products, or some combination?
- Do you want to communicate your business values, the product you are supplying, product quality, production practices (organic, local), price, availability, or some combination?
- How often will customers be contacted through advertising and communications?
- Why do you believe that the selected approach will be effective in reaching the target customer?

Use ***Worksheet # 14 (Promotion)*** to document information about your approach to promotion. Complete a worksheet for each market segment.

Operating Strategy

The operating strategy is divided into five sections:

- Introduction.
- Crop Management.
- Size and Capacity.
- Physical Resource Needs.
- Human Resource Needs.
- Regulation and Policy.



Brownfields to Farmers Market Shelton, Connecticut

Introduction

The introduction for the Operating Strategy section summarizes for the reader:

- The approach for cultivating and harvesting the crops (Crop Management).
- The estimated production capacity of the farm (Size and Capacity).
- The physical resources needed to operate the farm (Physical Resources).
- The human resources needed to operate the farm (Human Resources).
- The regulatory issues and requirements that need to be addressed in order to start-up and operate the farm (Regulatory and Policy Issues).

It should also describe the approach that was taken in developing the operating strategy.

Crop Management

Crop management for a farm involves maximizing the food crops that can be produced on a piece of land to meet the objectives of the marketing strategy, in terms of the type, amount, and quality of crops that are to be produced. This involves an understanding of both the approach that will be used to produce the crops and the schedule for planting and harvesting the crops.

Discuss your approach to crop production including the specific method to be used such as vertical gardens, raised beds, surface planting, hydroponics, aquaponics, cold houses, or green houses.

Consider the following questions:

- How will you produce your crops?
- Will you use cold houses, hot houses, vertical gardens, raised beds, tilling natural soil, or some combination?

- Will your crops be produced organically?
- Do you intend to be certified as an organic producer?
- What will be accomplished in-house or purchased?

Will existing soil be used and will actions be need to improve existing soil conditions such as pH, organic content, nitrogen (N), phosphorus (P), and potassium (K)?
Will compost or mulch be produced on your farm or purchased?
Will seedlings be produced on your farm or purchased?

What production management alternatives are going to be implemented for issues such as weed, pest, and disease control, soil fertility, crop rotation, tillage, water supply and irrigation, seed and plant selection, waste handling and disposal, and crop quality control?

- How will plantings be made to achieve the required crop harvest to meet the marketing strategy (e.g., overplanting)?
- Will you be planting and harvesting during multiple seasons, such as spring, summer, fall, and/or winter?
- How will your planting and harvesting schedules change over the first five years of production (e.g., crop rotation)?

Use ***Worksheet # 15 (Crop Management)*** to document information about your approach to production management. Use ***Worksheet # 16 (Planting and Harvesting Schedules)*** to evaluate your approach to planting and harvesting. Use ***Worksheet #17 (Farm Planning)*** to assist in estimating the operating expense for the farm.

YIELD

Discuss the estimate for the amount of crops that can be repeatedly produced (e.g., pounds of produce per month for each market segment and crop type) given the crop management approach, property size, and available resources. The output should be estimated for the first five years of operation. You may also want to estimate a high and low case output for purposes of evaluating the range of potential output against the objectives of the marketing strategy. These output projections should be consistent with your plans for the growth of the business. Describe your growth plans.

Use ***Worksheet # 18 (Yield)*** to document information about the farm capacity and size. Refer to data from ***Worksheet #17 (Farm Planning)*** to assist in estimating the size and capacity of the farm.

PHYSICAL RESOURCE NEEDS

Physical resources include land, buildings, and equipment necessary to produce and market your crops to meet the objectives of your marketing strategy. Discuss your physical resource needs and how they will be acquired. Describe the environmental factors related to the resources that will be needed to run the farm, such as water, electricity, and the impacts the farm may have on the environment (e.g., waste generation and disposal).

Consider the following questions:

- How much land will you need initially and within five years?
- How much land do you have available?
- Will you acquire land or lease land?
- Are there known or potential environmental issues on the property that will require assessment or cleanup on the property or require specific farming techniques to address?
- Has an environmental assessment and/or remedial action been conducted on the
- property? Are there physical conditions that present challenges to the use of the property (e.g., concrete foundations or floor slabs remaining, environmental restrains (e.g., land use restrictions)?
- What types of buildings and other structures are required initially and within five years?
- What resources will be needed for the farm, such as water, electricity, and waste disposal?
  What equipment, such as roto-tillers, tractors, vehicles, or refrigerators, is needed initially and within five years?
  What tools, such as rakes, hoes, and seed planters are needed initially and within five years?
  What supplies, such as fertilizers, mulch, compost, humus, seeds, crates, or labels, are needed?
  What type of irrigation system such as tile drains, drip zone irrigation or sprinkler system will be needed initially and within five years?
- How will resources be acquired?

Use ***Worksheet # 19 (Physical Resources)*** to document information about your physical resource needs.

HUMAN RESOURCE NEEDS

Describe the manpower needed to operate the farm. This should include management as well as farm labor. Estimates of the number and types of workers needed can be made by identifying the specific tasks that will be required on a daily basis on the farm, including administrative and management responsibilities, and estimating the number of hours per month for each task. These tasks can be grouped by skill or experience and the total number of hours for each group estimated. As an example, tasks can be grouped into marketing, operating, administrative, and finance.

Consider the following questions:

- What are the workforce needs for the first three to five years?
- What types of positions will be created for the farm?
- How many workers will be required for each position?
- What skills or experience will be required for each position?
- Will training be required or provided?
- Considering the number and types of workers needed, will the workforce consist of volunteers, part-time workers, full-time workers, third party services, or some combination?
- How will workers be compensated?

What are the typical ranges for salaries for each position (e.g., $/hour, $/year)? Will benefits, such as vacation or medical coverage, be provided?

Use ***Worksheet # 20 (Manpower Needs)*** and ***Worksheet # 21 (Workforce Needs)*** to document information about workforce needs.

Regulation and Policy

Operating a farm business will require a number of state or local zoning, permitting, licensing, and other regulatory issues be addressed. These regulatory requirements could have a significant impact on your production and operating plans, as well as on start-up costs. To minimize the impacts and properly plan production activities, identify the types of permits, licenses, or regulations and associated fees required to start up and conduct the business. Describe the political or legal factors that will influence or limit your activities. Your business must operate within governmental and regulatory requirements, such as zoning, planning and building requirements, waste management requirements, and sales and other tax requirements.

Consider the following questions:

- Are there political or legal factors that will influence or limit your activities?
- What regulatory requirements exist, such as conditional use permits, waste handling and disposal requirements or permits, health and safety plans and permits, building permits and inspection requirements, environmental permits, business licenses, and food handlers' licenses?

  Are there regulatory requirements or industry standards for handling, storing, packaging, and distributing the products?

  What conditions or issues are associated with each regulatory requirement?

  Can you meet each regulatory requirement?

  What fees are associated with the identified permits, licenses, or regulations?

Use ***Worksheet # 22 (Regulation and Policy)*** to document information about your approach to regulations and policies.

Financial Strategy

The financial strategy is divided into seven sections:

- Introduction.
- Expenses.
- Income.
- Profit and Loss.
- Fixed Assets.
- Funding Requirements.
- Risk Management.



Urban Oaks Farm, New Britain, Connecticut

INTRODUCTION

The introduction to the Financial Strategy summarizes for the reader:

- The estimated expenses for start-up and operation of the farm (Expenses).
- The projected income for the farm (Income).
- The projected profitability of the farm (Profitability).
- The anticipated fixed assets (Fixed Assets).
- The potential source of funding (Funding).
- The potential risks to the successful operation of the farm (Risk Management).

It should also describe the approach that was taken in developing the financial strategy.

EXPENSES

Develop a five-year projection for the annual expenses for the farm including adjustments for inflation using information such as the consumer price index (www.bls.gov/cpi/). The expenses should include the marketing expenses, operating expenses, and human resource expenses discussed in the marketing, operating, and human resource strategy sections of this business plan handbook. Expenses should also include administrative expenses related to the administration and management of the farm and one-time or initial start-up expenses, such as initial operating expenses, site preparation, environmental investigations, and remedial actions not treated or included as part of fixed asset costs. Discuss any assumptions used to develop the estimated expenses.

Use ***Worksheet # 23 (Expenses)*** to calculate and document the annual expenses.

INCOME

Develop a five-year projection for the annual income for the farm. The income should include receipts from the sales of produce and other products from the farm, less any loss associated with spoilage or product which cannot be sold. It should also include income from grants, donations, rent, or other sources

which are anticipated on an annual basis to cover operating expenses. It is helpful to break down projected sales income by market segment to identify the contribution to income and evaluate the performance of each market segment. Identify any assumptions that were used to estimate the income.

Consider the following questions:

- For sources of income other than sales receipts, what are the sources of funding?
- What is the anticipated amount of funding that will be obtained from each source?
- What, if any, are the limitations on the use of the funding?

Use ***Worksheet # 24 (Income)*** to calculate and document the annual income.

Profit and Loss

Develop a five-year projection for the annual profit or loss for the farm. The annual profit or loss is the difference between the estimated annual expense and the estimated annual income.

Use ***Worksheet # 25 (Profit and Loss)*** to calculate and document the annual profit or loss.

Fixed Assets

Develop a five-year projection for the fixed assets that will require initial purchase or construction costs. Fixed assets normally include items such as land and buildings, motor vehicles, furniture, office equipment, computers, fixtures and fittings, and plant and machinery. These are items that are normally depreciated over time for tax purposes. Discuss any assumptions that were used to estimate the fixed asset costs.

Use ***Worksheet # 26 (Fixed Assets)*** to calculate and document the fixed assets and estimated costs to purchase and install.

Funding Requirements

Describe the sources and amount of funding (capital) required to purchase and install the fixed assets needed to start up the farm and achieve the five-year goals of the business plan. Discuss the plans for obtaining the needed funding for the farm. Donations of equipment, such as vertical gardens or hoop houses, should be discussed along with the value associated with the donation. Any associated expenses should be included in the projected expenses for the farm (See Worksheet # 23).

Consider the following questions:

- What are the sources or potential sources of the funding?
- How much is needed?
- Will some or all of the capital requirements be financed?
- Are there specific limitations on the funding?
- What are the critical assumptions concerning the funding?
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What is the timing of the funding and how will it impact the achievement of the business plan? Are there any expenses associated with obtaining financing or funding, such as consulting expenses, filing fees, insurance?
Is some of the funding going to be achieved through donations of equipment, buildings, or other fixed assets?

Use ***Worksheet # 27 (Funding)*** to calculate and document the sources of funding, the anticipated amount of funding that will be obtained from each source, and what, if any, are the limitations on the use of the funding. Use ***Worksheet # 28 (Funding Information)*** to document information concerning the funding needs and sources.

Risk Management

Identify and evaluate potential risks that can impact the financial strategy and the success of the business plan.

Consider the following questions:

- What are the potential risks that may need to be managed, such as production risks related to failure of a crop or unexpected low yield or environmental risks such as restrictions on land use?
  - What are the marketing risks related to unexpected competitive actions, such as lower than expected competitor pricing?
- What are the financial risks related to loss of funding sources or low sales volume, or labor issues related to labor injuries or loss of the farm manager?
- How likely are the risks to occur?
- What can be done or what is planned to minimize these potential risks if they occur?
- What are the potential impacts on the financial strategy if there were changes in the assumptions for sales or production?

Use ***Worksheet # 29 (Risk Management)*** to document information on the potential risks that can impact the financial strategy.

Executive Summary

With the completion of the marketing, operating, and financial strategies, the details of the business plan are essentially complete. To finalize the business plan, an executive summary is developed. While the executive summary is the first section of your business plan, it is typically the last section to be written. The executive summary is a one or two page synopsis of your business plan that describes the plan and highlights the significant information presented in the plan.

The executive summary should provide a brief overview of the farm's:

- Product(s) or service(s).
- Target market(s) and marketing and sales plan.
- Development plan.
- Operating plan.
- Management structure and key personnel. Financial
- plan.

It is important to consider that the executive summary may be useful as a standalone summary of the business plan. The executive summary, therefore, should be written as a standalone document so that the summary, by itself, provides sufficient information for a reader to understand the business.

Appendices



Appendix A: List of Provided Worksheets

Worksheet		Purpose	Where to Find It
1	Before You Begin	Document your reasons, expertise and resource needs.	Urban Farm Business PlanWorksheets (MS Word)
2	Introduction	Document the information to include in the Business Plan introduction.	Urban Farm Business Plan-Worksheets (MS Word)
3	Vision	Document the information to include in the Business Plan vision statement.	Urban Farm Business Plan-Worksheets (MS Word)
4	Mission	Document the information to include in the Business Plan mission statement.	Urban Farm Business Plan-Worksheets (MS Word)
5	Goals	Document the information to include in the Business Plan goal discussion.	Urban Farm Business Plan-Worksheets (MS Word)
6	Organization & Management	Document the information about the organization & management of your business.	Urban Farm Business Plan-Worksheets (MS Word)
7	Market Analysis	Document the information to include in the market section.	Urban Farm Business Plan-Worksheets (MS Word)
8	Market Segments	Document the information about customers and market segments (complete one worksheet for each market segment).	Urban Farm Business Plan-Worksheets (MS Word)
9	Product	Document the information about your product (complete one worksheet for each market segment).	Urban Farm Business Plan-Worksheets (MS Word)
10	Distribution	Document the information about your approach to storage and distribution (complete one worksheet for each market segment).	Urban Farm Business Plan-Worksheets (MS Word)
11	Pricing	Document the information about your approach to pricing (complete one worksheet for each market segment).	Urban Farm Business Plan-Worksheets (MS Word)
12	Sales Volume	Document the information about potential sales volumes.	Urban Farm Business Plan-Worksheets (MS Word)
13	Competition	Document the information about competitors (complete one worksheet for each market segment).	Urban Farm Business Plan-Worksheets (MS Word)
14	Promotion	Document the information about your approach to promotion (complete one worksheet for each market segment).	Urban Farm Business Plan-Worksheets (MS Word)
15	Crop Management	Document the information about your approach to production management.	Urban Farm Business Plan-Worksheets (MS Word)
16	Planting & Harvesting Schedules	Evaluate approach to planting and harvesting.	Urban Farm Business Plan-Worksheets (MS Word)
17	Farm Planning	Assist in estimating the operating expense for the farm and size and capacity of the farm.	Urban Farm Business Plan-Worksheets (MS Excel)

Worksheet		Purpose	Where to Find It
18	Yield	Document the information about farm capacity and size.	Urban Farm Business Plan-Worksheets (MS Word)
19	Physical Resources	Document the information about the physical resource needs.	Urban Farm Business Plan-Worksheets (MS Word)
20	Manpower Needs	Document the information about workforce needs.	Urban Farm Business Plan-Worksheets (MS Word)
21	Workforce Needs	Document the information about workforce needs.	Urban Farm Business Plan-Worksheets (MS Word)
22	Regulation & Policy	Document the information about your approach to regulations and policies.	Urban Farm Business Plan-Worksheets (MS Word)
23	Expenses	Calculate and document annual expenses.	Urban Farm Business Plan-Worksheets (MS Excel)
24	Income	Calculate and document the annual income.	Urban Farm Business Plan-Worksheets (MS Excel)
25	Profit & Loss	Calculate and document the annual profit or loss.	Urban Farm Business Plan-Worksheets (MS Excel)
26	Fixed Assets	Calculate and document the fixed assets and estimated costs to purchase and install.	Urban Farm Business Plan-Worksheets (MS Excel)
27	Funding	Calculate and document the sources of funding, the anticipated amount of funding that will be obtained from each source, and what, if any, are the limitations on the use of the funding.	Urban Farm Business Plan-Worksheets (MS Excel)
28	Funding Information	Document the information concerning the funding needs and sources.	Urban Farm Business Plan-Worksheets (MS Word)
29	Risk Management	Document the information about the potential risks that can impact the financial strategy.	Urban Farm Business Plan-Worksheets (MS Word)

Appendix B: Example Worksheets

The following example worksheets are provided to demonstrate the type of specific information that should be collected in order to develop a business plan. The information provided in the example worksheets is for a hypothetical site and project scenario. The data presented in the example worksheets demonstrate how information flows from one worksheet to another and does not necessarily reflect any particular project assumptions. When inputting data into the blank worksheets, care should be taken to ensure data inputs reflect individual urban farm assumptions.

Example Worksheet # 1 Before You Begin

Think about the primary reasons why you want to start an urban farm and the expertise and resources needed to develop the business plan.

What are your primary reasons for starting an urban farm?
Place an abandoned industrial property into an economically viable and accessible source of fresh locally grown fruits and vegetables to the residents, businesses, and institutions within the community. Provide job training and educational opportunities to the surrounding community.
What expertise is needed on your planning team?
Marketing expertise to evaluate and identify the markets and products that should be the focus of the growing center. Operating and production expertise to evaluate and identify the growing approaches, requirement and facility requirements, and manpower needs. Environmental expertise to evaluate impacts of property environmental condition and appropriate actions. Developing sources of funding and evaluating operating expense and income requirements.
What resources will be needed to develop the business plan?
Consulting support to guide the drafting of the business plan, develop a marketing analysis and recommendation on markets and products. Support from the *Nonprofit Food Group X* and *Community-based Group Y* to develop the operating strategy. Funding for consulting requirements.
What values do you bring to this business that will help you define the success of the business?
Importance of food choices, healthy diets and lifestyles, and nutrition education. Foster a sense of community by reconnecting people with locally grown foods. Benefit public health and the environmental by cleaning up brownfields properties. Develop sustainable reuses support community economic, social, and environmental goals by utilizing operation and production techniques that minimize pollution and conserve resources and providing opportunities for job training and education. Provide affordable fresh fruits and vegetables.

Example Worksheet # 2 Introduction

The introduction describes the purpose of the business plan and the key issues addressed by the plan.

What is the purpose of the business plan?
Outline the approach for the development, operation, and funding of the growing center. The business plan will also serve as a planning tool for the longer-term growth of the growing center and provide information to potential sources of funding for the development and operation of the growing center.
What information is contained in the business plan?
The business plan outlines the strategy for producing and marketing fresh fruits and vegetables within the area around the growing center. It describes the market to be targeted, the crops to be produced, the method of production, manpower needs and strategies for funding the development and operation of the growing center.
How was the business plan developed?
The business plan was developed with the help of the business planning team, students and professors from the University of Town X, and consultants funded by EPA and other sources.
Who are the members of the business planning team?
[Name] – Town X Community Development Corporation *[Name] – County Y Improvement Corporation* *[Name] – County Y Improvement Corporation* *[Name] – Assets Town X [Name]* *– Private Enterprises [Name] –* *The Collaborative Inc.* *[Name] – University of Town X*
What are the potential risks to the successful start up of the farm?
Funding for the development and expansion of the growing center. Sufficient volunteers and community support to construct and operate the facility. Crop yield and quality along with the timing of achieving consistent, viable, and marketable crops. Insufficient income and the need for funding to off-set the expenses during the first three to five years.

Example Worksheet # 3 Vision

The vision statement is an inspirational statement that describes your vision for the future of the farm and how your values will be incorporated into your farm.

What economic, environmental, or community values are important to the success of the farm?

Economically viable source of fresh locally grown fruits and vegetables and related products to our community. Productive reuse of abandoned properties, local jobs, and job training. Benefit public health and the environment by cleaning up and utilizing operation and production techniques that minimize pollution and conserve resources. Providing nutrition education and job training.
What products or services (in a general sense) do you expect to provide?
Fresh fruits and vegetables. Job training. Nutrition education.
Who are your target customers?
Members of the community surrounding the growing center including residents and commercial food business such as restaurants and community meal services.
What customer or market needs will your business address?
Provide fresh fruits and vegetables to residents that do not have easy access to these products or the economic means to purchase these products. Provided locally grown fresh fruit and vegetables to restaurants in the community.
What do you expect the business to look like in the future?
Growing and marketing fruits and vegetables to the residents and business in the community utilizing organic and sustainable production methods generating sufficient income to off-set expenses.
How do you expect the business to be perceived by the community and customers in the future?
Community asset that provides not only fresh fruits and vegetables, but education, job training and a source of pride for the community. It is anticipated that the community will develop a sense of ownership in the operation and success of the growing center through volunteer efforts and purchase of its products. It is also anticipated that restaurants and other business will prefer products grown at the growing center and proudly advertise the growing center as the source of those products. In addition, it is hoped that the growing center will be a model for similar operations within the Town X area and other areas of the country.

Example Worksheet # 4 Mission

The mission statement is a simple statement that communicates the fundamental purpose and expectations for the farm to customers and others outside of the business.

What is the overall purpose of your farm?
Promote the production and purchase of locally grown foods and to demonstrate the viability and sustainability of urban food production and commerce and its role as an integral part of the community landscape.
What is the overall goal of your farm?
Provide the community with access to affordable fresh produce, jobs and job training, and education on growing and preserving fresh produce and improved health through better diet.
What do you want your business to be known for in the future?
Quality locally grown fresh fruit and vegetables. A source of education, training and community pride.
To who do you want the mission statement to communicate?
The social and economic benefits of urban farming and the viability and sustainability of such efforts.

Example Worksheet # 5 Goals

The goals describe what is to be achieved by the business in the future.

What will the business market?
The business will market fresh fruits and vegetables consistent with the cultural and dietary needs of the community.
How will the business operate?
The business will operate under the umbrella of the Town X CDC. It is expected that within the first five years that the facility will be producing crops over in three growing seasons – spring, summer, fall. Crop production will be accomplished using vertical gardens and hoop houses with raised growing beds. Marketing will be through a farm stand on the property and direct marketing to customers.
Who will be involved in operations?
The growing center will be managed by an experience farm manager and be staffed by students and community volunteers.
What income or earnings are expected from the business?

The growing center is expected to operate at a loss until the fifth year of operation, Income and expenses of approximately $100,000 are expected by the fifth year of operation.

What are the short-term goals (1-5 years)?

Engage the community in the growing center operations and production.

Construct the initial hoop house and install the vertical gardens with initial crops in summer 2011.

Construct the farm stand and training center.

Bring the facility to its full anticipated production capacity consisting of four hoop houses, vertical gardens, a farm stand, a training center, and support buildings.

Sales will be to both local residents, transient residents at the farm stand, and to local food service business.

Example Worksheet # 5 Goals

What are the long-term goals (greater than 5 years)?

Expand the market to larger food service businesses such as nursing homes, school lunch programs and expand the facility to meet the needs of these additional markets. This would require the acquisition of additional property in the area of the growing center.

Incorporate aquaponics into the production operations.

Add composting operations.

Additional products such as jams, salsas, and packaged salad mixes.

The growing center will be able to off-set operating expenses with annual income and generate an annual profit.

What goals are most important to achieving success in the business?

Engaging the community in the operation and production of the growing center. Volunteer workers are an important component of the construction and initial operation of the facility.

Bringing the facility up to full production within the first five years.

What short-term goals are necessary for the long term success of the business?

Developing the market through sales.

Engaging the community in the growing center operations and production.

What is the priority of the goals?
1) Engage the community in the growing center operations and production. 2) Construct the initial hoop house and install the vertical gardens with initial crops in summer 2011. 3) Construct the farm stand and training center. 4) Sales will be to both local residents, transient residents at the farm stand, and to local food service business. 5) Bring the facility to its full anticipated production capacity consisting of four hoop houses, vertical gardens, a farm stand, a training center, and support buildings.

Example Worksheet # 6 Organization and Management

Describe how the business will be organized and who will manage the business.

How will the business be organized?
The growing center will be operated by the Town X Community Development Corporation (CDC). The facility will be managed by a farm manager employed by the Town X CDC reporting to the Executive director. Administrative, financial, and legal support will be provided by existing Town X CDC staff.
What is the ownership structure of the business?
The growing center will be owned by the Town X CDC.
Will there be an overseeing board or board of directors? Who will be on it? What will their roles be in the business? Will there be compensation for these directors?
The operation of the growing center will be overseen by the Executive Director and Board of the Town X CDC.
How will the business management be organized? A simple organization chart may be useful to explain the organization.
A farm manager will manage the day-to-day operations of the farm. Staff and volunteer workers will report to the farm manager. The farm manager will report to the Executive Director of the Town X CDC. Administrative activities of the farm will be managed by the Executive Director of the Town X CDC.
Who will be the key managers who will run the business?
The key managers are the farm manager and the Executive Director of the Town X CDC.
What unique skills do the key managers bring to the business?

The farm manager brings a background in agriculture, crop, and farm management. The Executive Director of the Town X CDC provides administrative, marketing, and financial experience.
What will be the duties and responsibilities of the key managers?
The farm manager will manage the day-to-day operations of the farm. Staff and volunteer workers will report to the farm manager. The farm manager will report to the Executive Director of the Town X CDC. Administrative activities of the farm will be managed by the Executive Director of the Town X CDC.
How will the key managers be compensated?
The farm manager will be paid and hourly rate with certain benefits. The Executive Director will perform the responsibilities associated with the growing center as part of the Executive Director position.

Example Worksheet # 7 Market Analysis

The market analysis describes the general environment in which your business will be operating.

What are the economic factors that affect a potential customer's purchasing power and spending?
Low- to moderate-income neighborhood surrounding the growing center that is currently underserved by full service grocery stores. Households have lower spending power than those in the greater County Y area.
What are the demographic factors that describe who potential customers are, where they are, and how many are likely to buy your product?
The site neighborhood is bounded by major area east-west and north-south corridors that experience significant traffic counts. The growing center is strategically located between downtown Town X and the University of Town X campus with the potential to capture vehicular traffic from non-residents. The growing center's proximity to large concentrations of consumers facilitates transportation and delivery of product. Per capita consumption of fresh fruits and vegetables has increased steadily between 1980 and 2001, and is projected to continue to increase through 2020. According to the United States Department of Agriculture's Agricultural Marketing Resource Center (2004), between 1980 and 2001, per capita consumption of fresh fruits increased by 19% and consumption of vegetables (including potatoes) increased by 29%. The USDA forecasts that the trend toward increased consumption of fresh fruits and vegetables will continue. Per capita expenditures on fruits and vegetables are expected to have the highest increases among all types of foods through 2020.
What are the social and cultural factors related to the basic values, perceptions, preferences, and behaviors of your potential customers?

There is a growing desire among the community for easily accessible and reasonably priced fresh fruits and vegetables consistent with the cultural make-up of the community.
What voids in the market will be filled by your farm?
Availability of locally grown organically grown fruits and vegetables for the direct to consumer and wholesale markets within an approximate 2-mile radius of the growing center.

– Market Segments

Example Worksheet # 8

Divide the larger target market into submarkets (market segments), such as direct marketing to individual households or business-to-business marketing. Describe the characteristics of each market segment. Complete a worksheet for each market segment.

Market Segment: Retail, Direct to Consumer
What is the size and geographic location?
Primary market area includes downtown and neighborhoods within approximately 2.0 miles of the growing center.
What characteristics (demographics) define the target customers?
The market area consists of low- to moderate income with lower-than-average and educational attainment levels.
What are the attributes of the market segment related to personality, values, attitudes, interests, or lifestyles?
Types of crops to be grown. Access to and ease of purchase. Social and economic impact on the immediate neighborhood.
What are the needs and preferences of the market segment?
Easily accessible and reasonably priced fresh fruits and vegetables consistent with the cultural make-up of the community.
What are the trends and/or market conditions for each market segment?
Per capita consumption of fresh fruits and vegetables has increased steadily between 1980 and 2001, and is projected to continue to increase through 2020. Growing consumer preferences for fresh, organic, local produce is driving a greater diversity of fruit and vegetable offerings in grocery stores, and a strong increase in farmers markets. Farm-to-consumer sales are a relatively small share of the overall "food consumed at home" market (1.1% in 2009).
What product will appeal to each market segment?

Fresh, affordable and healthy fruits and vegetables.

Example Worksheet # 8

Market Segment: Retail, Direct to Consumer
What motivates buying decisions in each market segment?
Mobility – ability to travel to grocery store. Easy access to the produce. Reasonably priced (affordable) produce. Locally produced quality produce.
What evidence is there that potential customers in each market segment want the product?
In addition to national studies that show an increasing trend in the purchase of organic, fresh produce, surveys of 173 local residents conducted by the Toledo CDC indicate that residents in the area of the growing center are interested in purchasing locally grown fruits and vegetables.

Market Segment: Wholesale, Direct to Restaurants
What is the size and geographic location?
Primary market area includes restaurants downtown and neighborhoods within approximately 2.0 miles of the growing center.
What characteristics (demographics) define the target customers?
Experienced chefs with knowledge of the nutritional values of fruits and vegetables.
What are the attributes of the market segment related to personality, values, attitudes, interests, or lifestyles?
Types of crops to be grown. Require high quality and appearance. Looking for cost effective product or sufficient quality and appearance to obtain premium price for fresh, organic fruits and vegetables.
What are the needs and preferences of the market segment?

Competitively priced fresh fruits and vegetables. Availability to meet demand. Fruits and vegetables compatible with their menus.

Example Worksheet # 8

Market Segment: Wholesale, Direct to Restaurants
What are the trends and/or market conditions for each market segment?
Per capita consumption of fresh fruits and vegetables has increased steadily between 1980 and 2001, and is projected to continue to increase through 2020. Growing consumer preferences for fresh, organic, local produce is driving a greater diversity of fruit and vegetable offerings in grocery stores, and a strong increase in farmers markets. Buying fresh, local foods is one of the strongest trends among today's chefs, listed among the top 10 trends of 2010 in the American Restaurant Association's survey of 1,800 U.S. chefs.
What product will appeal to each market segment?
Fresh, affordable and healthy fruits and vegetables.
What motivates buying decisions in each market segment?
Reasonably priced produce. Quality and appearance. Compatibility with menu. Consistent supply.
What evidence is there that potential customers in each market segment want the product?
Chefs in the Town X area who currently purchase fresh produce from local farms responded positively to the proposed Town X Growing Center concept. Several noted that they would be interested in purchasing produce from the Town X Growing Center, once established.

Example Worksheet # 9 Products

Describe the products to be offered and how they will compete in each market segment. Complete a worksheet for each market segment.

Market Segment: Retail, Direct to Consumer
What products will be offered?
Herbs – (basil, sage, dill, parsley, rosemary). Leaf greens (collard, turnip). Salad greens. Broccoli. Cucumbers. Cabbage. Spinach. Berries (strawberries, raspberries, blackberries). Potatoes (Longer term in years three to five). Tilapia and other fish (Longer term based on implementation of aquaponics in year's three to five). Other crops will be added based on demand and growing capabilities.
What is the product availability (seasonal offerings)?
What specific product characteristics meet the needs of the market segment?
Fresh. Locally grown. Appearance. Accessibility.
How are your products unique?
Grown locally at a facility supported by the community. Provide job training and nutritional education to the community. Restore a former abandoned industrial property to a productive use.
Why would a customer prefer your product to a competitor's?
The growing center will cater to the needs of the local community with respect to crop planning and community quality of life. Support job training and local education.

Example Worksheet # 9 Products

Market Segment: Wholesale, Direct to Restaurants
What products will be offered?
Herbs – (basil, sage, dill, parsley, rosemary). Baby vegetables (carrots and beets). Salad greens. Broccoli. Cucumbers. Spinach. Berries (strawberries, raspberries). Other crops will be added based on demand and growing capabilities.
What is the product availability (seasonal offerings)?
What specific product characteristics meet the needs of the market segment?
Fresh. Locally grown. Appearance. Cost.
How are your products unique?
Grown locally at a facility supported by the community.
Why would a customer prefer your product to a competitor's?
The growing center will cater to the needs of the local community with respect to crop planning and community quality of life. Support job training and local education.

Example Worksheet # 10 Distribution

Describe how the product is planned to be distributed and how the product will get to each market segment. Complete a worksheet for each market segment.

Market Segment: Retail, Direct to Consumer
Will the product be pre-packaged? How will the product be packaged?

The product will be sold by the piece to consumers at the farm stand on the growing center or at local farmers markets. Fruits and vegetables shipped off the growing center will be packaged in cartons, crates or bags, as appropriate for the specific fruit or vegetable.
Will the product be stored prior to sale? How will the product be stored?
Fruits and vegetables will not be stored for extended periods of time at the growing center; however, harvested fruits and vegetables will be stored within the storage building or hoop house on the growing center property until sold or donated. Fruits and vegetables that cannot be sold within two to three days of harvest will be donated to local food service providers for the homeless or elderly.
How will the product be distributed (farm stand, deliveries)?
Farm stand on the growing center property. Community group volunteers will distribute to local churches, senior centers, and youth groups. Produce will be hauled to select Town X area farmers markets on a weekly or bi-weekly basis.
How will product quality be maintained during storage and distribution?
As noted previously, fruits and vegetables will not be stored for long periods of time. Harvested crops will be placed in cartons or crates as appropriate for the particular fruit or vegetable and stored within the storage building or hoop house on the growing center property.
Why is the selected distribution approach best for the market segment?
The product of the growing center is fresh fruits and vegetables. Long term storage of the crops will not meet this objective or objectives related to quality and appearance.
How will your business gain access to the market segment and distribution channels?
A network of community group volunteers who focus on churches, senior centers, youth and family centers. Events and tasting at the growing center and at area farmers markets.
How often will the product be made available to customers in each marketing segment (deliveries, days and hours of operation)?
Once or twice a week to senior groups, schools, and churches.

Example Worksheet # 10 Distribution

Market Segment: Wholesale, Direct to Restaurants
Will the product be pre-packaged? How will the product be packaged?
The product will be sold by the piece to chefs at the farm stand on the growing center or at local farmers markets. Fruits and vegetables shipped off the growing center will be packaged in cartons, crates or bags, as appropriate for the specific fruit or vegetable.
Will the product be stored prior to sale? How will the product be stored?
Fruits and vegetables will not be stored for extended periods of time at the growing center; however, harvested fruits and vegetables will be stored within the storage building or hoop house on the growing center property until sold or donated. Fruits and vegetables that cannot be sold within two to three days of harvest will be donated to local food service providers for the homeless or elderly.
How will the product be distributed (farm stand, deliveries)?
Farm stand on the growing center property. Community group volunteers will distribute to local restaurants.
How will product quality be maintained during storage and distribution?
Fruits and vegetables will not be stored for long periods of time. Harvested crops will be placed in cartons or crates as appropriate for the particular fruit or vegetable and stored within the storage building or hoop house on the growing center property.
Why is the selected distribution approach best for the market segment?
The product of the growing center is fresh fruits and vegetables. Long term storage of the crops will not meet this objective or objectives related to quality and appearance.
How will your business gain access to the market segment and distribution channels?
A network of community group volunteers who will make direct contact with chefs at local restaurants. Events and tasting at the growing center and at area farmers markets.
How often will the product be made available to customers in each marketing segment (deliveries, days and hours of operation)?
Deliveries will be based on the needs of the restaurant; however, it is anticipated that deliveries, where required, will be two to three times per week.

Example Worksheet # 11 Pricing

Describe the pricing strategy for each market segment and why it will be effective with the target customer in the market segment. Pricing is based on prevailing market pricing and costs of producing and distributing the product. Complete a worksheet for each market segment.

Market Segment: Retail, Direct to Consumer
What are the prevailing market prices for similar products?
Market prices vary depending on season and crop yield.
What is the likely ability of your business to set prices?
The growing center has substantial opportunity for setting prices. At the farm stand on the growing center, pricing can reflect the lower overhead and lack of distribution costs resulting in lower that competition pricing. At farmer's markets, pricing can be competitive with the competition. In addition, the growing center has the opportunity to provide fresh fruits and vegetables to neighbors of the growing center in exchange for volunteer work at the center.
What is the sensitivity of demand to price?
For the primary market of residents living within a two-mile radius of the growing center, price will be a significant component of their decision to purchase fruits and vegetables from the growing center. Pricing will need to be within the limits of the low to middle income range of these residents.
How will the product be priced for each market segment?
The product will be priced based on competitive pricing and local economic means. In addition, pricing will be adjusted in exchange for volunteer labor and other activities to support the growing center.
How does your pricing strategy compare with the competition?
The growing center has an advantage in that it will have a lower overhead and distribution costs than many of its competitors. It also has the opportunity to provide "pick your own" pricing and pricing adjustments based on volunteer support.
What evidence is there that the target market will accept the price?
Surveys conducted by the Town X CDC indicate that if fresh fruits and vegetables can be provided at a cost equal to or less than the current sources of these items, that the community is likely to purchase their produce from the growing center.
Why will the selected pricing strategy be effective?
The pricing strategy is competitive and recognizes the economic requirements of the community.

Example Worksheet # 11 Pricing

Market Segment: Wholesale, Direct to Restaurants
What are the prevailing market prices for similar products?
Market prices vary depending on season and crop yield. Below are estimates based on 2010 market wholesale prices: Herbs – $10.00 to $15.00 per pound. Baby vegetables – $4.00 - $5.00 per pound. Salad greens – romaine $1.50 per pound; butter bib $2.00 each. Broccoli – $0.67 - $1.00 per pound. Cucumbers – $0.65 per pound. Spinach – $1.75 per pound. Berries (strawberries – $2.75 - $3.50 per pound, raspberries – $5.00 per pint).
What is the likely ability of your business to set prices?
The growing center has substantial opportunity for setting prices; however, prices will need to be competitive with the wholesale market.
What is the sensitivity of demand to price?
Demand will be very sensitive to price; although there may be opportunity for a small premium based on the community basis of the growing center assuming a quality product.
How will the product be priced for each market segment?
The product will be priced based on the competition.
How does your pricing strategy compare with the competition?
The growing center has an advantage in that it will have a lower overhead and distribution costs than many of its competitors. It also has the opportunity to provide "pick your own" pricing and pricing adjustments based on volunteer support.
What evidence is there that the target market will accept the price?
The marketing analysis indicates that if consistent quality fresh fruits and vegetables can be provided at a cost equal to or less than the current sources of these items, that the restaurants are likely to purchase their produce from the growing center.

Why will the selected pricing strategy be effective?
The pricing strategy is competitive.

Example Worksheet # 12 Sales Volume

Develop simple sales projections for each market segment using information about average product consumption, geographic location, and customer attributes, needs, and preferences. Complete a worksheet for each market segment.

Market Segment: Retail, Direct to Consumer
When and how long will the product be available for this market segment?
Initial crops will be available in the summer of 2011. It is planned to provide produce over three growing seasons (spring, summer, and fall).
What is the potential number of customers for each market segment?
Residents with a 2-mile radius of the growing center. Transient consumers. Consumers at local farmers markets.
What is the potential volume per customer for the market segment?
Volume per customer estimate not developed.
What is the potential sales volume for the market segment?
It is anticipated that total sales volume based on farm capacity will be approximately $27,000 in the fifth year of operation.
What assumptions were made about the market segment?
The primary, or target customer is residents of the surrounding low-income neighborhoods that have limited access to fresh fruits and vegetables. It is expected that sales to these customers will be made at the farm stand at the growing center, or at targeted locations such as churches, senior centers, youth centers and schools. Direct to customer sales will likely also be conducted from sales sites such as local farmers markets to a larger area within County Y competing regionally with a wide variety of grocers, farm stands and other retailers.

What research was conducted or referenced about the market segment?
A Market Analysis was conducted by Firm Z for the Town X CDC. Surveys of area residents were conducted by the Town X CDC.

Example Worksheet # 12 Sales Volume

Market Segment: Wholesale, Direct to Restaurants
When and how long will the product be available for this market segment?
Initial crops for this market segment the third year of the growing center operation in order to achieve the quality, appearance and supply of product required by this market segment. It is planned to provide produce over three growing seasons (spring, summer, and fall).
What is the potential number of customers for each market segment?
The potential market is any restaurant within the downtown area and a 2-mile radius of the growing center. The State Regional 2010 Directory identifies over 30 restaurants and catering facilities that utilize locally grown produce.
What is the potential volume per customer for the market segment?
It is anticipated that total sales volume based on farm capacity will be approximately $20,000 in the fifth year of operation.
What is the potential sales volume for the market segment?
Volume per customer estimate not developed.
What assumptions were made about the market segment?
Chefs will be more likely to buy fresh produce produced in the immediate area of the restaurant. It is expected that sales to these customers will be made at the farm stand at the growing center and direct marketing to the restaurants.
What research was conducted or referenced about the market segment?
A Market Analysis was conducted by Firm Z for the Town X CDC including surveys of chefs in the market area.

Example Worksheet # 13 Competition

Describe the competition for each market segment and how the business will be positioned to compete in each market segment. Complete a worksheet for each market segment.

Market Segment: Retail, Direct to Consumer
Who are the competitors for each market segment?
There is no direct retail competition in the immediate site neighborhood. Larger chain grocers such as Market A and Chain Grocery Store "S" are located on the northern fringe of the market area and there is a Chain Grocery Store "SL" located less than 0.5 miles north of the growing center at the corner of "L" and "M" Streets. Town X Farmers Market (downtown and suburban locations). Natural Food Co-op.
What are the advantages of your business in this market segment?
Location within the community with weak retail competition - Over 70% of the residents surveyed in the area of the growing center responded that if fresh local produce were available in their area, they would be very likely to purchase locally. The highest share of those who responded positively to this question responded that they would be most likely to purchase produce at a farmers market in the community. Produce that is local and organic; an accessible location; highly visible; community ties and neighborhood investment; established networks with community groups from the Town X CDC; at the source fruits and vegetables.
What are the disadvantages of your business in this market segment?
The convenience of shopping at larger grocery stores will compete with the growing center as shoppers may favor one stop shopping over fresh and local fruits and vegetables. Mobility of the residents within the PMA; Consumer Buying Patterns: Produce is not as "cost efficient" as fast food.
How will your business differentiate itself from your competitors? Why will customers switch to or select this business?
Community based business that not only provides fresh fruits and vegetables, but provides job training, nutritional education, and volunteer opportunities for the community. Community supported agriculture (CSA) approach will be implemented once the crop production reaches a critical mass sufficient to support this approach. Customers will frequent this facility because of its accessibility, convenience, quality product.

Example Worksheet # 13 Competition

Market Segment: Wholesale, Direct to Restaurants
Who are the competitors for each market segment?
The growing center would compete with grocery stores, produce wholesalers and local farms for business with local restaurants. Area growers include: • Berry Farm, Town Y, USA (berries and berry products). • "X" Farms, Town A, USA. • "B" Farms, Town B, USA. • "C" Greenhouse and Strawberry Farm, Town C, USA. • "LK" Farm, Town C, USA. • "MQ" Orchards, Town D, USA. • "TMC" Farm, Town E, USA. • "GT" Farms, Town D, USA (strawberries only). • "Z" Farms, Town F, USA. Area wholesale distributors of fresh local produce include*: • "AP" & Sons & Daughter Too, Town X, USA. • "C" Foods Inc., Town X, USA. • "SO" Produce Company, Town X, USA. • "S" Foods, Town X, USA.
What are the advantages of your business in this market segment?
Location within the community. Produce that is local and organic. An accessible location; highly visible. Community ties and neighborhood investment. At the source fruits and vegetables.
What are the disadvantages of your business in this market segment?
The convenience of purchasing from larger farms or wholesale suppliers. Limited selection of fruits and vegetables. New to the market segment.
How will your business differentiate itself from your competitors? Why will customers switch to or select this business?

Community based business that not only provides fresh fruits and vegetables, but provides job training, nutritional education, and volunteer opportunities for the community.

Customers will frequent this facility because of its accessibility, convenience, quality product, community support.

Example Worksheet # 14 Promotion

Describe how the product will be sold and what will be communicated to customers in each market segment. Complete a worksheet for each market segment.

Market Segment: Retail, Direct to Consumer
How will your business gain access to the market segments?
Soliciting support and ownership by the community of the growing center in the surrounding neighborhood. Town X CDC contacts with local organizations, churches and other community groups. Erect signs visible from "D" Avenue as well as "D" Street to direct visitors to the growing center and on the fence surrounding the growing center. Community recruitment and volunteers for the development and operation of the growing center. Program participation: Supplemental Nutrition Assistance Program (SNAP), Women, Infants, and Children (WIC) supplemental nutrition program, and Farmer's Market Nutrition Program (FMNP). Reward volunteer groups with snacks and/or take-away such as a share of the crop.
What approach will you use for promotion?
During the first year, the surrounding neighborhood and interest organizations will be asked to participate in a number of promotions: tree planting, and opening ceremony, web promotions, database management, marketing communications and program participation. Contest to develop the logo for the growing center. Students and artists from the surrounding neighborhood will be asked to create the signs with materials donated to the Town X Growing Center from Habitat for Humanity or other local organizations. Competition for local artists and students could be coordinated by a local high school art teacher.
What message will you communicate to your potential customers?
Fresh fruits and vegetables locally grown within the community. Community volunteers needed and welcomed. Educational and job training opportunities. Encourage ownership in the growing center and its success within the community.

How often will customers be contacted through advertising and communications?
Regular (at least monthly) visits to local church groups, senior centers, youth centers and school classes to work and learn during the Town X Growing Center's first growing year.

Example Worksheet # 14 Promotion

Market Segment: Wholesale, Direct to Restaurants
How will your business gain access to the market segments and distribution channels?
Direct contact with chefs at local restaurants. Requests by customers of restaurants that are also members of the community around the growing center.
What approach will you use for promotion?
Direct contact with chefs at local restaurants. Word of mouth by customers of restaurants that are also members of the community around the growing center. Advertising (e.g., fliers).
What message will you communicate to your potential customers?
Quality fresh fruits and vegetables locally grown within the community. Competitively priced. Consistent supply.
How often will customers be contacted through advertising and communications?
Regular (at least monthly) contacts or visits to area restaurants.

Example Worksheet # 15 Crop Management

Production management for a farm involves maximizing the food crops that can be produced on a piece of land in order to meet the objectives of the marketing strategy, in terms of the type, amount, and quality of crops that are to be produced, and the profitability of those crops.

What approach will be used for crop production (native soil plantings, raised beds, aquaponics)?

Crops will be grown in four 30 feet wide by 96 feet long hoop houses. Each hoop house will contain 24 – 30 four feet wide by eight feet long raised planter beds. Vertical gardens will be used during the spring and summer growing seasons for berries. It is anticipated that one of the four hoop houses will include an aquaponics system to be utilized for both raising fish such as tilapia and vegetables.

In year one, a single hoop house along with vertical gardens will be installed with initial plantings in the spring. The second and third hoop houses will be erected during the first year for use in the second year. The fourth hoop house will be erected in the second year for use in the third year with the aquaponics production anticipated in the fourth or fifth year of operation using a portion or all of one of the fourth hoop house. The vertical gardens will be installed and plantings accomplished in spring of the first year.

Crop production techniques will be developed with the assistance of Town X Grows, the University of Town X, and the *Nonprofit Food Technology*.

In addition to crop production facilities, an 1800 square foot educational facility including a class room and rest rooms will be constructed on the site during the first year. In addition, a free standing farm stand will also be provided on the side with an enclosure added in the second year or third year.

Storage of tools and other equipment will be on shelves and benches constructed within the hoop houses until a storage shed is erected in the second year.

What crop management alternatives will be implemented (e.g., weed, pest and disease control)?

All crop production will use organic growing methods to meet the criteria of a certified organic crop production facility. Organic pest management practices will be implemented to develop and maintain healthy soils and strong plants that can withstand pests and encourage beneficial insects by creating environments that attract them. Crop selection will focus on biodiversity in the crops and crop varieties that are resistant to pests and diseases. Selected approved substances will be used when necessary.

How will soil fertility be addressed (e.g., enhance existing soils, compost, mulch, fertilizer)?

Organic materials such as cover crops, crop residues, and compost will be added to soils to build soil organic matter and improve the ability of the soil to supply nutrients to the plants. It is anticipated that composting will be conducted on the growing center.

What type of water supply (e.g., city water, well) and irrigation system will be used (e.g., tile drains, drip zone irrigation, sprinkler systems)?

Water is supplied by the municipal water system. Plant irrigation will initially be accomplished by hand watering using a water spigot, hose and nozzle. Once there is a better understanding of the quantities of water needed other methods of watering such as drip irrigation will be evaluated.

Will seeds or seedlings be used? How will seed and plant selection be accomplished?

Seeds and seedlings will be obtained from a combination of "BS" Farms, Town X Grows, and Town X Botanical Gardens. Seedlings will ultimately be developed at the Growing Center.

Example Worksheet # 15 Crop Management

What waste handling and disposal will be required and how will it be accomplished?
Organic waste such as crop residues will be composted on the site. Recyclable materials such as plastics, paper, and cardboard will be recycled. Extra crops that are not sold will be donated to community food centers. Disposal wastes will be minimized.
What quality control measures will be needed?
Quality control will be needed for all aspects of crop production and harvesting. Quality control will need to address soil fertility, plant survival, and the quality and appearance of the crops.
How will security for the property, equipment, and crops be accomplished (e.g., fencing, cameras)?
The property is fenced around its perimeter. An access gate for vehicles to enter the site and walk gates for customers and workers to enter the site.
Identify any other crop management issues (itemize)?
No other issues are identified at this time.

Example Worksheet # 16 Planting and Harvesting Schedule

Discuss your planting and harvesting schedules.

How will plantings be made to achieve the required crop harvest to meet the marketing strategy?

An aggressive operational plan focused on highly productive cropping systems including crop rotation, succession planting, intercropping, companion planting, and timing of plantings including removal of plants prior to full production capacity to allow for the start of a second crop to advance production of a crop. It is anticipated that several growing seasons will be necessary prior to identification of the most productive approach for maximum capacity.

What is your planting and harvesting schedule? Identify the year each crop will first be planted.

Crop	Year	Activity	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Broccoli	1	Plant					X	X								X	X									
		Harvest									X	X	X							X	X	X				
Leaf Greens	1	Plant				X	X	X	X							X	X	X	X							
		Harvest							X	X	X	X	X						X	X	X	X	X			
Herbs	1	Plant							X	X	X	X	X	X	X	X										
		Harvest										X	X	X	X	X	X	X	X	X	X					
Cucumbers	1	Plant									X	X	X	X	X	X										
		Harvest												X	X	X	X	X	X	X						
Spinach	1	Plant						X	X									X	X							
		Harvest							X	X	X	X							X	X	X	X				
Cabbage	1	Plant				X	X	X							X	X	X									
		Harvest									X	X	X	X						X	X	X	X			
Potatoes	3	Plant					X	X																		
		Harvest										X	X	X	X	X	X									
Carrots	3	Plant			X	X	X										X	X								
		Harvest									X	X	X								X	X	X			
Beets	3	Plant					X	X	X								X	X								
		Harvest							X	X	X	X	X							X	X	X				
~~Strawberries~~	~~1~~	Plant					X	X																		

		Harvest								X	X	X	X											

Note: *Estimates are based on three seasons of production. These estimates are provided for evaluation purposes and need to be reviewed and updated by the Farm Manager based on actual crops and planting and harvest schedules.*

Example Worksheet # 17 Farm Planning

Estimate the operating expense and size and capacity of the farm.

Business Name **Town X Growing Center**

Hoop House		
Total Length	96	ft
Total Width	30	ft
Width of Row	1.5	ft
Footpath Area	30%	percent
Tool Storage Area	25	ft2
Composting Area	25	ft2
Other	50	ft2
TOTAL GROWING AREA	**1916**	**ft2**
TOTAL BED LENGTH	**1277**	**ft**
Growing Medium (For Raised Beds)		

Depth	18	inches
TOTAL SOIL VOLUME	**958**	**yards**

Hoop House

Crop	Percent of Total Growing Area	Crops					Inputs				
		Distance Between Plants (ft)	Time to Maturity (from seed) (days)	Yield (per plant) (pounds)	Yield (per foot of row) (pounds)	Market Price (per pound) ($)	Seed/ Starter ($/plant)	Nutrients ($/ft2/day)	Pest Control ($/ft2/day)	Water ($/ft2/day)	**TOTAL COST OF INPUTS ($/ft2/day)**
Broccoli	15%	2.0	60	1.50	0.8	$ 1.69	$0.010	$0.001	$ 0.001	$ 0.001	**$0.003**
Leaf Greens	25%	0.5	45	0.38	0.8	$3.00	$0.010	$0.001	$0.001	$0.001	**$0.003**
Herbs	5%	0.3	60	0.02	0.1	$3.00	$0.010	$0.001	$0.001	$0.001	**$ 0.004**
Cucumbers	15%	1.0	45	1.20	1.2	$ 0.65	$0.010	$0.001	$0.001	$0.001	**$0.003**
Spinach	25%	0.3	45	0.13	0.4	$1.75	$0.010	$0.001	$0.001	$0.001	**$0.004**
Cabbage	15%	2.0	75	3.00	1.5	$0.69	$0.010	$0.001	$0.001	$0.001	**$0.003**
Total	100%										

Example Worksheet # 17 Farm Planning

Data Calculations and Outputs **Hoop House**

Crop	Percent of Total Growing Area	Total Length of Row (ft)	Expected Annual Yield		Value of Annual Yield		Annual Cost of Inputs		Growing Seasons

			3 Season (lbs)	4 Season (lbs)	3 Season	4 Season	3 Season	4 Season	
Broccoli	15%	192	656	874	$1,108	$1,477	$243	$ 323	3
Leaf Greens	25%	319	1457	1943	$4,371	$5,828	$452	$602	3
Herbs	5%	64	15	19	$44	$58	$92	$122	3
Cucumbers	15%	192	1399	1865	$909	$1,212	$254	$338	3
Spinach	25%	319	777	1036	$1,360	$1,813	$481	$641	3
Cabbage	15%	192	1049	1399	$724	$965	$241	$322	3
	100%	**1277**			**$8,515**	**$11,354**	**$1,762**	**$2,349**	

Example Worksheet # 18– Yield (Size and Capacity)

Describe the production capacity and plans for future growth. Complete one worksheet for each market segment. Farm Planning worksheets are provided in Appendix B to assist in estimating the size and capacity of the farm. An electronic version is available, upon request.

What is the estimated output for each crop for this market segment during the first five years of production (e.g., pounds of produce per month)?

Market Segment: Retail, Direct to Consumer

Crop	Year 1	Year 2	Year 3	Year 4	Year 5
Expected Output					
Broccoli	656	1,345	1062	1316	1135
Leaf Greens	1,457	2,990	2124	2631	2271
Herbs	15	30	35	44	38
Cucumbers	1,399	2,870	2265	2807	2422
Spinach	777	1,595	1133	1403	1211
Cabbage	1049	2153	2549	3157	2725
Potatoes	0	0	1133	1403	1211
Carrots	0	0	944	1169	1009
Beets	0	0	1416	1754	1514
Strawberries	600	600	600	600	600

What are the plans for growth of the business for this market segment?

Initial sales for this market will be through the onsite farm stand and local farmers markets. Growth in this market will be through increased crop production and variety and the establishment of a Community Supported Agriculture (CSA) approach for the farm. In addition, acceptance of Electronic Benefit Cards (EBT) cards and participation in resident assistance programs will also be pursued.

Note: *Estimates are based on three seasons of production. These estimates are provided for evaluation purposes and need to be reviewed and updated by the Farm Manager based on actual crops and planting and harvest schedules. Strawberry production assumes 20 vertical units with five growing pots and four plants per pot.*

Example Worksheet # 18– Yield (Size and Capacity)

What is the estimated output for each crop for this market segment during the first five years of production (e.g., pounds of produce per month)?

Market Segment: Wholesale, Direct to Restaurants

Crop	Year 1	Year 2	Year 3	Year 4	Year 5
Expected Output (lbs)					
Broccoli	0	0	295	501	1,022
Leaf Greens	0	0	590	1,002	2,044
Herbs	0	0	10	17	34
Cucumbers	0	0	629	1,069	2,180
Spinach	0	0	315	535	1,090
Cabbage	0	0	315	535	1,090
Carrots	0	0	965	1,292	1,938
Beets	0	0	965	1,292	1,938
Strawberries	0	0	0	0	0

What are the plans for growth of the business for this market segment?

Entry into this market is not anticipated until crop production techniques and product quality objectives for this market segment have been achieved. This is expected in the third year of operation. Growth in this market segment will be achieved through direct marketing to local restaurants and expansion of the crop variety to meet the needs of this market.

Note: *Estimates are based on three seasons of production. These estimates are provided for evaluation purposes and need to be reviewed and updated by the Farm Manager based on actual crops and planting and harvest schedules*.

Example Worksheet # 19 – Physical Resources

Physical resources include land, buildings, and equipment necessary to produce and market your crops to meet the objectives of the marketing strategy. Describe your physical resource needs and how they will be acquired.

List the resources needed	*Describe the physical resource and how it will be acquired. Describe any issues which may affect the use of or access to the resource (e.g., suspected or know environmental contamination on the property).*
Land	
1646 Town X Avenue, Town X, USA.	Two plus acre former industrial property has been acquired by the Town X CDC. Environmental issues consistent with the former industrial use of the property were identified and environmental assessment and remediation activities conducted on the property. Approximately 60% of the property is covered by concrete associated with the floor and foundation of the former building located on the property. Soil on the property is not suitable for growing. The concrete pads must remain in place as a condition of the environmental remedial action.
Buildings	
Four 30 feet by 96 feet hoop houses. Educational facility (1800 square feet). Storage building.	Hoop houses will be purchased as a kit and erected on the site. Lumber and additional hardware will also be purchased. The educational facility and storage building will be designed for the specific purposed and constructed on site.
Other Structures	

Vertical gardens. Raised beds. Farm stand.	Vertical gardens have been donated by *Nonprofit Food Technology* and will be erected on the site. Lumber and other hardware for construction of the raised beds will be purchased. The farm stand will initially be an "open air" stand located on the property. An enclosed farm stand is anticipated in the fourth or fifth year of operation.

Example Worksheet # 19 – Physical Resources

Equipment	
No specific equipment has been identified for the initial years of operation.	Once crop production reaches the full capacity of the facility, it is anticipated that a vehicle may be needed to deliver product. This is not anticipated until at least the fifth year of operation.
Tools	
Gardening tools. Construction/maintenance tools.	Gardening tools include racks, shovels, hoses, spray nozzles. Tools will be obtained through donations or purchased as needed. Construction/maintenance tools include hand tools such as hammers, screw drivers, wrenches and power tools such as saws and drills. Tools will be obtained through donations or purchased as needed.
Supplies	
Soil. Compost.	Soil and compost will be needed initially to establish the raised beds and initiate crop production. Soil and compost will be obtained through donations or purchased as needed. Compost is anticipated to be produced on site in the future.
Utilities	
Water. Electric. Sewer. Natural gas.	Utilities will be purchased from local suppliers. Water lines with frost proof spigots will need to be run to each hoop hose and the vertical gardens as they are constructed. Electricity for lighting and weather proof electrical outlets will also need to be run to each hoop house and the vertical garden as they are constructed. Water, electric, sewer, and natural gas will need to be provided to the education facility and electricity will need to be provided to the storage shed and farm stand on the site as part of the building construction.

Other Resources (Itemize)?	
Composting facility.	The type of facility will be evaluated once anticipated production quality and productivity has been achieved and the amount of composted needed has been determined. In addition, a source of organic material other than crop residue generated on the site may be needed.

Example Worksheet # 20 Manpower Needs

Identify the labor tasks and estimate the number of hours per week and weeks per year required for each task.

Task	Year 1			Year 2			Year 3			Year 4			Year 5		
	Hours/ week	Weeks/ year	Total	Hours/ week	Weeks/ year	Total	Hours/ week	Weeks/ year	Total	Hours/ week	Weeks/ year	Total	Hours/ week	Weeks/ year	Total
Marketing															
Sales/deliveries	10	30	300	10	30	300	20	30	600	20	30	600	30	30	900
Promotion	10	5	50	10	5	50	10	5	50	10	5	50	10	5	50
Marketing Total	**20**	**35**	**350**	**20**	**35**	**350**	**30**	**35**	**650**	**30**	**35**	**650**	**40**	**35**	**950**
Operations															
Farm Manager	40	52	2080	40	52	2080	40	52	2080	40	52	2080	40	52	2080
Farm volunteers (Crop management)	60	52	3120	60	52	3120	60	52	3120	60	52	3120	60	52	3120
Farm volunteers (harvest)	60	30	1800	90	30	2700	90	30	2700	120	30	3600	120	30	3600
Construction volunteers (Hoop houses)	240	2	480	240	2	480	240	2	480	240	2	480			
Operations Total	**400**	**136**	**7480**	**430**	**136**	**8380**	**430**	**136**	**8380**	**460**	**136**	**9280**	**220**	**134**	**8800**

Example Worksheet # 20 Manpower Needs

Task	Year 1			Year 2			Year 3			Year 4			Year 5		
	Hours/ week	Weeks/ year	Total	Hours/ week	Weeks/ year	Total	Hours/ week	Weeks/ year	Total	Hours/ week	Weeks/ year	Total	Hours/ week	Weeks/ year	Total
Administrative															
Administrative services (Town X CDC)	4	50	200	4	50	200	4	50	200	4	50	200	4	50	200
Administrative Total	**4**	**50**	**200**	**4**	**50**	**200**	**4**	**50**	**200**	**4**	**50**	**200**	**4**	**50**	**200**
Financial															
Financial services (Town X CDC)	4	50	200	4	50	200	4	50	200	4	50	200	4	50	
Financial Total	**4**	**50**	**200**	**4**	**50**	**200**	**4**	**50**	**200**	**4**	**50**	**200**	**4**	**50**	**200**

Note: *Manpower will need to be re-evaluated by the Farm Manager and Director of Town X CDC as the farm is brought into production. Initial manpower needs may be higher in order to set-up the facility and begin operations.*

Example Worksheet # 21 Workforce Needs

Describe the manpower needed to operate the farm. This should include management, as well as farm labor.

Position description	What skills or experience are needed?	How will positions be filled (e.g., full-time, part-time, volunteer, service contractor)?	What benefits will be offered?	Typical salary range
Farm manager.	Knowledge of farm management, three season growing using hoop houses and vertical gardens, and organic farming techniques.	Full-time.	?	$35,000 to $40,000 per year.
Farm workers.	No specific skills or experience required.	Part-time volunteers.	None.	None.
Promotion.	Knowledge of advertising and graphics.	Part-time volunteers.	None.	None.
Sales and distribution.	Experience in sales, drivers license and vehicle.	Part-time volunteers.	None.	None.
General workers.	Basic skills in construction for assembly of hoop houses.	Part-time volunteers.	None.	None.
Administrative support.	Basic administrative skills.	Part-time – will be filled by existing Toledo CDC employees.	Existing benefits.	Existing salary.
Financial support.	Basic financial skills.	Part-time – will be filled by existing Toledo CDC employees.	Existing benefits.	Existing salary.
What training will be required and how will it be accomplished?				
Training will be accomplished by the farm manager for all farm workers. Sales, promotion, and delivery training will be provided by Town X CDC.				

Example Worksheet # 22 Regulation and Policy

Identify the type of permits, licenses, regulations, or certifications and associated fees required to start up and conduct the business.

What regulatory requirements exist? What conditions or issues are associated with each requirement? What fees will be incurred? Can the requirement be met?				
Regulatory Issue	**Requirement**	**Conditions or Issues**	**Fees ($)**	**Can it be met?**
Planning.	Planning approval is required and has been received.	No conditions.	No Fees.	Yes.
Zoning.	Property zoning includes agricultural uses.	No conditions.	No Fees.	Yes.
Waste handling and disposal.	No specific waste handling requirements; however, composting may require approvals.			
Health.				
Safety.	Federal and state worker safety will need to be considered for employees and labor.			Yes.
Building.	Building permits will be needed for all structures.			Yes.
Inspections.	Inspections will be required for new construction.			Yes.

Environmental.	Environmental issues have been addressed through the State Voluntary Action Program. Site assessment and remedial action are complete.	Native soil cannot be used for crop production, concrete pads must remain.	No.	Yes.

Example Worksheet # 22 Regulation and Policy

What regulatory requirements exist? What conditions or issues are associated with each requirement? What fees will be incurred? Can the requirement be met?				
Regulatory Issue	**Requirement**	**Conditions or Issues**	**Fees ($)**	**Can it be met?**
Food handling (handling, storing, packaging, and distributing).				
Business operations.				
Sales tax.				
Other (itemize).				

Note: *Additional information will need to be obtained in order to identify regulatory issues.*

Example Worksheet # 23 – Annual Expenses

Estimate the annual expenses for the farm.

Detailed Expenses	Year 1	Year 2	Year 3	Year 4	Year 5	Assumptions
						Assumption for annual adjustment for inflation percentage. *Identify any additional assumptions used to develop the expense estimates.*
Direct Farm Operating Costs						
Annual setup and removal						
Hoop house-temporary	-	-	-	-	-	Hoop houses to be permanent - One-time cost for installation.
Vertical garden	100	100	100	100	100	Vertical gardens will be installed by volunteers or farm manager, cost for miscellaneous items for set-up.
Other						
100	100	100	100			
1,000	1,000	2,000				
			2,000			
1,000	1,000	2,000	2,000			

Example Worksheet # 23 – Annual Expenses

	0					
Total annual setup and removal						
Repairs and Maintenance						
Minor repairs to hoop houses and raised beds.	Repairs and Maintenance					
Total repairs and maintenance						
Equipment and Tools						
Fuel	-	-	-	-	-	No fuel use is anticipated.
Equipment leases (long-term)	-	-	-	-	-	No leases anticipated.
Rentals (short-term or daily)	-	-	-	-	-	No rentals anticipated.
Processing equipment	-	-	-	-	-	No processing equipment anticipated.
Tools	100	100	100	100	100	Annual expenditure to replaced worn or broken tools.

Example Worksheet # 23 – Annual Expenses

Tractor		-	-	-	-	-	No tractor anticipated.
Detailed Expenses		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Assumptions**
Truck		-	-	-	-	-	A truck or delivery vehicle may be needed but not anticipated in first five years.
Other							
100	100	100	100	100			
100	200	300	400	400			
100	200	300	400	400			
-	1,000	1,000	500	500			
900	1,000	1,500	1,800	2,000			
1,100	2,400	3,100	3,100	3,300			

Human Resources &
Personnel

Example Worksheet # 23 – Annual Expenses

Direct Farm Payroll	31,200	31,200	31,200	31,200	31,200	Assumed $15.00 per hour for 2080 hours per year.
Manager salaries						
Hourly payroll	-	-	-	-	-	Additional labor is assumed to be volunteer.
Temporary workers	-	-	-	-	-	
Benefits	1,560	1,560	1,560	1,560	1,560	Additional labor is assumed to be volunteer. Assumed to be 5% of salary.
Workers compensation insurance	1,872	1,872	1,872	1,872	1,872	Assumed to be 6% of salary.
Payroll taxes	6,240	6,240	6,240	6,240	6,240	Assumed to be 20% of salary.
Payroll service fees	-	-	-	-	-	Assumed to be covered by Town X CDC.
Volunteer expenses	2,000	2,000	3,000	3,000	3,000	Miscellaneous costs for volunteers.
Administrative payroll	-	-	-	-	-	Assumed to be covered by Town X CDC.
Total equipment						
Seed & Soil Materials						

Example Worksheet # 23 – Annual Expenses

Soil condition and pest control is anticipated Fertilizers and pesticides through soil management techniques.

Seeds and seedlings will be donated or Seed/seedlings seedlings started at farm.

Assume compost will be generated on site in Soil preparation later years.

Supplies

Other

Total materials

Detailed Expenses	Year 1	Year 2	Year 3	Year 4	Year 5	Assumptions
Training and professional development	500	500	500	500	500	Cost to attend conferences/training session for Farm Manager.

Example Worksheet # 23 – Annual Expenses

Professional							
Accounting							
Consulting							
Contractors				-	-	-	-
Legal				-	-	-	-
				-	-	-	-
Other				-	-	-	-
43,372	43,372	44,372	44,372	44,372			
-				-	-	-	-
300				300	300	400	400
1,000				1,000	1,500	2,000	2,000
-				-	-	-	-
-				-	-	-	-
1,300				1,300	1,800	2,400	2,400

- Assumed to be covered by Town X CDC.
- Assumed to be covered by Town X CDC.
- Assumed to be covered by Town X CDC.
- Assumed to be covered by Town X CDC.

Total human resources

Sales and Distribution

Delivery Assumed to be handled by volunteers.

Example Worksheet # 23 – Annual Expenses

Fuel, travel & vehicles Volunteer fuel reimbursement.						
Packaging materials (crates, bags) Bags and/or crates for produce.						
Storage No storage anticipated.						
Rent No rent anticipated.						
Other						
Total sales and distribution						
Marketing and Advertising						
	300	300	300	300	300	Marketing materials.
Advertising	300	300	300	300	300	Marketing materials.
	300	300	300	300	300	Marketing communications.
Direct marketing	500	500	500	500	500	Periodic mailers to 1000 plus.
Mailing and advertising supplies						
Postage						
Public and press relations						
Signs	150	150	150	150	150	New and replacement signs - materials only - labor assumed to be volunteer.
Detailed Expenses	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Assumptions**

Example Worksheet # 23 – Annual Expenses

Web site and web advertising						Assumed to be maintained by Town X CDC and volunteers.
Licensing						
Other	500	500	500	500	500	Volunteer expense reimbursement.
2,050	2,050	2,050	2,050	2,050		
2,000	2,000	2,000	2,000	2,000		
1,200	1,200	1,200	1,200	1,200		
500	600	750	800	800		
600	600	600	600	600		
1,000	1,800	1,800	1,800	1,800		
5,300	6,200	6,350	6,400	6,400		

Example Worksheet # 23 – Annual Expenses

General and Administrative					
Bank Charges	-	-	-	-	-
	-	-	-	-	
Computers					-
Insurance	2,000	2,000	2,000	2,000	
	2,000	2,000	2,000	2,000	
Liability					2,000
Property & Casualty					2,000
	-	-	-	-	
Licenses, permits, and fees	500	500	500	500	
	-	-	-	-	
Miscellaneous	500	500	500	500	-
Office equipment					500
Postage					-
Rent and leases					500
Supplies					
Taxes - entity or corporation					
Taxes - property					
Total marketing and advertising					

Example Worksheet # 23 – Annual Expenses

Utilities

Electric

Telephone Cell phone for farm manager.

Water

Sewer

Heat (oil, gas)

Total utilities

Detailed Expenses	Year 1	Year 2	Year 3	Year 4	Year 5	Assumptions
Other						
	5,000	5,000	5,000	5,000	5,000	

Example Worksheet # 23 – Annual Expenses

1,550				
150				
1,000				
	5,000	5,000	5,000	
5,000				-
7,700	5,000	5,000	5,000	-
-	-	-	-	-

Total general

Example Worksheet # 23 – and administrative

One-Time or Start-up Costs

Deposits with public utilities
Community recruitment, opening ceremony Promotion for opening

Example Worksheet # 23 – Annual Expenses

(Based on Market Study estimate).

Initial signs and log development (Based on Signs

Market Study estimate).

Web ordering system

Site Cleanup, shrub and

Other

tree removal

Initial Soil/Compost for Initial cost for soil/compost to set up beds in beds new hoop houses.

Total start-up costs

Non-cash expenses

Depreciation

Total non-cash expenses

Example Worksheet # 24 Projected Income

Detailed Income	Year 1	Year 2	Year 3	Year 4	Year 5	Assumptions and Limitations
Farm Sales						
Retail	10,315	19,275	28,877	32,658	27,170	Assumed 100%, 100%, 85%, 75%, 65% of sales in year 1, 2, 3, 4, 5, respectively.
Wholesale	-	-	5,096	11,219	15,707	Assumed 0%, 0%, 15%, 25%, 35% of sales in year 1, 2, 3, 4, 5, respectively.
Other programs	35,000	30,000	25,000	20,000	15,000	CSA Income from retail sales.
Less: Spoilage	103	193	340	459	449	Assumed to be 1% of crop.
Net Projected Sales	10,000	5,000	5,000	5,000	5,000	
Other sources of Income	3,000	3,000	3,000	3,000	3,000	
Grants						
USDA Grant Assumed	-	-	-	-	-	Initial year based on Market Research proposal. reduce funding in subsequent years.
Local Grants Assumed reduce funding in subsequent years.	-	-	-	-	-	Initial year based on Market Research proposal.
Donations	48,000	38,000	33,000	28,000	23,000	
Special Events Initial year based on Market Research proposal.						
(Source)						
Interest income						
Rental income						
Total other income						

Example Worksheet # 25 Income and Expense

Estimate the annual profit or loss for the farm.

Profit & Loss Projection	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Income					
Projected Sales	10,419	19,468	34,313	46,336	45,326
Grants and other income	48,000	38,000	33,000	28,000	23,000
Total Income	58,419	57,468	67,313	74,336	68,326
Direct Operating Expenses Annual					
setup and removal	100	100	100	100	100
Total repairs and maintenance	1,000	1,000	1,000	2,000	2,000
Equipment and Tools	100	100	100	100	100
Seed & Soil Materials	1,100	2,400	3,100	3,100	3,300
Human Resources & Personnel	43,372	43,372	44,372	44,372	44,372
subtotal	45,672	46,972	48,672	49,672	49,872
Indirect Operating Expenses					
Sales and Distribution	1,300	1,300	1,800	2,400	2,400
Marketing and Advertising	2,050	2,050	2,050	2,050	2,050
Utilities	5,300	6,200	6,350	6,400	6,400
Total Operating Expenses	54,322	46,850	49,200	50,850	51,050
Net Operating Income(Loss)	**4,097**	**946**	**8,441**	**13,814**	**7,604**
General and Administrative	5,000	5,000	5,000	5,000	5,000
One-Time or Start-up Costs	7,700	5,000	5,000	5,000	-
Net Income Before Non-Cash Items	(8,603)	(9,054)	(1,559)	3,814	2,604
Depreciation and other non-cash expenses	-	-	-	-	-
Net Income Before Taxes	(8,603)	618	8,113	13,486	12,276

Example Worksheet # 25 –

Income Taxes (if any)

Income and Expense

Profit & Loss Projection	Year 1	Year 2	Year 3	Year 4	Year 5
Net Income (Loss)		(9,672)	(9,672)	(9,672)	(9,672)

Example Worksheet # 27 – Projected Fixed Assets

Estimate the fixed assets for the farm.

Fixed Assets	Year 1	Year 2	Year 3	Year 4	Year 5
Initial Cash Outlay for Fixed Asset					
Land (Purchase or Lease)	-	-	-	-	-
Site preparation	188,000				
Hoop house (including construction labor)[3]	16,000	16,000	16,000	16,000	-
Raised beds/planters	2,250	2,250	2,250	2,250	-
Vertical garden hardware	4,500	-	-	-	-
Buildings and other structures (Itemize)	297,000				
Sales shed or farmstand			40,000	162,000	
Equipment (Itemize)					
Other	5,000	1,000	1,000	1,000	

Assumptions

Identify any assumptions used to develop the expense estimates.

Example Worksheet # 28 –

					(Building and site prep estimates based on January 2011 preliminary project cost estimate.)
					Labor assumed to be performed by volunteers. Labor assumed to be performed by volunteers. Labor assumed to be performed by volunteers.
					Educational Facility.
					Enclosed farm stand, Shed.
					Installation of electric and water for hoop houses, repair of fences and installation of gates.
Total outlays for fixed assets	512,750	19,250	59,250	181,250	-

[3] It is assumed that four Hoop Houses will be built on the site over four years as outlined under Example Worksheet #5 – Goals.

Projected Funding

Estimate the funding sources for the farm.

Available Capital	Year 1	Year 2	Year 3	Year 4	Year 5	Assumptions and Limitations
						Identify any assumptions used to develop the expense estimates or limitations on the use of grants, donations or other funds.
Grants						
County Port Authority	28,500		10,000	10,000		Development and Administration grant.
State Community Development Finance Fund	20,000		10,000	20,000		Received – Site preparation, building construction, storage building.
Local Foundation Grant	35,000					Potential – Purchase of hoop houses.
CDBG	437,000			106,000		Potential – Site development, education center, farm stand.
USDA Grant: Community Food Project		10,000	15,000	20,000		Potential – Provide funding for capital improvements, hoop houses.
Donations						
Nonprofit Food Technology	7,000		15,000	15,000		Donation of vertical garden equipment, hoop houses.
Local donations and Fund raising events	10,000	10,000	10,000	10,000	10,000	Offset portion of farm manger salary.
Loans						
Investment						
Financing						
Other sources of capital						

:t # 30 —

Total available capital	537,500	20,000	60,000	181,000	10,000

Example Worksheet # 31 – Funding Information

Describe the sources of funding (capital) to purchase and install the fixed assets needed to start up the farm and achieve the business plan.

What are the potential sources of funding?
Funding for Site preparation, hoop houses, education facility and storage building - Department of Housing and Urban Development (HUD) Community Development Block Grant (CDBG). County Port Authority. *Nonprofit Food Technology*. Local donations and fund raising events.
Are there specific limitations on the funding?
HUD CDGB funds can be used for the improvement of communities through assistance to low- to moderateincome persons and addressing slum and blight.
What are the critical assumptions concerning the funding?
Funding is available and can be obtained within the time constraints for construction. HUD CDGB funds will be invested in public facility activities that will spur further economic investment and maximize job creation/retention.
What is the timing of the funding and how will it impact the achievement of the business plan?
It is essential that funding be obtained in late fall in order to ensure that improvements are in place for the growing season.
How will the funding be obtained?
HUD CDGB funding will be obtained through a grant application to Town X. Funding applications will be submitted to appropriate funding source. Fund raising events will be held on the farm at area community facilities.
Are there expenses associated with the funding?
There will be administrative expenses in developing the information needed for the applications and preparing the applications for the grant funding. There will be costs for fund raising events.

Example Worksheet # 29 – Risk Management

Identify and evaluate potential risks that can impact the financial strategy and the success of the business plan.

What are the potential risks that may need to be managed?	**How likely is the risk to occur (high, medium, low)?**	**What is planned to minimize potential risks if they occur?**
Production: Crop failure or unusually small yields.	High - Smaller than planned yield rates are likely during the first few years.	Farm Manager's primary objective during the first few years will be to implement cultivation techniques that minimize overhead and maximize production. This will be accomplished with support from the University of Town X, *Nonprofit Food Technology*, and Town X Grows.
Marketing: Unable to sell full production.	Medium.	Focused promotion and marketing approach. Utilize volunteers to interact with potential customers.
Financial: Unable to obtain sufficient funding to sustain the first three to four years and to fund growth.	High.	Incorporate fund raising using events at the farm and focus effort to obtain federal, state, and/or private funding.
Labor: Unable to find sufficient volunteers and maintain consistent labor force. Performance of Farm Manager.	Medium.	Utilize educational activities at local high schools and trade schools, and the University of Town X, and solicit neighborhood and community groups for support and volunteer time.
Other.		

www.epa.gov/brownfields/urbanga

EPA-905-K-11-002
September 2011- Update



US EPA Region 5 77
W. Jackson Blvd.
Chicago, IL 60604

Summary Description for Module 9

Title:	Module 9: Introduction to Permaculture
Instructor:	Patrick Johnson
Prerequisites, if applicable:	None
Class Time:	9:00AM – 11:30AM
Learning Objective:	In this module students will learn and began to apply the fundamental principles of permaculture. They will begin by exploring their current worldview of how they look at such permaculture elements as agriculture and landscape design and how trained permaculturalist look at these fields via permaculture ethics and design principles.
Instructor Media Needs:	Screen Projector Screen Pointer Computer
Class Materials and/or Supplies Needed:	Instructor provided printed copies of class notes with review questions at the end of the chapter (MSWord) PowerPoint slides (in electronic and/or printed format)
Class Activities:	1. The instructor will present an introduction to permaculture. 2. The core ethics of permaculture will be outlined. 3. Permaculture principle of natural systems and design will be discussed. 4. We will have a discussion on patterns in design.
Knowledge Gained:	Students will gain an understanding of some basic feature of permaculture as design system.
Skills Gained:	Students will gain the skills of identify patterns in the natural work and how are applied in permaculture.
Abilities Gained:	Students will begin to see our world as a permaculturalists does.
Exam Description:	A quiz will be administered in the first and second section.

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Permaculture

Patrick Johnson

(*Certified Permaculturalist*)

Section 1: Introduction

What is "Permaculture?" Permaculture was initially defined as permanent agriculture. Later Bill Mollison, one of the principal founders of permaculture, defined it as "permanent culture".

Permaculture was as conceived by Bill Mollison and David Holmgren is said to be an, "integrated, evolving system of perennial or self-perpetuating plant and animal species useful to man."

Later the definition used on Permaculture One, is "Consciously designed landscapes which mimic the patterns and relationships found in nature, while yielding an abundance of food, fiber and energy for provision of local needs."

We define permaculture here as a system of ecological design based on three ethical principles:

Permaculture Ethnic

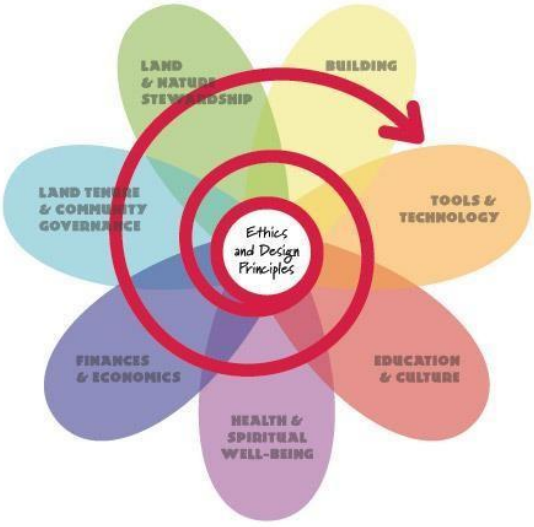
Care of the Earth –includes all living and non-living things, such as animals, plants, land, water and air.

Care of People – pass on anything surplus to our needs (labor, money, information). For the above aims.

Implicit in the above is the "Life Ethic": all living organisms are not only means but ends. In addition to their instrumental value to humans and other living organisms, they have an intrinsic worth,

Permaculture is "open sourced". This means that permaculture definitions and techniques change as new ideas are developed by practitioners of permaculture.

David Holmgren in "Permaculture Principles & Pathways Beyond Sustainability" summarizes permaculture with the "Permaculture Flower".



Permaculture spears of influence include: landscape design, organic farming and gardening, green building, water conservation, animal husbandry as well as social and political influence.

Permaculture is also said to be a network of individuals and groups spreading permaculture design solutions in both rich and poor countries on all continents. Permaculture has shown its local adaptability mostly by local interpolation of the Permaculture Design Course (PDC). The PDC has accelerated the growth and expansion of permaculture.

Design Principles of Permaculture

1. Observe and Interact
2. Catch and Store Energy
3. Obtain a Yield
4. Apply Self-Regulation and Accept Feedback
5. Use and value Renewable Resources and Services
6. Produce No Waste
7. Design from Patterns to Details
8. Integrate Rather than Segregate
9. Use Small and Slow Solutions
10. Use and Value Diversity
11. Use Edge and Value the Marginal
12. Creatively use and Respond to Change

Section II: Patterns

As was learned in the first section of our discussion, permaculture is based on learning from nature then try to mimic natural patterns found in nature. Let look at some pattern found in nature by viewing this short video: https://www.youtube.com/watch?v=u_CaCie8R4U.

Common Pattern in nature:

Branching Patterns (example)

Wave Patterns (example)

Spiral Patterns (example)

Flow Patterns (example)

Natural Pattern implications in design:

A) Edge effect: the interface between two ecosystems represents a third, more complex system which combines both. The interface, or edge, receives more light and nutrients and so is more productive.
B) Harmonics and area: increase in linear effects while the area is constrained'
    a. Low productivity (square, circle pond)
    b. Productivity increase as the shape of the pond is changed to produce more "margin or edge. The number of plants around the edge may almost double, and so may the number of fish since they are mainly marginal feeders.

Other examples of patterning with edge include:

- Circle garden rather that linear garden (saves space and water)
- Trellis on zig-zag pattern rather than straight line
- Crop planted in strips and contours with companionable crop in between strips (crops receive more light for photosynthesis and yield is high for both)
- Windbreak can be planted either to deflect wind or to tunnel it into a gap for wind power.
- Gardens can make use of "keyhole" pattern to maximize space and yield.

If time allows the following discussion will take place: Discussion of the Fibanacci Numbers (nature) vs. Man's exponential growth pattern (use of resources).

Summary Description for Module 10

Title:	Module 10: Plant Disease Management
Instructor:	Dr. Zelalem Mersha, Assistant Professor, Plant Pathology
Prerequisites:	None
Class Time:	9:00AM – 11:30AM & 12:00PM – 3:00PM
Learning Objective:	After completing the module, the student will become familiar with the pathogen groups (fungi, bacteria, viruses, and nematodes) that can cause plant disease. This will allow the participants to conduct basic disease identification, the first step in disease management. Students will then be introduced to the multitude of methods (cultural, resistance, chemical, etc.) that are available to producers. To assess learning, students will be given both a pre-course and post-course exams.
Instructor Media Needs:	Computer for PPT file on memory stick, projector
Class Materials and/or Supplies Needed:	The instructor will provide handouts
Class Activities:	1. Identification of major pathogen groups 2. Become familiar with basic concepts of suppressing disease in conventional and organic settings
Knowledge Gained:	Students will learn how to approach disease diagnostics and how to implement measures to suppress levels of them.
Skills Gained:	Students will be equipped with skills to conduct initial disease diagnostics and how to implement a disease management plan.
Abilities Gained:	Students will be able to diagnose diseases and learn what measures can prevent them.
Exam Description:	Prior to Module 11, students will be given a pre-module exam to assess their baseline knowledge on plant pathology. Students will receive a post-module exam to assess their learning progress.

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Disease Management Principles

Zelalem Mersha, PhD
PLANT AND SOIL SCIENCES
Assistant Professor of Plant Pathology
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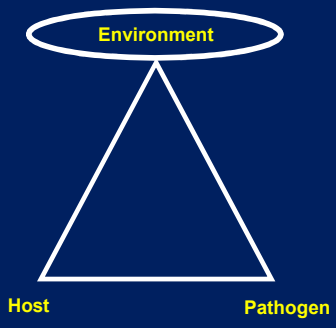




Control of Plant Diseases

- Three Major Categories
  - Cultural / Biological
  - Resistance
  - Chemical
- Most successful program includes all of the above!
- Integrated Pest Management – Term usually reserved for Insect Control, but appropriate here also

The Disease Triangle



Late Blight

- Caused by the Oomycete fungus: *Phytophthora infestans*
- Favored by cool and wet conditions:
  - Temperature: <85 – 90 F; Optimal of 65 – 75 F
  - Moisture: Disease needs 8 hours of leaf wetness (rainfall, irrigation, or dews/fogs)

Late Blight History

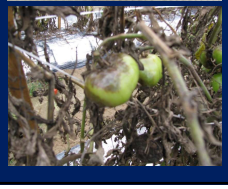
- Caused Irish Potato Famine in 1840's
  - 1.5 million deaths
  - 1.5 million immigrants into US
- Monoculture and favorable environmental conditions over several years
- Seed pieces transferred disease from year to year (1844 – 1846)

Late Blight Symptomology



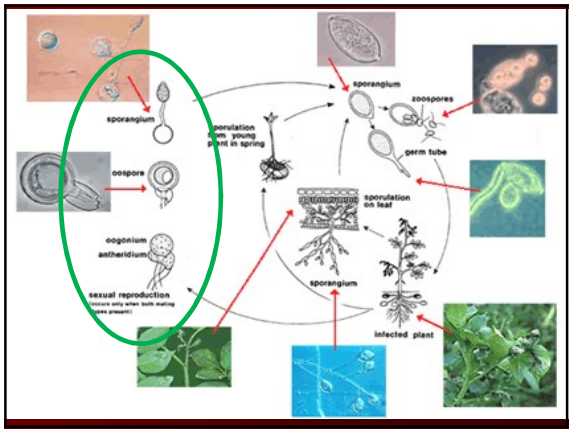






Biology of *P. infestans*

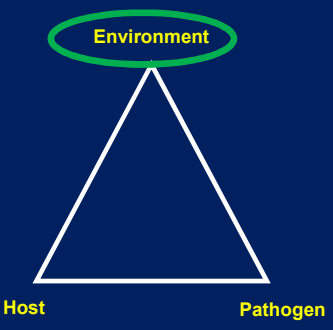
- Obligate parasite – meaning
  - Needs host
  - Cannot overwinter in soil/debris in Mid-Atlantic
- Natural Movement
  - Air currents/Rain events
- 'Other' Movement/Overwintering
  - Transplants
  - Greenhouse
  - Mating Types / Sexual Reproduction



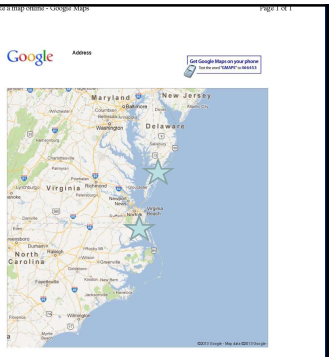
Late Blight Genotype in the US

Genotype	Host(s)	Mating Type
US-8	Potato	A2
US-11	Potato/Tomato	A1
US-20	Tomato	A2
US-21	Tomato	A2
US-22	Potato/Tomato	A2
US-23	Potato/Tomato	A1
US-24	Potato	A1

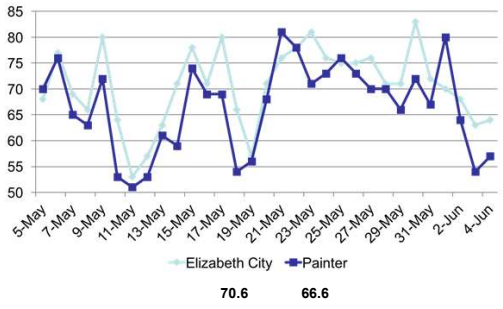
Keys to Late Blight Occurrence



A Tale of Two "Cities" in 2012 -Elizabeth City, NC -Painter, VA



Avg. RH% for May 5 – June 4, 2012



70.6 66.6

Late Blight Management

- Weather
  - At its mercy
  - Plant in areas that receive full sunlight and are not low lying
- Avoid excessive overhead irrigation
- Heirloom cultivars at greater risk
- Use certified potato seed pieces/transplants
- Scouting!

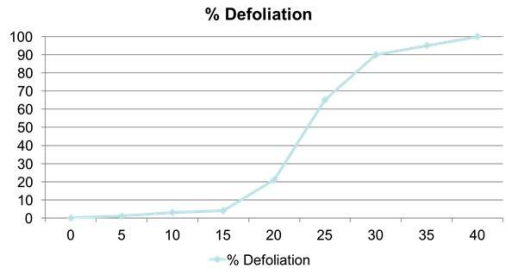
Late Blight Management

- Some resistance in Potato
  - Chieftain
  - Chippewa
  - Norchip
  - Superior
- Tomato
  - Defiant
  - Mt. Magic
  - Mt. Merit
  - Plum Regal

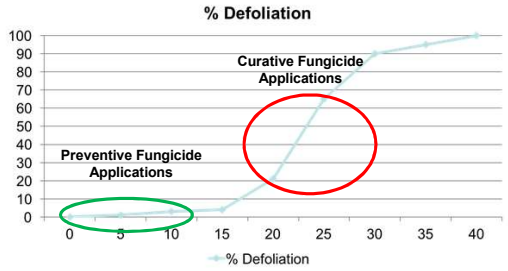
Late Blight Management

- If disease is not present in our area:
- Prevention is the key
  - Chlorothalonil / mancozeb
  - Copper/Sulfur Organic
  - Spray on 7 - 10 day schedule
  - Coverage of plant is important

Typical Late Blight Development



Typical Late Blight Development



Control of Plant Diseases

Cultural / Biological

- Crop Rotation
  - Single most effective / important tactic
  - Rotation to a non-host or fallow (best)
  - Effective on soilborne fungi, bacteria and nematodes
  - Not economically feasible sometimes due to land limitations

Control of Plant Diseases
Cultural / Biological

- Sanitation
  - Two types
    - Pre – Introduction onto your farm
    - Post – Introduction onto your farm
  - Buy certified seed (generally grown in disease free areas)
  - Avoid purchasing plant bed produced transplants (can carry soilborne pathogens)
  - Disinfect newly purchased equipment
  - In a disease is present in only certain areas, work that area last or disinfect equipment before going into clean fields

Control of Plant Diseases
Cultural / Biological

- Inoculum Reduction
  - Remove or bury crop residues
  - Control weeds
  - Steam or bleach greenhouse trays / benches and planting tools (also stakes)
  - Crop rotation

Control of Plant Diseases
Cultural / Biological

- Avoidance
  - Avoid infested areas
  - Planting time
- Irrigation Management
  - Irrigate with pathogen free water
  - Avoid overhead irrigation when possible (drip is preferable)
  - Avoid over irrigation

Control of Plant Diseases
Cultural / Biological

- Moisture Management
  - Avoid overseeding/overplanting (determine proper plant spacing both within and across rows)
  - Avoid overfertilization
  - If disease is present, avoid over irrigating
  - Avoid planting in low lying areas

Control of Plant Diseases
Cultural / Biological

- Biological Control
  - Antagonist of pathogens
  - Some work, some don't!
  - Follow labeled instructions
  - Consult recommendations guide or extension personnel to certify that

Control of Plant Diseases
Resistance

- Safest and Easiest Method of Disease Control is the use of Resistant Cultivars
- Most effective control for viral diseases
- Can be disease specific, resistance to one disease doesn't mean resistance to all (multiple disease resistance possible)

Control of Plant Diseases
Resistance

- Advantages
  - Can be complete resistance to a pest
  - Reduction of pesticide applications
  - No need to alter planting plans or purchase new equipment
  - Environmental and Antagonist Friendly

Control of Plant Diseases
Resistance

- Disadvantages
  - Seed can be expensive or hard to find
  - May be resistant only up to a certain level (may be overcome)
  - Fruit quality or timing may be different from conventional cultivars

Control of Plant Diseases
Chemical

- Pesticides
  - Two main types
    - General Use – Available to general public
    - Restricted Use – Available only to licensed applicators
  - Pesticide licenses may be obtained through your local extension office
  - Can control fungi, bacteria and nematodes
  - Viruses – No viricides
  - Label is the law!

Control of Plant Diseases
Chemical

- Fungicides (Pesticides for Fungi)
  - Two main types
    - Systemic – Penetrates and spreads throughout the plant
    - Protectant – Does not penetrate plant tissue but is adhered to the plant

Systemic Fungicides

- Active within the plant.
- Contact fungicide at site of placement.
- Not as subject to wash off.
- Longer residual than protectants
- Systemics will protect new growth.
- May control infections curatively
- May affect fungal development only at a specific site (= higher probability of fungicide resistance to develop!)

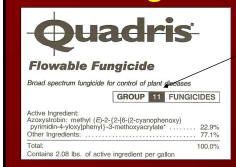
Protectant fungicides (FRAC group M)

- Active only at the site of placement.
- Subject to washing off during rainfall or overhead irrigation
- Do not penetrate plant tissue.
- All new growth must be protected while conditions are favorable for disease development.
- Affect fungi at multiple sites - therefore, have reduced chances for resistance development!

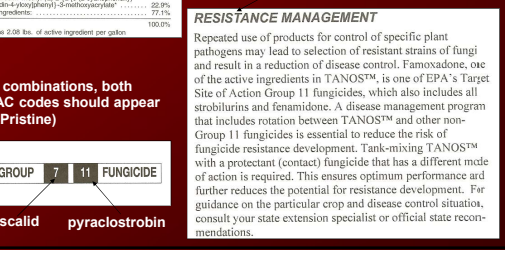
What are FRAC codes?

- With FRAC, fungicides with similar modes of action (MOA) are grouped together into the same FRAC code…
- FRAC codes are organized by numbers and letters…
  - (43 numbered groups and 3 letter groups to date)
  - FRAC code 1 = Benlate (Benzimidazoles) where resistance known since 1970's!
  - FRAC code 11 – Quadris, Cabrio (strobilurins or QoI fungicides)

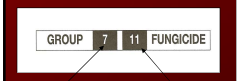
Finding FRAC Codes on Labels



FRAC codes for resistance management can be found on front of label or in resistance management guidelines.



For combinations, both FRAC codes should appear (ie. Pristine)



boscalid **pyraclostrobin**

Control of Plant Diseases
Chemical

- **Bactericides (Pesticides for Bacteria)**
  - **Two main types**
    - **Protectant – Does not penetrate plant tissue but is adhered to the plant (copper/sulfur, etc)**
    - **Antibodies – Effective but resistance can develop readily**

Control of Plant Diseases
Chemical

- **Nematicides (Pesticides for Nematodes)**
  - **Generally Restricted Use and fairly toxic**
  - **Most target nervous system of nematodes and insects**
  - **Soil applied (fumigants or liquids)**

Disease Identification

- **First step in successful disease management**
- **Extension Agents → ESAREC Plant Disease Diagnostic Lab or Blacksburg Plant Dis. Diag. Lab**
- **Soil Samples**
- **Self Diagnosis**

Self Diagnosis Resources

- **APS Compendium of Diseases (~$65)**
- **www.apsnet.org/apsstore**
- **Currently ~40 available**



Pesticide Resources

- www.cdms.net
- Most updated site for labels and msds
- Search by material or by company

CDMS | Data Logic Knowledge

Virginia Ag Pest Advisory

- http://www.sripmc.org/Virginia/
- Disease updates, Insect updates, labeling changes
- Weekly emails or immediate alerts
- Sign up at website, ,~400 subscribers

Virginia Cooperative Extension
Virginia Tech
Virginia Agricultural Experiment Station

Southern IPM Center

Local Listservs

- ESAREC
- Accomack and Northampton Co VCE

Questions?



Top 10 (+1) Vegetable Diseases in Virginia

Zelalem Mersha, PhD
Plant and Soil Sciences
Assistant Professor of Plant Pathology
Phone: 804-524-2694 Fax: 804-524-5622 Location: 139 M. T. Carter Bldg. Email: zmersha@vsu.edu

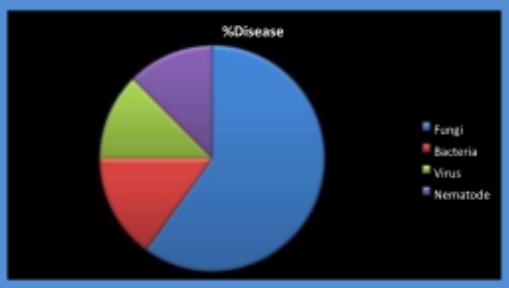
Disclaimers!

- Not ranked…too hard
- Just because a pathogen is not on this list doesn't mean it cannot be YOUR worst problem
- Weather conditions have a huge impact on disease severity / annual differences

Keys to Disease Occurrence



Pathogen Group Prevalence



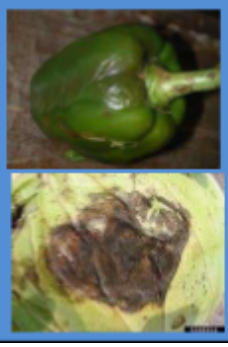
Top Ten Veg Diseases in VA

- Bacterial Soft Rot
- Cucurbit Downy Mildew
- Cucurbit Powdery Mildew
- Damping – Off
- Nematodes
- Phytophthora Root Rots
- Southern Blight
- Tomato Early Blight
- Tomato Late Blight
- Tomato Spotted Wilt Virus

Bacterial Soft Rot

- Pathogens: Erwinia / Pectobacterium sp.
- Hosts: beans, cabbage, carrot, corn, onion, crucifers, pepper, potato, sweet potato and tomato
- Region wide
- Generally seen in postharvest settings, reduces shelf life / marketability but can be in field

Bacterial So



Bacterial Soft Rot

- In – field suppression:
  - Plant on well drained land
  - Avoid dense populations
  - Disease – free seeds / transplants
  - Avoid 'working' plants when moisture is present within the canopy

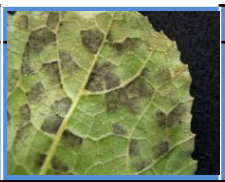
Cucurbit Downy Mildew

- Infects all cucurbits, worse on cukes and pumpkins
- Cultivar resistance, but not reliable or complete
- Fungicides
  - Previcur Flex
  - Presidio
  - Ranman
  - Alt. with chlorothalonil and mancozeb/maneb



2009 Cucumber DM Screen

- SMR 58
- Weekly Sprays (40GPA/3 nozzles per row)
- Treatments
  - 1. NTC
  - 2. Previcur Flex (1.2 pt)
  - 3. Presidio (3 floz)
  - 4. Presidio (4 floz)
  - 5. Ranman (2.75 floz)
  - 6. Tanos (8 oz)
  - 7. Revus (8 floz)
  - 8. Reason (5.5 floz)
  - 9. Previcur Flex (1.2pt) + Reason (5.5 floz)
  - 10. Bravo WS (2 pt) alt. Penncozeb (2 lb)
  - 11. Previcur (1.2 pt) A + Gavel (2 lb) BD + Presidio (4 floz) CE
  - 12. Gavel (2 lb)



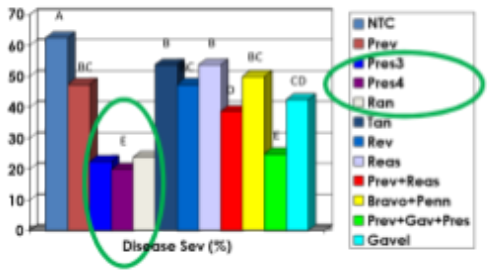
Bacterial Soft Rot

- Post-harvest suppression:
  - Harvest under dry conditions
  - Handle produce gently
  - Clean harvest equipment/containers
  - Chlorinated wash water (75 ppm free chlorine)
  - Never wash tomato / pepper fruit in water colder than the fruit

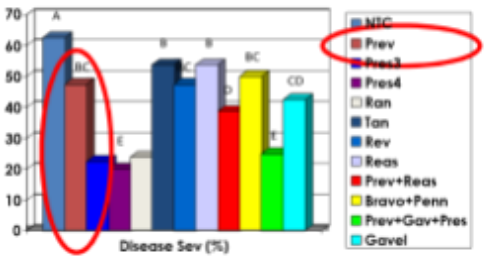
Top Ten Veg Diseases in VA

- *Bacterial Soft Rot*
- Cucurbit Downy Mildew
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- Damping – Off
- Nematodes
- Phytophthora Root Rots
- Southern Blight
- Tomato Early Blight
- Tomato Late Blight
- Tomato Spotted Wilt Virus

2009 Cucumber DM Screen



2009 Cucumber DM Screen



Cucurbit Downy Mildew

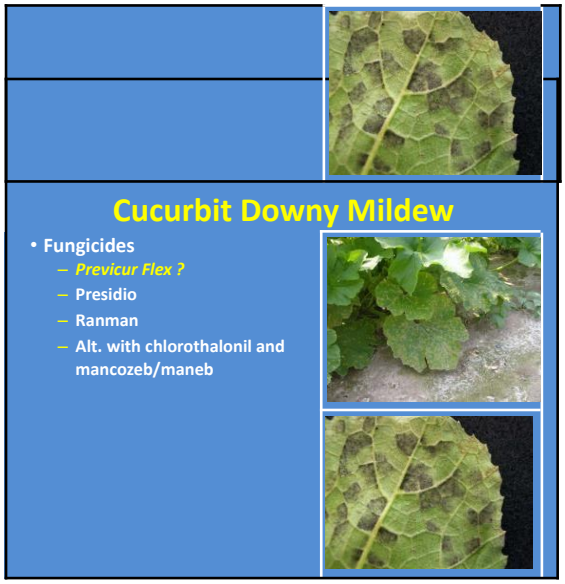
- Fungicides
  - *Previcur Flex ? – Presidio ?*
  - Ranman
  - Alt. with chlorothalonil and mancozeb/maneb
- Add to list?
  - Zampro
  - Tanos (again) – Gavel?



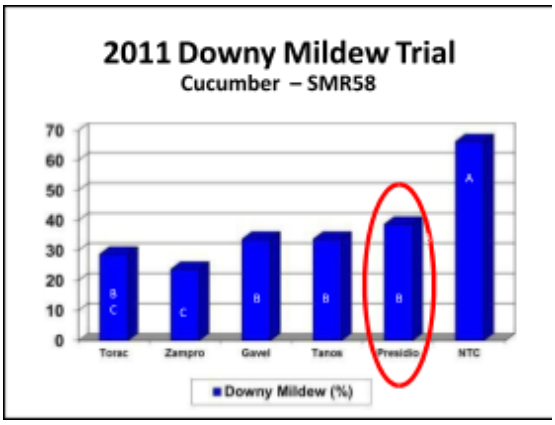
Cucurbit Downy Mildew

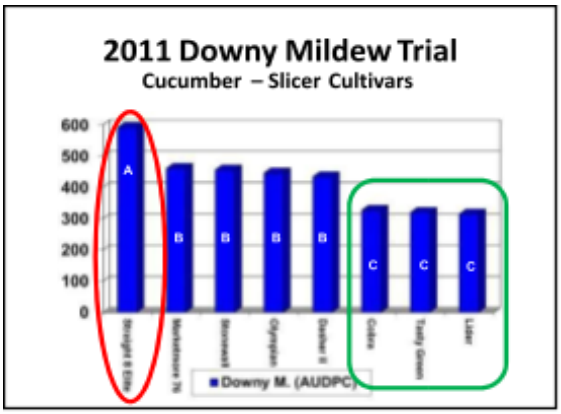
Slicers – IPM Trial

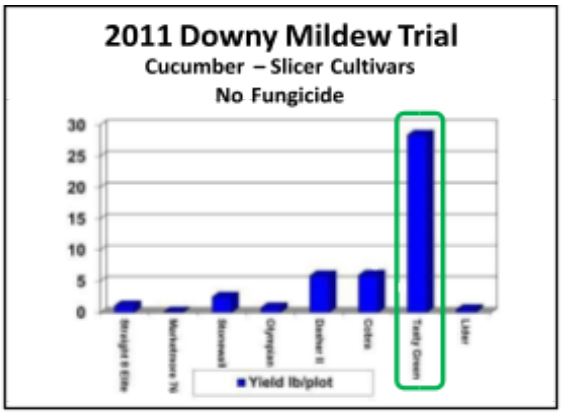
- Eight Cultivars Tested
- Three Fungicide Spray Programs
  - Nontreated
  - 2 Sprays (Ranman & Presidio 14d)
  - 4 Sprays (Ranman & Presidio twice 7d)
- Disease and Yields


Cucurbit Downy Mildew
• Fungicides
– Previcur Flex ?
– Presidio
– Ranman
– Alt. with chlorothalonil and mancozeb/maneb




2011 Downy Mildew Trial
Cucumber – SMR58
70
60
50
40
30
20
10
0
B C
C
B
B
B
A
Torac
Zampro
Gavel
Tanos
Presidio
NTC
Downy Mildew (%)


2011 Downy Mildew Trial
Cucumber – Slicer Cultivars
600
500
400
300
200
100
0
A
B
B
B
B
C
C
C
Downy M. (AUDPC)


2011 Downy Mildew Trial
Cucumber – Slicer Cultivars
No Fungicide
30
25
20
15
10
5
0
Yield lb/plot

2011 Downy Mildew Trial Cucumber – Slicer IPM

- 4 sprays > 2 sprays > no sprays
- No sprays on Tasty Green outyielded Straight 8 Elite with 4 sprays (28.4 to 26.7 lbs)
- Tasty Green with two sprays outyielded all other cultivars with two sprays
- Best bets for slicer cukes: Tasty Green & Cobra
- Intermediates: Dasher II & Stonewall

2009 Pumpkin Organic DM Screen

- Rockafellow
- Weekly Sprays (40GPA/3 nozzles per row)
- Treatments
  - 1. NTC
  - 2. Serenade Max (2 lb)
  - 3. Sonata (3 qt)
  - 4. OxiDate (1% v/v)
  - 5. Champ (2 lb)
  - 6. Microthiol (7.5 lb)
  - 7. Actinovate (9 oz)
  - 8. Sporan (1.5% v/v)

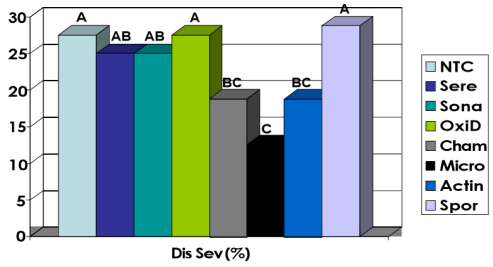
Downy Mildew Suppression

- Host 'Tolerance'
- Selective Planting
- Plant in well drained, full sun areas
- Scout regularly
- Observe CDM ipmPIPE website
  - http://cdm.ipmpipe.org/

Top Ten Veg Diseases in VA

- *Bacterial Soft Rot*
- *Cucurbit Downy Mildew*
- Cucurbit Powdery Mildew
- Damping – Off
- Nematodes
- Phytophthora Root Rots
- Southern Blight
- Tomato Early Blight
- Tomato Late Blight
- Tomato Spotted Wilt Virus

2009 Pumpkin Organic DM Screen



NO SIGNIFICANT DIFFERENCES IN YIELD

Downy Mildew Fungicides

- Ranman most consistent and efficacious fungicide
- Presidio & Previcur Flex – Some uncertainties, particularly on cucumber
- Chlorothalonil / Mancozeb best protectants
- Revus – Response on pumpkins, not on other cucurbits
- Organic – Copper, Sulfur, Actinovate

Cucurbit Powdery Mildew

- Appears as sparse white stringy growth on top and bottom of leaves, can also infect the stem
- Prefers dewy nights with dry days (6 hr. leaf moisture)
- Hits plant harder from flowering/fruit set on
- Management starts with tolerant cultivars



Pumpkin Powdery Mildew
Resistant Cultivars

- Mini – Sized Fruit
  - Gold Dust (0.5)
  - Wee-B-Little (0.5)
  - Sweet Lightning (1.5)
  - Treasure (1.5)

Pumpkin Powdery Mildew
Resistant Cultivars

- Large – Sized Fruit
  - Camaro (20)
  - Magic Lantern (20)
  - Magic Wand (20)
  - Mustang (22)
  - Gladiator (25)
  - Spartan (25)
  - Super Herc (25)
  - Aladdin (30)

Yellow Squash Powdery Mildew
Resistant Cultivars

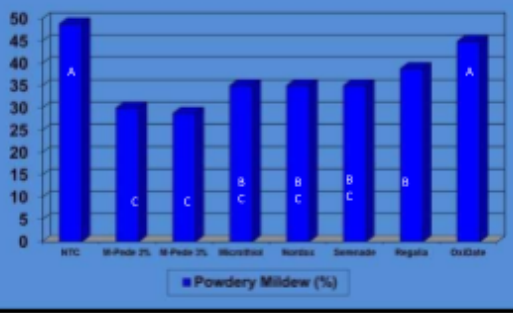
- Success
- SunGlo
- Sunray

Cucurbit Powdery Mildew

- Quintec & Torino (best) – Quintec not for squash/cukes
- Rally & Procure (good)
- Pristine, Fontelis, Folicur, chlorothalonil (some)
- Luna Experience for watermelon (GSB)
- Preventative and resistant cultivars



2011 Organic Powdery Mildew Trial
Summer Squash



Zucchini Powdery Mildew
Resistant Cultivars

- Romulus PM
- Amatista
- Payroll (~)

Acorn Squash Powdery Mildew
Resistant Cultivars

- Sweet Reba
- Autumn Delight
- Honey Bear
- Royal Ace PM
- Table Star

Cucurbit Powdery Mildew

- Organic Control
  - Sulfur
  - Copper
  - M-Pede
  - Serenade (~)
  - Regalia (~)



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- Tomato Late Blight
- Tomato Spotted Wilt Virus

Seedling Damping - Off

- Caused by various species of fungi: Rhizoctonia, Pythium, Phytophthora, etc.
- Can either occur in the soil or after emergence
- Stand and vigor problems
- Generally…due to excessive rainfall around planting or after emergence coupled with temperature issues
- All vegetables

Seedling Damping - Off



Base Seed Treatments

- Captan
  - Dicarboxamide
  - Been around for 40 years roughly
  - Broad spectrum protectant
- Thiram
  - Dithiocarbamate
  - Been around for 40 years
  - Broad spectrum protectant

Components

- Mefenoxam (Apron) or metalaxyl (Allegiance)
- Field product – Ridomil Gold/Ridomil
- Effective on Pythium and Phytophthora diseases of seedlings

Components – Insecticides

- Thiamethoxam (Cruiser)
- Clothianidin (Poncho)
- Imidacloprid (Gaucho)
  - Lack of herbicides
  - Harvest dates
  - Plant structure
- Fastest growing sub-industry of crop protection

Seed Treatments

- Thiamethoxam (Cruiser) – quick / vigorous stand in vegetables

Vegetable Seed Treatments

- Syngenta Vegetable Seed Treatments offered by vegetable seed companies
- Package only
- Fludioxonil + mefenoxam + thiamethoxam
- Tops MZ
- Evolve

Vegetable Seed Treatments

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- Package only
- Fludioxonil + mefenoxam + thiamethoxam
- Tops MZ
- Evolve

Fertilizer Technologies

- Syngenta Vegetable Seed Treatments offered by vegetable seed companies
- Package only of now:
  - Fludioxonil + mefenoxam + thiamethoxam
  - Tops MZ
  - Evolve

Components

- Fludioxonil (Maxim)
- Field product – ingredient in Switch
- Effective on Rhizoctonia and Fusarium diseases of seedlings (Aspergillus / Penicillium)

Components

- Azoxystrobin (Dynasty)
- Field product – Quadris
- Effective on Rhizoctonia, Pythium and Phytophthora diseases of seedlings (Aspergillus / Penicillium)
- Quickly growing label
- Careful with snap/legumes
- Trifloxystrobin (Trilex)

Future Technologies

- Nematodes – Avicta/Votivo
  - Sweet Corn
  - Beans
- Growth Regulators

Top Ten Veg Diseases in VA

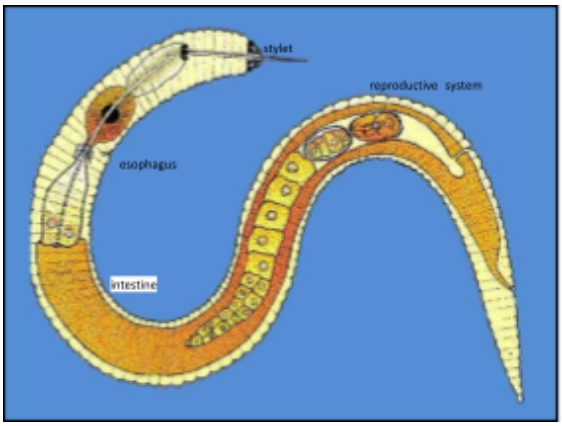
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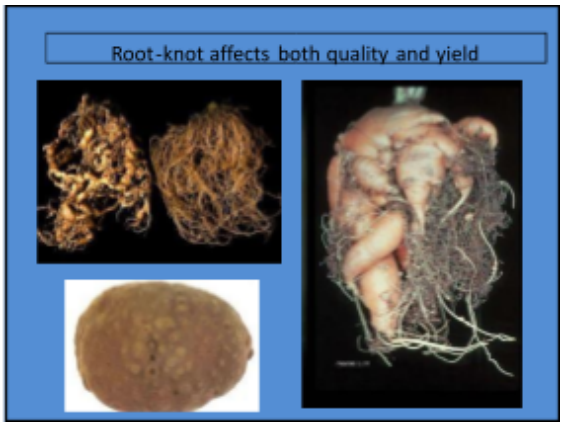
Root-Knot Nematode Management

- Crop rotation and other cultural practices • Testing several experimental products
  - MANA – MCW-2; expected registration in 2014/2015
  - Experimentals
- Currently, Vydate (repeated applications) offers best protection (fumigation)

Top Ten Veg Diseases in VA

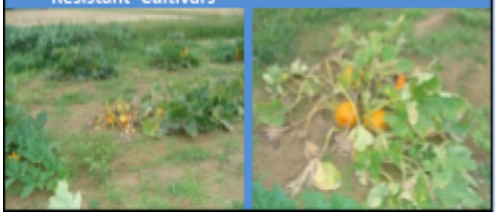
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stylet
reproductive system
esophagus
intestine


Root-knot affects both quality and yield

Phytophthora Crown Rot

- Phytophthora – Revus, Ranman, and Presidio has some activity but need to compliment with Ridomil Gold PPI or fumigation / Resistant Cultivars



Phytophthora Crown Rot

Resistant Cultivars

- Apprentice (1)
- Lil' Ironsides (3)
- Iron Man (4)
- Gargoyle (4)
- Cannon Ball (4)
- Warlock (25)
- Also have some tolerance to Fusarium Fruit Rot

Phytophthora Crown Rot

Cultural Practices

- Crop Rotation (No cucurbits, peppers, etc.)
- Avoid low lying areas
- Avoid over irrigation and overhead irrigation
- Plant on plastic covered raised beds

Top Ten Veg Diseases in VA

- *Bacterial Soft Rot*
- *Cucurbit Downy Mildew*
- *Cucurbit Powdery Mildew*
- *Damping – Off*
- *Nematodes*
- *Phytophthora Root Rots*
- Southern Blight
- Tomato Early Blight
- Tomato Late Blight
- Tomato Spotted Wilt Virus

Southern Blight

- Fungal pathogen: Sclerotium rolfsii
- Hosts: Tomato, Pepper, all other vegetable crops except for grains
- Virginia is a transition state for this pathogen, little in north, more the further south you go
- Likes warm and humid weather, 80+ temps

Southern Blight



Southern Blight

- Crop Rotation to 'grain' crops
- Limited fungicides in vegetables, Quadris through drip? Directed sprays?
- Deep plowing / fumigation
- Reduced canopy thickness, anything to reduce moisture within canopy

Top Ten Veg Diseases in VA

- *Bacterial Soft Rot*
- *Cucurbit Downy Mildew*
- *Cucurbit Powdery Mildew*
- *Damping – Off*
- *Nematodes*
- *Phytophthora Root Rots*
- *Southern Blight*
- Tomato Early Blight
- Tomato Late Blight
- Tomato Spotted Wilt Virus

Tomato/Potato Early Blight

- Caused by *Alternaria solani* or *Alternaria tomatophilia*
- Pathogen on tomato and potato
- Prefers higher temperatures than late blight and not as moisture dependent



Tomato/Potato Early Blight

- Over the past decade managed primarily through the use of strobilurin fungicides (Quadris, Cabrio, and Tanos)
- Data from NC and NY indicates resistant strains present in fields where strobies are used frequently
- Pest Advisories
- Resistance Management Approach
  - Tank mix with chlorothalonil/mancozeb
  - Incorporate other materials effective on early blight (Endura, Swtich, Revus Top, Gavel)

Top Ten Veg Diseases in VA

- *Bacterial Soft Rot*
- *Cucurbit Downy Mildew*
- *Cucurbit Powdery Mildew*
- *Damping – Off*
- *Nematodes*
- *Phytophthora Root Rots*
- *Southern Blight*
- *Tomato Early Blight*
- Tomato Late Blight
- Tomato Spotted Wilt Virus

Late Blight

- Caused by the Oomycete fungus: *Phytophthora infestans*
- Favored by cool and wet conditions:
  - Temperature: <85 F; Optimal of 65 – 75 F
  - Moisture: Disease needs 8 hours of leaf wetness (rainfall, irrigation, or dews/fogs)

Late Blight History

- Caused Irish Potato Famine in 1840's
  - 1.5 million deaths
  - 1.5 million immigrants into US
- Monoculture and favorable environmental conditions over several years
- Seed pieces transferred disease from year to year (1844 – 1846)

Late Blight Symptomology



Late Blight Management

- Weather
  - At its mercy
  - Plant in areas that receive full sunlight and are not low lying
- Avoid excessive overhead irrigation
- Stake / String Tomatoes
- Heirloom cultivars at greater risk
- Scout – Inspect GH/Transplants
- Purchase only disease free transplants
- Destroy infected early crops

Late Blight Management

- If disease is not present in our area:
- Prevention is the key
  - Chlorothalonil
  - Spray on 7 - 10 day schedule
  - Coverage of plant is important
- Monitor tomato/potato disease advisory and extension information

Late Blight Management

- Once present in area/field
  - Curzate
  - Forum
  - Gavel
  - Ranman
  - Revus Top/Revus
  - Presidio
  - Previcur Flex
  - Tanos

Top Ten Veg Diseases in VA

- *Bacterial Soft Rot*
- *Cucurbit Downy Mildew*
- *Cucurbit Powdery Mildew*
- *Damping – Off*
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- *Phytophthora Root Rots*
- *Southern Blight*
- *Tomato Early Blight*
- *Tomato Late Blight*
- Tomato Spotted Wilt Virus

Tomato Spotted Wilt Virus

Vectored by Thrips



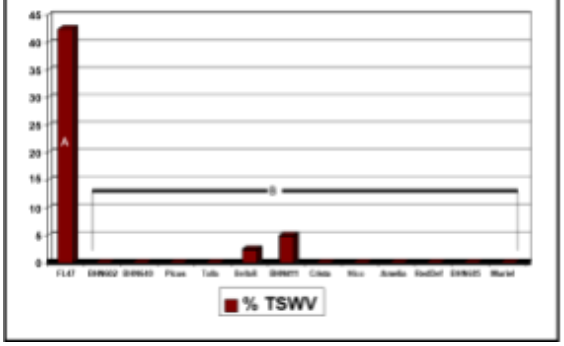
TSWV Variety Trials – 2008 - 2010

ESAREC, Pungo and TAREC Locations

- Rounds
  - FL 47 (Suscept.)
  - BHN602
  - BHN640
  - Talladega
  - Bella Rosa
  - Crista
  - Nico
  - Amelia
  - Red Defender
- Romas
  - Picus
  - BHN411 (Suscept.)
  - BHN685
  - Muriel

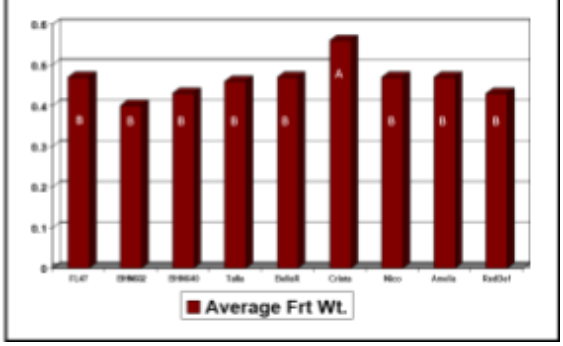
TOMATO SPOTTED WILT - 2008

TSWV Trial – 816 (TAREC)



TOMATO SPOTTED WILT - 2008

TSWV Trial – 816 (TAREC)



TSWV Pepper Variety Trials

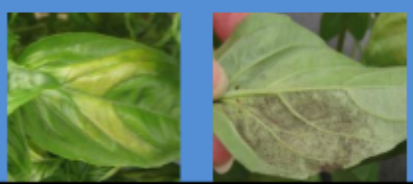
- Bell
  - Brigadier
  - Declaration
  - Heritage*
  - Paladin
  - Stiletto
- Specialty
  - Boris*



Basil Downy Mildew

Disease First observed in the USA:

Florida in October 2007



Downy mildew - Basil



Downy Mildew - Basil

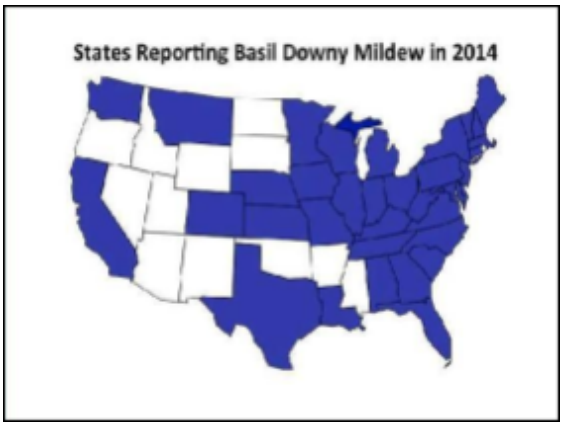


Obligate pathogen. Living plant tissue required for survival; pathogen's survival spore (oospore), produced through sexual reproduction, has not been found.

Host plants. Basil only. **NOT coleus.** New DM on coleus is different.

Sources. Seed. Wind-dispersed spores. Transplants. Produce.



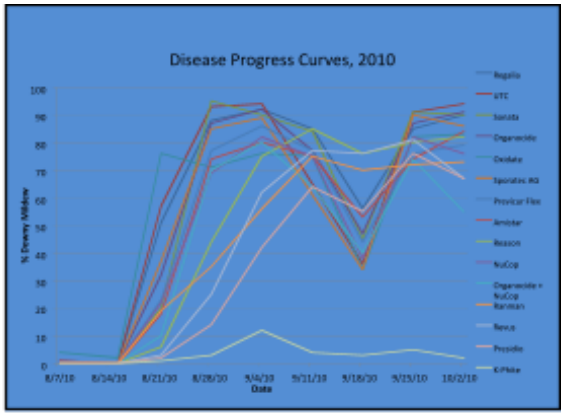


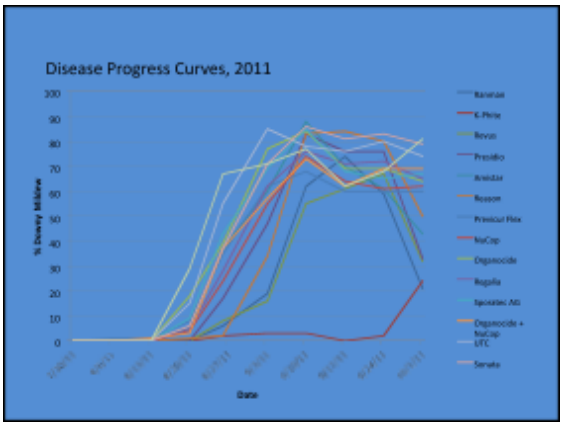
Basil Downy Mildew Reports, 2009-14

74 New York
39 Virginia
38 Pennsylvania
34 Maryland
32 Florida
30 Massachusetts
27 New Jersey
26 Connecticut
21 Ohio
19 Illinois
18 North Carolina
17 California
16 Minnesota
15 Wisconsin
13 Delaware
13 Georgia
11 South Carolina
11 Vermont
10 Indiana
10 New Hampshire
9 Maine
9 Tennessee
8 Michigan
8 Texas

Managing Basil Downy Mildew

Pathogen-free seed. Steam treated. Less susceptible varieties + types.
('Eleonora' sweet basil + spice types)
Disease-free transplants; inspect.
Focus production when risk of disease low.
Scout routinely. Check monitoring site.
Fungicides. Apply preventively.
Reduce RH in GH (<85%): Fans. Lights. Wide plant spacing. Bottom watering. Base heating.
Lights on overnight, first half, <7 hr dark.
Heat. 113F for 48 hr killed spores on plants.
Destroy crop promptly when done.
Thorough sanitation following outbreak.





Contact Information

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Summary Description for Module 11

Title:	Module 11: Plant Propagation and Nursery Management
Instructor:	Dr. Laban K. Rutto, Associate Professor of Alternative Crops
Prerequisites, if applicable:	Some experience working with plants
Class Time:	9:00AM – 11:30AM & 12:00PM – 3:00PM
Learning Objective:	This module will cover common plant propagation methods including starting plants from seed, and vegetative propagation methods including use of cuttings, slips, splits, and bulbs. Techniques including grafting, budding, layering, and tissue culture will also be discussed. Basic principles of media selection, climate control, and principles of nursery management will also be addressed.
Instructor Media Needs:	• PowerPoint Projector • Laptop Computer
Class Materials and/or Supplies Needed:	• White Board • Markers and eraser
Class Activities:	1. Discussion of the different plant propagation approaches 2. Note taking 3. Engagement in demonstrations and practical exercises
Knowledge Gained:	By the end of the class, students will understand: • Differences between sexual and asexual methods of plant propagation • The science behind seed development and viability • The concept of totipotency and how it underlies asexual propagation • The theory behind tissue culture and mass propagation
Skills Gained:	The following skills will be gained by the end of the training: • Seed processing and handling (seedbed management). • Starting and transplanting seedlings • Preparing leaf, stem, and root cuttings • Basic grafting and budding
Abilities Gained:	At the end of the module, learners will be able to: • Harvest and preserve seed • Perform basic quality control including germination testing • Determine the best time for cuttings • harvesting seed
Exam Description:	A written quiz will be administered at the end of the class (50% of total mark). A practical exam (50% of total mark) will involve pricking out seedlings with success measured as the number of surviving seedlings after one week.

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URBAN AGRICULTURE CERTIFICATION PROGRAM

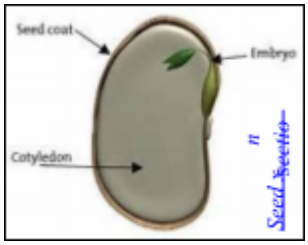
Plant Propagation Module

1. A brief history of plant propagation Plant propagation is the process of increasing the number of plants of a species or cultivar through either sexual (seed) or asexual (vegetative) methods. In nature, plant propagation is most often sexual (production of viable seed). When exposed to ideal environmental conditions, seeds germinate and grow into mature reproductive plants. Over the years, horticulturists have also developed asexual propagation methods that use vegetative plant parts.

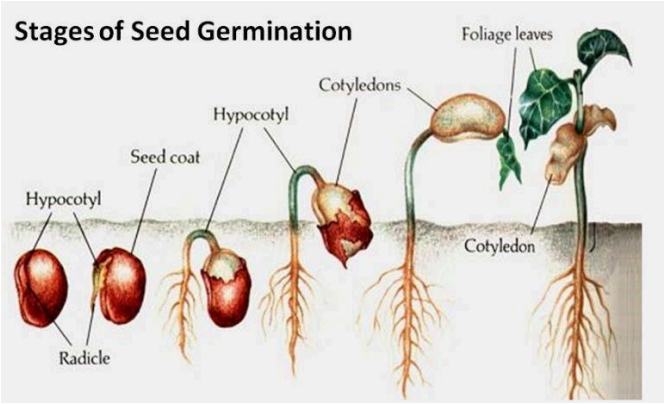
Plant propagation anchored human civilization by enabling managed cultivation of crop plants and a sedentary lifestyle conducive to long-term planning and accumulation of wealth. Pioneering farmers mastered the arts of sexual and asexual propagation by observing natural processes e.g. seed dispersal and accidental grafting. As a result, ancient civilizations throughout the world were able to grow a wide range of food, feed and fiber crops.

It is believed that the turning point for agriculture in the old world occurred in the Middle East around 8,000 BC when chance hybridization between wild wheat and goat grass eventually gave rise to bread wheat. The Roman poet Virgil (70-19 BC) recorded the many species e.g. date palm, olives, cabbage, and radish that were grown from seed, and it is reported that propagation by cuttings and grafting were fairly common in Greece, the Middle East, Egypt, and China by 2,000 BC. Layering was adapted from natural layering and it is reported that the Chinese may have pioneered air-layering about 4000 years ago.

2. Sexual propagation



Propagation by seed is relatively easy and often requires no special equipment. Seeds are formed when pollen is transferred from the anther to the stigma of a flower and fertilization occurs. In self-pollinated plants, every seed produced carries the same genetic makeup of the parent plant (barring mutations). In crosspollinated plants with two parents, the seed will contain a mixture of genes from the male and female parents. This continual reshuffling of genetic material results in different gene combinations that help plant species adapt to changing environments. A seed consists of three primary components: the embryo (undeveloped plant); the endosperm (food storage); and a protective covering (seed coat). For propagation to succeed, it is important to start with high-quality, viable seeds. Seed viability is expressed as the estimated percent germination rate. Saving seed from one season to the next is advised against because storage conditions required to maintain seed viability are difficult to maintain often resulting in poor germination rates for home-grown seed. Additionally, most modern crop cultivars segregate (do not "breed true") when raised from saved seed.



Seed germination

Seed germination is a complex process that occurs when a viable seed with proper internal conditions is exposed to favorable environmental conditions. Internal conditions important for germination include seed coat properties and dormancy. Environmental factors that influence seed germination include moisture, temperature, air (oxygen) and, in certain cases, light. Ideal germination conditions vary by species, so it is important to know your crop (information on germination time and other plant characteristics is usually provided on seed packets). Germination time for

most crops will range from five to seven days for quick crops to 21 days for slow species.

Seed coat

Some species of plants produce seeds that are nearly impervious to water. In nature, this characteristic tends to preserve the longevity of the seeds, but it also makes them less likely to germinate immediately after being produced. Most legumes produce such seeds; black locust and Kentucky coffee tree are classic examples.

Germination can be improved in seeds with a hard seed coat by modifying the protective covering e.g. by soaking the seeds in warm water, briefly dipping them in acid, or mechanically weakening the seed coat with a file, sandpaper or other method of abrasion.

Some species produce seeds that contain abscisic acid, a chemical that inhibits germination. For these species, germination occurs after certain changes take place within the seed in response to environmental conditions. In nature, this period of adjustment (after-ripening), prevents fall-produced seeds from germinating until the following spring when conditions are more conducive to seedling survival. After-ripening can be artificially induced by exposing seed to a combination of cool and moist conditions in a process called stratification. Optimal stratification temperatures usually range from 35-45ºF but vary with species as does duration.

Most seeds have low water content and require moisture to germinate. The nature of the seed and seed coat, as well as the availability of moisture greatly affect germination success. Species vary in the amount of moisture needed to prompt germination. For example, cucurbits (e.g., melons and cucumber) and cole crops (e.g., cabbage and broccoli) will germinate in soil with relatively low moisture, while celery requires well hydrated soil to germinate.

Plants can be grouped according to how temperature affects germination of their seeds:

- Plants that germinate only at low temperatures.
- Plants that germinate only at high temperatures.
- Plants that germinate over a relatively wide range of temperatures.

Usually the temperature preference of the mature plant indicates which category its seeds fall into. For example, cole crops prefer cool temperatures and bear seed that will germinate at relatively low soil temperatures. Conversely, corn does best in warm temperatures and needs relatively warm soil to germinate. Germination occurs in most plants at soil temperatures ranging from 75-80ºF.

Seeds in storage must respire to remain viable and oxygen is necessary for this process. Additionally, oxygen is involved in the initial reactions that trigger germination. Heavy soils that limit oxygen availability to seeds are associated with poor germination. Overwatering after seeding can also adversely affect germination rate.

Light

Some seeds require light to germinate. Others require darkness. This difference will affect planting depth requirements. If small seeds were to germinate deep in the soil, they would probably use up their stored reserves and die before being able to emerge and start photosynthesis. Thus, these small seeds must be at or near the soil surface to be exposed to light, which enables germination to occur. They will emerge and begin photosynthesis before stored food is depleted. Others including species found in forest settings, will not germinate until an opening in the canopy allows sufficient light for seedling growth.

Starting seeds indoors

For early planting, many annuals can be started indoors well ahead of the outdoor planting season. The proper sowing time in preparation for outdoor transplanting varies from four to 10 weeks depending on the species. The following considerations come into play when one is preparing to produce seedlings indoors:

These should be clean, sturdy, and fit into available indoor space for growing plants. Proper containers help get seedlings off to a good start and can save time during transplanting. Plastic trays, flats and pots are well suited to this purpose and are widely used. Clay pots can also be used, but they are more difficult to disinfect between uses. Peat pots and compressed peat pellets are popular biodegradable choices that facilitate the planting of the container along with the seedling thus reducing transplanting shock.

Media for starting seeds should be loose, porous and fine textured. Propagation blends containing a mixture of peat moss, vermiculite and perlite are commercially available. Fine grade vermiculite used alone also provides good seed germination. Soil or sand alone or in a blend should be avoided because soil tends to drain

poorly in containers, and both soil and sand often harbor pathogens that could attack seeds or seedlings.

Seedling care

After germination, seedlings should be provided with the best possible growing conditions to ensure stocky, vigorous plants for outdoor planting. They should be placed in a bright, south-facing window or provided with 14-16 hours daily of fluorescent lighting. Most annuals and vegetables prefer night temperatures between 60 and 65°F, with daytime temperatures 10-15 degrees warmer.

Maintain high relative humidity around the seedlings (>45% for most species) and start regularly fertilizing them with a water-soluble fertilizer at half the recommended rate a few days after emergence. Fertilizing frequency depends on species, and environmental conditions. Sanitation is critical for disease prevention and the grower should always watch out for problems (e.g., diseases or insects). "Damping off", the most common seedling disease can be managed by drenching the seedlings with a fungicide labeled for *Rhizoctonia*, at half the rate recommended for mature plants.

For certain species, seedlings may have to be transplanted into bigger pots. Usually, seedlings are ready to transplant when the first "true" leaves are fully expanded (letting seedlings grow too big could reduce transplant success). Make holes for the transplants in the medium filling the new container using a dibble or any other convenient tool e.g. small trowel or old knife to create a hole large enough to accept the root system. Loosen the media near the roots of the seedling to be transplanted then gently lift the seedling making sure to hold it by the leaves. Place the seedling and any media attached to the roots in the predibbled hole. Lower the root system into the hole to the same depth the seedling was growing during germination then gently firm the medium around the plant. Water thoroughly and place it in a good growing environment for the particular species. Fertilize immediately after transplanting with a starter solution at half the rate recommended for mature plants, then fertilize at the standard rate 10-14 days thereafter.


Wood dibble

3. Asexual propagation

This technique involves the use of vegetative plant parts to generate clones (exact genetic copies) of parent plants. The advantages associated with vegetative propagation include the capacity to:

i. Mass produce uniform copies of a desired plant genotype (e.g. in banana tissue culture).
ii. Grow plants to a size suitable for transplanting in less time than from seed.
iii. Overcome challenges associated with poor seed viability or sterility in some species.

The most common methods of asexual propagation include the use of cuttings, layering, division, grafting, budding, and tissue culture in a sterile environment.

Cuttings

Plant parts (cuttings) excised from a parent plant are rooted to form new plants are called. Cuttings are classified according to the nature of the source material (herbaceous, softwood, semi-hardwood or hardwood) or the part of the plant removed to form the cutting (stem, leaf, root). For landscape plants, "softwood" refers to new growth in the current season; semi-hardwood to succulent but partially matured current season tissue (usually taken in late summer); hardwood cuttings are taken from woody plants during dormancy in late fall or early winter.

Stem cuttings are sections with dormant buds and no leaves while stem tip cuttings usually consist of the growing point (apical meristem) and at least one fully expanded leaf.


Stem and stem tip cutting

Cuttings 4 to 6 inches in length should be taken from vigorous, healthy plants by cutting with a sharp, clean knife. For most species, a rooting hormone that contains a plant-growth hormone e.g. IAA, IBA or NAA is used to improve rooting success and to encourage more vigorous roots. Rooting agents should always be used as directed by the manufacturer. After dipping in rooting hormone, cuttings should be placed (stuck) into a propagation medium that retains moisture but still allows for good gas exchange.

Leaf cuttings include a leaf blade or the blade with a portion of the petiole. Leaf and bud cuttings are similar to stem-tip cuttings minus the apical meristem (dormant buds at the leaf axil or node serve as the growing points). This means a single stem can yield only one stem-tip cutting, but several leaf and bud cuttings.


Leaf cutting


Leaf-bud cutting

Leaf cuttings must first form roots and later shoots, and depending on the species, it can take several months before a rooted leaf cutting is ready for transplanting.

For stem and leaf cuttings, the medium should be kept moist and high relative humidity maintained by covering the rooting trays/pot with a clear plastic dome or sheet (achieved by use of a misting system in commercial operations). Rooting temperature should be maintained at 75-80°F to hasten root formation.

Among species that can be propagated from root sections e.g. horse radish, fig, weeping willow etc., cuttings are usually taken from mature plants during their dormancy.

For plants with large roots, cuttings should be wounded by making a slanted cut 2-6 inches from the top before storing for about 3 weeks in moist sawdust, peat moss, or sand at 40˚F. After storage, cuttings are inserted vertically into rooting medium such that the top is about level with the medium. This method is often used outdoors.

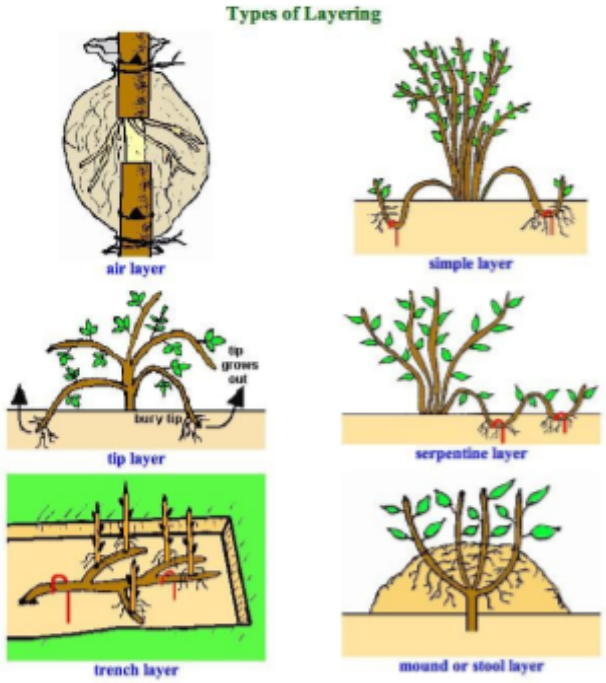

Root cutting

For species with small roots, 1-2 inch sections are taken and buried horizontally about 1/2 inch below the medium surface. This method is usually used indoors or in a hotbed.

In some species, root cuttings produce new shoots which then form their own root systems while in others, cuttings first develop root systems before producing new shoots.

Layering

This method is used when other propagation methods e.g. seeding, use of cuttings, or budding/grafting are not practical or effective. It consists of rooting a new plant while it is still attached to the parent plant. Because an entire branch of the parent plant is often needed to form a single new plant, this method yields only a few plants from each parent. Layering is simple to perform and requires no special equipment or structures. Methods include air, tip, simple, compound, and mound (stool) layering.



Air layering

This method is popular for propagating houseplants. It involves establishing a root system on a stem above the ground. The air layer may be made at any point on a stem of proper maturity (about 12 inches from the tip for many plants).

The procedure for air layering is as follows: Remove all leaves several inches below and above the point where the layer is to be made. Wound the center of the layering area either by making a slanting cut upward an inch or more in length and about halfway through the branch (insert a small piece of wood in the wound to keep it open so that it does not heal back together), or by removing a strip of bark ½-1 inch wide around the branch. Apply a rooting hormone to the wounded surface.

Pack moist unmilled sphagnum moss around the branch to fully cover the wound. To secure the moss in place and prevent drying, wrap a clear plastic sheet (to be able to see when roots have formed) around it and secure each end with tape or string.

Dig a hole 3 to 4 inches deep and secure a shoot tip in it before covering with soil. The tip initially grows downward before bending sharply and growing upward. Roots form at the bend and the recurved tip sticks out of the ground to become a new plant. Separate the plant from the parent for planting in the early spring or late fall. Examples of species that can be propagated by tip layering include purple and black raspberries, and trailing blackberries. *Simple layering*

Simple layering may be performed whenever a plant has a branch low enough to be pulled down to the ground and buried, with the shoot tip protruding from the soil.

Many plants root when a branch is bent sharply upward. However, the process can be expedited by wounding the stem at the point where it curves upward. This can be done by making a 2 inch slanting cut above or below the bend, 12 inches from the tip. Dust the cut with a rooting hormone and secure the branch or stem with a wooden peg or wire wicket in a trench 3 to 4 inches deep then bend the tip upward. If the cut was made on the topside, give the branch a half twist. If the branch is stiff, insert a stake next to the shoot to hold the tip in an upright position. Fill the trench and mound the soil slightly so the wounded portion of the stem is 4-6 inches below the surface.

This type of layering should be done in early spring on dormant one-year-old shoots. Keep the soil around the layer moist at all times by mulching with straw, leaves or sawdust. The layer may form roots during the first season, but it should not be separated from the parent plant until the following spring (some hard-to-root plants may take two years to root).

After the layer is well rooted, cut off the branch where it enters the soil then wait for two to three weeks before transplanting it to a protected spot or container where it can be tended carefully for one year before moving to a permanent location.

This technique is simple layering performed multiple times and is suitable for long vines. The shoot is alternately covered and exposed with wounding done on the lower portion of each curve. This method is suitable for vining plants such as honeysuckle, clematis or wisteria. The following spring, after rooting has taken place, the branch is cut into segments at the spots where the branch enters the soil.

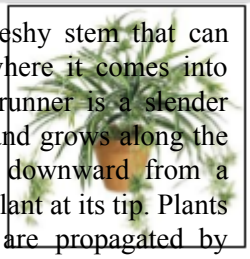
Dig a shallow trench near the parent plant to be layered. Gently bent over an entire branch, lay it in the trench, and cover it with 2-4 inches of soil. After a few weeks, roots will develop along the stem and new shoots will form at each node. When the new plants have grown to a desirable size, they can be separated and planted. This method can be used on fruit and nut tree species like apple, pear, apricot, and almond. *Mound (stool) layering*

This method is useful with heavy stemmed, closely branched shrubs and rootstocks of some tree fruits. The plant is cut back to 1 inch above the soil surface during the dormant season. When new shoots emerge in the spring, mound soil over them as they grow to allow roots to develop at the bases. The soil layers are removed in the dormant season and the shoots excised as individually rooted plants. Mound layering can be used to propagate rootstocks from apple, spirea, quince, daphne, magnolia, gooseberry and other species.

Division

This is one of the best ways to propagate herbaceous perennial plants. It can be considered a modification of layering, as the new plants form before they are detached from their parent plants. As a general rule, plants that flower in spring and early summer should be divided in late summer or fall. Those flowering in summer and fall should be divided in early spring before new growth begins. The following plant parts can be used in this method:

Stolons and runners



A stolon is a horizontal, often fleshy stem that can root, then produce new shoots where it comes into contact with growth medium. A runner is a slender stem that originates in a leaf axil and grows along the ground or *Note plantlets at the tips* downward from a hanging basket, producing a new plant at its tip. Plants that produce stolons or runners are propagated by severing the new plants from their parent stems. Plantlets at the tips of runners may be rooted while still attached to the parent, or detached and placed in a rooting medium. Examples include strawberry, spider plant, and begonia.

Offsets

Plants with a rosetted stem often reproduce by forming new shoots at the base or leaf axil. The new shoots can be separated from the parent plant once they have developed their own root system. U f some species may be removed and p 2 medium. Some of these must be cu s may be simply lifted off the paren s include date palm, some cacti, and bro



Excising an offset

Separation

This is a term applied to a method by which plants that produce bulbs, corms or crowns can be multiplied. Species like tulips and narcissus usually produce new bulbs around the original planting. These bulb clumps should be separated every 3 to 5 years for larger blooms and to increase plant population. The bulbs are dug up after the leaves have withered, gently pulled apart, then immediately replanted so that they can develop a root system. For these new plantings, large ones should

bloom in the first year, but smaller ones may take 2-3 years before flowering.

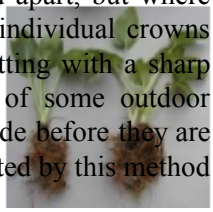
In species like crocus and gladiolus that are propagated from corms, a large new corm forms on top of the old corm, and tiny cormels form around the large corm. Dig up the corms after the leaves wither and allow them to dry in indirect light for 2 or 3 weeks. Remove the cormels, then gently separate the new corm from the old corm. Dust all new corms with a fungicide and store in a cool place until planting.



Corms and cormels

Crowns

Plants with more than one rooted crown may be divided and the crowns planted separately. If the stems are not joined the plants can be gently pulled apart, but where they are united by horizontal stems, individual crowns will are separated by cutting with a sharp knife to minimize injury. Divisions of some outdoor plants should be dusted with a fungicide before they are replanted. Species that can be propagated by this method include snake plant and iris.



Rooted crowns

Grafting

Grafting is the act of joining two plants or their parts into one organism. The lower part of the graft is known as the rootstock and becomes the root system (and in some cases part of the lower trunk). The upper part is known as the scion and becomes the top of the plant. For the graft to be successful, the cambium of the stock and scion must be closely aligned and the two plant parts bound to ensure good sustained contact. The union must be kept from drying out until the graft "takes".

Most often grafting is used to provide a desirable cultivar with a more vigorous, hardy, or disease/pest resistant rootstock. Grafting can also be used to influence plant stature e.g. the use of dwarfing rootstocks or interstocks (a piece of the plant that is grafted between the scion and stock) in apple to produce smaller plants. Although grafting primarily involves only two plants, multiple grafts can be used to combine several plants to produce, for example, an apple tree that bears several cultivars of fruit, or a rose bush different flower colors.

The best time for grafting is in the spring as growth starts. Grafting techniques can be divided into four basic types: whip, cleft, bark and side grafting. The method selected will largely depend on the size of stock and scion. *Whip or bench graft*

This a fairly easy technique that is used when the scion and stock are of similar diameter (preferably between ¼ inch and ½ inch). The stock can be either a plant growing in the field or a dormant bare root plant. The stock should be smooth and straight-grained. Avoid grafting near a point where side twigs or branches have developed. The scion should be year-old wood, preferably the same diameter as the stock. If the stock is larger than the scion, contact can be made on only one side. The scion should never be larger than the stock.



i. Preparing the stock and scion For this technique, the cuts made in both stock and scion should match. On both parts, make a smooth, sloping cut 1 to 2½ inches long depending on the thickness of the material. This first cut should be a single, smooth one with no waves or whittling.

ii. Cutting the stock

Make a slanting cut about 2 inches from the base of the rootstock. Although grafts may be made with a simple union of two slanting cuts, the strongest graft results from a whip-and-tongue system. To form the tongue, hold the one-sided, slanting cut facing you and support it with your finger. About one-third of the distance down from the tip of this cut, make a downward cut about ½ inch long as close to parallel with the grain of the wood as possible. iii. Cutting the scion

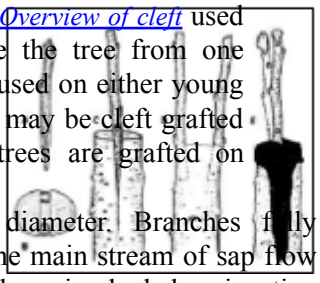
The cutting procedure should be exactly the same as that for the stock. The only difference is that the cuts are made at the bottom end of the scion, whereas they were made at the top of the stock. The more similar the cuts on the two pieces, the greater the chance of a successful graft union. iv. Fitting the stock and scion

After the cuts are made on both parts, push them together tightly enough so that the cut surfaces match as closely as possible (Figure 14). The cambial area immediately under the bark of both pieces must be aligned for a graft union to develop. If the scion and stock are not the same size, match the cambiums on one side only. The lower tip of the scion should not hang over the stock.

v. Protecting the graft

In most cases, it is best to bind the graft with grafting tape or plastic adhesive tape to maintain contact between cambial areas. After wrapping, uniformly apply grafting wax around the wrapping to prevent the graft union from drying. Care should be taken during wrapping and waxing not to dislodge cambial alignment. Remove the wrapping material about a month after the scion starts growing.

Cleft graft



The cleft graft is commonly *Overview of cleft* used to top work a tree (change the tree from one variety to another) It can be used on either young or mature trees. Young trees may be cleft grafted on the trunk, while older trees are grafted on branches not more than 2½ inches in diameter. Branches fully exposed to sunlight and in the main stream of sap flow produce better results than those in shaded or inactive areas, and grafts on upright branches grow better than those on horizontal branches.

When top working large trees, it is best to graft about half the branches the first (upper center branches), and the remainder in the second year. The best time to top work is just as growth begins in the spring.

i. Preparing the stock

Select a smooth, knot-free, straight-grained section. Saw the branch off at a right angle to the grain taking care not to tear or split the bark. If the saw cut is not smooth, use a knife to trim off the rough edges. The bark must be tight to form a successful graft. Using a grafting tool, or a heavy knife that can be tapped with a mallet, drive the blade into the stub to split the stock through the center so that a split extends about 2 inches down into the branch. ii. Preparing the scion

The scion should be made from year-old wood about ¼ inch in diameter. The scion should contain at least three buds and be long enough so that it can be inserted with the lowest bud just above the stock. Start below the lowest bud, and make a long, smooth cut toward the base. The cut should have a surface about 1 to 1½ inches long. Turn the scion to the opposite side and make a second smooth cut of the same length such that the side with the lowest bud is slightly thicker than the other side (see A).

iii. Inserting the scion

With a grafting chisel or small wedge, carefully open the crack in the stock wide enough for the scions. Insert scions at each side of the crack with the thicker side facing out (see B and D above) with the cambiums in contact. The best contact point is about ¼ inch below the shoulder of the stock. After properly positioning the scion, remove the wedge or chisel from the slit. The pressure of the stock against the scion should be greatest where the cambiums touch. When the scion is properly located, the cut surface of the scion wedge should be almost entirely hidden (see C above).

iv. Waxing the cleft graft

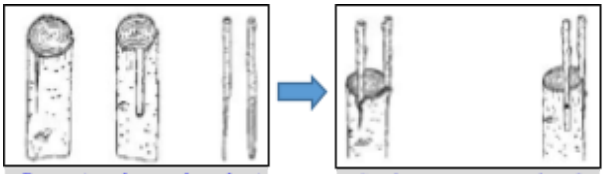
To prevent drying, all cut surfaces should be covered with grafting wax (see E above). Cracks sometimes develop as the wax sets and it is important to check the wax after a few days and again after several weeks to ensure that all surfaces remain covered.

v. Caring for the graft

After the graft begins to grow, it will continue to require attention. Do not prune branches that grow during the first season. However, grafts that grow vigorously may need to be pinched at the tip to stimulate branching.

Some training and branch selection may be necessary after the second year. This should be done during the usual pruning time in late winter or early spring. If both scions in a cleft grow one should be shortened to allow the other to become dominant. The second graft will eventually have to be removed but should be left in place for as long as possible to accelerate would healing at the graft.

Bark, or veneer grafting is usually done on branches ranging from an inch to several inches in diameter.



Preparing the stock and scio *Grafting scion onto the stoc*

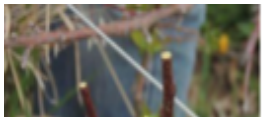
i. Preparing the stock

The branch or trunk is cut off at a right angle in the same manner as described for cleft grafting. Bark grafting should be made only when the bark slips (easily separates from the wood), usually as growth begins in early spring. The stock is prepared either by making a single straight cut in the bark about ¾ inch long, or making two slits in separated by the width of the scion.

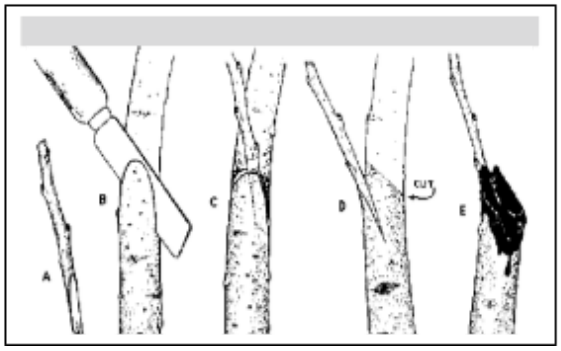
ii. Preparing the scion

The scion should be dormant. For deciduous plants, this means collecting scions in advance and keeping them refrigerated in a plastic bag to prevent drying. Scions should be 4 to 5 inches long with two to three buds. Prepare the base of the scion by cutting inward 1½ to 2 inches from the base, then downward, forming a shoulder followed by a long, smooth cut. The long cut should extend about one-third through the twig, keeping the base strong enough to insert but not too thick. Make a short cut on the opposite side of the long cut to give the base of the scion a wedge shape for easier insertion. iii. Inserting the scion.

If necessary, use a knife to initially separate the bark from the wood on the stock. Push the scion down and center it in the slit or between both slits if the double slit



method is used. Insert the scion until the shoulder rests on the stub. If the scion is large enough, one or two small nails may be used to fasten the scion to the stock. For smaller branches, electrical or masking tape is used to bind the scion onto the stock. The graft should be protected from drying by applying grafting wax over all open surfaces (a canopy of clear plastic can also be used). *Side, or stub, graft*



Overview of side or stub grafting

The side or stub graft is suitable for plants that are too large for a whip graft but not large enough for cleft or bark grafting. The diameter of the plant or branch that will serve as the stock should be 1 to 2 inches while that of the scion should be about ¼ inch.

i. Preparing the stock

Select a smooth area near the base then use a sharp knife to make a slanted downward cut into the stock extending about halfway through the branch.

ii. Preparing the scion

The scion should contain have two to three buds and be about 3 inches long. Make a wedge at the end of the scion similar to that made for cleft grafting but shorter (1 inch or less) with one side slightly thicker than the other.
iii. Inserting the scion

Pull the upper part of the stock back to open the cut then insert the scion into the cut with the slightly thicker side lying along the cambium. Set the scion at a slight angle to give maximum contact. When the top is released, the scion should be held in place so that tacking or wrapping is unnecessary. Cut the stock or stock branch about 5 to 6 inches above the graft and remove any lateral branches on the stub that might crowd the graft as it begins to grow. To prevent drying, cover all cut surfaces on the graft with wax. The tip of the scion, as well as any cuts when removing lateral branches should also be waxed. When the scion has started growth, the remainder of the stock should be carefully cut closer to the graft taking care to wax the new cut.

Budding

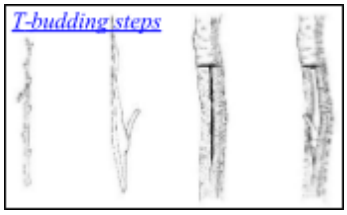
Budding is a method of grafting in which the scion is a single bud rather than a piece of stem or twig. Many of the same conditions and materials used for other forms of grafting also apply to budding. It is most frequently used to multiply a variety that cannot be produced from seed. It may also be used for top working trees that cannot be easily grafted with cleft or whip grafts.

Budding, particularly T-budding, is faster than any other grafting technique and produces a high percentage of successful unions.

Budding is also well adapted to plant shoots less than an inch in diameter. In larger branches, buds may be inserted in vigorously growing twigs near the upper part of the plant. Besides ease and success, budding usually produces a stronger union than those made with other grafting techniques. And because only a single bud is used per graft, it is a more beneficial method where scion wood is in limited supply.

T-budding should be done when the bark of the stock slips (easily separates from the wood) and scion buds are fully developed. Most budding is done from late July to early September with buds set at this time normally remaining dormant until the following spring. Spring budding (in March and April) is also possible but is less desirable than fall budding.

T-budding steps



i. Selecting the stock
Young plants to be used as stock must have new, vigorous growth. Remove shoots on the lower 6 inches of the trunk in early summer to create a smooth surface to work on. Most budding of young plants is done 2 to 3 inches above the ground though it is possible to bud higher.

ii. Obtaining budsticks

Use twigs from the current season growth taken from the plant to be propagated. The twig should be vigorous and healthy with plump mature buds (buds on the center of the twig are generally better than those near the tip or the base). Immediately after cutting, clip off all the leaves leaving about ½ inch of the petiole to serve as handle.

Budsticks should be used as soon as they are taken from the tree. Where this is not possible, they can be stored temporarily in a cool, moist environment.

iii. Preparing the bud

The bud and a small sliver of the wood underneath it are cut from the budstick using an upward slicing motion. The cut should begin about 1/2 to 3/4 inch below the bud, and should go deep enough into the wood so that when the cut is finished about 1/2 to 3/4 above the bud, the bark and a small sliver of wood are cut off. A perpendicular cut across the top of the upward cut will separate it from the bud stick.

iv. Preparing the stock

A T-cut in the stock is the most common and successful budding method. On a smooth, branch-free location on the stock, make a vertical cut about 1½ inches long that is parallel with the grain of the wood by drawing the knife upward. Next, make a crosscut at the top of the vertical cut to form a T, giving the crosscut a slightly downward angle to make ease insertion of the bud piece. Cut through the bark but not into the wood. Once inserted, the bud should sit at the center of this vertical slit.

v. Inserting the bud

After making the two cuts to form the T, gently lift the bark at the junction of the two cuts with the knife. Prepare the bud as described above then promptly insert it into the stock by placing the base of the bud into the slit at the top of the T cut then sliding it into the vertical slit until the perpendicular cut made to separate the bud from the budstick is even with or below the cross cut on the stock. vi. Wrapping the bud

After the bud has been placed in the T-cut, it should be wrapped with grafting tape or rubber budding strips. It is best to start wrapping from above the graft going downward to avoid pushing the bud out of the T-cut. Make three or four wraps above the bud and three or four below and finish with a self-binding loop. Make sure to cover the horizontal cut on the T but to leave the bud exposed.

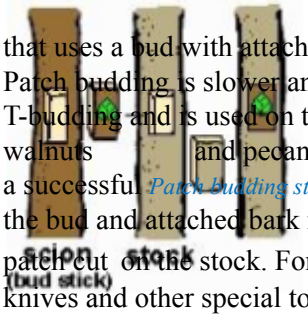
vii. Caring for the bud

Check the bud 7 to 10 days after it has been inserted. By then, it is possible to tell whether or not it has formed a union. If both the bud and the surrounding bark of the bud shield are shriveled and dry, it has not taken. Where a union has formed, the bud and shield will look fresh and non-elastic wrapping materials, if used, should be removed at this time. Elastic wrapping bands can be removed any time, while biodegradable materials should be left to deteriorate naturally.

To prevent birds from alighting on and breaking the developing bud shoot, cut off the stock 4 to 5 inches above the bud. The 4 to 5 inch stub will be removed later when the shoot is larger and more durable.

While the bud is developing, growth from the stock should be prevented by removing any shoots that appear below the bud before they exceed 2 to 3 inches in length. Do not prune the new branch from the grafted bud during the first summer (if there is danger of it being broken by wind, tie it to a stake or devise other means of support).

Patch budding



Patch budding steps

Patch budding is a technique that uses a bud with attached bark, instead of a budstick. Patch budding is slower and more difficult than T-budding and is used on thick-barked trees (e.g., walnuts and pecans) that cannot be Tbudded. For a successful patch bud, the size of the bud and attached bark must be the same size as the patch cut on the stock. For this reason, double-bladed knives and other special tools that make perfectly parallel cuts have been devised to improve the chances of success in patch grafting.

i. Preparation of budsticks

Prepare for patch budding in late summer by selecting budsticks two to three weeks in advance. At that time, cut the leaf blades from the areas to be used, but allow the petioles to remain. The budsticks will be harvested later as needed and by that time, the petioles will have dropped and the leaf scars healed over. After cutting, budsticks should be kept moist and protected from direct sun or intense heat. ii. Removal of the bud patch.

To remove the bud from the budstick, use a double-bladed knife to make parallel horizontal cuts equally spaced above and below the bud. Then, make vertical cuts about an inch apart at each end of the horizontal cuts. This makes a patch about 1 inch square. Remove the patch from the budstick by pushing sideways. Pulling it from the stick may result in pulling out the center of the bud. If the core of the bud stays on the budstick, the patch bud will not grow.

iii. Preparing the stock

A patch similar to that made for the bud must also be made in a clean, straight-grained portion of the stock. Remove the bark from the stock and promptly insert the patch with the bud. Do both operations quickly to ensure neither the bud nor stock has a chance to dry. While the inserted patch should fit snugly on all four sides, a snug fit is especially important at the top and bottom.

iv. Wrapping the bud patch

Immediately after insertion, wrap the patch. If the bark of the stock is thicker than that of the bud, pare it down so that the bud will not be loose after wrapping. Do not cover the bud during wrapping, but all four cuts must be covered. Use heavy cotton string, nursery adhesive tape or masking tape to firmly secure the bud in place without constricting the bud union then wax the edges of the wrap. About 10 days after budding, check to make sure the graft has taken before releasing the wrapping by making a single vertical cut on the backside of the stock, away from the bud. Do not try to pull off the wrapping if it sticks to the bud or stock.

v. Cutting back the stock.

As with other forms of budding, do not cut the stock back until the bud union is completed. When the budding is done in fall, do not cut the stock back until growth starts in the spring. If the budding is done in the spring, cut the stock back about 10 days after it has formed a union.

Tissue culture

Tissue culture, or micropropagation, is the art and science of propagating plants *in vitro,* which means "in glass," in this case, a propagation tube. It functions on the principle of totipotency (the ability of plant cells to differentiate into all cell types).

Tissue culture techniques allow thousands of new plants to be obtained from a single plant, making it an attractive technique for rapidly multiplying new cultivars. Its limitations include the need for specialized equipment, facilities, and highly skilled labor.



The tissue culture process can be divided into four steps or stages: explanting, multiplication, organogenesis and acclimatization.

i. Explanting

The piece of tissue (cell or cells) taken from a plant to be used in tissue culture propagation is known as the explant. This often is the apical meristem, but it can be other plant tissue. Explants should only be taken from healthy plants and need to be surface sterilized before use. After sterilization, the explant is placed on the surface of the sterilized medium in the culture tube.

ii. Multiplication

Wounding plant tissue induces cellular division. In tissue culture, the cells of the explant form an undifferentiated mass of cells known as a callus. This callus continues to grow in size during the multiplication stage.

iii. Organogenesis

With time, the callus cells begin to differentiate into distinct tissues that form organs. The callus will first develop a root system; a shoot system will form soon after. At this time a miniature plant can be seen growing in the culture tube with its roots in the culture medium.
iv. Acclimatization

Once the new plantlet becomes large enough to handle, it can be removed from the culture tube and planted in a growing medium. Newly transplanted plantlets are placed in carefully controlled conditions of light, temperature and humidity for several weeks as they adjust to their new environment. Following this period, they are ready to be grown at a greenhouse before transplanting.

While tissue culture is a viable method of increasing the numbers of a single clone (compared with conventional asexual propagation methods), the success rate for tissue culture depends on the skill of the technician practicing it. The environment created inside the culture tube is ideal for harmful microbes as well as for plant formation. Contamination is a constant problem and leads to disappointing results. Moreover, each plant species has its own special growing requirements. While these have been established for many important horticultural species, there are many more species whose requirements have yet to be determined.

Legal considerations

The U.S. Plant Patent Law was passed in 1930 to encourage the development of new, improved cultivars of asexually propagated plants by allowing them to be patented. The law gives patent holders legal rights to control reproduction of a particular cultivar and to assess a royalty to others who reproduce it for profit. This royalty is meant to provide financial motivation for plant breeders to continue developing improved cultivars of important species. Plant patents are valid for 20 years after the patent application is filed. It is illegal to propagate for personal gain patented plant material without written permission from the holder of the patent rights. This permission takes the form of a legal contract and dictates the royalty to be paid for each propagule, along with other stipulations.

The Plant Variety Protection Act, a similar law passed by Congress in 1970, places restrictions on the reproduction of sexually propagated plants. Before this, one of the few ways plant breeders could profit from their work was to guard the identity of the parents of hybrids. Non-hybrid or "standard bred" cultivars were fair game for anyone to reproduce and use as a seed source for future crops. This is no longer the case. Seed of protected varieties must be purchased from a source approved by the holder of propagation rights. The source will have paid a royalty to the developer for the right to reproduce or sell the variety. If an operator chooses to save seed from a protected variety for future use, he or she must pay a royalty to the holder of reproduction rights.

References

1. Alan Togood (Editor-in-Chief). Plant propagation. American Horticultural Society, 1999.
2. David Trinklein. Plant propagation. Division of Plant Sciences, University of Missouri Extension, 2009.
3. Diane Relf and Elizabeth Ball. Propagation by cuttings, layering and division. Virginia Cooperative Extension Publication# 26-002, 2009.
4. Various online sources (please follow links to specific pages).

Summary Description for Module 12

Title:	Module 12: Vegetable, Small Fruit and High Tunnel
Instructor:	Dr. Sanjun Gu, Assoc. Prof. and Extension Specialist, Horticulture
Prerequisites, if applicable:	Some experience working with plants
Class Time:	9:00AM – 11:30AM & 12:00PM – 3:00PM
Learning Objective:	For this module, participants will learn about the following: • Classification systems and identification of the major vegetables and small fruits; • High tunnel basics; • Cultivation and cropping systems; • Field establishment and cultural practices; • Postharvest and storage.
Instructor Media Needs:	• PowerPoint Projector • Laptop Computer
Class Materials and/or Supplies Needed:	• White Board • Markers and eraser
Class Activities:	1. Discussion on the major vegetables and small fruits 2. Discussion on the high tunnel technology 3. Discussion on the establishment and cultural practices, including postharvest and storage 4. A tour of the high tunnels with vegetable and small fruit crops.
Knowledge Gained:	By the end of the class, students will understand: • Production techniques of the main vegetable and small fruits; • The optimal operation of high tunnels for horticultural production. • Various cultivation and cropping systems.
Skills Gained:	The following skills will be gained by the end of the training: • Techniques for vegetables and small fruits production; • The basics of high tunnel management; • Field establishment and cultural practices vegetables and fruits; • Postharvest and storage.

Abilities Gained:	At the end of the module, learners will be able to: • Identify the major vegetable and small fruit crops • Plant/transplant vegetable seeds/transplants • Manage temperature control in high tunnels • Optimize postharvest and storage environmental conditions.
Exam Description:	Onsite quiz: high tunnel structure, plant ID, small machines and equipment. Lecture-based assessment: Ten (10) questions based on class notes for the module.; At-home assignment: photos of participants' urban farm or gardens.

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Of all vegetable species, only 50 or so are of great importance commercially. Grouping those species into similar groups makes identification and cultivation easier as vegetable crops in a group may have *similar environment requirement, share similar pests* and *be cultivated similarly*. Vegetables in the same Family or group are not options for rotation. The common classifications of vegetable crops include botanical, edible part, life cycle, sensitivity to temperatures, and a combination of botany and accepted use. Listed below is ***classification based on Family group and accepted use*** that has been widely adapted. This method divides vegetable crops into 10 groups. In some other countries, *aquatic vegetables* and *edible fungi* are two additional vegetable groups.

1. *Cole vegetables.* They are also called crucifers or *Brassicas,* belonging to the Brassicaceae or mustard family. This family consists of over 3,200 species. Most of them are indigenous to temperate and cold climates. They usually flower in spring and could be considered biennial crops if to produce seeds. Important vegetables included in this group are cabbage, broccoli, cauliflower, and Brussels sprouts.
2. *Leafy greens.* Leafy crops are usually consumed after cooking, but could be also eaten raw. Vegetables in this group include spinach, collards, kale, endive, mustard greens, and some herbs. They are cool or cold season crops.
3. *(Leafy) Salad greens.* Crops used mainly for their leaves and eaten raw. Major vegetables are lettuce, celery, parsley, etc. They are cool season crops and usually will not overwinter in North Carolina.
4. *Perennial vegetables.* Perennial vegetables stay in field for more than 2 years. Their aboveground parts are killed each winter in most part of North Carolina but the roots remain alive and send up shoots in the spring. Plants in this grouping include members from the Lilliaceae (asparagus), Asteraceae (globe artichoke), and Polygonaceae (rhubarb) families.
5. *Root vegetables.* Crops that have a prominent, fleshy underground structure, which could be a root or hypocotyl with a taproot forming below. Major root crops come from the Apiaceae (carrots), Chenopodiaceae (beets), Brassicaceae (turnip and rutabaga), and Convolvulaceae (sweet potato) families. Note that potato is a stem (tuber), not a root so it is not listed in this group.

6. *Bulbs*. All are species of *Allium* in the Alliaceae family. The plants have bulbs or corms. Crops of importance include onion, garlic, and leeks.
7. *Legumes*. All are members of the Fabaceae or pea family. The pea family has about 600 genera and 12,000 species. They are primarily herbaceous plants in temperate climates but can exist as trees and shrubs in tropical climates. Many members of the family can fix nitrogen in their roots. Crops in this group include common bean, English pea, Southern pea, and lima bean. Edible part could be immature pods and seeds, or dry seeds. Legumes grown for dry seeds (grains) are called *pulses*.
8. *Sweet corn.* A member of the Poaceae or grass family. It is consumed at immature seed stage. The young and tender cobs are also consumed (cooked) as vegetables in Southeastern Asia.
9. *Solanum vegetables.* All are members of the Solanaceae or nightshade family. There are about 90 genera and about 2,200 species in this family. Many species contain alkaloids such as solanine, nicotine, and atropine that are poisonous. Vegetables in this family include tomatoes, peppers, eggplants, and Irish potatoes. Tomato, eggplant and pepper are also regarded as ***Fruit or Fruiting Vegetables***. Please note that tobacco is also in this family. Growing fruit vegetables after potato or tobacco is not recommended.
10. *Cucurbit vegetables.* They are members of the Cucurbitaceae or gourd family. This family consists of about 100 genera and 500 to 700 species. Important vegetables in this family include cucumber, watermelon, melon, pumpkin and squash.

Common Practices in Vegetable Production

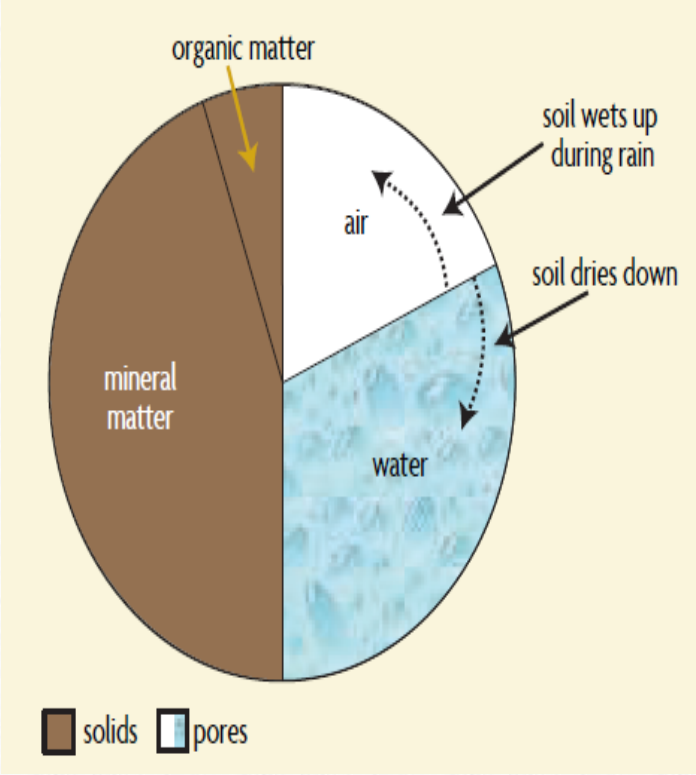
Soil Management and Fertilization

Vegetable Soils

- Vegetables have relatively limited root system and are fast growing. Therefore they need high level of soil fertility.
- The best soils for vegetables are well drained, fairly deep and relatively high in organic matter (3-5%)
  - 1% or less is typical for large-scale productions
- It is very important to know the physical and chemical property of your soil.

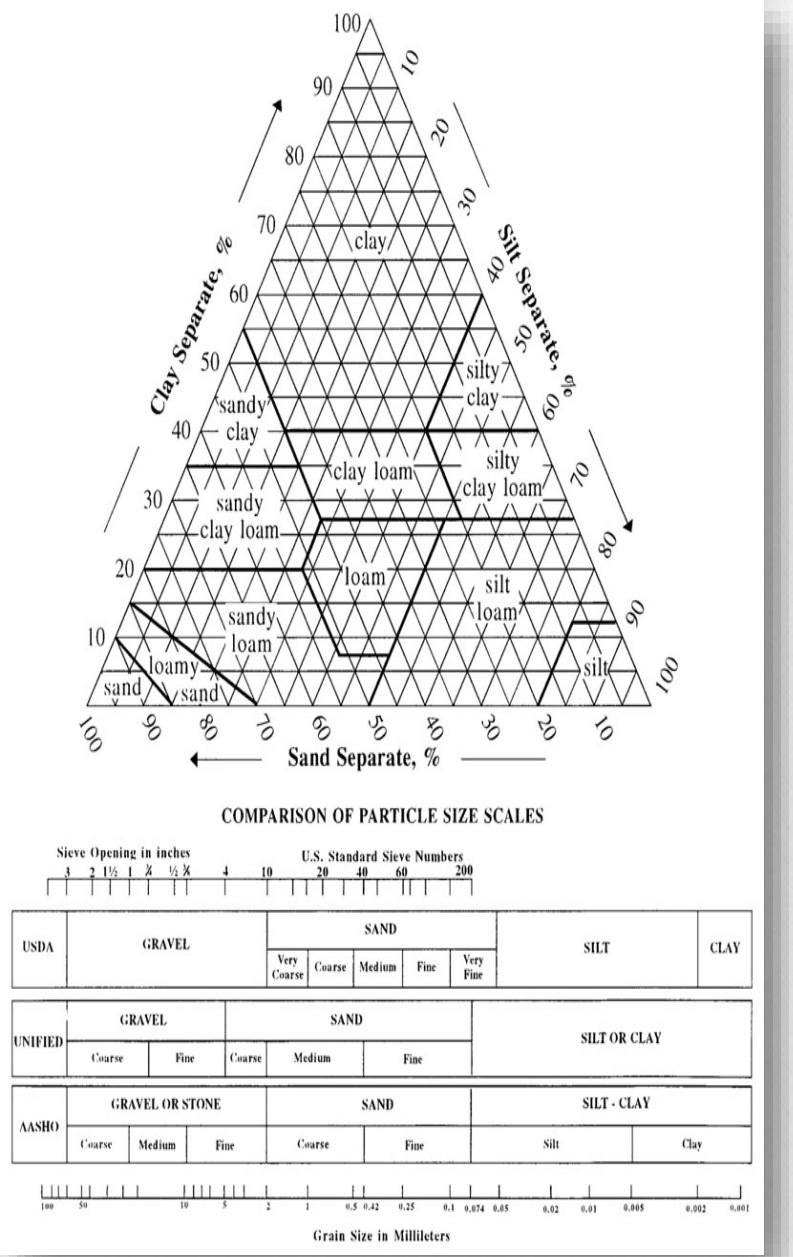
Physical Property

- Soil consists of 50% solid particles and 50% pores which can be filled with water/air
- Over 45% of the solid particles are minerals and the rest could be organic matter
  - Organic Soil vs Mineral Soil



Soil Type

- Sandy loams and silt loams are ***preferred*** for most vegetable crops.
- Loamy sand and sandy loam soils are generally better suited for **early** market crops.
- Loam and silt loam soils are generally better suited for **late** fresh market or processing crops.
- Deep, well-drained organic soils are idea for leafy vegetables, bulbs and root vegetables.



Soil Organic Matter (SOM)

- ***SOM*** has an overwhelming effect on almost all soil properties.
- A typical soil for agriculture only has 1-6% of organic matter, which consists of three distinctly different components, *living organisms*, *fresh residues* and *well decomposed residues (**Humus**)*.
- Soil tests measure Humus for SOM
- Deep colored soil has more SOM
- SOM increases the cation exchange capacity
- In most cultivated soils, long-term increase in SOM is **unlikely**

Chemical Property

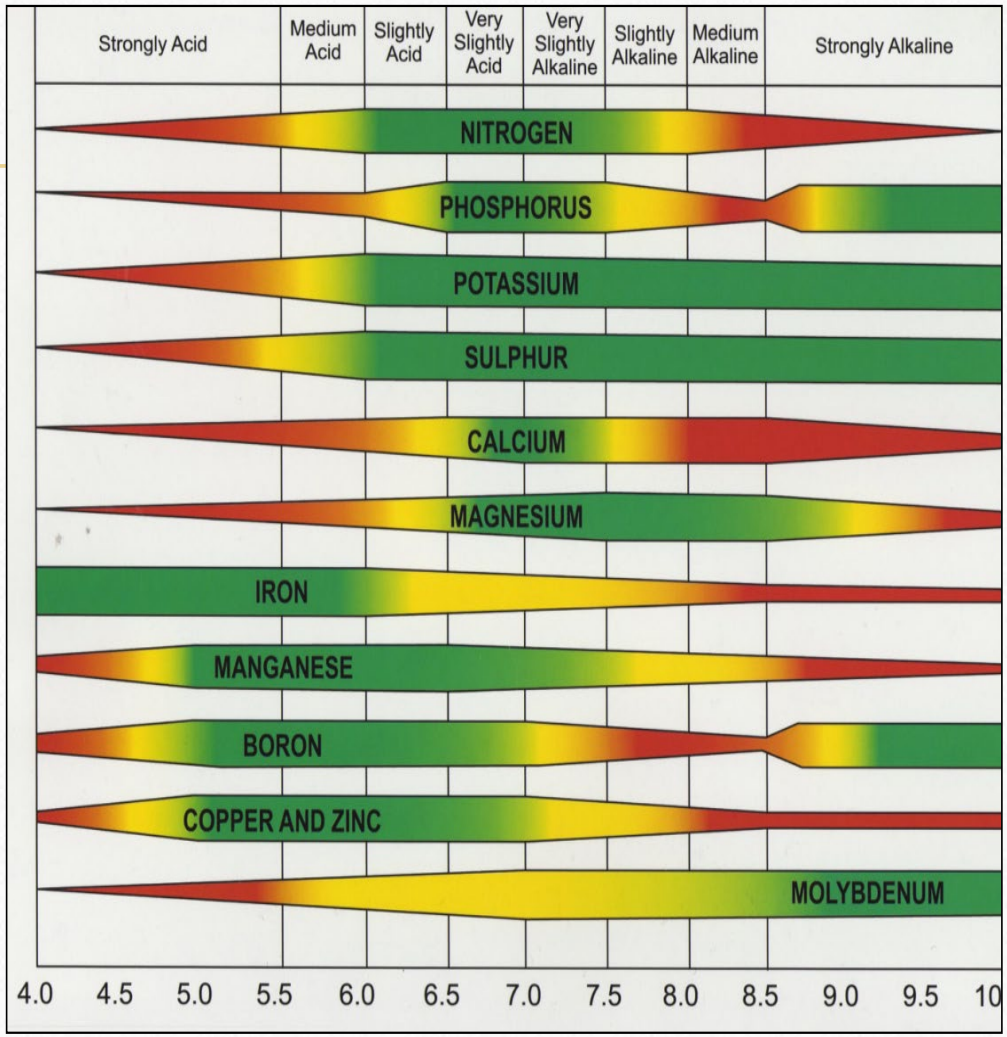
- Soil pH, salinity and Cation Exchange Capacity (CEC)
  - Determined by mineral elements compositions
- Plants need 16 essential nutrients to grow and reproduce, 13 of them are mineral elements
  - From air and water: C, H_2, and O_2
  - Primary nutrients: Nitrogen (N), Phosphorus (P), and Potassium (K)
  - Secondary nutrients: Sulfur (S), Calcium (Ca), and Magnesium (Mg)
  - The micronutrients (trace elements): Zinc (Zn), Iron (Fe), Copper (Cu), Manganese (Mn), Boron (B), Molybdenum (Mo), and Chlorine (Cl).

Mineral Nutrient	Deficiency symptoms	Occurrence
Nitrogen (N)	Stems thin, erect, hard. Leaves small, yellow; some crops' (tomato) undersides are reddish. Lower leaves affected first.	On sandy soils especially after heavy rain or after over-irrigation. Also on organic soils during cool growing seasons.
Phosphorus (P)	Stems thin and shortened. Leaves develop purple color. Older leaves affected first. Plants stunted and maturity delayed.	On acidic soils or very basic soils. Also when soils are cool and wet.
Potassium (K)	Older leaves develop gray or tan areas on leaf margins. Eventually a scorch appears on the entire margin. Older leaves affected first.	On sandy soils following leaching rains or over-irrigation.
Boron (B)	Growing tips die and leaves are distorted. Specific diseases caused by boron deficiency include brown curd and hollow stem of cauliflower, cracked stem of celery, blackheart of beet, and internal browning of turnip.	On soils with pH above 6.8 or on sandy, leached soils, or on crops with very high demand, e.g. Cole crops.
Calcium (Ca)	Growing-point growth restricted on shoots and roots. Specific deficiencies include blossom-end rot of tomato, pepper and watermelon, celery blackheart, and cauliflower or cabbage tip-burn.	On strongly acidic soils, or during severe droughts.
Copper (Cu)	Yellowing of young leaves, stunting of plants. Onion bulbs are soft with thin, pale scales.	On organic soils or occasionally new mineral soils.
Iron (Fe)	Distinct yellow or white areas between veins on youngest leaves.	On soils with pH above 6.8.
Magnesium (Mg)	Initially older leaves show yellowing between veins, followed by yellowing of young leaves. Older leaves soon fall.	On strongly acidic soils, or on leached sandy soils.
Manganese (Mn)	Yellow mottled areas between veins on youngest leaves, not as intense as iron deficiency.	On soils with pH above 6.4.
Molybdenum (Mo)	Pale, distorted, narrow leaves with some inter-veinal yellowing of older leaves, e.g. whiptail disease of cauliflower. Rare.	On very acidic soils.
Zinc (Zn)	Small reddish spots on cotyledon leaves of beans; light areas (white bud) of corn leaves.	On wet, cold soils in early spring or where excessive phosphorus is present.
Sulfur (S)	General yellowing of younger leaves and reduced growth.	On very sandy soils, low in organic matter, especially following continued use of sulfur-free fertilizers.
Chlorine (Cl)	Deficiencies very rare.	Usually only under laboratory conditions.

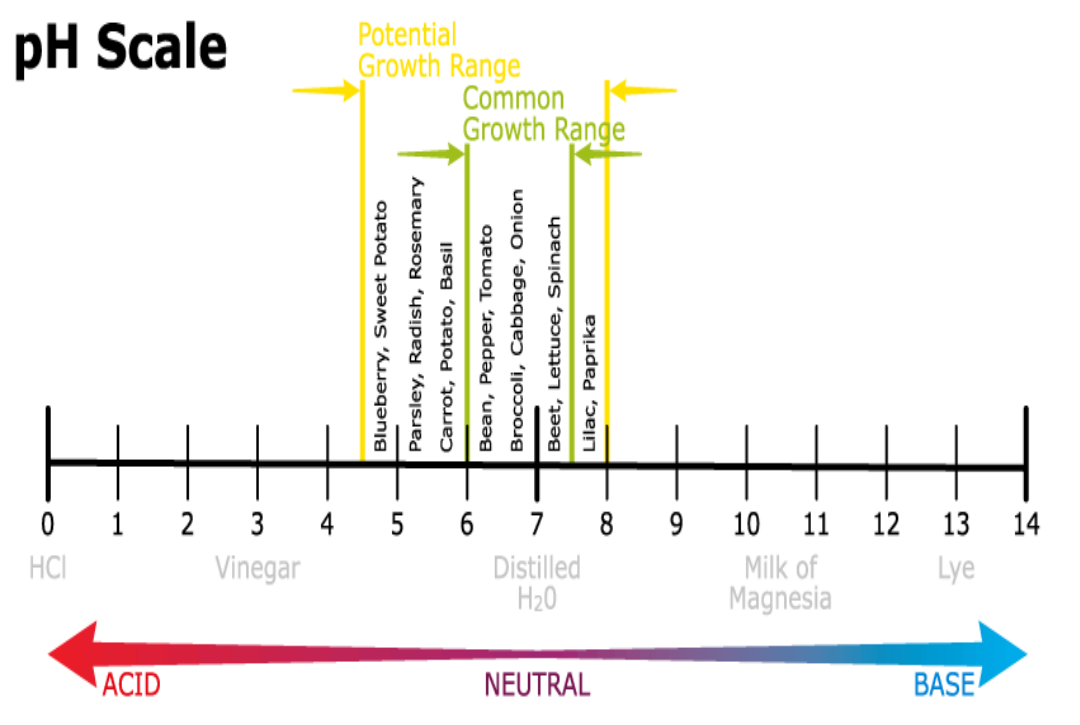
Soil pH

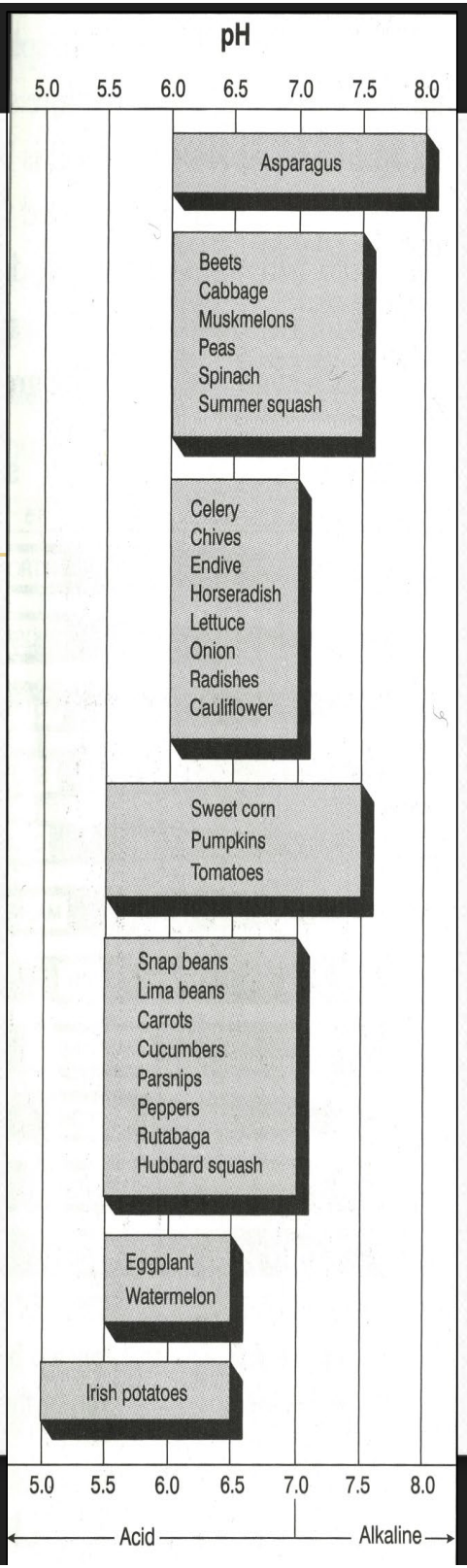
- Soil pH indicates soil acidity or alkalinity. A pH of 7 means neutral soil.
- It is the most important factor determining micronutrient availability for vegetable crops.
- Most vegetables prefer **slightly acidic** soils, where mineral nutrients are largely available.
- The availability of mineral nutrients under different pH is different between an **organic soil** and a **mineral soil (<20% organic carbon by weight)**.
- Vegetable crops have different tolerance to soil pH.
- If your soil pH is not ideal, **liming to increase** the pH or applying **sulfur** related compound **to decrease** the pH is needed.
  - ✓ This could be an annual practice.

Influence of pH on the availability of plant nutrients in mineral soils



Optimum pH range for (vegetable) crops





Cation-Exchange Capacity (CEC)

- A cation is a positively charged ion. Most mineral nutrients are cations: Ca^{2+}, Mg^{2+}, K^{+}, NH_4^{+}, Zn^{2+}, Cu^{2+}, and Mn^{2+}.
- These cations are in the soil solution and are in dynamic equilibrium with the cations adsorbed on the surface of clay and organic matter.
- CEC is a measure of the quantity of cations that can be adsorbed and held by a soil.
- CEC is dependent upon the amount of **organic matter and clay** in soils and on the types of clay.
- In general, the **higher OM and clay** (negatively charged) content, the **higher the CEC**.

Soil Salinity

- The soluble salts refers to the inorganic soil constituents (ions) that are dissolved in the soil water.
- The electrical conductivity measurement is reported in millimhos per centimeter (mmhos/cm, about 640 mg/L salt).
- High soluble salts can restrict root growth, cause burning of the foliage, and limit crop yields.
- Vegetable crops differ in their sensitivity to soluble salts.

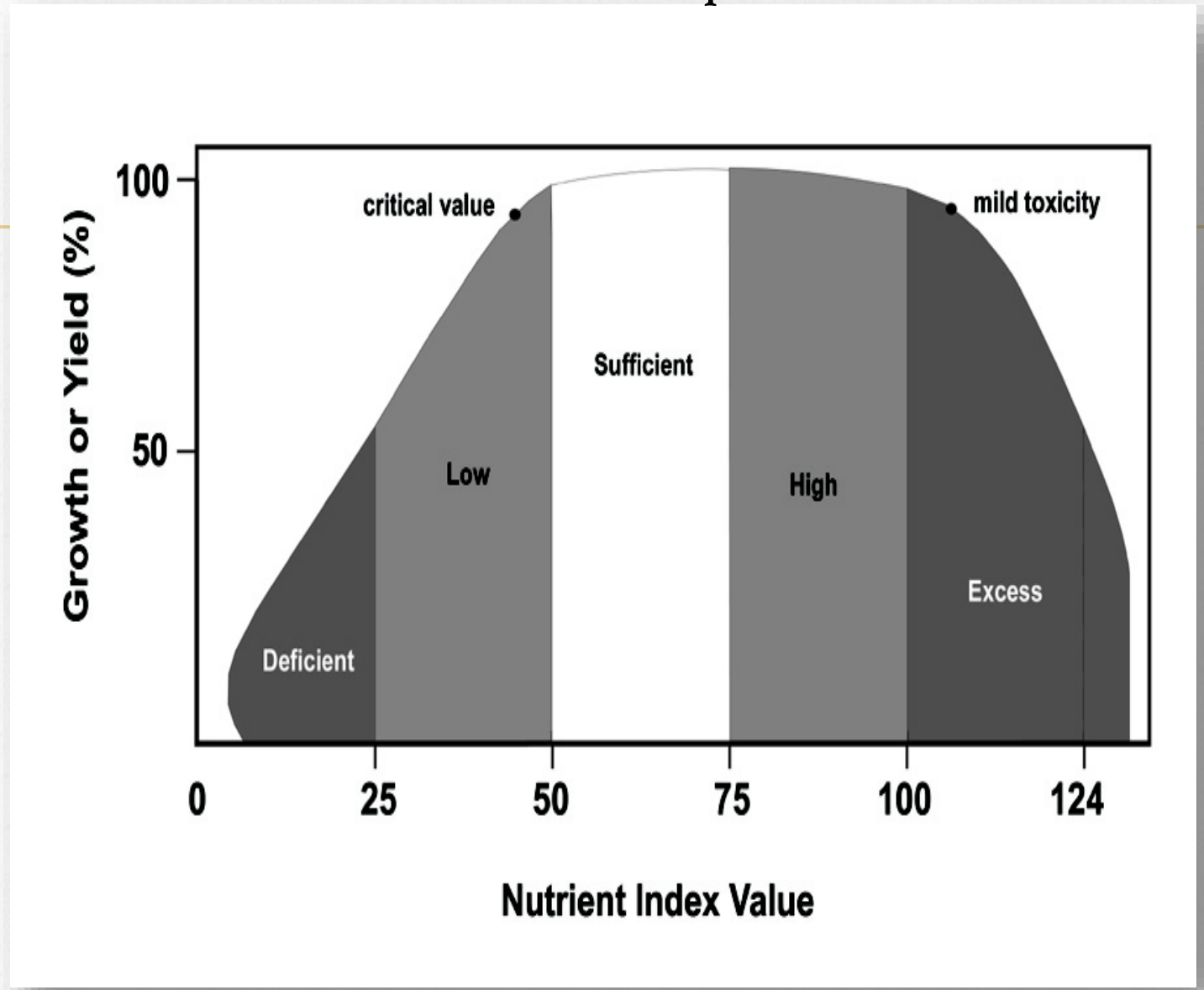
Relative salt tolerance of vegetables (based on growth rather than yield)

Vegetable	Maximum soil salinity (threshold) without yield loss (mmhos/cm*, ≈ 640 mg/L salt)	Decrease in yield above the threshold (% per mmhos/cm)
Sensitive crops		
Bean	1.0	19
Carrot	1.0	14
Onion	1.2	16
Turnip	0.9	9
Moderately sensitive		
Broad bean	1.6	10
Broccoli	2.8	9
Cabbage	1.8	10
Celery	1.8	6
Corn, sweet	1.7	12
Cucumber	2.5	13
Lettuce	1.3	13
Pepper	1.5	14
Potato	1.7	12
Radish	1.2	13
Spinach	2.0	8
Squash, scallop	3.2	16
Sweet potato	1.5	11
Tomato	2.5	10
Moderately tolerant		
Beet	4.0	9
Squash, zucchini	4.7	9
Tolerant		
Asparagus	8-16	Not available
Swiss chard	8-16	Not available

Soil Test interpretation and recommendations

Soil test rating	Relative yield without adding nutrients	Efficiency of adding fertilizers	Recommendations
Low	50-75%	>90%	Annual application to produce maximum response and increase soil fertility
Medium	75-100%	60-90%	Normal annual application to produce maximum yields.
High	100%	10-60%	Small applications to maintain soil level. Amount suggested may be doubled and applied in alternate years.
Very high	100%	<10%	None until level drops back into high range. This rating permits growers, without risk of loss in yields, to benefit economically from high levels added in previous years. Where no P or K is applied, soils should be resampled in 2 years. When phosphorus is extremely high, further additions may limit the availability of Fe and/or Zn.

Expectation of yield or growth (%) in response to increasing nutrient concentration and interpretation index

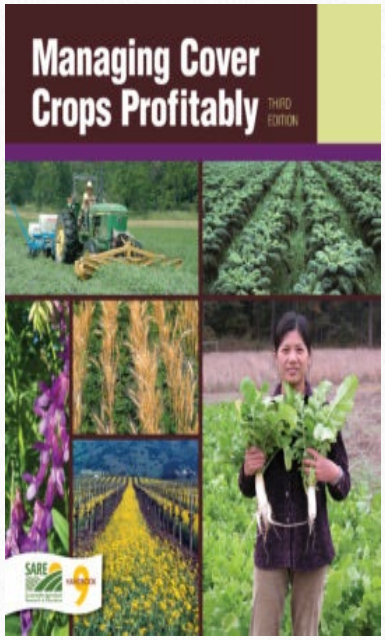


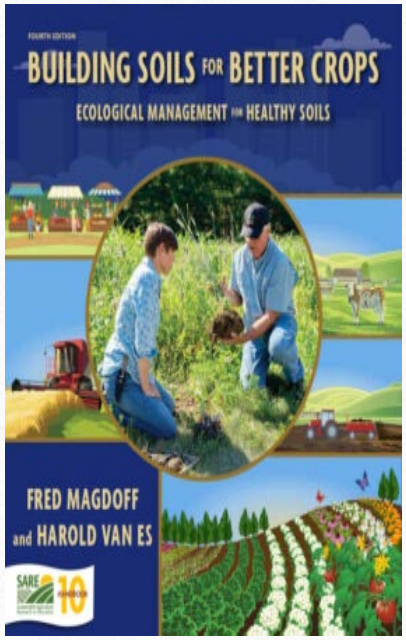
Field Preparation

- Successful vegetable stand establishment requires a planting bed with soil in good tilth.
- The soil should be free of trash, clods, and any other debris that interfere with seed germination or plant root growth.
- Field should be loosened 6-8 inches.
- Adding fertilizers: organic vs chemical
- Plowing: spring vs. fall (better)
  - Till vs no-till: moisture conservation, erosion control, weed control, pest control, early production (soil temperature)
- Raised beds vs flat beds
  - Plastic mulch and drip irrigation

Improve Soil Health/Fertility

- Increase organic matter
  - Cover cropping: every scale of production
  - Add compost: small scale
  - Add animal manure: small scale
- Soil inoculation





https://www.sare.org/resources/managing-cover-crops-profitably-3rd-edition/
https://www.sare.org/resources/building-soils-for-better-crops/

Fertilizing Vegetable Crops

- Understand organic fertilizer: compost, manure, cover crops
  - Slow release
- Understand chemical fertilizer:
  - The formula: 5-10-5 (N-P_2O_5-K_2O) or 1-2-1 (ratio)
  - Advantage and disadvantage: fast reaction, salt built-up
- Based on the soil test at the beginning:
  - 40/60 or 50/50 or all at once (short-season crops)
    - ✓ For vegetable production we should add a bit more fertilizer than crops really need
  - Heavy feeder (tomato) vs light feeder (lettuce)
- Based on **tissue analyses** during the growing season

Methods of Application

- Broadcasting
- Banding
- Side-dressing
- Start solution at transplanting: Rich in P
- Foliar feeding
- Fertigation



Recommended concentrations of micronutrients for foliar applications

Nutrient	Source	Foliar application lb/acre
Boron	Borax	2 to 5
	Solubor1	1 to 1.5
Copper	Copper sulfate	2 to 5
Iron	Ferrous sulfate	2 to 3
	Chelated iron	0.75 to 1
Manganese	Manganous sulfate	2 to 4
Molybdenum	Sodium molybdate	0.25 to 0.50
Zinc	Zinc sulfate	2 to 4
	Chelated zinc	0.75 to 1
Calcium	Calcium chloride	5 to 10
	Calcium nitrate	5 to 10
Magnesium	Magnesium sulfate	10 to 15

For Nitrogen: <1000 ppm or 1% to avoid chemical burn, esp. for transplants

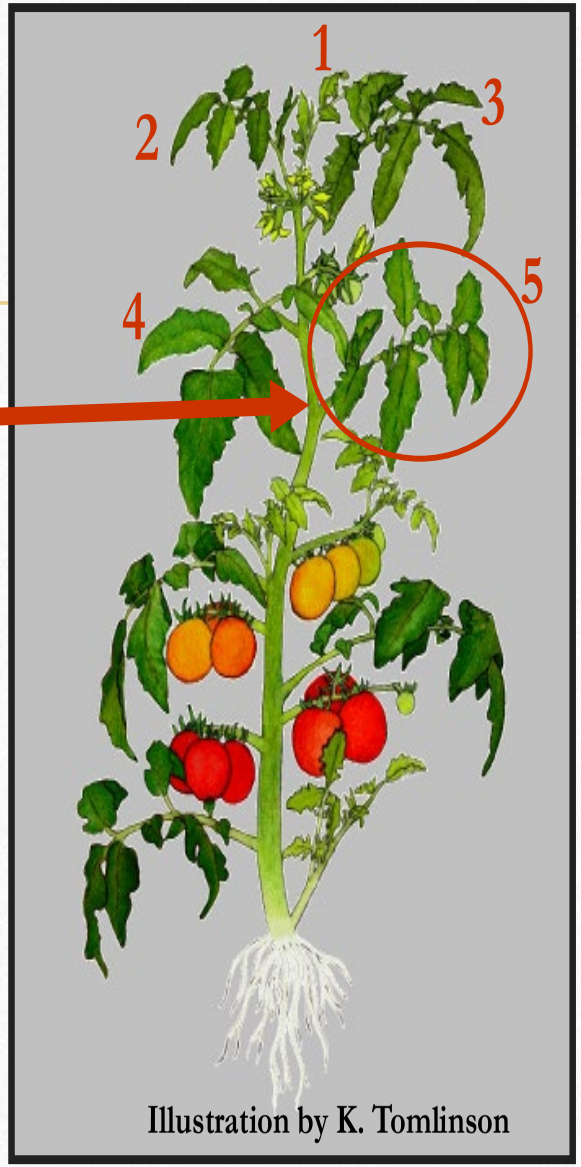
Tissue Analysis

- For most crops, interpretations are based on sampling the most recent mature leaf (MRML).
- The MRML is the most fully expanded or mature leaf and is generally the 3rd to 5th leaf below the growing point.
- It is neither dull from age nor shiny green from immaturity.

- Nutritional status at time of sampling
- Concentrations of 11 essential nutrients
  - N, P, K
  - Ca, Mg, S
  - Fe, Mn, Zn, Cu, B
  - plus Na

Tomato MRML

The 5th entire leaf from the plant's growing point



Macronutrients (%)	
N	3.5 – 5.0
P	0.3 – 0.65
K	3.5 – 4.5
Ca	1.0 – 3.0
Mg	0.35 – 1.0
S	0.2 – 1.0

Micronutrients (ppm)	
Fe	50 – 300
Mn	25 – 200
Zn	18 – 80
Cu	5 – 35
B	30 – 75

Irrigation and Mulching

Water

- Vegetable yield and quality suffer rapidly from drought, as >80% of a vegetable is water
- Water comes from two major sources:
  - Natural precipitation
  - Irrigation
- In most areas, rainfall is either inadequate or too inconsistent for optimum production, so irrigation is **essential** in vegetable production

Water Content of Selected Vegetables

Vegetable Plant Part	Fresh Weight (%)
Cucumber fruit	96
Lettuce head	94
Cabbage head	90
Potato tuber	79
Tomato	85-95
Tomato fruit	94
Sweet corn	85
Carrot roots	88
Asparagus tips	88

Critical periods of water need for vegetables

Crop	Critical Period
Asparagus	Brush (fern) development
Beans, Lima	Pollination and pod development
Beans, Snap	Pod enlargement
Broccoli, Cabbage, Cauliflower	Head development
Carrots	Root enlargement
Corn	Silking and tasseling, ear development
Cucumbers	Flowering and fruit development
Eggplants	Flowering and fruit development
Lettuce	Head development
Melons	Flowering and fruit development
Onions, Dry	Bulb enlargement
Peas, Southern and English	Seed enlargement and flowering
Peppers	Flowering and fruit development
Potatoes, Irish	Tuber set and tuber enlargement
Radishes	Root enlargement
Squash, Summer	Bud development and flowering
Sweet potato	Root enlargement
Tomatoes	Early flowering, fruit set, and enlargement
Turnips	Root enlargement

Irrigation

- The frequency and amount of water
  - individual vegetable crop
  - growth age
  - soil type and the current soil moisture
  - weather conditions
- Generally 1 to 1.5 acre inches of water are required each week, although this need decreases to 0.75 inches per week during cooler seasons.
- Shallow-rooted vegetables: every 4-6 days in sandy soil; every 10-12 days in clay soil
  - Depending on weather

Roots

- The effective rooting depth of vegetable crops determines the ability of water absorption from the soil profile.
- Most vegetable crops absorb water in the surface soil.
- **Vegetables root types (if not transplanted!)**
  - Shallow roots (6-12″soil depth): beet, broccoli, carrot, cauliflower, celery, greens & herbs, onion, pepper, radish and spinach
  - Medium roots (18-24″): cabbage, Brussels sprout, cucumber, eggplant, muskmelon, pea, potato, snap bean, summer squash, sweet corn and tomato
  - Deep roots (>26″): asparagus, lima bean, pumpkin, sweet potato, watermelon and winter squash

When to Irrigate

- Two common ways of estimating soil water deficit
  - Soil water tension: measured with soil moisture sensors such as electrical resistance moisture blocks or tensiometers
    - ✓ Soil type should be considered when using these meters.
  - The feel and appearance of soil with a soil probe.
- Irrigation should occur when the water depletion 20-25% at the effective rooting depth.



Table 8.2. Relative Frequency and Amount of Irrigation Water for Vegetable Crops as Affected by Soil Type and Rooting Depth (for summer conditions, Davis, California)

Rooting Depth	Sandy Soil		Loam Soil		Clay Soil	
	Irrigation Interval	Application Rate	Irrigation Interval	Application Rate	Irrigation Interval	Application Rate
	(days)	*(in.)*	*(days)*	*(in.)*	*(days)*	*(in.)*
Shallow (0–2 ft.)	4–6	1–2	7–10	2–3	10–12	3–4
Medium (0–4 ft.)	7–10	2–3	10–15	3–4	15–20	4–5
Deep (0–6 ft.)	10–12	3–4	20–30	4–5	30	5–6

Soil Type	Soil moisture to begin irrigating (centibar)
Loamy sand, sandy loam, very fine sandy loam	25
Silt loam	40
Clay loam, silt clay loam	60

Water Source and Food Safety

- Water supply: well, pond, lake, stream, river, **city water**
  - **Surface water**
- Water Quality: salts, pH, boron, sediments, algae, bacteria (*E. coli*)
  - For drip irrigation, well water might be the best
    - City water is great but could be cost prohibitive
- GAP/GHP, FASMA

Irrigation Methods

- **Surface Irrigation**
  - Flood irrigation
  - Furrow irrigation
  - Sprinkler Irrigation
- **Center-pivot and linear-move systems**
  - Travelling guns
  - Portable pipe
  - Solid-set pipe
  - Wheel-roll system
- **Trickle (Drip) Irrigation**
- Sub-irrigation: applies water below the soil surface to raise the watertable into or near the plant root zone

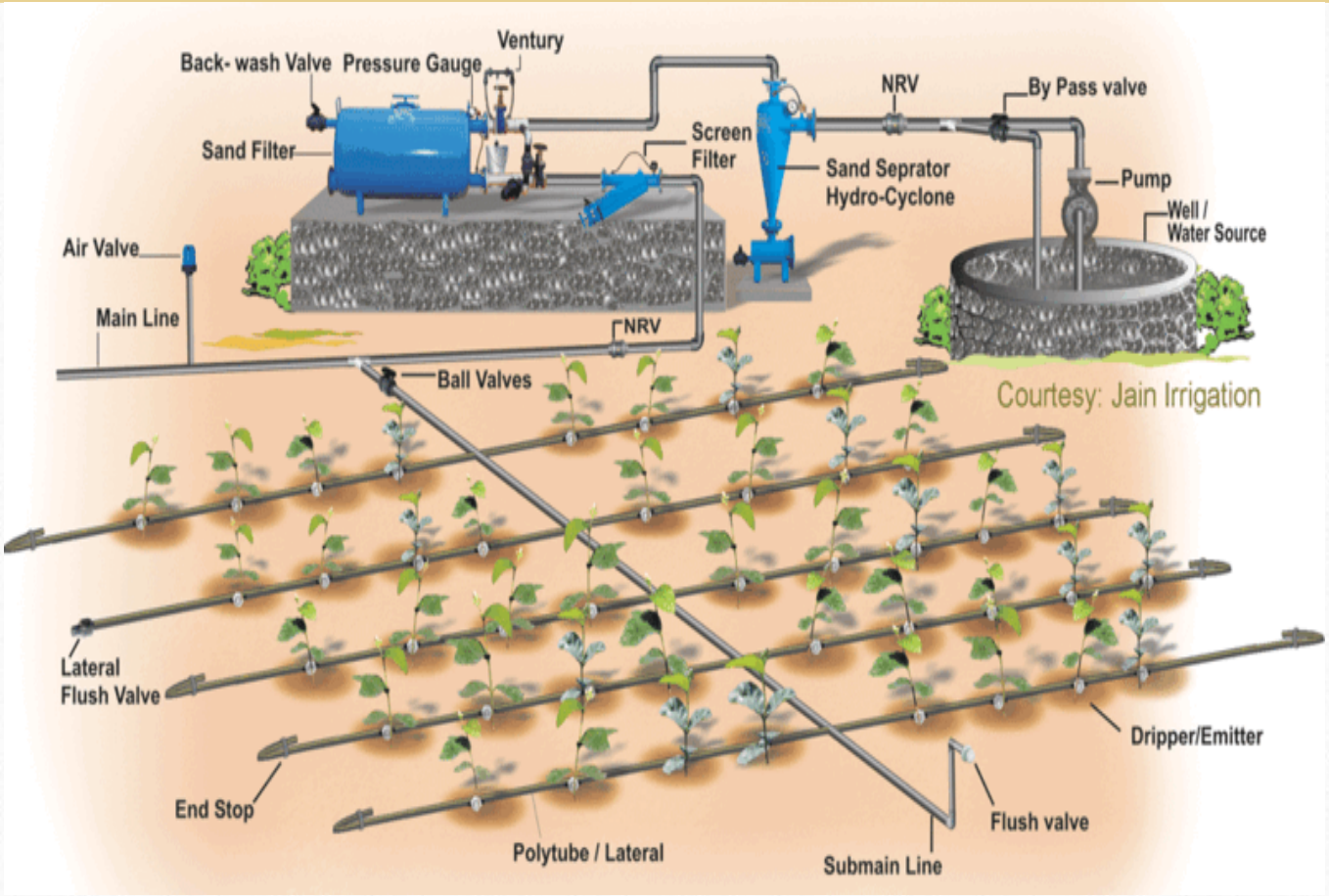




TABLE 8.6 *Advantages and disadvantages of the various irrigation systems*

System	Advantages	Disadvantages
Furrow		
	• Low initial cost • Disease avoidance	• Uneven water distribution • Crusting can occur • Poor water conservation • High water use • Salt may concentrate near plants • Land must be leveled
Sprinkler		
	• Good soil moisture • Leaches excess salts • Reduces crusting • Relatively uniform water • Can be used on unlevel land	• High initial cost • Encourages weed growth • High energy requirement • May encourage some diseases
Trickle		
	• Requires little water • Can cut irrigation labor cost • Can harvest or spray • Efficient water use • Can be used on sloped land • Fertilizer and some fungicides can be applied through the system	• Can be costly

Drip Irrigation System



Plastic mulch with raised beds and drip irrigation systems for Irrigation, Fertigation and Chemigation









Drip Irrigation Cost:

An up-to-5-acre Irrigation System

Item	Cost (2009)
2 in. centrifugal pump on 6.5 HP engine	$595
Filter, disc cannister (2")	190*
Fertilizer Injector	160
2 tensiometers: 12" & 18" and service kit	180
Layflat, 2" (300 ft. roll)	200
Suction hose and strainer	100
Fittings, valves, gauges, etc	75
Total (5-7 yrs. reusable)	$1,500
Annual per-acre expenses	• 8-10 mil drip tape and black plastic mulch(1 mil, 4 ft wide): $0.053/ft x 7,260 linear ft= $380 • depreciation/rental costs on mulch layer and waterwheel setter

Drip Irrigation

- In many cases, it is ***inappropriate*** to apply more than 0.25 inch of water at a time with drip irrigation systems, especially when Fertigation or Chemigation is conducted.
- Doing so can move water below the plant's root zone, carrying nutrients and pesticides beyond the reach of the plant's roots.

Hours needed to apply 1-inch water to the mulched area

Drip tape flow rate		Mulched Width (ft)				
gph/100ft	gpm/100ft	2.0	2.5	3.0	3.5	4.0
8	0.13	15.5	19.5	23.5	27.0	31.0
10	0.17	12.5	16.5	18.5	22.0	25.0
12	0.20	10.5	13.0	15.5	18.0	21.0
16	0.27	8.0	10.0	11.5	13.5	15.5
18	0.30	7.0	8.5	10.5	12.0	14.0
20	0.33	6.0	8.0	9.5	11.0	12.5
24	0.40	5.0	6.5	8.0	9.0	10.5
30	0.50	4.0	5.0	6.0	7.0	8.5
36	0.60	3.5	4.5	5.0	6.0	7.0
40	0.67	3.0	4.0	4.5	5.5	6.0
42	0.70	3.0	4.0	4.5	5.0	6.0
48	0.80	2.5	3.0	4.0	4.5	5.0
50	0.83	2.5	3.0	4.0	4.5	5.0
54	0.90	2.5	3.0	3.5	4.0	4.5
60	1.00	2.0	2.5	3.0	3.5	4.0

Maximum irrigation periods (hours) for drip irrigation systems

Flow rate of drip tape		Soil Texture				
gph/100ft	gpm/100ft	sand	loam	Sandy loam	clay	Silt loam
12	0.2	5.0	8.0	11.5	15.5	17.5
18	0.3	3.5	5.0	7.5	10.5	11.5
24	0.4	2.5	4.0	5.5	8.0	8.5
30	0.5	2.0	3.0	4.5	6.5	7.0
36	0.6	1.5	2.5	4.0	5.0	6.0
42	0.7	1.5	2.0	3.0	4.5	5.0
48	0.8	1.5	2.0	3.0	4.0	4.5

Organic vs Plastic Mulch



Disadvantages of organic mulching

- Slow soil warming-up in spring, NOT good for "season extension"
- Fake "wet surface"
- Cause nitrogen starvation: straw, wood chips, saw dust, newspaper, etc. with high C:N ratio
- May introduce weed seeds
- Only for small scale production



Plastic Mulch





Pigmented Plastic Mulch




Degradable Mulch

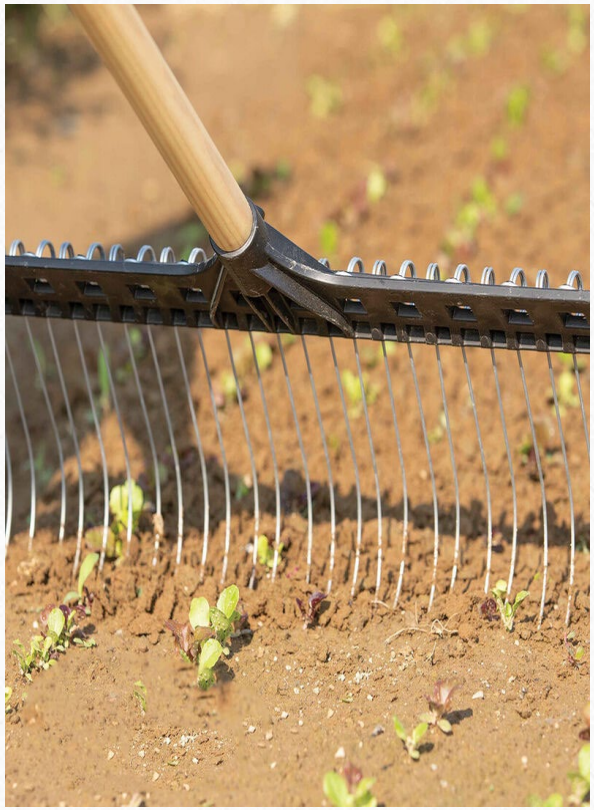
Common Practices in Vegetable Production-III

Plant Management

For Direct Seeded Vegetables

- **Root vegetables (carrots, radish, beets); beans, peas, sweet corns**

- Thinning
  - Not used often in large-scale production
  - Common practice for gardening and small-scale production
    - ✓ Mostly manual (pull out or cut), can use a rake
    - ✓ Combined with cultivating
- Weed control
- Trellising
  - Not for large scale
  - Mesh type of trellis



Weed Control

- Chemical methods
  - Pre-emergent herbicides
  - Post-emergent herbicides
    - ✓ Pesticide resistant beets
  - ✓ Herbicide resistance
- Non-chemical methods
  - Before sowing: plow and rotary hoeing
  - After sowing
    - ✓ Cultivating
    - ✓ Mulching
    - ✓ Flame weeder/Burning (organic method)



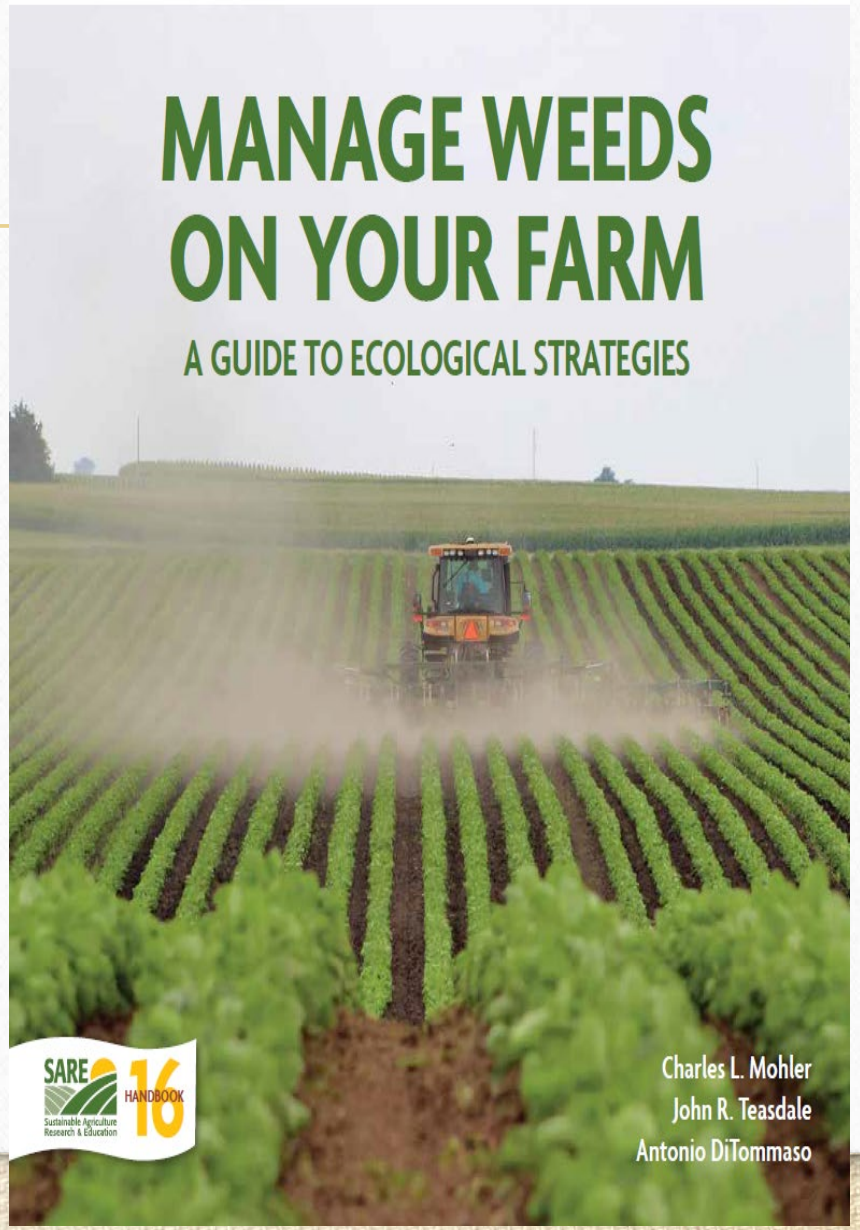


Manage Weeds on Your Farm

A Guide to Ecological Strategies

- https://www.sare.org/wp-content/uploads/Manage-Weeds-on-Your-Farm.pdf





Transplanted Vegetables

- Replace dead plants (disease and insect damages)
- Weed control: similar to direct seeded, but easier
  - In Beds
    - ✓ Use plastic mulch or organic mulch
    - ✓ Not a problem once plants shade the field
  - Between beds: mowing, mulching (organic or landscape fabric)
- Plant training/trellising/pruning
  - Fruiting vegetables: Florida Weave System/cages
    - ✓ Prune off suckers up to the 1st fruit cluster
    - ✓ Prune off old/diseased leaves
  - Vining crops: not practical for large scales, typical in protected culture systems and home gardens (save space)
    - ✓ Trellis netting
    - ✓ Roller-hook system



Pollination of "Fruit" Vegetables

- Pulse Vegetables (Legumes: beans and peas): strictly self-pollinated, no pollinators needed
- Fruiting vegetables (Solanums: tomato, pepper and eggplants)
  - ✓ Self-pollinated, pollinators help but not needed
  - ✓ Need air movement
- Vining vegetables (cucurbits)
  - ✓ Cross pollinated, pollinators a must
  - ✓ Except for some parthenocarpic cultivars (seedless)/types: cucumber, summer squash
    - Seedless watermelon is triploid, different from other parthenocarpic cucrbits





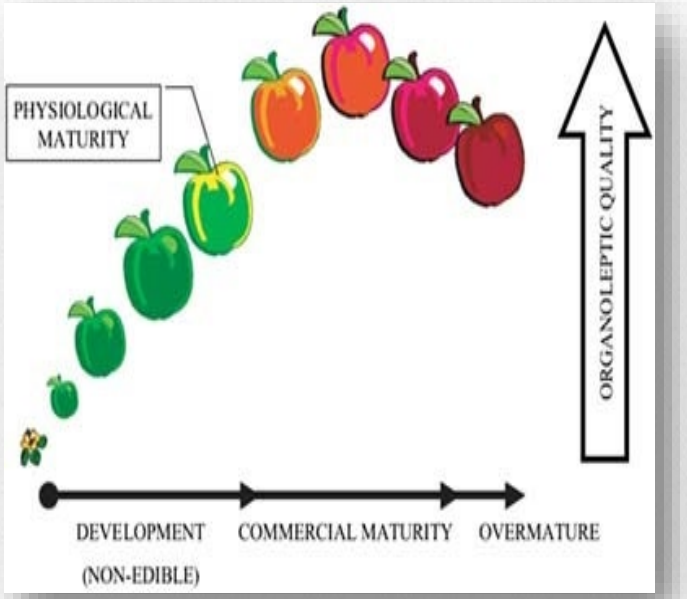




Harvesting and Storage

Maturity and Harvest

- Horticultural maturity: The stage at which a commodity has reached a sufficient stage of development that after harvesting and postharvest handling (including ripening), its quality will be at least the minimum acceptable
  - ✓ **Developed marketable appearance and edibility**
  - ✓ **Biological, physiological, and horticultural maturity**
- Vegetables harvested <u>before fully mature</u>
  - ✓ Leafy vegetables
  - ✓ Immature fruit: okra, cucumber, snow peas, eggplant, green beans, sweet corns, summer squash (zucchini), bitter melon, luffa
- Vegetables harvested <u>at full maturity</u> (or reached full size that will mature after harvest, **climacteric fruit**)
  - Winter squash, pumpkins, melon, watermelon
  - Tomato, bell pepper
- Vegetables harvested at <u>both immature and mature stages</u>
  - Potato, sweet potato
  - Some root vegetables: radish, turnips, beets, carrots
  - Bulbs: (green) onion, green garlic
  - Those vegetables may lose premium if over ripen



Harvest Criteria according to Edible Plant Part

- Fruit Vegetables
  - Immature: legumes, cucumber, summer squash, eggplant, pepper, okra, sweet corn
  - Mature fruit: melon, watermelon, pumpkins, winter squash, vine-ripened tomato, red pepper
- Leaf and Stem Vegetables
  - Mostly immature: by size (e.g., baby spinach vs bunch spinach)
- Floral Vegetables: by head size, not fully mature (artichoke, broccoli, cauliflower)
- Roots, Tubers, and Bulbs Vegetables: various stages (new potato vs storage potato, baby carrots vs fill-sized carrots, baby ginger vs mature ginger)

Harvest Methods and Time

- Hand-harvesting: majority of crops
- Mechanical harvesting: usually not for fresh market vegetables
- Consumer harvesting: U-pick (e.g., strawberry, pumpkins)
- Harvest time: when produce is "cool" (morning, evening/night)

- After harvest (for local markets): trimming, washing, packing, delivering, etc

Handling after Harvest

- **Goal**: to maintain produce quality (**appearance**, texture, flavor)

- Prevent Injury
  - Pre-packaging/packaging
- (Cold) Storage: Temperature/Humidity Control
  - Reduce respiration: lower temperatures—quickly reduce field heat; increase CO_2 level
  - Prevent water loss: higher humidity
- Shipping/delivering (refrigerated)
- Post-harvest maturing for climacteric fruit
  - Treat with ethylene
  - Wait (home gardeners, for example harvest full size green tomato before frost hits)

Groups of Vegetables for Storage

1. Cold (32-36 °F) and moist conditions (> 85% relatively humidity): leaf and salad greens, Cole crops, peas, root vegetables, green onion/garlic
2. Cold and dry conditions (65-70% RH): garlic, onions
3. Cool (40-55 °F) and moist conditions: beans, cucumber, tomato, bell pepper, eggplants, melon, watermelon, potato.
4. Warm (55-60 °F) and dry conditions: hot pepper, pumpkins, winter squash, sweet potato

Table 1. Fruits & Vegetables that require cold, moist conditions

Vegetable	Temperature (°F)	Relative Humidity (%)	Length of Storage
Asparagus	32-36	95	2-3 weeks
Apples	32	90	2-6 months
Beets	32	95	3-5 months
Broccoli	32	95	10-14 days
Brussels Sprouts	32	95	3-5 weeks
Cabbage, Early	32	95	3-6 weeks
Cabbage, Late	32	95	3-4 months
Cabbage, Chinese	32	95	1-2 months
Carrots, mature	32	95	4-5 months
Carrots, immature	32	95	4-6 weeks
Cauliflower	32	95	2-4 weeks
Celeriac	32	95	3-4 months
Celery	32	95	2-3 months
Collards	32	95	10-14 days
Corn, sweet	32	95	4-8 days
Endive, Escarole	32	95	2-3 weeks
Grapes	32	90	4-6 weeks
Kale	32	95	10-14 days
Leeks, green	32	95	1-3 months
Lettuce	32	95	2-3 weeks
Parsley	32	95	1-2 months
Parsnips	32	95	2-6 months
Pears	32	95	2-7 months
Peas, green	32	95	1-3 weeks
Potatoes, early	50	90	1-3 weeks
Potatoes, late	39	90	4-9 months
Radishes, spring	32	95	3-4 weeks
Radishes, winter	32	95	2-4 months
Rhubarb	32	95	2-4 weeks
Rutabagas	32	95	2-4 months
Spinach	32	95	10-14 days

Table 2. Vegetables that require cool, moist conditions

Vegetable	Temperature (°F)	Relative Humidity (%)	Length of Storage
Beans, snap	40-50	95	7-10 days
Cucumbers	45-50	95	10-14 days
Eggplant	45-50	90	1 week
Cantaloupe	40	90	15 days
Watermelon	40-50	80-85	2-3 weeks
Peppers, sweet	45-50	95	2-3 weeks
Potatoes, early	50	90	1-3 weeks
Potatoes, late	40	90	4-9 months
Tomatoes, green	50-70	90	1-3 weeks
Tomatoes, ripe	45-50	90	4-7 days

Table 3. Vegetables that require cold dry conditions

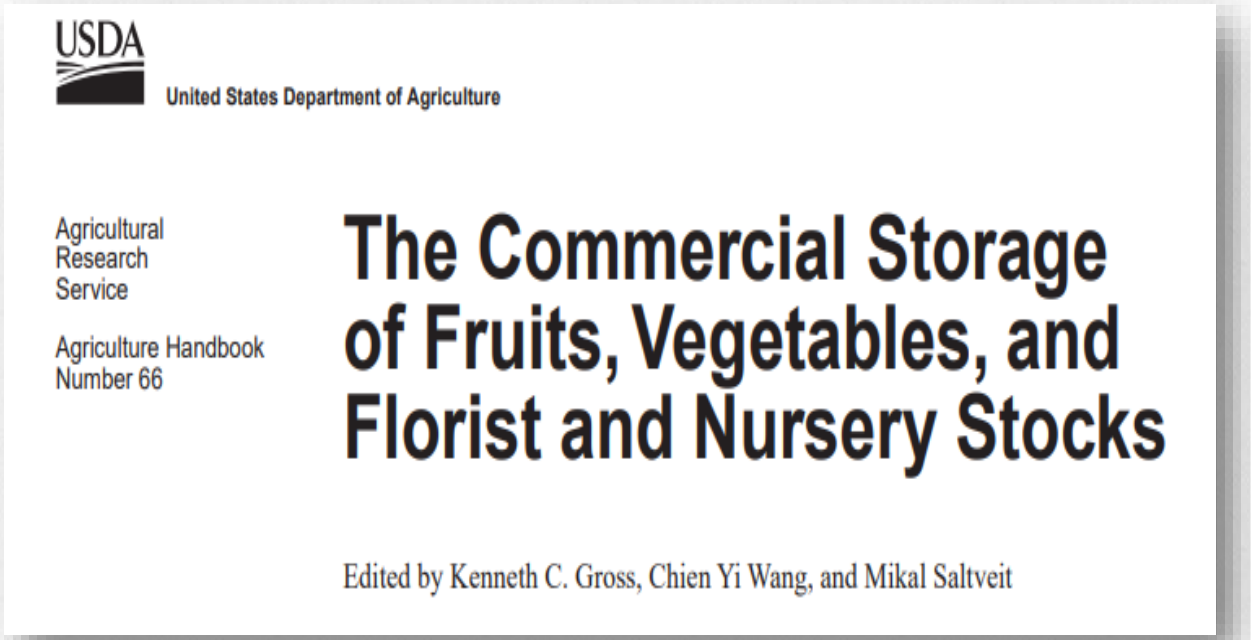
Vegetable	Temperature (°F)	Relative Humidity (%)	Length of Storage
Garlic	32	65-70	6-7 months
Onions	32	65-70	6-7 months

Table 4. Vegetables that require warm dry conditions.

Vegetable	Temperature (°F)	Relative Humidity (%)	Length of Storage
Peppers, hot	50	60-65	6 months
Pumpkins	50-55	70-75	2-3 months
Squash, winter	50-55	50-60	2-6 months
Sweet Potato	55-60	80-85	4-6 months

Vegetable	Temperature (ëF)	Relative Humidity (%)	Months of Storage
Beet	32	95	3-5
Cabbage	32	95	3-4
Chinese Cabbage	32	95	1-2
Carrot	32	95	4-5
Celeriac	32	95	3-4
Parsnip	32	95	2-6
Radish	32	95	2-4
Rutabaga	32	95	2-4
Potato	39	90	4-9
Garlic	32	65-70	6-7
Onion	32	65-70	6-7
Pumpkin	50-55	70-75	2-3
Winter squash	50-55	50-60	2-6
Sweet potato	55-60	80-85	4-6
Winter melon	50-55	50-60	up to 12

https://www.ars.usda.gov/arsuserfiles/oc/np/commercialstorage/commercialstorage.pdf , 2016



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Small Fruit in the Home Garden

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As a general rule, plant selection and production area in a home garden should be limited to what you can properly care for. It is better to have a small, well-tended planting area rather than a large, neglected one. Small fruits offer certain advantages over fruit trees for home culture because small fruits require less space for the amount of fruit produced, and they bear fruit one or two years after planting. Success with small-fruit planting will depend on the attention given to all phases of production, including crop and variety selection, site selection, soil management, fertilization, pruning, and pest management.

Planning the Small-Fruit Garden

Site Selection

Locate your small-fruit planting in full sun as part of or near the vegetable garden. Select a site that is free from frost pockets, low/wet spots, and exposure to strong prevailing winds. Blueberries should be planted far enough from the roots of trees to avoid competition for moisture and nutrients. Blueberries can be planted to form a dense hedge or used in a foundation planting around the home. Where space is limited, small fruits could also be integrated with ornamental plants (see fig. 1). Caneberries (blackberry and raspberry) grow best on leveled lands. Grapes and raspberries can be planted on a trellis or a fence along a property line.

Strawberries can be used as a border for a flowerbed or as a groundcover. Avoid planting early varieties on south-facing slopes and be sure to select a site where tomatoes, potatoes, or eggplants have not been grown. These crops often carry verticillium wilt, which lives in the soil for many years, and some strawberry varieties are very susceptible to this disease.

Strawberries bloom very early in the spring, and the blossoms are easily killed by frost. In areas where late frosts are a hazard, try to select a site for planting that is slightly higher than surrounding areas. Do not set strawberries in soil that has recently been under sod. Land that was under crop cultivation for the prior year or two would have soil better prepared for strawberries and will assist in controlling weeds and white grubs — both of which are troublesome in strawberry plantings. Where grubs and ants are a problem, chemical control might be necessary.

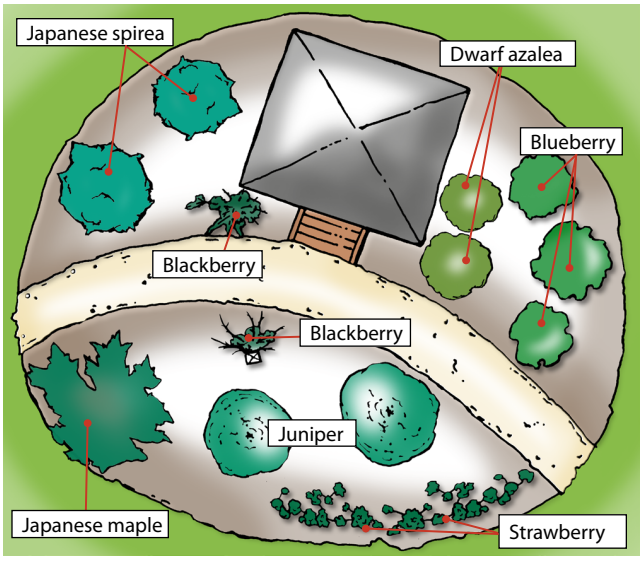


Figure 1. Small fruits can be integrated with ornamental plants in a home garden setting.

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Soils

Small fruits thrive in a fertile, sandy loam soil that is rich in organic matter, but they will give good returns on the average garden soil under adequate fertilization and good cultural practices. Incorporation of additional organic matter before planting is desirable. Small fruits are best planted on raised beds 8 to 12 inches high and 2 to 4 feet across. Drip irrigation is highly recommended.

For best results, small-fruit plants should be set no closer than the minimums indicated in table 1. Overcrowding frequently results in weak plants and low yields. It also makes insect and disease control more difficult.

Special attention should be given to variety selection. Varieties must be adapted to your soil and climatic conditions. If possible, without sacrificing too much yield or quality, select varieties with the fewest insect and disease problems. Table 2 lists some varieties of small fruits suggested for planting in the home garden under Virginia's environmental conditions. These varieties are highlighted in a table (over some others that are described only in the text sections that follow) because the authors have first-hand experience with these varieties in regard to production, berry flavor evaluation, and yield data collection. Currants and gooseberries are not included in this publication. For variety recommendations for currants and gooseberries, refer to Chapter 9 of The Mid-Atlantic Berry Guide for Commercial Growers, 2013-2014, available at http://extension.psu.edu/publications/agrs-097/view.

Table 1. Space requirement, yield, bearing age, and life expectancy of small-fruit plants.

Fruit expectancy	Minimum distance		Annual yield per plant (pounds)	Average bearing age (years)	Life expectancy (years)
	Between rows (feet)	Between plants (feet)			
Blackberry (erect)	10	5	5-10	1	5-12
Blackberry (trailing)	8	6	5-10	1	5-12
Blueberry	6	5	4-6	3	20-30
Grape (American)	8	6	10	3	20-30
Grape (hybrids)	8	5	10	3	20-30
Grape (muscadine)	8	10	15	3	20-30
Raspberry (red)	8	3	3-5	1	5-12
Raspberry (black)	8	4	3-5	1	5-12
Raspberry (purple)	8	3	3-5	1	5-12
Strawberry (June-bearing and day-neutral)	3	1	1-2*	1	1-2
Strawberry (ever-bearing)	3	1	.75-1	.33	2

* Per parent plant grown in the matted-row system.

Table 2. Suggested varieties for home small-fruit planting.

Crop	Variety	Type[1]	Fruit size[2]	Yield/plant (pounds)	Flavor[3]
Blueberry	Brightwell	R	M	5	G
	Powderblue	R	M	5	G
	Premier	R	M	5	G
	O'Neal	SH	M	2-3	VG
	Suziblue	SH	VL	2-3	E
	Duke	NH	M	2-3	VG
	Legacy	NH	M	5	VG[t]

Table 2. Suggested varieties for home small-fruit planting. (cont.)

Crop	Variety	Type[4]	Fruit size[2]	Yield/plant (pounds)	Flavor[3]
Blackberry	Chester	F	M	10-15	G
	Kiowa	F	VL	10-15	E
	Natchez	F	VL	5-10	G
	Navaho	F	M	5-10	E
	Prime-Ark 45	P	L	10-15	VG
	Prime-Ark Freedom	P	VL	10-15	VG
Crop	**Variety**	**Type[4]**	**Fruit size[2]**	**Yield/plant (pounds)**	**Flavor[3]**
Raspberry (red)	Caroline	P	M	3-5	E
	Heritage	P	M	5	G
	Himbo Top	P	L	3-5	VG
	Joan J	P	M	3-5	E
	Josephine	P	L	3-5	E
	Killarney[5]	F	M	3	G
	Nova[5]	F	M	3	E
Crop	**Variety**	**Type[6]**	**—**	**Fruit color[6]**	**Flower type**
Grapes (for table use)	Concord	Seeded	—	Blue/black	—
	Delaware	Seeded	—	Red	—
	Himrod	Seedless	—	Golden-yellow	—
	Mars	Seedless	—	Black	—
	Niagara	Seeded	—	White/green	—
	Seneca	Seeded	—	White/yellow	—
	Steuben	Seeded	—	Blue/black	—
	Sunbelt	Seeded	—	Blue/black	—
Grapes (for wine)	Chambourcin[7]	—	—	Red	—
	Chardonel[7]	—	—	White	—
	Norton	—	—	Red	—
	Traminette	—	—	White	—
	Vidal Blanc[7]	—	—	White	—
Grapes (muscadine)	Carlos	—	—	Bronze	Perfect
	Magnolia	—	—	Bronze	Perfect
	Nesbitt	—	—	Black	Perfect
	Scuppernong	—	—	Greenish-bronze	Female
Crop	**Variety**	**Type[9]**	**Fruit size**	**Yield/plant (pounds)**	**Flavor[3]**
Strawberry (June-bearing varieties)	Camarosa[8]	MS	M	0.8-2	G
	Camino Real	ES to MS	L	1-2	VG
	Chandler	MS	M	1-1.5	G
	Flavorfest	MS to LS	M	0.8-1.5	VG
	Sweet Charlie[8]	ES	S	0.5-0.8	E

[1] Type: R = rabbiteye, SH = southern highbush, NH = northern highbush. Rabbiteye and southern highbush varieties are suitable for southern and Central Virginia; northern highbush varieties are suitable for Northern Virginia and the mountains.

[2] Fruit size: VL = very large, L = large, M = medium, S = small.

[3] Flavor: E = excellent, VG = very good, G = good.

[4] Type: F = floricane (one crop per year), P = primocane (two crops per year). All blackberry varieties listed are thornless except for Kiowa and Prime-Ark 45.

[5] Killarney and Nova are floricane-bearing raspberries not suitable for southern or Central Virginia.

[6] For grapes: seeded or seedless type and fruit color (table or muscadine grapes) or wine color (red or white).

[7] These grape varieties must be grafted to a rootstock to ensure adequate vigor and tolerance to root-feeding phylloxera.

[8] Camarosa and Sweet Charlie are suitable only for the Coastal Plains and Piedmont regions of the state.

[9] Bearing: ES = early season; MS = midseason; LS = late season.

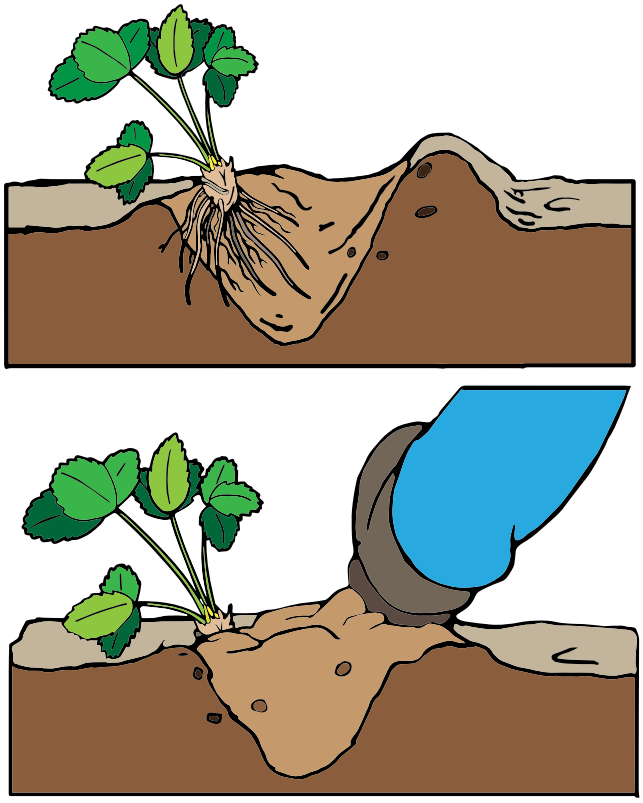


Figure 2. Plants are temporarily placed in a trench and packed with soil around the roots to prevent drying of roots until they are to be transplanted to their final spot.

Ordering Plants and Caring for Your Transplants

Placing Your Order

Obtain the best nursery stock available. Buy certified plants from a reputable nursery. Place your order early, as soon as you decide what you want. Specify variety, size, and grade of plants desired and the preferred time of shipment. It is best to have the plants arrive at the time you are ready to set them out. Unless you specify otherwise, some nurseries will only send plant material at the proper time to be planted in your area.

When your order arrives, unpack the bundles and inspect the plants. The roots should be moist and have a bright, fresh appearance. Shriveled roots indicate that the plants have been allowed to freeze or dry out in storage or transit. Such plants seldom survive. Water the root system lightly only if the roots are very dry.

Minimizing Plant Stress

If the plants cannot be set immediately, they should be kept in cold storage. Wrap them in a garbage bag or other material that will prevent them from drying out and store them at a temperature just above freezing. Strawberry plants in small quantities can be held in the refrigerator for a few days. If refrigerated storage is not available, remove the plants from the bundle and heel them carefully in a trench of moist soil in a shaded location (fig. 2). Pack the soil firmly around the roots to eliminate all air pockets and to prevent the roots from drying out.

There is probably nothing that causes more disappointment and failure in small-fruit plantings than the lack of careful preparation and attention to detail at the time the plantings are established. Prepare the soil by loosening it and making it free of clods. Set the plants carefully, irrigate well, and generally create conditions favorable for new growth. Detailed suggestions for the establishment of each of the small fruits follows. These suggestions should be closely followed for best results.

Once planting has been established, future success will depend on the care given. If the planting is to be productive and long-lived, it must be properly fertilized. Competition from weeds or other plants must be avoided. Insects and diseases must be controlled, and the plants must be properly pruned. Study the maintenance suggestions for each of the small-fruit crops and plan to care for the planting properly. To do otherwise will probably result in disappointment and wasted effort.

Blueberries

Three types of blueberries can be grown in home gardens in Virginia: rabbiteye, southern highbush, and northern highbush. Although blueberries can be grown in any area where native blueberries, azaleas, mountain laurel, or rhododendrons do well, they have a better flavor when grown where nights are cool during the ripening season. They are very exacting in soil and moisture requirements. Berries should be picked as soon as they ripen to minimize an infestation with spotted wing drosophila.

Rabbiteye and southern-highbush-type blueberries are best-suited for climates where summers are generally hotter. These varieties have low winter

chilling requirements. “Chilling” is a measure of accumulated hours of temperatures below 45 F in the dormant season. In general, the chilling requirement for rabbiteye and southern highbush type is 250 to 600 hours; for northern highbush, the requirement is 800 to 1,000 hours. Therefore, when buying blueberry plants for your garden, make sure to ask whether you are buying rabbiteye, southern highbush, or northern highbush type. Home growers can find information on chilling hours achieved at a given geographic location for blueberry growing season from the State Climate Office of North Carolina at https://climate.ncsu.edu/cronos/blueberry/chill_model?-. This site uses a slightly more complex model for calculating chilling hours as compared to the one described above.

Variety Selection

To provide adequate cross-pollination and to increase chances for a good crop of fruit, two or more varieties that bloom at the same time should be planted. The following varieties suggested for planting ripen over a six- to eight-week period beginning in early June and continuing through July. Most are vigorous and productive under good growing conditions and produce berries of large size and good quality.

Rabbiteye Varieties

Alapaha, Climax, Premier, Titan, and Vernon are early season varieties. Brightwell, Powderblue, and Tifblue are midseason varieties. Centurion and Ochlokonee are late-season varieties. In Central and southern Virginia, planting early, mid-, and late-season rabbiteye varieties will allow you to harvest fruits during the July-August months.

Titan is a new variety; it is the largest fruited rabbiteye variety that has been developed to date. Vernon also has large berries. Alapaha and Ochlockonee have medium-sized berries with good eating quality and less-pronounced seeds than other rabbiteye varieties.

Southern Highbush Varieties

Most of the southern highbush varieties bloom early in the season and could be damaged by frosts in late spring. Southern highbush varieties are recommended for Central and southern Virginia. Suziblue, Palmetto, and O’Neal are early-season varieties. Suziblue has very large fruit and excellent flavor. Palmetto is a medium-sized berry with outstanding flavor. O’Neal is a popular variety with medium size and very good flavor fruit. Camellia, Jubilee, and Magnolia are midseason southern highbush. Camellia has a very large-sized fruit. Jubilee and Magnolia are smaller-fruited varieties with good plant vigor. Bird and deer feeding can be a problem with southern highbush varieties.

Northern Highbush Varieties

Northern highbush blueberries are self-fertile; however, larger and earlier ripening berries result if several varieties are planted for cross-pollination. In Virginia, the northern highbush varieties should be planted in Northern Virginia and in the mountain region with adequate soil conditions.

Duke, Earliblue, Patriot, and Spartan are early season northern highbush varieties. Duke is a popular variety with medium-sized fruit and very good flavor. Earliblue produces very early in the season; it is not a heavy producer. Patriot is a heavy producer with very large berry size. Spartan has large berry size and good flavor.

Bluecrop, Blueray, and Legacy are midseason northern highbush blueberries. Bluecrop, although lacking in vigor, is very hardy and drought-resistant. The fruits are medium-sized. Blueray is very hardy and productive and is recommended for planting. The fruit is large, dark blue, and flavorful. Legacy is a highly adaptable variety, slower in production in the first few years; however, yields can be very high once the plants become established.

Elliott and Jersey are late-season northern highbush varieties. Elliott has a good, mild flavor when fully ripe (if not fully ripe, the flavor will be very tart). It is winter-hardy and bears firm, medium-sized fruits. Jersey, one of the leading commercial varieties, is also a favorite in the home garden. The plants are vigorous and hardy, producing heavy crops of medium, dark berries of good quality. Because these are picked fully ripe, they are also more susceptible to damage caused by spotted winged drosophila.

Establishing the Planting

Soils

Blueberries are shallow-rooted plants and must either be irrigated, heavily mulched, or planted in a soil with a high water table. Adequate drainage must be provided because they cannot tolerate saturated soils. A high

water table in clay soils promotes root rot diseases. Raised beds with drip irrigation are preferable. They grow best in porous, moist, sandy soils high in organic matter, with a pH range of 4.2 to 5.2. Have the soil tested and if the pH is not in the 4.2 to 5.2 range, work materials such as peat moss, pine needles, pine bark, or sulfur into the area where the plants are to be set. This should be done six months to a year before planting. To acidify sandy soils, sulfur is recommended at the rate of 0.75 pound per 100 square feet for each full point the soil tests above pH 4.5. On heavier soils, use 1.5 to 2 pounds. Once proper soil pH is established, it can be maintained through the annual use of an acid fertilizer, such as ammonium sulfate or cottonseed meal. The soil's pH should be tested every three years.

Planting

Vigorous, 2-year-old plants about 15 inches high are recommended for planting. Set them in early spring about three or four weeks before the average date of the last frost. For rabbiteye varieties, plant every 4 to 5 feet in a row, with 10 feet between rows. For northern and southern high bush varieties, plant 3 to 4 feet in a row, and 6 to 8 feet between rows.

Give the roots plenty of room. Where the plants are to be set, dig the holes wider than the root systems and as deep as necessary. It is not necessary to incorporate organic matter or other soil amendments into the backfill soil. Trim off diseased and damaged portions of the top and roots and set the plants at the same depth that they grew in the nursery. Spread the roots out and carefully firm the soil over them. Water thoroughly after planting.

Maintaining the Planting

Soil Management

Mulching is the preferred soil management practice in the blueberry planting. The entire area around and between the plants should be mulched. Hardwood or softwood bark and sawdust, applied to a depth of 4 or 5 inches is recommended. Many growers use a combination mulch — a layer of leaves on the bottom with 2 or 3 inches of sawdust on top. Renewed annually, this heavy mulch retains moisture, keeps the soil cool, and adds needed organic matter. If soil pH is an issue, make sure to mulch with pine bark or apply sulfur on top of mulch. Mulches provide a relatively warm environment, and can attract voles particularly during winter season. In areas where voles are a problem, mulch application should be less thick and be applied more frequently. Control through trapping and chemical baiting may be needed.

Fertilization

No fertilizer should be applied at planting time, and usually none is needed during the first growing season. On poor soils, however, the application of 2 ounces of ammonium sulfate around each plant about the first of June is beneficial.

Ammonium sulfate, at the rate of two ounces per plant, should be spread in a circle around each plant, about 6 to 8 inches from its base, just before the buds begin to swell the second spring. Increase the amount each succeeding spring by one ounce, until each mature bush is receiving a total of 8 ounces annually. Cottonseed meal has proven to be an excellent fertilizer for blueberries and is used by many home gardeners. It supplies the needed nutrients and helps maintain an acid soil. Use it at the rate of one half pound per plant. Where sawdust is used as a mulch, it will be necessary to apply additional nitrogen to prevent a deficiency as the sawdust decays. Usually about 0.75 pound of ammonium sulfate for each bushel of sawdust is sufficient.

Pruning

Until the end of the third growing season, pruning consists mainly of the removal of low spreading canes, and dead and broken branches. As the bushes come into bearing, regular annual pruning will be necessary. This may be done any time from leaf fall until before

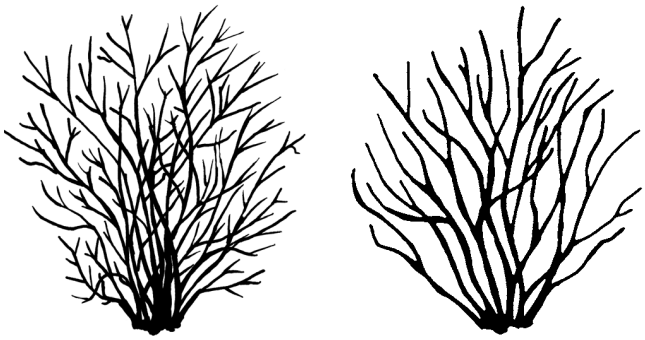


Figure 3. Left, unpruned blueberry plant. Right, after pruning, a mature blueberry bush should have 10 to 15 canes.

growth begins in the spring. A mature blueberry plant should produce three to five new canes per year. During pruning, clean out old, dead wood, and keep three best 1-year-old canes. Locate the oldest canes and prune out one of every six existing canes; cut as close to the ground as possible. A mature blueberry bush should have 10 to 15 canes: two to three canes each of 1-, 2-, 3-, 4-, and 5-year-old canes (fig. 3).

Pest Management

Birds are by far the greatest pests in blueberry planting. Covering the bushes with wire cages, plastic netting, or loosely woven cotton fabric cloth (e.g., tobacco cloth) is perhaps the best method of control. Aluminum pie tins have been used successfully. They are suspended by a string or wire above the bushes such that they twist and turn in the breeze and keep the birds away. Spotted wing drosophila will lay eggs on ripe or ripening fruits; infestations can be minimized by picking fruits as soon as they are ripe.

Harvesting the Planting

Some varieties of blueberry will bear the second year after planting. Full production is reached in about six years, with a yield of 4 to 6 quarts per plant, depending on vigor and the amount of pruning. Blueberries hang on the bushes well and are not as perishable as blackberries or raspberries. Picking is usually necessary only once every five to seven days, more frequently if bird pressure is high. Blueberries will keep for several weeks in cold storage.

Caneberries

Both raspberries and blackberries (often referred to as caneberries or brambles) will usually yield a moderate crop of fruit the second year after planting and a full crop in the third season. With good management, it is possible for gardeners to extend the productive life of well-maintained plantings beyond 10 years.

Variety Selection

Caneberry plants are biennial in nature; the crowns are perennial. New canes grow from buds at the crown each year. For blackberry and raspberry, there are two fruiting types: primocane and floricane. Primocane fruiting-type raspberry and blackberry bear fruits on the first-year cane (shoot), which is ready for harvest in late summer. After harvest, if the cane is pruned at the point below where it produced fruit in the first year, the lower part of the cane will produce another crop (second harvest) the following summer after the cane is exposed to chilling during winter months. The second year cane, bearing fruit, is referred to as "floricane fruiting-type." Therefore, primocane fruiting blackberry and raspberry varieties can produce two crops (harvests) each year.

Of the many varieties of blackberries and raspberries available, few have proven totally satisfactory for growing under Virginia conditions. Only top-quality, virus-free, 1-year-old plants of the best varieties should be planted.

Blackberries

Of interest to homeowners would be the thornless blackberry varieties that would allow children and adults to pick berries without the concern of being scratched on the skin. However, there are some very tasty and productive thorny blackberry varieties. Information about some popular blackberry varieties follows.

- Chester is a thornless, late-bearing, semierect variety that is high in yields with a medium fruit size. The variety is resistant to cane blight.
- Kiowa is a thorny, early-season variety that bears the world's biggest blackberry fruit. Kiowa blooms earlier and longer than other blackberry varieties. The berry ripens in early June.
- Natchez is a thornless, early-bearing variety that produces large fruit that ripens in early June. When fully ripened, it is very sweet and tasty. Natchez is a semierect variety and needs trellising for improved production and better fruit quality.
- Navaho is a thornless, erect, mid- to late-season blackberry that produces better-quality fruits when trellised. Fruit shape is conic, berry size is medium but very firm, and the flavor is excellent.
- Prime-Ark 45 is thorny primocane variety that produces firm berries, free of molds and diseases. Berries are large in size with good flavor and are suitable for long-distance shipping.
- Prime-Ark Freedom is the world's first thornless primocane-bearing variety, released in 2013. This is an erect type that produces very large fruits and has

a good flavor. The fruit is harvested in the fall and is good for fresh consumption. As a primocane-type blackberry, the Prime-Ark Freedom can produce two crops per year.

Dewberries and boysenberries are also included under blackberries. Dewberry is a trailing form of blackberry, and boysenberry is a hybrid of loganberry (Rubus loganobaccus) and various blackberries and raspberries. The boysenberry plant is easily winter-killed and should be planted only in areas with mild winters. Plants are extremely vigorous and productive, and the berries are large and flavorful when fully ripe. Thornless boysenberries are also available. Recommended varieties of dewberry and boysenberry include the following.

- Lavaca, a seedling of the boysenberry, is superior to its parent in production, size, and resistance to cold and disease. Fruit is also firmer, less acidic, and of slightly better quality.
- Lucretia Dewberry, the best of the trailing blackberries, is relatively winter-hardy, vigorous, and productive. Fruits are very large — often 1.5 inches long — shiny, sweet-flavor berries.

Raspberries

Raspberry types are based on berry color: red, black, and purple. Chances for success with raspberry plantings are better if the plantings are located in the cooler mountain sections of the state. Fruit production and quality can be improved if trellises are used when planting raspberry.

Red raspberries have generally been more successful in warmer areas of the state than have the other types.

- Caroline is an early primocane-bearing variety. Fruit is conical, medium-sized, and firm and has excellent flavor. The variety has medium vigor and good disease resistance.
- Heritage is a primocane-bearing variety. Fruit is medium-sized, firm, and of good quality. This variety is resistant to most diseases but is susceptible to late leaf rust.
- Himbo Top is a primocane-bearing variety with high tolerance to phytophthora root rot disease. This variety produces a large, firm, conic fruit, bright red in color, with very good flavor.
- Jaclyn is the earliest of the primocane-bearing varieties. Fruits are dark red, large, and have an excellent flavor. Used primarily for fresh consumption.
- Joan J is a very productive, spine-free, primocane-bearing variety. Fruit is very firm, glossy, and dark red in color. Used for fresh consumption.
- Josephine is a primocane-bearing variety that has an upright, vigorous plant. Berries are dark red in color, large, have excellent flavor, and a long shelf life. Plant is resistant to potato leafhopper.
- Killarney is a high-yielding, floricane-bearing variety. Fruit is medium-sized and bright-colored, but it is soft in warm weather. This is a hardy cultivar and suitable for colder climates. Susceptible to mildew and anthracnose. Good flavor and freezing quality.
- Latham is a floricane-bearing variety. Plants are vigorous with few spines, are moderately productive, and susceptible to fire blight and powdery mildew. Berries are small in size, soft, and somewhat tart.
- Nova is midseason, floricane-bearing variety. Fruits are somewhat acidic in taste. Considered to have better-than-average shelf life. Plants are hardy and resistant to cane diseases and late leaf rust but are susceptible to cane botrytis.

Black raspberries are very susceptible to viral diseases and are readily infected when grown near red varieties carrying a virus. Plants of red and black raspberries should be separated by at least 700 feet.

- Cumberland, a floricane-bearing variety, ripens about one week later than New Logan. Cumberland has long been a favored variety due to its attractive firm berries with fair flavor. Plants are vigorous and productive but not particularly cold-hardy.
- Jewel, a floricane-bearing variety, has firm, glossy, large, and flavorful fruits. Plants are vigorous, cold-hardy, upright, and resistant to most diseases. Jewel is a high-yielding variety.
- New Logan yields heavy crops of good-quality, large, glossy black fruits. Plants hold up well during drought and are relatively tolerant to mosaic and other raspberry diseases.

Purple raspberries are a hybrid of the red and black types. The fruits have a purple color and are usually larger than the parent varieties. They are tarter in taste compared to either the reds or black raspberries and are best used in jams, jellies, and pies. They are excellent for quick freezing. Plants are less hardy than the parents but are vigorous and very productive.

- Brandywine is the best purple raspberry available. It ripens later than most red or black varieties. The fruit is large, firm, and quite tart but of good quality. This variety is resistant to most diseases but is susceptible to crown gall.
- Royalty has a delicious sweet flavor, soft fruit, and high productivity. It is excellent for fresh use and for jam and jelly. Royalty is resistant to mosaic-transmitting aphids and raspberry fruit worm. Canes have thorns.

Establishing the Planting

Soils

Caneberries grow best in deep, sandy loam soils rich in organic matter. Ideal soil should have a pH of 6.0 to 6.5 and be well-drained to a depth of at least 3 feet. Caneberries are sensitive to excess waterlogging, and even temporary water accumulation can weaken canes, hinder plant growth, and increase incidences of diseases — particularly root rots. Therefore they are best grown on raised beds.

Planting

Caneberries should be planted in late fall or early in spring, about four weeks before the average date of the last frost. Work the soil as for garden vegetables, particularly where the plants are to be set. When planting in rows, allow at least 8 feet between rows to facilitate cultivation. Red and purple raspberries can be set 3 feet apart within the row; set erect and semierect blackberries plants 5 feet apart. Black raspberry rows should be no less than 4 to 5 feet apart and trailing blackberry rows no less than 6 feet apart.

Set the plants at about the same depth they grew in the nursery. The crown should be at least 2 inches below the soil line. Spread out the roots and firm the soil carefully around them. Do not allow the roots to dry out. Most caneberry fruits come with a portion of the old cane attached. This serves as a handle in setting the plants. Soon after new growth begins, the handle can be cut off at the surface of the ground and destroyed as a safeguard against possible anthracnose infection.

Maintaining the Planting

Soil Management

Caneberries grow best in soils containing 3 percent or more organic matter. Organic matter in soil can be maintained using a permanent mulch. Mulch should be applied soon after setting the plants and maintained throughout the life of the planting by replenishing annually or as needed. Hardwood or softwood bark should be applied at least 5 or 6 inches in depth. If mulch material is unavailable or if cultivation seems necessary, keep the cultivation very shallow to avoid disturbing the roots and repeat cultivation as often as necessary to control weeds until the beginning of harvest.

Fertilization

If materials low in nitrogen are used, it might be necessary to add sufficient nitrogenous fertilizer to prevent a temporary deficiency as the mulch begins to decay. Usually about 0.5 pound nitrate of soda or 0.75 pound of 10-10-10 for each 100 square feet of mulched area will be enough. On fertile soils or where good mulch is maintained, it is usually unnecessary to make an application of fertilizer in the caneberry planting. Additional fertilizer should be added after a soil test has been done and on the basis of recommendations. If growth is poor, adding 2 to 3 pounds ammonium nitrate to each 100 feet of row when growth begins in the spring will be beneficial. Adjustments to fertilizer grades and amount should be made based on plant growth and soil type. However, do not overfertilize because it could result in too much vegetative growth, burning of foliage, yield loss, injury to roots, a decrease in fruit quality, and an increase in disease.

Training and Pruning

Trailing and erect-growing blackberries and black and purple raspberries need some kind of support. They can be grown on a trellis, trained along a fence, or tied to stakes. Other caneberries can either be trained to supports or — with more severe pruning — grown as upright, self-supporting plants. Red raspberries sucker so they are frequently grown in hedgerows.

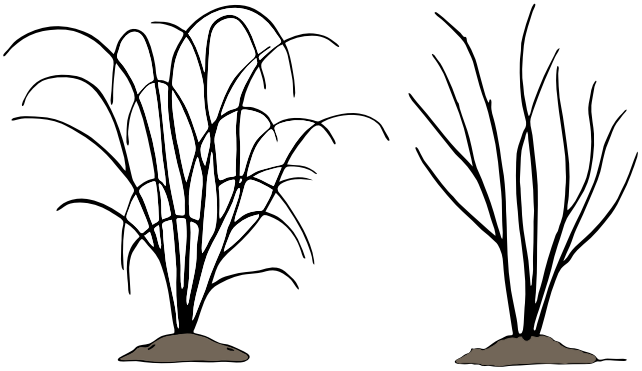


Figure 4. Left, an unpruned blackberry plant. Right, once plants are dormant, only retain four to five of the best canes.

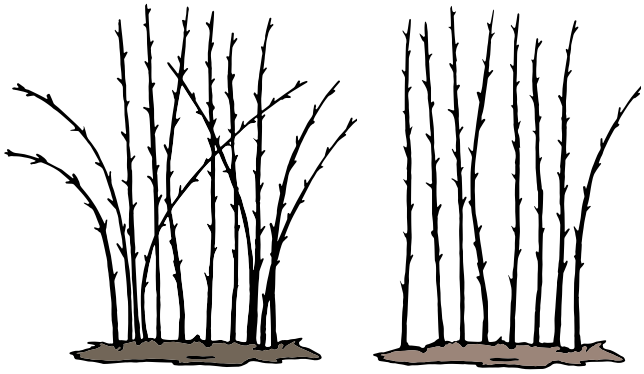


Figure 5. For plants grown in hedgerows, thin canes to 6 to 8 inches. The figure shows, left, before thinning, and right, after thinning.

On vigorous sites, some type of minimal containment trellising might be needed in some seasons.

A simple trellis, used in many home gardens, consists of two wires stretched at 3- and 5-foot levels between posts set 15 to 20 feet apart. Fruiting canes are tied to these wires in the spring. The erect varieties are tied where the canes cross the wires. Canes of trailing varieties are tied horizontally along the wires or fanned out from the ground and tied where they cross each wire.

Where stakes are used for support, they are driven into the ground about 1 foot from each plant and allowed to extend 4 or 5 feet above the ground. Canes are tied to the stake at a point about midway between the ground and the tips of the canes and again near the ends of the canes.

Dormant pruning is usually delayed until the danger of severe cold has passed and accomplished before the buds begin to swell in spring. Dormant pruning consists of the removal of all dead, weak, diseased, and severely damaged canes and the selection and pruning of the fruiting canes for the coming season. At the dormant pruning, thin each plant until only four or five of the best canes remain. Where possible, fruiting canes 0.5 inch or more in diameter are selected. Cut the lateral branches of the black raspberry to 9 to 12 inches long, those of the purple raspberry to 12 to 15 inches long, and the blackberry to 15 to 18 inches long (fig. 4). At the dormant pruning where supports are used, head the canes to 5 feet in height. Canes grown without support should be headed to 3 feet. All dead and weak canes should be removed after harvest or at the dormant pruning. They should be thinned to seven or eight of the best canes per hill, cut to about 5 feet in length, and tied to either a stake or trellis.

Summer top pruning stimulates lateral branching. Summer top pruning consists of removing the top 3 to 4 inches of the new shoots by snapping them off with the fingers or cutting them with shears or a knife. Where trained to supports, let them grow 6 to 8 inches taller than the support before topping. Blackberry plants should be summer top pruned when the young shoots (primocanes) are about 5 feet tall. For black raspberries and purple raspberries, summer topping should be done when young shoots are about 3 to 4 feet tall. To prevent the planting from becoming too thick and reducing yields, it could be necessary to remove excess sucker plants as they appear. This can be done either with a hoe or by hand. In the hedgerow type of culture, leave only three or four shoots per running foot of row. Grown in hills, four to five new shoots can be allowed to develop in each hill. If the plants are grown in hedgerows, keep the width of the rows to 18 inches or less and remove all plants outside the row areas. Thin the canes within the hedgerows to 6 to 8 inches apart, saving the best canes (fig. 5).

Where canes are supported either by a trellis or stakes, cut the canes back to a convenient height for berry picking, usually about 5 feet. Grown as upright self-supporting plants without the use of trellises or stakes, the canes should be cut back to about 3 feet in height whether in hills or in hedgerows. Any lateral branches should be cut to about 10 inches in length.

Primocane-bearing red raspberries and blackberries should not be summer topped because this will reduce the potential of canes to bear fruits in summer. Primocane-type raspberry and blackberry bear fruits on the first-year cane (shoot) that are ready for harvest in late summer. After harvest, if the cane is pruned at the point below where it produced fruit in the first year, the lower part of the cane will produce another crop (second harvest) the next summer after the cane is exposed to chilling during the winter months. In the late winter, three to four canes from each plant are selected and tied to a trellis for the second harvest, and the rest of the canes are pruned from the soil level (fig. 6). This will allow the new primocane to grow for the first year's harvest while the last year's primocanes produce the second harvest. It is important to prune and remove canes after the second harvest and allow the new canes to grow.

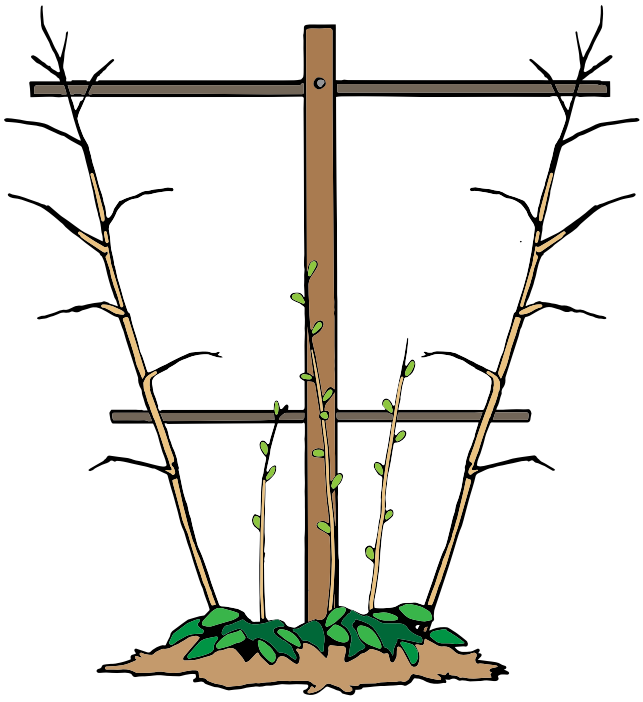


Figure 6. Primocane-fruiting raspberry with second-year canes and new canes.

Grapes

Grapes of some type can be grown almost anywhere. The careful selection of cultivated varieties compatible with local soil and climatic conditions has led to successful production in home gardens and commercial vineyards.

Table Grapes

Grape varieties should be selected for their intended use. Some seeded varieties such as Concord or Niagara can be used either for fresh table consumption, home juice or jelly production, or for wine production, but most varieties were developed or selected for a specific use. The following varieties are generally classified by intended use and have fared reasonably well over a wide geographic area of Virginia, with certain noted qualifications. All-American, hybrid, and Vitis vinifera grapes are self-fertile, meaning that a different pollenizer is not required for them to adequately set fruit.

- Concord is by far the most widely planted blue-black grape. The good-quality fruit ripens unevenly in the hotter areas of the state. A similar variety called Sunbelt was developed in Arkansas to ripen more uniformly in hot climates. Concord is an excellent and versatile variety for the home gardener. The vines are vigorous and productive, and except for black rot, they are relatively disease-tolerant.
- Delaware is a high-quality, red grape ripening about one week before Concord. Quite susceptible to downy mildew, this variety produces clusters and berries that are rather small and vines that grow slowly. Delaware has an unusually good balance of sweetness and acidity. It yields fine-quality white wines and is often used in blends for sparkling wine.
- Himrod, a golden-yellow grape, has good flavor and is considered seedless, although vestigial seeds can be present. Hardy, vigorous, and productive, it has been superior to its sister seedling, Interlaken, in areas where both have been grown.
- Mars has medium-sized, seedless, blue-black berries of the slip-skin type and is sweet and enjoyable. It is a cold-hardy plant with high resistance to black rot, powdery mildew, and downy mildew.
- Niagara has green-white berries and is used in wine and as a table grape. It is the most widely planted white American grape in the U.S. and is used extensively for white juice.
- Seneca, an early-season yellow grape, is noted for its good flavor and tender pulp. It holds well on the vine and will keep in cold storage for about two months after harvest. Vine vigor and productivity are only moderate, and this variety is quite susceptible to black rot and powdery mildew.

- Steuben is a blue-black variety ripening about one week after Concord. The berries are medium in size with a sweet, spicy flavor. They keep well in storage. The vines are hardy, vigorous, and productive. Steuben makes a very nice wine in addition to its use as a table grape.

Wine Grapes

American and Hybrid Varieties

- Chambourcin is a black grape that produces a red wine often compared to merlot. Although Chambourcin can be grown on its own roots, graft it to a rootstock such as C-3309, 101-14, or 420-A for best performance.

- Chardonel is a midseason, white wine grape. It is productive and generally more disease-resistant than one of its parents, chardonnay. Chardonel must be purchased from a grapevine nursery as a grafted grapevine. We recommend any commonly used rootstock variety, such as C-3309, 101-14, or 420-A.

- Norton is a late-ripening, American-type wine grape hybrid of *Vitis aestivalis*. It is a black grape with small clusters and small berries. The fruit can be very acidic, and vines should be trained to a high wire cordon, affording excellent fruit exposure to help reduce fruit acidity.

- Traminette is a midseason, white wine grape with good productivity and partial resistance to several fungal diseases. It produces a wine with some of the spicy, roselike characteristics similar to one of its parents, Gewürztraminer.

- Vidal Blanc is a mid- to late-season white wine grape. It is moderately susceptible to downy mildew, powdery mildew, and aerial phylloxera. Vidal should be purchased from a grapevine nursery as a grafted grapevine. We recommend any commonly used rootstock variety, such as C-3309, 101-14, or 420-A.

Vitis vinifera Varieties

Vitis vinifera grape varieties are the most important and the most abundant grapes grown globally for wine and raisin production. They are, however, difficult to grow in the backyard situation. Vinifera varieties are extremely susceptible to many diseases; most are susceptible to winter cold injury below 5 F, and all vinifera varieties must be grafted to rootstocks tolerant of grape phylloxera. If you choose to grow vinifera grape varieties, pay particular attention to the disease management described in the Pest Management, section.

- Cabernet Franc is a black grape that produces fine red wine. Vines are vigorous and more cold-hardy than other black vinifera types.

- Chardonnay, considered by many to be superior to all other varieties for dry white wine, is only moderate in hardiness, vigor, and productivity. It is a medium-sized, white grape in a compact cluster ripening three to five days ahead of Concord. Vines are extremely sensitive to fungal diseases such as powdery mildew, downy mildew, and black rot.

Muscadine Varieties

In areas where it is adapted, the muscadine grape is a favorite for home plantings. It is highly desirable for juice, jam, and jelly, and some varieties are cultivated for the unusual style of the wine. Muscadine grapes are cold-tender and should not be planted where temperatures fall below 5 F. In Virginia, plant only in U.S. Department of Agriculture's plant hardiness zones 7b or greater (see https://planthardiness.ars.usda.gov/).

Many muscadine varieties have imperfect flowers and require pollination from either male or perfect-flowered varieties. Of those suggested for planting, Carlos, Magnolia, and Nesbitt are perfect-flowered and will supply adequate pollination for female-flowered varieties such as Scuppernong.

- Carlos, a 1970 introduction from North Carolina, is a perfect-flowered bronze variety ripening with Scuppernong and similar in size and flavor. It makes excellent white wine and is relatively cold-hardy, disease-resistant, and productive. It is recommended for both commercial and home garden plantings.

- Magnolia is a perfect-flowered, bronze variety of large size and very high quality. The vine is vigorous and very productive.

- Nesbitt is a large, black, perfect-flowered variety from North Carolina. Fruit ripens over a three-week period and vines are relatively cold-hardy.

- Scuppernong, a name commonly applied to all bronze-skinned muscadine grapes, is the oldest and

best-known variety. Berry clusters are usually small and shatter badly, but the grape quality is good and it has a very distinctive flavor. As a female-flowered variety, Scuppernong would require a pollinator variety that blooms at roughly the same time.

Establishing the Planting

Site and Soil Essentials

Grapes should be planted where they have the benefit of the sun for most of the day. They are deep-rooted plants, frequently penetrating to a depth of 6 to 8 feet under good soil conditions. Most grapes require 160 or more frost-free days to ripen the crop, so the site should be relatively high to surrounding topography to allow cold air drainage, and the general climate of the area should afford at least 160 frost-free days. Good air movement aids disease management. Avoid use of volatile herbicides such as those that contain 2,4-D or dicamba in the vicinity of the grape planting because grapevines can be severely damaged by drift from such herbicides.

Grapevines grow best on well-drained, sandy loam soils with 2 to 5 percent organic matter and moderate fertility. Sandy or heavy clay soils may be used, however, if provisions are made for adequate fertilization, moisture, and soil drainage. Grapes are tolerant of a wide range of soil acidity but prefer a 6.0 to 6.8 pH range.

Planting

Dormant grapevines are usually set in early spring, at or slightly before the average date of the last frost. Vigorous, 1-year-old plants are preferred. Allow plenty of room between plants within a given row — at least 5 feet for the American bunch varieties and 8 feet or more for the vigorous-growing muscadine type. Trim the roots to about 6 inches in length to encourage formation of feeder roots near the trunk. Where the vines are to be set, dig the holes large enough so the roots can be spread without crowding and the plants can be set at about the same depth that they were grown in the nursery. For grafted vines, use care in firming the soil around set vines to ensure that the graft union remains about 3 inches above the final settled soil line. After buds have broken and all risk of frost has passed, prune the planted vine to a single cane and head it back to two buds.

Maintaining the Planting

Soil Management

Mulching is the preferred soil management practice in home grape planting as mulch will suppress weeds and conserve soil moisture. Using hardwood or softwood bark mulch to a depth of 4 to 6 inches is recommended. There have been cases where mice have girdled vines with mulch up to the trunk, so it is best to keep some space between the trunk and mulch through the winter.

Although grapes are deep-rooted plants, they do not compete well with weeds and grass, especially shortly after planting. If mulch material is unavailable, some cultivation should be done. Cultivation should be shallow and performed only as necessary to eliminate undesired vegetation.

Fertilization

Like all fruit plants, grapes usually require nitrogen fertilization. Except in sandy soils, this element could be the only one needed in the fertilization program. In the home garden, 2 ounces of calcium nitrate (15.5 percent nitrogen) per vine should be applied after growth begins in the spring. Spread the fertilizer in a circle around the plant, 10 to 12 inches from the trunk. Repeat the application about six weeks later. Repeat this fertilization at the same timing and rates in the second and third seasons. A blended fertilizer, such as 10-10-10, applied at 3 ounces per vine can be substituted where phosphorus and potassium are also needed.

Fertilizer applications to mature, bearing vines should be based on the growth and vigor of the plant. If the average cane growth is only 3 feet or less, additional nitrogen might be needed. Where proper pruning is practiced and competition from weeds and grass is kept to a minimum, however, it is doubtful that you will need to go beyond the amount recommended for a 3-year-old vine.

Training and Pruning

Much attention is given to the training and pruning of grapes. To be most productive, they must be trained to a definite system and pruned rather severely. There are several training systems used. Two that are commonly used are the vertical trellis and the overhead arbor. Both of these are satisfactory in home planting if kept well-pruned.

Of the many variations of the vertical trellis, the single-trunk, four-arm Kniffin system is the most popular (fig. 7). Posts are set 15 to 20 feet apart and extend 5 feet above the ground. Two wires are stretched between the posts, the lower being about 2.5 feet above the ground and the upper at the top of the posts. Set between the posts, the vine is trained to a single trunk with four semipermanent arms, each cut back to 6 to 10 inches in length. One arm is trained in each direction on the lower wire.

During annual winter pruning, one cane is saved from those that grew from near the base of each arm the previous summer. This cane is cut back to about 10 buds. The fruit in the coming season is borne on shoots developing from those buds. Select another cane from each arm, preferably one that grew near the trunk, and cut it back to a short stub with two buds. This is a renewal spur. It should grow vigorously in the spring and be the new fruiting cane selected the following winter. All other growth on the vine should be removed. This leaves four fruiting canes, one on each arm with eight to 10 buds each, and four renewal spurs, one on each arm cut back to two buds each.

The same training and pruning techniques can be used effectively in training grapes to an arbor system. Arbors are generally overhead structures occasionally used in home plantings to add a decorative feature to the garden or lawn. Many variations can be found by browsing the Web. The principal difference between trellises and arbors is that the wires supporting the grapevine arms are placed overhead and parallel with each other on the arbor instead of vertically on trellis posts. Overhead wires or wooden frames are usually placed 6 to 7 feet above the ground, well within reach.

If an arm dies or for any reason needs to be replaced, choose the largest cane that has grown from the trunk near the base of the dead arm and train it to the trellis wire. To renew the trunk, train a strong shoot from the base of the old trunk to the trellis as though it was the cane of a new vine. Establish the arms in the same manner as for a new vine and cut off the old trunk.

A high-wire cordon training system can be used with varieties such as Norton that have trailing or procumbent shoot growth habits (fig. 8). The top wire of the trellis is placed about 6 feet above the ground. One or two trunks are trained up to this wire and then horizontally extended along the top wire to which they are loosely tied. These horizontal trunk extensions are called "cordons" and are annually pruned to short, two- to four-node "spurs" derived from the previous season's canes. It is important to train or comb the current growing season's shoots downward from the cordons if using a high-wire system.

Pruning can be done at any time after the vines become dormant. In areas where there is danger of winter injury, pruning should be delayed until early spring. Vines pruned very late could "bleed"

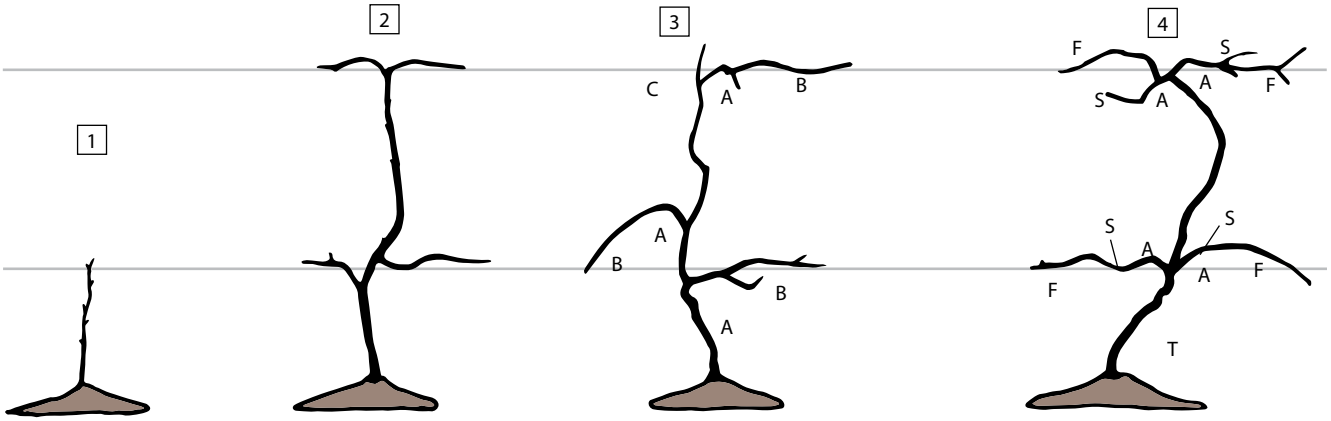


Figure 7. Stages in training the young vine to the single trunk, four-arm Kniffin system. (1) After pruning the first winter: The single cane is cut back and tied to the lower wire. If the cane has grown less than 3 feet during the first summer, it should again be cut back to two buds. (2) After pruning the second winter: Two new canes of four or five buds each are tied on the bottom wire. A third new cane is tied up to the top wire and cut off. (3) After pruning the third winter: Three of the arms (A) and the fruiting canes (B) have been formed. A cane (C) with four or five buds is left to establish the fourth arm. (4) A fully formed vine after pruning the fourth winter: The arms (A) should be shorter than those shown. The vine consists of a single permanent trunk (T), four semipermanent fruiting arms (A), four annual fruiting canes (F), and four renewal spurs (S) with two buds on each.

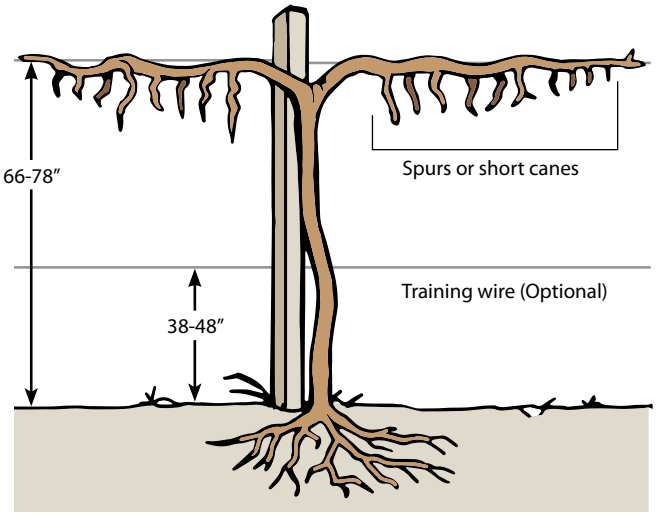


Figure 8. High-wire, cordon-trained system for grapevines. Cordons are semipermanent, horizontal extensions of the trunk(s). Cordon length will depend on in-row vine spacing; the cordon of one vine should extend almost to the cordons of the adjacent vines in the row. Cordons are pruned to short canes or spurs of one to four nodes in length. Total node number should not exceed about five nodes per linear feet of row. Thus, for vines spaced 7 feet apart in the row, total retained nodes should not exceed 35.

excessively, but there is no evidence that this is injurious. "Bleeding" here refers to the oozing or flow of sap from pruning wounds, a phenomenon caused by positive sap pressure within the vine when soil begins to warm in spring.

Pest Management

Grapes and grapevines are subject to diseases and insect pests. Certain varieties, such as Norton, as well as most muscadine varieties, are relatively resistant to common fungal diseases. On the other hand, all of the *Vitis vinifera* varieties and many of the hybrid grape varieties are either moderately or highly susceptible to one or more fungal diseases, including black rot, downy mildew, and powdery mildew. Chief insect pests include Japanese beetles and grape berry moth. If acceptable to the grower, a fungicide spray program will likely be minimally required for American and hybrid grapes and mandatory for *Vitis vinifera* varieties to avoid crop loss to these diseases. Japanese beetle and grape berry moth infestations vary from year to year and might or might not require insecticide sprays. For further information on chemical pest management, please consult Virginia Cooperative Extension's Pest Management Guide for home fruit production, available at https://www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/456/456-018/ENTO-462.pdf.

In addition to potential disease and insect threats, ripe grapes are attractive to birds, deer, and raccoons. Bird netting can be used to exclude birds, but it must be applied to the planting soon after grapes begin to acquire color and ripen. Vertebrate pests such as deer and raccoons can be excluded with woven wire, electric fencing, or combinations of fencing small enough to exclude raccoons and tall enough (8 to 10 feet) to discourage deer.

Harvesting the Planting

For best quality, bunch grapes should be fully ripe when harvested. They will not improve in sugar content or flavor after being removed from the vine. Most varieties should be used immediately because they do not keep well after ripening. Cut the clusters off with a knife or shears to avoid bruising the fruit and damaging the vine.

Muscadine grapes grow either singly or in small, loose clusters. Some varieties can be shaken off easily when ripe; others have to be hand-picked. The grapes should be used soon after harvesting since their storage life is relatively short.

Strawberries

Strawberries are the most widely cultivated small fruit in America. They are the favorite of many for pies, jams, jellies, preserves, and for eating fresh. Strawberries are adaptable to a range of soil and climatic conditions, and are well-suited to the home garden (where supplemental watering is readily accessible).

Variety Selection

Strawberry varieties vary in their adaptability to soil and climatic conditions and can be classified into short-day or June-bearing types, and day-neutral or ever-bearing types. The short-day strawberries will initiate flower buds when days are shorter than 14

hours or when temperatures are below 60 F. Most of the varieties that fruit solely in May-June are short-day varieties, with flower buds initiated from late August to early November; however, the short days in spring (March) will also initiate flower buds. Day-neutral varieties will initiate crown growth and flower buds throughout the season except when temperatures are very high (above 86 F). These varieties will bear fruits in May-June with yields somewhat lower than short-day varieties. Day-neutral varieties will yield a second crop in midsummer at most locations and a third crop, its highest yield, in late summer and early fall. The varieties suggested for planting in Virginia have been selected on the basis of plant vigor, productivity, and quality of the fruit. Virus-free plants of these varieties are available and should be purchased. To keep disease pressure low, replace the strawberries each year and plant the new berries at a different location in the garden than the previous year.

Short-Day or June-Bearing Varieties

- Camino Real has a compact growth habit and a darker fruit color compared to Camarosa. Fruit is attractive and conical in shape. This variety is suitable for both fresh market and processing and is resistant to verticillium wilt and root and crown rots.

- Camarosa is a widely grown cultivar in the world. It has good disease profile resistance but is susceptible to verticillium wilt. Fruit is large, firm, and holds well in the rain. The fruit tastes better when it is picked past its glossy red stage.

- Chandler is another variety popular throughout the world and is greatly adaptable to the eastern United States. Fruit is medium to large in size with medium firmness. Chandler has good taste, is high-yielding, and is suitable for fresh consumption and processing. This variety is susceptible to diseases but harvests over a long period.

- Delmarvel is productive on a variety of different soil types. It is an attractive, large-sized berry with good aroma and flavor. Plants are disease-resistant except for *Rhizoctonia* but exhibit good winter hardiness.

- Earliglow is a variety noted for its superior dessert quality and disease resistance. The medium-large berries are very attractive with a glossy appearance and deep red color. It is one of the best for eating fresh, as a frozen product, and in jams and jellies. The plants are very vigorous and productive; however, they bloom early and are subject to frost injury, and late berries are small in size.

- Flavorfest is a mid- to late-season variety, with a sweet-tasting berry, and a medium-sized fruit. This variety is resistant to anthracnose disease.

- Lateglow was developed for its production of late-season fruit and good disease resistance. Its berries are very large, symmetrical, and attractive. It is a good dessert variety and can be eaten fresh or frozen.

- Sweet Charlie is a winter tender variety with overall lower yields for the season. This variety has a small fruit size. It is grown for its early bearing capacity, excellent flavor, and sweet taste. The plants are susceptible to *Phytophthora*.

Day-Neutral or Ever-Bearing Varieties

- Albion has a relatively open plant canopy. It is resistant to wilts and rots and is one of the most widely grown varieties in Northern California. Berries are cone-shaped with a dark red hue and a sweet flavor. The variety is good for fresh consumption and processing.

- San Andreas has good disease resistance. This variety produces high quality fruit and has an outstanding flavor and an exceptional appearance. Fruits are medium to large in size and symmetrical conic in shape. Fruit color is slightly lighter than Albion. This variety is suitable for fresh market, processing, and home gardens.

Establishing the Planting

Soils

Although strawberries grow best in a fertile, sandy loam soil with a pH of 5.9-6.5, they can be grown successfully in any good garden soil that is well-drained and well-supplied with organic matter. Soil for strawberries should be thoroughly prepared for planting — it should be loose and free of lumps. Raised beds are preferable.

Planting

Virus-free plugs should be set out in late fall or dormant crowns in early spring, about three or four

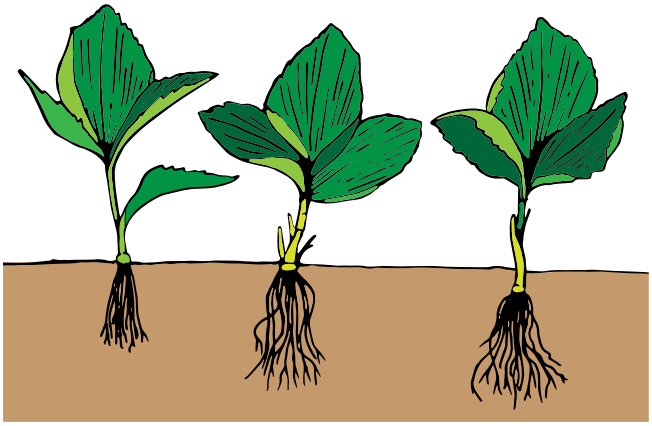


Figure 9. Planting depths: left, too shallow; center, correct depth; right, too deep.

weeks before the average date of the last frost. Plants should be placed no less than 12 inches apart in rows that are 2 to 3 feet apart. Take care to set each plant so the base of the bud is at the soil level (fig. 9). Spread the roots out and firm the soil carefully around them to prevent air pockets, which allow them to dry out.

Maintaining the Planting

Soil Management

Cultivation for weed control in strawberries should begin soon after planting and continue at approximately two to three week intervals throughout the first growing season. Cultivation must be shallow to prevent root injury. Hoe as often as necessary to remove grass and weeds growing between the plants.

In colder areas, home garden strawberry plantings should be winter mulched. Any organic material free of weed seeds makes acceptable mulch. Hay, straw, and pine needles are most frequently used. Mulch should be applied 2 to 4 inches deep over and around the plants after the first freezing weather in the fall when the soil is below 50 F (usually around mid-December). This protects them from injury due to freezing and heaving of the soil during the winter. After the danger of frost is over in the spring, about half the mulch should be raked off the plants into the area between the rows. Mulch left around the plants will help keep the berries clean, conserve moisture, reduce diseases, and check weed growth.

Fertilization

Two to three weeks before planting, broadcast 4 pounds of 10-10-10 fertilizer per 100 linear feet of row. If leaves appear light green in color after three to four weeks of transplanting, side dress with 1.5 pounds of ammonium nitrate per 100 feet of row. The limited shallow root systems will not initially benefit from fertilizer placed in the row middles. In coastal plains in late January or February, apply 0.75 pound of ammonium nitrate. In spring, choose a fertilizer grade with higher phosphorus and potassium and apply 0.5 pound of nitrogen per 100 feet of row.

Production System

There are two popular training systems used in strawberry production — the hill system or "plasticulture" system and the matted-row system. Modifications of these systems can be found.

In the hill system or plasticulture system, plants are spaced 12 to 16 inches apart in a single or staggered double row. All runners are removed as soon as they appear, and the plants are encouraged to multiply in large crowns. This system is desired by many because the planting is easier to cultivate and harvest, and it produces larger, better berries than other systems. However, many plants are required and the initial cost of the planting is high. Black plastic mulch is particularly effective with this training system, but it requires drip irrigation lines for optimum performance. This plasticulture system is currently popular with commercial growers.

Under the matted-row system used by many home gardeners, runner plants are allowed to set freely in all directions. The original plants should be set 18 to 24 inches apart in the row. Keeping the width of the plant bed narrow (16 to 18 inches) results in a good grade of fruit that is easy to pick. During the planting season, all flower stems on the plants should be removed as soon as they appear. This strengthens the plants and allows early and vigorous runner production. Runner plants formed early bear the best fruit the following year.

Renovation

If your strawberry planting is in a vigorous condition, it can be retained for fruiting the second year. However, allowing a planting to fruit more than two years often results in smaller berries and weak plants.

If retaining plants, remove the mulch and clip the tops of the plants to within 1 inch of the crowns with a scythe or mower soon after harvest (mid-July). If insects and foliage diseases are prevalent, move the leaves, mulch material out of the planting, and burn them. Apply a quickly soluble nitrogen fertilizer such as ammonium nitrate (NH_4NO_3) at 0.25 to 0.50 pound or 1 to 2 pounds of 10-10-10 per 100 feet of row to encourage vigorous top growth. Any good garden fertilizer supplying an equivalent amount of nitrogen can be used if desired.

Some plant thinning might be needed, particularly in the matted-row system. Thin plants (remove the oldest) to 6 to 8 inches apart after new foliage appears. Keep the planting free of weeds throughout the summer, irrigating when necessary during the dry season to keep the plants growing vigorously. Fertilize again in the early fall as recommended for the first year and renew the mulch after freezing weather begins.

Pest Management

Birds are one of the biggest pests in strawberry planting. It might be necessary to cover the plants with plastic netting to keep the crop from being eaten before the berries are ripe enough to harvest. Aluminum pie tins or used metallic compact discs — suspended by a string or wire above the plants in such a manner that they twist and turn in the breeze — could be successful in keeping birds away.

Culture of Ever-Bearing Varieties

Irrigation is particularly important for ever-bearing varieties because the late-summer/early-fall crop ripens during a period when soil moisture is usually quite low. Soil preparation and fertilizer requirements before planting are the same as those for regular varieties. Best yields are obtained from ever-bearing varieties if they are set in early spring in the hill system about 1 foot apart, cultivated for the first 10 to 14 days, and then mulched to a depth of 1 to 2 inches with sawdust. As the sawdust decays, the development of a nitrogen deficiency could occur. It can be quickly overcome with the application of 1 pound of 10-10-10 to each 100 square feet of mulched area.

Remove runners as soon as they appear to encourage the plants to multiply in large crowns. Blossom clusters should be removed until the plants have become firmly established and are growing vigorously, usually about the first of August. Berries will begin to ripen about a month later, and plants will continue to bear fruit until frost if weed growth is kept down and adequate moisture is supplied. Allow the plants to bear fruit for the spring and fall crops the second year, then replant the following spring.

Harvesting the Planting

In the home garden, strawberries should be allowed to develop an overall red color and become fully ripened before harvesting. Sometimes the tops (sun-exposed) are red but the bottoms are still white and not ready for harvest. It is at the fully ripe stage that the sugar content is highest and the flavor is best. It may be necessary to harvest every day during the peak of the season, especially in warm periods.

Harvest the berries carefully by the stems just above the caps to prevent bruising. Pick all that are ripe. Ripe fruits when left unpicked on the plant, increase infestation of strawberry sap beetle and spotted wing drosophila. Ripe strawberries can be held for a day or two in a refrigerator.

Strawberry Growing in Pyramids and Barrels

In a garden where space is extremely limited or where the gardener wishes to use the strawberry planting as a novelty or decorative feature, the strawberry pyramid or the strawberry barrel can be useful and interesting. Pyramids can be square or round. The frames for a square pyramid can be constructed out of landscaping wood. A suggested soil mixture for the pyramid is two parts good garden soil, one part peat, and one part sand.

In preparing a strawberry barrel, 1-inch diameter holes are made in the sides of the barrel at approximately 8-inch spacing. As the barrel is filled with successive layers of soil, strawberry plants are carefully inserted through the holes so that the roots are held firmly in contact with the soil. A porous tile inserted down the middle of the barrel will facilitate water reaching all of the plants (fig. 10). Though the strawberry barrel may be a successful novelty, yields of fruit will be smaller than those in open field culture, and much more attention to planting, watering, and winter protection are required.

Damage to the strawberry plants growing under normal cultural conditions can be expected if they are not protected from extreme cold during the winter. Owing to the fact that plants growing in a pyramid or barrel are elevated above normal ground level and therefore are highly exposed, additional winter damage can be expected to roots, crowns, and fruit buds. Consequently, care must be taken to provide adequate winter protection. Pyramids can be mulched with 6 to 8 inches of straw after the soil is frozen. In the coldest part of the state, strawberries in barrels will survive better if protected with burlap covering. In cold winters, enclose straw in the burlap for added insulation. However, even with careful mulching, some plant injury can be expected during severe winters.

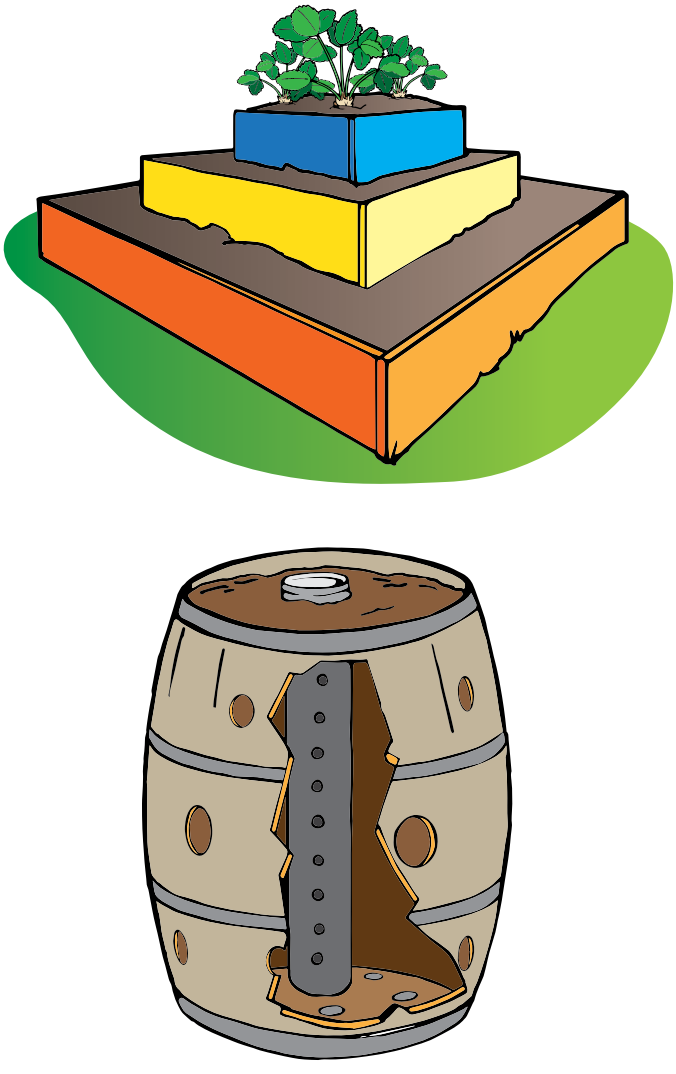


Figure 10. Plants can be grown in a pyramid setting or a barrel, in a home garden.

Acknowledgements

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High Tunnel Basics

Sanjun Gu

Extension Horticulture at Virginia State University

April 27, 2024. VCE SUACP



Outline

high tunnel basics

high tunnel crops choices

high tunnel management

High Tunnel Farming

https://online.fliphtml5.com/nbdy/vsse/#p=1



Let's Review field production first!

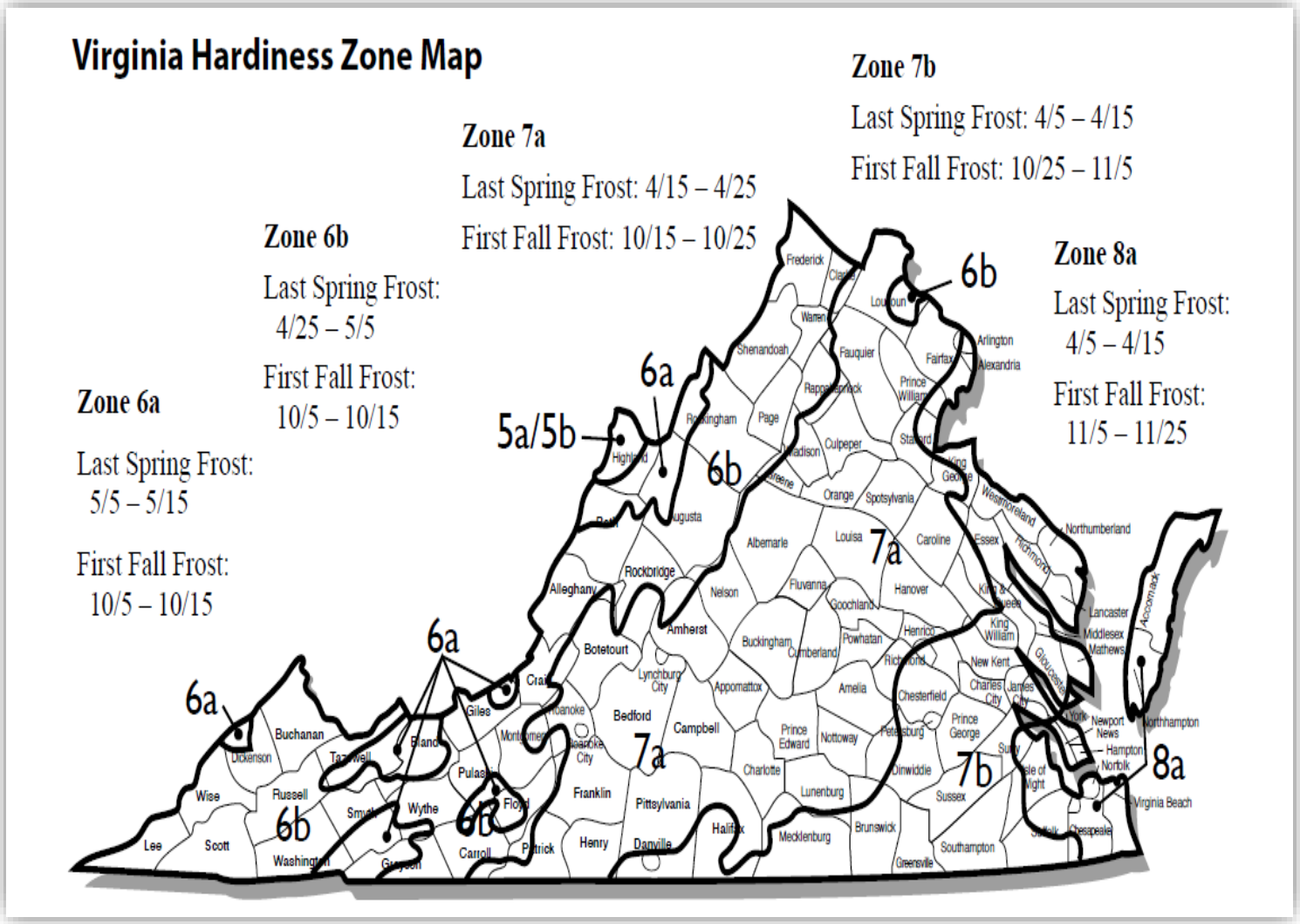
- Growing season
  - » The period of time in a year when the climate is prime for cultivated plants to experience the most growth.

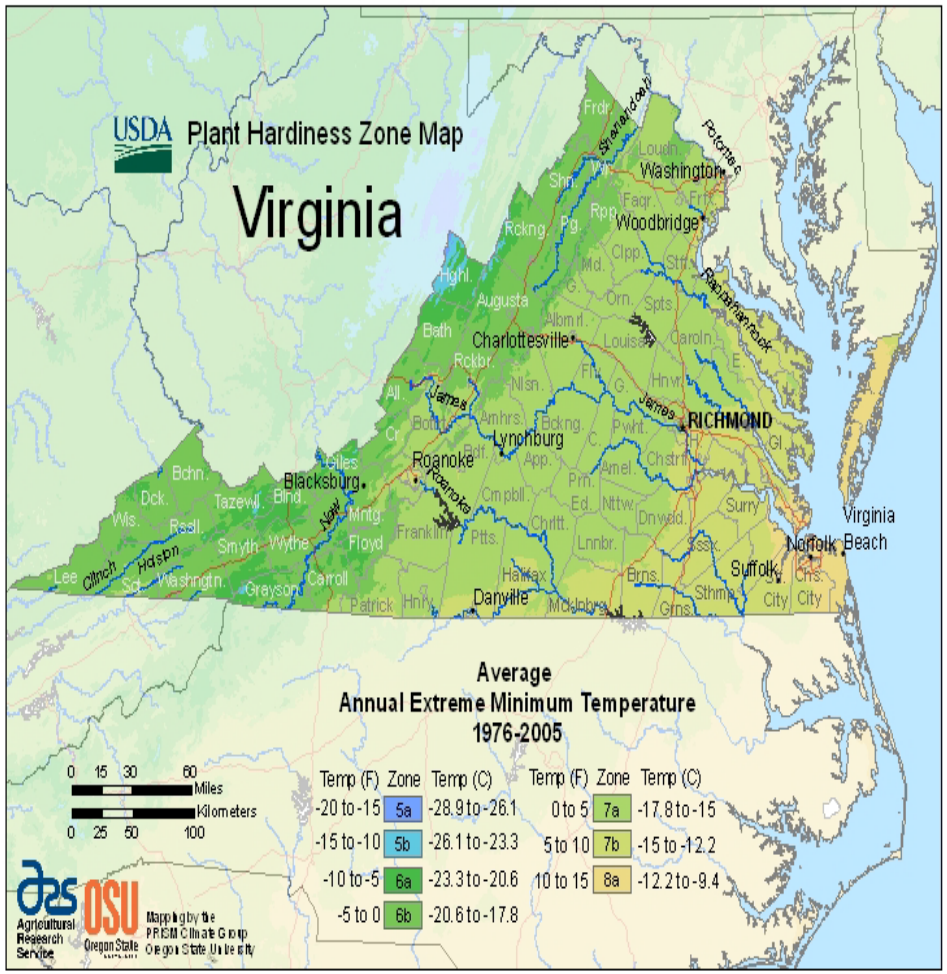
- Season extension
  - » frost free days and production
  - » USDA plant hardiness zones
  - » Season extension practices

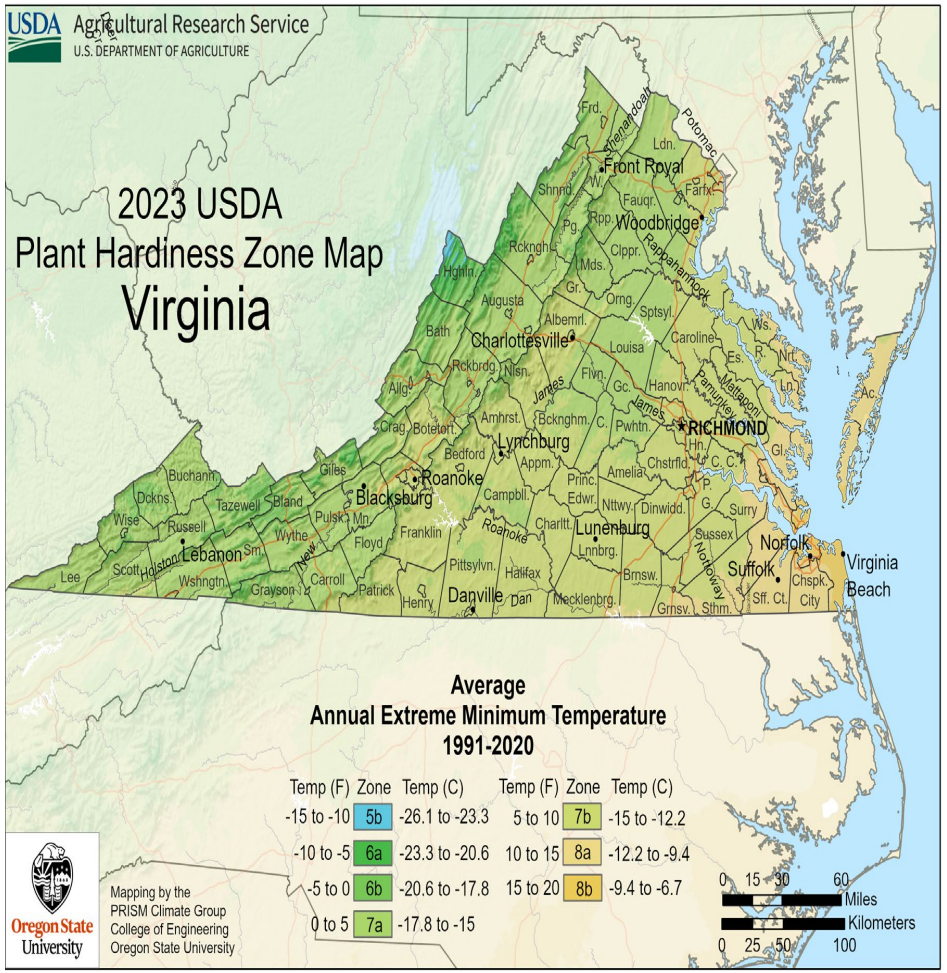
Plant Hardiness Zones and Frost Free Days

- Plant hardiness zones: a reference for survival of a species based on extreme low temperature records

- Plant hardiness zones: a reference for survival of a species based on extreme low temperature records
- Frost Free Days




USDA Plant Hardiness Zone Map
Virginia
Average
Annual Extreme Minimum Temperature
1976-2005
Temp (F) Zone Temp (C)
-20 to -15 5a -28.9 to -26.1
-15 to -10 5b -26.1 to -23.3
-10 to -5 6a -23.3 to -20.6
-5 to 0 6b -20.6 to -17.8
0 to 5 7a -17.8 to -15
5 to 10 7b -15 to -12.2
10 to 15 8a -12.2 to -9.4
0 15 30 60 Miles
0 25 50 100 Kilometers
Agricultural Research Service
OSU Oregon State University
Mapping by the PRISM Climate Group Oregon State University
Washington
Woodbridge
Charlottesville
RICHMOND
Lynchburg
Roanoke
Blacksburg
Danville
Suffolk
Norfolk
Virginia Beach


USDA Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE
2023 USDA
Plant Hardiness Zone Map
Virginia
Average
Annual Extreme Minimum Temperature
1991-2020
Temp (F) Zone Temp (C)
-15 to -10 5b -26.1 to -23.3
-10 to -5 6a -23.3 to -20.6
-5 to 0 6b -20.6 to -17.8
0 to 5 7a -17.8 to -15
5 to 10 7b -15 to -12.2
10 to 15 8a -12.2 to -9.4
15 to 20 8b -9.4 to -6.7
0 15 30 60 Miles
0 25 50 100 Kilometers
Oregon State University
Mapping by the PRISM Climate Group College of Engineering Oregon State University
Front Royal
Woodbridge
Charlottesville
RICHMOND
Lynchburg
Roanoke
Blacksburg
Lunenburg
Danville
Suffolk
Norfolk
Virginia Beach

Common Field Production Practices



- ✓ *Transplanting*
- ✓ *Compost/manure/cover crops*
- ✓ *Raised beds*
- ✓ *Plastic mulch*
- ✓ *Drip irrigation*
- ✓ *Row covers*
- ✓ *Low tunnels*
- ✓ *High tunnels*
- ✓ *Greenhouse*





1. What is a high tunnel?

High Tunnels

definition

Unheated, plastic-covered structures that provide an intermediate level of environmental protection and control, compared to open field and greenhouse conditions.

- **Sun light is (usually) the sole heat source: no heating/supplement lighting**
- **Passive ventilation: no cooling**
- **It has straight (high) side walls**
- **One or two layers of poly**
- **Usually grow in soil**
- **Low-tech, low cost**
  - **Materials: \$0.5-\$4.5/ft^2**
  - **Construction: varies, 30-50% of materials cost**

A: Bow or Hoop

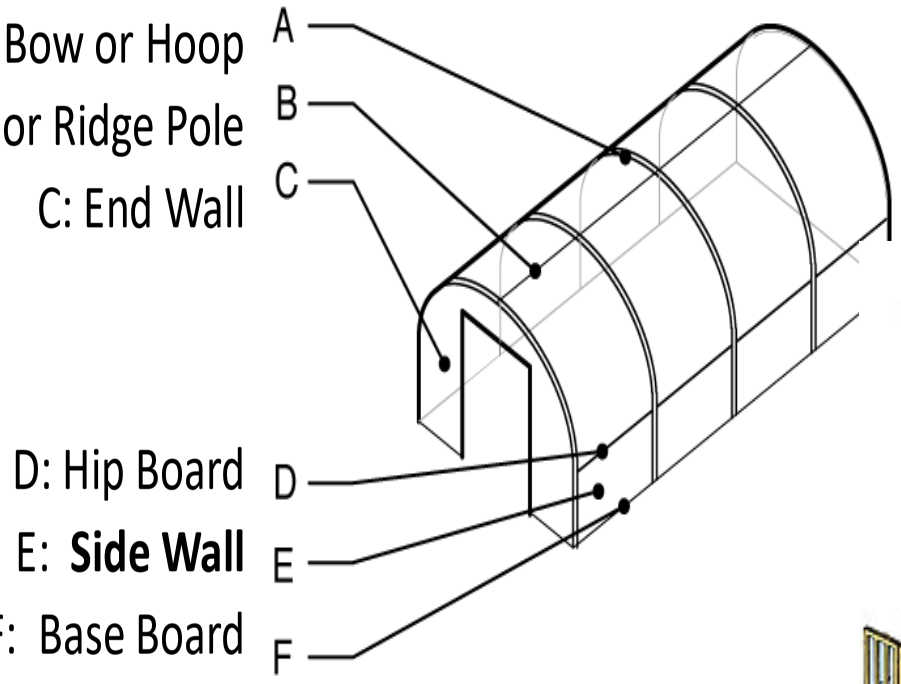
B: Purlin or Ridge Pole

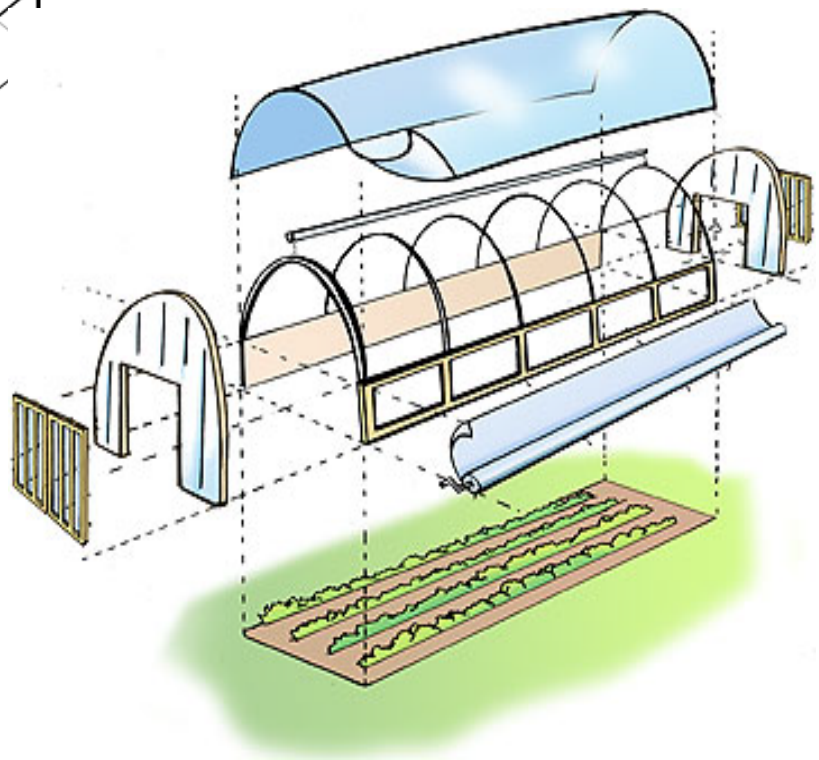
C: End Wall

D: Hip Board

E: **Side Wall**

F: Base Board





Types of High Tunnels

- **Single** bay vs. multi-bay
  - Hay-Grove: three seasons
- **Gothic** vs Quonset design
  - All multi-bay high tunnels are Quonset
- **Fixed** vs. Moveable





High Tunnel vs Hoophouse

- **A high tunnel reflects the word High**
  - Walk upright
  - Work comfortably
  - Operate small machines: small tractors and rototillers
- **A high tunnel has vertical side walls**
  - For passive ventilation: either roll-up or drop-down curtains
  - For operation at the sides
  - Avoid rain water to fall into the tunnel
  - Other purposes: install screens for insect control




High Tunnels @ A&T Research Farm
Organic

2. Can you make money with a high tunnel?

High Tunnel and Small Farms: a Perfect Match

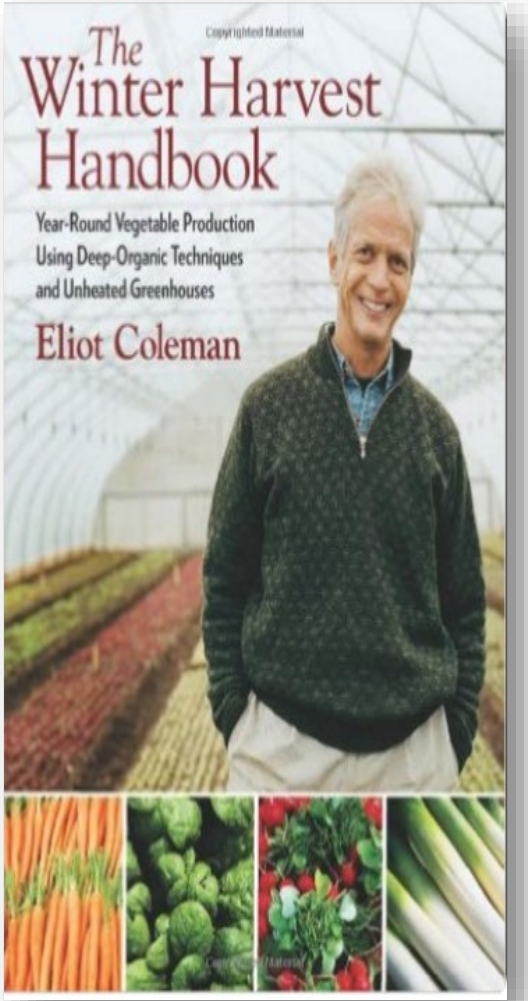
- Fixed cost: high tunnel related
- Variable costs
  - Materials
    - ✓ Crop choices
  - Labor
    - ✓ Small farmers themselves
- Markets
  - Marketing channels
  - Price: organic, all natural, chemical free, conventional
    - ✓ Name your price for out-of-season produce?
- Expectations/Goals

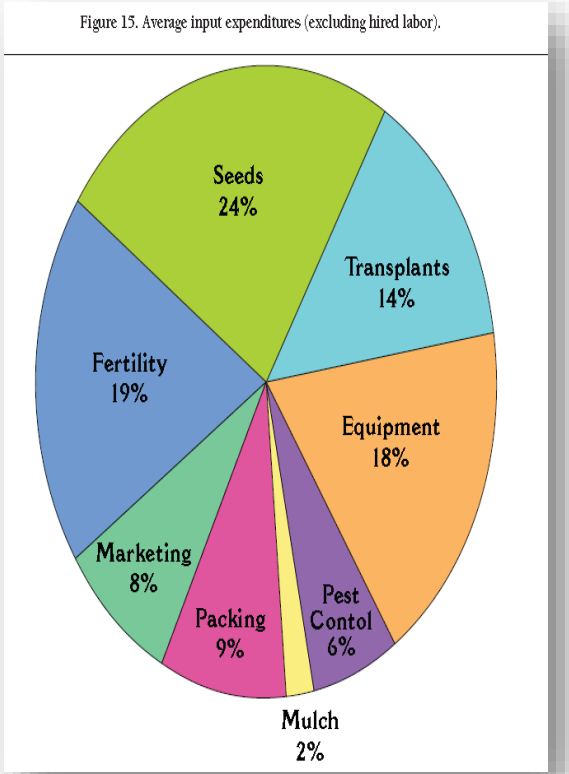
	Ft^2
1 acre	**43,560**
30' x 96'	2,880
21' x 96'	2,016
30' x 72'	2,160

NRCS, cost shares

High Tunnel Economic Potential

- Goal: $5-10/ft^2 net income
  - $14,400-$28,800/year for a 30' x 96' tunnel
- Material cost of high tunnel: <$0.5-4.5/ft^2
  - $1,440-$12,960, 30'x 96' tunnel
  - Money back in 1-2 years
- Construction: 1/3 to ½ cost of materials
  - 120-140 man hours
- Operation (labor)
  - The greatest cost
  - Harvest and bed preparation use more labor than crop management
- Operation (non-labor)
  - Seed, fertility, equipment and transplants
  - Repairs





Costs and Potential Income One short season-organic greens

- Total cost: $1831.50
- Potential income

Crop	Units	Price ($)	Total ($)
Pak choi	.27 lb/plant	3.50/lb	556.00
Head lettuce	.19 lb/plant	2.50/lb	419.00
Bunch spinach	.16 lb/plant	3.00/lb	282.00
Salad mix	.27 lb/ft^2	10.00/lb	437.00
Spinach mix	.19 lb/ft^2	10.00/lb	308.00
Greens mix	.45 lb/ft^2	10.00/lb	729.00

- Potential net income: $2731 - $1831.50 = **$899.50** or **$0.31/ft^2 ($1.5/ft^2)**

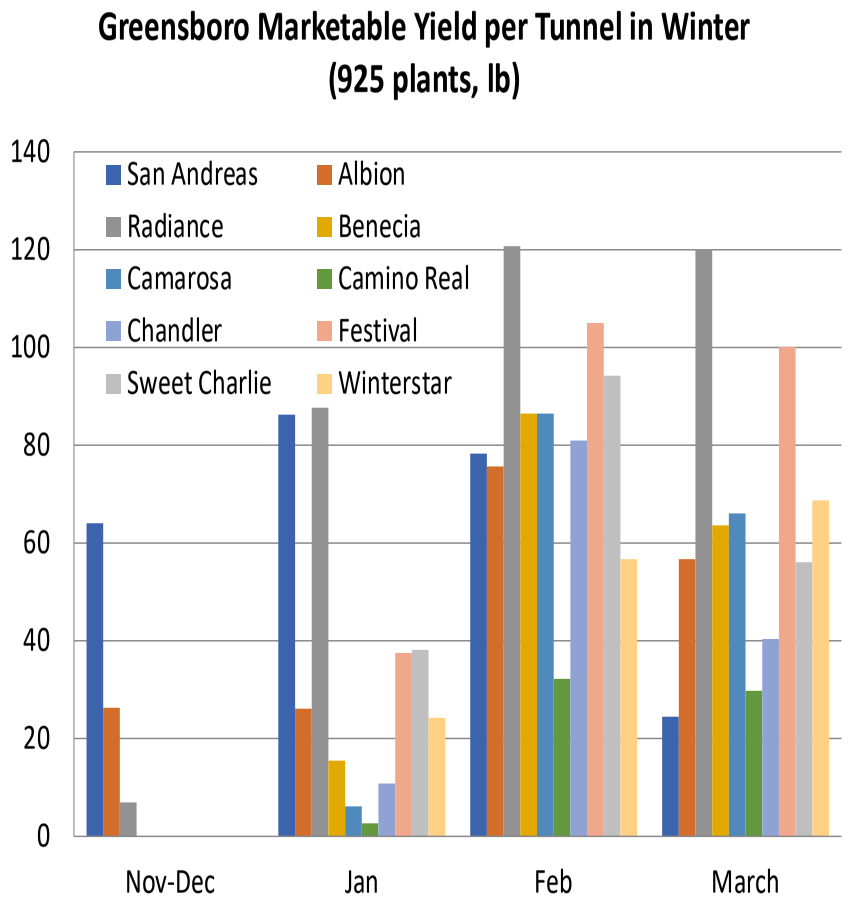
Costs and Potential Income (organic warm-season vegetables)

Crop	Units	Price ($)	Total ($)
Cucumber	10 fruit/plant	2.50/ea	6000.00
Tomato	8.7 lb/plant	3.50/lb	7308.00
Pepper	17 fruit/plant	1.50/ea	6120.00

- Total costs: $2877.50
- Potential income: $19428
- Potential net income: $19428.00 - $2877.50 = **$16550.50** or **$5.75/ft^2**

Strawberry

- Cost of a high tunnel: <$3.5/ft^2 (10 years)
  - ~0.35/ft^2
- Cost of labor and materials
  - $825 materials
  - $2,050 labor
  - ~$1/ft^2
- Gross income projection
  - 1 foot spacing, ~1,500 plants/HT
  - 1.25-1.5 lb/plant, $8/lb (organic, out-of-season)
  - $15k-$18k or $5.21-6.25/ft^2
- Projected net income: $3.9-4.9/ft^2



3. What will a high tunnel do?

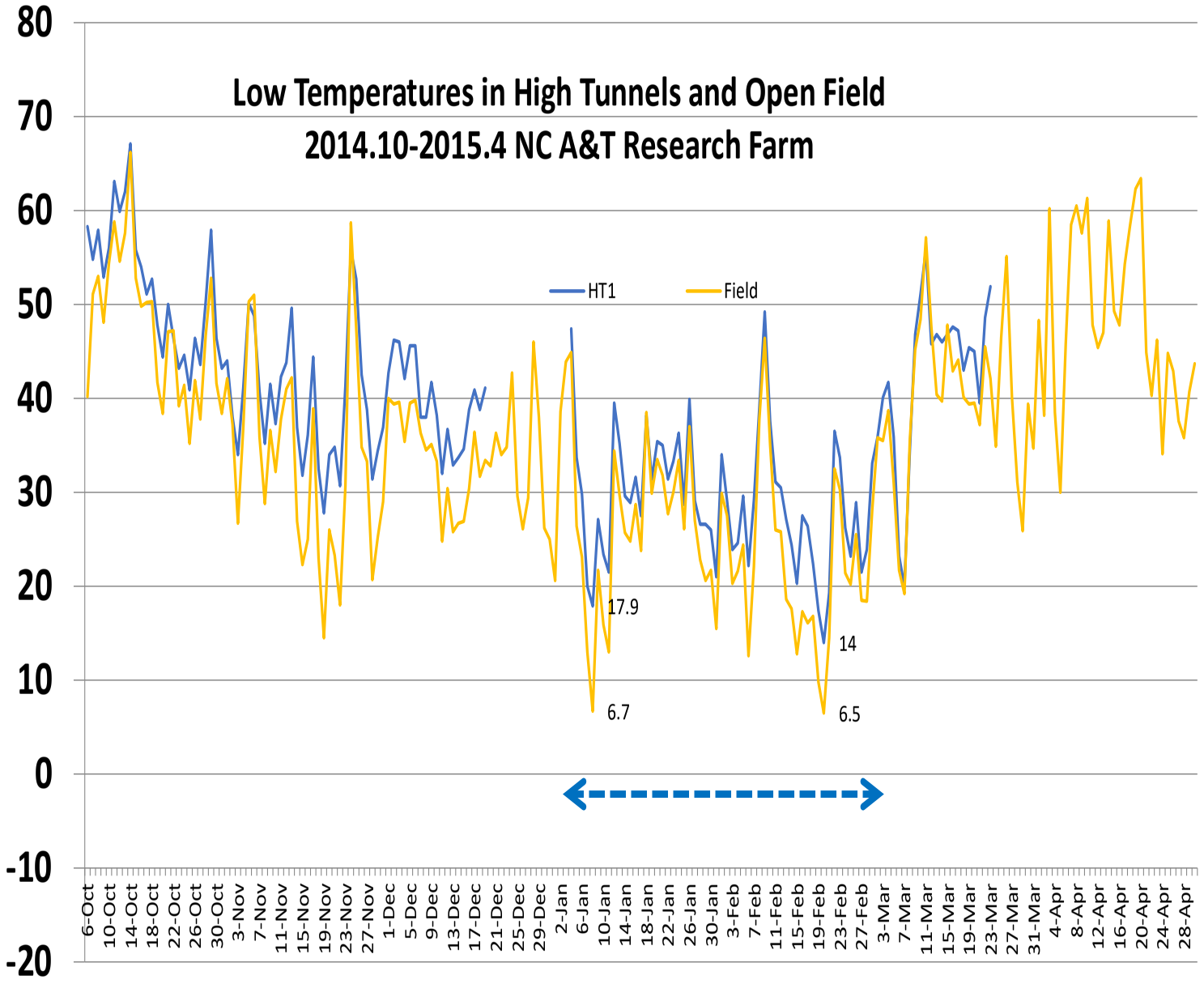
The Microclimate in High Tunnels

...makes season extension possible

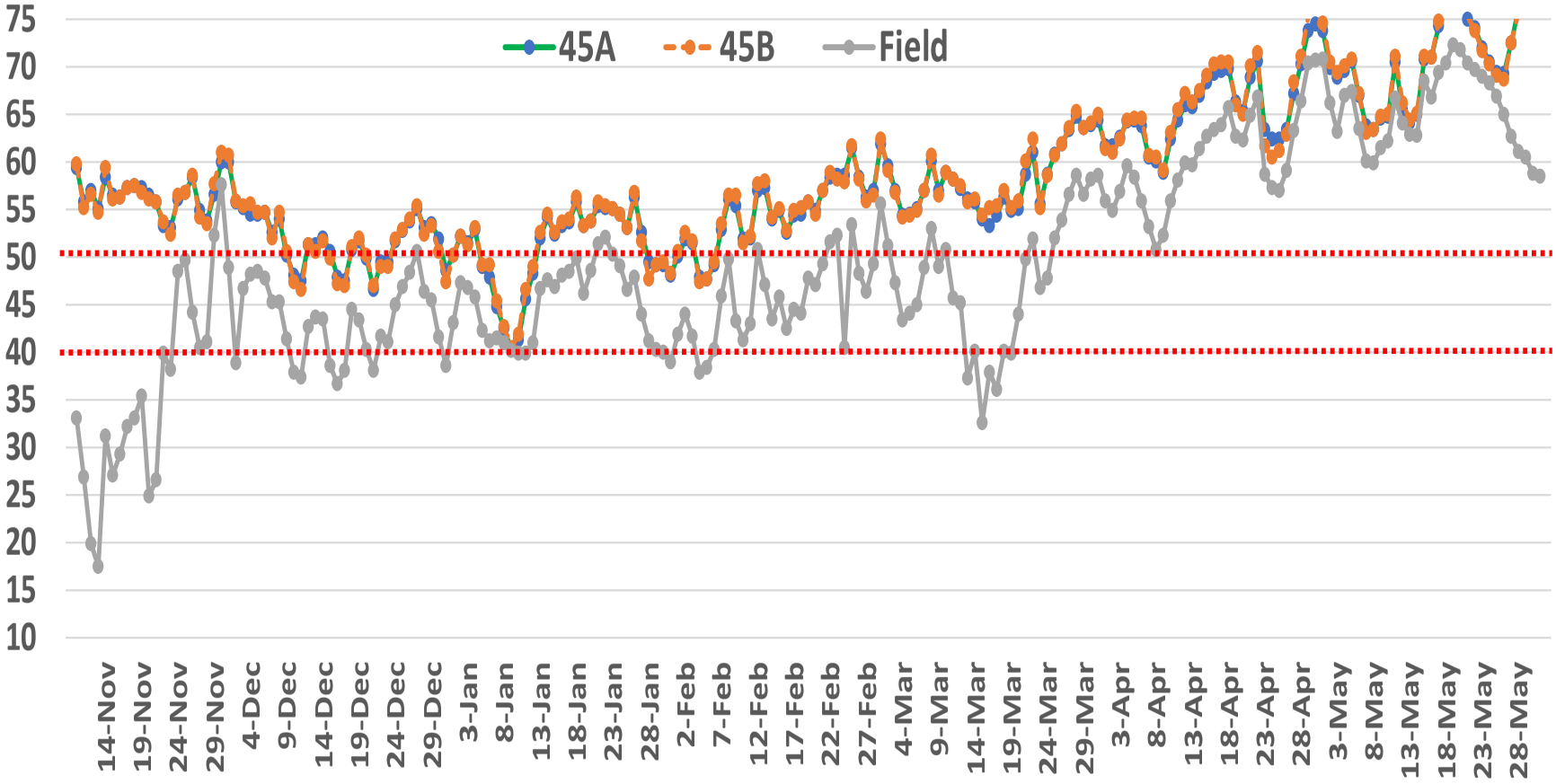




Low Temp.


Low Temperatures in High Tunnels and Open Field
2014.10-2015.4 NC A&T Research Farm
HT1
Field
17.9
6.7
14
6.5
80
70
60
50
40
30
20
10
0
-10
-20
6-Oct
10-Oct
14-Oct
18-Oct
22-Oct
26-Oct
30-Oct
3-Nov
7-Nov
11-Nov
15-Nov
19-Nov
23-Nov
27-Nov
1-Dec
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11-Feb
15-Feb
19-Feb
23-Feb
27-Feb
3-Mar
7-Mar
11-Mar
15-Mar
19-Mar
23-Mar
27-Mar
31-Mar
4-Apr
8-Apr
12-Apr
16-Apr
20-Apr
24-Apr
28-Apr

2016/17 Low Soil Temperatures—Field and Strawberry Tunnels



Microclimate Summary in a High Tunnel

Zone 7&8

- High Tunnels provide 1-2 plant hardiness zones protection with row covers
- Frost free days increased at least by 5 weeks
- Growing Degree Days are greatly enhanced in high tunnels so plants will mature early
- Sunlight: single-layer plastic seems to work as well as double-layer (inflated)
- Soil temperatures rarely go below 40°F in winter
- Air temperatures could be too high for plants on a sunny day in deep winter
  - Shade cloth reduces light intensity and temperature
- Humidity in high tunnels closely related to irrigation *and could be high*
  - High disease incidence potential
  - Be careful with row covers touching leaves

Application in Production: Microclimate

- Cold hardiness zone: moves up 1 to 2 zones
  - More species and cultivar choices
  - Longer growing season: gain 4-6 weeks each end
- More GDD/Frost Free Days
  - Mature early
  - Planting date flexible
  - Harvest date
  - Longer growing season
- Sunlight
  - Quality produce
  - Shade cloth for summer production
  - ✓ Can use single or double layer poly
- Humidity in high tunnels
  - Control humidity and leaf wetness with ventilation and drip irrigation
  - ✓ High disease incidence potential: with row covers
- Wind
  - Easy management of row covers and low tunnels
  - ✓ Pollination and disease issues possible
- Overwinter production of cool season vegetables possible
- ✓ Overwinter production of warm season vegetables impossible

5. Where do I buy a high tunnel?

- Start with a singe-bay tunnel
- Get experience with a small one
- Use Gothic design in heavy snow area
- Try stationary high tunnel first

Home-made vs Commercial High Tunnel

- If possible, buy a (smaller) commercial high tunnel to avoid figuring out everything by yourself!
  - Companies with years of high tunnel experience have refined their models
  - A pre-drilled kit will save you lots of hassle
- However, there are plenty home-made types online with detailed instructions.
  - PVC pipe tunnels? NOT a good choice
- If a NRCS cost-share tunnel, you have to buy a commercial kit (has to be approved by NRCS)









Side Curtains

- ✓ Roll-up
- ✓ Drop-down







Endwalls

Commercial High Tunnels

- Atlas: http://www.atlasgreenhouse.com/greenhouses/coldframe/
- FarmTek: http://www.farmtek.com/farm/supplies/cat1a;ft_high_tunnels_cold_frames.html
- Four seasons tools: http://www.smallfarmtools.com/pages/high-tunnels
- HayGrove: http://www.haygrove.com/hightunnels/
- Puckett: http://www.puckettgreenhouses.com/
- Rimol: http://www.rimolgreenhouses.com/greenhouse-series/high-tunnel
- Zimmerman's: http://www.zimmermanshightunnels.com/ or through Morgan County Seeds https://www.morgancountyseeds.com/product-category/buildings-equipment-supplies/buildings/high-tunnels/

Ask about extra-support and automation.

6. Can I build a high tunnel myself?

High tunnel construction is not as hard as you would think!



High Tunnel Construction

- Choosing the right site is the most important
- A High tunnel is a relatively permanent structure
  - Code: there might be no clear regulation available so the construction can be greatly delayed
  - Tax



- Construction is not easy but definitely manageable
  - Construction costs: 20-80% of the materials cost might be asked if hiring a contractor
  - Grading site and driving in posts might require contract labor
  - Assemble parts on the ground if all possible



Site Selection

- Sunlight!!!—No shade or minimize shade
- Level land: grade <3% along the length
- Avoid cold air pockets
- Access to water is essential
- Access to electricity is desired
- Snow load: wind break can pile up snow on your tunnel
- Drainage: avoid draining into the tunnel
- Soil:
  - Fertile soils
  - No history of perennial weeds or diseases
  - Free of large stones
- Wild animals?





Orientation

- Site specific
  - Below Lat. 40°, north-south
  - Above Lat. 40°, east-west
- Side walls (the length) perpendicular to prevailing winds desired
- Windbreaks recommended in windy areas.
- Ensure good air flow

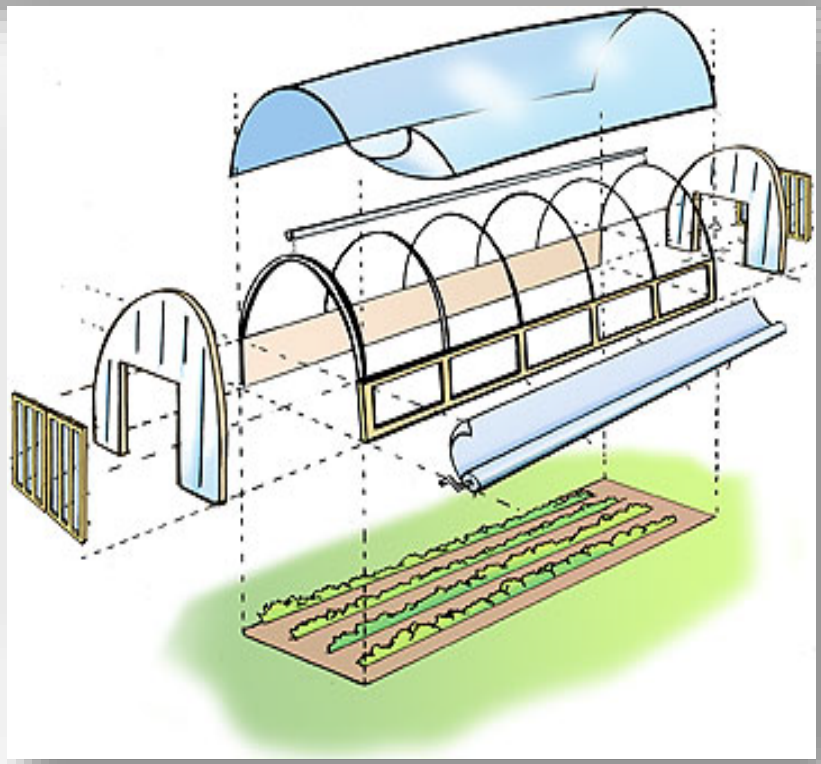




Plan well *and*
expect the unexpected







high tunnel construction

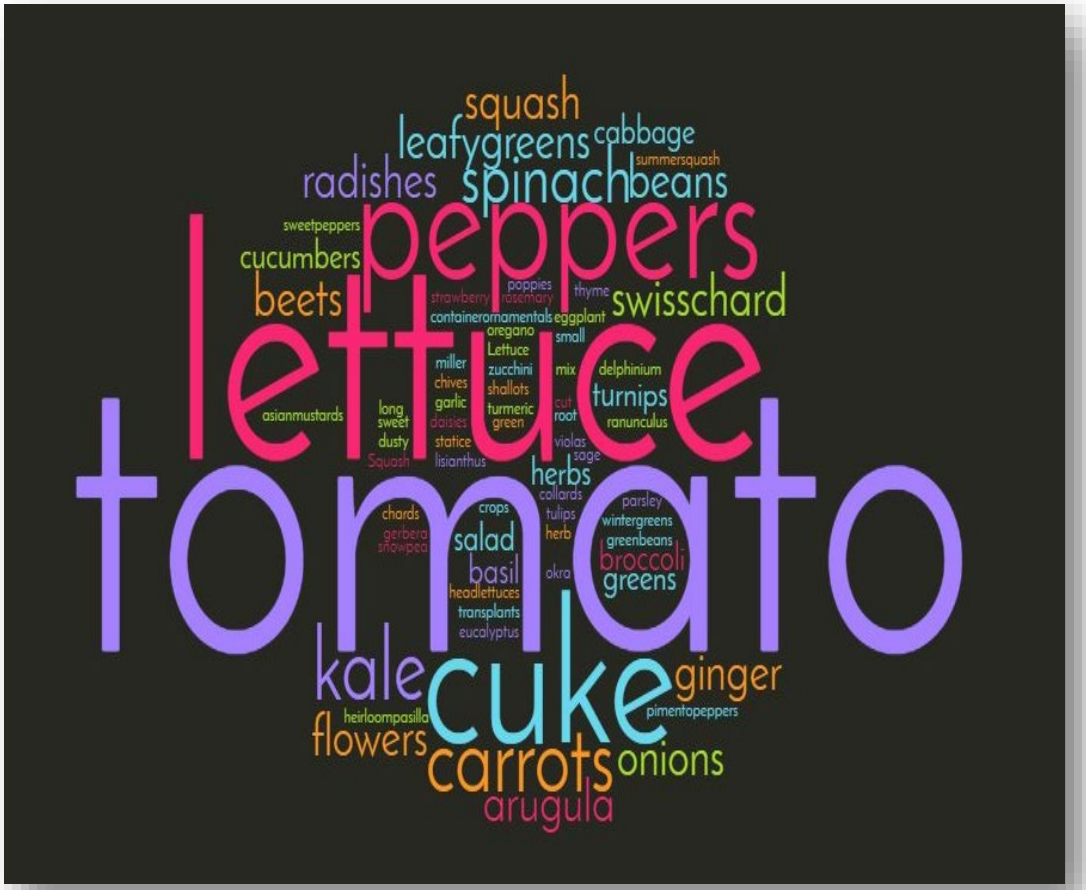
Construction

- ✓ Prepare site, gather tools, machines and labor
- ✓ Assemble bows
- ✓ Drive in end-posts (side walls)
- ✓ Install bows
- ✓ Install purlins, braces, trusses, etc
- ✓ Install hip boards, base boards, side curtains
- ✓ Install end walls, doors
- ✓ Install optional systems: ventilation, gutters, etc
- ✓ Cover high tunnels with polyplastic film



7. What to grow in a high tunnel?

Vegetable Crops for High Tunnels



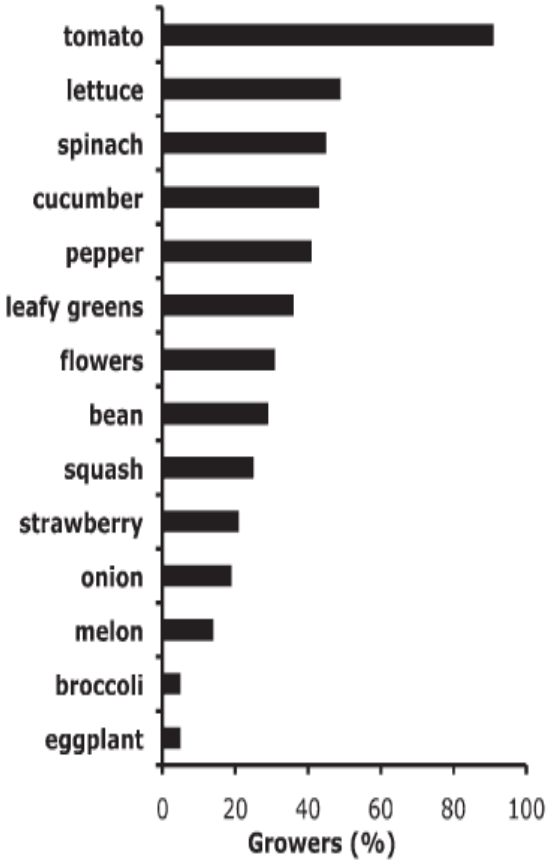


Fig. 4. Proportion of growers that reported producing various crops in high tunnels during the previous 4 years. Results of a survey of 81 growers from Iowa, Kansas, Missouri, and Nebraska conducted from 2005 to 2007.

West Virginia

1800 ft^2 bed space

Modified from Dr. Lewis Jett

Crop	Ft^2/plant	Yield/ft^2 (lbs.)	Price/lb.	Total Revenue ($)	Time (days)	$/$ft^2$/day	Rank
Cucumbers	4	2.5	3.00	13500	65	208.00	1
Kale	0.6	1.0	6.00	10800	60	180.00	2
Lettuce	0.2	1.0	6.00	10800	65	166.00	3
Tomatoes	8	2.5	2.50	11250	100	113.00	4
Spinach	0.2	1.0	4.00	7200	65	111.00	5
Carrots	0.2	1.3	3.00	7020	75	94.00	6
Beets	0.2	1.25	2.50	5625	75	75.00	7
Peppers	4	2.0	1.00	3600	100	42.00	8
Ch. Cabbage	1.5	2	1.65	2700	70	39.00	9
Beans (bush)	0.1	0.5	2.00	1800	65	28.00	10
Eggplants	6	0.7	2.00	2520	100	25.00	11
Peas	0.1	0.5	2.00	1800	75	24.00	12
Strawberries	2	0.8	3.00	4320	200	22.00	13
Broccoli	1.5	0.4	2.50	1800	80	21.00	14
Summer Squash	8	0.6	1.00	1080	70	15.00	15
Melons	8	1.5	0.50	1350	120	14.00	16

Some crops tried at A&T high tunnels















Winter Crops

- Lettuce
- Spinach
- Kale
- Snow pea
- Pac Choi
- Chinese Cabbage
- Swiss Chard
- Beets
- Turnips
- Radish
- Carrots
- Cilantro
- Chinese celery
- Asparagus lettuce



Markets and Human Resources (labor) decide what to grow!

- Four season harvest means year around market
  - Keep your customers
- Four season production
  - Keep your farmhand employed (*get paid and paid well*)
  - Contribute to local food production and economy
- Summer vacation?
  - Make the winter your main harvest season



No plan on what to grow?



Do Cover Crops!



Planting Dates—The General Rule

- Warm Season vegetables
  - Spring: 3-4 weeks earlier than the outdoor season
  - Fall: last harvest around the first freezing event in HT (3-4 weeks after the 1st field frost)
- Cold tolerant vegetables
  - Spring: 4-6 weeks earlier than the outdoor season
  - Fall: last harvest around New Year
- Cold hardy vegetables
  - Can be grown through winter
  - Latest planting/sowing month: December in zone 8, November in zone 7, and October in Zone 6
  - The 10-hour day length could be a reference



8. How to manage high tunnel and crops

- Management of high tunnel
- Management of crops

Considerations

- Drainage
- Insect screen
- Spring/summer
  - Ventilation
  - Shading
- Fall/winter
  - Insulation
  - Ventilation
  - Increment weather: wind and snow



Ventilation

Passive

- By side curtains
- By doors
- By windows on doors

Active

- Through fans
  - » Buy some fans to circulate air in HT if electricity is available



Air Temperature

- **Cold season vegetable:** Optimal temperatures 60-68°F. Start to vent the tunnel when temperature reaches around 65°F.
- **Warm season vegetable:** Optimal temperatures 68-85°F. Start to vent the tunnel around 85°F.

- **Use row covers (>1.2 oz/yard^2) for frost protection**
- **Try to vent ~30 minutes in the afternoon even it is cold outside.**
- **Emergent heating**

Crops	GDD Base (°F)	Minimum for the Edible Part (°F)	Optimum Range (°F)
Onion	35	35	55-75
Spinach	35	35	60-65
Carrot	38	45	60-65
Strawberry	39	40	65-75
Asparagus	40	50	60-80
Beet, Broccoli, Cabbage, Collards	40	40	60-65
Lettuce	40	35	60-65
Potato	40	40	60-65
Pea	40	40	60-65
Squash	45	60	65-75
Bean, Snap	50	60	60-70
Cantaloupe	50	60	65-75
Pepper	50	60	70-75
Tomato	51	50	70-75
Cucumber	55	60	65-75

Soil temperature

- > 40°F for cold hardy vegetables.
- > 50°F for warm season vegetables

- Use compost/manure--preplant
- Use plastic film
- Use row covers
- Avoid freezing surface water



Light

- Avoid shade
- Choose a right plastic film
- Clean up plastic film before November
- Lift row cover even on cloudy days
- Supplement with LED light?



Snow removal

Ready for sleepless nights!









Key Practices: High Tunnel Specific



- Build fertile soil: compost, manure, cover crops
- Choose the right cultivars
- Do Transplants!
  - Direct seeding only for baby vegetables, root vegetables, beans and peas
- Use raised beds and drip tapes
- Use (plastic) mulch for warm season vegetables
- Use row covers or low tunnels within the tunnel
- Trellis to save space and mitigate disease
- Use IPM tactics
- Soil (solar) Sterilization/Bio-fumigation
- Grafting
- Flood tunnel to remove excessive salts
- Include a quick season of cover crops

Use small machines and tools

- Small tractor/walk-behind tractor (BCS)
- Transplanter (Japan)
- Seeder











Trellising/Training/ Pruning: efficient use of space, disease control...



2017 trial

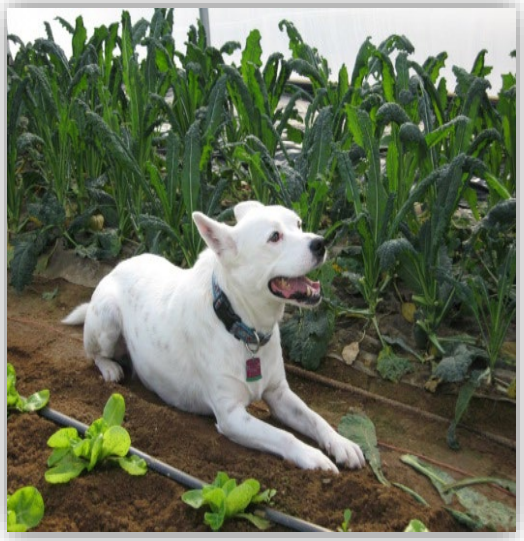
Organic English Cucumber with Insect Screens



Benefits

- Relatively lower cost
- Extended the growing and marketing season
  - Four-season harvest / sales
- High yield, better quality
- High profitability
- Semi-controlled environment
  - Easier to apply BMP
  - Less disease incidence
  - Easier pest monitoring and control
  - Workable in inclement weather
- Organic production is feasible
- Can be modified to a greenhouse or used for other purposes such as for animal production



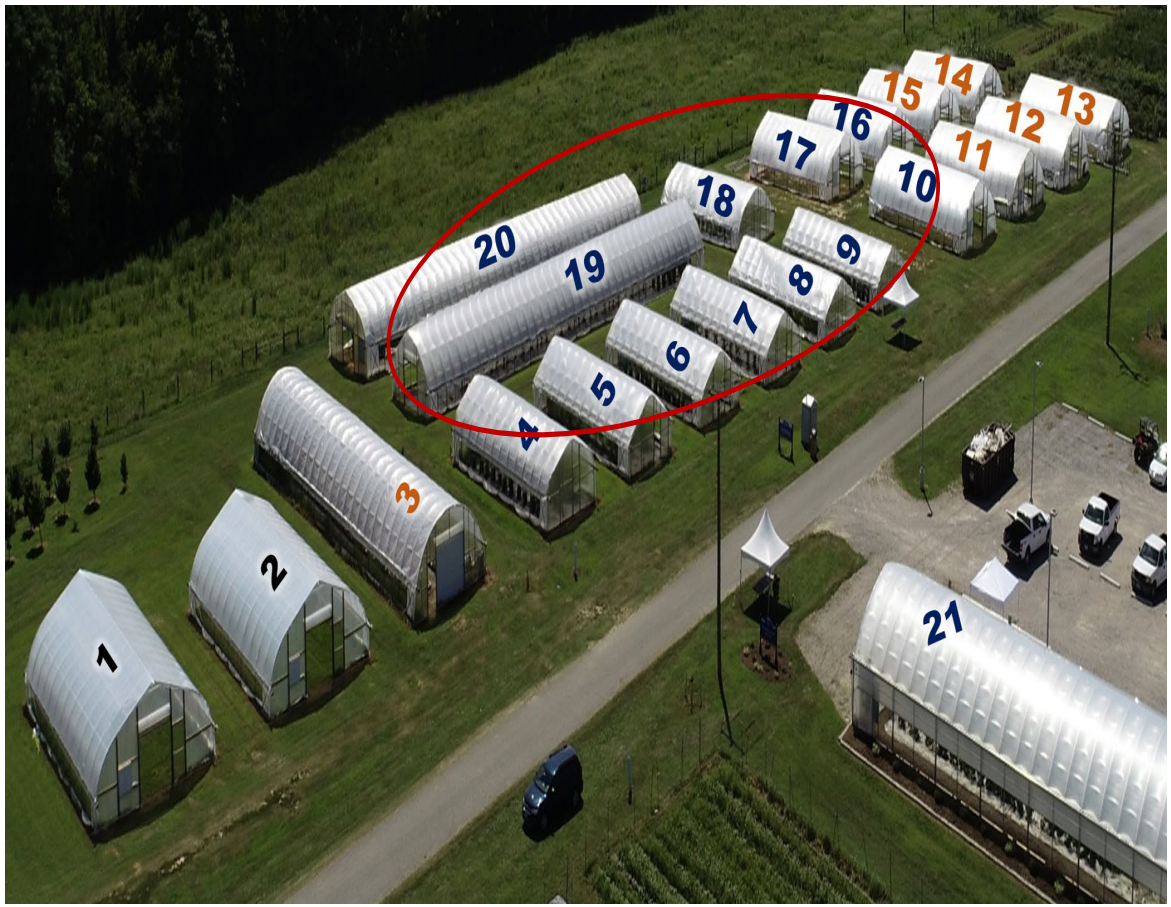


Disadvantages

- Initial cost could be high
- Intensive labor and maintenance
- Pest control can be challenging
- Irrigation a definite requirement
- Accumulation of salts and soil-borne disease if not managed carefully
- Risk of collapse due to heavy snow, heavy wind, etc.

VIRGINIA STATE VSU College of Agriculture

VSU high tunnels



Virginia Cooperative Extension
Virginia Tech • Virginia State University

www.agriculture.vsu.edu

VIRGINIA STATE VSU College of Agriculture

Organic Agriculture Food Production: Opportunities and Challenges

Sanjun Gu, Ph.D
Horticulture Extension Specialist and Associate Professor
Cooperative Extension at VSU

Outline

What: concept and history

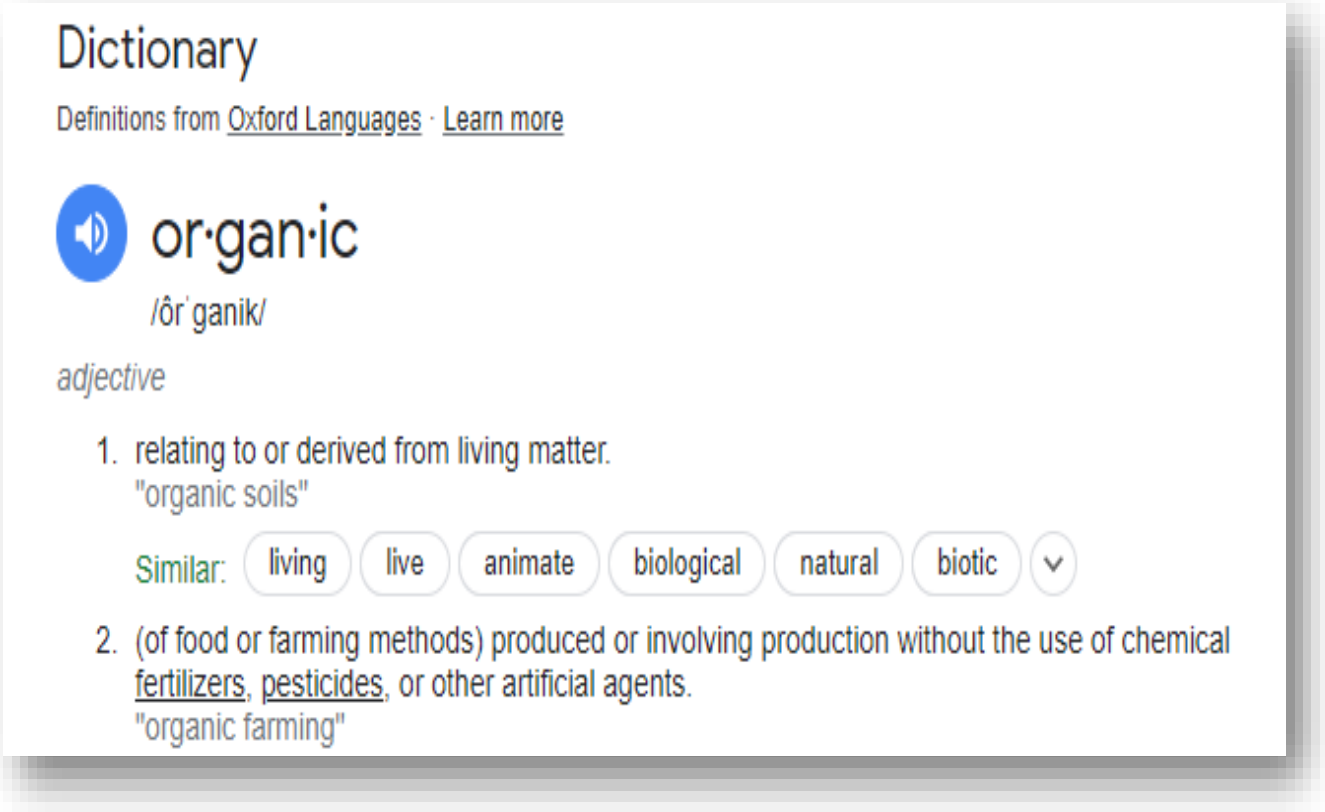
Why: opportunities

How: regulations, practices

What's in it for me?: challenges and looking ahead

What Is Organic?

What are Organic Foods?



Dictionary

Definitions from Oxford Languages · Learn more

or·gan·ic

/ôrˈganik/

adjective

1. relating to or derived from living matter.
   "organic soils"

   Similar: living | live | animate | biological | natural | biotic

2. (of food or farming methods) produced or involving production without the use of chemical fertilizers, pesticides, or other artificial agents.
   "organic farming"

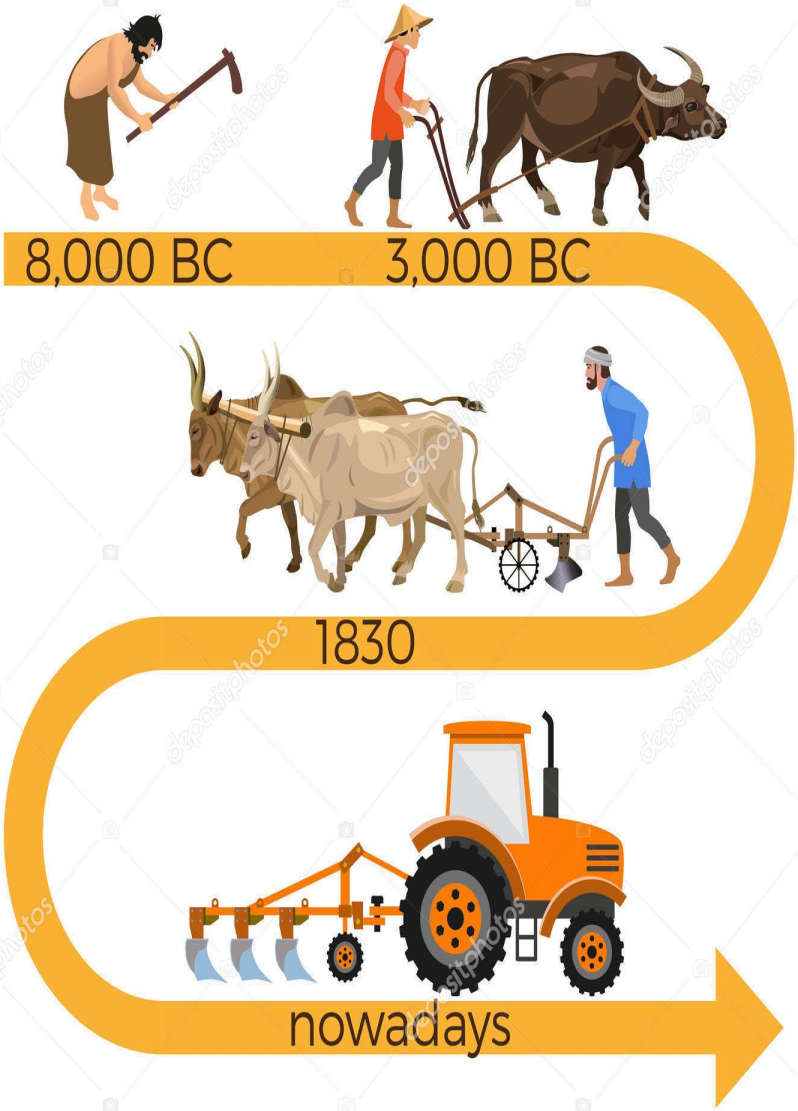






depositphotos Image ID: 186974268 www.depositphotos.com

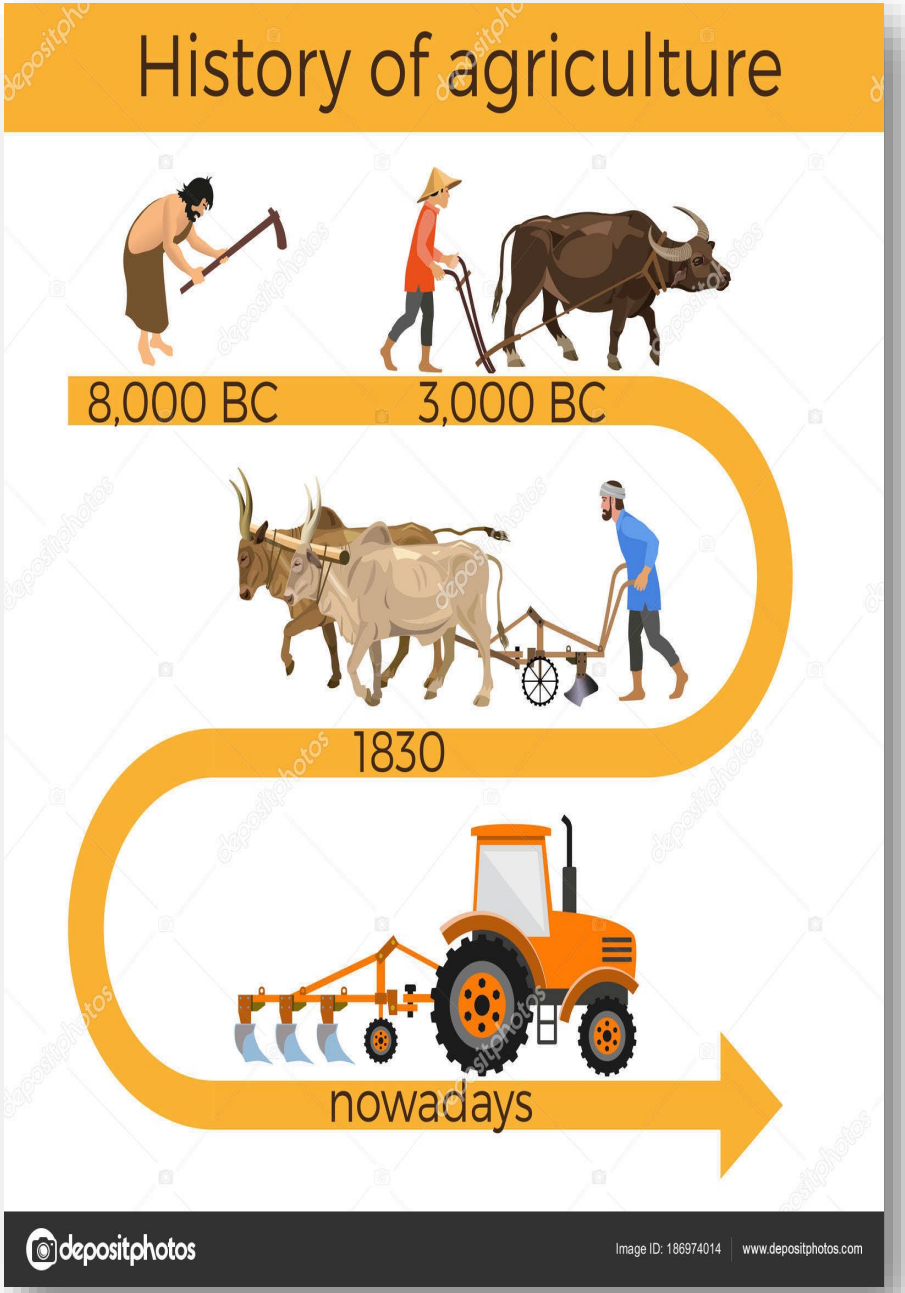
History of agriculture

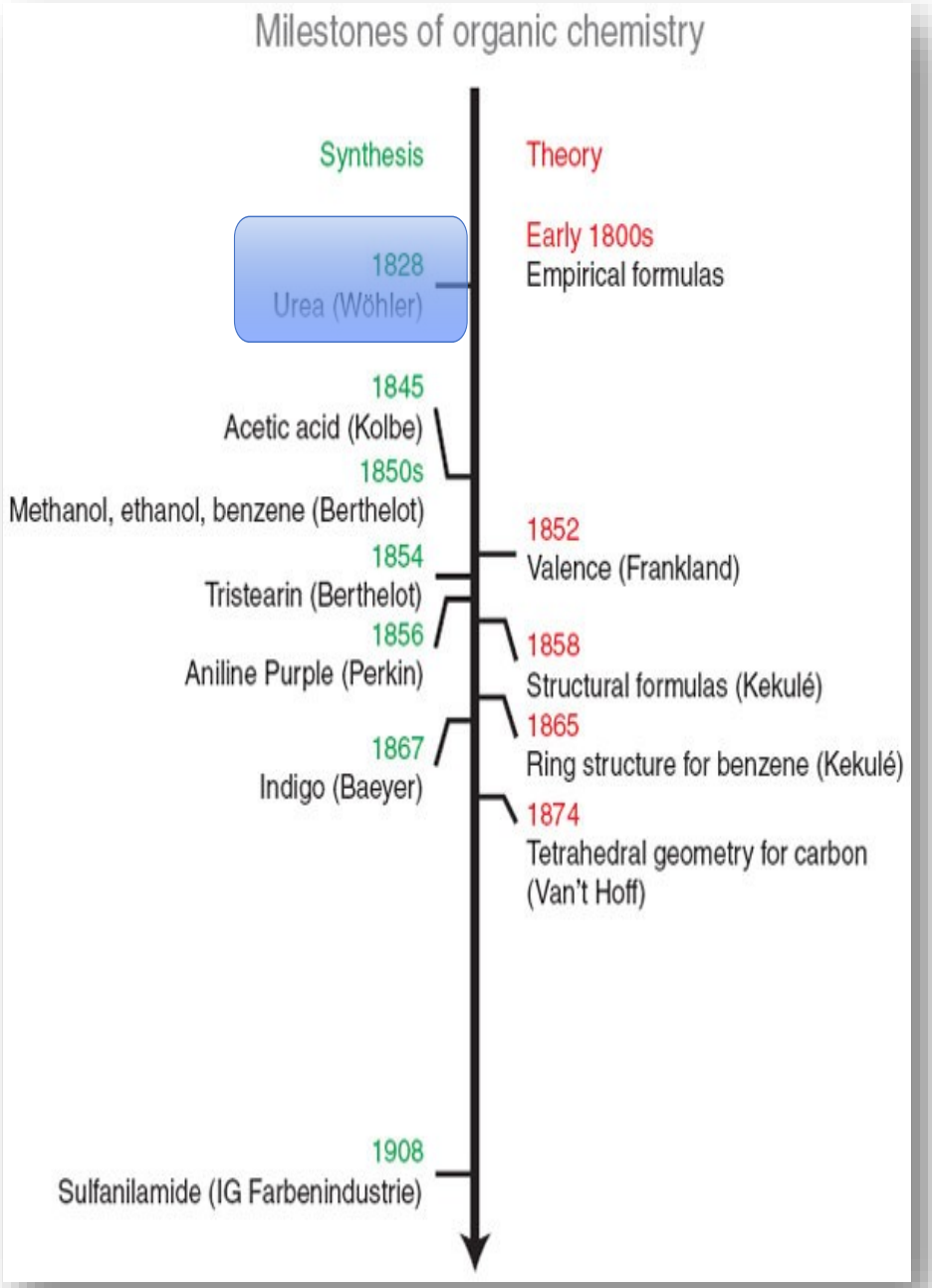


depositphotos Image ID: 186974014 www.depositphotos.com

In 1828, the German chemist Friedrich Wöhler could hardly contain his excitement as he wrote to his former mentor, Jöns Jakob Berzelius, of a new finding: "I must tell you that I can prepare urea without requiring a kidney of an animal, either man or dog."

Brian J Yeh & Wendell A Lim. 2007. Synthetic biology: lessons from the history of synthetic organic chemistry. NATURE CHEMICAL BIOLOGY VOLUME 3 NUMBER 9 521-525.


History of agriculture
8,000 BC
3,000 BC
1830
nowadays
depositphotos
Image ID: 186974014
www.depositphotos.com


Milestones of organic chemistry
Synthesis
Theory
1828
Urea (Wöhler)
Early 1800s
Empirical formulas
1845
Acetic acid (Kolbe)
1850s
Methanol, ethanol, benzene (Berthelot)
1852
Valence (Frankland)
1854
Tristearin (Berthelot)
1856
Aniline Purple (Perkin)
1858
Structural formulas (Kekulé)
1865
Ring structure for benzene (Kekulé)
1867
Indigo (Baeyer)
1874
Tetrahedral geometry for carbon
(Van't Hoff)
1908
Sulfanilamide (IG Farbenindustrie)

The Organic Foods Production Act of 1990 "requires the Secretary of Agriculture to establish a National List of Allowed and Prohibited Substances which identifies synthetic substances that may be used, and the nonsynthetic substances that cannot be used, in organic production and handling operations." Under this act, the Secretary of Agriculture promulgated regulations establishing the National Organic Program (NOP) in 2000.



USDA
ORGANIC

100% NATURAL
ORGANIC
PRODUCTS
CERTIFIED
100% ORGANIC
PRODUCTS
Natural
product
100% ORGANIC
Natural
INGREDIENTS
Organic
NATURAL
ORGANIC
PRODUCT
PREMIUM
Natural
PRODUCT
Premium Quality
ORGANIC
PRODUCTS
100%
ORGANIC
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ORGANIC
Adobe Stock | #124714504

NOP, National Organic Program of USDA

It makes rules—The National Organic Standards!

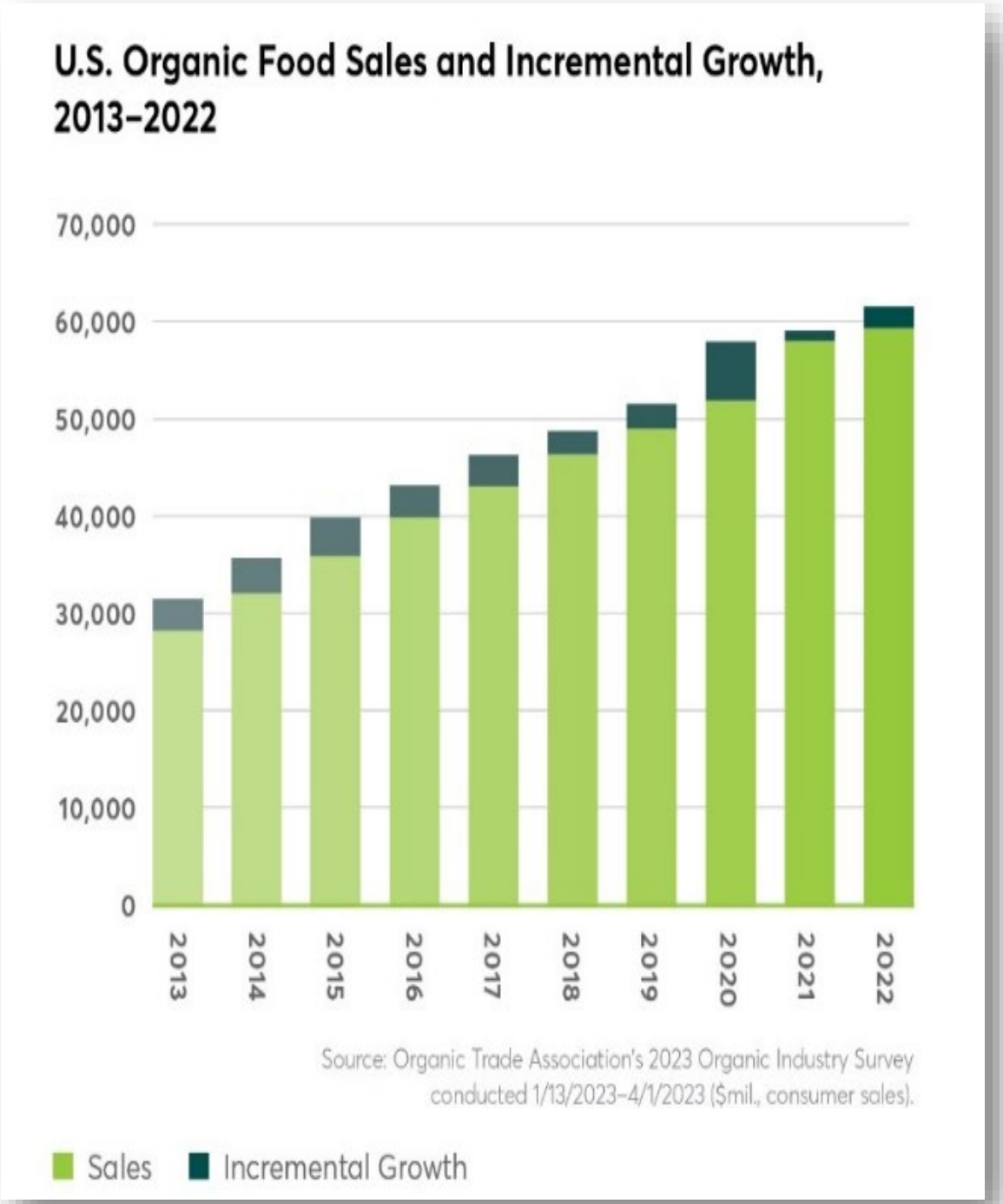
- Organic produce: grown without prohibited substances (synthetic fertilizers and pesticides) applied for three years prior to harvest.
- Organic meat: animals raised in living conditions of their natural behaviors (ability to graze on pasture), fed 100% organic feed and forage, and no antibiotics or hormones.
- Organic products: 100%, 95%, 70%

Organic and USDA Certified Organic

- **Organic** describes any food that is produced **without** chemical fertilizers, pesticides, or antibiotics.
- **Organic Agriculture**: a production system that is managed to respond to site-specific conditions by integrating cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity.
- In the US, USDA certifies food as organic if it has been grown in soil:
  - No **synthetic** fertilizer or pesticides (with exceptions)
  - A full **three years** prior to harvest.



Status and Opportunities



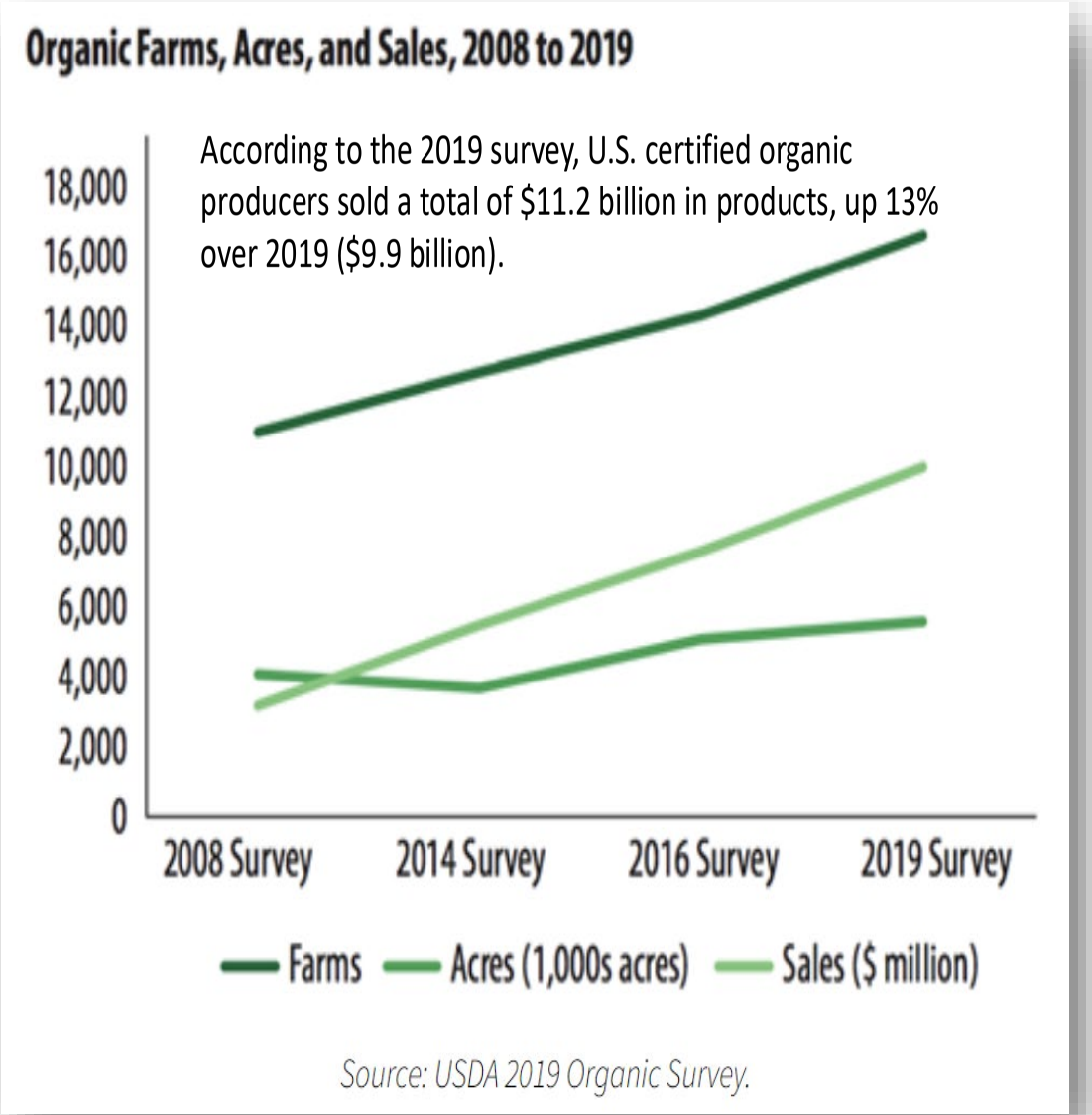
2023 Organic Trade Association Survey: Organic food sales in the United States in 2022 broke through $60 billion for the first time! ($67.6 B)

USDA 2021 Survey

- US certified farms : 174,55, 16,585 &14,217 (2021, 2019&2016 USDA surveys)
  - » NC: 335, 347, 247 farms
  - » VA: 166 (2021)
- US: 4.9M (21), 5.5M (19) and 50. M (19) acres
  - » NC: 38.9k, 47.74k, 31.8k acres
    - **$308M, $369.8M, $224.0M**
    - **More row crops, livestock and eggs**

REFLECTIONS

- Only a small portion of organic farms
  - » 46,000 (NC) vs 2,019,000 (US) total farms in 2020
  - » 0.73% vs 0.86%
- The value was from organic farm's sales
  - » Very different from the organic food sales: $11.2 B vs > $67.6 B



Organic Farms

Farm Characteristics:

Sales Class	Percent of Farms	Percent of Sales
< $10,000	11%	0.1%
$10,000 – $99,999	38%	3%
$100,000 – $249,000	22%	6%
$250,000 – $499,999	12%	7%
$500,000 +	17%	84%

Source: Highlights of the 2019 Organic Survey

71% are small farms (<$250k)





Processed organic food products

- Organic: ≥ 95% certified organic content.
- Made with Organic: ≥ 70% <95% certified organic content.
  - Can't use USDA organic seal
- Organic ingredient: <70% percent? May identify specific ingredients as organic in the ingredients list.

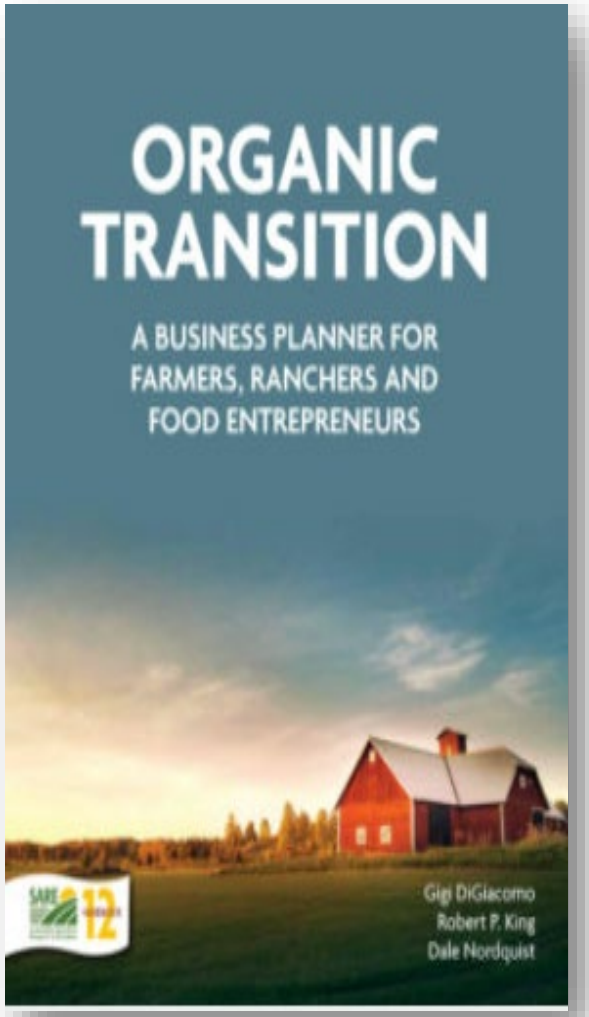
How is use of the USDA Organic seal protected?

People who sell or label a product "organic" when they know it does not meet USDA standards can be assessed a financial penalty with fines of several thousands of dollars for each violation (see 7 CFR 3.91(i)(b)(xxxvi)).

Challenges

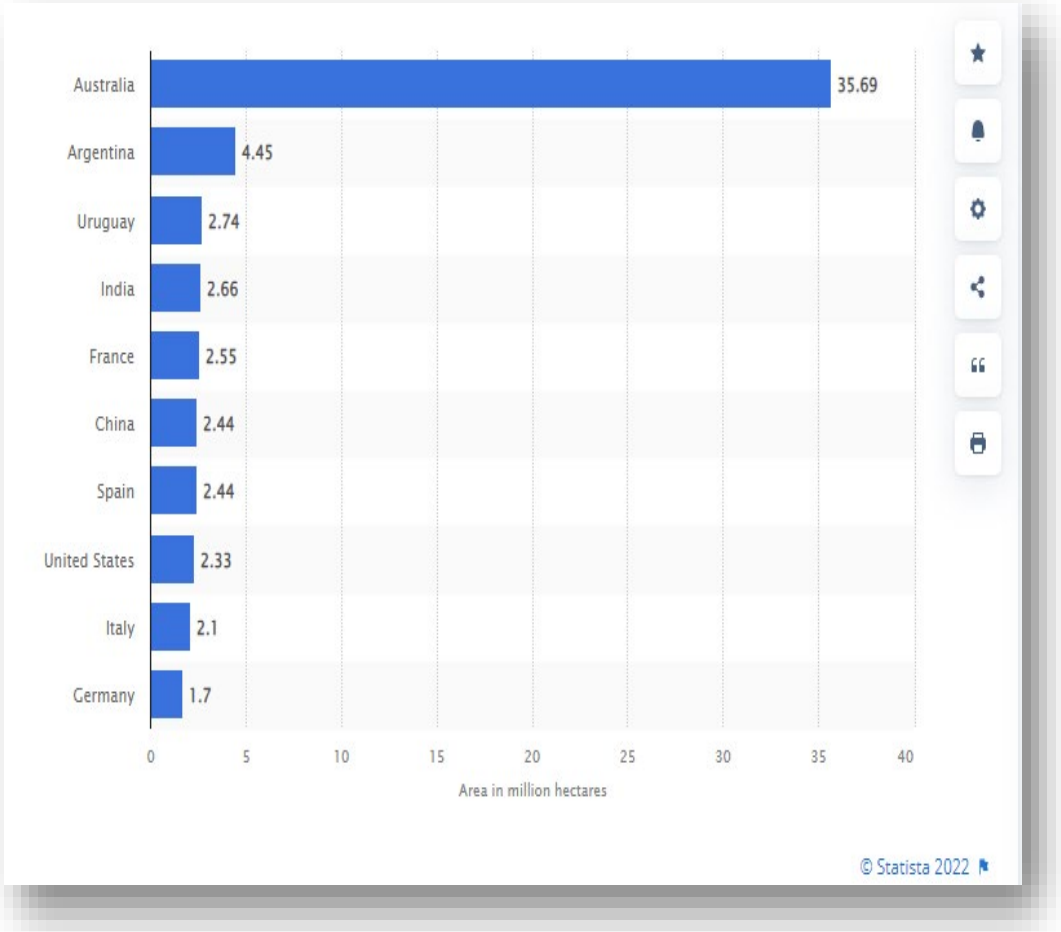
Challenges: production related

- Low yield
- Labor intensive
- Climate, soil, pests
- Pests: fewer and more expensive pest control options
  - OMRI list
- Racial equity: BIPOC producers experiencing more many production challenges
- **Organically grown but not certified?**

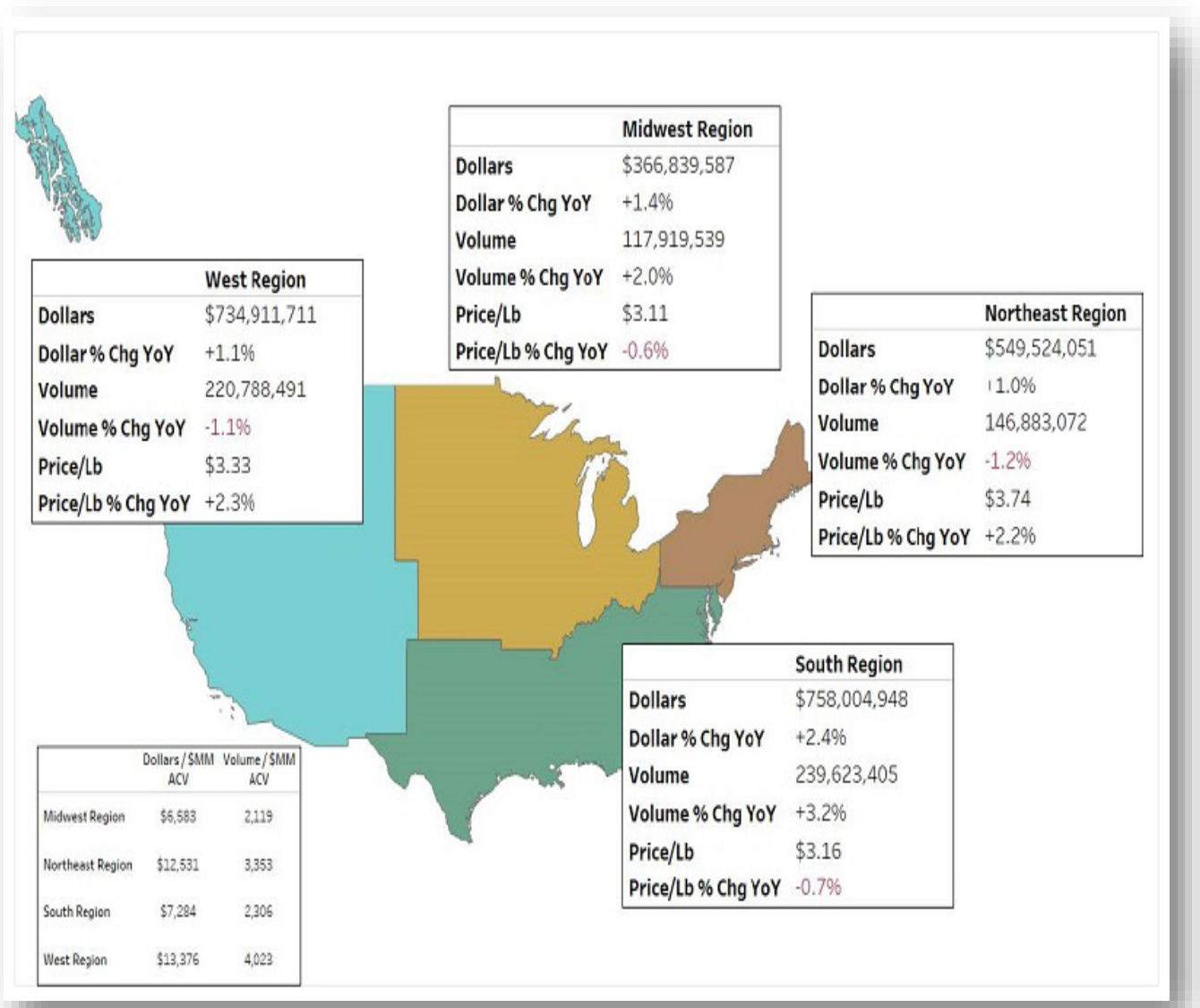


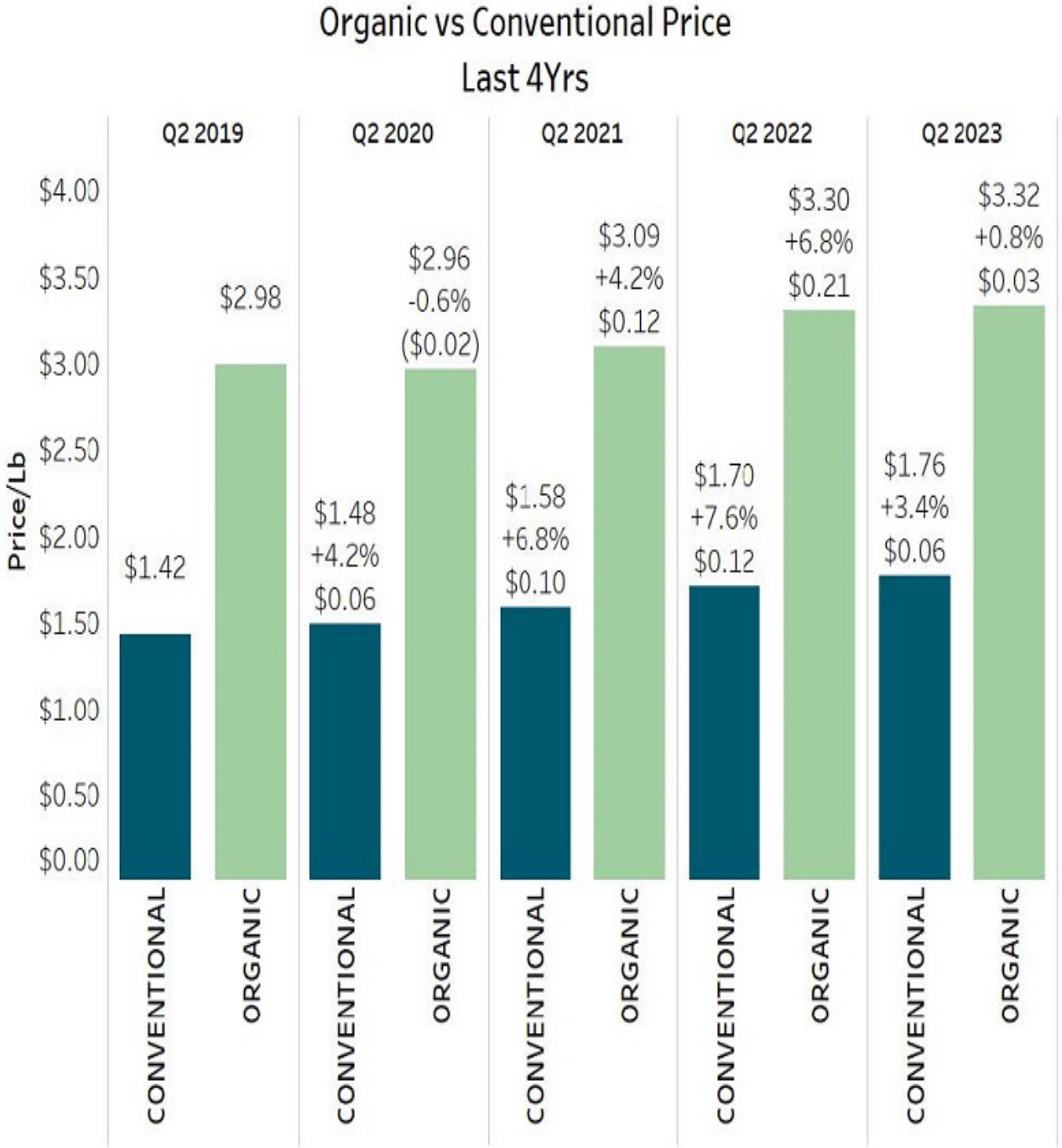
Challenges: non-production

- Regulations
  - Policy change
  - Process: paperwork
- Certification
  - Cost: hundreds to several thousands
    - exempt <$5k
  - Annual renewal
- Markets
  - Direct sales vs box stores
  - Shrinking price premium
  - International competitors



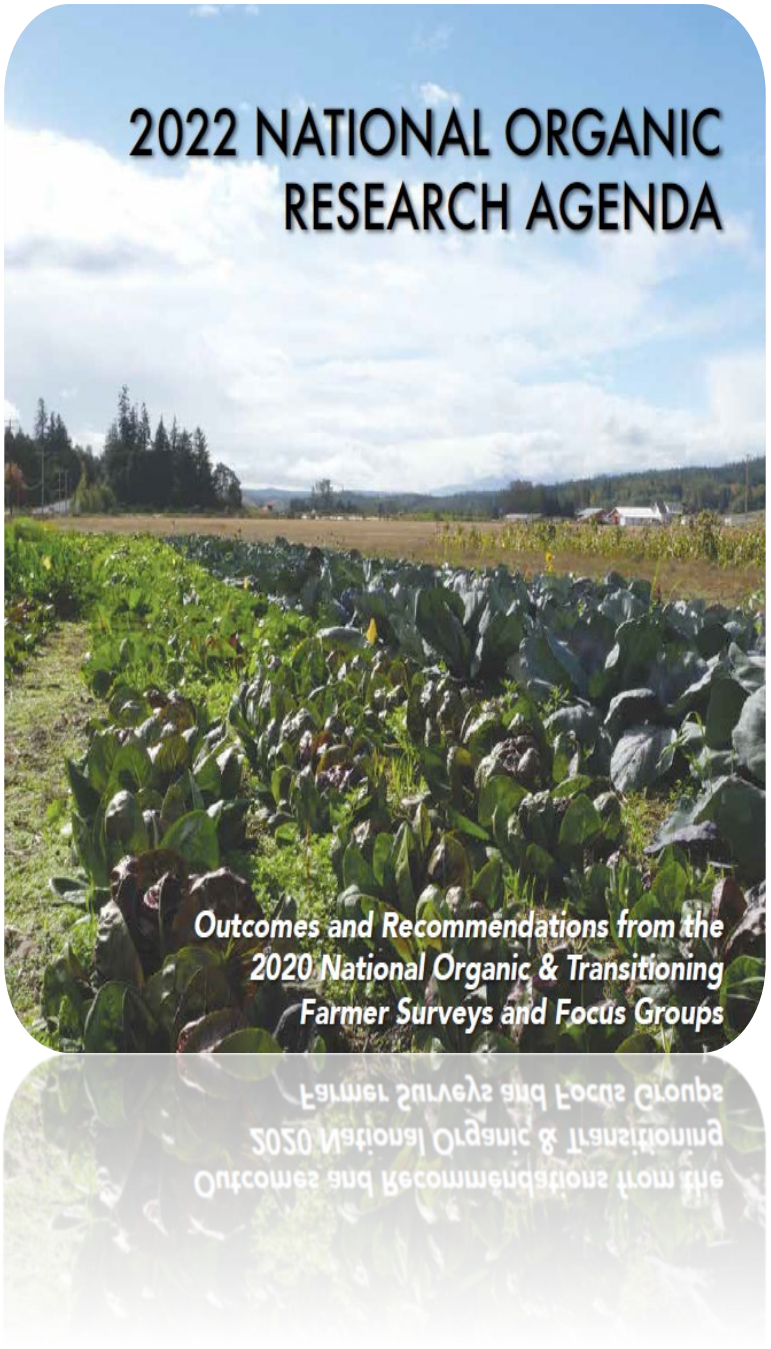
The price gap between organic and conventional foods is shrinking…





As conventional produce outperformed organic produce in dollar growth, it appears price increases on conventional produce are being more easily absorbed by consumers than the higher prices in organics.

- OPN Organic Produce Network



The 2022 National Organic Research Agenda

Research Priorities

- Organic Weed Management
- Manage Production Costs and Maintain Adequate Yields in Organic Systems
- Soil Health, Organic Matter, and Soil Life
- Organic Insect Pest and Disease Control
- Organic Seeds and Crop Cultivars
- Organic Livestock Production
- Cover Crops, Rotations, Intercropping, Organic Amendments, and Water Resources
- Adaptation to Climate Change



Outreach Strategies: Translating Research into Practice

- Emphasize Farmer-to-farmer Learning in Organic Education and Technical Assistance
- Build Capacity of Extension, NRCS, and other Agricultural Professionals to Serve the Organic Farming Sector
- Provide Training and Technical Assistance for Transitioning and Beginning Organic Producers
- Increased Investment in Nonprofit Agricultural Organizations
- Disseminate Research Outcomes, Educational Materials, and Practical Information and Tools via Multiple Venues and Formats
- Develop a Centralized Location for Organic Information Resources and Coordinate Rollout and Announcement of New Resources
- Deliver Information, Training, and Technical Assistance on Priority Topics



Others selected

- Building Racial Equity and Supporting BIPOC Producers in the Organic Sector
- Organic Markets, USDA Certification, and Organic Integrity
  - » Research and Technical Assistance to Support Organic Integrity and Market Access
  - » Strengthen Federal Policies to Protect Organic Integrity and Organic Farmer Livelihoods
  - » Reform Recordkeeping for USDA Certified Organic Operations



Organic in urban settings -- discussion



Photo from the Organic Agenda

- Organic and sustainability

  Organic and food safety

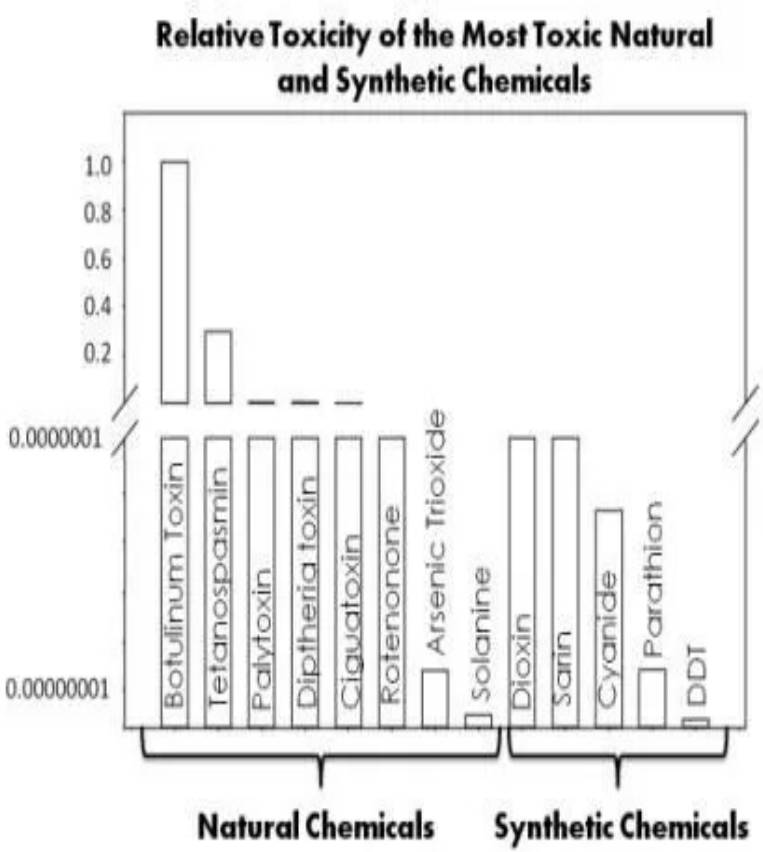
  Organic pesticides still are pesticides

Natural vs. Synthetic Chemicals Is a Gray Area

- https://blogs.scientificamerican.com/guest-blog/natural-vs-synthetic-chemicals-is-a-gray-matter/

- "man-made is bad and natural is good"!

- Natural pesticides allowed in organic farming are just as toxic as synthetic pesticides!



How to get certified

1. **Develop an organic plan:** tilling/growing/grazing, harvesting, storing and transporting
2. **Implement the organic system plan. Have it reviewed by a certifying agent.**
3. **Receive inspection.**
4. **Have a certifying agent review the inspection report.**
5. **Receive a decision from the certifier.**
   - The organic farm or facility continues to update its plan as it modifies its practices, and an inspection is done at least once a year to maintain certification.

https://www.usda.gov/media/blog/2012/10/10/organic-101-five-steps-organic-certification

The National List of Allowed and Prohibited Substances in Organic: https://www.ecfr.gov/current/title-7/subtitle-B/chapter-I/subchapter-M/part-205/subpart-G/subject-group-ECFR0ebc5d139b750cd

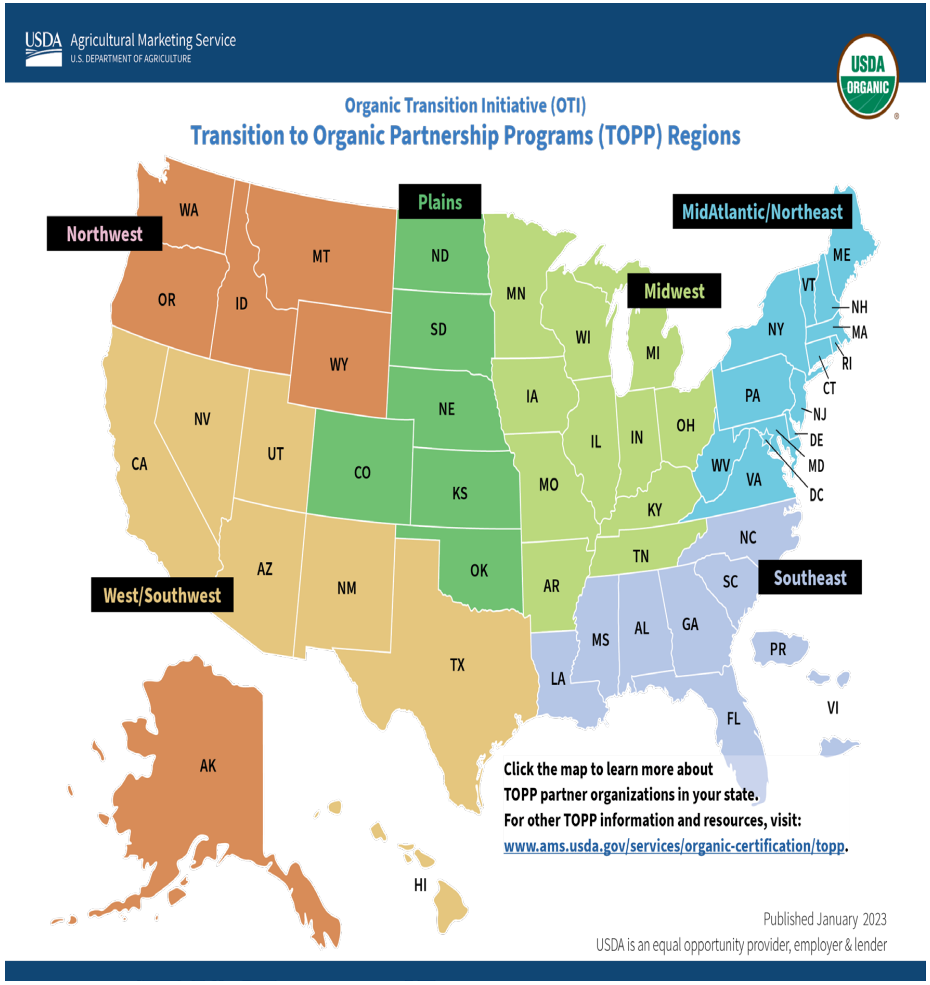
- The Organic Materials Review Institue (OMRI) list: omri.org



Organic Certifying Agents

Organic operations are certified by private, foreign or State entities that have been accredited by USDA.

- About 80 agenceys in the US
- Organic Certifier Locator: https://organic.ams.usda.gov/integrity/Certifiers/CertifiersLocationsSearchPage
  - » None in North Carolina
  - » One in Virginia
- How to get help?
  - » County Extension
  - » USDA Transition to Organic Partnership Programs (TOPP)
  - » NRCS: Organic Transition Initiative (OTI)
    - Offers help to make up the price difference
  - » Carolina Farm Stewardship Association annual Sustainable Ag. Conference offers organic training



https://www.ams.usda.gov/services/organic-certification/topp

Summary Description for Module 13

Title:	Module 13: Hydroponic & Aquaponic Production Systems
Instructor:	Joshua Dusci, Extension Associate – Indoor Agriculture
Prerequisites:	Familiarity with horticulture crop production
Class Time:	9:00AM – 11:30AM
Learning Objective:	Participants in this module will learn the basic principles of greenhouse operation and management including propagation, environmental control, irrigation, economically important crops, and pest control. Participants will learn about the selection, construction, use and management of season extension technologies such as high tunnels, low tunnels and row covers. Alternative production systems i.e. hydroponics and aquaponics will be studied. Emphasis in all subject areas will be placed on practical application of several management procedures.
Instructor Media Needs:	Screen Projector Screen to Project upon Computer
Class Materials and/or Supplies Needed:	Instructor will provide various handouts.
Class Activities:	1. Lecture on subject matter 2. Tour and hands-on demonstration of subject matter
Knowledge Gained:	Students will gain knowledge in how to manage a greenhouse or high tunnel.
Skills Gained:	Students will understand how to use logic and critical thinking to evaluate plant growth and development as related to greenhouse and alternative production system conditions.
Abilities Gained:	Students will develop a systematic thinking process to identify problems in the greenhouse/high tunnel environment.
Exam Description:	Question based examination of subject matter including multiple choice and essays.

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Greenhouse Production and Management, Season Extension, Alternative Cropping Systems

Christopher Mullins
Assistant Professor and Extension Specialist for Greenhouse and Specialty Crops
Virginia State University; (804) 524-5834; cmullins@vsu.edu

9.1 Introduction

In the U.S., the greenhouse vegetable industry is a mixture of small, family run operations and a small number of large, multi-acre facilities. Most family operations range in size from 2,500 to 10,000 square feet in size and the larger operations are generally greater than 5 acres. Greenhouse vegetable production has, in the past, been located near large metropolitan areas for easy transportation. However, the trend for the last decade for the larger operations has been to site greenhouses in the southwest portion of the U.S. This is in part due to more favorable environmental conditions, improved transportation technology, and inexpensive land prices. In Virginia, the majority of vegetable greenhouses are family operations with one or two greenhouses with the largest operation being less than 3 acres in size.



In the U.S. and Virginia, tomatoes are the leading vegetable crop grown in greenhouses, followed by European cucumbers, lettuce, peppers, and herbs. The greenhouse tomato industry has increased so rapidly in the last few years that it now represents an estimated 17% of fresh tomato supply. These tomatoes now have a year-round presence in grocery stores. This is certainly different from the 1970's and 1980's when greenhouse tomatoes were seasonally located in the produce section of the grocery store and were a very small segment of the fresh tomato supply. This trend for greenhouse tomatoes has been fueled by an increase in the per capita consumption of fresh tomatoes and improvements in all phases of greenhouse tomato production.



This section will discuss the main greenhouse vegetable crops and their

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production, as well as structures and the unique considerations for growing select vegetables in protected culture.

9.2 Types of Structures

Greenhouses can vary in size, construction materials, environmental control systems and cost. Most urban settings will utilize a single or multiple small greenhouses to accomplish the production goals. Single quonset style would be utilized over gutterconnected structures. Greenhouse glazing is most commonly polyethylene sheeting, polycarbonate panels, glass and acrylic panels. However, in most small operations two layers of polyethylene film is most commonly used.

Vegetables can be grown in heated and unheated greenhouses, however traditionally most production has been in structures with active heating and cooling systems. In the last few years, many growers have started using unheated greenhouses or high tunnels to extend the growing season for vegetables.

9.3 High Tunnels

High tunnels are simple greenhouse structures often costing two to three times



less than conventional greenhouses. These structures allow growers to extend the growing season in the spring and fall. Year round production is not the goal with these houses; rather the growers are trying to get ahead of their competition by being first in the spring or last in the fall with their product. High tunnels protect crops from adverse weather conditions, such as light frost, hail, rain, and high wind. Usually growers see 5-8° F protection from outside temperature. Generally higher yields and improved quality, over field production, have been reported.

9.4 Management

High tunnels have passive heating and cooling systems. Heating relies on warming from the sunlight during daytime to carry over through the night, in order to keep temperatures from dropping below freezing.



Cooling is accomplished by means of side curtain venting. Curtains can either be rollup, which ventilate from the low on the side curtain as it is



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rolled up, or drop-down, which ventilate from the top of the side curtain as it is dropped down. Crops are usually grown in the ground, like field production, and not in containers or artificial media.

Most often a more conventional greenhouse is used for producing vegetables. The structures have active heating and cooling systems and can be used for year-round production. More expensive than high tunnels, conventional greenhouses have fewer limitations with respect to production. There is greater ability by the grower to effect a change to environmental conditions. These greenhouses can be single quonset/gothic style or can be gutter connected. Plants are usually grown in containers with soilless media or in nutrient solution.



9.5 Alternative Cropping Systems

This section will cover hydroponic tomato and lettuce/herbs. These are two of the most important greenhouse vegetable crops, however are in no way the only crops grown in greenhouses. The section will also discuss small-scale aquaponic production. High tunnel production of these crops is usually done in ground and not in containers or artificial media and lies somewhere between field production and greenhouse production.

9.5.1 Hydroponic Tomato Production

Tomatoes are a very important crop for production in greenhouses. The plant is relatively easy to grow and demand by consumers is high. Generally when growers start growing crops in a greenhouse, tomatoes are the first ones they try. Market value of tomatoes can be high; however growers soon find out that production costs are also high. Management and labor intensity is very high also, as one 30' x 96' tomato greenhouse can need as much as 30 to 50 labor hours per week.



Most smaller growers produce tomatoes in a bag culture system. In this system, five gallon plastic bags are filled with peat or bark based soilless media for planting of the young plants. Spray stakes or drip irrigation emitters are used to water the bags throughout the growing season. Many growers use automated irrigation timers to adjust the frequency and duration of irrigation. New



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transplants need only 2-4 ounces of water each day; however, at maturity the plants can require 2-3 quarts per day.

Most growers in Virginia grow a single crop of tomatoes per year. This involves starting seed in the first two weeks in August. Transplanting into the production house would begin in mid-September and harvesting would start in December and continue until July.



Greenhouse tomatoes need four to five square feet per plant or approximately 10,000 plants per acre. For example, at 30' x 96' greenhouse will hold 576 to 720 plants. However, if you use any floor space for storage, packing, or grading that area would need to be taken into consideration. Plants can be arranged in rows four feet apart with in-row spacing of 18" to 24".

Variety selection is important as there are many types and varieties available. Serious growers use hybrid seed specifically bred for greenhouse production. Currently, *Trust*, *Blitz*, and *Cobra* are beefsteak varieties most worth considering for commercial production. Cluster types and grape types are becoming more popular in the U.S. and in Europe however are still minor compared to beefsteak varieties grown. Greenhouse tomato seeds generally cost 3 to 4 times more than field types. Following are several companies that sell tomato varieties and other seeds specifically for greenhouse production:



www.johnnyseeds.com

www.paramount-seeds.com

www.cropking.com

www.hydro-gardens.com

High quality transplants are important for your tomato crop. This is generally done in a separate transplant house then moved into the production house. Most growers will make their own transplants using a peat based germination media in flats to be pricked out later or directly into two inch net pots. With temperatures at 75-80° F seedlings will emerge in 7 to 10 days. After 3-4 weeks the six inch transplants are ready to go into the grow bags.

Fertilization for the crop is provided through the drip irrigation system. Water soluble fertilizer is either mixed



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in a bulk tank then used directly on the crop or is mixed in high concentration to be pushed through a fertilizer injector to the crop. Either method is usually provided to the crop in a drain to waste manner. In this system any leachate is not collected but drains directly into the ground. In areas of high humidity or poor drainage the leachate can be collected and removed from the greenhouse.

Growers use a complete fertilizer such as 511-26 along with calcium nitrate, potassium nitrate, and magnesium sulfate to provide nutrition to the plants. Concentrations of nutrients supplied by the Modified Steiner Solution (one of the most common formulas) are as follows:

ppm	Element
171	N (nitrogen)
48	P (phosphorus)
304	K (potassium)
180	Ca (calcium)
48	Mg (magnesium)
3	Fe (iron)
2	Mn (manganese)
1	B (boron)
0.4	Zn (zinc)
0.2	Cu (copper)
0.1	Mo (molybdenum)

This could be achieved by dissolving the following in 100 gallons of water:

5-11-26	12.8
Magnesium Sulfate	3.2
Calcium Nitrate	8.6
Potassium Nitrate	1.4

This formulation would be provided to the plants at 50% concentration from transplant to the fourth cluster then at 90% from the fourth cluster on. During warm, sunny conditions in late spring 100% solution would be used. Please refer to the Reference/Resource section for more detailed information of fertilization.

Greenhouse tomatoes are trained to one main stem. This is accomplished by taking off all side shoots (suckers). To do this, wait until the shoot is 2-3 inches long. Then



break off the shoot by bending from side to side. It is best not to use knives or scissors to cut the shoots. The stem is clipped to a trellis string that is attached. These clips are attached around the stem and to the string every 10-12 inches.



Pollination is provided by hand pollination using a hand

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pollinator or by using bumble bee hives. These hives can provide the most efficient means of pollination. A hive costs approximately $100 for a 30' x 96' tomato house and last for 5-6 weeks. If pollinating by using a hand pollinator, this task should be done 3-4 times per week between 11 am and 1pm each day. This is usually the time of lowest humidity when the pollen will move the best.

Tomatoes do best with night temperatures no lower than 62°F and day temperatures between 70-82°F. Optimum relative humidity would be 60-70 percent; however that can be difficult to obtain.

Insect pests most common to greenhouse tomato production are whitefly, aphid, thrips, and spider mite. Many growers are adopting an integrated pest management approach to production. In this system, the grower uses various methods to manage pest problems. By integrating cultural, physical, biological, and chemical pest control the grower can manage pest problems in an economically and ecologically sound way. Powdery mildew and grey mold are the most common fungal problems associated with greenhouse tomatoes. For a detailed list of insecticides, fungicides, and beneficial insects, please see the Reference/Resource section of this chapter.



9.5.2 Hydroponic Lettuce/Greens Production

Lettuce and greens are grouped together here, as their production systems are the same. Both are very easy to grow in a greenhouse environment. Both require labor input at planting and harvest, but little maintenance in between. Direct cost of production can be low relative to tomatoes. However the demand for lettuce and greens are not as high as tomatoes. Also lettuce and greens are perishable and require refrigeration on site and for transportation. For some growers the high profit potential makes lettuce and greens an attractive crop. Although greenhouse production of lettuce is small in comparison to field grown, it has a specific market niche as a gourmet, high quality item.





Variety selection is important with lettuce

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It is also known buttercrunch. Bibb varieties such as *Rex*,



standards. *Rex* is one variety that resists bolting in as European *Ostinata*, and *Vegas* are industry

high temperature conditions. Other types such as Romaine, Lolla Rosa, and Oakleaf are also grown. The seed companies listed in the previous section have many lettuce varieties and types for most growing conditions. Commons greens grown in greenhouses are arugula, pac choi, mache, and cress. Culinary herbs such as basil also can be produced in the same systems.

The plants are started in cubes that are 1" x 1" x1.5". These cubes come precut in a sheet that fits in a common 10" x 20" flat and adds no nutrition to the plant. The only purpose for the cube is as a substrate for root growth. Oasis and Rockwool are the two different brands that can be purchased for this operation.



Most lettuce and greens seeds are very small; so many growers opt to use pelleted seed. This is seed that is covered with a layer of clay and makes it slightly larger for easier planting. Lettuce seed do not require light for germination and will germinate in 5-6 days if kept approximately 70° F. Seedlings are ready for transplanting in approximately 14-18 days, when they reach the 3-4 leaf stage.

Lettuce and greens are transplanted into a hydroponic system, where they are grown to market size. The plant roots are bathed in a nutrient solution with no soil. Lettuce seedlings are spaced at approximately 1.5-2 plants per square foot. Two main systems are used to grow lettuce, greens, and herbs in a greenhouse.

- NFT
- Raft/Floatbed

NFT or nutrient film technique is the most common system used by growers to produce lettuce/greens. In this system,

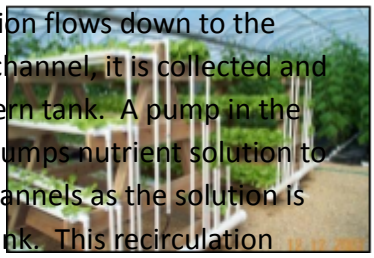
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specially made growing channels are used to contain the plants and provide flowing nutrient solution at the root zone.



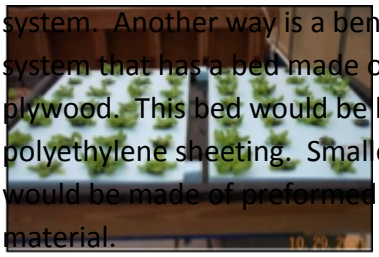
Two inch diameter PVC pipe can also be used and can be an affordable alternative to manufactured channels. These channels are supported by a bench or table system which can be flat or in an A-frame. Inlet lines at the high end of the system deliver nutrient solution into the channel. After the nutrient solution flows down to the other end of the channel, it is collected and returned to a cistern tank. A pump in the tank continually pumps nutrient solution to the inlet of the channels as the solution is returned to the tank. This recirculation system moves nutrient solution through the channels 24 hours each day. Floatbed or raft culture is a system that





uses beds containing nutrient solution. On these beds are floated a raft containing the crop being grown. The raft or board floats on the nutrient solution while holding the plants on its surface. The roots of the plants hang into the nutrient solution.

Growers use different types of beds for this production system. On ground beds made of concrete or lumber with plastic lining is common is this production system. Another way is a bench high system that has a bed made of lumber and plywood. This bed would be lined with polyethylene sheeting. Smaller systems would be made of preformed plastic material.



Growth parameters for the floatbed system are the same as the NFT system. In both, daytime temperature should be maintained between 68 and 78° F. Electrical conductivity should be maintained between 1.8 and 2.3 mmhos/cm and the optimum pH range should be 5.5-6. Complete fertilizers such as 5-1-26 and 8-15-36 should be used along with calcium nitrate and magnesium sulfate.

9.5.3 Small-Scale Aquaponics

Aquaponics is most often thought of as the integration of a hydroponics plant production system with a recirculating aquaculture



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system. A hydroponic system (closed or open) involves growing plants without soil i.e. in only nutrient solution or in some type of artificial media. A recirculating aquaculture system (RAS) most often is the production of fish in a closed system where the operation water is cleaned through a filter system. Independently, hydroponic systems and RAS have been shown to be productive and commercially viable. However, there have been concerns surrounding the sustainability of modern aquaculture. To that end, growers and consumers have been looking for a potentially more sustainable system in aquaponics.

Aquaponic systems were first described in the 1970's and have existed both through grower's trials and institutional research. In that work, much information has been produced about aquaponics and there are many examples of systems, both small and large. However in this publication we want to give an overview of principles and considerations when endeavoring to build and use a smallscale aquaponics system. For a more detailed account of certain aspects of this paper, please see the reference section.



A small-scale system could be thought of as a "home" or "hobby" size unit but could include scaled up versions where growers could be considered part-time commercial. Generally in these small-scale systems, fish tank volume is less than 500 gallons and could be thought of as family-scale.

Major components of the system would be:

- Fish tank
- Plant growth system (NFT, media bed, deep water culture
- Solids filter
- biofilter

In a simple aquaponics system, effluent from the fish tank is sent through filters (solids removal and biofiltration) then to the plant production unit before returning to the fish tank. In this system, solid fish wastes are removed and ammonia in the water is converted to nitrate by bacteria living in the system. The nitrate and other minerals then feed the plants. In this way; plants, fish and bacteria thrive in a balanced symbiotic relationship. Growers must realize that this system requires the management of all three organisms to be successful.



www.hydro-gardens.com

www.hydrofarm.com

www.generalhydroponics.com

www.koppert.com

www.biobest.com

References and Resources

This section should provide the reader with an overview of greenhouse production. The following are sources of additional, more specific information about the subject and vendors that deal with related products. Additionally, more in-depth discussion of the section will be provided during class lectures.

Southern Region Aquaculture Center Factsheet 5007
https://srac-aquaponics.tamu.edu/serveFactSheet/9

http://edis.ifas.ufl.edu/pdffiles/CV/CV24400.pdf www.msucares.com/pubs/publications/p1828.pdf

www.ag.arizona.edu/hydroponictomatoes/

www.cornellcea.com/handbook_home.htm

www.uky.edu/Ag/Horticulture/anderson/brassica.pdf

www.attra.ncat.org/publication.html

www.ers.usda.gov/publications/err2/

http://ohioline.osu.edu/b672/pdf/Green_Insect.pdf http://msucares.com/pubs/publications/p1861.pdf

www.paramount-seeds.com

www.cropking.com

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Questions

1) NFT is a:
   a) Fertilizer
   b) Herbicide
   c) Hydroponic production system
   d) Government agency
2) Side shoots should be taken off tomatoes by:
   a) Spraying with special chemical for that purpose
   b) Bending shoots side to side until they snap off
   c) Cutting with scissors
   d) Should be left on
3) Greenhouse tomatoes grow best with nighttime temperatures of: a) 32°F
   b) No lower than 62°F
   c) 85°F
   d) 45-55°F
4) In Virginia, most hydroponic vegetable production is carried out in: a) Shade houses
   b) Retail garden centers
   c) High tunnels
   d) Conventional greenhouses
5) *Trust* is a common greenhouse vegetable variety of: a) Raspberry
   b) Lettuce
   c) Cucumber
   d) Tomato
6) Hydroponics could be defined as:
   a) Growing plants without soil
   b) A method of greenhouse construction
   c) Virginia's largest greenhouse company
   d) A water filter
7) The leading vegetable crop grown in greenhouses is: a) Cucumber
   b) Lettuce
   c) Tomato
   d) Bittermelon
8) In Virginia, most greenhouse vegetable greenhouse operations are:
   a) Large, corporate facilities
   b) Family owned with greater than 15 acres in production
   c) Family owned with less than 3 acres
   in production
   d) State run facilities 9) Aquaponics is:
   a) Method of swimming
   b) Production system that symbiotically grows a plant and fish crop
   c) Production of sea anemone
   d) Seed propagation in water

Summary Description for Module 14

Title:	Module 14: Urban Aquaculture
Instructor:	Dr. Nicholas Ramano
Prerequisites:	Basic biology and chemistry
Class Time:	12:00PM – 3:00PM
Learning Objective:	After completing Module 10: Animal Husbandry II, the student learner will able to utilize best aquaculture practices, basic water management and water quality analysis techniques. In order to graduate from the certificate program, the student learner will submit via email file attachment, a proposed aquaculture operation to be incorporated into an urban farm environment.
Instructor Media Needs:	Video and ppt projector Screen Computer with internet access
Class Materials and/or Supplies Needed:	Instructor provided-water quality test kits and oxygen meters. Instructor provided fish population and culture units. Instructor provided fish population sampling nets
Class Activities:	1. Presentation of best aquaculture practices information needed for a urban aquafarming 2. Demonstration/participation in fish sampling 3. Demonstration/participation in water quality evaluation 4. Hands-on practical fish spawning activities 5. Discussion of proposed aquaculture urban farm plans 6. Q & A
Knowledge Gained:	Students will gain best aquaculture management knowledge as part of an urban
Skills Gained:	Students will gain skills in water quality analysis and sampling
Abilities Gained:	Students will be able to complete a personal aquaculture plan for an urban farm.
Exam Description:	Pre-Test Post-Test

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Biofloc technology in aquaculture: how to culture shrimp anywhere

Authored by Nicholas Romano, Associate Professor and Extension Specialist, College of Agriculture, Virginia State University

Introduction

Aquaculture systems can be broadly divided into two main types, open and closed. Open aquaculture is a system where new clean water is continuously being added, such as fish cages in the ocean. Therefore, in open aquaculture there is no need for filters to maintain good water quality. Closed aquaculture is a system where the water is not exchanged often and therefore some process is required to maintain water quality. In ponds, the natural algae and plants help remove excess nitrogen and phosphorus while in tanks, specialized filters are constantly used to clean the water. There are some drawbacks to closed aquaculture. First, not everyone has access to large ponds to farm fish or shrimp nor are they all designed for aquaculture. Second, closed aquaculture in tanks, such as recirculating aquaculture systems (RAS) require pumps, filters, and air blowers to maintain water quality which requires some initial investment to get started. There is a newer system called "biofloc technology" (BFT) that requires only a tank and aeration.

The development of BFT fist began in Brazil and Israel where researchers independently found that adding molasses to ponds encouraged natural blooms in various microorganisms that kept the water healthy. As they moved this protocol to tanks and added more molasses, they found that the water not only had a great deal of life (other than the farmed fish or shrimp) but the water quality was maintained without any need for filters. The water itself became the filter by simply adding molasses to create "bioflocs". This spurned a "blue revolution" throughout much of the world where some form of BFT has been adopted to farm shrimp in ponds or tanks.

In essence, BFT is simply adding an organic carbon source to water which leads to the creation of a natural aquatic ecosystem that would be found in estuaries where shrimp spend their early life. This is because the nutrients produced from the aquatic animal (fish or shrimp), such as ammonia (a type of nitrogen) that would otherwise accumulate to toxic levels, are transformed by bacteria into small nutritious particles (called 'bioflocs') that can be consumed by the fish or shrimp. Therefore, because the nutrients are recycled, there is little need to bring in new water ('zero-exchange system') and thus provides a great deal of flexibility in where these can be set up.

The most common application of BFT is to produce shrimp in areas that have no access to natural seawater. In fact, culturing shrimp that are away from natural waterways helps ensure outside diseases are not introduced, which greatly improves biosecurity. It then becomes possible to culture shrimp at the large scale or small scale (such as your backyard) using simple technology. While BFT can be used to produce shrimp faster than traditional methods (such as ponds or RAS), there are certain aspects that need to be understood first before starting. This fact sheet will provide information on the

mechanisms that create BFT, what the bioflocs are composed of, and how to create and maintain your own BFT system to produce shrimp in almost any area.

How BFT works

Bacteria exist in every natural waterway where some provide benefits to animals and plants (such as “probiotics”), others are harmful (such as “pathogens”) while the majority are benign (are neither probiotics or pathogens). The same is true in aquaculture systems. Therefore, instead of trying to eliminate all bacteria (which is not entirely feasible anyway), probiotic bacteria are encouraged to grow to help improve water quality along with the health of the farmed animal. With BFT, conditions are created to encourage probiotic to flourish and these bacteria create bioflocs.

In order to create bioflocs, there needs to be both nitrogen and organic carbon in the water, but the ratios of these need to favor carbon. Having an adequate supply of nitrogen is not normally a problem because when fish and shrimp eat, they will excrete nitrogen in the form of ammonia (and much lower amounts of urea). It is advisable for ammonia to be as low as possible (at least below 2 mg/L) to minimize the chances of toxicity to the aquatic animal. In most closed systems, ammonia is converted by nitrifying bacteria to nitrite and then to a less toxic form of nitrate. Nitrate can gradually increase but can be removed by algae and plants. If the uptake is insufficient, then it becomes necessary to exchange new water.

In a wellbalanced biofloc system, both ammonia and nitrite are removed before being converted into nitrate by a different type of bacteria, known as ‘heterotrophic bacteria’. In order for heterotrophic bacteria to flourish and dominate the system, the carbon to nitrogen (C/N) ratio needs to increase. The greater the C/N ratio the more dominant the heterotrophic bacteria becomes, but it is generally practiced at 15 to 20 (details on achieving this ratio are provided in “Calculating C/N ratios”). When heterotrophic bacteria grow, they will assimilate to otherwise toxic nitrogen (in the form of ammonia and nitrite) into building blocks for their growth. As the bacteria multiply in numbers, they secrete a mucus-like substance (known as ‘extracellular polymeric substances’) that consists of proteins, polysaccharides, humic acid and nucleic acids (Li et al. 2022), and this acts like a glue in the water. Thus, live, dead and inert particles in the water, such as microalgae, plankton, uneaten feed, etc., will all start sticking together to the point where they become large enough for the animal to consume (Fig. 1).



Figure 1. Types of microorganisms and debris that floc together to form “bioflocs”. (Nicholas Romano, Virginia Cooperative Extension).

The removal of ammonia from heterotrophic bacteria is much faster than in a biofilter. If ammonia is present, then several hours after adding carbon the water can start to change color from clear (Fig. 2a) to a milky white color (Fig. 2b).

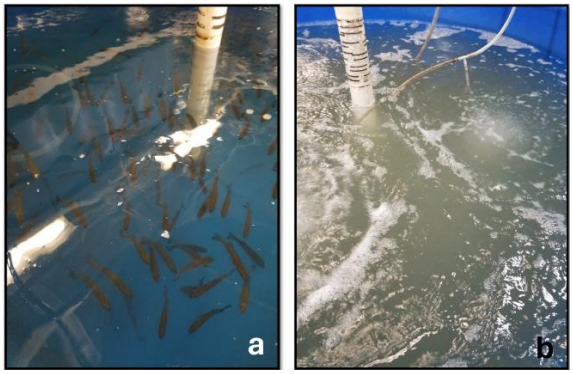


Figure 2. Before adding carbon in a traditional recirculating system that had an ammonia level of 4 mg/L (a) and 6 hours after adding carbon to the water changed color and the ammonia was at 0 mg/L (b) (Nicholas Romano, Virginia Cooperative Extension).

As the bioflocs begin to mature, they start to have a 'snow-like' appearance where the bacteria are just starting to stick particles in the water together (Fig. 3a). Further maturation is characterized by more of an orange-brownish color and the bioflocs become denser (Fig. 3b).

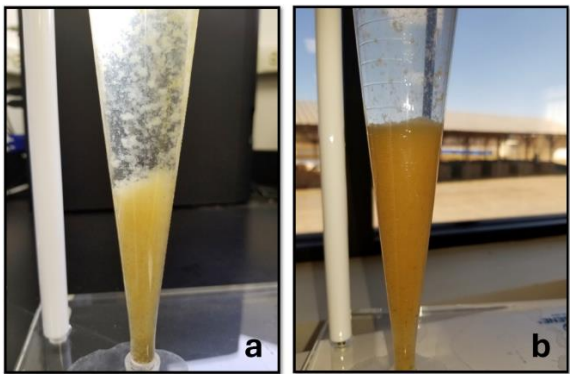


Figure 3: Young bioflocs in an Imhoff cone (a) versus two weeks later (b) when the bioflocs become denser and more nutritious (Nicholas Romano, Virginia Cooperative Extension).

Bioflocs generally form faster than the ability of the animals to eat, which causes the bioflocs to accumulate. The accumulation of bioflocs will then darken the water, and depending on how much microalgae is present, it will take on a brownish green or brownish color (Fig. 4). Using molasses as the carbon source will cause the water to be more brown for two reasons. First from the molasses itself which will shade out the microalgae. It can be alarming seeing the water appear 'dirty', but this is normal. A well-balanced biofloc system is actually an active and productive ecosystem that is comprised of various microorganisms that clean the water and provide a constant source of nutrition to the animal. In fact, BFT can improve the health of the animal as well as competitively exclude and/or suppress various pathogenic bacteria.



Figure 4. Example of what the culture water can look like in a well-established biofloc system (Nicholas Romano, Virginia Cooperative Extension).

Calculating C/N ratios

The desired C/N ratio depends on the protein content of the food and how much food was added from the previous day. The protein content of fish/shrimp feeds is required to be clearly labelled (often on an attached tag) and is usually in a range of 25-45%. Adding the appropriate amount of sugar to achieve the desired C/N ratio is based on three assumptions.

1) a portion of the nitrogen is bound in protein (at 16%) (see in equation #2)
2) this nitrogen is not fully utilized by the animal and is excreted into the water (at 75%) (seen in equation #3). The majority of nitrogen is excreted into the water as toxic ammonia and can quickly reach toxic levels.
3) The organic source of carbon (sugar, rice bran, etc.) consists of approximately 40% actual carbon (the remainder is mostly hydrogen and oxygen)

Below are the four equations necessary to calculate how much sugar to add, which can be easily uploaded into a spreadsheet to quickly provide the answer.

$$\#1)\ \boldsymbol{Amount\ of\ protein\ added\ =\ amount\ of\ food\ added\ \times\ \frac{protein\ content\ in\ food\ (\%)}{100}}$$

$$\#2)\ \boldsymbol{Actual\ nitrogen\ =\ (amount\ of\ protein\ added\ \times 0.16)}$$

*note that 0.16 is multiplied because 16% of protein is nitrogen

$$\#3)\ \boldsymbol{Nitrogen\ in\ water\ (excreted)\ =\ (actual\ nitrogen\ \times 0.75)}$$

*note that 0.75 is multiplied based on the assumption that 75% of nitrogen consumed by the shrimp or fish is eventually excreted to the water

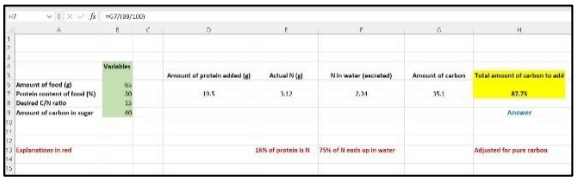
$$\#4)\ \boldsymbol{Amount\ of\ carbon\ to\ add\ =\ (nitrogen\ in\ water\ \times desired\ carbon\ to\ nitrogen\ ratio)}$$

*note that the carbon to nitrogen ratio is often chosen between 10 – 20

$$\#5)\ \boldsymbol{Amount\ of\ sugar\ to\ add\ =\ \frac{Amount\ of\ carbon\ to\ add}{0.4}}$$

*note that 0.4 is divided because 40% of carbon is in sugar

These calculations can be put into a spreadsheet, so each day the amount of feeds provided can be entered to provide the answer for amount of carbon to add (Fig. 5).



	A	B	C	D	F	F	G	H
1								
2								
3								
4		Variables		Amount of protein added (g)	Actual N (g)	N in water (excreted)	Amount of carbon	Total amount of carbon to add
5	Amount of food (g)	60						
6	Protein content of food (%)	30		19.5	3.12	2.34	35.1	87.75
7	Desired C/N ratio	15						
8	Amount of carbon in sugar	40						Answer
9								
10								
11								
12	Explanations in red				16% of protein is N	75% of N ends up in water		Adjusted for pure carbon
13								
14								

Figure 5. Biofloc calculations added into a spreadsheet.

It is important to point out that these calculations are just a guide, and the ammonia and nitrite should be weekly measured (ideally, 30 min. – 1 hr. after sugar is added). If there is no ammonia or nitrite then can keep following the calculations. However, if ammonia or nitrite become elevated (Fig. 6) then either more sugar is should be added (or exchanged in extreme cases). The amount of ammonia is hen based on the volume of the culture water and amount of ammonia + nitrite measured. For example, if the culture water is 1,000 L and ammonia is 5 mg/L (which is high and action is required), this means there is 5 grams of ammonia that need to removed. So, if a C/N ratio is 20 is desired 5 is multiplied by 20 to yield 160. Since 40% of sugar is carbon (as mentioned previously) then would divide 160/0.4 to yield 400 grams of sugar to add.

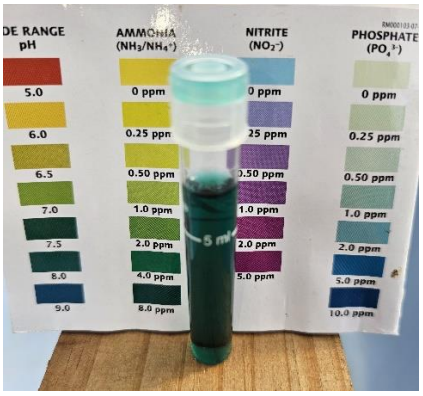


Figure 6: Ammonia being tested by adding drops and comparing the resulting color with a color chart to quickly assess water quality (Nicholas Romano, Virginia Cooperative Extension).

Type of organic carbon to use

There are various types of organic carbon that can produce bioflocs and some of these include molasses, table sugar, glycerol, and rice bran. Often the choice depends on the availability/cost of these and each have their own benefits and drawbacks. For example, like other sugars, molasses is highly soluble but also helps darken the water, which will reduce the chances that microalgae take over the system. In contrast, rice bran is less soluble because it is fibrous (like what is found in wood) and thus it takes time for the rice bran to degrade and become available to the bacteria. A benefit of rice bran is that it does contain more minerals, vitamins and other bioactive compounds that can help support microorganisms, like zooplankton. Some farmers have found good results with fermenting rice bran with probiotics to degrade the more indigestible fibers to increase water solubility (Romano et al. 2018).

It is important to note that molasses can be sulfured or natural, which will influence biofloc production. Sulfured molasses is produced from immature sugar cane and sulfur dioxide fumes are used to help ripen but also extend the shelf-life where it acts as a preservative. However, the sulfur will kill the bacteria (or at least stop their growth) and thus bioflocs production is insufficient.

Nutritional value of bioflocs

Bioflocs are not the primary source of nutrition and are also not a 'complete diet' for either fish or shrimp. Instead, bioflocs are considered as a constantly available supplemental food source that can contain various beneficial nutrients such as vitamin C, minerals, long chain polyunstaturated fatty acids as well as various bioactive compounds produced by probiotics. Additionally, bioflocs also contain macronutrients that include protein, lipids and carbohydrates. The type of organic carbon provided can influence the type of microorganisms and thus the proximate composition. For example, bioflocs produced from starch had high lipid content (Table 1), which is believed to be from more microalgae (Wei et al. 2016).

Table 1. Proximate composition (%) of bioflocs produced from different carbon sources added.

Proximate	Glucose	Starch	Glycerol
Crude protein	41.2	31.5	35.5
Crude lipid	6.1	8.5	4.2
Carbohydrate	37.7	47.6	45.1
Ash	15.0	12.4	15.2
Energy	18.2	18.7	17.5

Data compiled from Wei et al. (2016)

Moreover, the biofloc composition also depends on light intensity/duration, salinity/temperature of the water, age/size of the biofloc, type of shrimp feed and even the type of animal being cultured. Therefore, because bioflocs are active and dynamic, the nutritional composition can fluctuate over time.

Aeration

Biofloc systems are microbially based and the amount of oxygen must not only support the requirements of the cultured animal but also the bacteria and other microorganisms. The overall demand from organisms other than the cultured animal is called the 'biological oxygen demand', which is substantially higher compared to clear water systems. Therefore, the provision of adequate aeration cannot be overemphasized, and they have two main functions,

1) Mixing: bringing oxygen poor water to the surface as well as ensuring all the water is continuously moving to prevent bioflocs from settling and decomposing. Decomposition of bioflocs (or any organic) requires oxygen by the bacteria, which strips oxygen out of the water.
2) Diffusion of oxygen: the gas bubbles produced by aerators will cause oxygen in the bubbles to naturally diffuse out into the water

In biofloc tanks, aeration is often supplied with airstones (such as those often seen in pet store aquaria) as well as with soaker hoses (aerotubes) or with venturi. The measurement of oxygen in water is termed, 'dissolved oxygen' (DO) and should be above 5 mg/L. The DO can quickly decrease right after sugar is added and so the DO should be measured before adding sugar or 1 hour afterwards. If the DO falls below 5 mg/L

then it may be necessary to either add more aeration, reduce the stocking density of shrimp, or conduct solids management (discussed later).

Regardless of the aeration type, this needs to be equally distributed to keep the bioflocs suspended in the water and adequate mixing (Fig. 7). Otherwise, if the bioflocs settle on the bottom for extended periods then they can decompose, which will strip oxygen out of the water and produce toxic gases, such as hydrogen sulfide that characteristically has a rotten egg smell. On the other hand, aeration cannot be too intense because this can disrupt the swimming and feeding activities of the animals and even the formation of bioflocs. A general rule is that there should be around 4 times more aeration to create a healthy biofloc-based system compared to an equivalent clearwater system.



Figure 7. Example of aeration provided in a biofloc-based system in which air tubes ring around the tank to provide equal mixing to the entire tank.

Light

Biofloc can be done indoors or outdoors and with or without coverings or shade cloth. The duration and intensity of light will greatly influence the amount of microalgae in the water, which relies on light for their photosynthesis. Studies have shown that natural lighting conditions leads to the best water quality and shrimp/prawn performance compared to constant light or constant dark (Baloi et al. 2013; Tao et al. 2021). This is likely due to the benefits of having some microalgae present in the water that includes removing toxic nitrogen (ammonia, nitrite and nitrate) produced from the animal as well as the microalgae acting as a nutritional source for zooplankton (rotifers, copepods, nematodes, etc.) and becoming part of the biofloc itself. Many microalgae types can be high in protein, lipids and various bioactive compounds that benefit the animal.

Management of pH

Bacteria are always working in a biofloc-based environment in which ammonia is constantly being removed. Such action removes alkalinity, which is the capacity of the water to resist changes in pH. So water with low alkalinity (below 50 mg/L $CaCO_3$) can experience more rapid and wide pH changes, such as during the night when microalgae stop photosynthesizing, any disruptions to aeration (which would lead to CO_2 accumulation) or high microbial activity (such as right after carbon is added). Rapid changes in pH can quickly cause stress in aquatic animals and any stress makes them more vulnerable to disease.

The optimal alkalinity and pH for shrimp (and for most fish species) is 100 – 200 mg/L $CaCO_3$ and 7.3 – 7.8, respectively. Therefore, “buffers” need to be added to maintain these levels, which is often done using sodium carbonate (known as ‘baking soda’) or calcium carbonate. When calcium carbonate is added to water and dissociates, this will release bicarbonate (HCO_3^-) that can accept hydrogen ions (H^+) that cause acidity. Below is the formula for the dissociation of calcium carbonate.

$CaCO_3$ (calcium carbonate) + H_2O + CO_2 (carbon dioxide) → Ca^{2+} (calcium) + 2 HCO_3^- (bicarbonate)

The use of hydrated lime (mostly composed of calcium oxide) or potassium oxide can also accept hydrogen ions, but both are highly alkaline and caustic. Thus, there is a risk of the pH increasing too rapidly. A rapid increase in pH, even by 1 unit, can stress or even kill the bacteria and fish/shrimp. It is generally recommended that sodium carbonate is added at a fourth compared to the amount of food. For example, one kilogram of sodium carbonate should be added for every four kilograms of food added to the system.

Management of solids

Bioflocs will accumulate faster than the ability of the shrimp to consume them which will eventually get to a point where such accumulation begins to stress the shrimp. In essence, the bioflocs begin to disrupt the ability of the shrimp to breathe while the biological oxygen demand of the system becomes so high that aeration is not sufficient to keep the dissolved oxygen sufficiently elevated. This creates a dangerous combination that makes the shrimp more vulnerable to diseases and poor water quality. Once some shrimp die, this strips more oxygen out of the water and releases ammonia which can cascade into a total mortality.

It is generally advised that 'solids management' should be done when the total suspended solids approach 600 mg/L. There are three main ways to conduct solids management.

1) Periodic removal
2) Transfer to new tanks (batch culture)
3) Hybrid system with RAS (continuous removal)

Periodic removal

In this method, a submersible pump is added to the biofloc tank and then pumped to a conical tank (settling chamber) with a valve at the bottom. After filling, the bioflocs are allowed to settle (around 1 hour) and the valve at the bottom is opened to release concentrated bioflocs to come out. Once the concentrated bioflocs are flushed out, the valve is closed and the submersible pump is placed into the settling chamber where the clear water is pumped back to the biofloc tank (Fig. 8). This will help to minimize the amount of water loss from the system and should be done at least every 2 weeks to ensure bioflocs are at a safe level for the health of the shrimp. Important note: an aquarium pump should be used that is only powerful enough to pump water from the culture tank to the settlement tank. This is because if the pump is too powerful then this can damage the shrimp inside.

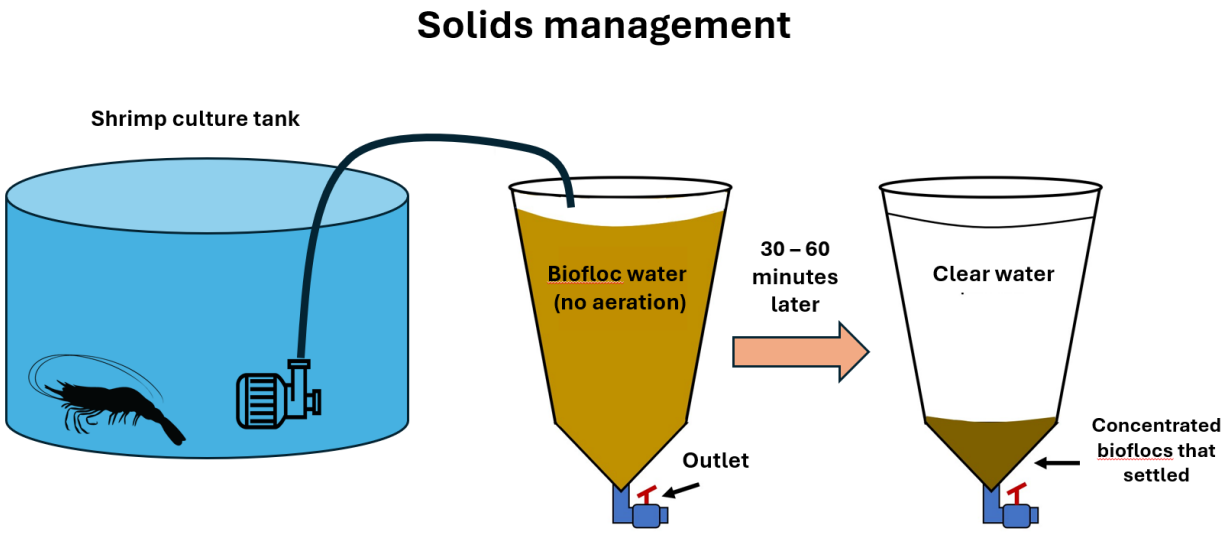


Figure 8. Solids management where a submersible pump is temporarily used to pump biofloc-rich water into a conical settling tank. After 30 – 60 minutes of allowing the bioflocs to settle, the outlet is opened to collect the concentrated bioflocs and then the clear water is pumped back (using the same submersible pump) to the culture tank (Nicholas Romano, Virginia Cooperative Extension).

Transfer to new tanks

On some farms, the shrimp are moved to new tanks every 2 months or so during which time the shrimp can be divided among 2 other tanks. Such a division reduces the stocking density, which can be an important strategy because the larger shrimp need more room and it also reduces cannibalism. When transferring to a new tank, some of the biofloc-rich water (around 10%) from the original tank can be added to the new tank to help kick start biofloc production. A final transfer is then repeated again after around 2 months until harvest (total of 6 months from start to finish). Therefore, each time the shrimp are transferred into their new tanks, this is solids management. However, it is still advisable to measure the total dissolved solids to ensure these remain below 600 mg/L. In fact, it is still common to periodically conduct solids management (as described above) to help ensure a healthy system for the shrimp.

While this system is effective, it does have some drawbacks. This includes the need to dispose of and create new saline water, which can be expensive. Additionally, there is a need for greater numbers of tanks to accommodate the transfers.

Hybrid system with RAS

The "hybrid system" is where biofloc is combined with a "recirculating aquaculture system" (RAS). This kind of a system is designed to continuously separate out the bioflocs slowly to obtain clear water. Then before the clear water is returned to the culture tank, it goes through a "biofilter", which is a common feature on a RAS. Before discussing how this system operates, it will be important to know how a biofilter works. A biofilter is any container that houses small beads that act as a living space for nitrifying bacteria. These

bacteria, which will naturally grow, convert ammonia into nitrite and then into nitrate. This is a process called "nitrification" and the formula is below,

$$2\ NH_4^+ \text{ (ammonia)} + 3\ O_2 \text{ (oxygen)} \rightarrow 2\ NO_2^- \text{ (nitrite)} + 2\ H_2O \text{ (water)} + 4\ H^+ \text{ (acidity)}$$

$$2\ NO_2^- \text{ (nitrite)} + O_2 \rightarrow 2\ NO_3^- \text{ (nitrate)}$$

Nitrate is the end product and is much less toxic than ammonia or nitrite. Thus, this biofilter acts as a back up to maintain water quality. For example, if there is a day when not enough carbon is added (or even at all), then the biofilter will help prevent any sudden increases in ammonia from occurring that would stress the shrimp.

The optimal flow rate to the settling chamber is 3 – 5 L/min. and thus a small aquaria pump can be used. The pump moves the water from the culture tank to a settling tanks. In order to help the bioflocs settle, an upwelling of water is created. This is where the water flows down a central pipe and the water exits from the bottom. During this time, the heavier bioflocs are settling to the bottom of the tank where they concentrate and can later be removed by opening the bottom valves. Meanwhile, the clear water rises to the top of the settling chamber and overflows to the biofilter. Water from the biofilter then overflows back to the culture tank.

Most suitable species for BFT

While BFT was first viewed as a water quality management strategy, it was found that some species are well suited for BFT whereas for others it causes stress. The suitability of BFT is largely based on the ability of the animal to collect and consume the bioflocs but also their tolerance to high amounts of suspended solids. In particular, several shrimp and prawn species are not only suitable for BFT but can actually grow faster than those in clearwater. This is generally attributed to the shrimp/prawns consuming bioflocs that have beneficial ingredients that might not otherwise be present in commercial diets.

Some fish are also suitable for BFT, and these include tilapia, catfish and bluegill. However, more carnivorous fish such as largemouth bass (Micropterus salmoides) (Romano et al. 2020) and tench (Tinica tinca) (Vinatea et al. 2018) these are not suitable. This is likely due to a combination of the fish being unable to consume the small particles as well as the accumulation of suspended solids causes stress, which in turn causes the fish to secrete extra mucus that clogs their gills and disrupts their ability to breath.

Drawbacks to BFT

One of the big drawbacks to BFT is that aeration is necessary and should be without any interruptions. If aeration is interrupted for longer than an hour, this can jeopardize the survival of all the shrimp in the tank. This is because without aeration, most of the bioflocs will settle to the bottom where they will begin to decompose. The bioflocs are then decomposed by bacteria, which will strip much of the oxygen out of the water. Therefore, it would be important to consider having a backup generator for aeration, especially for large systems to prevent the loss of an entire crop.

The other drawback is because the water visibility is greatly reduced, this makes it difficult to monitor the feeding activity and overall growth/health/survival of the shrimp. For example, it can be difficult to estimate how much food to provide or how often because it's

not possible to visually feed to apparent satiation. It is a general guideline that shrimp will eat 5% of their biomass each day and so knowing how many shrimp were initially stocked and taking a random sample of shrimp to weigh every 2 weeks will help you to make informed decision on how much food to provide each day.

Starting a biofloc-based system

Starting a biofloc system is a much lower investment than a traditional recirculating system and require some different items. Below is a checklist prior to stocking the system with shrimp. With regards to equipment, the first consideration is the type of culture system, whether this will be large/small, bought/fabricated or static/hybrid system.

Biofloc-based systems are well suited for tanks, and generally the larger the better. This is because larger systems are less prone to rapid changes in water quality (such as dissolved oxygen, ammonia and pH), which will give the farmer some extra time to make adjustments before the shrimp stresses or dies. Starting from 500 L upwards is generally recommended. Fiberglass tanks are durable, but they can quickly become expensive as the sizes increase. A cheaper alternative includes above ground swimming pools or even fabricating metal frames with plywood walls that are lined with pond liner. Another advantage is that there is more control over exactly how large the system can be to suit a given area.

While shrimp often swim around, they spend most of their time on the bottom. Therefore, to minimize potentially aggressive interactions with each other, culture systems that are wider than taller are recommended. Additionally, adding some shelters such as nets and PVC pipes (especially in the early stages) can be done to provide even more areas for the shrimp which can reduce aggressive interactions.

Table 2. Checklist of the required equipment and consumables necessary to start shrimp cultured in a biofloc-based system.

Equipment	**Purpose**
Tank or culture system	Area to culture shrimp in
Hides	Reduce cannibalism by increasing surface area for shrimp
Airblower	Source of aeration
Airstones and tubing	Delivery of aeration
Refractometer	To measure salinity
Digital probe	To measure pH, dissolved oxygen and total dissolved solids
Back up generator	Important to consider for large systems
Imhoff cone	To measure biofloc volume
Consumables	**Purpose**
Shrimp feed	Main source of nutrition for shrimp (needs to be designed for shrimp)
Salt	Must be marine salt, not table salt or Epsom salt
Organic carbon	Can be sugar, molasses, rice bran or glycerol as the most commonly used
Sodium bicarbonate	To ensure pH remains above 7
Test kit	To measure ammonia, nitrite and nitrate
Probiotics	*Optional*, some studies show a benefit and others not

Current trends and issues

According to 2023 surveys conducted by Dr. Andrew Ray from Kentucky State University on shrimp farmers in the United States, the most preferred method of culture was either BFT (52%) or BFT hybrid with RAS (26%), followed by clearwater RAS (7%) and flow-through (7%) and the last were ponds (4%). It is important to point out that among the 66 farmers contacted, only 36 actually responded, and thus the results may not be fully accurate. Additionally, it should be kept in mind that ponds are the preferred culture method in other countries including Ecuador, India, China, and throughout south east Asia.

The most commonly produced shrimp were white shrimp, *Litopenaeus vannamei* (83%) followed by freshwater prawns, *Macrobrachium rosenbergii* (7%) and black tiger shrimp, *Penaeus monodon* (3%). Although 40% stated they were "not at all profitable", 43% were "moderately or somewhat profitable". Therefore, even though the market price of marine shrimp is relatively high with an average of $14.01/pound. It is recommended that to stay profitable, the cost for production should be below $8.04/pound. Much of the sales were in various ways including on farm (64%) along with farmer's markets (55%), restaurants (59%), online sales (23%), supermarkets (23%) and food distribution services (23%).

Some of the research needs includes ways to reduce costs of feeds and operation. Additionally, many found that permitting requirements, shipping regulations and the need to simplify government regulations were obstacles to expansion. Additionally, there was some concern over cheaper imports, but this could be mitigated by promoting quality of "fresh never frozen" shrimp.

References

Baloi, M., Arantes, R. Schveitzer, R., Magnotti, C., Vinatea, L., 2013. Performance of Pacific white shrimp *Litopenaeus vannamei* raised in biofloc systems with varying levels of light exposure. Aquacultural Engineering 52, 39-44.

Li, Y., Luo, W., Liu, W., Yang, Y., Lei, Z., Tao, X., Wang, B., 2022. C058 and other functional microorganisms promote the synthesis of extracellular polymer substances in mycelium biofloc. Catalysts 12, 693.

Lim, Y.S., Ganesan, P., Varman, M., Hamad, F.A., Krishnasamy, S., 2021. Effects of microbubble aeration on water quality and growth performance of *Litopeneaus vannamei* in biofloc system. Aquacultural Engineering 93, 102159.

Romano, N., 2017. Aquamimicry: A revolutionary concept for shrimp farming. Global Aquaculture Advocate. February 10.

Romano, N., Dauda, A.B., Ikhsan, N., Karim, M., Kamarudin, M.S., 2018. Fermenting rice bran as a carbon source for biofloc technology improved the water quality, growth, feeding efficiencies, and biochemical composition of African catfish *Clarias gariepinus*. Aquaculture Research 49, 3691-3701.

Romano, N., Surratt, A., Renukdas, N., Monico, J., Egnew, N., Sinha, A.K., 2020. Assessing the feasibility of biofloc technology to largemouth bass *Micropterus salmoides* juveniles: Insights into their welfare and physiology. Aquaculture 520, 735008.

Tao, C.T., Khoa, T.N.D., Truyen, P.M., Hoa, N.V., An, C.M., Hai, T.N., 2021. Effect of light intensity on growth and survival rate of freshwater prawn (*Macrobrachium rosenbergii*) at larvae and postlarvae stages in biofloc system. AACL Bioflux 14, 3556-3565.

Wei, Y., Liao, S.A., Wang, A. 2016. The effect of different carbon sources on the nutritional composition, microbial community and structure of bioflocs. Aquaculture 465, 88-93.

Summary Description for Module 15

Title:	Module 15: Urban Aquaculture
Instructor:	Dr. Brian L. Nerrie, Extension Specialist, Aquaculture
Prerequisites:	Basic biology and chemistry
Class Time:	12:00PM – 3:00PM
Learning Objective:	After completing Module 10: Animal Husbandry II, the student learner will be able to utilize best aquaculture practices, basic water management and water quality analysis techniques. In order to graduate from the certificate program, the student learner will submit via email file attachment, a proposed aquaculture operation to be incorporated into an urban farm environment.
Instructor Media Needs:	Video and ppt projector Screen Computer with internet access
Class Materials and/or Supplies Needed:	Instructor provided-water quality test kits and oxygen meters. Instructor provided fish population and culture units. Instructor provided fish population sampling nets
Class Activities:	1. Presentation of best aquaculture practices information needed for a urban aquafarming 2. Demonstration/participation in fish sampling 3. Demonstration/participation in water quality evaluation 4. Hands-on practical fish spawning activities 5. Discussion of proposed aquaculture urban farm plans 6. Q & A
Knowledge Gained:	Students will gain best aquaculture management knowledge as part of an urban
Skills Gained:	Students will gain skills in water quality analysis and sampling
Abilities Gained:	Students will be able to complete a personal aquaculture plan for an urban farm.
Exam Description:	Pre-Test Post-Test

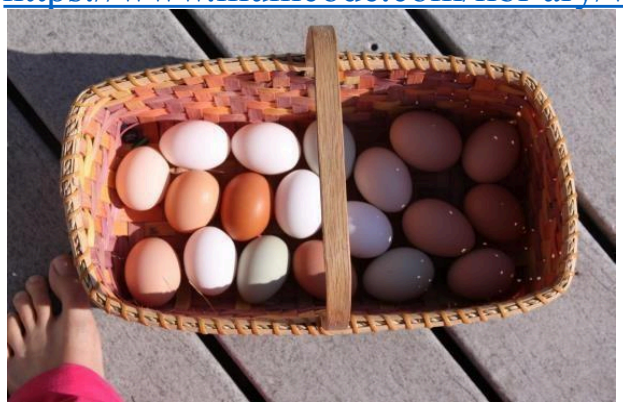
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Urban Poultry

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1. Determining zoning codes for keeping animals in urban areas

- https://www.municode.com/libr ary/va



2. What type of Poultry



- Chickens: meat, eggs, show, feathers or pets
- Turkeys: meat
- Ducks: meat, eggs, or show

- Geese: meat, show, or feathers/down
- Pigeons: meat, show or fun
- Pheasants: meat or hunting
- Guinea fowl: meat, control ticks
- Peafowl: meat or show

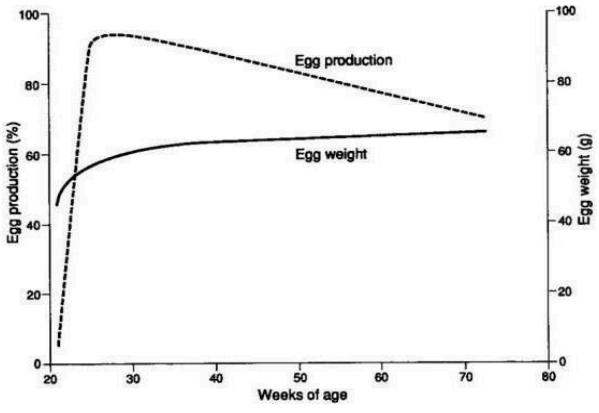
3. Raising meat chickens

- Getting chicks
- NPIP certified hatchery
- Preparing for chicks
- Clean and disinfect
- Feeders and waterers
- Heat source
- Caring for chicks
- Brooding period
- Feeds

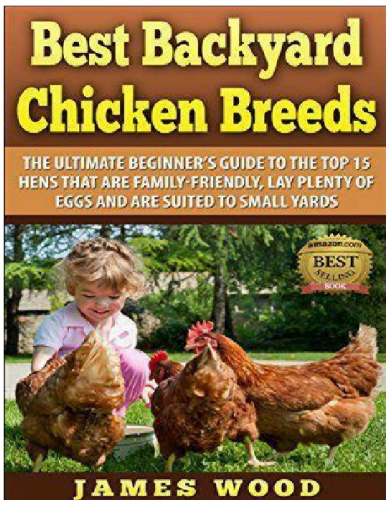


4. Raising chickens for egg production

- Egg production
- Variables affecting egg production
- Light management



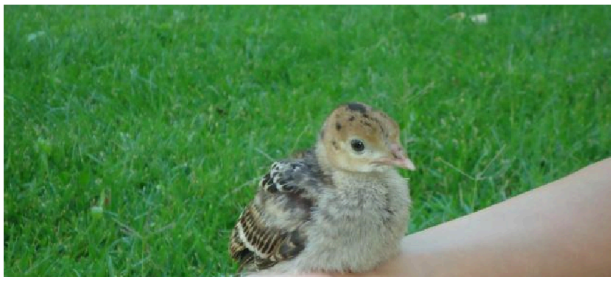
- Space needed
- Identifying laying hens
- Reasons for no laying
- Breed selection - things to keep in mind
- Egg Production capabilities
- Cold/winter tolerance
- Disease resistance
- Temperament
- Foraging ability
- Potential mothering abilities
- https://livestockconservancy.org/images/uploads/docs/pickachicken.pdf





5. Raising meat turkeys

- Type of turkey
- One breed but many varieties
- Brooding



- poults (young turkeys one day old and older) are more difficult to get started than chicks
- Processing

6. Raising duck for consumption

- Obtaining ducks
- Breeds?
- Where to buy?
- Preparing for ducks
- Clean and disinfect
- Feeders and waterers
- Heat source
- Caring for ducks
- Brooding period
- Feeds



7. Raising geese, quail, quinea fowls andpigeons

- Geese
- Meat production
- Feather/down production
- Guard animals
- Extremely territorial
- Fatty liver production



- Breed choice
- Nutrition
- Weeders
- Effective weeders because of their love for grass

- Quail
- Japanese
- Have been selectively bred for either meat or egg production
- There is a niche market for specialty products such as fresh or pickled quail eggs and fresh or frozen quail



- Bobwhite
- Most commonly raised for release into hunting preserves
- Also raised as part of intensive meat production.

- Quinea fowls
- Selection and Purchase
- Keets vs. quineas
- Brooding and rearing
- Susceptible to dampness
- Hatching
- Mating and nesting



- Pigeons
- Breed selection
- Meat
- Squab production
- Exhibition
- Several breeds for showing
- Sporting
- Homing pigeons



8. Brooding and taking care of youngstock

- To ensure new flocks get off to a good start it is important to have the right equipment and knowledge of the needs of young birds



- Shelter
- Bedding material
- Heat source
- Brooder guard
- Feeding and water equipment

9. Feeding and nutritional requirements

- From an economic standpoint, feeding typically accounts for 60 to 70 percent of the cost of production



- **Nutrients** provide poultry the energy and material needed for the development of bone, flesh, feathers, and eggs
- Water
- Carbohydrates
- Fats
- Proteins
- Minerals
- Vitamins
- Poultry should be fed a balanced diet



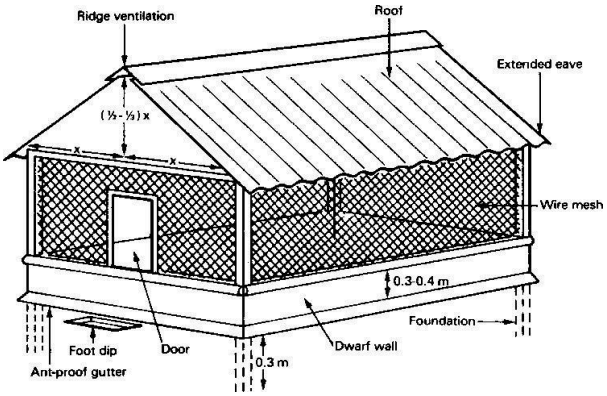
- Feed consumption typically increases in the winter and decrease in the summer
- Extremely important toensure access to clean, fresh water, especially during the heat of summer

10. Health, housing and equipment



- Health
- Salmonella
- Common disease
- Frostbite
- Blood spot and colored eggs
- Internal and external parasites
- Approved drugs for use in poultry
- Dead disposal

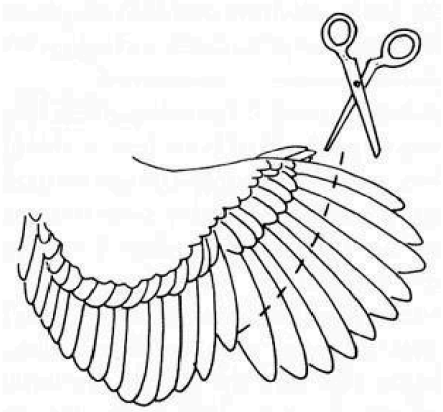
- Design – accessibility and safety
- Space – large enough for good air circulation
- Ventilation - maintain adequate oxygen levels while removing carbon dioxide, moisture, dust, and odors



- Insulation - keep heat in during winter and out during summer
- Lighting - light affects growth, reproduction, and behavior
- Perches – chickens prefer them
- Litter material – what makes good litter

11. Poultry behavior management

- Wing clipping
- Prevent birds from escaping
- Beak clipping
- Prevent feather pecking and cannibalism
- Toe clipping
- Eliminate toenails



12. Federal Poultry Exemptions

Summary Table of Exemptions and Limitations					
Criteria	Custom	Producer/Grower - 1,000 Bird Limit	Producer/Grower - 20,000 Bird Limit	Producer/Grower or Other Person - 20,000 Bird Limit	Small Enterprise
Slaughter Limit	NO LIMIT	YES - 1,000 PER CALENDAR YEAR	YES - 20,000 PER CALENDAR YEAR	YES - 20,000 PER CALENDAR YEAR	YES - 20,000 PER CALENDAR YEAR
Further Processing	YES	YES	YES	YES	CUT UP ONLY
Sell to Home Consu	NO	YES	YES	YES	YES
Sell to any HRI*	NO	YES	YES	NOT TO ALL HRIs**	YES
Sell to Distributor	NO	YES	YES	NO	YES
Sell to Retail Store	NO	YES	YES	NO	YES
Inter-State Sale	NO	NO	NO	NO	NO
Buy Live Birds from Farmers for Processing and Sell Back for Distribution by Farmers (or others).***	NO	NO	NO	NO	YES
*HRI = Hotels, Restaurants, and Institutions					
**Product produced under the Producer/Grower or Other Person Exemption may not be sold to institutions.					
*** Restrictions apply, see below for further details.					

Summary Description for Module 16

Title:	Module 16: Small Ruminants
Instructor:	Dr. Dahlia O'Brien, Professor – Small Ruminants
Prerequisites, if applicable:	Not Applicable
Class Time:	12:00PM – 3:00PM
Learning Objective:	After completing Module 11, participants will learn about the following topics as it relates to small ruminants: Zoning codes – determining which animals are allowed and under what conditions; Selection – learn how to select healthy animals to make your animal production more successful; Feeding – learn about the nutritional requirements and what you'll have to provide to meet these needs; Breeding and taking care of young stock – learn about the reproductive cycle, when and how to breed, gestation length, preparing for birthing, and caring for young stock; Health –healthy animals are more productive, profitable and enjoyable to raise so you'll learn about prevention, diagnosis and treatment of common diseases; Housing and equipment – learn about shelter, supplies and/or equipment needed to handle and raise animals in your backyard; and Marketing – learn about how important it is to know who your customers are and how to explore local options to selling your products.
Instructor Media Needs:	Screen Projector, Screen to Project upon and Computer
Class Materials and/or Supplies Needed:	Instructor provided-Lectures; Live animals for demonstrations and hands-on activities
Class Activities:	1. Lecture on zoning codes, selection, feeding, breeding and taking care of young stock, health, housing and equipment and marketing 2. Hands on activities on body conformation, body condition scoring, aging, vaccinations, deworming, and hoof care
Knowledge Gained:	Students will gain knowledge on how to select and purchase healthy sheep and goats and how to manage them successfully and profitably
Skills Gained:	Students will gain skills in evaluating sheep and goats for body conformation issues, nutritional needs and how to correctly trim hooves and administer vaccinations and oral drenches
Abilities Gained:	Increased knowledge on sheep and goat rearing and hands-on-experience with various management activities
Exam Description:	Increased knowledge assessed by the administration of a pre- and post-test with participants scoring > 70% on post-test

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Small-Scale Sustainable Rabbit Production

By Anne Fanatico and Camille Green NCAT Agriculture Specialists
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New Zealand White rabbits. Photo: Piotr Bizior, www.bizior.com

The National Sustainable Agriculture Information Service, ATTRA *(www.attra.ncat.org)*, was developed and is managed by the National Center for Appropriate Technology (NCAT). The project is funded through a cooperative agreement with the United States Department of Agriculture's Rural Business-Cooperative Service. Visit the NCAT website (*www.ncat.org/ sarc_current.php*) for more information on our other sustainable agriculture and energy projects.

This publication provides an introduction to small-scale rabbit production, focusing on meat rabbits and sustainable rabbit management.

Introduction

In the United States, the meat rabbit industry was more signifi cant around the time of World War II but has since declined. In recent years, a new movement of commercial rabbit production has increased for a handful of reasons: niche markets,

Rabbits are raised for many diff erent uses, and they can play an important role in a small sustainable farming operation.

R

While the most common use in agricultural feasibility of ecological management, and as a component of the Slow Food movement.

industries is for meat, rabbits also are raised for pelts, manure, show, and laboratory use. Rabbit meat is high in protein and low in fat, calories, and cholesterol when compared to most of the meats eaten in the United States (Samkol and Lukefahr, 2008).

While raising rabbits is a labor-intensive endeavor, there are many reasons to consider doing so on a small farm: rabbits are quiet and small, their meat is nutritious, litters are large with short generation intervals (meaning a quick economic return), and they are efficient at extracting protein from forage (Samkol and Lukefahr, 2008); however, rabbit production has recently gained attention as an effective means of alleviating poverty in developing countries (Lukefahr, 2008). In addition, organic rabbit production is a relatively untapped market. Rabbit meat has great potential to feed economically disadvantaged people and could be promoted in the United States as a healthful, natural meat and a small farm asset.

Related ATTRA Publications
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Planning for Profit in Sustainable Farming

Small-Scale Livestock Production

Guide for Organic Livestock Producers

Direct Marketing

Selling to Restaurants

Social Media Tools for Farm Product Marketing

Rabbit Uses

Rabbit meat is fine-grained, lean, and mild and it can be cooked much like poultry. Meat rabbits are either sold as fryers (young rabbits at or below four or five pounds) or as stewers (older rabbits with tougher meat) (USDA-APHIS-VS, 2002). Rabbit meat is lower in fat, cholesterol, and calories than beef, chicken, lamb, pork, and turkey, while being comparable in protein (Lukefahr et al., 1998).

Rabbit manure can be a great garden fertilizer and compost ingredient, since it can be a relatively high source of nitrogen, phosphorus, and potassium, as well as a source of secondary nutrients (Kelly and Crouse, no date; Lukefahr et al., 1998). Worms can be raised in the rabbit manure to produce fishing bait and worm castings (Hemenway, 2009), and the manure can be used as a nitrogen source in thermophillic compost.

Breeds

Two medium-size breeds, the New Zealand White (NZW) and the Californian, are the most important for meat production. They have white fur that is difficult to see if a few pieces are stuck to the carcass, and they have higher meat-to-bone ratios (Spencer, 2011). The NZW is considered the best breed overall, considering mothering ability and carcass characteristics. However, crossing male Californians to female NZWs and then breeding the female from this cross back to male Californians results in larger litter sizes and heavier fryers than using straight NZWs.

Other meat breeds include Californian, Champagne d' Argent, English Spot, and Flemish Giant, but these may not receive a premium price because of the colored fur. A relatively new hybrid breed developed from crosses of Flemish Giant, Champagne d'Argent, and Californian named the Altex (a combination of Alabama and Texas, as the breed was developed between Alabama and Texas A&M), has been bred for commercial viability. This breed is more heat-tolerant and gains more weight quicker than other breeds—reaching up to 10 to 20 pounds. For more information, visit http://users.tamuk.edu/kfsdl00/rabb.html.

Breeds developed for fur include American Chinchilla, Checkered Giant,

Silver Marten, and Rex. Th e Angora was developed for wool and meat. Laboratory breeds include Dutch, English Spot, Himalayan, and Polish (Shaeff er et al., 2008). Pet breeds include Holland Lop, Polish, Dutch, and Mini Lop (www.arba.net). Th ere are many other breeds of domestic rabbit that are raised for meat, show, laboratory use, and fur and wool production.

Housing

Rabbit housing depends on the scale and purpose of the operation. *Rabbit Housing: Hutches, Cages, Wires* by James McNitt is useful for planning and designing housing (see Further Resources). While there are many rabbit housing designs, McNitt points out a handful of basic requirements: comfort for rabbits, protect rabbits from predators and prevent them from escaping, protect rabbits from extreme weather, allow easy access to the rabbits, be easy to clean or "self-cleaning," and, lastly, aff ordable to build and maintain (McNitt, 2009). It is economical to make use of any outbuildings already available on a property. Even a lean-to in warm areas can provide a roof to keep out the rain and sun, but dogs and predators could be a problem if they are not fenced out. An experienced producer with a stable market may want to build a specialized building. In areas with mild climates, housing can be open-walled (for example, a long, narrow A-frame with a walkway down the middle and a row of cages on either side with roll-down plastic curtains or hinged boards for cold weather). In cold regions where there are prolonged periods below freezing, buildings need to be enclosed to prevent drafts and conserve body heat. Heating is usually not necessary since rabbits have thick fur coats. However, drafts in cold weather can be a problem, particularly for newborn kits in the nest box. In fact, backyard producers often do not breed rabbits in the wintertime. Unheated rabbitries risk freezing of water supplies in cold weather. Even if the lines are heated, the watering nipples can still freeze.

Hot weather is even more of a concern than cold weather. With high humidity and temperatures above 90°F, adult rabbits overheat. Rabbits are ideally kept where the temperature can be maintained at 62°F.

In any type of building, ventilation is very important in reducing ammonia buildup and helping the animals stay cool during hot periods. Open-walled buildings can be ventilated by natural air fl ow. An enclosed building will require fan-assisted ventilation, and in hot areas, cool cells or foggers can help cool the building. Single levels of cages are easier to ventilate and cool than stacked rows of cages.

Commercial rabbitries normally house animals in all-wire cages suspended above the ground. Th e cages are hung at a height convenient for the producer, usually at waist level. Manure pellets fall through the wire bottom to the ground instead of remaining in the cage, preventing coccidiosis— a parasitic infection spread by contact with the manure. Th e manure accumulates on the ground or in specially dug pits, often sand-lined, until the manure is removed by wheelbarrow, tractor, or, in some cases, an automatic scraper.

Quonset-style cages are rounded on top and save on wire material. Th e placement of the doors on ***building*** quonset cages allows for easy access to the rabbits

Feeding

Rabbits eat only plants and are classifi ed as non-ruminant herbivores. Th ey recycle feed by re-ingesting the cecotropes. Cecotropes are small particles of digested food that collect in the cecum (hindgut), which the rabbit excretes once a day and then consumes. Cecatropes are sometimes called "night feces" and look softer than the round, hard pellets usually seen. Rabbits require high-fi ber diets, which are bulky and low in density, unlike poultry or swine (Lukefahr et al., 2004). While purchasing commercial feed is common in commercial operations, there is an increasing amount of research being conducted on forage-based rabbits and other self-sustaining means of feeding the herd.

Commercial Pelletshile

Rabbits are usually fed a commercial pelleted diet that is balanced in the necessary

nutrients **or** (it is easier to reach into quonset than square-style (protein, energy, vitamins, and minerals). Th ese **designing rabbit**

cages). However, it is important to ensure rabbits have suffi cient space. While building or designing rabbit housing, remember that rabbits tend to gnaw, especially on wood.

If plastic water lines are used to deliver water, attach them to the outside of the cage so the rabbits cannot chew them.

On a backyard scale, a small, free-standing unit (called a *hutch*) can be built to house a few animals outside. Various publications that give designs are listed in Further Resources.

Th e Polyface Farm has developed a mixed rabbitry and chicken coop in which rabbits are suspended above the chickens, as well as a mobile hutch that acts similar to a chicken tractor (www. polyfacefarms.com). Raising rabbits above laying hens allows the manure to be processed by the chickens, so the hens get whatever nutrients are left over, and ammonia does not build up. Th e mobile pen allows for a reduction in purchased feed.

Toby Hemenway describes a system where an open box is placed underneath an elevated rabbit hutch. Th e box is lined with up to six inches of shredded newspaper and peat moss or dry leaves, and collects manure, urine, and spilt food. After the box is relatively full, red worms are added to the mix and then covered. A second box is set out underneath the hutch, and by the time it is ready for worms, the fi rst box of compost should be fi nished (Hemenway, 2009).

diets contain alfalfa, grain (barley, wheat mill byproducts), protein supplements (soybean meal), vitamins, and mineral supplements.

With a small operation, it may be economical to reduce the amount of pellets by feeding rabbits available greens. Greens and succulents include fresh legumes (alfalfa, clover), grasses, vegetables (lettuce, celery), roots and tubers (carrots, potatoes), weeds (dandelions), and comfrey. Clean table scraps that fi t into these categories are also acceptable. If greens complement a pelleted diet, the amount of pellets can be reduced by 50% without lowering rabbit production. However, since fresh greens are about 80% to 90% water, it is diffi cult to raise rabbits solely on these materials because they are not nutrient-dense. Over-feeding of fresh greens may also cause indigestion.

housing, remember that rabbits tend to gnaw, especially on wood.

Forage

Rabbits can be pastured in outdoor pens placed on the ground, which allows them to harvest their own fresh forage. Fryers can be kept in outdoor pens with wooden slats or chicken wire on the fl oor to prevent the rabbits from digging out of the pen. Pens are moved daily to fresh pasture, and the rabbits are provided with concentrate feed. Ideally, rabbits won't graze the same area of pasture again for at least six months to prevent the spread of coccidiosis.

Th ere are many diff erent production models



An example of a movable outdoor pen designed for forage. Photo: NCAT

for raising rabbits on pasture. Some producers choose for rabbits to be born and raised to weaning indoors. Th e weaned rabbits are then moved to portable cages on pasture. Rabbits raised on pasture may take longer to reach slaughter weight. Rabbits that have been bred for commercial confi nement production may not perform well on pasture. You may have to spend time experimenting with breeds and breeding to fi nd the type of

animal that best fi ts your production system. As with any livestock, you should purchase breeding stock that has been raised in a similar manner to your production system. So if you are raising rabbits on pasture, it is in your best interest to buy stock from another pasture producer instead of stock that has been raised indoors and fed only a commercial feed ration.

Growing local feed for rabbits is also an option. Research has been conducted on using water spinach, sweet potato, cassava foliage, mulberry leaves, and other plants and found that such crops can replace or be combined with conventional feed ingredients (Samkol and Lukefahr, 2008). Another study claims that growing sweet potato forage along with a small amount of cereal grain for an energy supplement can be a self-sustaining program for a small farm (Lukefahr et al., 2010).

Homemade Diets

Instead of a commercial pelleted diet, producers can mix their own feedstuff s, especially if they grow or purchase their own feed ingredients. Before commercial pellets were available, people often raised rabbits on a diet of alfalfa hay and white oats. Th is is an acceptable diet if salt licks are also provided.

A legume hay such as alfalfa or clover provides high protein and fi ber and can be included at a level of about 50% to 60% of the total diet. A concentrate for energy (grains such as oats or barley) is needed at a level of about 20% to 30%. Th e grain should be rolled or ground to facilitate digestion. Feeding too much grain can cause a carbohydrate overload in the hindgut and the animal may die from enteritis (diarrhea). Grain by-products that are high in fi ber, such as wheat bran or wheat mill run, are also good options. Adding hay to increase fi ber and decrease the amount of grain fed will also reduce enteritis. A small amount of protein concentrate such as soybean meal or sunfl ower meal at about 10% of the diet ensures adequate protein. Rabbit diets need to have about 16% to 17% crude protein, as well as mineral supplements or salt spools.

Th e grain and hay ingredients mentioned above are relatively dry (only about 10% moisture). Rabbits do not relish eating a powder-dry mixture. If the mixture is moistened with feed-grade molasses, it will be more palatable to the animals. If the alfalfa or other forage is in hay form, it can be off ered separately.

More feed wastage can occur with non-pelleted rations than with pelleted rations. Th e rabbits may feed selectively, and the cage bottom and ground below can become littered with hay. Keep this in mind when considering the cost-eff ectiveness of feeding home-mixed rations rather than commercial pellets. It may be possible to have a feed mill custom mix a pellet ration.

Having a balanced ration ensures that diets contain the proper amount of nutrients for rabbits during diff erent stages of growth or reproduction. Th e book *Rabbit Feeding and Nutrition* (see Further Resources) includes a section on ration balancing and nutrient requirements.

Reproduction

An important part of reproductive management is taking the female (doe) to the male's (buck's) cage. Otherwise, the buck would spend his time marking new territory in the doe's cage instead of breeding. Breeding should occur within about one minute. If it does not occur, the doe should be removed and the process should be tried again in a few days. Th e doe should not be left in with the buck for long periods of time because they

may fi ght. Rabbits do not have a heat cycle like many animals do—rabbits ovulate after mating.

Th e doe's abdomen may be palpated 10 to 14 days after breeding to see if she is pregnant. Th e embryos are round and feel like grapes (Gill, 2004). Birth of the kits (kindling) occurs in 31 days with NZWs. A nest box with wood shavings or other bedding material is placed in the doe's cage at 29 days so she can pull fur and build a nest.

It is a good policy to breed several does on the same day in order to be able to divide large litters at kindling among the does. NZWs make good foster mothers. Being touched by human hands at birth does not harm the kits or cause the mother to reject them. Eight or nine kits with each NZW

months after kindling for four to fi ve litters per year. Kits are generally weaned at 30 days of age; however, if the doe is rebred at one and a half months after kindling, the kits can be left with their mothers for up to two months. Th is is a particularly useful practice if cage space is limited. With top nutrition and management, some producers wait only one to seven days after kindling to rebreed the doe for maximum production (up to 11 litters per year). However, does may require a rest after three or four breedings at this accelerated rate. A good doe sends an average of 50 fryers a year to market. Young rabbits (fryers) should be separated by gender after 12 weeks to prevent fi ghting and inbreeding.

Management

It is important to keep production records in order to know when to carry out crucial activities such as putting in the nest box, and to aid in choosing the best replacement stock. Ear tags or tattoos are necessary with large numbers of rabbits. Sanitation is very important. When fur and dust accumulate on cages, they can be removed by burning with a propane torch. Nest boxes should be cleaned and disinfected after use (one ounce of bleach to one gallon water is a good cleaning solution).

Health

Mastitis, or infl ammation of the mammary glands, is a common disease in rabbits but it is treatable with antibiotics. Th e bacteria *Pasteurella* causes snuffl es and pneumonia; chronic *Pasteurella* suff erers should be culled from the herd. Rabbits showing overgrown teeth, those developing sore hocks, and poor producers should also be culled.

If antibiotics are used to treat disease, a withdrawal period is required before slaughter to ensure that residues have cleared the animal's system. Since antibiotics and hormones are not routinely used in rabbit production, the meat is especially appropriate for natural and organic markets.

Processing

Rabbits that receive good nutrition reach a market weight of four to fi ve pounds live weight within

do—rabbits ovulate after mating.

Rabbit processing generally consists of stunning or killing the animal, hanging it to bleed, removing the head, removing feet and tails, removing skins, eviscerating, washing the carcass, chilling the carcass in a water tank or refrigerated room, aging the carcass under refrigeration, and packaging.

In a plant, an automated line reduces labor for rabbit processing compared to a manual overhead track but is subject to possible electrical breakdowns and other problems. If you are planning to establish a USDA-inspected plant, contact the USDA Food Safety and Inspection Service (FSIS). Th ere is very little information available on building plans for rabbit processing; however, much of the equipment is very similar to or the same as poultry-processing equipment. Also, since rabbits are not classifi ed as livestock, USDA inspection is voluntary (USDA-APHIS, 2002).

Under voluntary federal inspection, each rabbit and its organs are inspected to ensure it is wholesome, free from disease, and slaughtered under USDA poultry regulations. Voluntary inspection of rabbits (along with game meats) is handled under the Agricultural Marketing Act (USDA-FSIS, 2006). Since rabbit inspection is voluntary, the federal government does not pay for inspection and the producer must cover the costs. According to the USDA-FSIS (2006), when rabbit is not

voluntarily inspected, the processor is subject to Food and Drug Administration (FDA)

mother are an appropriate number. Cannibalism 10 to 12 weeks and are marketed as fryers. It may

by the mother is often due to poor nutrition, but take longer to reach market weight with poorer

sometimes it may have no apparent cause. nutrition. Older rabbits (usually above six pounds) ***not***

culled from the herd are less valuable due to ***heat cycle***

Rebreeding can take place about one and a half

meat and are marketed as stewers.

R ***abbits do have a*** tough ***like many animals***

In many ways, the rabbits are more suited for small-scale bit

inspection under the Federal Food, Drug, and Cosmetic Act. Some states only permit the sale of rabbit if it is inspected under state laws. Contact the USDA-FSIS for information on regulations in your state. Also check with any states to which you plan to ship rabbit meat.

Products other than meat include breeding stock, manure fertilizer, and worm production from the manure. Some processors sell "biologicals" after slaughter—such as brains and blood—to pharmaceutical companies.

Marketing

Marketing rabbits can be diffi cult and frustrating because there are few processors who buy live rabbits, and supply and demand can be unstable. In wintertime, producers may have a more dif- ple rabbit meat prepared in diff erent recipes, get fi cult time raising rabbits and supply is therefore limited. In the summertime, supply can become glutted. A market report from the American Rab- of the meat, and see exhibits of crafts that can be bit Breeders Association is available at www.arba. made from rabbit products, such as rugs from the tools can also engage consumers with the farming operation. Customer bases include local health food stores or grocery stores interested in carrying farm-fresh products (these usually require a steady supply), farmers markets, and restaurants.

Besides the sale of meat, rabbits can also be raised and sold for pets and show animals.

Th ousands of youth across the country participate in 4-H rabbit projects and shows. Raising rabbits for these purposes is very diff erent than raising them for slaughter. Th ere are dozens of recognized breeds. If you are selling rabbits for show, you must pay special attention to the various characteristics specifi c to a particular breed.

A Rabbit Field Day at a school could provide the opportunity for people to handle live rabbits, sam-

production than large-scale, industrial production.

net/Processors.htm. Th is report includes the names and addresses of processors, along with information on current prices paid for fryers and stewers.

Direct Marketing

Th e United States does not have a history of rabbit consumption. However, there is untapped potential, especially for the natural and organic markets. ATTRA can provide more information on organic production and certifi cation.

Direct marketing requires extra time and eff ort for the producer but provides the opportunity to produce a high-quality product, educate the consumer, and develop customer loyalty.

In establishing a direct market, you can start with producing meat for family or selling to neighbors and friends. Providing free samples to businesses patronized by the producer, at county fairs, and similar venues can acquaint potential customers with the product. Advertising through newspaper, radio, fl yers, brochure, and the Internet can be eff ective. Some farms send out a newsletter to past customers describing activities at the farm and emphasizing the quality of their products.

Education helps to build a loyal customer base. Presentations to local organizations and civic groups may attract consumers interested in lowering fat and cholesterol in their diets. New social media

pelts and rabbit foot key chains. Rabbit producers may be able to coordinate with 4-H groups or the Cooperative Extension Service in order to carry out a project of this kind.

Summary

Th e U.S. rabbit industry has many challenges. Rabbit meat is high in cost compared to other livestock and should be considered a luxury meat. Feasibility studies and business planning are necessary if you are planning to invest money in rabbit production. Raising rabbits is a business a producer should grow into gradually as experience increases and management improves. In many ways, rabbits are more suited for small-scale production than large-scale, industrial production.

It is diffi cult to automate rabbit production because does must be housed individually due to territorial behavior. Th eir feed costs can be high because they require a high-fi ber, low-energy diet that costs more to produce than typical corn and soybean diets fed to poultry and swine. For example, alfalfa is an excellent feed for rabbits but it is expensive. However, qualities that make rabbits less suitable for industrial production make them more suitable for small-scale production. Th ey can eat forages, hay, garden waste, and high-fi ber milling by-products like wheat bran, and they can be an important part of a diversifi ed farm.

Case Study: Seely's Ark

Beth Seely, of Seely's Ark, a commercial meat rabbit operation in Florida, started with three does and one buck a little over 20 years ago. Today, she manages roughly 500 breeding does on 10 acres of land. Seely's Ark initially marketed directly to high-end restaurants. Now, it is the only supplier of rabbit meat to Publix Super Markets, a quickly growing grocery chain in the South.

How did this successful rabbit farm get its start? Although Beth grew up on a dairy, her interest in rabbit farming didn't begin until she moved back to the country after years in the city. "Th en I caught the bug! I had to farm," she recalls. Rabbits are an ideal livestock option for her because they do not require much land and are physically easier for her to handle than larger livestock. Beth started her farm with three does and one buck, and as the herd grew, so did her operation. She considers 500 breeding does to be as large as Seely's Ark can get without hiring outside help.

Like any operation, Beth faces challenges, which, she says, generally relate to the time and labor required to be successful in rabbit husbandry, developing a year-round product, and dealing with a sometimes fi nicky market. Another major limiting factor is that there is little automated technology for rabbit production. With a 40-day reproduction cycle, the rabbits need a lot of attention, and the process can be time- and labor-intensive.

Seely's Ark is primarily a meat operation, although they have experimented with other markets to varying degrees of success. Th eir location is too rural for there

to be much of a pet industry, and they no longer sell rabbits to labs because the lab industry now requires rabbits that have been raised in sterile environments. Th ey do sell some breeding stock, and because their line has been developed for best heat tolerance, they are even able to export some stock to Caribbean and Central American countries. For supplemental income, fi shing worms are raised in bins underneath the suspended rabbit hutches.

While high temperatures have allowed Seely's Ark to develop a unique rabbit operation that is successful in traditionally prohibitive conditions, they also have posed great challenges. In the early days of her operation, rabbit breeders in Beth's region stopped breeding from June through November because temperatures simply got too hot for the rabbits, which is not only a danger to their health but can also slow their growth. Th rough diff erent techniques—mainly what she attributes to the "right genetic material" and a breed of rabbit specifi cally developed for larger sizes and higher heat tolerance (Altex, along with the traditional New Zealand and Californian)—she is able to breed rabbits nearly yearround, ensuring a continual supply for market.

Rabbits at Seely's Ark are fed a pelleted mix— developed in partnership with a local mill that now uses the same recipe as its shelf mix—that specifi cally takes into account the extremely high temperatures. Th e new mix is lower in carbohydrates, since a diet that is too high in carbohydrates can cause sickness and even death in a rabbit.

Beth admits that she has access to an ideal market—Florida has an ethnically diverse population, and most other countries don't have the same issue with eating rabbit as does the United States. In the winter especially, with contingents of Canadians and Europeans who overwinter in Florida, there is a much higher retail demand for rabbit meat.

Growing into the commercial meat rabbit industry has had its ups and downs for Beth Seely— and certainly its share of challenges—but Seely's Ark has been a consistently successful economic endeavor in a growing industry in the sustainable agriculture movement.

References

Gill, Charlie. 2004. Th e art of palpation. Countryside Magazine. Sept/Oct. www.arba.net/PDFs/palpation.pdf

Hemenway, Toby. 2009. Gaia's Garden: A Guide to HomeScale Permaculture. Chelsea Green Publishing. White River Junction, VT. p. 171.

Kelly, Lelia Scott and Keith Crouse. No date. Organic and Inorganic Fertilizers and Materials for the Home Gardener. Mississippi State University Extension Service. http://msucares.com/pubs/publications/p2572.pdf

Lukefahr, Steven. 2008. Role of organic rabbit farming for poverty alleviation. Proceedings MEKARN Rabbit Conference: Organic rabbit production from forages. Cantho University, Vietnam. November 25-27. www.mekarn.org/prorab/luke.htm

Lukefahr, Steven, Joe Paschal, and John Ford. Cooperative Extension Services. 1998. Backyard Production of Meat Rabbits in Texas. Texas Agricultural Extension Service, Texas A& M, College Station, TX.

Lukefahr, Steven, P.R. Cheeke, J.I. McNitt, and N.M. Patton. 2004. Limitations of intensive meat rabbit production in North America: A review. Canadian Journal of Animal Science. Vol. 84, p. 349-360.

Lukefahr, Steven. 2012. Th e Rabbit Research Program at TAMUK. June 12. http://users.tamuk.edu/kfsdl00/rabb.html.

Lukefahr, Steven, G. Schuster, K.G. McCuistion, T. Verma, R. Flores. 2010. Self-SustainingRabbit Projects: A Pilot Study Involving Feed of Sweet Potato Forage. Proceedings of the 4th Rabbit Congress of the Americas. Cordoba, Argentina.

McNitt, James. 2009. Rabbit Housing: Hutches, Cages, Wires. Southern University Agricultural Research and Extension Center. Baton Rouge, LA.

Samkol, P. and S.D. Lukefahr. 2008. A Challenging Role for Organic Rabbit Production Towards Poverty Alleviation in South East Asia. 9th World Rabbit Congress. Verona, Italy.

Shaeff er, Robert, Lynn Kime, and Jayson Harper. 2008. Cooperative Extension Services. Agricultural Alternatives: Rabbit Production. College of Agricultural Sciences, Pennsylvania State University, Park, PA.

Spencer, Robert. 2011. Cooperative Extension Service. 1997. Guidelines for Entry into Meat Rabbit Production: Rabbit Production 101. Alabama Cooperative Extension, Alabama A&M and Auburn Universities.

USDA-APHIS-VS. 2002. U.S. Rabbit Industry Profi le. United States Department of Agriculture/Animal and Plant Health Inspection Service/Veterinary Services, Centers for Epidemiology and Animal Health, Center for Emerging Issues, Fort Collins, CO. www.aphis.usda.gov/animal_health/emergingissues/downloads/RabbitReport1.pdf

USDA-FSIS. 2006. Rabbit From Farm to Table. Fact Sheet. www.fsis.usda.gov/Fact_Sheets/Rabbit_from_Farm_to_Table/index.asp

Further Resources

Online Resources and Websites

AWI's Humane Husbandry Program Expands; Rabbits Hop onto the Scene. By Animal Welfare Institute. http://awionline.org/content-types-orchid-legacy/awi-quarterly/awishumane-husbandry-program-expands-rabbits-hop-scene

Basic explanation of AWI's Human Husbandry Program and how it relates to rabbits.

Breed Information – ALBC Conservation Priority List. 2012. By American Livestock Breeds Conservancy. www.albc-usa.org/cpl/wtchlist.html#rabbits

Don't Tell the Kids. 2010. By Kim Severson. Th e New York Times. March 2. www.nytimes.com/2010/03/03/dining/03rabbit.html?pagewanted=1&_r=2&hp&

Life as a Polyface Apprentice. Online blog posting by apprentices at Polyface Farm. Sample blogs include:

- Butchering Rabbits, http://polyfaceapprentice.blogspot.com/2009/01/butchering-rabbits.html
- Hare Pen, http://polyfaceapprentice.blogspot.com/2009/02/hare-pen.html
- Rabbits and Layers, http://polyfaceapprentice.blogspot.com/2009/01/rabbits-and-layers.html

Meat Rabbit Breeders. http://rabbitbreeders.us/meat-rabbit-breeders

Online directory of meat rabbit breeders by state. Also off ers information about raising rabbits, and sells various supplies.

Rabbit - Meat Enterprise Budget. 2009. By Alabama Cooperative Extension. www.aces.edu/agriculture/businessmanagement/budgets/rabbit.php

A sample budget for rabbit meat production, in Microsoft Excel format.

Rabbit Production. 2010. Mississippi Agriculture and Forestry Experiment Station. Mississippi State University

Extension Service. http://msucares.com/livestock/small_animal/ index.html

Th is useful resource list identifi es publications, fact sheets, and other resources.

Rabbits. 2012. By Agricultural Marketing Resource Center. www.agmrc.org/commodities__products/livestock/rabbits

A good resource on rabbit production that includes information on marketing and production, as well as case studies.

Th e Rabbit Research Program at TAMUK. 2012. http://users.tamuk.edu/kfsdl00/rabb.html *Gives an overview of the rabbit research program at Texas A&M University-Kingsville, and lists diff erent publications and resources.*

Rabbits - From the Animal's Point of View (Parts 1 through 5). 2009. By M. Smith, C.L. Meehan, and J.M. MA. University of California Agriculture and Natural Resources, Oakland, CA. http://anrcatalog.ucdavis.edu/ Items/8389.aspx

A fi ve-part curriculum developed for 4-H that can be downloaded free.

Voluntary Inspection of Rabbits and Edible Products Th ereof. U.S. Law. 9 C.F.R. PART 354. http://law.justia. com/cfr/title09/9cfr354_main_02.html
Th e voluntary rabbit inspection law.

Organizations, Associations, and Agencies

American Branch-World Rabbit Science Association (AB-WRSA) http://biology.csustan.edu/Biology/abwrsa

Th e WRSA was created in Paris in 1976 to promote and exchange knowledge about rabbit sciences.

American Rabbit Breeders Association (ARBA) www.arba.net

ARBA has over 23,000 members in the United States, Canada, and abroad. Its website off ers information and resources for rabbit breeders.

USDA Food Safety and Inspection Service (FSIS) www.fsis.usda.gov

Th e USDA-FSIS website provides information to protect health through food safety and is easily searchable for information.

U.S. Food and Drug Administration http://www.fda.gov/default.htm

Th e Federal Food, Drug, and Cosmetic Act page explains specifi cs of the act.

U.S. Department of Agriculture-Agriculture Marketing Service. 2002. United States Classes, Standards, and Grades for Rabbits. AMS 70.300 et seq. http://www.ams.usda.gov/ AMSv1.0/getfi le?dDocName=STELDEV3004378

U.S. standards and grade for rabbit meat. Includes a summary of standards of quality for carcasses and parts.

U.S. Department of Agriculture-Alternative Farming Systems Information Center. Rabbits. 2012. http://afsic.nal. usda.gov/grazing-systems-and-alternative-livestock-breeds/ raising-alternative-livestock-breeds/rabbits

A useful list that identifi es publications and online resources for rabbit producers.

Books and Other Publications

Growth of fryers reared and (or) fi nished using controlled grazing in movable pens. 2003. By J. McNitt, R. Way, M. Way, and I. Forrester-Anderson. World Rabbit Science. Vol. 11, No. 4. p. 189-198. https://ojs.upv.es/index.php/wrs/ article/view/507/494

Examines the productivity of fryers kindled in hanging wire cages and then fi nished on pasture, kindled and reared in a pasture pen, or kindled and reared in cages, as well as the feasibility of pasture raised rabbits.

Infl uence of open-air rearing on fatty acid composition and sensory properties of rabbit meat. 2004. By C. Cavani,
M. Bianchi, M. Petracci, T.G. Toschi, G.P. Parpinello, G. Kuzminsky, P. Morera, A. Finzi, World Rabbit Science. Vol. 12, No. 4. p. 247-258. https://ojs.upv.es/index.php/wrs/ article/view/568

Th is study examines the fatty acid (FA) composition of rabbit meat from rabbits raised in open-air moveable pasture hutches.

Rabbit Feeding and Nutrition. 1987. By Peter R. Cheeke. Academic Press, University of Minnesota, Minneapolis and St. Paul, MN.

An extensive book that discusses the nutritional needs and feeding requirements of rabbits.

Rabbit Housing: Hutches, Cages, Wires. 2009. By James McNitt, PhD, Southern University Agricultural Research and Extension Center, Baton Rouge, LA. http://www.suagcenter.com/News%20Archives/Feb-Apr2009/RabbitHousingManual.html

Raising Meat Rabbits. 2005. By Cooperative Extension Services. Cornell Cooperative Extension, Cornell University, Ithaca, NY. http://www.ansci.cornell.edu/beef/docs/raising_ mrabbits.pdf

A short but useful fact sheet that includes an estimated budget worksheet.

Proceedings of the 8th World Rabbit Congress. 2004. Puebla, Mexico. http://world-rabbit-science.com/WRSA-Proceedings/Congress-2004-Puebla/Puebla-2004-a.htm

A collection of conference papers ranging from rabbit genetics to meat quality and processing.

Individual Contacts

Beth Seely
Seely's Ark
6151 NE 21st Ave
Ocala, FL 34479
352-489-8353
SeelyArk1@aol.com

Th e source of the case study, Beth Seely is a wealth of information on rabbit production.

Statistics on organic production of rabbits on grassland. 2002. By F. Lebas, L. Lebreton, and T. Martin. Cuniculture Paris. Vol. 164. p. 74-80.

Studies the profi tability of organic pastured rabbits.

Appendix 1: Sample Budget

Sample Fryer Rabbit Budget

Based on 20 does and two bucks producing fi ve litters per year (seven kits per litter)

Expenses	Quantity	Price	Total	Your Estimate
Feed	5 tons	$440/ton	$2,200	
Health program			$25	
Marketing			$200	
Supplies			$50	
Labor	150 to 200 hours			
Replacement breeding stock			$280	
Buildings, cages, and handling facilities			$750	
Total Expenses (not including labor)			**$3,505**	

Assumed production:
35 fryers x 20 does = 700 fryers marketed
700 x 5 pounds each = 3500 pounds
3500 pounds x $1.20*/pound = $4,200
*For current market prices and to fi nd a processor/buyer see www.arba.net/processors.htm.
Income $4,200
Expenses $3,505
Net Profi t $695

Budget adapted from Shaeff er, R. and J. Harper. 2008. Rabbit Production. Pennsylvania State University. http://extension.psu.edu/ag-alternatives/animals/rabbit-production and Smith, Tom. No date. Commercial Rabbit Production.

Mississippi State University. www.poultry.msstate.edu/extension/pdf/rabbit_production.pdf

Notes

Small-Scale Sustainable Rabbit Production

By Anne Fanatico and Camille Green,
NCAT Agriculture Specialists

Published December 2012
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Cathy Svejkovsky, Editor Amy
Smith, Production

This publication is available on the Web at:
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Small-scale/Backyard Rabbit Production

Dahlia O'Brien, Extension Specialist/Small Ruminants, Virginia State University
Tracy Porter, Small Farms Outreach Program Agent, Virginia State University

U.S. Rabbit Production

- ✔ Rabbits are raised for many different purposes including meat, Angora wool, breeding stock, pets and also for laboratory use.
- ✔ Rabbits can also be raised for their skin/hide.
- ✔ Rabbit meat is high in protein and low in fat, calories, and cholesterol when compared to most other meats eaten in the U.S.
- ✔ More than 5,000 farms sold approximately 850,000 rabbits nationally in 2012.
- ✔ Small enterprises have < 50 – 100 rabbits while larger/full-time enterprises have at least 600 females and 60 males.

New Zealand White



Breeds for meat production

- ✔ The most important breeds for meat production include the New Zealand White (NZW) and the Californian.
- ✔ When considering mothering ability and carcass characteristics, the NZW excel compared to other breeds.

Table 1. Common commercial meat rabbit breeds

Breed	Use	Mature Weight (lbs.)
New Zealand White	Meat	9 - 12
Californian	Meat	8 - 11
Flemish Giant	Meat	13 - 20
Florida White	Meat	5 - 8
Angora	Fiber/meat	9 - 12

Reproduction

- ✔ Female is called a doe while a male is called a buck.
- ✔ Female is sexually mature at 6 months, depending on breed, with males usually ready for breeding at 7 months.
- ✔ Females are induced ovulators (ovulate 10 – 12 hrs. after mating has occurred)
- ✔ Day length affects reproduction and conception rates decrease during the shorter days of fall and winter ✔ Young are called kits.
- ✔ The process of giving birth is called kindling.

- ✔ When mating, bring the female to the male, otherwise buck will spend all of his time marking his new territory.
- ✔ They should mate within one minute. If not, remove the doe and bring her back to the male in a few hours - days.
- ✔ To determine pregnancy, the doe's stomach can be palpated at 10 – 14 days (embryos feel like grapes).
- ✔ The gestation period of a doe is 31 – 32 days.
- ✔ Nest box with shavings/bedding should be placed with doe about 3 – 5 days before kindling so the doe can pull her fur and finish ✔ building her nest.
- ✔ The average litter is 8 – 10 kits.
- ✔ Kits are usually weaned at 30 days of age. ✔ Each doe produces 25 to 50 live rabbits a year, which will yield 125 to 250 pounds of meat.



Doe with litter

Prior to kindling, a nest box should be placed in the hutch prior to kindling (provides protection of the litter). During winter, provide a den (constructed of wood) with extra bedding for additional insulation. The dimensions of the den should be large enough that you can stuff it sufficiently with extra straw or hay. The opening should only be large enough for the rabbit to enter and the door should be oriented so that it is draft free. During summer, in extreme heat, provide cool drinking water and place frozen plastic bottles, pans or buckets inside the hutch keep rabbits cool.

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Housing

- ✔ Many different types of hutches can be used for mature rabbits.
- ✔ Basic hutch requirements include: comfort, protection from extreme weather and all the predators, prevention of escape, and easy to clean.
- ✔ Does with litters should be provided all the feed they can eat.
- ✔ Fresh, clean water should be provided every

Nutrition

- ✔ Commercial pellets can meet all of a rabbit's nutritional requirements and might be more convenient.
- ✔ Can also provide a homemade diet of hay and grain. and there are many designs available.
- ✔ Typical diet is 6 – 8 ounces of pellets/head/day

- ✔ Rabbit hutches should be placed in an area with plenty of shade.
- ✔ All metal cages help to prevent unsanitary conditions that could lead to an unhealthy environment.
- ✔ Cages/hutches should be at least 30 inches wide, 30 inches deep, and 20 inches high for mature rabbits.
- ✔ Younger/smaller rabbits may be kept in small groups in one pen.
- ✔ A small feeder and watering system should be available in each cage.
- ✔ Check water/watering system for issues with freezing daily (more in warm/hot weather or when the doe is with her litter).
- ✔ On a small operation, may be more economical to feed rabbits available greens to reduce the amount of pellets
- ✔ Rabbits love fresh legumes (alfalfa, clover), vegetables (lettuce, celery, and kale), roots and tubers (carrots, potatoes), weeds (dandelions), and grass.
- ✔ Fresh greens can make up to 50% of the diet without affecting overall production (too much greens can cause indigestion and reduce growth since it's mostly water).

Rabbits are raised at Virginia State University as part of our Urban Agriculture Program.
For information about rabbit production, please contact Dahlia O'Brien at dobrien@vsu.edu or Tracy Porter at tporter@vsu.edu

Virginia Cooperative Extension
Virginia Tech • Virginia State University

Do you want to raise sheep or goats?

Here are a few things to consider…….

Dr. Dahlia O'Brien, Extension Specialist, Small Ruminants, Virginia State University

Why?

The first question you should ask yourself is why do I want to raise sheep and/or goats? Is it for additional income, control of weeds and brush on your land, 4-H/FFA projects for the kids/grandkids or just for fun (pets/companions)? This will then influence the next decision on what type of sheep/goat should I raise……meat, milk or fiber? The reason you want to raise them will then determine what breed to choose for that purpose.



Breed Selection

As a beginning sheep or goat producer, you need to be able to select the best breed that meets your needs and those of your potential buyers. Some top meat goat breeds include Boer, Spanish, Kiko and Myotonic breeds while dairy breeds include Nubian, Alpine, Toggenburg and Saanan. If you choose fiber then Angora and Cashmere goats are your choices. Many sheep breeds are considered to be dual-purpose and can be raised for meat and wool. However, these breeds usually excel at one or the other. Common meat breeds include Cheviot, Dorset, Suffolk, Hampshire and Katahdins while wool breeds include Merino, Ramboillet, American Cormo and Leicester breeds. The top two dairy breeds in the U.S. include the East Freisian and Lacuane breeds. For more information on these breeds and others please visit:
http://www.extension.org/pages/19282/goatbreeds for goat breeds and
http://www.sheep101.info/breeds.html for sheep breeds

Facilities and equipment

Fencing is critical to keeping sheep and goats contained. Goats can be extremely difficult to contain so an effective fence is an important part of goat rearing. Typically some sort of perimeter/boundary (example, high tensile electric, woven wire, mesh wire) is required to keep animals in and keep predators out. Interior fencing (polywire, polytape, electric netting) can then be used to separate into smaller grazing paddocks. Some type of working corrals is also recommended (livestock panels, metal gates etc.). Another important consideration is where feed will be stored and how it will be fed. Troughs, hay feeders, water source, and mineral feeders need to be available. In times of inclement weather, sheep and goats will need access to barns, sheds or other available shelter. In addition, a working pen is often required when working/managing the herd for vaccinations, deworming, hoof trimming, shearing etc.

Feeds and feeding

Proper nutrition is important for the health and productivity of any sheep/goat operation. These animals should be provided with a balanced ration providing all the nutrients required for efficient growth and development. It is recommended that you follow the National Research Council's nutrient requirement and feed composition tables to balance rations for sheep and goats. Nutrient requirements will differ for herd maintenance, breeding, pregnancy, lactation and for growing lambs and kids. Langston University has an available tool for calculation the requirements for goats at http://www.langston.edu/nutrient-requirementcalculators

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Institute and State University, Virginia State University, and the U.S. Department of Agriculture cooperating. Edwin J. Jones, Director, Virginia Cooperative Extension, Virginia Tech, Blacksburg; M. Ray McKinnie, Interim Administrator, 1890 Extension Program, Virginia State University, Petersburg.

Reproduction

Puberty is defined as when a female reaches sexual maturity and exhibits estrus (standing heat; 5 – 12 months of age) or when a male's reproductive organs become functional, his secondary sexual characteristics develops and he is ready to successfully mate (5 - 7 months). Table 1 has some reproductive facts for sheep and goats. Purebreeding is the mating of males and females from a single breed and is practiced when you are showing or selling breeding stock or if you want to preserve a rare or heritage breed. A crossbreeding system on the other hand is the mating of males and females from different breeds. Crossbreeding is practiced on most farms and promotes hybrid vigor (crossbred offspring are superior to their purebred parents). Sheep and goats are short day breeders (reproductive cycle affected by changing day length), and are usually bred during the fall for subsequent lambing in spring. During the breeding season, one male can breed 20 – 30 females and is typically left with the females for approximately 50 days. Feeding and management during late gestation is critical as 70 % of fetal growth occurs during the last 4 to 6 weeks of pregnancy. In addition, mammary (udder) growth is occurring during this period. Following lambing, it is critical that lambs receive colostrum (first milk rich in antibodies) during the first 24 hours of life. Young lambs and kids will consume milk until weaned (the practice of removing from young the milk diet provided by the mother).

Health

Sheep and goats suffer from similar diseases and are very susceptible to internal parasites. It is recommended that small ruminants be vaccinated against the clostridial diseases (enterotoxemia, bloody scours and tetanus) and a rigid health care plan be put in place working closely with a veterinarian.



Table 1. Reproduction facts of goats and sheep

Trait	Goats	Sheep
Age at puberty		
Male	4 – 6 mos.	4 – 6 mos.
Female	5 – 8 mos.	6 – 9 mos.
Estrous cycle length	21 days (18 – 22)	17 days (14 – 19)
Duration of estrus	12 – 36 hrs.	24 – 36 hrs.
Ovulation	12 – 36 hrs. after estrus onset	24 - 30 hrs. after estrus onset
Length of pregnancy	146 - 155 days	140 – 159 days

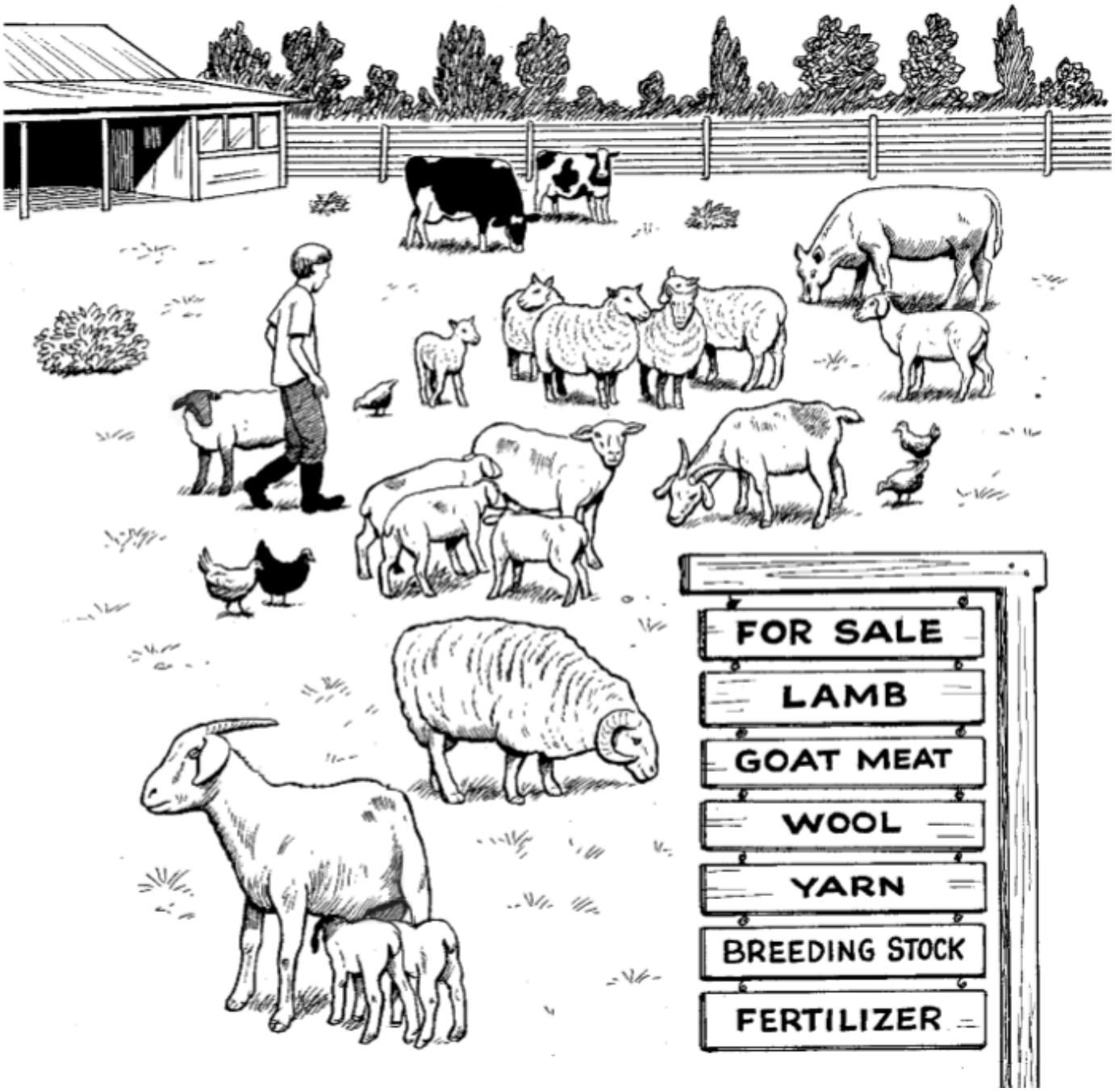
Dr. Dahlia O'Brien, Associate Professor, Small Ruminant Extension Specialist, Virginia Cooperative Extension, Phone: (**804) 524-6963,** Email: **dobrien@vsu.edu,** P.O. Box 9081, Petersburg, VA 23806

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Institute and State University, Virginia State University, and the U.S. Department of Agriculture cooperating. Edwin J. Jones, Director, Virginia Cooperative Extension, Virginia Tech, Blacksburg; M. Ray McKinnie, Interim Administrator, 1890 Extension Program, Virginia State University, Petersburg.

An Illustrated Guide to ATTRA Sheep and Goat Production



A Publication of ATTRA - National Sustainable Agriculture Information Service • 1-800-346-9140 • www.attra.ncat.org

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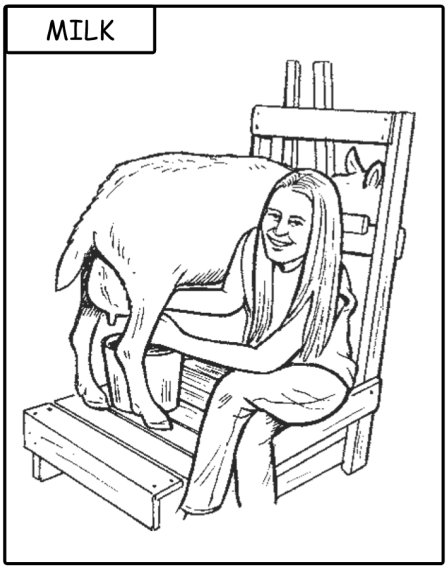
Technology Funding for the Business-Cooperative Service. information on our sustainable

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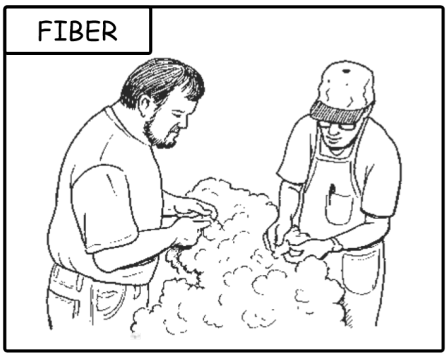
- Meat Goats: Sustainable

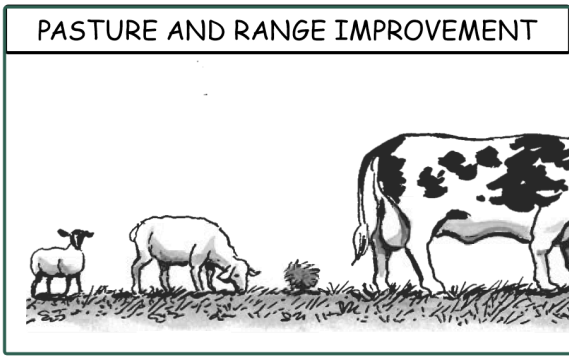
Sheep and goats are versatile animals and can be valuable and enjoyab
many farms.











Following are some things you need to know before adding sheep or go

INTRODUCTION

Related ATTRA Publications

- Goats: Sustainable Production Overview
- Production
- Dairy Goats: Sustainable Production
- Sustainable Sheep Production
- Dairy Sheep
- Small Ruminant

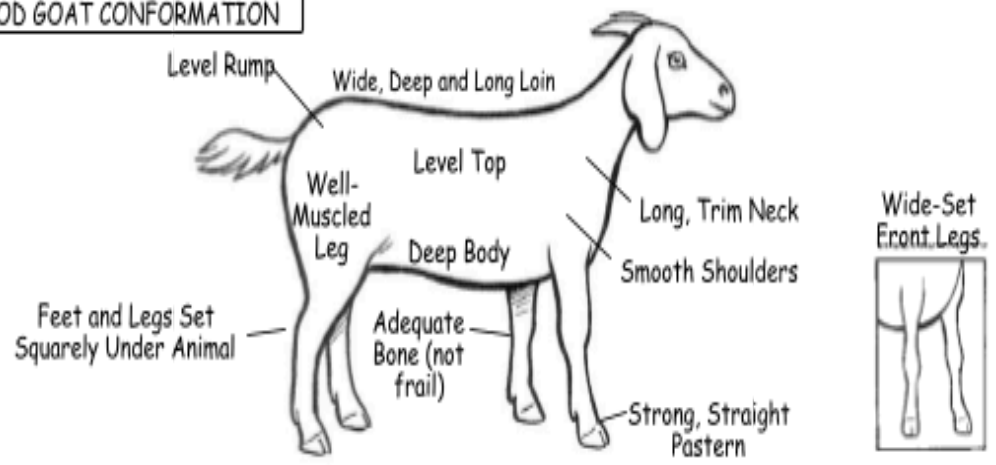
Sustainability Checksheet

- Managing Internal Parasites in Sheep and Goats
- Pasture, Rangeland and Grazing Management
- Ruminant Nutrition for Graziers

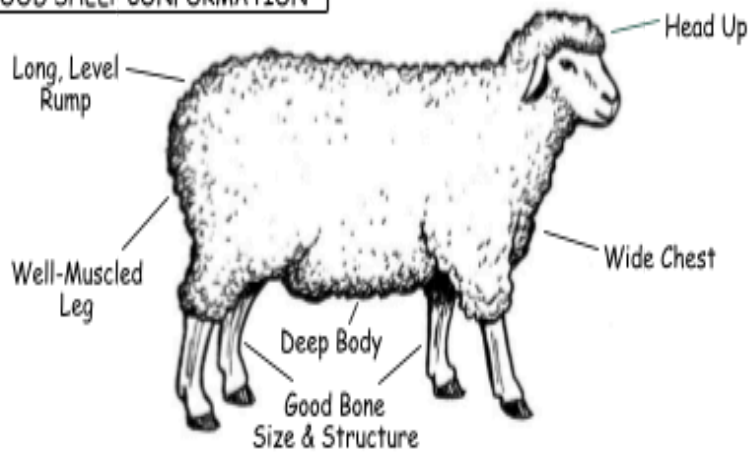
SELECTION

Your sheep or goat business will be much more enjoyable and successful if you begin with healthy animals with proper conformation. These are characteristics you should look for when selecting stock.

GOOD GOAT CONFORMATION



GOOD SHEEP CONFORMATION



Animals with good conformation are:

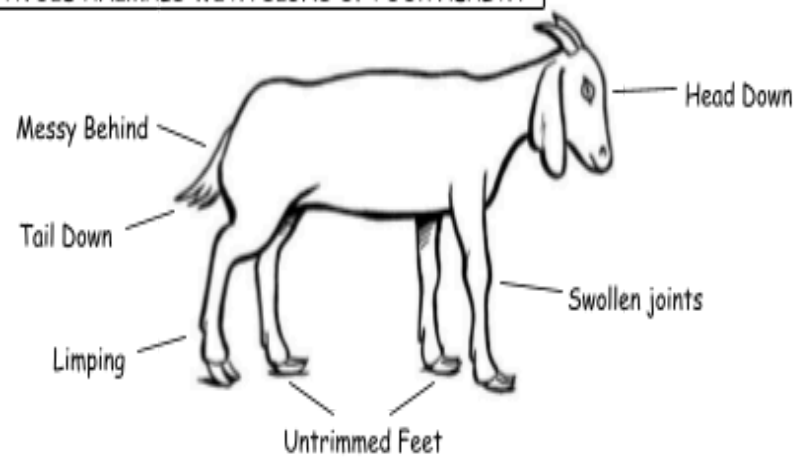
- Strong in structure
- Deep bodied
- Wide chested
- Able to walk squarely on feet and legs

Animals in good health are:

- Robust
- Alert
- Bright eyed
- Lively

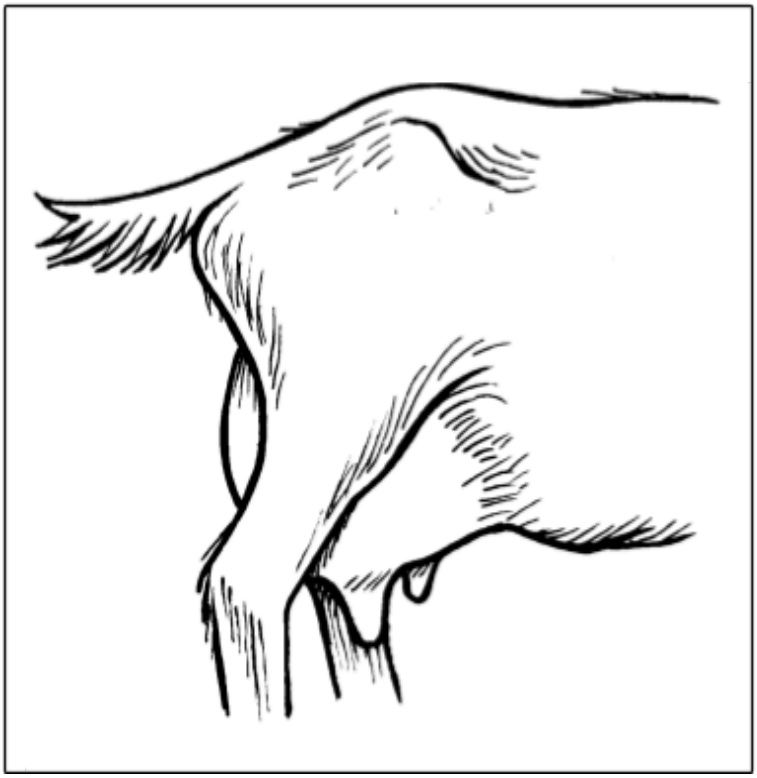
Healthy goats are shiny with a smooth coat and are free of abscesses.

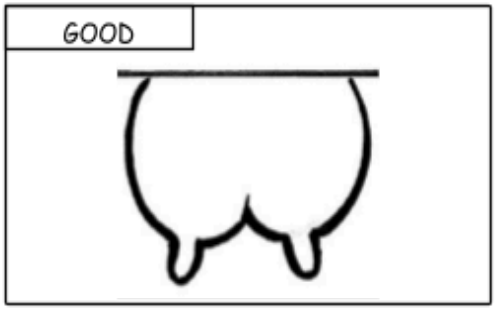
AVOID ANIMALS WITH SIGNS OF POOR HEALTH



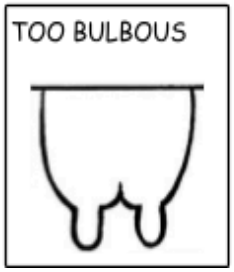
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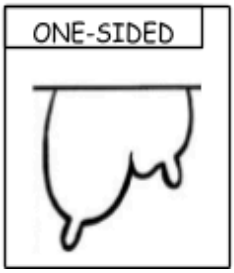
Does and ewes should have a well-balanced udder with two functional teats.



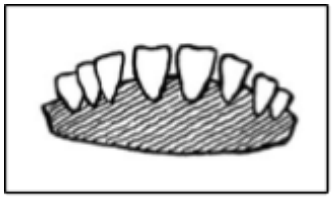


Avoid animals with really small or really large teats. Other udders to avoid:

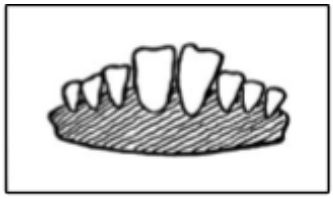




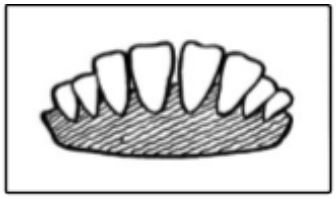
Select animals with good teeth and a proper bite. You can determine an animal's age by looking at its teeth.



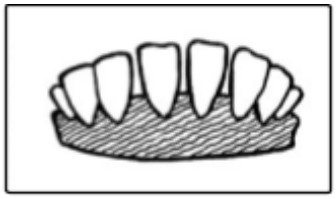
MILK TEETH (Baby Teeth): Less than 1 year of age



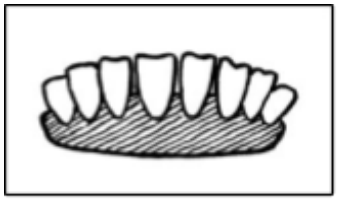
2 ADULT TEETH: 1 Year



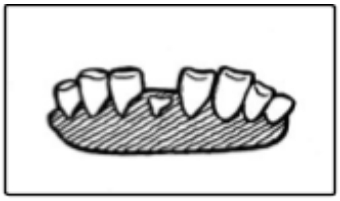
4 ADULT TEETH: 2 years



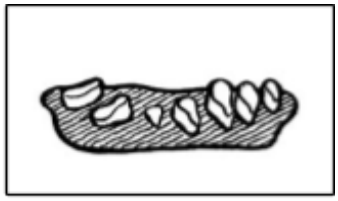
6 ADULT TEETH: 3 years



ALL 8 ADULT TEETH:



WORN MOUTH or



GUMMY: Aged

4 years	BROKEN MOUTH: Over 5 years of age

FEEDING AND PASTURE

- Goats prefer to browse, or eat things such as brush, leaves, and small trees.
- Sheep prefer to eat broadleaf plants (forbs) and grasses.
- Sheep and goats are able to select the most nutritious parts of a plant.

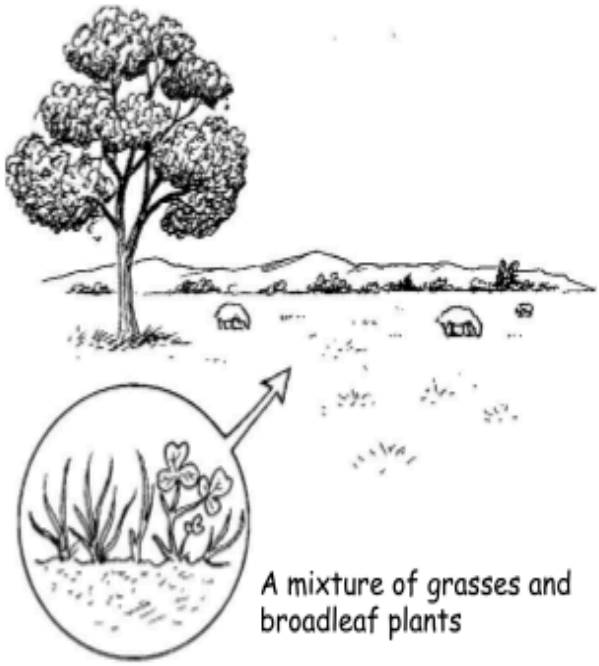
SHEEP GRAZING



GOAT BROWSING



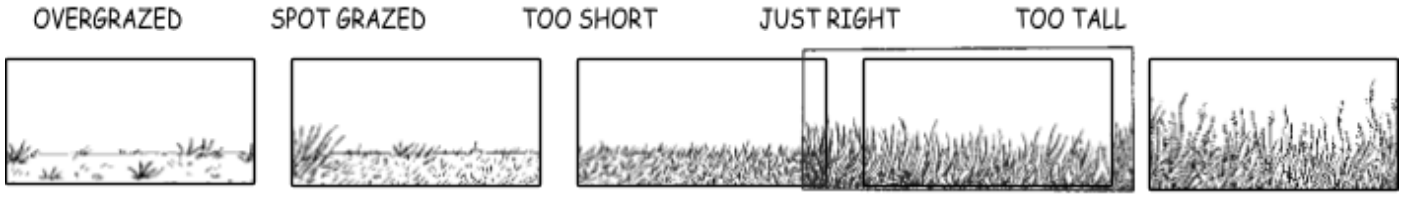
DIVERSE, HEALTHY PASTURE



A mixture of grasses and broadleaf plants

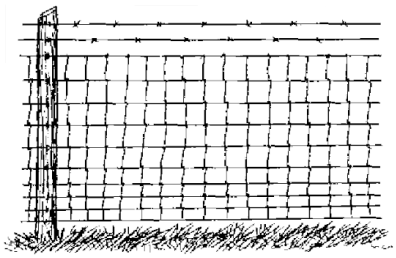
- Sheep and goats like to have a variety of forages to choose from.
- If you provide diverse forages to your animals, they are able to select a diet that meets their nutritional needs.
- It is important to always provide a clean water supply and fresh minerals.

Maintain proper forage height; don't let your animals graze forage under two inches.

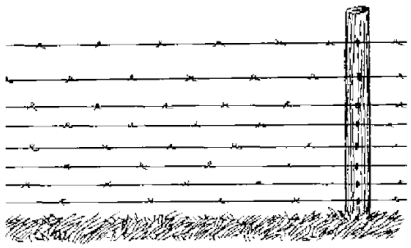


- Proper fencing is necessary for sheep and goat production. You must have adequate fencing in place before getting animals!
- There are many options to keep animals in and predators out.

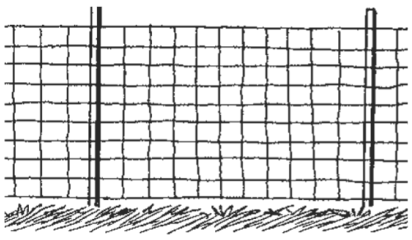
WOVEN WIRE WITH BARBED WIRE



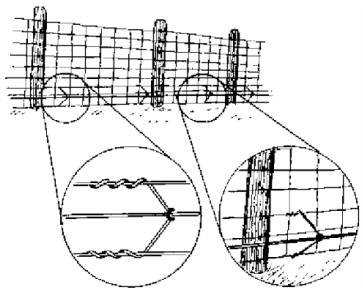
MULTIPLE STRANDS OF BARBED WIRE



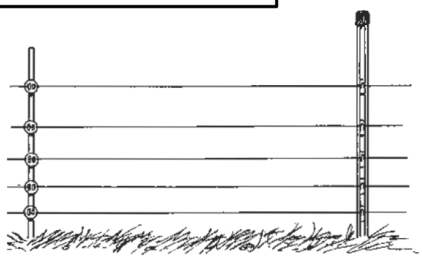
PORTABLE ELECTRIC NET FENCING



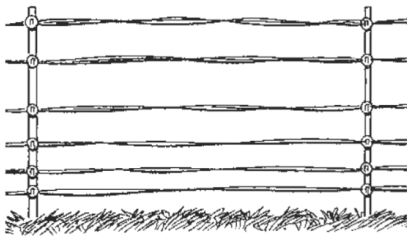
OFF-SET ELECTRIC FENCE



FIVE STRANDS OF ELECTRIC WIRE

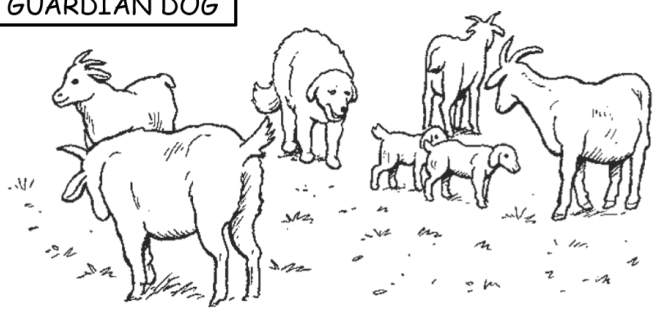


MULTIPLE STRANDS OF ELECTRIC POLYTAPE

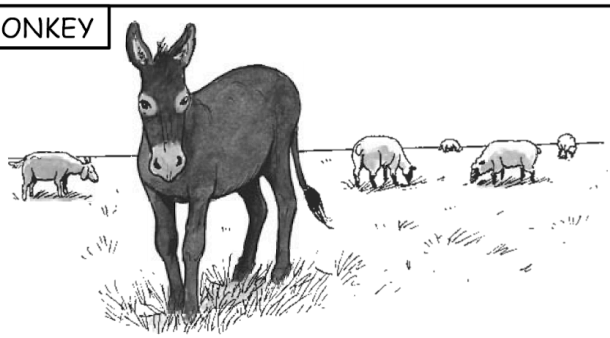


There are many methods for dealing with potential predators.

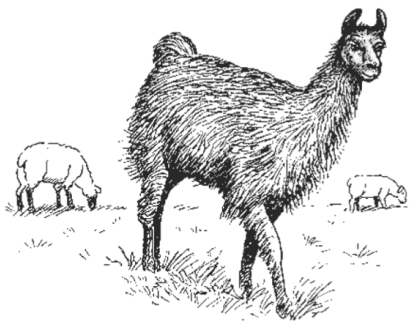
GUARDIAN DOG



DONKEY

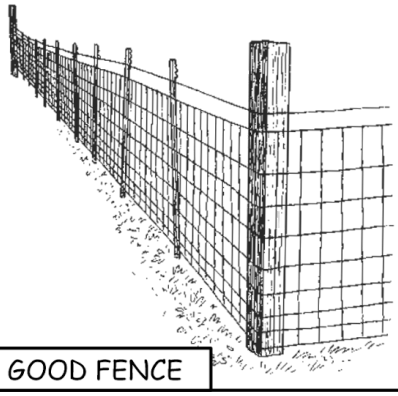


LLAMA



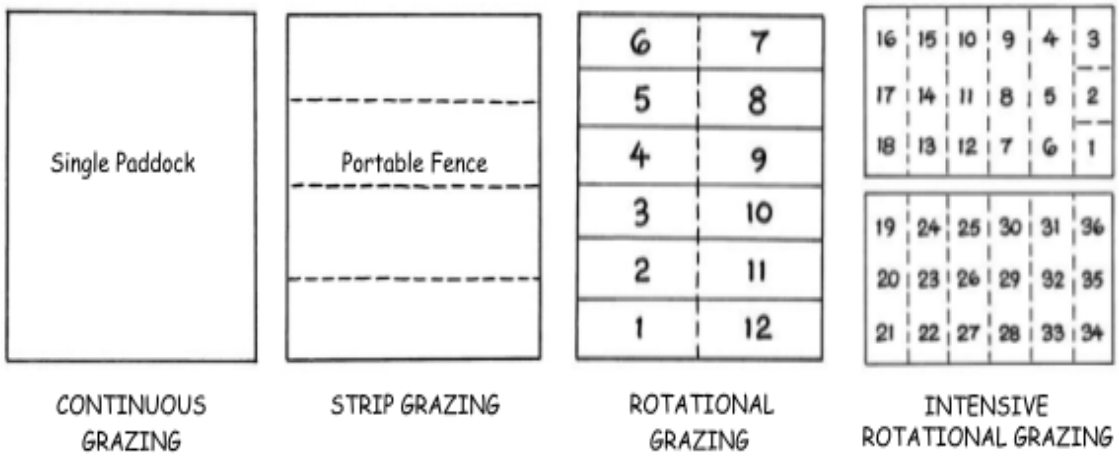


NIGHT PENNING



GOOD FENCE

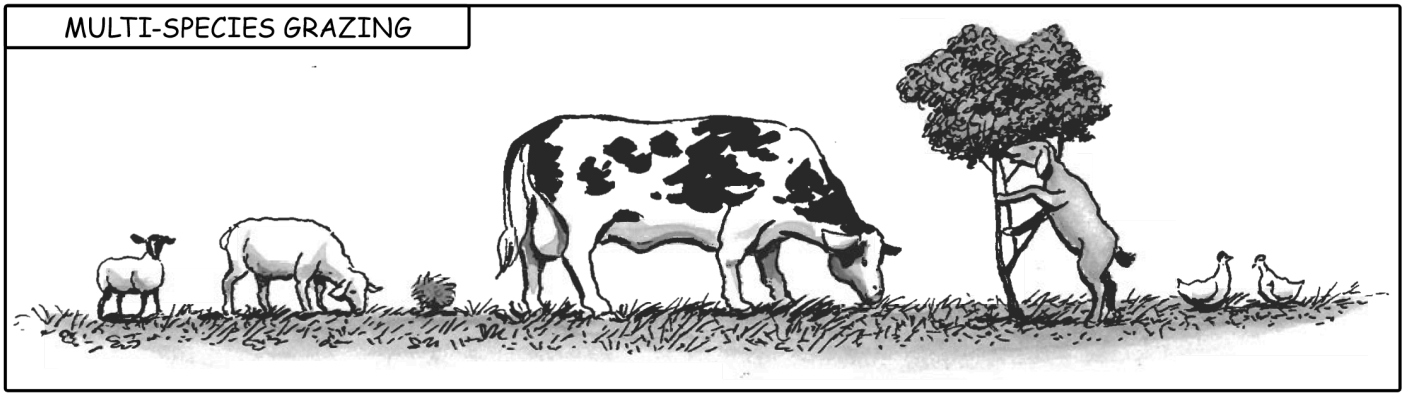
- Allow pastures and forages a time to rest after periods of grazing.
- Having multiple pastures or paddocks (see below) to rotate animals through will use forages more efficiently. Use a combination of permanent and portable fencing to subdivide paddocks. Numbers indicate possible number of paddocks and grazing sequence.



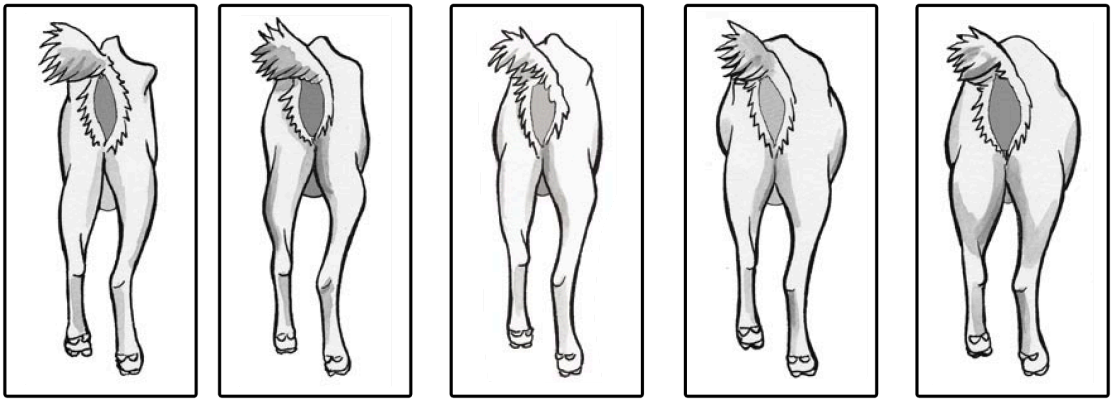
CONTINUOUS GRAZING | STRIP GRAZING | ROTATIONAL GRAZING | INTENSIVE ROTATIONAL GRAZING

- Sheep, goats, and cattle have different forage preferences. The animals won't compete for food, and pastures will be evenly grazed.
- You can run different species together, or you can follow one species with another in a rotation.

MULTI-SPECIES GRAZING

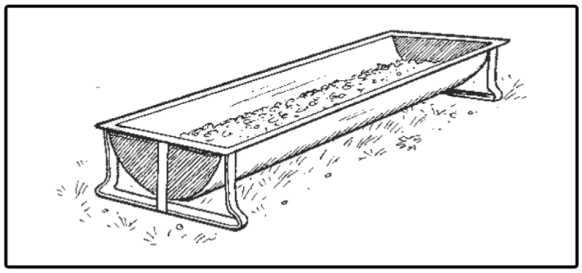


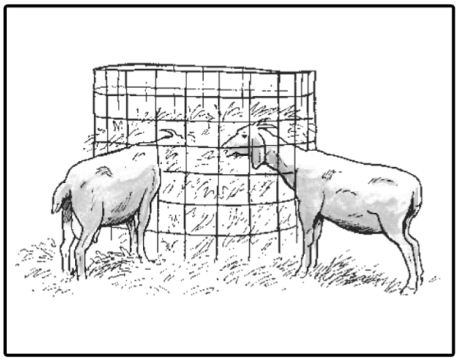
It is important to manage forages so that animals maintain proper body condition. You don't want your animals too fat or too thin. Look at spine, hip bones, ribs, and legs.

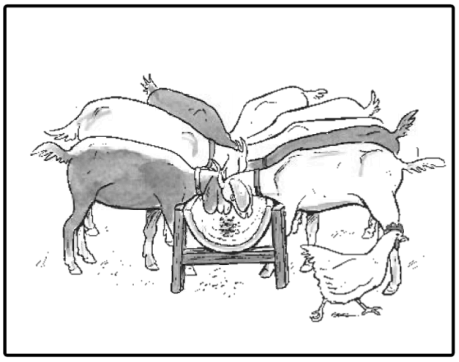


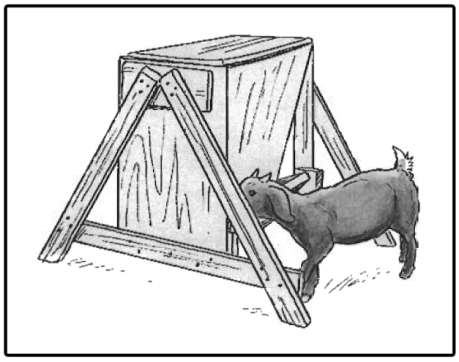
TOO THIN | THIN | SATISFACTORY | SATISFACTORY BUT TENDING TOWARDS FAT | TOO FAT

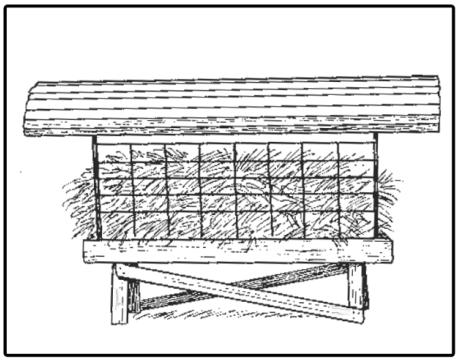
- Occasionally hay or grain will have to be fed. Use proper feeders to keep feed clean and off of the ground.
- Use a hay feeder to reduce waste.
- There are various options for feeders.

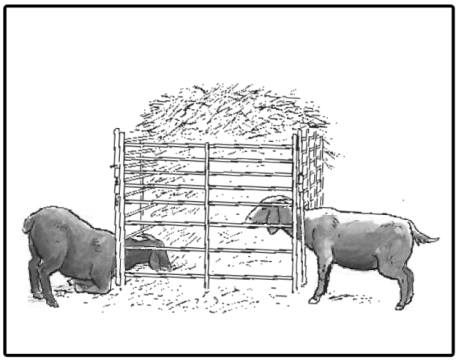


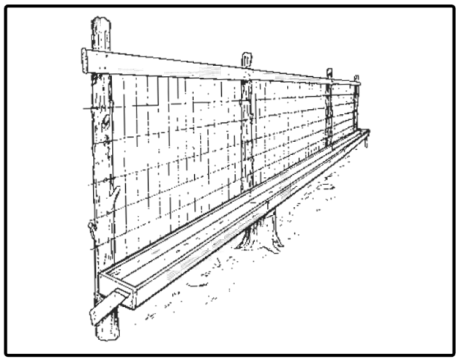












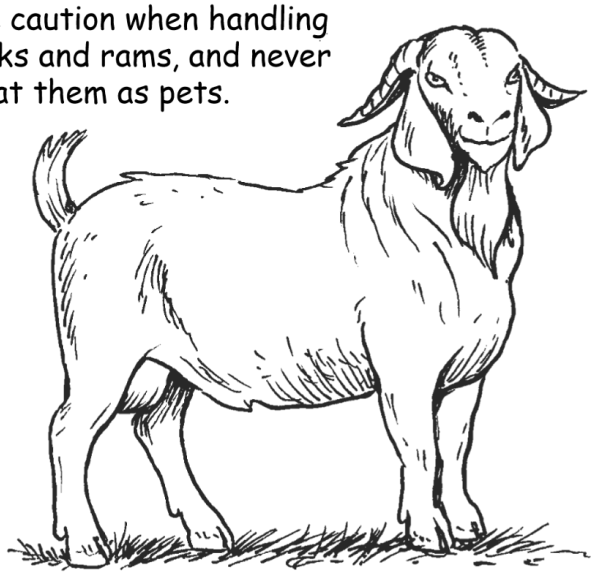
BREEDING AND YOUNG STOCK

The foundation of your herd is the herd sire. It is worth spending money and attention on a good buck or ram.

Selection considerations:
- Fertility
- Health and hardiness
- Adaptation to environment and management
- Internal parasite resistance
- Body type
- Marketing goals

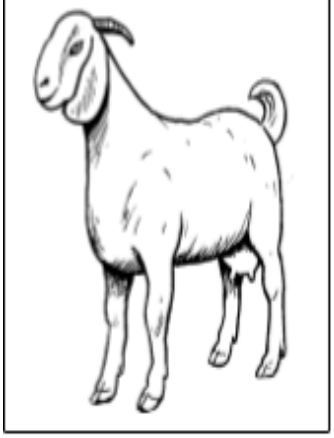
MEAT GOAT BUCK

Use caution when handling bucks and rams, and never treat them as pets.

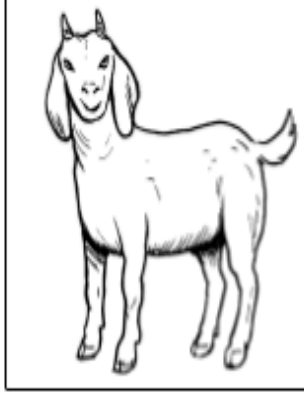


If ewes and does are at least 3/4 of their adult size, they can lamb or kid at one year of age.

FULL GROWN ADULT



3/4 OF ADULT SIZE - MAY BE BRED



1/2 OF ADULT SIZE - DO NOT BREED

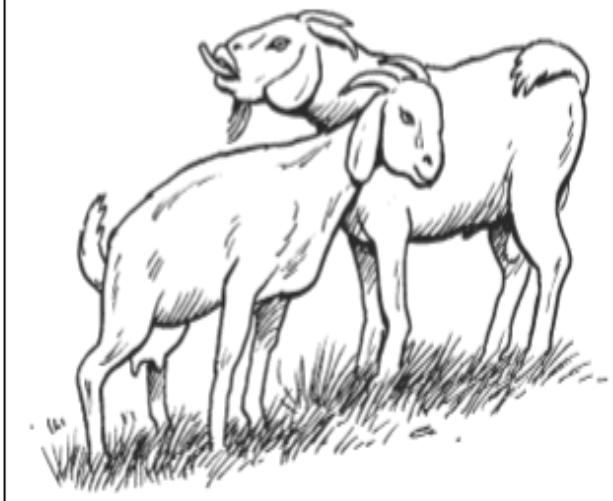


The usual breeding season is August to January. Kids and lambs will arrive five months after breeding.

Turn the buck or ram with the females five months before you want the kids or lambs to be born. Watch the herd or flock and note breeding activity.

CALCULATING DUE DATES	
date BRED	**date DUE**
Jan. 1	May 31
Feb. 10	July 10
Mar. 2	July 30
Apr. 1	Aug. 29
May 1	Sept. 28
June 30	Nov. 27
July 30	Dec. 27
Aug. 29	Jan. 26
Sept. 28	Feb. 25
Oct. 28	Mar. 27
Nov. 27	Apr. 26
Dec. 27	May 26

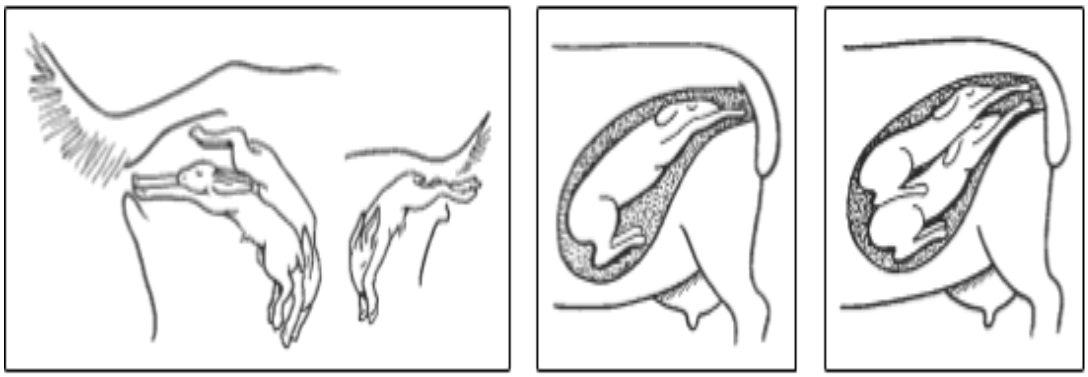
SIGNS OF HEAT



Records are useful for decision-making. Here is an example of a kidding record.

KIDDING						
Animal ID	**Bred**	**Due**	**Kidded**	**No. in Litter**	**Sire**	**Comments**

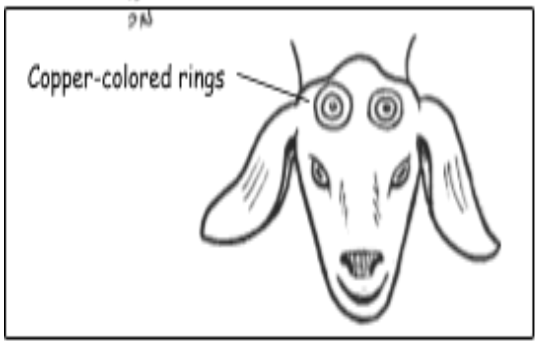
This is how a kid or lamb is normally born. It usually takes about an hour of labor.



Colostrum (the first milk) contains vital antibodies and nutrients. Be sure all kids and lambs receive colostrum shortly after birth. Contact your vet or ATTRA for more information on newborn care.

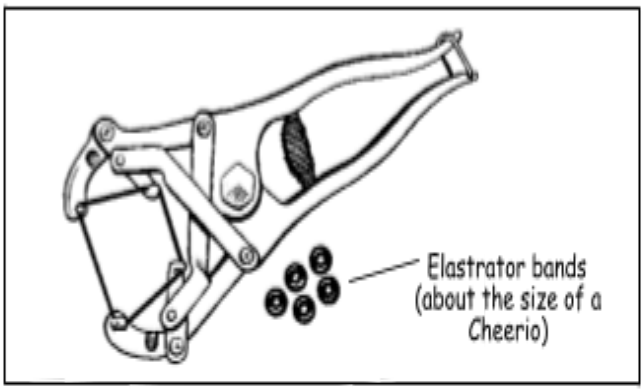
Disbudding dairy goat kids (to be done before 10 days of age):

1. heat iron
2. restrain kid
3. hold hot iron over horn bud as shown for 10-20 seconds.
4. check for copper rings on both horn buds.

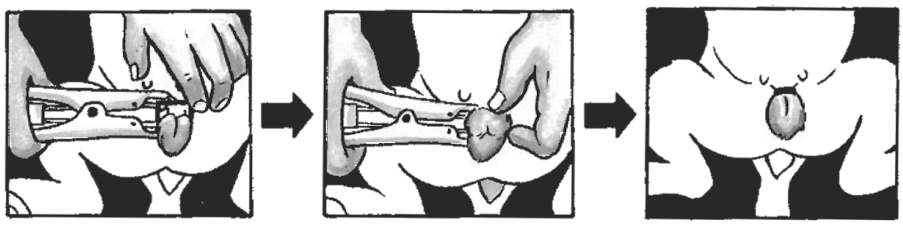




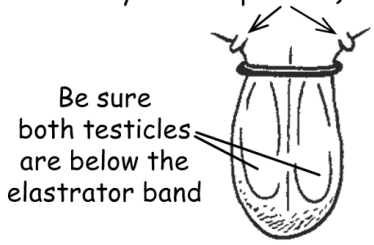
Elastrator tool for docking tails and castrating lambs and kids.



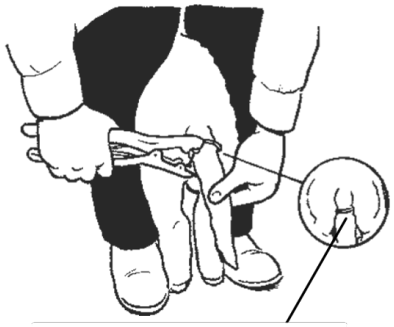
Castrating with elastrator (to be done before 10 days of age).

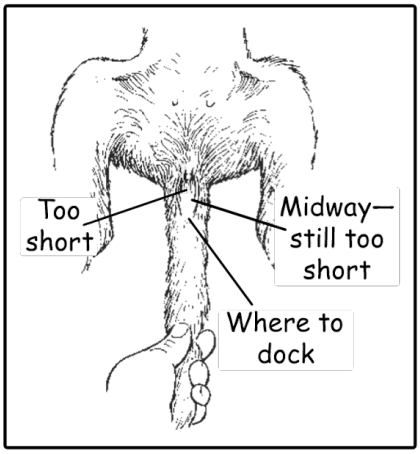


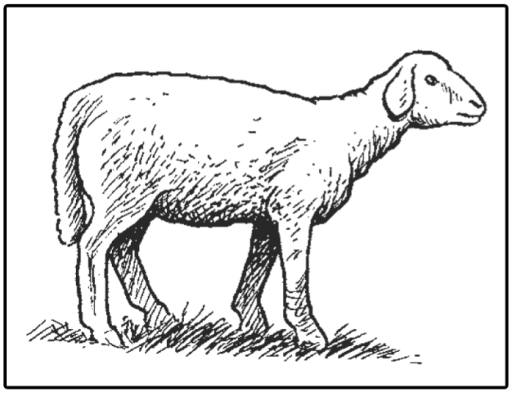
TESTICLES



Docking a lamb's tail with elastrator.

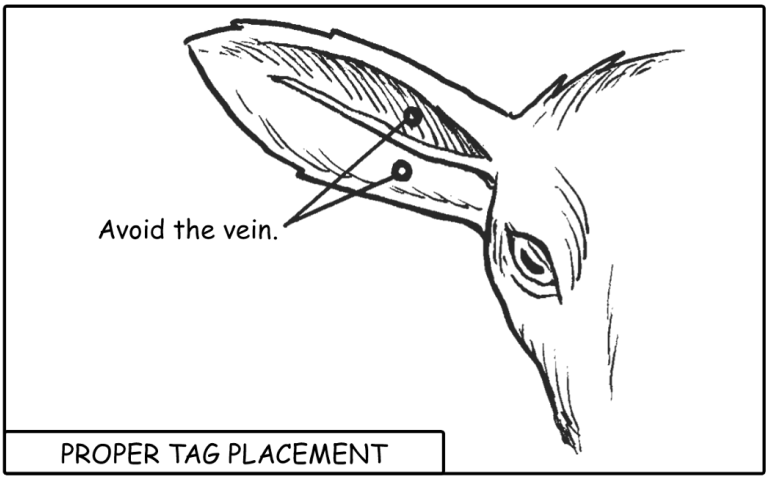




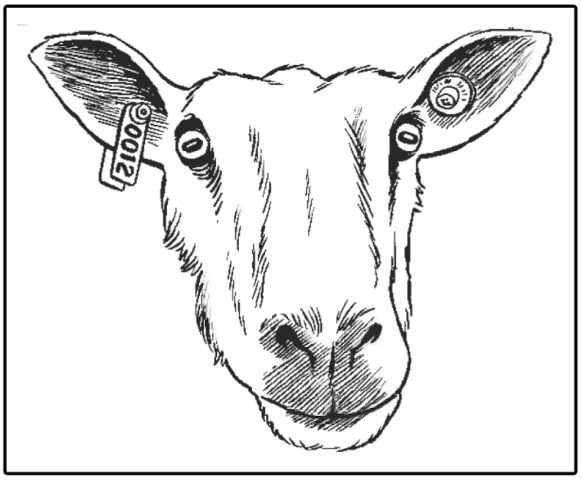


Hair sheep do not need to have their tails docked.

All animals should be permanently identified with ear tags, tattoos, or ear notching.

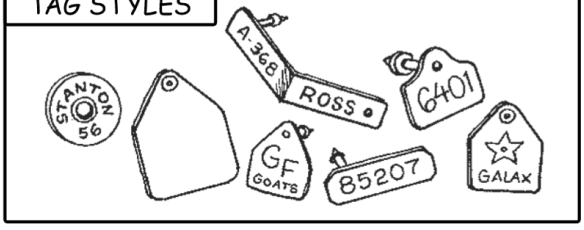


PROPER TAG PLACEMENT



- All states require certain sheep and goats to be officially identified on change of ownership, as part of USDA's Scrapie program.
- Call 1-866-USDA-TAG for information and to request your free tags.

TAG STYLES



HEALTH

- Healthy, productive animals are more profitable and enjoyable to raise. Refer to the *Selection* section for signs of healthy and sick animals.
- It is important to have a working relationship with a veterinarian. A veterinarian can help with prevention, diagnosis, and treatment of disease.

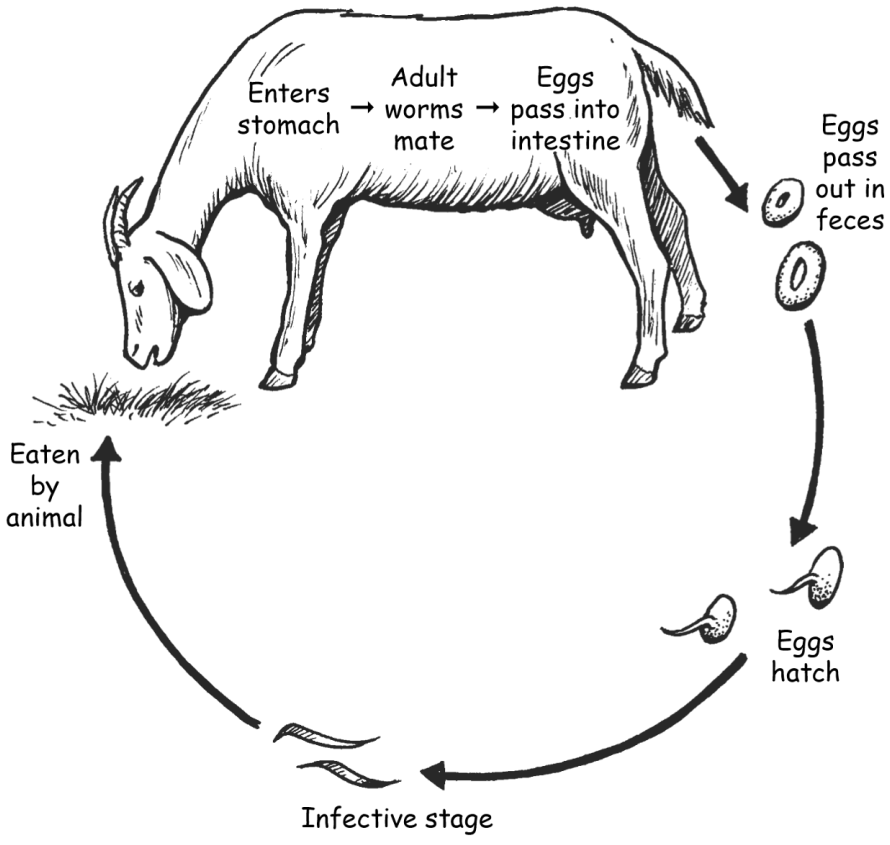


Keep records of health treatments, including day of treatment and withdrawal periods.

HEALTH				
Animal ID	**Date**	**Condition**	**Treatment**	**Comments**

- Internal parasites are one of the primary health concerns for sheep and goat producers.
- Parasite eggs are passed by the animals, and infective larvae are picked up from pasture.

INTERNAL PARASITE LIFE CYCLE



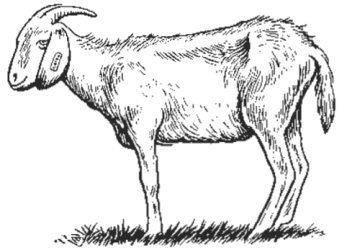
Signs of parasitism include:

- Rough hair coat
- Thin/unthrifty
- Bottle jaw
- Anemia

BOTTLE JAW



ROUGH HAIR COAT, THIN



FAMACHA®



Compare color of eyelid to FAMACHA® card

- FAMACHA® is a tool used to identify anemic animals (a sign of parasitism). By using FAMACHA® producers can identify and treat only the animals that need deworming.
- This system is useful where barberpole worms are the main parasite. Contact your veterinarian to learn more about FAMACHA®. Also see www.scsrpc.org

There are many vaccinations that can be given. The most common vaccinations are CD-T (clostridium/overeating disease and tetanus).

INJECTION SITES



Injection methods

SUBCUTANEOUS

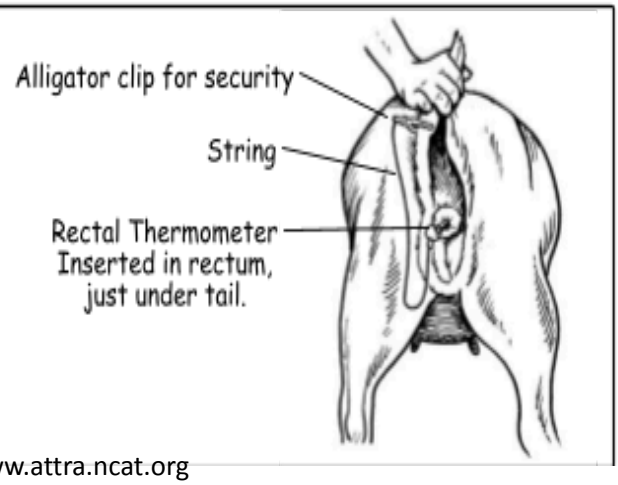


INTRAMUSCULAR



When administering drugs, pay close attention to dosages and withdrawal periods. Most drugs have a withdrawal time for meat and milk.





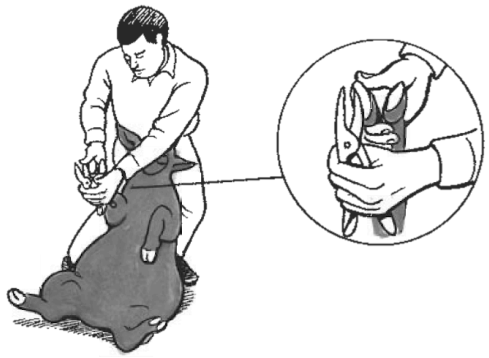
- Knowing how to take your animals' temperature is helpful in determining signs of illness.
- Normal temperature of sheep and goats is 102° F

Occasionally sheep and goats need to have their hooves trimmed. Keeping hooves trimmed helps animals to walk properly and helps prevent other hoof problems such as foot rot.





TRIMMING SHEEP HOOVES



1



Dig dirt out from toes.

2



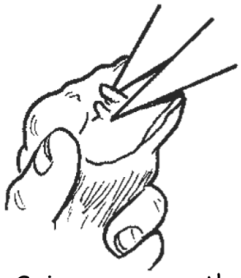
Trim, parallel to hoof hairline, all loose excess nail.

3



Pare heels to same level as toes.

4



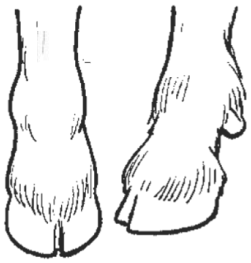
Snip away growth between toes.

5



Pare the soft heel tissue until hoof surface is smooth and flat.

6



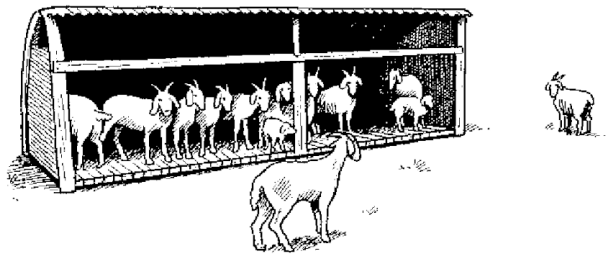
Finished hooves.

- Good health depends on you! To prevent disease, provide:
  - Good nutrition, with plenty of forage
  - Low-stress environment and handling
  - Good pasture management
  - Good sanitation
  - Protection from predators
  - Vaccinations as recommended by your veterinarian.
- Observe your animals and respond quickly to any problems.
- Animals who are poor producers or have chronic health problems should be culled.

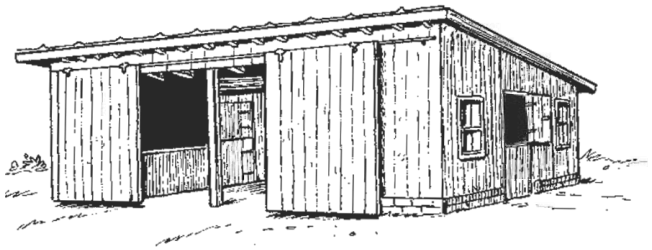
EQUIPMENT AND HANDLING

- Sheep and goats are easy to handle and do not require a lot of equipment.
- You should provide a shelter to protect animals from rain, snow, and cold winds.
- There are many different shelter options, from simple structures to more complex barns.

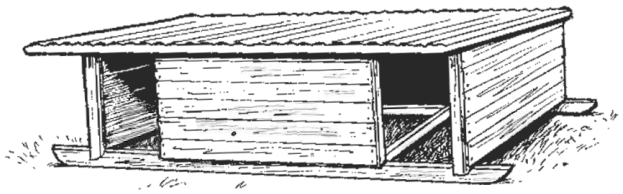
THREE-SIDED SHELTERS WITH OPEN SIDE AWAY FROM PREVAILING WINDS ARE IDEAL.



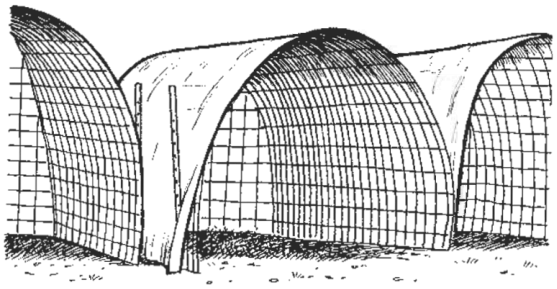
PERMANENT BARN



MOVEABLE SHELTER ON SKIDS



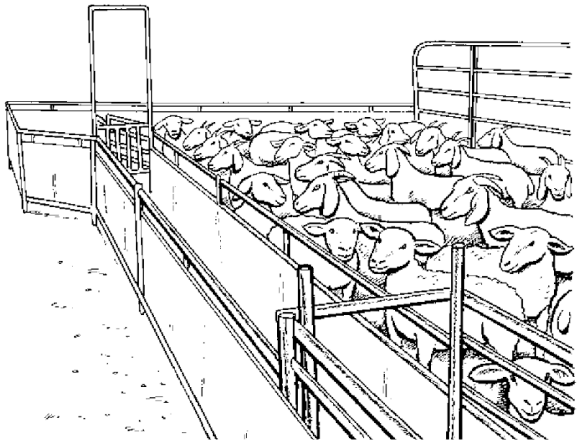
HOOPED CATTLE PANELS WITH TIGHT TARP



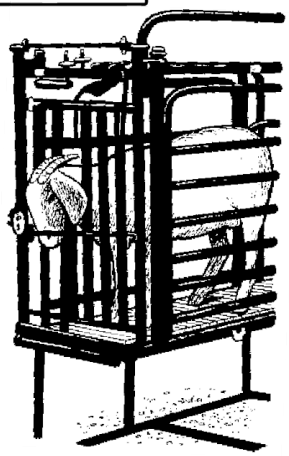
- Clean, dry, well-ventilated shelters help animals stay healthy.
- Moveable shelters help prevent manure buildup in an area.
- Shelters and working facilities can be home built for lower cost.

A catch pen, chute, and head gate are helpful when working with sheep and goats. For very small flocks, a catch pen is sufficient.

CATCH PEN AND CHUTE

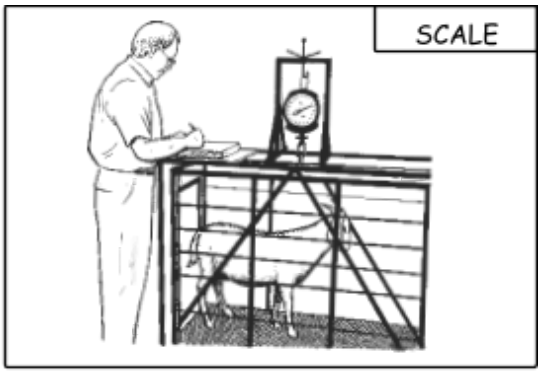


HEAD GATE



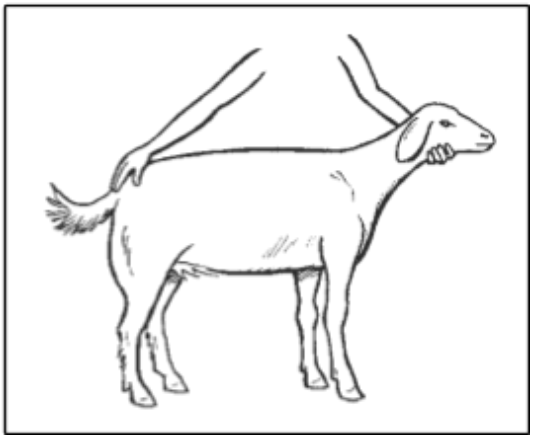
A scale is very useful. Knowing animal weight helps you:

- Monitor animal growth
- Calculate dosages of medications
- Decide when to market animals
- Determine a selling price

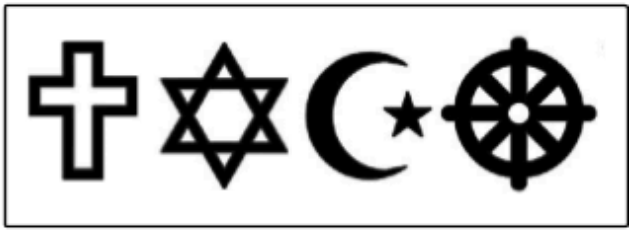


- Sheep can be restrained by setting them on their rump.
- Goats should be restrained by holding them under the jaw and the rump.
- Sheep and goats are easier to control if you keep their heads held high.

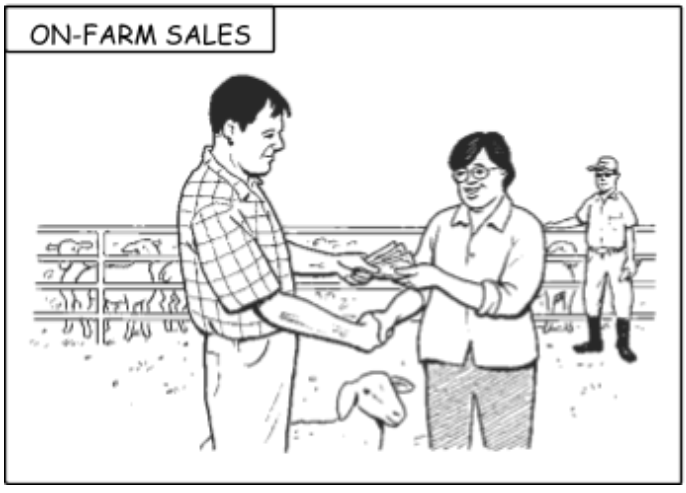


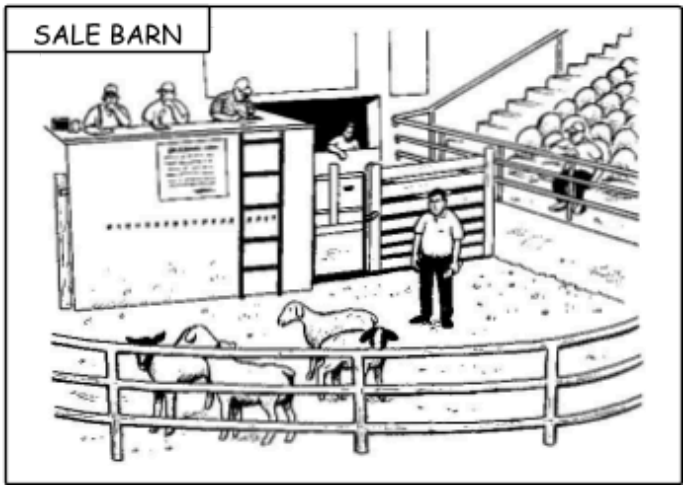


- When marketing sheep and goats, it is important to determine who your customers are and what they want.
- Many religious and ethnic groups prefer lamb and goat.



Explore local options for selling your products. Market options include:

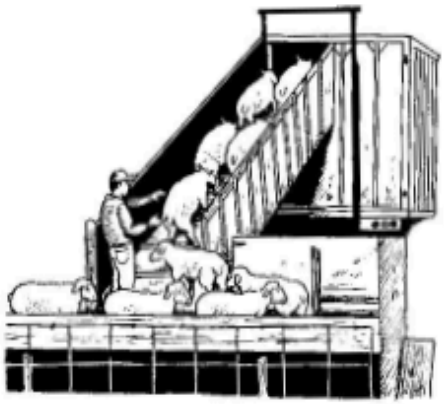




MARKETING

MARKETING continued

COOPERATIVE SALE



Producers pool their animals to sell a large group to a buyer.

WHOLESALE



Selling carcasses to butcher shops and restaurants.

RETAIL



Selling packaged cuts.

GRADED SALE



USDA grader inspects animals. Heavier muscled animals bring a premium.

Other products:

ORGANIC

USDA ORGANIC

You may explore organic sheep and goat production. First determine if there is a market and if organic production would be profitable. Contact ATTRA for more information.

GRAZING SERVICES



Sheep and goats can improve land by controlling brush or invasive weeds. Some landowners are willing to pay for this service.

FLEECE



Wool and mohair can be sold to individuals or to a pooled sale. Higher grade fleeces will bring a better price.

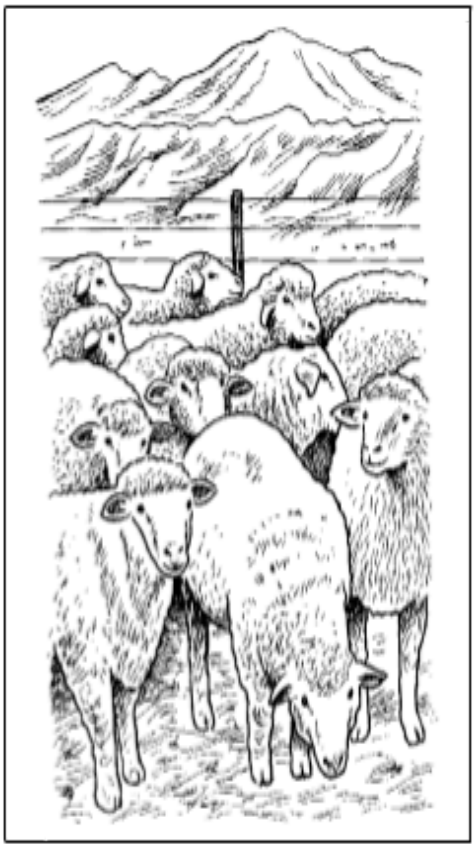
MILK



Rules for selling milk and milk products vary by state.

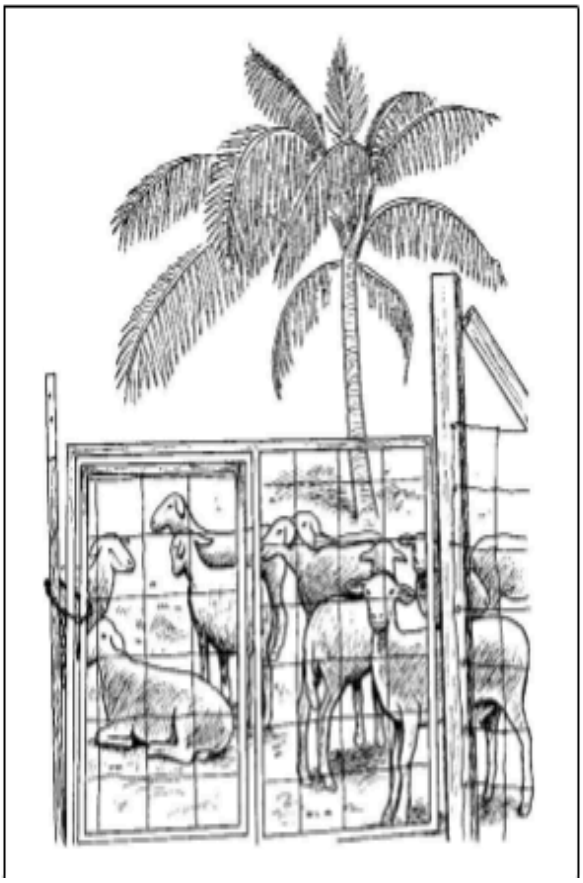
CONCLUSION

Wherever you live, sheep and goats may have a place on your farm. You must first determine the goals for your farm and then explore profitability of the sheep and goat enterprise. To learn more, see the resources listed on the next page.









FINDING OUT MORE: Resources for sheep and goat producers

Call **ATTRA** at 800-346-9140 or visit *www.attra.ncat.org* for free publications about sheep and goat production, pasture management, predator control, internal parasite control, and more.

Your local **Cooperative Extension Service** will often sponsor workshops and seminars to help you learn more. Your local agent can also put you in touch with other producers, inform you of markets in the area, and assist you in learning about regulations that affect your business. If you have difficulty locating the agent, you may call ATTRA (800-346-9140) and we will find the number.

Visit your **public library** and explore the shelves where agriculture books are located. A partial list of useful titles may be found in the ATTRA publication *Small Ruminant Resource List*. You may call 800-346-9140 to ask for a free copy of the list or download it at *www.attra.ncat.org/attra-pub/small_ruminant_resources.html*.

You will also find a wealth of information **online**. The *Small Ruminant Resource List* includes many good websites to explore. There are many training courses and short tutorials available online as well, including:

Maryland Small Ruminant Page
www.sheepandgoat.com

Sheep 101
http://www.sheep101.info/

Sheep 201
http://www.sheep101.info/201/index.html

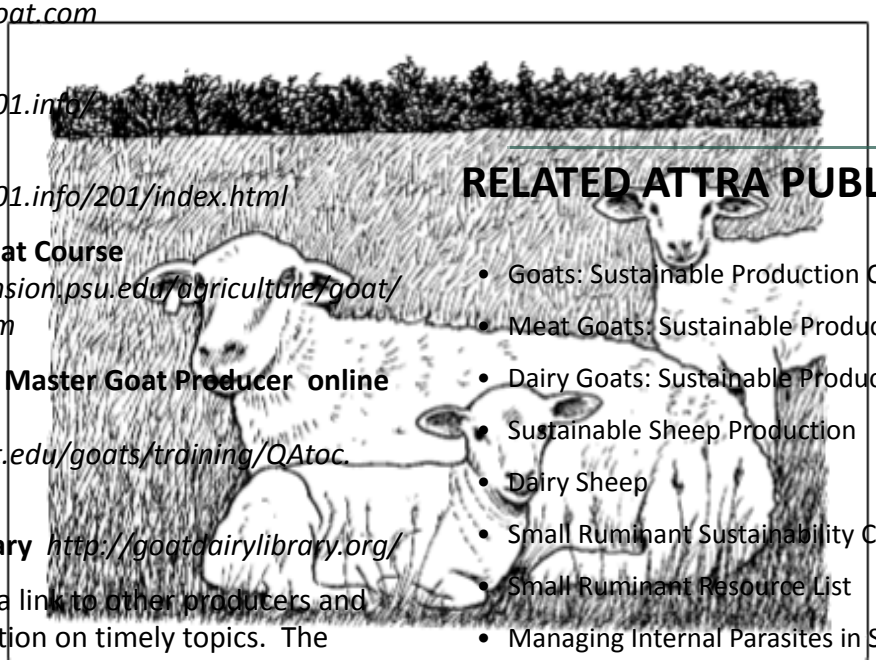
Penn State Meat Goat Course
http://bedford.extension.psu.edu/agriculture/goat/Goat%20Lessons.htm

Langston University Master Goat Producer online course
http://www.luresext.edu/goats/training/QAtoc.html

The Goat Dairy Library *http://goatdairylibrary.org/*

A good **magazine** is a link to other producers and to continuing education on timely topics. The *Small Ruminant Resource List* includes some of the most relevant magazine titles.

Learning from **other producers** is most beneficial. If you have opportunity to visit another farm, you can observe practices that work well, and some that do not: you can ask questions and look at facilities and discuss markets. If possible, it is good to cooperate with others in your area to build a strong network of sheep and goat producers.



RELATED ATTRA PUBLICATIONS

- Goats: Sustainable Production Overview
- Meat Goats: Sustainable Production
- Dairy Goats: Sustainable Production
- Sustainable Sheep Production
- Dairy Sheep
- Small Ruminant Sustainability Checksheet
- Small Ruminant Resource List
- Managing Internal Parasites in Sheep and Goats

- Pasture, Rangeland and Grazing Management
- Ruminant Nutrition for Graziers
- Tools for Managing Internal Parasites in Small Ruminants: Copper Wire Particles
- Tools for Managing Internal Parasites in Small Ruminants: Sericea Lespedza
- Predator Control for Sustainable and Organic Livestock Production
- Pastures: Sustainable Management
- Multi-Species Grazing
- Rotational Grazing
- Paddock Design, Fencing, and Water Systems for Controlled Grazing
- Value-added Dairy Options
- NCAT's Organic Livestock Workbook
- The Organic Chronicles
- Pastures: Going Organic
- Organic Farm Certification and the National Organic Program

Special thanks for review

Jack Black
Joe Black
Dr. Steve Hart
Gary Jones
Bruce Lane
Janice Neighbor

ing this publication to:

Dr. An Peischel
Dr. Charlotte Clifford
Rathert, DVM
Dr. Beth Walker
Stuart Weiss

We would also like to tha nk NCAT staff members
Karen Van Epen, Rex Duf
Lee Ri

An Illustrated Guide to Sheep and Goat Production
By Linda Coffey and Margo Hale
NCAT Agriculture Specialists ©
2008 NCAT

Robert Armstrong, Illustrations Robyn Metzger, Production

This publication is available on the Web at:
www.attra.ncat.org/attra-pub/sheep_illus.html
or
www.attra.ncat.org/attra-pub/PDF/sheep_illus.pdf

IP330
Slot 323
Version 101508

Summary Description for Module 17

Title:	Module 17: Backyard Livestock Demonstration
Instructor(s):	Dr. Dahlia O'Brien-Extentsion Specialist/Small Ruminants
Prerequisites, if applicable:	Not Applicable
Class Time:	9:00AM – 11:30AM & 12:00PM – 3:00PM
Learning Objective:	The objective of this module is to participate in hands-on exercises on backyard livestock including the pre- and post-processing of meat products.
Instructor Media Needs:	None
Class Materials and/or Supplies Needed:	Instructor provided: Live animals for hands-on activities; Processing equipment
Class Activities:	1. Hands-on exercise on chicken processing 2. Hands-on exercise on processing quails 3. Hands-on exercise on processing rabbits 4. Hands-on exercise on eggs handling.
Knowledge Gained:	Students will gain knowledge on how to safely process various livestock products.
Skills Gained:	Students will gain skills on proper handling of various livestock species pre and post processing while following the recommended practices.
Abilities Gained:	Increased knowledge on processing livestock for meat and eggs.
Exam Description:	Increased knowledge assessed by participation and by observation of each step followed in the hand-on exercise.

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Sustainable Urban Agriculture Certification Program

