

VEGETABLE GARDENING

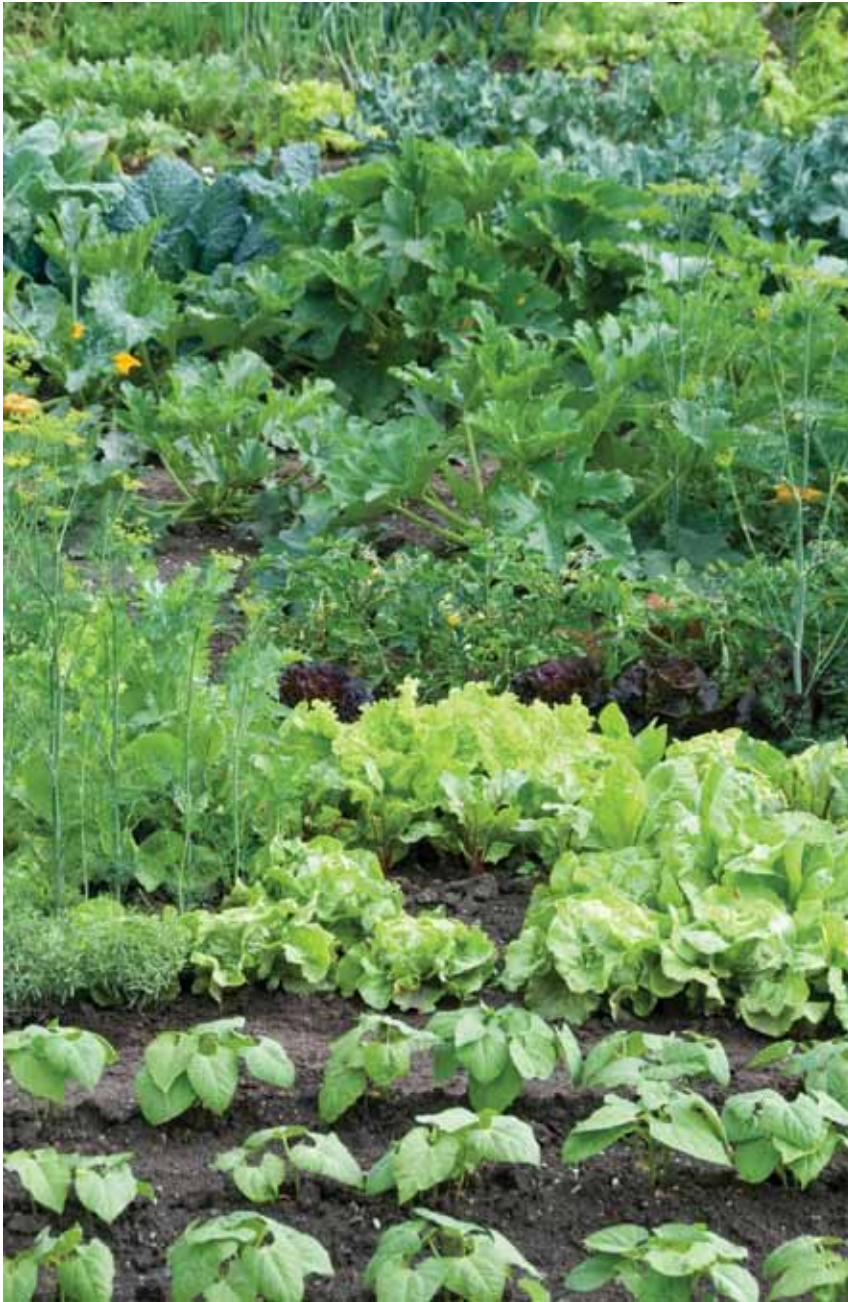
Recommendations for Home Gardeners in Pennsylvania



PENNSTATE



COLLEGE OF AGRICULTURAL SCIENCES



Hello, fellow gardeners!

Gardening has been the number one hobby of Americans for a while, but this year its popularity grew like bamboo. This might have been due to a shift in priorities stimulated by the current economic climate or the establishment of a number of high-profile gardens, like the ones at the White House and United States Department of Agriculture. In my case, my family gardens because you can't beat the taste of a tomato straight from the garden, and don't get me started on how tender the asparagus is! Whether you're new to gardening or have been gardening for as long as you can remember, we put this guide together for you.

Who are "we"? We are extension educators in counties across Pennsylvania and specialists at Penn State in various disciplines related to growing vegetables—basically, we've dedicated our professional lives to these plants. We study them, we experiment with them, we grow them, we help farmers and gardeners grow them, and we eat lots and lots of them. We're the people who say things like, "Well, actually, it's not a cantaloupe; it's a muskmelon and possibly the cultivar 'Athena'," at 4th of July picnics or, "Did you know that potatoes are actually underground stems?" at Thanksgiving dinner. We put this guide together to pass on some of this information to you. It's packed full of information about growing vegetables—from selecting the best site for your garden to harvesting your vegetables. We hope you enjoy this guide as much as we enjoy sweet bell peppers, garlic, zucchini, pumpkins, lettuce, kohlrabi, rutabaga. . . .

—*Elsa Sánchez, Associate Professor of Horticultural Systems Management*

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SELECTING A GARDEN SITE



Choose the site for your garden carefully. The garden site will affect all other gardening practices, so select the best site possible to grow healthy plants. When deciding on a site, consider exposure to sunlight, soil type, and pesticide contamination.

Exposure to Sunlight

Vegetables need sunlight in order to grow well and produce large yields. A good site receives a minimum of 6 hours of full sun each day, with 8–10 hours being ideal. Consider shading from buildings, fences, trees, and shrubs when selecting your garden site. Vegetables do not compete well with trees or other plants for sunlight, moisture, and nutrients. When selecting a garden site, avoid the vicinity of large trees, even if the vegetables would not be shaded to any great extent. Sites with southern exposures are generally warmer than those with northern exposures.

Soil

Soils are made up of different particles called sand, silt, and clay. Sand makes up the largest of these particles (0.05–2.0 millimeters in diameter), followed by silt (0.05–0.002 millimeter in diameter), and clay makes up the smallest particles (less than 0.002 millimeter in diameter). Most soils are made up of a combination of sand, silt, and clay, which affects soil drainage, structure, and fertility.

Pick a site with good drainage. This is important for promoting good root growth and avoiding plant diseases, particularly root rots. Soil type affects drainage. Heavy clay soils are slow in drying out and are difficult to cultivate and work properly. Extremely sandy soils may lack organic matter and may dry out too rapidly between watering. The best soil is between these two extremes. The exact type of soil, however, is not as important if it is well drained, adequately supplied with organic matter, and retains moisture. One strategy for selecting a site is to avoid areas where water pools for long periods of time.

Adding organic matter in the form of decaying plant or animal material effectively improves soil structure. When incorporated into soil, organic matter acts to:

- Increase the ability of soil to hold water and tiny particles of clay apart so they can drain out excess water more easily
- Provide clay soil with needed pore space, which lets in air essential to good plant growth
- Prevent tiny particles of clay soil from cementing themselves together and, therefore, becoming more easily penetrated by plant roots
- Fill in excess pore space of sandy soil, thus slowing down drainage and increasing the ability to hold water
- Moderate soil temperature
- Release nitrogen and other nutrients for plant use through the process of decay
- Increase the cation exchange capacity of soil—specifically, calcium, potassium, and magnesium—so that soils can hold and release more nutrients

- Buffer soil to reduce stresses such as drought on plant growth
- Provide a food source for the soil microorganisms that improve overall soil properties

Heavy soils low in organic matter and soils containing large amounts of very fine clay tend to harden and crust on the soil surface. Clay soils are resistant to changes in their structure; however, incorporating coarse sand or organic matter may improve a small area. You can work an inch or two of coarse sand or organic matter into the soil in any one year. Sand improves soil drainage and workability of clay soils, but beyond that it is of limited value compared to organic matter.

Sources of organic matter include manure, compost, peat moss, spent mushroom substrate, and sawdust. Organic matter can be produced in the form of winter cover crops, such as hairy vetch or winter rye; green manure crops, such as vetches or clovers; or sod when the land is not used for gardening. A legume-grass mixture, such as rye and hairy vetch, is an effective green manure crop for improving soil.

Select a spot with good fertility. Perform a soil test to more accurately determine the fertility status of the soil (discussed further in later sections). If other plants are growing healthily in the site, it likely has good fertility.

Pesticide Exposure

Some sites have a greater chance of contamination from pesticides than other sites. It's best to avoid those sites. For example, if your neighbor's lawn is free of weeds while yours has dandelions, this might be an indication that your neighbor is using an herbicide. In that case, avoid planting near the property border shared with your neighbor. Also, avoid rights-of-way where power lines are located and locations near railroad tracks or highways since these areas are generally sprayed annually with persistent herbicides.

Rotate the location of the garden every few years when space is available. This will help improve the condition of the soil and avoid plant diseases. At the very least, you will want to rotate among plant families within the garden.

For more information on plant families, see "Plant Rotation in the Garden Based on Plant Families" at consumerhorticulture.psu.edu/file/plant%20families.pdf.



PREPARING THE SITE

**“A NATION THAT
DESTROYS ITS SOIL
DESTROYS ITSELF.”**

— FRANKLIN DELANO
ROOSEVELT



Fall is the most desirable time to work the soil when sod is going to be turned under. This allows more time for the sod to decompose during fall and early spring and results in better conditions for garden plants. If sod is not planted on the site, work it during fall or early spring. Several advantages exist for preparing the site in fall. You may be able to plant earlier in spring because the soil is basically ready; organic matter that is added in fall will have had more time to decay; and other soil amendments such as lime, sulfur, and rock phosphate have more time to react with soil particles. In addition, insects and disease-causing organisms may be killed when exposed to harsher soil environments or being buried. If the garden is on a sloped area, consider working soil in the spring or planting a fall cover crop. If soils on sloped sites are left bare over the winter, erosion and/or runoff can occur, which can have negative consequences for the garden soil and possibly



result in broader environmental concerns such as contamination of groundwater with nitrogen and/or phosphorus.

Whether you choose to prepare the garden in fall or spring, do not work soils unless they are sufficiently dry. To determine if soil is sufficiently dry, press a handful of soil tightly in your hand. It should readily crumble when released if it is sufficiently dry; if it forms a compact, muddy mass, it is too wet to be worked. Heavy clay soils that are worked when they are wet lose their crumbly texture, become hard, compact, lumpy, and, consequently, unproductive. Several seasons of careful handling are often required to restore such a soil to normal condition and production.

Many gardeners choose to work the soil using a rototiller. If the area is smaller, you can also effectively use a shovel. Regardless of what equipment you use to prepare the soil, consider soil tilth, or the physical condition of the soil. Each soil has characteristics that determine the tilth best suited for planting. No soil should be worked to a fineness that will result in crusting of the soil surface after rain events or watering. Leave some heavy garden soils (those high in clay) comparatively rough and cloddy to promote aeration and water movement and reduce crusting of the soil surface.

Soil Testing

Soil is the foundation for growing plants. Plants will thrive in a good soil and struggle in a poor soil. In order to treat your soil well, you need to learn as much about it as possible. One of the best ways to learn about your soil is by testing it. Soil testing can provide information about the soil pH, nutrient levels, ability to hold nutrients, organic matter content, and soluble salt levels. Using the unique results from your soil test, recommendations are provided for adjusting pH and nutrient levels, depending on who performs the soil testing. You can purchase soil testing kits from your local county cooperative extension office or garden supply center. We recommend testing your soil at least every 3 years.

For more information on soil testing, see “Don’t Guess . . . Soil Test” at consumerhorticulture.psu.edu/files/dont%20guess%20soil%20test.pdf.

Adjusting Soil pH

Soil pH is a measure of how acidic or alkaline a soil is. In general, vegetables grow best with a soil pH between 6.0 and 6.5. Soil test results may indicate a need for a liming material if the pH is lower than 6.0. Whenever possible, apply a liming material during fall before planting to provide several months for these materials to begin reacting with soil particles. Liming materials include limestone (dolomite or calcitic) and wood ashes. If soil test results indicate that the soil pH is above optimum, it will need to be lowered. Some materials for lowering soil pH include sulfur, peat moss, and cottonseed meal. For large areas, sulfur is likely the most economical option. Sulfur reacts slowly with soil particles; therefore, allow several months for changes in soil pH to occur after applying it. Whenever possible, apply sulfur well in advance of planting to provide sufficient time for reaction with soil particles.

Organic Matter Content

The organic matter content of a soil can be analyzed as an additional test when submitting a soil sample through Penn State. Most vegetables grow best in soils with organic matter contents between 2 and 5 percent. As detailed in the Selecting a Garden Site section (page 2), organic matter has many benefits. If the organic matter content of your soil is below 2 percent, consider adding amendments to your soil to increase the organic matter content.

Soluble Salt Levels

A soil's soluble salt level can also be analyzed as an additional test when submitting a soil sample through Penn State. High soluble salt levels (beginning at below 0.40 millimhos per centimeter for some salt-sensitive vegetables) can be harmful to plants. If your garden site is exposed to rainfall and snow, the soluble salt level is not likely to be damaging to plant growth. However, if you are using a protective structure, like a high tunnel, soluble salts levels can become high enough to harm plants. If levels get too high, there are options for decreasing them. Check with a Master Gardener in your county if you are in this situation or see "Dealing with High Soluble Salt Levels in High Tunnels" at horticulture.psu.edu/cms/files/gazetteJul2009.pdf.

For more information on gardening in high tunnels, see "Extending the Gardening Season with High Tunnels" at consumerhorticulture.psu.edu/files/hightunnels.pdf.

Adjusting Soil Nutrient Levels

You will need fertilizers or soil amendments to replenish nutrients depleted from a soil. Vegetables remove nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) from soil in quantity. You will most likely need to replenish these five nutrients, which are the chief ingredients of fertilizers.

Organic Fertilizers and Soil Amendments

Organic fertilizers include all kinds of animal manures, composts, and other plant or animal products. Examples are bone meal, blood meal, and soybean meal.

Many local municipalities have composting facilities where composts can be obtained for a nominal fee or, in some locations, for free. You can also purchase composts from garden centers. Making your own compost is a great option, if you have a location to do it, because you can control what makes up the compost. For more information on making your own compost, see "Home Composting: A Guide for Home Gardeners" at consumerhorticulture.psu.edu/files/home_composting.pdf.

You can also improve the soil by growing green manure crops. Green manure crops are plants you incorporate into the soil before or just after they begin flowering, while they are still young, green, and succulent. As they break down, nutrients are released into the soil that can be used by subsequent plants grown in the site. Many types of green manure crops are available and can be used for different purposes, including adding nitrogen to the soil, increasing the soil organic matter content, suppressing weeds, and scavenging soil nutrients.

Fresh manures can be tricky to use because they can contain high nitrogen and salt levels, which can negatively affect plants. Additionally, disease-causing organisms can be present in manures, which can contaminate edible products



from the garden. For these reasons, use caution when using manures. When organic farmers use fresh manure, they must incorporate it into the soil a minimum of 120 days prior to harvesting crops with the edible portion in contact with the soil (e.g., watermelon or squash). If they are growing crops that do not have the edible portion in contact with soil (e.g., peppers or staked or caged tomatoes), they must incorporate manure into the soil a minimum of 90 days prior to harvest. Organic farmers cannot use sewage sludge. These are also good guidelines for gardeners using manure.

—Advantages of Organic Fertilizers

Organic fertilizers are less caustic and will cause less burning of plants than inorganic fertilizers if used in large applications. Nutrients in organic materials are more slowly available to plants, which means that they are available to the plant for a longer time.

—Disadvantages of Organic Fertilizers

Organic fertilizers are typically more expensive than inorganic types. Organic materials alone are not balanced sources of plant nutrients and their analysis in terms of the five major nutrients is generally low. Nutrients in organic fertilizers are in an insoluble form and are only made available to plants as the material decays in the soil. When organic materials low in nitrogen are added to the soil, plants and decomposing microorganisms compete for soil nitrogen. This competition can sometimes adversely affect plant growth.

Inorganic Fertilizers

Inorganic fertilizers include various mineral salts that contain plant nutrients in combination with other elements. Except where heavy applications of manure are made, a mixed fertilizer containing N, P, and K will best fit garden needs. The fertilizer analysis is the percentage of N, phosphate (P_2O_5) and potash (K_2O) of a material and is found on the fertilizer container. Various fertilizer analyses suitable for general garden use are 5-10-5, 5-10-10, 8-16-8, and 8-24-8. Special, highly water-soluble, high-phosphate materials such as 11-52-17 and 10-55-10 are also available and highly recommended as starter solutions for transplants.

Unmixed fertilizers that carry only one element are also available. Most important of these unmixed materials are nitrogen and phosphate

carriers. Nitrogen carriers vary from 16 to 45 percent nitrogen.

Phosphate fertilizers carry only phosphorus, which promotes flower, fruit, and seed development. It also strengthens plant stems and stimulates root growth.

Potassium (potash in fertilizer) contributes heavily to the growth of root vegetables. It also has a stimulating effect on plant vigor and health.

—Advantages of Inorganic Fertilizers

Nutrients in inorganic fertilizers are in soluble form—most commonly, and therefore are available to plants quickly rather than long lasting. Chemical fertilizers are relatively high in terms of nutrients they contain; thus, you need to add only a small amount to the soil to provide the needed nutrients. Inorganic fertilizers are usually more economical than organic ones.

—Disadvantages of Inorganic Fertilizers

Since relatively small amounts of inorganic fertilizers are needed to provide adequate plant nutrients, they tend to be overapplied. Soluble nutrients in concentrated solution are caustic to growing plants and can cause injury when overapplied. Some nutrients in inorganic fertilizers are very soluble and move with the soil water; therefore, they can be lost from the plant root zone by leaching and have negative environmental consequences.

You can purchase fertilizers at garden centers or through gardening catalogs. If you are interested in organic fertilizers, ask personnel in your gardening center which products are used in organic farming. Gardening catalogs will typically identify a product as allowable in organic farming.

You can also plan plant rotations that more efficiently use nutrients in the soil. Rotate plants that are heavy nitrogen users (e.g., lettuce, cauliflower, sweet corn) with plants that can add nitrogen to the soil (e.g., beans, peas). Another strategy is to rotate plants that use a large amount of different nutrients. For example, melons are heavy users of phosphorus, while garlic uses potassium heavily. Another strategy is to rotate deep-rooted plants (e.g., potatoes) with shallow-rooted plants (e.g., onions).

For more information on plant rotations, see “Plant Rotation in the Garden Based on Plant Families” at consumerhorticulture.psu.edu/files/plant%20families.pdf.

MULCHING

Broadly speaking, a mulch is any material applied to the soil surface that protects plant roots from temperature extremes or drought or keeps fruit clean. Select a specific mulching material based on particular properties that enable it to create a more favorable environment for the plant. Although higher yields often result from the use of mulch, equivalent or lower yields may also occur under some circumstances. Such factors as the type of vegetable, time of year, soil type, rainfall, and soil and air temperature can all influence a plant's response to mulching. Remember, better growth and higher yields will only result when mulches improve the environment in which a plant is growing.

A mulch will:

- Conserve and maintain uniform moisture
- Help manage weeds
- Help prevent erosion
- Help prevent soil compaction and crusting
- Keep fruits from direct contact with the soil, thus minimizing fruit rots
- Affect soil temperatures; porous mulches generally reduce soil temperatures, and most nonpermeable mulches increase soil temperatures

Organic Mulches

Mulches generally fall into two broad categories: organic and synthetic. Organic mulches include straw, pine needles, grass clippings, leaf mold, composts, newspaper, sawdust, and bark scrapings. Organic mulches return organic matter and plant nutrients to the soil and improve soil tilth as they decay. Because most organic materials usually do not contain enough nitrogen to replace what is used up by the microorganisms causing its decay, available nitrogen in the soil may be depleted. Therefore, provide some additional nitrogen to replace amounts used in decomposition. Organic mulches tend to keep soil temperatures cooler compared to bare soil.

Synthetic Mulches

Synthetic mulches include landscape fabrics, paper products, and plastic.

Over the last 10 years, we have extensively tested the effect of plastic mulch color on various vegetables at Penn State. The following are some generalities that can be made regarding color:

1. Silver repels aphids.
2. Blue and white attract thrips.
3. Yellow attracts insects.
4. Disease pressure seems to decrease with plants grown on specific colors.

The following recommendations for specific vegetables are based on Penn State studies:

- **Tomatoes** appear to respond more to red mulch compared to black. There appears to be less early blight on plants grown on red mulch compared to black mulch. However, when the growing season is ideal, tomato response to red mulch is minimal.
- **Peppers** appear to respond more to silver mulch compared to black. Lowest yields were harvested from plants grown on either white or light blue mulch. In climates south of North Carolina, pepper response to white mulch would be entirely different. Pepper plants grown on green infrared-transmitting (IRT) mulch had similar marketable fruit yields compared to plants grown on black.





- **Eggplant** appears to respond more to red mulch compared to black. However, when the growing season is ideal, response to red mulch is minimal. The cultivar grown may also determine whether eggplant responds to the color of plastic mulch.
- **Cantaloupe** appears to respond more to green IRT or dark blue mulch compared to black. Lowest yields were harvested from plants grown on either white or black mulch. In climates south of North Carolina, cantaloupe response to white or black mulch may vary.
- **Cucumber** appears to respond more to dark blue mulch compared to black. Open-pollinated and hybrid cultivars responded differently to mulch color. Lowest yields were harvested from plants grown on yellow mulch. In climates below North Carolina, cucumber response to yellow mulch may be entirely different.
- **Summer squash** appears to respond more to dark blue mulch compared to black. Lowest zucchini yields were harvested from plants grown on yellow mulch. In climates below North Carolina, cucumber response to yellow mulch may be entirely different.
- **Onion** appears to respond more to several different mulch colors, including red, metalized silver, and black, compared to no plastic mulch, depending on cultivar. This trial evaluated red onions, but other onion types should respond similar to the red onion cultivars.
- **Potato** appears to respond more to several different mulch colors, including red, metalized silver, and black, compared to no plastic mulch.

Using a Mulch

- Before mulching, remove all weeds and prepare the soil for planting.
- Be prepared to water your plants. While mulches maintain soil moisture, they do not replace irrigation. Consider using drip irrigation tape on the soil surface beneath the mulch and next to the plant row.
- In rainy seasons, mulching may be harmful because it helps keep the soil too wet for adequate aeration.
- Plastic mulches do not readily break down, so remove them at the end of the gardening season.
- After organic mulches have served their purpose, turn them under for organic matter. Do this in the fall or at least several weeks before further planting.



GROWING VEGETABLES IN CONTAINERS



Many types of vegetables grow well in containers. Containers of vegetables look right at home among large flower pots on a patio or walkway. If you are limited in space, or even if you have a more standard vegetable garden, it's hard to beat the convenience of a few pots of selected vegetables and herbs right by your door.

At Penn State we have studied growing tomatoes, eggplants, and cucumbers in containers. Below are some tips based on our study:

1. Start with large enough pots. In our study, we used 14-inch and 20-inch pots. The 14-inch pots were plenty large for the eggplants and cucumbers and the 20-inch pots worked out well for the more top-heavy tomatoes. The large soil mass helps anchor the pots in the wind and provides enough volume for the large root systems of fruiting vegetables, and with so much fruit and foliage, the large volume is needed so the pots hold enough water to get through sunny days. Be sure your pots have plenty of drainage holes in
2. Use great potting media. Also, use the right potting media. Look for mixes that are labeled for larger pots as they usually contain coarser bulking materials, such as composted bark or coir (at least 25 percent), which degrade very little during a single growing season. One of the real challenges in keeping plants in pots for a long time is the breakdown of the potting media. Some peat moss is good, but mixes made primarily of peat moss are much better for producing young plants for replanting. Water-retaining crystals (polymers) may be helpful as they will hold water that can be available on those hot summer days when plants go through water quickly. You should be able to find large pot mixes in any good garden center. Since potting mixes vary widely, read the label carefully to be sure that the mix you are purchasing meets the requirements for larger containers.
3. Vegetables will not grow without being provided nutrients (fertilizer). One of the big advantages of using soilless media is how well they drain excess water, which greatly reduces the opportunity for soilborne diseases to get started. However, this same attribute also reduces the ability to hold onto fertilizer. Most mixes come with enough fertilizer to get through about 2 weeks or less. Again, based on our experience with other large pots, we suggest applying a pelleted, time-release fertilizer at planting. Use the rate on the fertilizer package, which is based on pot size. Every week thereafter give the plants a shot of liquid fertilizer high in potassium but low in nitrogen. In our trials, we used a fertilizer with the analysis 9-15-30, but any fertilizer with a similar ratio will work. Look for soluble or liquid fertilizers that are designed for fruiting vegetables, such as tomato fertilizers. If you prefer using organic fertilizers, try using a combination of fish emulsion, kelp meal, greensand, and bone meal.



4. As with in-ground vegetables, there are pests to deal with when growing vegetables in containers. Monitor your plants frequently to stay on top of pests.
5. Start with pot-friendly cultivars. In our trials, we've found the following:
 - a. Tomatoes, even compact cultivars, required caging and support because they got top-heavy. Support doesn't need to be very elaborate. The wire, cone-shaped tomato trellises you can find at most garden centers work well.
 - b. Eggplants did better with a single, narrow stake against which the plants could lie. Pot-type eggplants are narrow enough that more than one plant per pot could work.

c. Cucumber vines rapidly hit the ground and benefited from sitting on top of another pot that was inverted. Expect them to be very compact compared to garden types.

6. Consider planting multiple cultivars of tomatoes with different harvest dates. You might find that with a single cultivar of bush tomato nearly all of the fruit ripens over 3 weeks. Adding an early ripening cultivar and a compact cherry or grape tomato cultivar should make for a longer tomato season in containers.
7. At the research farm, we set up this entire study with a drip type of irrigation system often used by mum and container shrub growers. This system is very handy as it wastes little water and is set to water the plants on a regular basis. Look for similar systems at gardening centers or in gardening catalogs. At home, we hand-watered the plants daily until water ran out the bottom of the pots. As the plants filled the pots and started making fruit, they sometimes required twice-daily watering. This need for water was especially high with the tomatoes. We don't usually place trays under pots outside, but that may be necessary under the tomatoes if you can only water the plants once a day in July and August. The trays will hold enough water for the plants' roots to pull from during a hot, sunny day. Mature tomato plants with fruit will use about 1 gallon of water per day in July and August.



IRRIGATING

Drip irrigation used with some form of mulch will provide the most efficient use of water and best growing conditions. Drip irrigation places the water in the root zone without wetting the foliage, which can reduce incidence of diseases. Drip irrigation kits can be purchased at most garden or farm supply centers and will come with all the necessary components and directions for installation. Once you install drip irrigation you can use fertigation to apply water-soluble fertilizers via the drip irrigation system.

If using overhead sprinklers, the best time to irrigate is early in the morning on a bright, sunny day. The goal is for the leaves to dry off as quickly as possible to help avoid foliar diseases.

If watering with a hose, use a rose or dramm head instead of a pistol-grip nozzle and apply water until the soil is thoroughly wet to a depth of 8 inches. If possible, apply water at the base of the plants to minimize leaf wetness.



10 Tips for Conserving Water

1. Use a rain gauge. Generally, vegetables need 1 inch of water a week. By using a rain gauge you can determine how much of this need is met by rain and only apply supplemental water as needed.
2. Use a mulch. Mulches help conserve water (detailed in the Mulching section, page 7).
3. Use drip irrigation.
4. Plant drought-resistant cultivars. Look for cultivars that are drought resistant or tolerant when deciding what to grow.
5. Add organic matter. Adding organic matter (see Soil section, page 2) increases the soil's ability to hold water.
6. Manage weeds. When weeds are present, they compete with vegetables for sunlight, nutrients, and water. They can also be a source of disease.
7. Reduce wind. Wind speeds up evaporation and plant transpiration. If possible, plant a wind break if your garden is in a windy site.
8. Plant in blocks. Planting in blocks versus rows promotes shading of the roots.
9. Plant hard fescue between rows. If you use rows, planting hard fescue between rows will help conserve moisture by acting as a mulch.
10. Plant only what you and your family will eat.

SELECTING CULTIVARS

Cultivar selection is an important step in planting any garden. A good place to start is to ask your neighbors and friends who garden what their favorite cultivars are for the vegetables they grow. Also ask them about their watering practices and whether they use any special fertilizers, lime types, or mulches. All these practices affect how plants grow and their ultimate quality. Once you have a consensus of which are the most popular, try these alongside your past favorites. Try a new cultivar for at least two or three seasons before choosing the best for your purposes (to eliminate yearly differences). From then on, compare these cultivars with those in seed catalogs that are said to be new and improved.

The basic way to read a seed catalog effectively is to assume that often what is highlighted as a positive feature of a cultivar is fairly accurate, but that the weaknesses in the cultivar are not listed. For example, if a description indicates that a snap bean holds up very well and is excellent for canning, it probably means that it is not melt-in-your-mouth tender and is not particularly flavorful. Look farther down the column for a cultivar of snap bean that is very flavorful and tender for fresh use. Or, if the description of a tomato cultivar stresses flavor and high quality, but doesn't mention any disease resistance, it probably has none. Other cultivar descriptions may mention a whole host of resistances or tolerances and state nothing about eating quality. In general, try to choose cultivars with the most disease and insect (e.g., leafminer, carrot sawfly, thrips in cabbage) resistance or tolerance.

In general, the brighter the color of the edible part of the vegetable (which can be botanic fruits) the higher the phytonutrient content. For example, tomatoes and peppers (also watermelon, papaya) that are the brightest crimson or scarlet in color are the highest in lycopene. In the same way, orange cauliflower and purple or violet cauliflower have more phytonutrients than traditional snow white cauliflower. Also, yellow sweet corn is more nutritious than white sweet corn.

Selecting heirloom cultivars is very subjective, and they are usually more susceptible to pests and are more difficult to grow. We strongly suggest that you first compare your favorite cultivars with heirlooms. Once you have had success with these, you may then wish to experiment with the tastes, textures, colors, and appearances offered by the diversity of heirloom cultivars.

It is hard to go wrong by growing cultivars that are All America Selection (AAS) winners. These are usually very adapted to your area and often have high eating quality and adequate pest resistance. These are almost always coded in seed catalogs as AAS winners.

From past experience, below are some of the best seed catalogs for Pennsylvania gardeners:

- Burpee, www.burpee.com
- Gurney's Seed and Vegetable Company, www.gurneys.com
- Harris Seeds, www.harrisseeds.com
- Henry Field's Seed and Nursery, www.henry-fields.com
- Johnny's Selected Seeds (very extensive offerings), www.johnnyseeds.com
- Jung Seed, www.jungseed.com
- Park Seed, www.parkseed.com
- Pinetree Garden Seeds (very extensive offerings), www.superseeds.com
- Rohrer Seeds, www.rohrerseeds.com
- Seedway LLC, www.seedway.com
- Stokes Seeds, www.stokeseeds.com
- Territorial Seed (garlic, shallots, onions, lettuce, and cover crops), www.territorialseed.com
- Thompson and Morgan Seeds, tmseeds.com
- Vermont Bean Seed Company, www.vermontbean.com
- Veseys, www.veseys.com

Our criteria for selecting these catalogs are (1) the companies are located in Pennsylvania or the region where often the cultivars have been pretested for adaptation to our climate, (2) they give more detailed information than most on cultivar characteristics, including specific pest resistance, and (3) the seeds are reasonably priced.

TRANSPLANTS



Before buying transplants, examine the plants carefully. When inspecting leaves, stems, and roots, ask yourself the following questions:

- **Leaves.** Are leaves healthy, green, and free of lesions? Can you detect any insect(s) on the leaves? Lesions on leaves would indicate a possible disease problem, and chlorotic or discolored leaves may indicate a possible nutrient deficiency. Plants with very few leaves or unhealthy leaves seldom develop normally.
- **Stem.** Is the stem too long and thin (spindly)? Will it maintain the plant upright? Are there any lesions on the stem or is it girdled near the roots? If the stem exhibits any of these problems, chances are that the transplant will not develop normally or in a timely fashion.
- **Roots.** Are the roots white and as large as the vegetative portion of the plant? Roots need to be actively growing for the plant to establish quickly in the garden. If plants are producing adventitious roots (roots growing on the stem above the original primary root), suspect injury from insects, disease, chemicals, or mechanical damage. Roots that have been injured or stressed will take much longer to reestablish in the garden and thus delay plant growth and harvest date.

Another factor that will determine the success or failure of establishing your transplants is plant age. All vegetable transplants have an ideal age/size that enables them to continue active growth after transplanting and be somewhat resistant to environmental stress (see below). For example, the ideal age for tomato transplants is 6–8 weeks; plants younger than 6 weeks are not as tolerant to desiccation from wind, low temperatures (below 45°F), and drought. On the other hand, older plants (older than 10 weeks) have a relatively large aboveground mass that has initiated flowers and may be heading into the reproductive phase of growth; hence, the plants will produce fruit, but only a fraction of their full potential.

Age of transplants for ideal growth:

- Tomato: 6–8 weeks
- Pepper: 8–10 weeks
- Eggplant: 8–10 weeks
- Muskmelon: 2–3 weeks
- Squash: 2–3 weeks
- Cucumber: 2–3 weeks
- Celery: 9–12 weeks
- Onion: 9–12 weeks
- Cabbage: 6–7 weeks
- Cauliflower: 6–8 weeks
- Broccoli: 6–7 weeks
- Endive: 5–7 weeks

For more information, see “Growing Better Vegetable Plants” at resources.cas.psu.edu/ipm/POP/betterveg.pdf and “Homemade Potting Media” at consumerhorticulture.psu.edu/files/homemade_potting_media.pdf.

MANAGING PESTS



Pest management programs for garden vegetables should first focus on nonchemical or cultural methods. Resistant cultivars, proper cultural practices, and sanitation are important in an effective pest management program.

Cultural strategies are numerous, depend on the target pest, and include the following:

- Selecting good sites
- Selecting cultivars with resistance or tolerance to target pests
- Maintaining healthy and vigorous plants with good nutrient and moisture management; do not overfertilize, especially with nitrogen
- Promoting good air circulation within the garden to promote drying of the plants
- Using good sanitation practices for tools and equipment
- Rouging or removing plants that are diseased

- Using plant rotations to avoid the buildup of pests
- Creating habitats for beneficial insects
- Hand-weeding
- Mechanical weeding
- Using organic (e.g., straw or bark chips) and inorganic (e.g., plastic) mulches
- Using drip irrigation or watering at the base of the plants to minimize leaf wetness
- Working in the garden when the plants are dry

Diseases or insects may cause a serious reduction in the vigor, quality, and productivity of plants. The success or failure of a fungicide or an insecticide is related to correct identification of the pest problem; selection of the appropriate pesticide; the method, rate, and timing of application; and weather conditions at the time of application.

Always follow the directions on the container or package when mixing and applying pesticides. Never increase the amount of pesticide or decrease the amount of water you mix with the pesticide.

Color photos of disease symptoms may be seen in *Identifying Diseases of Vegetables*, for sale by the Publications Distribution Center, 112 Agricultural Administration Building, University Park, PA 16802, at vegdis.cas.psu.edu/identification.html, or from county extension offices.

Color photos of insects associated with garden plants and nearby landscapes are available in a book by Whitney Cranshaw, *Garden Insects of North America: The Ultimate Guide to Backyard Bugs* (Princeton: Princeton University Press, 2004). Fact sheets on numerous insect pests can be found at ento.psu.edu/extension/factsheets.

MANAGING WEEDS

Dense weeds not only rob vegetables of moisture, light, and nutrients but can also harbor insects and create an ideal environment for many disease-causing organisms. Eliminate young weed seedlings with shallow hoeing or cultivating. Never allow weeds to set seed. Place organic mulches such as straw (4–6 inches deep), newspaper, or cardboard around plants and between rows to reduce weeds and conserve moisture. Apply organic mulches only after the soil is warm (about June 10) because they decrease soil temperatures and therefore can increase frost severity. If using newspaper or cardboard, we strongly recommend wetting it thoroughly after applying it to the soil. Additionally, consider placing compost or composted manure on top of the newspaper or cardboard to promote their degradation and prevent temporary nitrogen tie-up.



Manage perennial weeds year-round near and in plantings as they can harbor disease-causing organisms.

To help keep weeds and weed seeds out of plantings during the fall and winter months, consider sowing a cover crop in late summer or fall (e.g., annual ryegrass or spring oats mixed with hairy vetch). Turn the cover crop into the soil about one month before spring planting.

As a general rule, avoid using herbicides for weed management in small planting areas for several reasons. First, no one herbicide that can be safely used on all kinds of vegetables is available. Second, herbicides are difficult to apply at proper rates in small areas with hand sprayers. In most cases, some areas will receive too little herbicide for effective weed management and other areas may receive such heavy rates that the vegetable plants will be damaged or killed. Also, you risk damaging or killing your plants from spray drift.



ASPARAGUS



Asparagus is an attractive and delicious perennial vegetable that can thrive for 25 years or more. The lacy, green foliage grows 6–8 feet high and can be used as an ornamental summer screen. Plant it along a fence, if there is plenty of sun, or on the north or east side of the site where it will not shade other vegetables or low-growing fruits.

Low in calories and high in flavor, a serving of 4 asparagus spears (60 grams) contains 10 calories, 1 gram of protein, 2 grams of carbohydrates, and only traces of fat. High in vitamin A and riboflavin and a very good source of thiamin, asparagus will produce its fine spears year after year once established.

How Asparagus Grows

The underground root system of asparagus is an extensive network of fleshy storage roots with small feeder roots that absorb water and nutrients. Storage roots are about the diameter of a pencil and may reach a length of 5–10 feet in good soil. They are attached to an underground stem called a rhizome; taken together, storage roots and a rhizome are commonly referred to as an asparagus crown. The crown is purchased for starting plants.

When the soil is warm and moisture is favorable, buds arise from the rhizome. Using carbohydrates and other nutrient reserves from the storage roots, they grow into edible spears. If not harvested, spears continue to develop into attractive, green, fernlike stalks (brush). Photosynthesis in the brush of the mature plant produces carbohydrates and other essential nutrients that are moved down to the storage roots, where these reserves supply energy for spear production in the following growing season. For these reasons, allow the brush to grow and protect it from insects, diseases, and other injury before natural maturity and frost stop plant growth in late fall. At that time, remove the brush.

Selecting Cultivars

The following cultivars are suggested for Pennsylvania:

‘Jersey Giant’

- F₁ hybrid
- High yield potential, pest resistance/tolerance, and very good eating quality
- Fusarium resistant or tolerant
- Rust resistant or tolerant
- Highest green spear productivity and quality in Pennsylvania

‘Jersey Knight’

- F₁ hybrid
- Fusarium resistant or tolerant
- Rust resistant or tolerant

‘Jersey Supreme’

- F₁ hybrid
- Fusarium resistant or tolerant
- Rust resistant or tolerant

‘Purple Passion’

- F₁ hybrid
- Highly productive, sweet, purple spears that turn green when cooked

Washington types are no longer recommended because they are not as resistant or productive as the cultivars above and produce many seeds that develop as volunteers the following year.

Seeds (and occasionally crowns) of the above cultivars are available from several prominent seed companies. Some may carry only one

cultivar and others several. Some bedding plant growers may offer them as transplants. Two major sources of crowns are:

WALKER PLANTS
105 PORCHTOWN ROAD
PITTSBURY, NJ 08318
PHONE: 856-358-2548
www.walkerplants.com

NOURSE FARMS, INC.
41 RIVER ROAD
SOUTH DEERFIELD, MA 01373
PHONE: 413-665-2658
www.horsefarms.com

You can purchase high-yielding, uniform seeds or even highly selected, extremely productive crowns or transplants from local garden supply stores.

Growing Asparagus

Asparagus needs a long growing season and sunny days for maximum photosynthesis. Ideal conditions are daytime temperatures from 75 to 85°F and nighttime readings of about 60°F to minimize respiration. These conditions favor storage of carbohydrates in the root system, thus enhancing the yield and quality of spears the following season.

Maintain soil pH between 6.5 and 6.8. Check pH carefully since asparagus does poorly at pH levels below 6.0.

Medium-high nitrogen is best for providing a balance between top and root growth, but the plant needs adequate phosphorus and a relatively high amount of potassium for maximum spear production. We strongly recommend fertilizing and liming as directed by soil test results (see Soil Testing section, page 4). In the absence of a test, before digging the furrow broadcast and turn under 7 pounds of 5-10-10 fertilizer (or equivalent) per 100 square feet a foot or more deep. If lime is needed, turn it under along with the fertilizer. To improve heavy soil that crusts readily, incorporate generous amounts of manure and organic matter (such as compost) at this time.

In the past, gardeners started most asparagus by planting crowns. If you do this, plant only healthy, one-year-old crowns, not two- or three-year-old crowns. Obtaining commercial crowns guaranteed to be free of fusarium root rot can be difficult, and, once introduced, this

disease will contaminate the soil and be difficult to manage.

One way to minimize the chance of introducing fusarium is to grow your own crowns or transplants from pathogen-free seed planted in a high-quality, pathogen-free growing medium. Produce crowns by direct-seeding a small area about 2 weeks before normally transplanting tomatoes into the site. Sow 3–4 seeds for each crown to be planted in the permanent bed 1 inch deep and 3 inches apart in rows 2½ feet apart. The following spring (February–April), when the plants are still dormant and the ground has thawed, carefully dig the crowns to minimize damage to the root system and then immediately plant them in a permanent bed as described below.

Growing Transplants

To grow transplants, sow the seed in pots 10 weeks before the frost-free date in your area. Use a commercial potting mixture of peat moss and vermiculite (pH 5.5–6.0) and sow 2 seeds ¾ inch deep in small pots (2-inch diameter) or in 2-inch plastic tray cells (so roots pop out easily).

Germinate the seeds at 75–85°F and then grow the seedlings at 70°F during the day and 65°F at night. Grow the plants in a greenhouse or window with full sunlight. When plants are not grown in the greenhouse, use supplementary fluorescent lights to extend the day length from 12 to 14 hours.

Apply a soluble complete fertilizer, such as 15-15-15 or 15-30-15, at half the recommended rate 3, 6, and 9 weeks after sowing the seed. Avoid fertilizer injury to the tender growth by lightly rinsing the foliage with water after fertilizing. Excessive nitrogen will promote large, tender tops and small root systems with limited food reserves in the storage roots. Quality transplants are not more than 10–12 inches high. Make the last fertilizer application just before transplanting, after the danger of the last killing frost. You may grow your own seedling transplants, or you may be able to get seedlings from a commercial plant grower who specializes in bedding plants. If local garden center operators don't sell seedling transplants, urge them to do so the following season.

Plant the crowns with the buds up in the bottom of an 8-inch-deep, 1-inch-wide, W-shaped furrow; cover with 1 inch of soil. Plant seedlings on small mounds in the bottom of a similar



furrow and cover the buds with 1 inch of soil. Crowns and transplants should be 12 inches apart within the row and about 36 inches from other vegetables or between rows. Seedlings will require some protection from standing water and excess soil that can wash into the furrow.

Maintaining Beds

As the asparagus grows, carefully fill the furrow with soil, but avoid covering any foliage. Furrows should be filled in by the end of the first growing season. In July, side-dress the plants with 6 pounds of 5-10-10 fertilizer and a ½-inch-thick layer of compost per 100 feet of row. Spread fertilizer and compost on either side of the asparagus and cultivate lightly into the soil. Where heavy, crusty soils are present, mulch in late October with 4–6 inches of straw or straw-manure mixture to minimize heaving from freeze-thaw cycles and soil crusting and to delay early spring emergence of spears, which can be injured by frost (40°F or lower). Before the asparagus emerges (about late March), broadcast lime as needed. At the same time, spread 3 ½ pounds of 5-10-10 (or compost) fertilizer per 100 square feet of bed. Rake the fertilizer and lime lightly about 1 inch into the soil, taking care to avoid damaging the asparagus crowns. About every third year, test the soil to monitor and correct your fertility program. Remove excess mulch just before spears begin to emerge in spring.

After the first growing season, asparagus plants do not require frequent irrigation because of the deep and extensive root system. Thorough watering (2 inches of water) slowly applied (such as with a soaker hose) every 2 weeks during dry weather is sufficient.

Maintain good foliage growth for maximum photosynthesis. Ferns 3 years or older should be 6–8 feet tall by early September. If they are not this vigorous, increase fertilizer applications, improve weed management, and make certain that crowns are getting adequate moisture during extended dry periods.

Adequate soil moisture is especially important during the first growing season. When necessary, water sufficiently to wet the soil 8 inches deep.

Harvesting Asparagus

Allow plants to develop an adequate storage root system in preparation for the first harvesting season. Harvesting or damaging the brush during the first growing season stunts the plants and can permanently reduce yield.

In the second year when the first spears emerge in spring, merely snap off the upper green, tender portion of all tight spears 7 to 10 inches long. Always harvest all spears that come up during the suggested harvest period.

The 1-2-4-8-week sequence is a good general rule for harvesting: pick for 1 week in the second year, 2 weeks the third year, 4 weeks the fourth year, and up to 8 weeks the fifth and following years depending on the vigor of the bed. Stop sooner if spear thickness drops. Harvest usually does not extend past June 15.

One 40-foot row of 5-year-old asparagus will yield approximately 10–25 pounds of spears during the average season.

When the harvest season is approximately half complete, carefully ridge 5–6 inches of soil over the row. This lowers the temperature around the crown, increases spear size, and blanches (whitens) the lower portion of the spear. Rake the ridge level immediately after the last harvest.

If the asparagus is to be consumed later or if one day's harvest is not enough for a meal, wash the spears and place the cut ends on moistened paper towels lining the bottom of a shallow pan, and arrange vertically. Refrigerate immediately. Good quality can be maintained for several days if they are kept at 40–45°F.

Insect Identification and Management

Asparagus Beetle

Beetles and grubs feed on young spears, ferns, and stems of the plants. Beetles are a problem particularly when they feed on the young shoots in the early spring. Beetles are approximately ¼ inch long and the body is wider than the head. Adult beetles can be identified by dark orange bodies with black spots. Grubs are orange with a humpbacked shape.

Management: If you do not see the beetle but notice plant damage, check for shiny black specks on the spear tips. The best time to manage beetles and grubs is early in the fall,



Asparagus beetle adult

before the first frost. Use a pesticide if extensive feeding occurs. If you use mulch around your plants, pull it away from the base of the plants in the early fall since this is where the grubs overwinter.

Asparagus Fern Caterpillar (Beet Armyworm)

These worms will feed on the foliage and stems of plants. They are pale green to light brown without any “hair” and range in size from ½ to 1¼ inches in length. They hatch from cream-white eggs that may be found on nearby foliage.

Management: When you have only a few plants, simply hand-pick the beetles from the plants. The best time to observe and remove the insects is during the early morning when they are most active. If you have many plants and notice extensive feeding, select an insecticide labeled for control of this pest.



Beet armyworm larva

Disease Identification and Management

Rust

Small pustules appear on the stems and leaves. The pustules are reddish or brownish and become dusty when they break open and release their spores. The discoloration can make entire plantings appear as though they matured prematurely.

Management: Try to avoid starting new plantings next to old plantings. Grow recommended resistant cultivars, such as ‘Jersey Giant’, ‘Jersey Knight’, and ‘Jersey Supreme’. If the disease appears, spray after harvest with mancozeb at 10-day intervals. Do not apply before harvest. When disease pressure is high, sprays may be needed in 1- and 2-year-old beds, even when using resistant cultivars.

Fusarium Wilt and Root Rot

In the spring, affected shoots are wilted, stunted, and sometimes dingy brown. Entire shoots on mature plants wilt during dry periods. Roots and/or the base of spears (lower stems) on affected plants have rotted areas that are reddish.

Management: Start new plantings in well-drained areas not previously planted to asparagus. Only plant disease-free crowns or transplants started from pathogen-free seed and grown in a pathogen-free growing medium or soil. For pathogen-free seeds and soil, prepare a sodium

hypochlorite solution—mix ½ tablespoon of household bleach with ½ cup of water—soak seeds for 10 minutes in the solution, and then rinse with clean water. Plant seeds immediately or dry thoroughly on paper towels.

Weed Management

Weed management is an important aspect of good asparagus culture. Weeds reduce yields by competing for water, nutrients, and sunlight. Never cultivate or hoe deep enough to prune or injure plant roots.

Since asparagus is one of the very few vegetables that not only tolerates high-soluble salts in soils but is salt loving, you can use a salt solution to manage weeds. In the early part of a bright day, dissolve up to 2 pounds of salt (NaCl₂) in a gallon of water and wet the weeds thoroughly. Repeat as necessary. You may spray or sprinkle salt brine on growing spears and mature ferns, but avoid applying it to tender seedlings or young ferns, unless these are weeds from fern berries. Never use dry granules.

To maintain weed suppression, place mulch (such as straw or grass clippings) around plants to reduce weed seed germination and conserve moisture. Another option is to apply spent mushroom compost or substrate (where available) about 4 inches deep in the spring and never remove it.

When you rotate out of a bed where salt spray has been used, grow beets for about 2 years before growing other vegetables.

BEANS



Cultural Practices

Beans need a greater amount of potash and phosphorus than nitrogen. A recommended fertilizer formula is 5-10-10 or an equivalent ratio. You may also use compost to provide nitrogen, phosphorus, and potassium, as well as secondary and trace elements.

Soil

Soils should have a moderate amount of humus (organic matter) and moderate levels of plant food. Bean plants tolerate a soil pH between 5.5 and 7.0, but best yields are achieved when the pH is between 6.0 and 6.8.

Planting

Generally, place seeds 1–1½ inches deep. Planting depth varies depending on soil texture and moisture content. Planting should be deeper in light loams and shallower in heavy soils. In optimal conditions, you can calculate the planting depth by multiplying the length of the bean seed (inches) by 1½ inches (depth).

Seed can be soaked in water (temperature of 50–60°F) overnight to accelerate germination. Do not do this if seeds are pretreated with fungicides or insecticides.

Snap beans are easily killed or injured by frosts. In general, plant after all danger of frost has passed and when the soil has adequate moisture. Plant fava and soybean types as early as the soil can be worked in the spring since they prefer cool temperatures for establishment. First plantings for all others can be done when the soil is moist and warm and day temperatures are 65°F (although 75°F is preferable) and night temperatures are 60–65°F. This will help minimize seed decay and seedling damping-off diseases, which are common problems when beans are planted in cold, wet soils.

Many cultivars of bush beans mature in 6–8 weeks. Successional sowing can be made at 2-week intervals.

Spacing

By growing bush cultivars, you can avoid the trouble and expense of using poles. Bush bean plants vary considerably in size, so the plant and row spacing should vary in proportion. Sow seeds such as bush snap, bush limas, green shell, and edible soybeans at least 2 inches apart within the row and preferably 4–6 inches between rows in a bed. You can thin the plants to one every 4 inches after they become established.

Harvesting

Harvest bush snap beans and pole snap beans anytime before the pods begin to toughen and the bean seeds begin to mature. Picking every 2 or 3 days, and only when the vines are dry, helps prevent bean rust and the spread of other diseases. Store beans in a cool place after harvesting to help prevent deterioration by loss of moisture.

Harvest lima, soy, and fava beans while the pods still have their attractive green color and are plump; they should not be allowed to lose their gloss or turn yellow. Their quality is best if they are eaten as soon as possible after being picked since their sugars quickly turn to starch.

Insect Identification and Management

Seedcorn maggots, potato leafhoppers, Mexican bean beetles, aphids, and mites are the most common insects to attack beans (see illustrations). You can usually achieve adequate plant populations by doubling the seeding rate, then thinning the plants to the desired population. You can also use commercial plant covers, such as Agrofabric Pro 17, Reemay, Agribon-12 or -19, and Agriforce, as a physical barrier to exclude insects, promote earlier yields, and provide protection from wind and light frost. Several types of lightweight, spunbonded fabrics, commonly called floating row covers, are economical and work well as insect barriers. Plant covers increase the temperature by 5°C and humidity by 25 percent inside the cover. They may remain on the plants until first harvest since beans are self-pollinated (don't need insects for pollination). When using pesticides, always read and follow label directions carefully regarding dilution, application, and disposal.

Seedcorn Maggots

Maggots pupate inside a dark brown, capsule-like puparium that resembles a grain of wheat. Seedcorn maggot puparia can be found in soil throughout the year, and maggots overwinter in these puparia. The adult flies emerge from the puparia during late April and early May. The adults are brownish gray flies that closely resemble common house flies, except that they are about half the size. Tiny, white, elongated eggs are deposited among debris and around plant stems near the soil surface. Eggs hatch in a few days and the maggots work their way into the soil in search of food.

Maggots are dirty white with a yellowish tinge and are legless, cylindrical, and tapered; full-grown maggots reach 1/5–1/4 inch in length. Maggots feed in the seed or on the underground parts of seedlings. Damaged seed may germinate, but too few food reserves may be left in the seed for the plant to survive. The time required to grow from egg to adult is 3–4 weeks. Three to five generations occur each year in Pennsylvania. Populations tend to decline during the dry months of summer.

Management: Seedcorn maggots tend to cause greater losses during cool, wet years and in areas with an abundance of decaying organic

matter, such as manure or a recently soil incorporated cover crop. Thoroughly incorporate organic matter into the soil well before planting. Any cultural practice that speeds up germination, plant emergence, and early plant growth helps reduce vegetable losses from maggots; such practices allow the plant to “outgrow” the feeding damage.

Planting in warm soils significantly helps plants outgrow maggot injury. If significant damage occurs, replant those areas. Look to see if maggots are still present. If maggots are small (less than 3/8 inch), wait 7–10 days for them to begin to pupate before replanting. Most chemically treated seed is designed to help prevent damage during seed storage. Additional treatments applied at planting are effective but are typically for commercial use. Sprays applied to soil after damage is seen are not effective.

Leafhoppers

The potato leafhopper overwinters to the south. Migrants arrive during the spring and early summer and develop three to four generations, often on alfalfa and other hosts. Adults and nymphs are yellow green to lime green and have a characteristic “sideways” walk. Adults are spindle shaped with tapered wings, reaching 1/8 inch in length. Nymphs are wingless. Eggs are deposited within the plant. After hatching, nymphs undergo five instars before becoming adults. When nymphs and adults feed, they disrupt the transport of fluids within the plant. Feeding results in symptoms called “hopperburn.” In beans, hopperburn appears as a curling of the leaves, stunting, yellowing, reduced root systems, and reduced yields and quality. The greatest damage comes from leafhopper feeding on young plants.

Management: Successive plantings usually provide some plantings that escape damage. Infestations that occur close to harvest can be tolerated. Insecticides labeled for leafhopper management are effective for reducing nymph and adult populations; repeat applications are needed to control both nymphs emerging from eggs and reinvading adults.



Seedcorn maggot larva



Seedcorn maggot adult



Potato leafhopper



Mexican bean beetle adult

Mexican Bean Beetle

Adults are round to oval, hard-bodied insects, about $\frac{1}{8}$ inch in length, yellow to coppery brown, with 16 black spots. Females lay clusters of yellow eggs on the undersides of leaves. Hatching larvae are yellow, cylindrical but tapered toward the rear, with branched spines. Pupae are also yellow and appear on the undersides of leaves. These beetles remove leaf tissue between the veins, resulting in a skeletonlike appearance.

Management: Removal by hand can be effective in small areas. Treat if defoliation exceeds 20 percent during prebloom or 10 percent during podding and there is potential for further defoliation. These levels of defoliation may result in earlier maturity of the beans.



Aphids

Aphids

Several species of aphids infest beans; pea aphid and bean aphid are common. Aphids are round to oblong, soft-bodied insects that are about $\frac{1}{8}$ inch long and extract plant sap. Both winged and wingless forms can be present. Colonies develop on undersides of leaves or on plant terminals. Direct damage by aphids is assumed to be minimal until populations build to high levels, but aphids transmit bean common mosaic virus.

Management: Remove plants that show signs of virus infection. Aphids are often controlled by natural parasites and predators that rely on these slow-moving insects as a host resource. High populations can be reduced with insecticides labeled for aphid management.



Two-spotted spider mite adults

Spider Mites

Spider mites are tiny, eight-legged animals most closely related to spiders. They appear as specks on the undersides of leaves. Mites rarely cause significant damage to beans in home gardens. Large populations are necessary to cause serious damage, but spider mite populations build up very quickly when temperatures are hot (greater than 80°F). Dry weather (less than 50 percent relative humidity) is also correlated with mite buildup. Mites can complete development in only 5–7 days under these conditions, two to three times faster than many of our other vegetable pests. Often, mites move in from nearby plants or weeds, and initial densities are high near planting edges. Mites pierce the epidermal cells of plants and extract plant

sap. Damage appears as leaves that are stippled, yellowing, and dirty. Leaves may dry and drop. There may be webbing between leaves or on the lower surfaces of the leaves.

Management: Removing damaged leaves may slow the spread of mites in a planting. Spot treat with a chemical labeled for mites when you first notice white stippling along the veins on the undersides of the leaves and 20 mites per leaflet are present.

Disease Identification and Management

Anthracnose (Fungal Disease)

Dark, oval, sunken cankers with tan centers develop on pods, stems, and seed leaves. Salmon-colored ooze appears under moist conditions. Dark, discolored areas may develop on veins and leaf petioles.

Bacterial Blight

Dead spots and blotches, sometimes with a yellow halo, develop on the leaves. On pods, water-soaked areas appear during wet periods and later become brownish as they dry.

Mosaic Virus

On mosaic-affected plants, young leaves may be stunted, curled, and mottled; yellowing may be distinct within mottled leaves. Pods can be distorted, blotchy with dark and light green, and, in severe cases, have bronze, blotchy areas.

Root Rots

Dark, usually dry, rotted areas can appear anywhere on roots and on the stem near the soil surface. Some of the rots can kill young plants, but affected plants are usually stunted with yellowish leaf margins. Sometimes the root rot fungi attack seeds before or during germination, causing seed decay, especially when germination is slowed by unfavorable conditions.

Downy Mildew of Lima Beans

A white downy mold develops on pods during moist conditions below 85°F. Affected areas on the pods are killed, and young shoots can be distorted.



Virus on bean leaves



Root rot

General Management Strategies

1. When possible, use cultivars with resistance to mosaic viruses.
2. Start with pathogen-free seed from well-known seed companies. Bacterial blights, anthracnose, and some mosaic virus diseases can be introduced with seed.
3. Rotate for 2–3 years out of the bean and pea family.
4. Avoid planting beans near gladiolus if mosaic virus has been a problem in past years. Gladiolus is a source of one mosaic virus that can be carried to beans by aphids.
5. Plant seed in well-drained soil after the soil has warmed sufficiently to promote rapid germination and plant growth. Seed rots and root rots become severe when seed germinates slowly and plants grow slowly in cool soil.
6. Do not provide excessive nutrients in fertilizer or manure. Excessive nutrients can result in excessive canopy growth and slow drying of plants, which can promote pod rots during extended wet periods.
7. Try to prevent aphid problems near and in the planting area. Aphids pick up and carry viruses; when feeding, they can put a virus into a plant within one minute.
8. Do not work in bean plantings when leaves are wet. Especially when bacteria that cause blights are present on any of the plants, the bacteria become sticky when wet and can be spread on hands, tools, and clothing.
9. As soon as harvest is complete for any planting, pull and discard or compost the plants. When old plants are left in the garden, pathogens continue to multiply on them and become an important source of inoculum that can result in more disease later during the current season, and pathogens can also survive overwinter in the soil on plant debris and initiate disease in future seasons.

BRASSICAS

(CABBAGE, CAULIFLOWER, BROCCOLI, AND BRUSSELS SPROUTS)



Selecting Cultivars

In addition to your standard cultivars, consider trying 'Jersey Wakefield' or cone-shaped, pointed cabbage types (e.g., 'Caraflex', 'Caramba'). These are thin leaved, early, and succulent.

Planting Dates

- Early cabbage: April 15–May 20
- Early broccoli and cauliflower: April 1–15

Seeding Dates

- Late cabbage: June 15–July 1
- Late broccoli and cauliflower: June 15–July 10

Spacing

Between rows:

- Cabbage and cauliflower: 2–3 feet apart
- Broccoli and Brussels sprouts: 3 feet apart

Between plants in a row:

- Cabbage: 9–18 inches apart
- Cauliflower and early broccoli: 12–18 inches
- Brussels sprouts and late broccoli: 18–24 inches

Mulches

Organic mulches can be used for growing brassicas. Apply the mulch after all danger of frost has passed. The mulch will help manage weeds and provide a more uniform soil temperature and moisture around plant roots.

Plastic mulches can also be used with success. When using floating rows (see next section), consider using black plastic mulch. Metalized silver plastic mulch can be used when floating row covers are not.



Floating Row Covers

Consider using floating row covers to eliminate early pest problems. Examples of floating row covers or plant covers are on page 21. Install the row covers immediately after planting and take them off at the first harvest for all brassicas. You can save row covers and reuse them in late fall for late winter harvest. Other benefits of using floating row covers are an earlier harvest and protection from late frosts because they hold temperatures surrounding the plants higher.

Special Precautions

Bolting in cabbage and buttoning (becoming unproductive by forming a very small head when the plant is too young) in cauliflower and broccoli often occur if an early planting is subjected to 10 or more continuous days of temperatures between 35 and 50°F. Also, the sensitivity of bolting depends on the cultivar. Bolting and buttoning can also be problems with large, old, or overstressed plants. For early spring plantings, set only small, hardy transplants with no more than 4–5 true leaves expanded. Young, sturdy, healthy, medium-sized transplants are considered best. Plants 4–6 weeks old, slightly hardened (held at 55°F for a week with minimal but adequate watering), with 4–5 true leaves resume growth faster and usually outyield larger, older, or severely hardened plants.

Avoid fertility practices that lead to excessive potash but low magnesium and low pH levels. Use a complete (N-P-K plus all secondary and trace elements) soluble fertilizer while growing the seedlings and at transplanting time in the garden to avoid boron deficiency (cross-cracking and browning of the stem pith) and molybdenum deficiency (outer leaves of cauliflower become whiplike and those of broccoli become cuplike).

Harvest cauliflower heads when they're still compact and before the "curd" opens and becomes "ricey."

Seed Treatment

Heat treatment helps manage bacterial black rot, blackleg, leaf spot, and downy mildew. Some companies offer seed treatment as an option. Always choose this option when available.

Insect Identification and Management

Aphids

Small ($\frac{1}{16}$ inch), dark green, and covered with grayish dust, these soft-bodied sucking insects collect in small colonies on the leaves. Their feeding causes curling and stunting of plants.

Management: Aphids are often managed by natural enemies that rely on these slow-moving insects as a host resource. High populations can be reduced with insecticides labeled for aphid management.

Cabbage Worms

These light-green, soft, velvety worms grow up to 1 inch long. Adults are white butterflies. Worms riddle the leaves with their feeding, and dark droppings lodge in axils of leaves.

Management: Color of worms and leaves are similar, making it difficult to locate worms, but hand-picking can be effective. Begin spraying plants with insecticides labeled for cabbage worm management when you see the first worms or signs of feeding.



Cabbage looper

Flea Beetles

These small ($\frac{1}{16}$ inch), black, jumping, hard-shelled beetles riddle the leaves of young plants by chewing numerous small holes in them.

Management: Clean cultivation and weed management are important since the beetles feed on many weeds. Suspending a floating row cover above the plants immediately after planting can protect them from damage. Plants with vigorous growth can withstand fairly high levels of feeding. Discard lightly infested leaves. When injury exceeds your tolerance, spray with an insecticide labeled to manage flea beetle on vegetables.



Crucifer flea beetles

Root Maggots

Root maggots are small ($\frac{1}{8}$ inch), dirty white maggots that feed on the stem below ground level. When yellow rocket (mustard family) first blooms, cabbage maggot flies begin laying eggs on roots or in soil near roots. Often they girdle the stem, causing plants to wilt and often die.

Management: You can avoid these pests by installing a row cover immediately after transplanting. Root maggot problems are worse in cool, wet soils high in organic matter. If you have problems with this insect, you may need to plant after the soil is warm (above 50°F at a 2-inch depth) to avoid damage.



Cabbage maggot flies



Cutworm larva

Cutworms and Borers

Cutworms are large (1–1½ inches), gray to black worms that cut off plants near ground level. Borers are dirty white worms (up to 1 inch long) that eat pinholes in leaves, leave sawdustlike frass on leaves and in leaf axils, and burrow into stems.

Management: Make 2½-inch collars from tar paper or waxed cardboard and place them around the bottom stem of the transplant with the sides in contact with the soil. Do immediately after transplanting since cutworms can attack plants the first evening.

Disease Identification and Management

Blackleg and Black Rot

Symptoms include leaf spots and stem cankers; outer leaves turn yellow and die. For black rot, the symptoms can vary depending on the type of brassica. Often, yellow, V-shaped lesions will develop along the leaf edge. For blackleg, leaf spots tend to be circular, tan to brown in the center, and surrounded by a yellow halo.

Management: Avoid areas where cabbage-related plants have grown within 4 years. Start with disease-free transplants grown from hot-water-treated seed or by a reputable plant grower. Avoid working around the plants when they are wet.

Leaf Spot and Downy Mildew

Leaf spots are up to 1 inch in diameter. Downy mildew appears as a yellow spot on the upper leaf surfaces and white downy mold on lower leaf surfaces.

Management: Start with disease-free transplants grown from hot-water-treated seed or by a reputable plant grower. Spray with fungicides labeled for leaf spot and downy mildew management when disease is anticipated and as needed.

Clubroot

Plants are stunted, chlorotic, and wilted and have swollen, distorted, and galled roots. Root galls are initially white and then become black and discolored.

Management: Follow recommendations for blackleg and black rot. In addition, if clubroot has been a problem, apply hydrated lime (1 pound per 30 square feet) in the spring before preparing the seedbed to raise the soil pH above 7.2–7.3. At harvest, remove plants, including roots; destroy or discard swollen roots.



Black rot

BULB VEGETABLES

(ONIONS, LEEKS, AND GARLIC)



Soil pH and Fertility

For all bulb vegetables, maintain soil pH between 6.2 and 6.8. Soil testing is strongly recommended for determining soil pH and nutrient status. You can purchase kits from your local county extension office or garden supply center.

Before applying chemical fertilizer, incorporate a ¼-inch layer of compost into the soil. For onions, shallots, and leeks, in the absence of a soil test, apply to each 100 square feet either 4½ pounds of 5-10-10 fertilizer where potash is deficient or 4½ pounds of 5-10-5 or equivalent where potash levels are higher. For garlic, use 3½ pounds per 100 square feet of the above fertilizers. Broadcast all fertilizers, and work them into the soil before planting.

Side-dress fall-planted garlic in March and onions and leeks about 6 weeks after planting. For garlic and pungent onions (or those for long-term storage), band ¼ pound (4 ounces) of ammonium sulfate per 100 linear feet of row. Place the fertilizer about 3 inches to either side of the plants and lightly work into the soil. For leeks and mild salad onions, use 1 pound of 5-10-10 (or equivalent that contains no sulfur) per 200 linear feet of row, again banding to the sides of the plants and working into the soil. To maintain the mild flavor of leeks and mild (short-storage) onions, be sure the fertilizer used contains no sulfur. For best bulb development of shallots, a light soil high in potassium and phosphorus but not too rich in nitrogen is recommended.

Selecting Cultivars

Garlic

Secure a strain of garlic from a local garlic grower, gardener, or seed house or garden center operator who has success with fall-planted garlic. Farmers' markets are also a good source of locally grown garlic—start looking in mid- to late August. Unlike most strains now sold commercially, such a strain will be acclimated to Pennsylvania and will produce and overwinter very well. Do not purchase garlic for planting from a grocery store because it is often treated with a sprout inhibitor. Plant garlic in the fall for greatest clove size and yields.

Two types of garlic exist: softneck and stiffneck. Softneck types are used for braiding and are commonly found in stores but are not generally hardy enough for Pennsylvania. Stiffneck types send up a hard, flowering stem and are more cold hardy than softnecks. Elephant garlic is not a true garlic but instead is best described as a bulbing leek. It is the least cold hardy of the garlics and is cultivated in the same manner as stiffneck garlic. Elephant garlic has a milder flavor than true garlic.

Onions

Onions can be classified as short-day, intermediate, long-day, or day-neutral. Any of these types of onions can be found as yellow, white, or red skin or flesh. The best sweet onions for Pennsylvania are the day-neutrals. The best storage onions are intermediate types.

Day-neutral hybrids, such as 'Super Star' and 'Candy', do extremely well in Pennsylvania, either direct-seeded or from transplants.

Sweet Spanish and Bermuda types are mild-flavored, large bulbs (3–5 inches diameter) that generally do not keep as long as other onion types. They are usually started from young transplants.

Red onions have deep red to purplish red skin, which makes them highly attractive in salads or wherever raw onion rings are used. Most cultivars adapted to Pennsylvania conditions are fairly pungent and generally keep better than Sweet Spanish types but not as well as the yellow storage types.

Regular yellow storage onion cultivars, when well cured with no defects, store well. Generally, the stronger the flavor of the onion, the longer it keeps.

Shallots

The Welsh type of shallot is milder and more leek flavored, has a light brown to tan skin, and keeps very well. The French-Italian type has a brownish red skin, a stronger flavor, and an aroma that resembles garlic. Traditionally planted as sets only, many new shallot hybrids are even better when direct-seeded in spring.



Sets, Transplants, or Direct-Seeding

Start older, nonhybrid, long-storage onions by sets in spring. For overwintering, plant shallot sets in late fall. In all but the warmest regions of Pennsylvania, grow leeks and certain onion types such as the very large Sweet Spanish types from transplants rather than seeds. Direct-seeding is very effective with ‘Super Star’ and ‘Candy’ and is sometimes possible for other types in the regions of southwestern and southeastern Pennsylvania with the longest growing seasons. Obtain transplants from nurseries, garden centers, hardware stores, or garden catalogs or by starting seed indoors or in a hotbed 10–12 weeks before planting.

Leeks

Since leek seedlings grow very slowly, sow them 14–16 weeks before planting them outdoors. Transplant when the plants are 8 inches tall and about pencil thickness. Cut off half of the green, leafy portion and be careful not to bend the roots when planting (trim them if you must).

Onions

Generally, plant sets for the best cooking and long-storage types. Sparsely sow seed indoors or in a hotbed 10–12 weeks before transplanting outdoors; set the young plants after all danger of severe frost has passed.

Shallots

Plant French types as sets in the spring or fall, and other types as sets only in the fall. To produce sets for later planting, start seeds indoors and transplant them outdoors in the spring. Start seeds 10–12 weeks before the last expected hard frost date; transplant seedlings outdoors after all danger of hard frost has passed.

Planting Dates

Transplant, direct-seed, or set onions and shallots about April 1–15 in central Pennsylvania. (Plant spring plantings about 3 weeks earlier in the warmest regions of the state and about 10 days later in the coldest regions.) Seed hardy, bunching onions in the fall; leeks around April 1–15 for late June to early July garden transplanting; and garlic cloves by October 15 (10 days earlier in colder, short-season areas and up to 3 weeks later in warm, long-season areas).

Depth of Seeding

Sow onion and leek seeds ½ inch deep. Plant garlic cloves and onion sets about 1–2 inches deep to eliminate bird scavenging or frost heaving. Be sure to plant onion sets and garlic cloves upright (point of the onion or clove up, flat part where roots form down). Set leek transplants in a trench about 6 inches deep and gradually fill the trench as the plants grow. Plant shallot seeds 1 inch deep. Plant shallot sets upright and at half their depth, making sure the tops remain uncovered.

Spacing

Between rows:

- Garlic: 1 foot for stiffneck types, 1½ feet for elephant garlic
- Leeks: 1½–2 feet
- Onions: transplants and direct-seeded, 1½–2 feet; bunching and sets, 1–2 feet
- Shallots: 9 inches

Within rows:

- Garlic: 6 inches
- Leeks: 5–6 inches
- Onions: set transplants 3–4 inches apart; thin direct-seeded plants to 3–4 inches; thin bunching types as you pull them; plant sets 1½–2 inches apart and pull every other plant for early harvest
- Shallots: 4–6 inches

Special Considerations

Garlic

Expose dormant cloves, divisions of the large bulb, or young garlic plants to temperatures of 40°F for 40 days to induce bulb formation. Planting cloves in the fall ensures proper cold exposure. Garlic yields tend to increase as the size of the mother clove increases. Therefore, use the smallest cloves (those less than 1 gram in weight) for cooking rather than planting. Make sure not to plant them so deep that the soil hampers their expansion, or so shallow that birds pull them out or frost heaves them out of the soil. Mulching in early December with weed-free straw or other organic material protects the cloves from frost heaving and provides weed control the following spring.

Stiffneck garlic strains produce flower stems (scapes) that form heads with bulbils in late May or early June. Remove these scapes as soon as you first notice them to produce larger bulbs. The Rocambole type of stiffneck garlic has scapes that are distinctly twisted or coiled, sometimes even double coiled. This coiling is perfectly normal and is not the result of any poor cultural practice or herbicide contamination. If scapes are not removed, they tend to straighten by the time of harvest and can be 5–6 feet tall. Also remove scapes from both stiffneck and elephant garlic to improve clove size. Use these scapes as cut flowers or eat them.



Leeks

As leeks begin to reach harvestable size, hill 3–4 inches of soil or organic mulch around the stems for maximum blanching. Hardy strains such as ‘Bandit’ will overwinter well if covered with marsh hay or straw mulch or with nearly continuous snow cover. A general rule is that leeks with short, thick stalks and bluish leaves overwinter well, but leeks with tall, thinner stalks and green leaves cannot survive Pennsylvania’s worst winters unless grown in high tunnels or cold frames.

Onions

Optimum growth for onions requires at least 1½ inches of water per week either through irrigation or rainfall. Inadequate watering will reduce bulb size and increase pungency. Medium-sized onion sets, ½–¾ inch in diameter, are best for producing mature onions. If large sets (over ¾ inch) are planted, many will send up seed stalks. Pinch off seed stalks as soon as they develop, or else thick, double-neck onions will likely be produced. Use thick, double-neck onions as immature green onions since they do not keep well and are undesirable for storage. Thick, double-necked bulbs are slow to cure and frequently succumb to neck rot.

Shallots

After five or six shoots have developed, mulch with straw, peat moss, or leaves. Mulching too heavily encourages onion maggots and root rot, but using no mulch necessitates frequent watering and cultivation.

Harvesting

Garlic

Fall-planted garlic in central Pennsylvania is ready to harvest about the second week in July. When the leaves start to brown, pull a sample. There is only a 10- to 14-day window for optimum garlic harvest. Before then, the garlic is unsegmented like an onion; after that period, the cloves will have grown and expanded to the point that the outer sheath will be split, exposing part of the naked clove. Bulbs with split sheaths are difficult to harvest and have a shorter storage life. Picked at the proper time, each bulb should be fully segmented and yet fully covered by a tight outer skin. Pull the garlic and allow it to dry in a well-ventilated, shaded area at 70–80°F; hotter areas and/or direct sun can caramelize garlic. After drying, remove the loose outer portions of the sheath and trim the roots and tops 1 inch from the bulb.

Leeks

Harvest leeks when they reach an edible size. Those transplanted in early July are ready for harvest by October. If overwintered, harvest in early spring before flower stalk formation (bolting) occurs.

Onions

When about half or more of the onion tops have fallen and started to turn brown, bend all of the tops over to promote maturation. When the tops are completely brown, pull the bulbs out of the ground and spread them to dry and cure in a well-ventilated area protected from direct sunlight. Either braid (bunch) the tops or trim to about 1 inch from the bulb and store in a slatted container. Breakdown in storage may result if the tops are cut too close to the bulb and the neck is not thoroughly dried. Close cutting allows decay organisms to have easy access to the bulb. Neck rot fungus only attacks onions that have been injured, wounded, or not properly cured.

Onions can also be stored in a mesh bag or by tying them into pantyhose. Place one onion in the pantyhose and knot it, then place the next one in and knot; do this until filled. To use throughout the winter, cut the desired number of onions from the chain.

Shallots

Like onions, shallots are mature when their tops have fallen over. You can accelerate maturity by bending all the tops over as soon as the first few bend. Before storing, cut the necks to within 2 inches of the bulb and dry thoroughly. Store shallots in a cool location with good air circulation.

Weed Management

All members of the *Allium* (onion) genus discussed here do not compete well with weeds. Alliums are shallow rooted and do not have large amounts of leaf area to capture sunlight. Large weeds drastically reduce yields in these vegetables. Therefore, it is very important to keep your plantings weed free. To reduce the amount of time needed to cultivate and pull weeds throughout the season, use some type of organic mulch or very reflective plastic mulch that cools soils. The mulch will conserve moisture, reduce or eliminate weed growth, and help keep the soil cooler.

Insect Identification and Management

Onion Thrips

Onion thrips occur in all areas. Adults are small ($\frac{1}{25}$ inch long), slender, and light yellow to brown in color. They overwinter on plants or debris in gardens, fence rows, and weedy areas. Thrips puncture the outer layer of the leaves with their rasplike mouthparts and feed on sap and bits of leaf tissue. They produce several generations each summer. Hot, dry weather is favorable for increased insect activity and plant injury. Small, whitish blotches on the leaves are characteristic symptoms of thrips injury. Thrips are hard to manage since they feed between the leaves.

Management: Maintain plant vigor. Limited control can be achieved by hosing down the plants (early in the day) on a regular basis when injury is first noticed. Some control will also result from using insecticidal soap (more effective on larvae than adults). The most effective control measure is to use an insecticide labeled for thrips management in vegetables (be careful to observe the days-to-harvest interval). Insecticide resistance has been a problem with onion thrips. Since the insects feed between leaves near the base of the plant, they are hard to reach with insecticides. Apply insecticides with sufficient water to ensure thorough coverage.

Red onions tend to be more susceptible to thrips than white onions, with yellow onions intermediate. Resistance to thrips infestation occurs in some cultivars of Sweet Spanish onions. All cultivars can tolerate populations of 25 thrips per plant. For well-managed, irrigated onions, plants can tolerate high populations of thrips without reducing yields. Bulb size can be reduced if populations greater than 50 thrips per plant are allowed to develop and persist. In onions, waiting until you see damage is not recommended. Sprays need to be based on high populations, but before feeding damage is readily apparent. Early plantings can sometimes be harvested before damaging populations develop.



Onion thrips (nymphs)



Onion thrips damage

Onion Maggots

Onion maggot problems vary from year to year. Maggots are more of a problem during and after a series of wet springs. They rarely attack any plants except onions (other related species attack other plants). As maggots infest young onions, the plants wilt and often die.

Larger onions may survive an attack, but the injured bulbs often rot in the garden or in storage.

The adult is a long-legged fly that is a little smaller than a house fly. The maggots are whitish in color and $\frac{1}{3}$ inch long when fully grown. Onion maggots overwinter in a resting stage known as pupae. Adult flies emerge in early spring and begin to lay their eggs in the soil near onions. Eggs hatch in 3–4 days and the maggots immediately bore into the plants. They feed and grow for about 3 weeks before changing to pupae. Adult flies emerge about 2 weeks later. Three to four generations occur each year, depending on the weather. The first brood is always more injurious to plants.

Management: Do not plant onion bulbs in the same location as the previous year. Remove and destroy infested plants. Protect plants from the first generation of adults by using a floating row cover held at least 6 inches from the plant stems.

Disease Identification and Management

Leaf Spots and Blights

Spots appear on leaves, which die prematurely. If spots are purplish in color with concentric rings, then the disease is called purple blotch. Spots that initially appear as white specks and are surrounded by a light green halo are diagnostic for Botrytis leaf blight. The spots eventually expand and can cover the entire leaf, causing it to turn brown and eventually die. For downy mildew, white specks similar to Botrytis leaf blight develop; but, under moist conditions, a white to purplish mold will develop on the surface of the lesions.

Management: Grow bulbs in a sunny, well-drained area. Allow at least 2 years without onion-related plants within the rotation. If needed for onions, spray with fungicides as directed on labels; fungicide materials should contain chlorothalonil, mancozeb, or a fixed copper. To be effective, start fungicide applications before disease is well established. Leaf spots and blights can be a problem where heavy dew or rainfall occurs frequently during the growing season. Use drip or trickle irrigation when possible to minimize leaf wetness. When possible, grow a cultivar that has resistance to the disease of concern.

Root Rots, Wilts, and Bulb Rots

Rots can develop on the roots and the base of bulbs. When rots are severe, plants can wilt in the garden, and many bulbs may rot during storage. Soft rots can be caused by several different types of bacteria.

Management: Grow bulbs in a sunny, well-drained area. Where root rots and wilts have been a problem, allow at least 4 years between onion-related plants. For storage onions, plant early enough to permit bulb maturation and drying before long, cold, wet periods in the fall. When necessary, dry onions inside before storage. When possible, grow a cultivar that has resistance to the disease of concern. Minimize any kind of injury to the plant to prevent openings through which bacteria and other pathogens can enter. Use drip or trickle irrigation when possible to minimize leaf wetness.



Purple blotch on onion



Onion bulb rot

CUCURBITS

(CUCUMBERS, MELONS, SQUASH, AND PUMPKINS)



Starting Seedlings

If you live in the colder areas of Pennsylvania where the growing season is short, you may need to start seeds of melons, squash, and pumpkin indoors 3–4 weeks before transplanting them outdoors. This will help ensure maximum yields before fall frosts.

Many gardeners and growers use peat pellets (e.g., Jiffy 7) or pots to grow transplants. Planting a peat pot with the seedling will reduce root damage, which often occurs when transplanting. Be sure to bury the peat pot completely when transplanting or wick action may cause it to dry out. When transplanting, thoroughly soak all pots with a high-phosphorus starter solution, such as 1 tablespoon of 10-55-10 dissolved in a gallon of water.

You can produce cucurbit transplants with 3 true leaves in 3 weeks by raising the soil temperature to about 85°F and providing adequate light. Either use bottom heat to warm the soil or raise the air temperature to 90°F. For watering, use water that has been warmed to about 85°F. Under these conditions, germination should occur in about 3 days.

After the seedlings have germinated, grow them at about 75°F during the day and 65°F at night. Harden the plants slightly during the last week before transplanting by watering less frequently and dropping the day temperature to 70°F and the night temperature to 60°F.

If you live in the warmer areas of Pennsylvania, you can grow cucurbits, especially cultivars with shorter maturity periods, by direct-seeding. Wait until at least the last frost date in your area to allow the soil to warm. Cucurbits germinate poorly in cool, wet soils.

Soil Fertility and pH

Except for watermelons, all the cucurbits mentioned here grow best in soils with a pH of 6.2–6.8. Watermelons grow well in soils with a pH of 5.5–6.8. We strongly recommend fertilizing and liming based on soil test results (purchase kits from your local county cooperative extension office or garden supply center). In the absence of a test, apply 3½ pounds of 5-10-5 fertilizer plus 1 pound of either 0-20-0 (regular superphosphate), well-decomposed compost or steamed bone meal to each 100 square feet of growing area for all the above cucurbits, except watermelon. For watermelon, use only 1½ pounds of 5-10-5 fertilizer but the same amount of phosphate, compost, or bone meal. If using compost or bone meal, incorporate it into the soil prior to planting.

All cucurbits benefit from relatively high levels of organic matter. Therefore, sowing a cover crop in the fall and winter before planting and judicious use of compost can be very beneficial. Since magnesium appears to be especially important for cucurbits, also consider applying 3 pounds of Epsom salts per 100 square feet if magnesium is expected to be low in your soil and has not been corrected with dolomitic limestone.

Planting or Direct-Seeding Dates

- Cucumbers (slicing): direct-seed May 15–June 30 (floating row covers are strongly suggested for additional warmth and for early cucumber beetle management)
- Cucumbers (pickling): direct-seed May 25–July 1
- Melon, watermelon, winter squash, and pumpkins: set transplants May 20–June 1 through black or dark blue plastic mulch

- Winter squash and pumpkins: direct-seed May 20–June 1
- Summer squash: direct-seed May 15–June 15 for early plantings, about August 1 for late plantings

Depth of Seeding

Seed 1 inch deep for all the discussed cucurbits.

Spacing

Between rows:

- Slicing cucumbers: 5 feet
- Pickling cucumbers: 4–5 feet
- Melons and small vine watermelons: 6–8 feet
- Standard vine watermelons, vining winter squash, and pumpkins: 8–10 feet
- Summer squash and bush winter squash: 3–5 feet

Within rows:

- Slicing cucumbers: 1 foot
- Pickling cucumbers: 6 inches
- Melons and small vine watermelons: 2 feet
- Standard vine watermelons, vining winter squash, and pumpkins: 3–5 feet
- Summer squash and bush winter squash: 3 feet

To conserve space, consider planting on the sunny side of corn rows. Vines will run between corn rows and, in the case of cucumbers, even climb the cornstalks.

Mulching

Black or dark blue plastic mulch or black landscape fabric is practically a must for successful melon production in heavy soils. It limits weeds, increases soil temperatures early in the season, eliminates soil packing and crusting, and maintains a more uniform distribution of moisture throughout the season. To ensure success, make sure that the soil is adequately moist (ideal moisture for transplanting) before you lay the plastic or landscape fabric. Plastic mulch and landscape fabric should never be applied over dry soil.

Organic mulches and certain reflective mulches (such as metalized silver) cool the soil and therefore should not be applied until cucurbits are well established.

Pollination

Provide floral and nesting resources to encourage pollination by insects. Information on how to conserve wild bees is summarized in the publication *Conserving Wild Bees in Pennsylvania*, which is available at pubs.cas.psu.edu/FreePubs/pdfs/uf023.pdf, through the Publications Distribution Center, 112 Agricultural Administration Building, University Park, PA 16802, or from county extension offices. Avoid using pesticides that are particularly harmful to bees during the blossoming period. Additionally, apply all pesticide sprays in the evening.

Floating Row Covers

To reduce insect pests that may transmit a virus, cover the plants with a row cover until they begin to flower. Plants are especially sensitive to insect damage when they are young; covering them reduces the need to apply pesticides. Examples of floating row covers or plant covers are on page 21.

Harvesting

Harvest cucumbers at almost any stage of development, before they begin to turn yellow. However, most slicing cucumbers are best when they are more than 5 inches long but still slender and dark green. When sliced, the seeds and seed cavity should still be immature. Harvest pickling cucumbers when they are the desired size—usually more than 2 inches long.

Harvest and eat summer squash while still young and tender, before the seeds ripen or the rind hardens.

Cucumbers and summer squash require regular picking about two to three times a week to attain maximum quality and production. Plants cease to produce if fruits are allowed to reach full maturity.

Most melons are harvested when they slip easily from the vine. However, some cultivars never slip. Fruit should show changes in color and degree of netting and a softening at the blossom end on older cultivars. Newer cultivars do not soften at the blossom end, as this affects quality during shipping and handling. Best eating maturity follows in 1–3 days, and best flavor is attained if melons are held near 70°F for the final ripening and then served or chilled before serving.

Watermelons are usually harvested when



fruits are full size for the cultivar and dull in color and when the bottom (portion touching the soil) turns from greenish white to a cream color. At this stage, the curly tendril closest to the point of vine attachment is often shriveled or dying.

Melons and watermelons that ripen on defoliated vines are generally very disappointing in quality.

Winter squash that is allowed to mature and develop hard rinds can be eaten after maturity or stored for winter use. Immature “acorn” types may be used as a substitute for summer squash, but those to be stored should be left to mature on the vine.

Harvest pumpkins when fruits are full size for the cultivar and when the rind is firm, glossy, and ideally fully colored. You may harvest fruit earlier (when the bottom—the portion touching the soil—is cream to orange in color), but generally fruit harvested early does not last as long as fruit that has been allowed to mature fully.

Squash and pumpkins for storage will rot unless the rinds are hard and well matured. After harvest, the ideal storage procedures are to cure at 80–85°F and a relative humidity of about 80 percent. After about 10 days remove and store at 55°F and about 55 percent relative humidity. Temperatures that are too high tend to dry the flesh too much, and temperatures that are too low can cause chilling injury and a subsequent reduction in shelf life.

Tips for Growing Giant Pumpkins

If you follow certain guidelines, your pumpkins can grow to several hundred pounds in weight. Below are tips for those of you who would like to try growing giant pumpkins.

1. Select “for show” cultivars such as ‘Dill’s Atlantic Giant’ or ‘Prizewinner’.
2. Follow pumpkin soil test recommendations for the amount and type of lime and fertilizer to incorporate into the soil.
3. Add well-rotted organic matter (e.g., rotted corn cobs, sphagnum peat moss, rotted sawdust, decomposed leaf mold, or animal manures) to a depth of 2 inches on top of the soil.
4. If phosphorus levels are deficient or optimal on your soil test recommendations, consider applying 1 pound per 100 square



feet of regular superphosphate (0-20-0) on top of the organic matter before incorporation into the soil. Unlike 0-46-0, the regular superphosphate also supplies calcium and sulfur to the soil.

5. Rototill or otherwise incorporate the fertilizer/organic matter material to a soil depth of 7–10 inches.
6. Start seed by sowing in thin-walled peat pots (Finn pots) or plastic trays (4 inch square by 3 inches deep) about 19 days before your anticipated planting date in the garden. Earliest optimum planting date in central Pennsylvania on plastic mulch is June 1–10 when both air and soil temperatures are warm (60°F). For locations south of State College, planting can occur 7–10 days earlier, and for locations north of State College about 7 days later.
7. Plant into 4-foot-wide, black or metalized silver plastic.
8. Space plants 12 feet apart in all directions.
9. At transplant time, add about 1 quart of a water-soluble, high-phosphorus starter solution, such as 12-48-8, and transplant into moist soil, preferably after a rain.
10. For additional soil moisture, take a 2-liter bottle and punch several small holes into the bottom of it. Then fill the bottle with water and place it near the plant (you may need to cut a hole in the plastic mulch the diameter of the bottle). Place at least three of these around the plant to maintain good moisture. Refill the bottle with water as they get depleted. The size of the pumpkin is directly related to available soil moisture.



11. Use drip irrigation and irrigate as often as needed. Every time you irrigate, alternate a water-soluble form of calcium nitrate with 15-15-15 or equivalent material at 20 percent of the recommended rate for greenhouses.
12. When plants begin to vine and air and soil temperatures are warm, add organic mulch around the plastic to hold more soil moisture and cool the soil.
13. Grow only one pumpkin fruit per plant.
14. Follow Penn State recommendations for managing disease and insect pests.
15. When pumpkin vines get fairly large, consider determining weekly whether any additional water or fertilizer (plant tissue testing) needs to be applied to maintain optimum growth.

Insect Identification and Management

Insects attack cucurbits from seeding until harvest. They can reduce the stand, defoliate the leaves, feed on roots or flowers, transmit bacterial and viral diseases, and create wounds that help fungal pathogens enter the plant. Major insect pests include seedcorn maggot, two types of cucumber beetles, squash vine borer, squash bug, two types of aphids, two-spotted spider mites, and whiteflies. Protect the planting from insect damage while concurrently ensuring pollination by bees. Row covers are effective against beetles, vine borers, and squash bugs, but they must be removed during flowering to allow for pollination.

Pollination Precaution

Cucurbits bear two types of flowers. Cucumbers, squash, pumpkin, and watermelon have separate male and female flowers, while melons have male flowers and flowers with both male and female organs. Bees are important for pollination. The dense and sticky pollen needs to be transferred to the female flowers to ensure well-shaped fruit and optimize yield. Fruit size and shape are related to the numbers of seeds produced, and each seed requires one or more pollen grains.

Flowers are usually open and attractive to bees for a short time—one day for pumpkins—and pollination must take place on the day the flower is open. Commercial growers use honey bees to pollinate cucurbits, but this expense is

not practical on a small scale. Be cautious when spraying any insecticides so that you are not killing the bees pollinating your planting. These include both bumble bees and ground-nesting bees native to Pennsylvania.

Seedcorn Maggot

Seedcorn maggots invade cucurbits, beans, and sweet corn. Adults are brownish gray flies that closely resemble common house flies, except that they are about half the size. The maggots deposit tiny, white, elongated eggs among debris and around plant stems near the soil surface. Eggs hatch in a few days, and the maggots work their way into the soil in search of food. Maggots are dirty white with a yellowish tinge; when fully grown they reach $\frac{1}{8}$ – $\frac{1}{4}$ inch in length.

Maggots feed in the seed or on the underground parts of seedlings. Damaged seed may germinate, but enough food reserves may not be left in the seed for the plant to survive. The time required for maggots to grow from egg to adult is 3–4 weeks. Three to five generations occur each year in Pennsylvania. Populations tend to decline during the dry summer months.

Management: Seedcorn maggots tend to cause greater losses during cool, wet years and in soils with an abundance of decaying organic matter, such as manure or a recently soil incorporated cover crop. Incorporate organic matter well before planting, and cover transplant root balls with soil. Any cultural practice that speeds up germination, plant emergence, and early plant growth helps reduce losses from maggots, allowing the plant to “outgrow” the feeding damage. Planting in warm soils significantly helps plants outgrow maggot injury.

If significant damage occurs, replant those areas. Look to see if maggots are still present. If they are small (less than $\frac{3}{8}$ inch), then wait 7–10 days for them to begin to pupate before replanting. Most chemically treated seed is designed to help prevent damage during seed storage. Additional treatments applied at planting are effective but are typically for commercial use. Sprays applied to soil after damage is seen are not effective.



Seedcorn maggot larva



Striped cucumber beetle adult

Striped and Spotted Cucumber Beetles

Two main types of cucumber beetle (striped and spotted) feed on cucurbits. Of these types, the striped cucumber beetle is present in the highest numbers and over the longest time span. Both the striped and the spotted cucumber beetles overwinter as adults. Striped cucumber beetles invade soon after transplanting and lay eggs at the base of plants. The hatching larvae feed on the roots of cucurbits, pupate, and then emerge as new adults in about 25–30 days. Two to three generations occur per year in Pennsylvania. In contrast, spotted cucumber beetles do not overwinter well in Pennsylvania, and immigrating adults from the south are present later in the season.

Adult feeding during early plant growth can cause stand reduction. Rind feeding by adults or larvae later in the season ruins the appearance of the fruit and may serve as entry routes for pathogens. Larval feeding also affects root development. Most important, the striped cucumber beetle spreads bacterial and viral diseases. The most important disease is bacterial wilt. Disease management currently relies on managing cucumber beetles. Even low beetle numbers on young plants can result in significant plant disease.

Management: See “bacterial wilt” in the disease identification and management section. Row covers can be effective if put on right at transplanting. The row covers will effectively exclude the beetles for as long as the planting is covered. If you can find a self-pollinating cultivar (some exist for cucumbers), then you can leave the floating row cover on until harvest. Otherwise, remove the cover to allow bees to pollinate the planting. Use of insecticides labeled for cucumber beetle management can be effective at stopping significant plant feeding, but you must apply insecticides quickly for them to also slow spread of the bacterial pathogen. Protecting the young plants is especially important.

In order to repel cucumber beetles, the cucumber cultivar must be genetically bitter free. Most seed catalogs either indicate that a cultivar is bitter free in the description or place them in an identifying category or grouping. Some cultivars (for example, ‘Tasty Jade’) taste sweet but do not have bitter-free genetics. These cultivars may be better suited for growing in greenhouses or high tunnels where insect levels are low and easier to manage than outdoors.



Squash vine borer larva

Squash Vine Borer

The squash vine borer, an important pest of squash, pumpkins, and gourds, is most destructive to late squash. Cucumbers and melons rarely become infested. Small plantings are the most seriously infested; in small plantings, eggs are concentrated onto fewer vines. Squash vine borers overwinter inside tough, silk-lined cocoons in the soil. The moths begin to emerge in late June; the day-flying adults are active during July and early August.

The adult is a clear-winged moth with a wing spread of 1¼ inches. The body is strikingly colored with orange and black markings. The hind legs are long and ornamented with tufts of long, orange, black, and white hairs. When in flight, the moth may easily be mistaken for a wasp.

They usually lay their eggs singly or in small groups on the stem near the soil surface. Eggs hatch in a week to 10 days, and the tiny borer enters the stem. The borer reaches maturity in approximately 40 days.

Borers attack fruit toward the end of the season when vines become woody. They leave the plant in August and September, enter the soil, and form overwintering cocoons. Only one generation occurs per year.

Symptoms of injury are a sudden wilting of a runner or the entire plant and yellow droppings on the soil surface near the plant base. The vine is hollowed out and partially filled with moist, shiny droppings, in the midst of which is the squash vine borer. Disease invades the damaged stems, causing the vines wither and die.

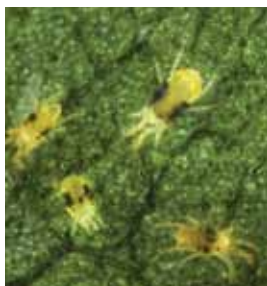
Management: Try excluding the pest by placing sleeves or collars on the vine stems at the base of plants or by removing borers from vines. When adults are flying, insecticides can be repeatedly applied to the base of plants.

Squash Bug

Squash bug adults are hard, brown to coppery brown, flattened, ½ inch long, and give off a distinct odor when handled. The adults overwinter in protected sites and emerge in late spring. Females lay shiny, orange to coppery brown eggs in clusters containing 4–40 eggs in more or less regular rows on the undersides of leaves. Eggs hatch in 1–2 weeks, with young squash bugs feeding on plants for 5 weeks before becoming adults. Only one generation occurs per year in Pennsylvania.



Squash bug



Adult two-spotted spider mites

Management: Place boards on the ground near the vines to help trap adults overnight and to let you know when they are moving into a planting. Trapped adults can then be removed. Scouting is best directed toward the eggs—begin at early flowering. You can achieve control by trapping out adults, repeatedly inspecting lower leaf surfaces, and removing eggs and young squash bugs. Chemical management requires thorough coverage underneath leaves. The insects are well protected under the large leaves of cucurbits. Make sure you are not moving into canopy closure with a population of squash bugs.

Aphids

Both melon aphids and green peach aphids infest cucurbits. Colonies develop on the undersides of leaves or on plant tips. Direct damage by aphids is minimal until populations build to high levels, but feeding causes distorted, stunted plants, and molds grow on a sticky substance emitted by aphids. Most important, aphids transmit several viruses.



Green peach aphids

Management: In small areas, remove plants that show signs of virus infection. Aphids are often controlled by natural enemies that rely on these slow-moving insects as a host resource. High populations can be reduced with insecticides labeled for aphid management.

Whiteflies

Adult whiteflies are small (1½ millimeters long) insects that look like tiny, white moths. Whiteflies do not overwinter in Pennsylvania; however, they can overwinter in greenhouses and affect transplants. Carefully inspect transplants before planting. Infested leaves dry out and drop, and sooty mold grows on honeydew excreted by whiteflies.

Management: Recognizing early infestations and removing infested plant parts slows population growth. Chemical management is difficult—the chemical must contact the whiteflies under the leaf surface. The eggs will probably survive; thus, you may need to make repeat applications to kill newly hatched whiteflies. Yellow sticky boards offer an alternative to chemical spray and are often available in garden centers. This tool is also useful to monitor your garden for small, flying insect pests. Shaking plants while holding a large yellow sticky board above the plant will capture many adults, and doing this daily will eventually reduce a population.



Powdery mildew on pumpkin



Downy mildew on cucumber

Two-Spotted Spider Mites

Spider mites are tiny, eight-legged animals most closely related to spiders. Large populations are required to cause serious damage, but spider mites build up very quickly when temperatures are hot (over 80°F). Dry weather (less than 50 percent relative humidity) also encourages mite buildup. Mites can reach full development in only 5–7 days under these conditions, two to three times faster than many other vegetable pests.

Often mites move in from nearby plants or weeds, especially when dry weather slows growth in these plants. Damage appears as stippled, yellowing, and dirty leaves, which may dry and drop. Webbing may be visible between the leaves or on their lower surfaces.

Management: Removing damaged leaves may slow the spread of mites in a small planting. Spot-treat with a chemical labeled for mites when you first notice white stippling on the undersides of leaves and when 20 mites per leaf are present.

Disease Identification and Management

Powdery Mildew

A white, powdery growth develops on both the upper and lower leaf surface, which distinguishes it from downy mildew. As the disease progresses, the entire leaf surface can become affected and eventually dies. This is favored by high temperatures and can progress with relative humidities as low as 54 percent.

Management: When possible, grow powdery-mildew-resistant cultivars. For example, resistant cucumber cultivars are ‘Salad Bush’, ‘Marketmore 76’, ‘Dasher II’, and ‘Diva’. For susceptible melon cultivars, limited control is possible by using fungicides such as sulfur, chlorothalonil, or fixed copper if started when disease first appears and continued at 7-day intervals.

Downy Mildew

Yellow to brown spots develop on the upper leaf surface and are delineated by the leaf veins. Under moist conditions, purplish gray mildew develops on the underside of the leaf. Spots typically develop on the oldest leaves first and can spread very quickly, causing the entire plant (especially cucumber) to collapse under moist,

warm conditions. Downy mildew does not survive in the soil in Pennsylvania. The pathogen blows in on wind currents when it is overcast and during rainstorms.

Management: Choose a sunny planting site. Avoid areas where cucurbits were grown within 3 years. When possible, use cultivars that are resistant. If disease appears early, plants can be sprayed with fixed copper or chlorothalonil at 7-day intervals, if necessary. Remove plants as soon as harvest is completed.

Bacterial Wilt

Bacterial wilt, which is transmitted by cucumber beetles during feeding, causes plants to wilt and die. Look for the presence of beetles and/or beetle chewing injury to help diagnose bacterial wilt. Bacterial wilt is most severe on melons and cucumbers, but this disease will infest some squash and pumpkin plantings. The disease is characterized by the wilting and drying of individual leaves. The leaves may wilt and recover during the night several times before finally dying.

Management: Use protective coverings such as a floating row cover to keep beetles off young plants (4–5 weeks old) when they are most susceptible to infection. Since the plants require pollination by an insect, remove the protective covering when plants begin to bloom and the threat of bacterial wilt has decreased. See cucumber beetle in the previous section.

Viruses

Plants are stunted and new leaves are mottled and distorted. Fruits can be malformed, stunted, and mottled.

Management: Grow resistant cucumber cultivars. Some cultivars of summer squash also are resistant to viruses. Use a floating row cover to exclude aphids, which transmit viruses. Since bees must pollinate the plants to produce fruit, remove the floating row cover once plants begin to blossom. Maintain good weed management since weeds can serve as a reservoir of the virus.

Leaf Spots

Anthracnose symptoms are the occurrence of light brown to reddish spots that develop on the leaves and eventually crack or drop out, giving them a “shothole” appearance. Infected leaves commonly die prematurely. Small, water-soaked areas on the leaf that turn gray to white and eventually drop out are symptoms of scab caused by a fungal pathogen. On cucumber fruit, dry, dead spots can develop, while on melons, the scablike spots have a grayish green mold appearance. Angular leaf spot can look similar to downy mildew, but it will not develop the gray mildew on the lower leaf surface under moist conditions.

Management: Choose a sunny planting site. Avoid areas where cucurbits have been grown within the previous 3 years. Grow scab-resistant cucumber cultivars. If necessary, use the same treatment as recommended for leaf spots. If disease appears early, spray plants with fixed copper or chlorothalonil at 7-day intervals or as otherwise directed on the label. Remove plants as soon a harvest is complete.

Fusarium Wilt

Fusarium wilt is characterized by a general dull green color to the leaves followed by a yellowing of the foliage. Symptoms are typically observed as wilting first on the older leaves of one side of the plant. The plant will recover at night but eventually collapse and die. If you cut the stem open, you can see the discoloration/browning of the vascular system. Absence of cucumber beetles helps distinguish Fusarium wilt from bacterial wilt.

Management: This pathogen is long lived in the soil, so if it is a problem, avoid areas where cucurbits were grown within the past 5–7 years. Grow wilt-resistant melon cultivars.



Pumpkin leaf virus

LEAFY VEGETABLES

(LETTUCE, SPINACH, TURNIP AND MUSTARD GREENS, ENDIVE, ESCAROLE, AND RADICCHIO)



Cultural Practices

Leafy vegetables are of best quality when harvested under moderately cool temperatures (45–65°F is ideal). Thus, in Pennsylvania, spring and fall plantings are recommended. Spinach, head lettuce, romaine, radicchio, and most leaf lettuce cultivars may bolt or go to seed during the long, warm days of summer, so it is important to plant at the proper times. A few exceptions are certain cultivars that are especially heat tolerant, such as those for spinach and mustard greens.

Loose, fertile, moist, sandy loam soils are best for growing leafy vegetables. Many of these have shallow root systems, so cultivate carefully.

Starting Seedlings

To grow certain cultivars of head lettuce, radicchio, and romaine or cos types in Pennsylvania, use transplants rather than seeds. Sow the seeds 5–7 weeks before the desired transplanting date. Certain cultivars require light for germination. Once germinated, transplant the seedlings into cells or flats with 1½ by 1½ inches or 2 by 2 inches of space between plants. Harden and transplant lettuce and radicchio as soon as the danger of a hard freeze (lower than 29°F) is over. Endive and escarole are often seeded in a

small row for later transplanting. Harden plants by reducing water and temperatures for about 3 days and placing them outdoors during the day for one week prior to transplanting. This helps plants adjust to outside conditions.

Soil pH and Fertility

All leafy vegetables, except lettuce, grow best in soils with a pH of 6.0–6.8. Lettuce grows best at about a pH of 6.5–7.0. We strongly recommend applying fertilizer and lime based on soil test results (purchase kits from your county extension office or garden supply center). In the absence of a soil test, apply 1–2 inches of compost and 3 pounds of 5-10-5 fertilizer per 100 square feet for head lettuce, romaine, mustard greens, and radicchio; use 4½ pounds per 100 square feet for spinach, leaf lettuce, endive, and escarole. In both cases, mix into the soil before seeding or transplanting.

Application and Side-Dress

Later, side-dress with small amounts of a high-nitrogen fertilizer, or compost one or two times during the growing season.

Seeding Dates (Outdoors)

- Leaf lettuce: April 1–August 1
- Head lettuce, romaine, and radicchio: August 1
- Spinach: April and the end of August
- Turnip and mustard: April 1–August 1
- Endive and escarole: May to the end of July

Transplanting Dates (Outdoors)

- Head lettuce, romaine, and radicchio: either April 20, August 15, or both

Depth of Seeding

- Lettuce, turnip greens, and mustard greens: ¼ inch
- Escarole, endive, spinach, and radicchio: ½ inch

Spacing

Between rows:

- Leaf lettuce, spinach, mustard, and turnip greens: 1½ feet
- Head lettuce, endive, and escarole: 2 feet

Within rows:

- Leaf lettuce: 6 inches
- Head lettuce and radicchio: 12 inches
- Spinach: 4–6 inches
- Turnip and mustard greens: 8 inches
- Endive and escarole: 15 inches

Harvesting

Lettuce

Head lettuce, romaine or cos types, and radicchio are best harvested when the heads are firm but not so hard as to indicate overmaturity. Harvest leaf lettuce anytime after the outer leaves are 4–6 inches long. First, pull entire plants where they are too thick. When proper stand is established, pick outer leaves as needed.

Spinach

Harvest spinach by cutting off the entire plant at the soil line anytime after the plant has 6–8 leaves. For mustard spinach (New Zealand), pick the tender new leaves at the tips of branches.

Greens

Harvest mustard and turnip greens once the outer leaves are 6–8 inches long. New leaves throughout the season will provide uninterrupted harvest until warm weather causes strong flavor and tough leaves to develop.

Fall Salad

Endive or escarole is fully developed when it is 10–12 inches in diameter. To maximize sweetness, tenderness, and crispness, consider blanching (cover with a row cover, corn shucks, or oak leaves or loosely tie the outer leaves with string or rubber bands to exclude light) 2–3 weeks before harvest.



Insect Identification and Management

Leafminers

Plants are often disfigured and damaged by the larvae of several species of small flies that live as maggots between the upper and lower surfaces of the leaves. Their feeding causes large, white blotches and winding trails through the interior of the leaf. Infected leaves are unattractive and unfit for human consumption.

The spinach leafminer prefers spinach, beet, and chard as hosts. The insect also attacks many species of weeds. Adult flies emerge in April in Pennsylvania and deposit eggs on the underside of the host plant's leaves. The eggs hatch in 4–6 days, and the young maggots bore directly into the leaves, where they feed for 10–14 days. Three generations occur each year.

Management: Eliminating weeds will aid in the management of leafminers. During most years, you may need sprays to prevent injury. Apply insecticides according to label directions.

Aphids

Aphids are small, soft-bodied insects often called plant lice. They spread several virus diseases, reduce plant vigor and yield, and contaminate leaves. Often natural enemies, such as beneficial parasites and many generalist predators (ladybeetles, lacewings, predatory bugs, and others) hold down aphid populations, especially if you have not recently used a broad-spectrum pesticide.

Management: Eliminating weeds will aid in the management of aphids. Reduce high populations with insecticides labeled for aphid management. Soapy water also aids in management.



Spinach leafminer larvae



Cabbage looper larva

Cabbage Worms

Two worms attack leafy vegetables: the cabbage looper and the imported cabbage worm. The tiny, light green worms are called loopers because of their characteristic way of walking. The looping movement results from having only two pairs of legs toward the tail end of the body. Loopers do not overwinter in Pennsylvania, so problems vary from year to year. However, during late August and September the looper can cause considerable injury.

The imported cabbage worm is velvety green with numerous ridges across the body. The worms have four pairs of legs on the center of the body. The cabbage worm is a persistent problem from early spring until frost. The adult insect is the common white butterfly often seen flying around cabbage plants.

Management: Avoid spraying insecticides directly over the tops of plants since most eggs and young loopers feed on the underside of leaves. To manage cabbage worms, use *Bacillus thuringiensis* (Bt) according to label directions. Bts are microbial insecticides and are not harmful to beneficial insects. They must be used on a regular schedule, but Bts are most effective when the worms are very small. Other insecticides are available for management of these pests; be sure to read and follow the directions on the label.

Pest management programs for growing vegetables use both cultural and chemical management measures. The success or failure of a fungicide or insecticide is related to correctly identifying the pest problem, the method of application, weather conditions, correct timing of sprays, and choosing the right pesticide.

Disease Identification and Management

Lettuce White Mold (Drop or Sclerotinia Mold) and Gray Mold (Botrytis Mold)

A wet rot appears at the base of the plant on the stem or where the outer leaves touch the soil. During wet weather, especially when plants are mature, rots progress into the head. Distinctive mold growth develops on the surface of affected tissue. Sclerotinia mold is white, and Botrytis mold is gray and appears powdery. Soft rot bacteria can follow the molds and result in slimy, rotted heads.

Management: Remove and discard diseased tissues (heads, dead leaves, and roots) as soon as symptoms appear. Do not plant lettuce in areas where similar disease has appeared in recent years on lettuce, cabbage, celery, tomatoes, or cucurbits. The pathogen can survive in the soil for 8–10 years. Plant in well-drained soil or on raised beds.

Downy Mildew

Yellow angular spots delineated by the leaf veins (similar to downy mildew on cucumber) first appear on the top surface of leaves. If downy mildew is the cause, a whitish, fuzzy mold will develop on the underside of leaves following wet, cool weather. Affected areas on leaves eventually become brown and die.

Management: Where disease is a persistent problem, plant resistant cultivars and rotate into other plant families. When necessary, consider applying labeled fungicide sprays that contain a fixed copper. Minimize leaf wetness by using drip or trickle irrigation or watering the base of the plants. If using an overhead sprinkler, water early in the day so the leaves have a chance to dry.

Spinach Mosaic

This can be a problem in fall plantings. First, young leaves on isolated plants become mottled; later, older leaves on these plants can turn yellowish, plants are stunted, and, in severe cases, plants may die. High temperatures promote rapid development of symptoms.

Management: Grow resistant cultivars.

Clubroot of Turnip and Mustard Greens

The first sign that clubroot is present is a wilting of plants. If soil is moist, symptoms may not become apparent until water stress occurs. Pull a wilted plant to determine whether the wilting is caused by clubroot or insect grubs. Clubroot is characterized by distinct swellings on the tap and branch roots.

Management: Rotate all plants in the cabbage family (brassicas: cabbage, cauliflower, broccoli, Brussels sprouts, radish, collards, kale, etc.) to plants in other families. Where clubroot is present, and after several years without growing brassicas, minimize clubroot by applying hydrated lime to the soil before planting (3–4 pounds per 100 square feet), mixing it thoroughly into the soil, and providing good soil drainage.

PEAS



Soil Fertility and pH

We strongly recommend adding fertilizer and lime as directed by soil test results. Purchase soil test kits from your county cooperative extension office or garden supply center. If you do not test the soil, apply 1–2 inches of compost, add 1½ pounds of 5-10-5 or equivalent fertilizer per 100 square feet, and work into soil. It is better to band the fertilizer at 2 inches to the side and 3 inches below the seed. Do not apply excessive nitrogen.

Planting Dates

Plant peas anytime in April in central Pennsylvania. Plant 2 weeks earlier in warmer regions of the state and 10 days later in cooler regions. If you wish to sow a later planting, try ‘Wando’ since it will withstand warm weather better than other cultivars.

Depth of Seeding

Plant all pea types 1–1½ inches deep.

Spacing

Space rows 3 feet apart. To obtain maximum yields from limited space, plant in double rows 6–8 inches apart. Space seeds 2–3 inches apart in the row.

Planting

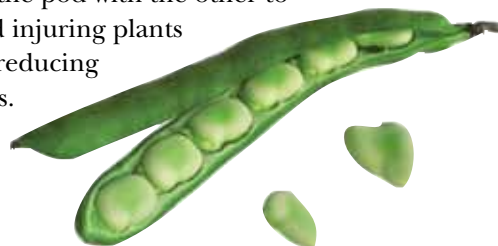
Although cool-season vegetables, peas germinate well, but slowly, at soil temperatures below 50°F. Plants can tolerate moderate freezes. Peas are injured by poor soil drainage anytime during growth.

Staking

Low-growing dwarf cultivars or semileafless types such as ‘Sugar Lace II’ do not need support, especially if grown in double rows. Tall-growing cultivars such as ‘Super Sugar Snap’ or ‘Mammoth Melting Sugar’ must be supported. Chicken wire, a trellis of string, or a row of twigs are some common supports.

Harvesting

Pick standard green (English) pea types while they are firm but still succulent. Pick flat-type, edible, podded peas (snow peas) before seed swellings become too evident. The newer, round, crisp, fleshy “snap” types should be picked when round and firm but still succulent. Snap and remove strings from both ends, but do not shell. Pea pods are firmly attached to their vine, so hold the vine with one hand and pull the pod with the other to avoid injuring plants and reducing yields.



Insect Identification and Management



Pea aphids

Pea Aphids

Aphids are green, soft-bodied, pear-shaped, slow-moving insects that are up to $\frac{1}{8}$ inch long. Colonies consist of winged and wingless adults and immature nymphs of various sizes. They usually congregate on the upper plant parts, on the undersides of leaves, inside immature folded leaves, on flowers, and on pods. As infestations build, aphids appear all along the stems and especially on the undersides of leaves. Plants become sticky from aphids' secretions, called honeydew.

Damage occurs when aphids insert their beaks into plants and suck out plant juices. This results in discolored foliage, stunted growth, curled leaves, and damage to the buds. Aphids can also spread virus diseases to plants on which they feed.

Management: Small infestations can sometimes be managed by washing the aphids from plants with a stream of water. Use of naturally occurring parasitoids and predators of aphids is fairly common. To manage heavy infestations, use insecticidal soap or an insecticide labeled to control aphids in vegetables.

Root Maggots

Maggots are small ($\frac{1}{4}$ inch), legless, and white. They feed on seeds and stems, preventing young plants from emerging. If plants do emerge, they fail to grow normally.

Management: Root maggot problems are worse in cool, wet soils that are high in organic matter. If you have problems with this insect, you may need to plant after the soil is warm to avoid damage. Replant if seedlings do not emerge within 7–10 days.

Disease Identification and Management

Root Rots and Wilts

Brown to red-brown lesions on the stems at the soil line and brown to black discoloration of the root system with few fine feeder roots are characteristics of general root rots. Characteristics of Fusarium wilt are progressive leaf yellowing (no external discoloration of the roots) and eventual wilting and death of the plant.

Management: Grow peas in a well-drained area where they have not been grown for at least 4 years. Fertilize adequately and follow soil test recommendations. Grow cultivars resistant to Fusarium.

Viruses

Affected plants may have mottled leaves, distorted pods, and dead stems.

Management: When available, grow virus-resistant cultivars. Also be sure to manage aphids since they can spread viruses (see the Pea Aphids section to the left).

PEPPERS



Starting Seedlings

You can grow pepper seedlings at home, but growing them requires more attention than tomato seedlings. Pepper seeds germinate rapidly only if the soil temperature is 80–85°F. Germination is very slow at 60°F and is severely restricted below 55°F. Sow seed ¼–½ inch deep in peat pellets or other growing media in a greenhouse about 7–8 weeks before planting in the garden. If seeds are sown too early, the plants will grow too large and result in being held back or planted too early. In either case, expect poor results.

If pepper seedlings are watered excessively or given insufficient light, they are more likely to rot off at the soil line than tomato seedlings grown under similar environmental conditions.

Soil Fertility and pH

Peppers grow best at a pH between 6.2 and 6.8. We strongly recommend fertilizing and liming as directed by soil test results (purchase kits from your county extension office or garden supply

center). In the absence of a test, for each 100 square feet, apply 3½ pounds of 5-10-5 fertilizer plus either 1 pound of 0-20-0 (regular superphosphate) or steamed bone meal (approximately 2-29-0). If using compost, incorporate it into the soil prior to fertilizing. Assume that potash levels are adequate to excessive wherever wood ashes, manures, or high rates of complete fertilizers have been previously applied.

Planting

Generally, June 1 is the time to transplant in central Pennsylvania. Transplant about 2–3 weeks earlier in warmer regions of the state and about June 10 in colder regions. Plants should be no more than 10 weeks old and air temperatures should average 65–70°F during the day; chilling injury and stunting can occur below 40°F.

A good transplant is disease free, slightly hardened, and 6–9 inches tall, with a sturdy stem. Transplants should be medium dark green; stem and leaf texture neither soft nor woody but strong and firm.

Before transplanting, slightly toughen plants by slowing down their rate of growth to prepare them to withstand such conditions as chilling, dry winds, shortages of water, or very high temperatures. Withholding water, but not to the point of wilting, and slightly lowering the optimal growing temperature by 10°F or less in the week prior to planting are the best ways to harden plants.

If possible, transplant into moist (but not wet) soil in the evening or on a cool, cloudy day, and then shade plants for a day or two to prevent wilting, which may occur in direct sun. If plants must be set during hot, sunny weather, it is best to plant them in late afternoon or evening. Press soil firmly around roots. Apply liquid fertilizer, compost, or plant starter solution at transplanting time. Dissolve a 10-55-10, 12-48-8, or similar high-phosphorus, all-soluble fertilizer at the rate of 1 tablespoon (½ ounce) per gallon of water. Pour 1 cup of solution into each hole, set plant, and press soil firmly around roots.

Spacing

- Between rows: 1½–3 feet
- Between plants in rows: 1–1½ feet (A wider spacing may encourage sunscald on fruit.)

Special Considerations

Young pepper transplants are more sensitive than tomatoes to extreme temperatures, wind, and direct sunlight. They do not recover readily from any serious shock or stunting.

Night temperatures below 60°F or above 75°F often result in poor fruit set; blossom drop is common during periods of abnormally cool or hot weather.

Avoid fertility practices that lead to excessive nitrogen, deficient levels of calcium and magnesium, and low pH. Low calcium levels or pH levels below 6.0, when coupled with deficiencies or excesses of moisture at blossom time, can result in blossom end rot.

Mulching

Consider using black or silver plastic mulch early or use straw mulch or other organic mulches after all danger of frost has passed. Plastic mulch will help manage weeds, increase soil temperature early in the season, eliminate soil compaction and crusting, and maintain a more uniform distribution of moisture throughout the season. Straw mulch will allow water to pass through to the soil, eliminate crusting, suppress weeds, reduce water evaporation, and cool the soil (only apply after entering the frost-free period). Be sure soil is adequately moist and apply fertilizer or compost before laying the plastic or straw. Never lay plastic mulch on dry soil.

Harvesting

Pick bell (or sweet) peppers either at the green mature stage when they reach full size or after they turn red (or golden yellow, orange, white, lilac, or purple in some cases). Hot peppers vary in size and shape. They are green in early maturity but quickly turn yellow, orange, or red. Both sweet and hot peppers are edible at all stages of growth. At harvest, cut sweet peppers from the plant; the branches usually are brittle and will break easily if pulled. Hot peppers generally detach from the plant much more easily than sweet peppers, and plants are less brittle.

Insect Identification and Management

Aphids

Several species of aphids infest peppers; green peach aphid and melon aphid are common. Aphids are soft-bodied, round to oblong, about ⅛-inch-long insects that feed by inserting their needlelike mouthparts into plants and extracting plant sap. Both winged and wingless forms can be present. Aphid outbreaks tend to be most frequent in hot, dry weather, while heavy rains (or directed sprays of water) will often reduce the aphid population to acceptable numbers. Colonies develop on undersides of leaves or on plant terminals. Direct damage by aphids is assumed to be minimal until populations build to high levels, but they can transmit viruses.

Management: In home gardens, remove plant parts with aphid colonies and entire plants that show signs of virus infection. Aphids are often managed by natural parasites and predators that rely on these slow-moving insects as a host resource. Beneficial insects can be released to help clean up an aphid population if caught early. Insecticides are not necessary unless numbers increase rapidly. High populations can be reduced with insecticides labeled for aphid control. Insecticidal soaps can also reduce populations.

European Corn Borers

Borers are up to 1 inch long, cream or flesh colored, and marked with numerous small, round, brown spots. They are the larva of moths that overwinter and have multiple (typically two) generations in Pennsylvania. Although moths strongly prefer corn for egg-laying sites, they will also lay eggs on leaves in peppers, and larva bore into the fruit under the calyx.

Management: A statewide monitoring network gives flight catches determined from pheromone traps. Contact your county extension office for more information. The flight information is presented as maps at www.pestwatch.psu.edu. The larvae feed inside the pepper fruit. The typical time to control the first brood with sprays is during the last two weeks of June. The typical time to control the second brood is during August.



European corn borer

Disease Identification and Management

Bacterial Spot

Spots are initially irregularly shaped and water soaked before becoming brown to black in color. As the disease progresses, the spots can coalesce together, creating large necrotic (dead) areas. Similar symptoms can develop on the fruit, but the spots are scabby and typically occur near the stem end of the fruit.

Phytophthora Blight

On the leaves, water-soaked spots develop and eventually turn dark gray to brown. As a result of root damage (rotted roots), affected plants wilt, and severely wilted leaves and branches die. Under severe disease pressure and where soil is wet, entire plants can die rapidly. Large rot areas can develop; at least 50 percent of a fruit can be affected. A whitish gray mold can appear on affected areas of fruit during wet periods.

Anthracnose

On the fruit, round to oval, tan lesions eventually develop concentric rings that are black to orange to tan in color. Similar symptoms can also develop on the leaves and stems.

Viruses

Symptoms vary depending on the virus or strain, the plant, the time of year, and environmental conditions. The range of symptoms may include leaf mottling, puckering, or curling; stem and petiole streaking; rough, deformed, or spotted fruit; stunted plants; and leaf, blossom, and fruit drop.

General Management Strategies

1. When possible, plant cultivars that have resistance to diseases of concern. Many cultivars are resistant to tomato mosaic virus (TMV), the most important virus, spread by contaminated hands or tools that rub against leaves. A few cultivars are resistant to potato virus Y (PVY) and/or tobacco etch virus (TEV), which are spread by aphids and rubbing leaves. Many are resistant to some strains of the bacterial spot pathogen, which affects both leaves and fruit.
2. Start with disease-free seed and transplants from reputable producers. Bacterial spot can be introduced with seed and transplants.

3. Plant peppers where peppers and tomatoes have not been grown for the past few years. The bacterial spot and Phytophthora blight pathogens can survive in soil for several years.
4. Plant peppers in garden locations that are unshaded. Bacterial spots are promoted when plant surfaces remain wet for long periods.
5. Plant peppers in garden locations with good moisture drainage. Phytophthora blight can occur where soil remains wet for long periods. The pathogen easily moves around in water, so minimize surface water runoff across the garden. Consider planting on raised beds.
6. Do not work in plantings when leaves are wet. The bacterial spot pathogen becomes sticky when wet and can be carried from plant to plant on hands, garden tools, and clothing.
7. Try to prevent aphid problems near and in the garden. Aphids pick up and carry some viruses; it takes only 1 minute for an aphid to transmit a virus to a plant.



Phytophthora blight

ROOT VEGETABLES

(BEETS, CARROTS, PARSNIPS, RADISHES, RUTABAGAS, SALSIFY, SCORZONERA, AND TURNIPS)



Soil pH and Fertility

All root vegetables, except beets and parsnips, grow best in soils with a pH of 6.2–6.8; beets and parsnips require a pH of 6.6–7.2 for maximum yields. Fertilize and lime as directed by soil test results (purchase kits from your county extension office or gardening center).

For beets, carrots, parsnips, salsify, and scorzonera, in the absence of a soil test, apply to each 100 square feet either 4½ pounds of 5-10-10 or equivalent fertilizer where potash tends to be low or 4½ pounds of 5-10-5 where potash levels are expected to be high, e.g., areas where wood ashes, manures, or high rates of complete fertilizers have been previously applied.

For radish, rutabaga, and turnip, apply 1½ pounds of 5-10-10 fertilizer plus ½ pound of 0-20-0 (regular superphosphate) or steamed bone meal. Do not apply excessive nitrogen to radishes and turnips or you may get more top growth than root development. Do not add fresh manure in the salsify bed under any circumstances—it causes forked and misshapen roots. On all root vegetables, use fully composted manures only applied the fall before planting.

Four to six weeks after seeding, side-dress carrots, parsnips, salsify, and scorzonera with either ¼ pound (4 ounces) of ammonium nitrate or 1½ pounds of 5-10-10 per 100 linear feet of row and rutabagas with 1½ pounds of 5-10-10

fertilizer per 100 linear feet of row. Place the fertilizer about 3 inches to either side of the plants and lightly work into the soil.

Carrots, beets, parsnips, radishes, salsify, scorzonera, and turnips require loose soils to develop proper size and high quality. Good soil depth is also very important for carrots, salsify, and parsnips. Heavy soils can be made lighter by adding compost, leaf mold, or vermiculite in a foot-wide band on the row. Spade deeply to thoroughly mix in the amendments and then plant seeds.

Do not use transplants. Their use will result in misshapen and poor-quality roots. Beets are an exception if carefully transplanted into loose soil.

Selecting Cultivars

Try hybrid root vegetables, which are often a dramatic improvement in taste, texture, holding ability, and pest resistance over nonhybrids.

Carrot Types

For all processing uses, Danvers and Nantes types are best for overall production and quality in Pennsylvania's predominantly limestone soils. For fresh table use, Nantes types are superior since they are bred for flavor. Nantes types have a blunt shape that can easily penetrate our soils. Hybrid Nantes cultivars are almost always superior to the original, open-pollinated cultivars.

Imperator types generally require very deep and loose soils or else they become distorted, forked, and split. They then frequently break when pulled. Chantenay types grow very well in Pennsylvania soils but are generally inferior for all uses.

Planting Dates

- Beets and carrots: April 1–July 10
- Parsnips, salsify, and scorzonera: April 15–30
- Radishes (spring and fall types): April 1–30 and August 10–September 1
- Radishes (winter type): July 25–August 5
- Rutabagas: July 1
- Turnips: April 1–30 and July 25–August 5



Seed spring plantings about 3 weeks earlier in the warmest regions of the state and about 10 days later in the coldest regions. Fall plantings should be seeded up to 10 days earlier in the colder, short-season areas and up to 3 weeks later in the warm, long-season areas.

Depth of Seeding

- Carrots, parsnips, and turnips: $\frac{1}{4}$ – $\frac{1}{2}$ inch
- Beet, radishes, and rutabagas: $\frac{1}{2}$ inch
- Salsify and scorzonera: 1 inch

Spacing

Between rows:

- Radishes (spring or fall planting): 1 foot
- Beets: 1–1½ feet
- Parsnip and rutabagas: 1½–2 feet
- Carrots, turnips, and winter radishes: 1–2 feet
- Salsify and scorzonera: up to 15 inches

Within rows:

- Radishes (spring or fall planting): 1 inch
- Beets and carrots: 1–3 inches
- Turnips and winter radishes: 2–6 inches
- Parsnips, salsify, and scorzonera: 3–4 inches
- Rutabagas: 5–8 inches

Special Considerations

Parsnips, radishes, rutabagas, salsify, and turnips are cool-season vegetables, giving the best quality when reaching usable size under moderately cool temperatures. Close relatives such as cabbage, broccoli, cauliflower, and kohlrabi should not be planted consecutively in the same location because of the potential for increased disease and insect problems.

Carrots and parsnips are slow to germinate; therefore, avoid soil crusting. Minimize soil crusting by placing a thin band of vermiculite, sand, or perlite over the seed row, not overworking heavier garden soils, not working soils that are too wet, or scattering a few radish seeds among the carrot and parsnip seeds to help break the crust. Salsify is also slow to germinate, and fresh seed should be used each year since seed remains viable for only 1–2 years. Just-sprouted salsify looks like grass, so use care when weeding.

Parsnip seeds retain vitality for only 1–2 years; therefore, do not use old seed. After plants are well established (in 5–6 weeks), thin the stand to 3–4 inches apart.

Spade soil fairly deep for carrots, salsify, and parsnips and avoid compacting the soil as much as possible during the growing season. To reduce greening of carrot and parsnip tops or shoulders, cover them during the last cultivation.

Since beets, rutabagas, and turnips have a fairly high boron requirement, consider sprinkling each 100 square feet of seeded row with a solution of 2 level teaspoons of Borax powder dissolved in 2 gallons of water (1 teaspoon per gallon). Although boron is an essential element, higher rates can be toxic to beets, rutabagas, turnips, and other vegetables, so do not apply Borax more than one time per season.

Radishes are sensitive to temperature and day length. Long days cause flowering or seed stalk formation, and warm temperatures encourage elongated tops and misshapen, elongated roots.

Harvesting

Harvest beets when the roots are 1–3 inches in diameter. Smaller size is best when tops are to be used as greens.

Harvest carrots when the roots reach acceptable size. Normally, this is when the roots of the Nantes types are $\frac{3}{4}$ –1 inch in diameter and Danvers types are up to 2½ inches in diameter at the top. Carrots are especially good if left in the soil for some frost and harvested before the ground freezes.

Leave parsnips, salsify, and scorzonera in the ground until late fall or overwinter them. If you plan to dig them from time to time during the winter, cut the tops off the salsify and scorzonera plants and cover the row with a suitable mulch to keep the soil from freezing too deeply. Salsify and scorzonera develop best flavor after several frosts, so delay harvest until that time.

Turnips reach edible size in 60 days or less, and rutabagas need about 90 days. Harvest mature turnips when the roots are about 1½–2 inches in diameter; rutabagas should be 2½–4 inches in diameter.

Radishes develop from planting to harvest more quickly than any other vegetable. They remain in prime condition only a short time, especially in warm weather.



Harvesting must be done promptly or the roots become pithy; storing for more than a week in a refrigerator may also cause even high-quality radishes to become pithy.

All these vegetables are best stored at temperatures near 32°F with a relative humidity of 95 percent. Beets, carrots, parsnips, and winter radishes keep most of the winter when stored properly. Turnips, rutabagas, salsify, and scorzonera keep from several weeks to a few months, while spring radishes keep only about a week.

Ethylene gas is one cause of the bitter flavor in stored carrots and parsnips. Never store these vegetables with or near apples, pears, tomatoes, or other natural ethylene producers.

Insect Identification and Management

Flea Beetles

These small, round, shiny, 1/16-inch-long beetles eat small holes in the leaves or skeletonize them. The most serious injury is caused to young plants early in the growing season. Flea beetles jump readily when approached. Injury gives plants a ragged and bleached appearance and growth is slowed.

Management: Clean cultivation and weed management are important since the beetles feed on many weeds. Suspending a floating row cover above the planting immediately after planting can protect plants from damage. Plants with vigorous growth can withstand fairly high levels of feeding without reducing total plant health; discard lightly infested leaves. When injury exceeds your tolerance, spray with an insecticide labeled to manage flea beetle on vegetables.

Green Peach Aphid

Aphids are small, soft-bodied, greenish, sucking insects that feed by inserting their needlelike mouthparts into plants and sucking out the sap. They are often seen in large colonies that form on the leaves and stems. Aphids overwinter as eggs on peach trees, and the eggs begin to hatch as the peaches bloom. During early spring, they stay on peach trees for several generations. Most aphids are wingless, but when conditions become crowded or food is depleted, some aphids develop wings and move to other plants and weeds. They produce many generations on the summer plants on which they feed.

Management: Clean cultivation and weed management are important since aphids feed on many weeds. When aphids first appear, spray with insecticidal soap or an insecticide labeled to manage aphids on vegetables. Aphid populations are heavily influenced by temperature, rainfall, number of natural enemies present, and pesticide applications. Aphid outbreaks tend to be most frequent in hot, dry weather, while heavy rains (or directed sprays of water) often reduce the aphid population to acceptable numbers.

Leafminers

Plants are often disfigured and damaged by several species of small flies that live in the maggot stage between the upper and lower surface of leaf tissue. Feeding causes large, white blotches and winding trails through the interior of the leaves, which are rendered unattractive and unfit for human consumption.

Management: Row covers can protect plants from leafminer damage. Remove and destroy individual leaves as you notice feeding damage. Otherwise, when miners first appear, spray with an insecticide labeled to manage leafminer in vegetables. Note: insecticides cannot control maggots already inside leaves at the time of application.

Carrot Rust Fly

The maggot of the rust fly is a pest of both carrots and parsnips.

Management: Since rust fly is not a problem every year, attempts at management may not prove practical. Row covers can be used to protect the planting. When you first notice rust fly injury, spray with an insecticide labeled to manage rust fly in vegetables.

Cabbage Maggot

Radishes, turnips, and rutabagas are favorite hosts for the cabbage maggot, which produces four and sometimes five broods (generations) per season. The first brood emerges in April when the yellow rocket weed is in bloom.

Management: Do not plant in the same location that plants in the brassica family (broccoli, Brussels sprouts, cabbage, cauliflower, kale) were grown the previous year. Avoid planting in areas that have recently decaying organic matter such as that immediately following the soil incorporation of animal manure or a cover



Carrot rust fly maggots

crop. Maintain plant vigor. Remove and destroy infested plants. Protect plants by using a floating row cover held at least 6 inches from the plants to prevent adult flies from laying eggs near the bases of the plants.

Cool, wet springs promote conditions that contribute to high populations of cabbage maggots. Scout and closely evaluate plantings of brassicas for cabbage maggots, especially during years with favorable conditions. The first summer generation of the cabbage maggot is the most damaging to plant health. Young plants are not able to withstand much root feeding from the cabbage maggot before wilting and death occur, especially if temperatures are low. Plants growing in warmer conditions can grow past low to moderate numbers of cabbage maggots.

Disease Identification and Management

Cercospora Leaf Spot of Beets

Symptoms are spots that are brown or gray with a purple border. They may develop late in the season. Most table beets are resistant to this disease. Severely diseased plants can become defoliated.

Management: Follow a 2- to 3-year rotation (i.e., don't plant beets in the same area for 2 or 3 years). Remove refuse from the garden as soon as beets are harvested. If necessary, a pesticide that contains fixed copper may help; follow the directions for mixing and application.

Leaf Spot and Root Canker of Parsnips

Spots develop on leaves and dead brown to black canker areas develop at the top of parsnip roots. Wet conditions promote this disease.

Management: Practice a 2-year rotation to make sure that any garden plant debris is thoroughly decomposed. Provide good soil drainage. Lime soil to obtain a pH of 7.0. Ridge soil over shoulders of roots.

Leaf Spots of Carrots (Alternaria, Cercospora, and Bacterial)

For *Alternaria* leaf spot, the initial symptoms are green brown, water-soaked, angular spots that become black to brown in color. *Cercospora* leaf blight lesions are more circular in shape with tan centers and dark borders. Bacterial leaf blight lesions are initially yellow angular spots that become irregularly shaped

and brown. For all the leaf spot diseases, as the lesions expand they coalesce and the entire leaf can eventually die. Reduced carrot size can result if the diseases occur early in the season; however, these diseases do not cause symptoms on the root.

Management: Grow carrots in a sunny location. Avoid growing carrots in the same area in consecutive years. Rotate out of carrots for 2–3 years. When a leaf spot problem is anticipated, some fungicides can be helpful if started as first symptoms appear and repeated at 7- to 10-day intervals as directed on the label. Use a pesticide that contains one or both chlorothalonil or fixed copper (this information will be listed on the label). At harvest, remove carrot leaves from the garden.

Root-Knot Nematodes

Nematodes are microscopic worms that live in soil. Root-knot nematodes enter the root and cause small swellings to develop on the side of the main root and on fine roots. If infected early in the season at the seedling stage, severe forking can develop. Damage to roots reduces plant vigor.

Management: Rotate vegetable types. Avoid planting susceptible vegetables in succeeding years. Susceptible vegetables include carrots, parsnips, tomatoes, lettuce, and cucurbits (squash, cucumber, melons, and pumpkin). Sweet corn (or any type of grain crop) is seldom affected and is a good option for affected areas. Provide the planting with a regular and adequate supply of moisture and fertilizer.

Clubroot of Turnip

Roots become swollen and distorted and leaves may become yellow, wilt, and then die.

Management: Avoid areas where turnips and cabbage-related plants were grown within 7 years. If clubroot has been a problem in past years, apply hydrated lime (1 pound per 30 square feet) in the spring before preparing the seedbed. Remove plants, including the roots, as soon as harvest is completed. Do not compost roots that have clubroot symptoms; discard them.

SWEET CORN, BABY CORN (PICKLING CORN), AND POPCORN



About Sweet Corn Types

Older, *su* (normal endosperm) corn types are best for cold soils, but they have the least sugar of all sweet corn types. Generally, *se/se*, some *se*, and new complex combinations like the *se/se/bt₂* types have the best flavor, texture, aroma, and high sugar content.

Any cultivars with even one *sh₂* dose (shrunken endosperm type) are not recommended for gardening because isolation (to avoid cross-pollination) can be a problem if other cultivars of sweet corn are grown in the neighborhood. Also, many people consider the kernels of *sh₂* types too sweet and too crisp whether eaten fresh, canned, or frozen. These types were developed for long-distance shipping to supermarkets. For short-term camping, hiking, or mini-vacation trips, *sh₂* types would hold acceptable quality the longest. The very best of all worlds are in the new *se/se/bt₂* types like ‘Serendipity’.

Usually, *se* and *se/se* types that are about 75 days or later in maturity and have deep kernels and long, fat ears (more recovery) make the best canning and freezing cultivars. Sometimes, a *se/se* type may have kernels that are considered too tender for canning. Because of their appearance, yellows are usually thought best for processing (especially canning) and whites considered poorest.

Soil Fertility and pH

Soil testing is strongly recommended to determine soil pH and nutrient status (purchase kits from your local county extension office or garden supply center). Sweet corn grows best at a soil pH between 6.0 and 6.8. Fertilize and lime as directed by soil test results.

In the absence of a soil test, fertilize in one of these ways: (1) apply 4½ pounds of 5-10-5 fertilizer per 100 square feet mixed with a 1-inch-thick layer of compost and incorporate as a broadcast treatment, or (2) mix compost with 3 pounds of 5-10-5 per 100 square feet prior to planting and then band 1 pound of 5-10-5 per 100 square feet at planting time (2 inches to the side and 2 inches below the seed).

Latitude

Some seed catalogs list optimal latitudes for growing sweet corn cultivars. Most of Pennsylvania lies between 40 and 42 degrees latitude, so consider a different cultivar if its latitude is above 42 degrees.

Planting Dates

Plant seed May 1–July 1 in central Pennsylvania. For successive harvests, sow a series of cultivars of varying maturities; also make several sowings of proven main-season types. Remember that corn responds to total heat units, so a later planting of the same cultivar will generally develop at a faster rate than an earlier planting.



Depth of Seeding

- Heavy or moist soils: 1 inch
- Dry or sandy soils: 1½ inches

Spacing

- Between rows: 2½–3 feet
- Between plants in row: 4 inches
- Thinning: early cultivars, 8–10 inches; late cultivars, 10–12 inches (thin when corn plants are 4 inches high)

Suggestions

To conserve space in a garden, plant corn next to vining cucurbits such as cucumbers. As the vines grow, they will tend to grow between the corn rows and up the stalks.

If possible, plant corn cultivars in small blocks to obtain maximum pollination. Four or more short rows of a cultivar side by side will give much better results than one long row. You can also plant corn in blocks thinned to a spacing of 17 by 17 inches to 20 by 20 inches.

Pick sweet corn at the milk stage—that is, as soon as kernels become well filled and plump, but before the starchy or dough stage develops (test a kernel near the tip by pinching). For maximum sweetness and tenderness, eat corn as soon as possible after picking. If quantities must be kept for a day or two, harvest during the cool, early morning hours and then keep the harvested ears out of the sun and just above freezing (about 34°F) until ready to use.

Insect Identification and Management

A statewide monitoring network gives flight catches determined from pheromone traps of European corn borer, corn earworm, and fall armyworm. Contact your county extension office for more information. The flight information is presented as maps at www.pestwatch.psu.edu.

Corn Earworms

Earworms are large (up to 1¾ inches long) and vary greatly in color from a light green or pink to brown with alternating light and dark stripes running lengthwise on the body. They are the larval life stage of moths that do not overwinter well in Pennsylvania but migrate into our area from the south annually. Pennsylvanians are typically dealing with the immigrants and their offspring. Therefore, the worms are a minor problem on early corn, but starting in early August, the planting



Corn earworm

can be heavily infested. Adult moths lay eggs directly on silks, and young larvae then tunnel directly into the tip of the ear. Use the Pest Watch Web site to determine when moths are moving into the area, and apply controls when moths are flying in your area. Controls can include either spraying the ear zone when plants are 30 percent, 50 percent, and 100 percent in silk, or brushing silks with horticultural oils if done several times as the silks grow. Cutting tips off ears removes worms. Several transgenic cultivars express a protein that provides tolerance to corn earworm.

European Corn Borers

Borers are up to 1 inch long, cream or flesh colored, and marked with numerous small, round, brown spots. They are the larva of moths that overwinter and have multiple (typically two) generations in Pennsylvania. They feed in all parts of the stem and ear. A line of pinholes across the leaves is characteristic of borer feeding since they bore through the leaf while it is still curled. Moths



European corn borer larva

are strongly attracted to tasseling and silking corn. The typical time to control the first brood with sprays is during the last two weeks of June. The typical time to control the second brood is during August. Check the Pest Watch Web site for current conditions. Several transgenic cultivars express a protein that provides resistance to European corn borer.

Fall Armyworms

Fully grown larvae are about 1½ inches long. Worm colors vary from light tan or green to black with a black stripe along each side. The head has a prominent “Y” with a series of dark spots running along the back, and the last or next-to-last abdominal segment has four distinct black dots. These moth larvae require warmer areas to overwinter and, thus, must migrate in from a great distance.

Sap Beetles

These beetles can be found feeding on silks from June through August. Dusky sap beetles are small, about ⅜ inch long. They are gray to black in color and oblong in shape. They invade plants when tassels begin to show, feed on green silks, and feed on kernels when the silks begin to brown. Damage from corn borer larvae and Japanese beetles attract sap beetles.

Flea Beetles

Flea beetles are small (⅓ inch), black, and can be recognized by their jumping habit when disturbed. They eat the surface from the leaf, causing a white streak parallel with the veins. Flea beetles are most abundant in warmer areas of the state and especially after mild winters. The beetles are most important in their transmission of a disease known as Stewart’s wilt or bacterial wilt. Grow resistant cultivars where wilt has been a problem.

General Management Strategies

Use the Pest Watch Web site to help determine when moths are flying in your area, and then use an insecticide labeled for managing vegetable insects in sweet corn, or horticultural oil if only corn earworm is the concern. *Bacillus thuringiensis* (Bt) sprays may be effective for corn borers. Cultivars that express bacterial proteins from Bt are effective.



Sap beetle adults



Corn smut on tassels

Disease Identification and Management

Stewart’s Bacterial Wilt

Yellow to brown streaks up to 1 inch wide develop on leaves and may extend the length of the leaf. Brown discoloration and sometimes rotted cavities form in the center of the stem near the soil line. Plants affected early may die; plants affected late may be stunted or merely have streaked leaves. The disease is caused by a bacterium that survives inside and is transmitted by flea beetles. The disease is most prevalent following mild winters, especially in the mildest parts of Pennsylvania because a greater number of flea beetles will survive during a mild winter.

Smut

Smut is characterized by the presence of large, fleshy, irregular galls on leaves, stems, ears, and tassels (male flowers). Immature galls are white and spongy; mature galls turn brown and contain powdery, dark spores. Smut is promoted by plant injury caused by cultivation, insects, and hail.

Rust and Leaf Spots

Rust is characterized by reddish to brown, rusty, powdery areas (pustules) on the top surfaces of leaves. Leaf spots can be small or large and range in color from white to tan to brown with a red border; the spots are usually elongated and appear first on oldest leaves. These diseases can be significant, but usually only late in the season.

General Management Strategies

Grow cultivars with resistance to Stewart’s wilt when needed. Remove and dispose of smut balls before they turn black and break open. Dispose of stalks and leaves as soon as harvest is over.

TOMATOES AND EGGPLANTS



Spacing

Staked tomatoes:

- Rows: 3–4 feet apart
- Plants: 15–24 inches apart in the row

Unstaked tomatoes:

- Rows: 2–3 feet apart
- Plants: 3–5 feet apart in the row

Eggplant:

- Rows: 3 feet apart
- Plants: 18 inches apart in the row

Planting Transplants

If plants are to be homegrown, sow tomato seed 6–8 weeks and eggplant seed 8–10 weeks before the plants will be set in the garden.

Slightly toughen or harden plants the last week before transplanting by placing them outdoors during the day. This helps plants adjust to outside conditions. Withholding water, but not to the point of wilting, and slightly lowering the optimum growing temperature by 10°F or less are the best ways to harden plants. Bring plants in at night if air temperatures are lower than 50°F.

Plant only well-grown, disease-free plants. A good transplant is slightly hardened, 6–9 inches tall, and has a sturdy stem (about the diameter of a lead pencil) and a leaf spread about equal to its height. The transplant should be a medium dark green, and the texture of the stem and leaves neither soft nor woody but strong and firm. The root system should be well developed. Eggplants are most successfully transplanted in individual containers such as peat pots. If possible, transplant into moist soil on a cool, cloudy day and then shade plants for a day or two to prevent wilting when the sun is bright. If plants must be transplanted during hot, sunny weather, plant in late afternoon or evening. Turn in some well-decomposed compost with each transplant. Apply liquid fertilizer or plant starter solution at transplanting; dissolve a 10-55-10, 12-48-8, or similar all-soluble, high-phosphate fertilizer at the rate of 2 tablespoons (1 ounce) per gallon of water. Pour 1 cup of solution into each hole, set the plant, and press soil firmly around roots.



Planting Dates

In central Pennsylvania, plant tomatoes May 20–June 1 after the danger of spring frost has passed; plant May 27–June 4 for eggplants.

Plant eggplants when they are no more than 10 weeks old and when air temperature averages about 70°F during the day. Chilling injury and stunting can occur below 40°F night temperatures.

Soil Fertility and pH

Soil testing is strongly recommended to determine soil pH and nutrient status (purchase kits from your local county cooperative extension office or garden supply center). Ideal pH range for tomatoes and eggplants is 6.2–6.8. Fertilize and lime as directed by soil test results. In the absence of a test, apply 1 inch of compost, then apply to each 100 square feet either 4½ pounds of 5-10-10 fertilizer where potash levels are low or 4½ pounds of 5-10-5 where potash levels are high, e.g., areas where wood ashes, manures, or high rates of complete fertilizers have been applied in previous years.

Mulching

Consider using either black or red plastic, straw mulch, or both. Plastic will help manage weeds, increase soil temperature early in the season, eliminate soil packing and crusting, and maintain a more uniform distribution of moisture throughout the season. Be sure the soil is adequately moist before laying plastic. Never lay plastic mulch on dry soil. Straw will allow water to pass through to the soil and offer the same qualities as plastic, except that it will not help warm the soil. Apply straw mulch between rows when no further frosts are expected.

Cultivation and Pruning

Never cultivate or hoe deep enough to damage plant roots. Prune side shoots (suckers) off tomatoes if you wish, but do not remove additional leaves near the top of the plant (where fruit is produced) until about September 1. Removal of leaves results in more sunscald on fruit and less fruit production. Of course, remove and discard any blighted bottom leaves as they appear.

Harvesting

Harvest tomatoes when fully ripe for best flavor and nutrition. Pick eggplant as soon as it attains satisfactory size, but before the surface loses its bright, glossy appearance; dullness indicates overmaturity and loss of quality. White seed becomes brownish in overmature fruits.

Special Considerations

Eggplant is more sensitive to cold temperatures than tomato. Eggplants can be injured by prolonged cool weather even without frost. Both set fruits optimally when night temperatures range from 58 to 70°F. Fruit set is reduced when night temperature is below or even much above this optimum range. Tomatoes are about 95 percent self-pollinated; eggplants are almost 50 percent insect pollinated, so encourage bees to visit the garden. For tomatoes, other factors responsible for or associated with the failure of blossoms to produce fruit are cultivar, overly hardened transplants, viruses, lack of sunshine or water, high winds, and excessive vegetative growth in the early stages of plant development.

Insect Identification and Management

Flea Beetles

Flea beetles overwinter as adults, emerge in the spring, and feed on various weeds and crops. Adults are very active and use enlarged hind legs to quickly jump off plants when disturbed. Some species are highly attracted to eggplants. Adult feeding appears as round holes that are initially not entirely through the leaf. Leaves will have a “shothole” appearance. High rates of immigration can defoliate young plants. Adults lay eggs at the base of plants, larvae feed on small roots or root hairs, and multiple generations occur in Pennsylvania.

Management: Clean cultivation and weed control around the garden are important since the beetles feed on many weeds. Protect plants with row covers, but be careful not to enclose adults under the row covers. Place row covers on plants at transplanting. Examples of row covers or plant covers are on page 21. Plants with vigorous growth can withstand fairly high levels of feeding without reducing total plant health; discard lightly infested leaves. When injury exceeds your tolerance, spray or dust with an insecticide labeled to control flea beetle on vegetables. Control of the early immigrating adults may help avoid higher populations later in the season because plants are younger at the time of control and less able to withstand feeding.

Colorado Potato Beetle

Colorado potato beetle feeds exclusively on solanaceous plants and can be a significant pest of potatoes, tomatoes, and eggplant. Adult beetles have characteristic cream and black stripes across the back. Females deposit orange eggs in clusters of 20–45 on the underside of leaves. Larvae are crimson in the early instars with black legs and two rows of black spots on the sides of their body. Large larvae are orange and appear bloated and humpbacked. Pupae are located in the soil. By far, the greatest damage to plants is by the late instar larvae and adults.

Two reproductive generations occur per growing season in Pennsylvania. The first comes from overwintering adults, and the second from in-field reproduction.

Management: Rotation prevents overwintering beetles from emerging directly in the fields regardless of the distance you rotate. The distance



Colorado potato beetle

you rotate influences how much you can reduce immigrating adult populations. The farther a planting is from the previous year's potato or tomato planting, the longer overwintering adult beetles take to infest it. Another cultural practice is to use straw mulch, which may interfere with adults finding the fields or may harbor more beetle predators.

Several predators are known to feed on beetle eggs, including one ladybird beetle (*Coleomagilla maculata*) and a predaceous stinkbug. One parasitoid, *Endovum putlerri*, has been very effective on Colorado potato beetle but only on eggplant. In home gardens, hand-picking and row covers are effective.

Aphids

Aphids are round to oblong, soft-bodied insects that are about $\frac{1}{8}$ inch long and extract plant sap. Both winged and wingless forms can be present. Colonies develop on undersides of leaves or on plant terminals. Direct damage by aphids is assumed to be minimal until populations build to high levels.

Management: Aphids are often controlled by natural parasites and predators, which rely on these slow-moving insects as a host resource. High populations can be reduced with insecticides labeled for aphid control.

Spider Mites

Spider mites are tiny, eight-legged animals most closely related to spiders. They appear as specks on the undersides of leaves. Large populations are required to cause serious damage, but spider mite populations build up very quickly when temperatures are hot (greater than 80°F). Dry weather (less than 50 percent relative humidity) is also correlated with mite buildup. Mites can complete development in only 5–7 days under these conditions—two to three times faster than many of the other vegetable pests. Mites pierce the epidermal cells of plants and extract plant sap. Damage appears as leaves that are stippled, yellowing, and dirty. Leaves may dry and drop. Webbing may be visible between leaves or on their lower surfaces.

Management: Removing damaged leaves may slow the spread of mites in a planting. Spot treat with a chemical labeled for mites when you first notice white stippling along the veins on the undersides of the leaves and 20 mites per leaflet are present.

Whiteflies

Adult whiteflies are small (1½ millimeters long) insects that look like tiny, white moths. Whiteflies do not overwinter in Pennsylvania; however, they can overwinter in greenhouses and affect transplants. Carefully inspect transplants before planting. Infested leaves dry out and drop, and sooty mold grows on honeydew excreted by whiteflies.

Management: Recognizing early infestations and removing infested plant parts slows population growth. Chemical management is difficult—the chemical must contact the whiteflies under the leaf surface. The eggs will probably survive; thus, you may need to make repeat applications to kill newly hatched whiteflies. Yellow sticky boards offer an alternative to chemical spray and are often available in garden centers. This tool is also useful to monitor your garden for small, flying insect pests. Shaking plants while holding a large yellow sticky board above the plant will capture many adults, and doing this daily will eventually reduce a population.

Tomato Fruitworm

The corn earworm, a very important pest of sweet corn, will also feed on tomatoes and other hosts. Thus, it also goes by the name tomato fruitworm. This good night-flying moth is able to move long distances and overwinters as a pupa about 2–4 inches deep in the soil. Tomato fruitworm usually appears later in the season because it has not overwintered well in Pennsylvania. Adults emerge in the spring. They are about $\frac{3}{4}$ to 1 inch in length, tan to buff colored, sometimes with some olive shading, with a wavy, darker band near the edge of the wings of younger specimens. The eyes have a distinct serpentine green reflection when held up to sunlight in live specimens. A darker brown spot is located about midway along the outer edge of the front wings. They fly when evening temperatures exceed 55°F, with increasing activity at higher temperatures. They can be caught up in winds and storms and deposited with the weather patterns. Females are strongly attracted to fresh silks of corn but will also lay eggs on tomatoes, typically after corn has passed the silking stage in the landscape. Eggs hatch in 2–4 days during the summer in Pennsylvania, and young larvae crawl away from light toward moist, shaded areas and burrow into fruit.



Tomato fruitworm

They feed on each other, which tends to limit the number of larvae to one per fruit. As they mature through six instars, they will leave large amounts of frass where they are feeding. Larval coloration will vary from greenish to yellow to reddish, with longitudinal stripes. The head is tan to yellow, which helps distinguish it from the fall armyworm or European corn borer, which have darker head capsules.

Other related species that infest tomato fruits include the European corn borer, fall armyworm, beet armyworm, and variegated cutworm.

Management: Since much of the population builds as populations move from the south, it makes sense to look at the densities from a regional viewpoint. See the Pest Watch Web site (www.pestwatch.psu.edu) for data collected with pheromone traps from 15–25 sites in Pennsylvania. When populations are high and corn is not silking in your landscape, you can use insecticides to protect young tomato fruit.

Disease Identification and Management

Wilts

Plants wilt and may die. There are several different causes. Some soil fungi (*Verticillium* and *Fusarium*) can cause wilting. In other cases, a toxin from black walnut and butternut tree roots can also cause wilting. In addition to yellowing of the leaves and wilting, the internal woody stem tissue turns brown in affected plants.

Management: Avoid garden areas where tomatoes, eggplants, peppers, potatoes, strawberries, and brambles were grown during the past few years. Do not plant near walnut or butternut trees. Grow tomato cultivars resistant to fungus wilts. As soon as harvest is complete, pull and destroy or discard plants.

Leaf Spots of Tomatoes (Early Blight, Late Blight, and Septoria Leaf Spot)

Early blight symptoms are dark-brown spots with dark, concentric rings (similar spots can develop on the stems). Septoria leaf spot symptoms are usually dark; eventually, the center of the spot becomes whitish to light brown, sometimes with tiny, dark specks evident in the light area. Both early blight and Septoria leaf spot symptoms usually start on the oldest leaves. Spotted leaves die prematurely, resulting in early defoliation, fruit sunscald, and poor fruit color. Late blight affects fruit and leaves. Irregular, greasy, gray areas develop on leaves, which expand rapidly in wet weather. On the underside of the leaf, white, fuzzy spores (seeds) of the pathogen can be seen when conditions are wet.

Management: See measures for managing fruit rot below.

Fruit Rots of Tomatoes (Anthracnose, Early Blight, Late Blight)

Many rots develop on fruit that touch the ground. Discrete spots also can develop on other fruit. Anthracnose primarily affects the fruit, causing small, circular, depressed lesions. Initially, the centers are tan but will become black as a result of the pathogen growing on the fruit surface. Contact with soil and wet conditions promote fruit rots.

Management: Choose a sunny planting site. Avoid garden areas where tomatoes were grown within the past few years. Ensure adequate fertility by following soil test recommendations.



Early blight on leaf



Severe early blight on fruit



Late blight leaf lesions



Late blight on fruit

Space plants to promote drying off of leaves and fruit; later. Support plants to keep fruit off the ground. When leaf surfaces are dry, remove and discard any blighted bottom leaves as soon as they are affected. Use appropriate fungicides when necessary. If leaf blights and fruit rots occur most years, spray with labeled fungicides when diseases are anticipated and repeat at 7-day intervals as needed. Use a pesticide that contains one or more of the following fungicide materials noted on the label: chlorothalonil, mancozeb, and fixed copper. For late blight, they must be applied before symptoms are observed. Follow the label. Remove symptomatic leaves or plant parts and kill the plant tissue by placing it in a black bag. Once the plant tissue is killed, the late blight pathogen cannot survive. Remove plants as soon as harvest is completed to reduce amount of fungal and bacterial inoculum that could be left in the soil as plant tissue decomposes.

Blossom End Rot of Tomatoes

This rot appears as a large, dry, brown to black, and often depressed, leathery area at the blossom end of fruit.

Management: Ensure adequate calcium and other nutrients in the soil by following soil test recommendations. Avoid moisture stress by mulching around plants, irrigating when dry, and avoiding close and deep cultivation that damages roots. The best irrigation for tomatoes is a slow watering that results in deep wetting of the soil without wetting the leaves. This encourages the plant to grow deep roots and avoids spreading disease organisms on leaves and fruit.

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