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](http://consumerhorticulture.psu.edu/file/plant%20families.pdf).
Preparing the Site

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.

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**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.

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**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.

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**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 (P₂O₅) and potash (K₂O) 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.

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**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.

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**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.

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### 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.