

# An Educator's Guide to Vegetable Gardening

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Weston Miller, Beret Halverson, and Gail Langellotto

**G**ardening is a powerful way to teach many important topics including basic food-growing skills, health and nutrition, environmental science, and more. Gardens provide opportunities for hands-on learning in a variety of subjects across a range of grade levels (see sidebar, page 2), but it can be intimidating to plan, install, and maintain an educational garden.

This publication provides a basic introduction to growing produce in an outdoor garden and includes information on recommended plants and a garden calendar. For more detailed information on any aspect of outdoor gardening, contact your local Oregon State University (OSU) Extension Master Gardener Program (<http://extension.oregonstate.edu/mg/>).

## A Full-Circle Approach to Educational Gardens

Using a holistic, full-circle approach in an educational garden allows you to demonstrate ecological processes that foster healthy soil, healthy plants, and healthy people (figure 1). For example, vegetable scraps from the cafeteria or grass clippings from the school lawn can be decomposed into compost. This compost provides essential nutrients to growing plants. Plants incorporate the nutrients in their tissues, and we receive these nutrients when we harvest, prepare, and eat garden produce. Gardening in this way can help students understand how soil, plants, and people are connected.

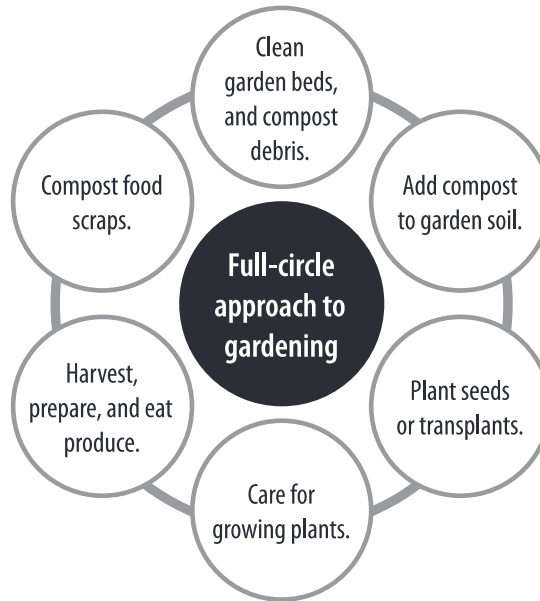


Figure 1. A full-circle approach to gardening.

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Weston Miller, community and urban horticulturist, Metro Area Extension; Beret Halverson, horticulture program assistant, Metro Area Extension; and Gail Langellotto, statewide coordinator, Oregon State University Extension Master Gardener Program; all of Oregon State University.

### **Gardening is hands-on learning.**

With careful lesson planning, it is possible to use an educational garden to teach concepts from a variety of subjects.

**Math:** A simple activity might include calculating the area of a rectangular garden bed. More complex operations might include measuring the rate of change in stem height.

**Social studies:** Students can trace the geographic and cultural origins of foods such as corn (Central America), apples (western Asia), and potatoes (southern Peru).

**Language arts:** Introduce garden-related vocabulary words in a language arts class, or have students write essays about observations or experiences in a garden.

**Science:** Gardens are useful for teaching an array of concepts including the scientific method (e.g., form and test hypotheses about factors that promote plant growth), basic botany (e.g., plant anatomy and physiology), and environmental science (e.g., composting and the nitrogen cycle).

**Health:** Gardening is a particularly appropriate vehicle to teach nutrition and health. Several studies have shown that garden-based curricula encourage increased fruit and vegetable consumption in young children.



Look for this symbol throughout the publication. It highlights tips for using garden tasks to supplement classroom lessons.

Briefly, a full-circle approach to gardening includes the following steps:

- Clean the garden by removing previous crops and weeds. Compost these materials.
- Add finished compost to garden soil.
- Plant seeds or transplants.
- Maintain growing plants by watering and weeding as needed.
- Harvest mature plants. Wash, prepare, and eat the produce.
- Compost leftover food scraps.
- Repeat the cycle.

See “Garden Tasks” (page 14) for more information on each of these steps.

Educators can work with students at any point in the full-circle process to teach key concepts in just about any subject. Ideally, students will work through the entire crop cycle (i.e., from compost to compost) so they experience each step. The cycle can be as short as 4 to 6 weeks for a fast-growing crop (e.g., radishes) or 4 to 6 months or longer for crops that require more time to mature (e.g., carrots, beets, broccoli, garlic, and onions).

If you have limited time with students, you may want to stagger planting times so crops are at different growth stages (e.g., seedling, vegetative growth, and fruiting structures) in different garden beds. In this way, you can demonstrate all or most parts of a crop cycle.

### **Seasonal Gardening in Oregon**


In Oregon, outdoor gardens can be used year round to grow vegetables. However, many vegetables require some sort of protection from winter temperatures. Access to a greenhouse, hoop house, raised-bed cloche, or cold frame makes it easier to garden year round and get the garden started in spring. In colder areas, such as central Oregon, a cold frame or greenhouse is required to grow vegetables year round.

This section describes general garden activities for each season. See Appendices A, B, and C (pages 18 to 25) for suggested planting times for various crops, and consult the OSU Extension Monthly Garden Calendar for reminders of key gardening chores.


Plan your educational garden and garden-based activities around the school year and crop cycles.

## Winter (December–February)

### *Make plans for the garden.*

 If your class has kept a garden journal, have students review their notes and discuss gardening successes and challenges. Together, students can choose which vegetables they want to plant when spring arrives.

Take soil samples, and have a laboratory perform a complete nutrient analysis of the garden soil.

 Alternatively, middle and high school students can perform a simple pH test in the classroom. Students can analyze the test results in terms of how soil pH influences nutrient availability (see “Soil Nutrients and pH,” page 11).

Besides planning, there are a few gardening tasks you can do during winter. Hot compost piles need to be turned throughout the year, and all compost piles should be protected from heavy winter rains. If your school has an industrial arts or woodworking class, you may be able to collaborate to build a cold frame or hotbed.

If you have access to a south-facing window with good sun exposure, you can plant windowsill gardens of greens (e.g., lettuce, arugula, and mustards) or herbs (e.g., parsley, cilantro, and rosemary). You can also start seeds of kale, broccoli, cabbage, or cauliflower.

You may be able to plant peas outdoors in late winter if the soil is workable (i.e., the soil does not stick to garden tools and crumbles easily when you grab a handful) **AND**

### **Learn More: Seasonal Gardening**

*How to Build Your Own Raised-Bed Cloche.*

OSU Extension publication EC 1627.

<http://extension.oregonstate.edu/catalog/>


OSU Extension Monthly Garden Calendar

<http://extension.oregonstate.edu/gardening/calendar>

consistently holds a temperature of at least 40°F. Winter is also a good time to plant many fruit trees and fruiting shrubs.

## Spring (March–May)

### *Plant cool-season crops and the first warm-season annuals.*

 Have students use a soil thermometer and graph daily or weekly changes in soil temperatures. Use students’ results as a guide to help you know when to plant various crops (see “When to plant,” page 14).

- Some cool-season crops (e.g., onions, kale, lettuce, and spinach) can be transplanted when the soil is consistently above 40°F. Potatoes can also be planted in spring.
- Seeds of carrots, beets, cilantro, and greens can be sown directly outdoors (direct-seeded) when the soil temperature is consistently above 50°F.
- Some warm-season vegetables (e.g., beans and sweet corn) can be planted when the soil is consistently above 60°F.
- Wait until the soil is consistently above 70°F to transplant tomatoes, squash, melons, peppers, and eggplants.

In areas with short growing seasons, start seeds indoors or continue to tend indoor seedlings that were planted in winter. Use a cold frame to harden off tender tissues of young seedlings before transplanting them into an outdoor garden (see “Transplants,” page 14). Access to a hoop house or greenhouse can significantly increase the variety and amount of vegetables you can grow in a spring garden.




Figure 2. Although raised beds (*left*) are a great way to garden where soil is less than optimal, it is less expensive and just as effective to garden in soil that is mounded into raised rows (*right*).

Photo on left by Gail Langellotto, © Oregon State University. Photo on right by Nancy Kirks, reproduced by permission.

Prepare garden soil for spring planting. Incorporate 1 inch or more of organic materials and other amendments; use the results of a soil analysis as a guide. If the garden is planned for a site with poorly drained or cold soil, consider building raised beds or mounding the ground to form raised garden rows (figure 2).

Begin monitoring for pests. Slugs, aphids, and other pests may feed on tender seedlings. Cabbageworms and cabbage maggots may appear in cole crops (e.g., broccoli, cabbage, and kale). Carrot rust flies may emerge, mate, and lay eggs on carrots and parsnips. Adult cucumber beetles are active in early spring, and their larvae feed on peas, snap beans, and other crops as the season progresses. When soil warms to 50°F and higher, wireworms may appear and feed on beans, potatoes, sugar beets, and other crops.

Identify pests before acting to manage them. Many insects, including ladybugs, lacewings, and predaceous bugs, are beneficial and help keep plant-feeding pests under control. Spring is a great time to plant alyssum and buckwheat, both of which attract beneficial insects to the garden.

 Ladybugs and lacewings are easy to identify as eggs, larvae, and adults. Teach students to identify these beneficial insects, and discuss insect life cycles.

Pest management in educational gardens should be focused on cultural, physical, and biological controls:

- **Cultural:** Practice proper garden sanitation, choose resistant varieties, and encourage healthy, vigorous plants.
- **Physical:** Use row covers, collars, and other barriers.
- **Biological:** Attract and conserve beneficial insects.

Chemical controls should be considered only as a last resort. All Oregon school districts are subject to the regulations of Oregon Senate Bill 637, which requires school districts to have an integrated pest management (IPM) plan and a designated IPM coordinator and to use the services of a licensed pesticide applicator for all pesticide applications on school property. For more information, contact your district IPM coordinator or the OSU Extension IPM in Schools Program.

### Learn More: School IPM

OSU Extension IPM in Schools Program

[http://www.ipmnet.org/Tim/IPM\\_in\\_Schools/IPM\\_in\\_Schools-Main\\_Page.html](http://www.ipmnet.org/Tim/IPM_in_Schools/IPM_in_Schools-Main_Page.html)

## Summer (June–August)

*Water, weed, harvest, and perform general garden maintenance.*

If you can arrange for the garden to be watered and weeded in summer, many warm-season crops (e.g., tomatoes, cucumbers, pumpkins, eggplants, and squash) can be enjoyed when students return to school in fall.

Fertilize about 1 to 2 months after planting by working compost or fertilizer into the soil alongside vegetables (side-dressing). Thin new plantings of lettuce, chard, and other leafy vegetables by harvesting young leaves, and then use these leaves in a salad. Harvest strawberries and summer squash frequently to encourage production into fall. As you harvest various crops, consider planting winter cover crops in vacant spaces (see “Planting Cover Crops,” page 17).

Midsummer is a good time to plant crops that will be ready to harvest in fall and winter (e.g., beets, bush beans, carrots, cauliflower, broccoli, lettuce, kale, peas, turnips, parsley, and parsnips).

Continue to monitor for pests, and focus management efforts on cultural, physical, and biological controls. After the ground has warmed in late spring, consider planting sunflowers and yarrow. When these plants bloom in summer, they attract many beneficial insects that help naturally control garden pests. Again, chemical controls should be considered only as a last resort and in cooperation with your school IPM coordinator.

## Fall (September–November)

*Harvest many crops including broccoli, melons, peppers, winter squash, pumpkins, and potatoes; clean up the garden, and prepare for spring planting.*

If green tomatoes remain on the vine, pick them before the first frost, and ripen them indoors. Other tender vegetables (e.g., cucumbers, summer squash, and corn) should also be harvested before the first frost.

Garden debris that remains after harvest can be composted. Don't compost diseased plants or weeds that have gone to flower or seed unless you are “hot composting” (i.e., compost temperatures are maintained between 120°F and 150°F). Composting these materials in cooler piles can promote diseases and weeds in next year's garden.

Apply mulch to root crops (e.g., carrots, parsnips, and beets). The mulch will protect plants from extreme temperature fluctuations, allowing you to harvest and enjoy root vegetables at their best, when winter arrives. Perennial crops (e.g., rhubarb and asparagus) can also be mulched in fall. These plants often provide the first garden harvests in spring. If you plan to grow a winter garden, place a portable cold frame over rows of winter vegetables before the first frost.

Garlic and scallion bulbs can be planted in fall. These will be ready for harvest the following summer.

As seasonal rains arrive in western Oregon, be on the lookout for slugs and snails. Consider appropriate, least-toxic controls if these pests are a problem.

One of the most important fall chores is to prepare the garden for spring planting by evenly spreading a thick layer of compost (2 to 4 inches) over planting areas and a layer of mulch (4 to 6 inches) over garden paths. The mulch will suppress winter and spring weeds, prevent soil compaction, and add organic matter to the soil as it degrades during winter.

Instead of applying mulch, you can plant a dense winter cover crop. Seed cover crops in fall, while soil temperatures are warm enough for good germination and when there is enough sun for plants to become well established before winter (see “Planting Cover Crops,” page 17).

### Learn More: Garden Basics

*Growing Your Own.* OSU Extension publication EM 9027.

<http://extension.oregonstate.edu/catalog/>

Contains advice on composting, container gardens, fall/winter gardens, fertilizing, insect pests, plant diseases, planting guidelines, raised beds, site selection, slugs, soil improvement, tilling, warm-season crops, watering, and weeds. Includes regional tips for various parts of Oregon.

## Choosing a Garden Site

Choose a site carefully to increase the probability of success in your gardening activities.

### Location

Look for a level area that has loose, well-drained soil and receives plenty of sun each day.

If the site is not near a water supply, you will have to carry or cart water from a distance. Not planning for irrigation is a common, and unfortunate, mistake in educational and community gardens. Without an adequate, easily accessible water supply, gardeners may lose enthusiasm, and the garden will struggle.

If you plan to plant near a building, observe the patterns of sun and shade throughout the day and through an entire growing season before planting. The building may shade the site during critical points in the growing season. If you must use a shaded area, choose shade-tolerant crops, and take advantage of windows or other reflective surfaces to direct light to the garden.

Avoid the following sites for a vegetable garden:

- **Close to shrubs and trees**  
(These plants create unwanted shade and compete with garden plants for water and nutrients.)
- **Low areas at the base of a hill or foot of a slope that are bordered by a fence**  
(Cool air and frost tend to settle in these areas and will negatively affect plant growth.)
- **Close to a creek**  
(The water table in the soil may be high, and the area may be subject to flooding.)
- **Windy areas**  
(If that is not possible, build or grow a windbreak.)

## Sunlight

Plants grown for fruit need **at least** 6 to 8 hours of sun each day. Tomatoes, peppers, melons, and squash are examples of fruit-bearing garden plants that require full sun.

Plants grown for leaves, stems, or buds can be grown in partial shade. No vegetable will grow in full, dense shade, but the following crops will do well with 4 to 6 hours of sun each day or with constant, dappled shade:

- Salad greens (e.g., leaf lettuce, arugula, endive, and cress)
- Leafy greens (e.g., chard, collard greens, mustard greens, spinach, and kale)
- Kohlrabi, broccoli, and cauliflower
- Peas and beans
- Turnips, radishes, and beets
- Rhubarb

## Raised Beds

Raised beds or mounds are good choices for educational gardens. They save space, are easier to weed, and reduce soil compaction that might be caused by walking through the garden. Defined beds make it easy for students to keep accurate records of garden observations and measurements. Crop rotation plans are easier to implement in raised beds. On sites with problem soil, it is easier to manage soil in raised beds than to address soil issues over a larger, undefined area.

In spring, raised beds warm and drain more quickly than ground soil. This allows for earlier planting in areas with heavy clay soil but also means that raised beds need to be watered more frequently than flat gardens.

Raised beds can be constructed from a variety of materials. Cedar and juniper are somewhat resistant to rot and won't rot as fast as some other woods. Composite decking materials and prefabricated kits can be used, but these can be costly. However, raised beds can be both simple and effective.

A simple frame, constructed from four pieces of 2-inch by 12-inch lumber, can be placed on the ground and filled with soil. The frame can easily be moved to different locations for new plantings or new seasons. Although many raised beds are built 3 to 4 feet wide, you may want to build them narrower so those with shorter arms can reach into the center of the bed.

Mounds or raised rows (figure 2) are low-cost alternatives that work well for many educational gardens.

## Making a Garden Plan

### Maps

Plan the garden on paper in fall or early winter. Make a list of plant varieties that are recommended for your area, and note the recommended planting date for each. Draw a map to show the arrangement and spacing of crops. If you plan to garden year round, draw a separate map for each season.

Plant tall and trellised crops on the north side of the garden so they won't shade shorter crops. Plant perennial crops along the side of the garden so you won't disturb them with annual tillage and replanting. Group crops by growing season. Planting spring crops together will allow you to plant later-maturing crops in the same area of the garden after the spring harvest.

### Crops and Varieties

If you are new to vegetable gardening, you may want to choose vegetables that are fairly easy to grow, if given proper care. If your educational garden follows the school calendar (i.e., students in school and at the garden from fall through spring), you may want to plant crops that mature during the school year. Cool-season crops to consider include carrots, leaf lettuce, peas, radishes, and spinach. Warm-season crops can be incorporated if care (e.g., watering, weeding, and harvesting) is provided over summer break. Warm-season crops to consider include beans, potatoes, summer squash, and tomatoes.

### Learn More: Variety Selection

*Vegetable variety trials*. OSU Extension publication EM 8777.

<http://extension.oregonstate.edu/catalog/>

See Appendices A, B, and C (pages 18 to 25) for general information on recommended crops and planting times. Appendix D (page 26) lists vegetable varieties that perform well in Oregon gardens.

### Hybrid and Open-Pollinated Varieties

Plant breeders often cross different varieties of plants to create offspring that have the best features of both parents. These offspring are called hybrids. If you plant seeds from a hybrid, the resulting plants may look very different from the parent plant. It is difficult to predict how seeds from hybrids will perform in the garden, or how the fruit will look and taste.

Open-pollinated varieties self-pollinate or are pollinated by wind, water, or insects. Many heirloom varieties are open pollinated. If you plant seeds from an open-pollinated plant, the resulting plants tend to have characteristics that are very similar to those of the parent plant.

Hybrid varieties are often easier to grow than open-pollinated varieties. However, if you want to save seed or prefer heirloom varieties of vegetables, you should opt for open-pollinated varieties. Seeds from open-pollinated beans, peas, tomatoes, peppers, and lettuce are good choices for beginning seed savers. Seeds from these plants are easy to collect and will "breed true" (i.e., be similar to their parent plant). Most other vegetables, especially those in the squash (cucurbit) and cabbage (brassica) families require special techniques for successful seed saving.

### Ordering and Purchasing Seed

Order seeds at least 2 to 4 months before they can be sown outdoors (Appendix A). This will allow you to start seeds indoors before transplanting seedlings to an outdoor garden.

Choose varieties that are recommended for your region, or for regions with colder climates than yours. This helps ensure that seeds are hardy to your area or can adapt to your climate. If certain diseases are prevalent in your area, look for varieties that exhibit resistance. For example, late blight is a fairly common disease on tomato. If you've been battling this disease or suspect it may pose a problem in the garden, consider choosing the tomato cultivar Legend or the cherry tomato cultivars Red Cherry and Sweetie, which are resistant to late blight.

Local nurseries, Extension Master Gardener programs, and companies that publish seed catalogs sometimes donate seed for use in educational gardens. A simple web search for "seed donations" will yield a list of commercial businesses and nonprofit organizations that donate seed to community and educational gardens.

## Garden Tools

Most gardeners regularly use a few basic tools (figure 3). Generally, you should shop for quality rather than quantity when purchasing garden tools. Quality tools will last a long time and are worth the initial investment and expense. Metal parts should be made of steel or hardened aluminum. These materials stay sharp, keep their shape, and outlast tools made out of softer metals.

However, if young children will use the tools, you may want to find plastic tool sets or child-size garden tools. You can also reuse old silverware; spoons can be used to dig holes to plant seeds or seedlings, and forks can be used to minimally till the soil.

It is important to keep tools clean and sharp. A sharp tool will shorten the amount of time you spend working and prolong the tool's useful life. Periodically wipe tools with linseed oil to protect and preserve metal surfaces. Use a wire brush to clean soil from tools. At the end of the gardening day, dip tools in a bucket of sand saturated with vegetable oil to keep them clean and guard against rusting throughout the season.

The following paragraphs describe some basic garden tools and their uses.

A hoe (figure 3) is useful for preparing beds, removing weeds, and breaking up hard soil. A scuffle hoe (figure 4) is good for chopping off small annual weeds; scrape it along the surface of the ground in front of you as if you were playing shuffleboard. A Warren hoe (figure 4) is useful for cultivating between plants and creating seed furrows. The "ears" on the top are designed to push soil back onto newly planted seeds.

A hand trowel (figure 3) is good for small digging jobs that don't require full-size tools. It is useful for transplanting seedlings and bulbs or digging up shallow-rooted weeds.

A rake (figure 3) is useful for clearing rocks and debris, smoothing soil, and spreading mulch. The rake handle should come up to the user's ear. Rakes that are too short will make your work harder and cause excess bending and strain on your back. Rakes that are too long can be difficult and frustrating for young gardeners to use.

Small hand cultivators (figure 5) are good for digging up perennial plant roots and weeding small areas, especially between closely spaced plants. Larger, long-handled cultivators have one to five pointed tines and can be used in a chopping and pulling motion to remove shallow-rooted weeds and break up the surface soil crust around plants.

Pickaxes and mattocks can be used to break up hard-packed soil. A pickax (figure 6) has a cutting blade for removing large roots. A dandelion digger (figure 6) is useful for digging up long taproots and prying out quackgrass rhizomes.





**Use garden tools safely and appropriately, and teach students to do the same:**

- Never lift or swing tools above the knees.
- Watch where you move the handle. Be aware of the sharp end at all times.
- When setting aside tools in the garden, place them away from main walkways and paths.
- Always place the sharp end toward the ground.

Tool photos by Beret Halverson, © Oregon State University, unless otherwise noted.

Figure 3. Most gardeners make regular use of (left to right) a hoe, shovel, rake, spading fork, and trowel. These tools are available in adult and child sizes (not shown).



Figure 4. The scuffle hoe (left) and Warren hoe (right) are shaped for different jobs in the garden.

Warren hoe photo by Red Pig Tools, reproduced by permission.



Figure 5. Small hand cultivators are useful for weeding in tight spots and breaking up the surface soil around plants. Long-handled cultivators are also available (not shown).



Figure 6. Pickaxes (left) can be used to break up hard-packed soil and remove large roots. A dandelion digger (right) can be used to dig up weeds with long taproots. Children should not use these tools.



### Identify the texture of your soil.

Students can determine the general texture of soil by using the feel, ball squeeze, and ribbon tests. To demonstrate the importance of replication in scientific studies, have students repeat these simple tests throughout the year to see if results remain the same or change.

- **Feel test:** Moisten soil (if necessary), and rub it between your fingers. Sandy soils will feel gritty. Silty soils will feel smooth, like flour. Clay soils will feel sticky.
- **Ball squeeze test:** Moisten a lump of soil, shape it into a ball in your hand, and squeeze the ball. Coarse-textured soils, which contain a lot of sand and very little clay, will break with only a little bit of pressure. Medium-textured soils, which contain a lot of silt and very little clay, will not easily fall apart but can be squeezed into different shapes. Fine-textured soils, which contain a lot of clay, will resist both breaking and changes in shape when squeezed.
- **Ribbon test:** Moisten a small lump of soil, and roll it between your thumb and fingers to form a rounded ribbon (i.e., a worm- or noodle-like shape). Soil that forms strong ribbons contains a lot of clay. Soil that will not easily form a ribbon contains a lot of silt. Soil that is loose and falls apart easily is sandy.

Sandy, silty, and clay soils are general terms used to describe the predominant texture of different soil types. You can use a soil textural triangle together with the jar test (see Colorado Master Gardener GardenNotes #214, *Estimating Soil Texture*, <http://cmg.colostate.edu/gardennotes/214.pdf>) to more specifically identify and describe the soil texture in your garden.

## Garden Soil

### Soil Texture and Structure

Soil texture is determined by the proportion of sand, silt, and clay particles in the soil. Sand particles dominate coarse soil. Silt particles are finer than sand particles. Clay particles are the smallest. Most soil contains a mix of sand, silt, and clay.

Sand, silt, and clay particles bind together to form aggregates called peds. The shape of soil peds determines soil structure. Root growth, microbial action, and earthworm activity all affect how soil particles aggregate into peds. Compaction can damage or destroy soil structure. To preserve soil structure, avoid unnecessary tilling, and reduce unnecessary foot or machine traffic on garden soil.

The spaces between peds are called macropores. Soil with many macropores drains quickly and does not have a high water-holding capacity. However, this type of soil allows air into the soil's profile. The spaces between soil particles are called micropores. Soil with many micropores holds water well but can be heavy and slow to drain.

Clay soil holds water well but is hard to dig and dries slowly in spring. Sandy soil needs frequent watering and lighter, more frequent fertilization. Sandy soil can generally be planted earlier in spring. Most vegetables perform best in soil with a loam or sandy loam texture. This type of soil has relatively high proportions of sand and silt particles and relatively low proportions of clay, which results in an optimum balance of water-holding capacity and drainage.

Gardening and landscaping soil is often sold under the term "topsoil." There are no legal standards for this term, so you should ask about and inspect the soil's texture, organic matter, and appearance before purchasing. The soil should be free of trash, debris, and rocks larger than 3 inches in diameter. The soil should contain about 5% organic matter. The ideal texture is a loam or sandy loam; this type of soil will not form clods when wet or fall apart when dry.

Ultimately, soil of any texture can be suitable for gardening. Be aware of the soil's limitations, and adjust your management techniques as needed.

### Soil Nutrients and pH

Soil supplies plants with 13 essential nutrients. These nutrients are classified as primary (e.g., nitrogen, phosphorus, and potassium), secondary (e.g., calcium, magnesium, and sulfur), or micronutrients (e.g., copper, manganese, zinc, boron, molybdenum, chlorine, and iron) depending on the amount needed by a particular plant. Plants with a deficiency in any of these nutrients can grow more slowly and yield less than plants with adequate levels of nutrients. Plants that are deficient in a particular nutrient often exhibit characteristic symptoms.

Soil pH is a measurement of acidity or alkalinity. Soil pH directly affects the availability

**Learn More: Lead in Soil**

*Evaluating and Reducing Lead Hazard in Gardens and Landscapes.* OSU Extension publication EC 1616.  
<http://extension.oregonstate.edu/catalog/>

of nutrients in the soil (figure 7) because the charged ions that determine soil pH hold or repel various nutrients. Soil in arid areas tends to be alkaline (high pH). Soil in rainy areas tends to be acidic (low pH). Though optimal soil pH varies for different vegetables, most perform best at a soil pH of 6.2 to 6.8. Before initially planting the garden and once very few years, have the soil tested to determine nutrient composition, organic matter content, and pH. If the garden is located on a former orchard or other site that may be contaminated with lead, evaluate the soil for potential lead hazards.

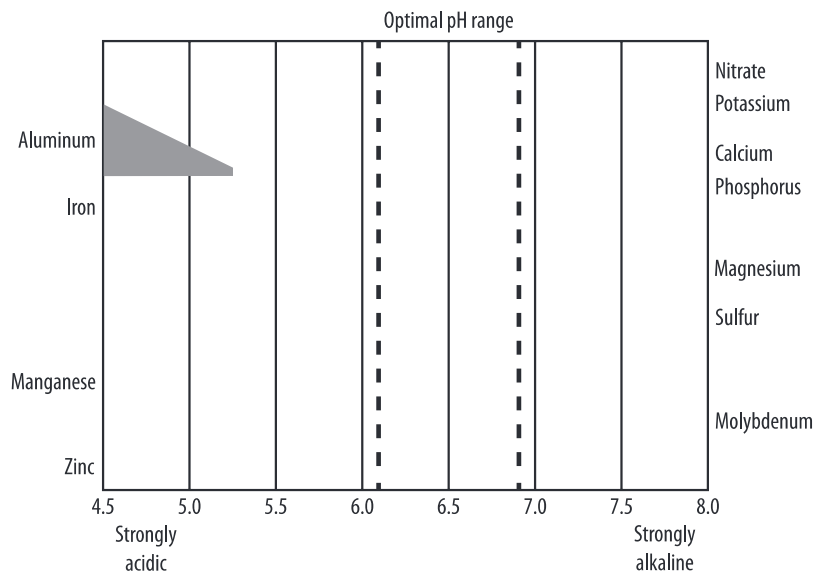



Figure 7. pH influences the availability of nutrients in the soil. The width of each bar represents the relative abundance of particular nutrients across the pH scale. Availability of iron, manganese, and zinc decreases as soil pH increases. Availability of calcium and molybdenum increases as soil pH increases. Most nutrients are available, and plants tend to perform best, at a soil pH of 6.2 to 6.8.

Image by Gail Langellotto, © Oregon State University, adapted with permission from an image created by Sam Angima, Oregon State University.

You can raise the pH of acidic soil by adding lime (calcium carbonate,  $\text{CaCO}_3$ ), dolomitic lime (calcium magnesium carbonate,  $\text{CaMg}(\text{CO}_3)_2$ ), quicklime (calcium oxide,  $\text{CaO}$ ), hydrated lime (calcium hydroxide,  $\text{Ca}(\text{OH})_2$ ), or wood ash to the soil. An advantage of using wood ash as a soil amendment is that it contains potassium and other trace elements. Spread ash judiciously to avoid addition of excessive salts and inadvertent production of ammonia gas, which may result if ash is added with nitrogen fertilizers.

You can lower the pH of alkaline soil by adding elemental sulfur. This is particularly useful for acid-loving plants, such as blueberries. Recommendations for acidifying soil vary depending on whether the garden is west or east of the Cascades.

 To supplement chemistry lessons about pH and soil chemistry, have students determine the pH of soils before and after adding lime or sulfur.

#### **Learn More: Soil pH**

*Acidifying Soil for Blueberries and Ornamental Plants in the Yard and Garden: West of the Cascade Mountain Range in Oregon and Washington.* OSU Extension publication EC 1560.

*Acidifying Soil in Landscapes and Gardens East of the Cascades.* OSU Extension publication EC 1585.

<http://extension.oregonstate.edu/catalog/>

#### **Learn More: Compost**

*Gardening with Composts, Mulches, and Row Covers.* OSU Extension publication EC 1247. <http://extension.oregonstate.edu/catalog/>

*Backyard Composting.* Washington State University Extension publication EB 1784. <https://pubs.wsu.edu/>

*Health and Safety Guidance for Composting in the School Setting.* Cornell University. <http://cwmi.css.cornell.edu/health.pdf>

## **Soil Microbes**


Healthy soil is teeming with life. One fourth of a teaspoon of soil can contain as many as a billion microorganisms. These microbes are most abundant in the rhizosphere, the thin layer of soil surrounding plants' roots.

In the soil, microorganisms work with arthropods, nematodes, and earthworms to break down the remains of plants and other organisms. Microbial action releases nutrients that are bound in organic material, making them available to plants. Soil microbes are most active when the soil temperature is between 70°F and 100°F.

Many gardening activities affect the abundance and diversity of soil organisms. Long-term studies have shown that bacteria, but not simple eukaryotes (e.g., protozoans), are more abundant in soil fertilized with organic versus inorganic fertilizers. A separate study found that tilling changes the species present in the microbial community but not the total biomass of soil microbes. When maintaining the garden, make sure to be a good steward of the soil and soil microbes.

## **Composting**

Composting is the art of managing the natural cycle of growth and decay. Many methods are available for managing this controlled decay process.

 Use composting to demonstrate the nutrient cycle and the action of soil microbes. Composting can also supplement lessons about the biodiversity of organisms in a soil ecosystem.

Carefully consider what materials you will compost. Composting food scraps may attract pests such as raccoons, rodents, dogs, cats, and flies. If you compost food scraps, use a closed and covered system. Yard debris composting systems are easier to maintain and provide a great way for students to practice composting.

## Tilling and Soil Amendments

For most soil types, fall tilling allows earlier spring planting and turns under large amounts of organic matter. This often results in better decomposition because temperatures are higher in fall (than in early spring) and there is more time for the process to take place before planting. Fall tilling also helps control harmful insects, diseases, and perennial weeds, which tend to die in harsh winter weather. Spring tilling is better for sandy soil, which may erode if exposed during winter rains.

When tilling, **DO NOT** overwork (pulverize) the soil or turn it over completely. This may upset the balance of microorganisms, significantly reduce earthworm populations, and bury coarse organic matter. Tilling too deeply destroys soil structure and can seal off the subsoil by creating a compaction layer that inhibits root growth and water infiltration.

Work the soil only when soil moisture conditions are correct. Tilling wet soil, particularly clay soil, can destroy soil structure by creating clods that harden into a solid mass. This mass will prevent root growth and water infiltration. To test soil moisture, squeeze a handful of soil into a ball. If it stays in a ball that won't shatter, it is too wet. If it won't form a ball at all, it is too dry. If it makes a ball that falls apart when pressed, it is just right for tilling.

There are many tools available for tilling. Choose equipment on the basis of garden size, your physical ability, time, and budget.

Hand tools such as spading forks, spades, and shovels are useful for tilling soil in raised beds. Use a spading fork if you are working in a small space and want to minimally affect soil structure. Wiggle it into the soil, pop the soil loose, and then use it to lightly rake the soil. Repeat this process as you work your way through the bed or down the row. Hand digging with a spade or shovel is another option.

It can be extremely helpful to use a mechanical tiller in a new, large garden. To preserve soil structure, till just deep enough to shatter the sod and root clumps. Deeper tillage can be

done with a spade or spading fork. A small garden tractor or farm tractor may be useful for very large areas. A benefit of mechanical tilling, which works the top 5 to 6 inches of soil, is that it mixes the upper layers of soil. However, mechanical tilling can also result in the newly loosened soil sinking back down into the tilled area after the first watering.

Add aged manure, limestone, rock fertilizers, or green manure to tilled soil several weeks before planting. Just before planting, add water-soluble fertilizers and 1 to 2 inches of finished compost. Compost makes the soil easier to work and creates a better medium for plant growth.

### Double-Digging

Double-digging is a tilling method that is useful for heavy, compacted soil. It is also a labor-intensive method. Dig a trench (1 foot wide by 1 foot deep) at one end of the garden, and put the removed soil into a garden cart or wheelbarrow. Add compost to the bottom of the trench, and break up compacted soil at the bottom of the trench. To do this, insert a spade or spading fork into the soil, and wiggle it back and forth. Next, dig a new trench adjacent to the initial trench, and put that removed soil into the initial trench. Add compost to the second trench and incorporate. Continue this process until you've worked the length of the garden. Mix the soil in the wheelbarrow with a generous amount of compost before returning it to the garden.

Because this process is extremely labor intensive, use a long-handled square spade to dig efficiently and spare your back. A spading fork (figure 3) works well for loosening soil in the trenches. Double-digging is best reserved for initial garden preparation and loosening severely compacted soil.

### Learn More: Soil Preparation

*Improving Garden Soils with Organic Matter.* OSU Extension publication EC 1561.

<http://extension.oregonstate.edu/catalog/>

*Double Digging.* Video from Kentucky State University.

<http://organic.kysu.edu/DoubleDig.shtml>

## Garden Tasks

### Planting

#### *When to plant*

Air and soil temperatures are critical to proper germination and healthy plant growth (Appendices A and B). Planting too early may prevent germination or expose tender tissues to late frosts. Planting too late shortens the growing season and may prevent warm-season crops from setting and ripening fruit. Nighttime temperatures are often more critical than daytime temperatures for plant development, particularly for fruit set on peppers, tomatoes, cucumbers, and melons. Optimum nighttime temperatures for fruit set in these plants range from 59°F to 68°F.

Track the soil and air temperatures where you will be planting. Determine soil temperatures by inserting a soil thermometer (available at most home and garden stores) into the soil to a depth of 3 to 4 inches. Before planting seeds, make sure that soil temperatures are consistently within the recommended range for several days.

#### *Seeds*

Seeds planted too early in spring can rot in cold soil before they have a chance to germinate. If you direct-seed crops in spring, it may be useful to presprout seeds before planting. To do this, place seeds between two layers of damp paper towels, and place the towels in a plastic bag. Keep the seeds warm and moist until they germinate. Use care when handling and planting newly germinated seeds to avoid damaging roots.

Another technique to hasten spring seeding is to cover the bed or planting area with clear plastic for 1 to 2 weeks before planting.

The plastic helps hold in heat and can dramatically improve soil temperatures. If air temperatures are still cool or skies are overcast after seeding, leave the plastic over the seeded area. Remove the plastic when seedlings start to emerge.

Remember that seeds should be planted about twice as deep as they are wide. Small seeds (e.g., carrots, radishes, and lettuce) have a very shallow planting depth and benefit from a light sprinkling of compost or fine potting soil, especially if soil is lumpy. Because of their larger size, seeds of melons, squash, corn, and cucumbers should be planted in “hills.” A hill means a group of seeds, not a mound of soil. Plant four to five seeds per hill. Thin to two to three plants per hill after germination. When the plants begin to grow rapidly, thin to a single plant by pinching out all but the most vigorous seedling.

Label the areas you’ve seeded so students can recognize plants during all growth stages. Use a pencil to label plastic or wooden stakes, or use an old pen to label copper plant tags. Avoid using markers, as the writing will fade in sunlight.

#### *Transplants*

Broccoli, cabbage, cauliflower, eggplants, lettuce, Chinese cabbage, tomatoes, and chard all do well if transplanted into a garden as seedlings. If you are purchasing seedlings, choose stocky, disease-free plants. Transplants should have a few sets of leaves and well-developed roots. Avoid plants that are too mature (i.e., yellow, woody, or already flowering) and plants that are root bound (i.e., have been in the pot so long that roots are long and wound together). To check the root system on smaller plants in plastic pots, gently tap on the bottom of the pot while holding the main stem between your middle and pointer fingers just above the soil, and tip the plant out of the pot against your hand.

#### **Learn More: Seeds**

*Propagating Plants from Seed.* Pacific Northwest Extension publication PNW 170. <http://extension.oregonstate.edu/catalog/>

Before transplanting seedlings, take time to harden them off (i.e., acclimate them to cooler outdoor temperatures). To do this, take seedlings outside during the day, and bring them in at night. Gradually expose seedlings to sunlight by providing shade or limiting the time spent in direct sun. Do this for 3 to 5 days depending on the plant variety and the weather. This process helps young tissues adapt to the colder weather and UV light of an outdoor garden. Transplant seedlings in the late afternoon or early evening to prevent wilting. Water seedlings several hours before transplanting, and handle them carefully to avoid damaging roots or bruising stems.

### How to transplant a seedling:

1. Dig a hole that is wider and slightly deeper than the root ball. You may want to place a starter solution in the bottom of the hole. The starter can be half-strength fish emulsion, finished manure, compost tea, or an organic fertilizer mixture. Mix the starter solution with the soil directly below where the seedling will go.
2. Set the seedling gently in the hole on top of the compressed soil. The bottom leaves should be about level with the top of the hole. Tomatoes are an exception; they can be planted with the bottom leaves beneath the top of the hole so that only two to three sets of leaves are exposed.
3. Fill the hole to the top with tepid water. Next, fill the hole with loose soil. As the water is absorbed, gently push more soil into the hole so the seedling settles into the soil. Gently compress the soil with your fist.

For the first few days after transplanting, protect transplants from wind and sun. Shield the south side of seedlings with newspaper or cardboard, or cover seedlings with milk jugs with the bottoms removed. Row covers also make excellent protective material. Water plants if there is insufficient rain; transplants need extra water the first week they are planted to become well established.

## Watering

Vegetable crops need about 1 inch of water per week from April to September, although the specific amount will vary depending on the crop, growth stage, and environmental conditions. During dry periods, a thorough weekly watering of 1 to 2 inches (65 to 130 gallons per 100 square feet) is adequate for most soil.

To use water efficiently, it is important to know the critical watering periods for each type of vegetable. In general, plants need the most water during their first weeks of growth, right after transplanting, and during flower and fruit development. Seedlings need more water at a shallower depth, and mature plants need deeper, less frequent watering.

Ground-level watering (trickle irrigation) is much more efficient than overhead watering (sprinklers or hoses). Trickle irrigation places water directly at the crop roots and helps reduce disease and weed growth. Soaker hoses are the least expensive and easiest type of trickle type irrigation to use. These fibrous hoses allow water to seep out slowly along their entire length. Emitter-type systems deliver water right to plant roots but are expensive and complex to set up. These systems also need filters or self-flushing features to prevent clogging.

Sprinklers and handheld hoses are examples of overhead irrigation. If you irrigate with a handheld hose, limit foliar disease by watering the base of the plant rather than the leaves. Watering early in the morning also helps prevent disease because it provides time for the foliage to dry out during the day. If you use an overhead sprinkler, apply water at a maximum rate of 0.5 inches per hour to avoid runoff.



To supplement math or physics lessons, have students calculate irrigation rates. Place a graduated cylinder, graduated beaker, or empty can in the area being irrigated. Check the water level every 5 minutes, and then calculate the irrigation rate in inches per hour.

## Weeding

It is important to remember that weeds are defined according to our perspective. A weed is any plant growing where we don't want it to grow.

Many weeds have positive attributes. Dandelion, purslane, chickweed, cress, mustard, and lambsquarters all provide edible greens. Native bees use spring-flowering weeds for nectar and pollen when few other plants are in bloom. Weeds are also a good source of nitrogen for the compost pile because they often have long roots that bring up elements from the subsoil. Composting makes these elements available to other plants.

*Note: Before consuming a wild plant (i.e., one you did not sow), make sure to verify its identity. Introduce the concept of foraging for wild greens to students only if you are sure they are capable of discriminating edible from inedible or potentially toxic plants.*

Compost weeds only after you remove seedheads and flowers and if you practice hot composting. Hot composting requires that the pile remain at 131°F for a minimum of 5 days (organic industry standard). If this is not possible, aim to keep the pile between 110°F and 160°F for 5 days. Removing seedheads and flowers helps prevent weeds from reemerging from compost added to garden soil.

Although weeds have some benefits, it is important to control weeds in the garden as soon as possible. Early removal prevents weeds from extracting moisture and nutrients from the soil. Some weeds produce many seeds (i.e., between 1,000 and 25,000 seeds per plant), so early and consistent weed control can dramatically reduce the weed seed bank and the total time spent controlling weeds. It is easiest to remove young weeds or to weed a day or two after rain or irrigation. Avoid weeding wet soil; this could damage soil structure.

There are many ways to prevent weeds. Close spacing of plants shades the soil and prevents many weed seedlings from growing.

Mulching prevents most annual weeds from emerging. Newspaper covered with mulch is an effective, low-cost weed barrier, but it will not smother tough perennial weeds, such as quackgrass, field bindweed, and dandelions. Also, the newspaper will degrade over time.

Be sure to mow or weed the edges of the garden; weeds that sprout or go to seed there can easily make it into the garden.

Planting cover crops for several seasons in a particularly weedy area can reduce weed problems. The cover crops outcompete weeds for sunlight, nutrients, and moisture. Mow or harvest cover crops regularly to control any weeds that may have germinated and grown in the cover-cropped area.

## Harvesting

Harvest produce at the correct time to ensure the best flavor and quality.

Pick **tomatoes** when they are fully colored but still firm. Once fully colored, tomatoes remain in good eating condition for about a week. They lose flavor when exposed to temperatures below 50°F. At the end of the season, pick unripe tomatoes and ripen them indoors.

Cut **green peppers** from the plant when they are firm and the size you want. Eventually, they will turn red. Pick other bell peppers as they become their mature color. Hot peppers generally get hotter as they mature.

It is best to harvest **snap peas** when the peas are half developed in the pod. Pods are edible until they are full size and begin to soften. Harvest **shelling peas** when the pods are full and still a uniform green color. Pick **snow peas** before the peas swell.

Harvest **summer squash** while their skin is tender. They are past the eating stage when their skin feels smooth or slick. Harvest **winter squash** (e.g., acorn, butternut, Hubbard, and Sweet Meat) when you cannot puncture their skin with your thumbnail. There is no hurry to harvest these until cold weather arrives. Cut winter squash from the plant with the stem attached. Keep them at 70°F for at least a week,



and then store them in a cool, dry room, such as an unheated garage. They will generally keep for 3 to 5 months.

Harvest **sweet corn** when kernels are filled and still milky. When the husk is firm, the ear should be ready to harvest. You can also peel back the husk a bit and check the ear. If it isn't ready, just fold the husk back over the ear, and check again in a few days.

Harvest **head lettuce and cabbage** when the heads are firm. Both crops will grow new leaves if you leave 2 to 3 inches of leaves above the crown of the plant when harvesting the main head.

**Beets, turnips, and kohlrabi** will taste best when harvested at about 2 to 2.5 inches in diameter. A few varieties grow bigger (e.g., super-large kohlrabi, mangels, and sugar beets).

### **Cleanup**

Begin cleaning up the garden after harvesting tender crops and caring for perennials and other crops that will remain in the garden over winter.

Pull up all stakes and trellises. Clear off plant material, rinse off soil, and let them dry in the sun to disinfect. Pull up all dead and unproductive plants, and place them in the compost pile. If this plant material is left in the garden, it provides a place for diseases and insects to overwinter.

If you have access to fallen leaves, shred and put them in the garden. Straw is a good option if you don't have leaves. This will add organic matter to garden soil and help suppress weeds. You may also save leaves for next year's garden mulch. Don't use walnut leaves as mulch or in compost; they have chemicals that may inhibit next year's crop growth.

### **Planting Cover Crops**

Cover crops, which are sometimes called "green manures," help prevent soil erosion, suppress weeds, and build productive soil. Plant cover crops after harvesting vegetables and removing garden debris. Cover crops are typically grown until they flower, at which point they are cut or mowed. Work the cut stems and foliage into the soil, and wait at least 2 to 3 weeks before planting vegetables.

Winter cover crops, such as crimson clover, are a great way to use garden space that would otherwise be vacant during the off-season. Summer cover crops, such as buckwheat, can be used to revitalize garden soil that needs to rest during the growing season. When in bloom, buckwheat has the added advantage of attracting beneficial insects. Plant buckwheat between rows or plants, and pull it before it goes to seed. Lay the pulled buckwheat on top of the soil, where it will act as an organic mulch. Avoid rye, winter-hardy cereals, and red clover; these plants grow aggressively and may be difficult to eradicate.

## Appendix A

### Vegetables that may be suitable for educational gardens when grown from seed.

Plants are listed according to maturation times (shortest to longest). Use a soil thermometer to time planting. Before planting seeds, make sure that soil temperatures are consistently within the recommended range for several days.

Plant	Days to maturity (from seed to harvest)	Optimum soil temperature for planting seeds (°F)	Optimum air temperature for plant development (°F)	Planting distance (inches)	Thin to (inches) <sup>1</sup>	Planting season	Notes
Radishes	28–40	50–65	50–65	0.5	2–3	Spring, Fall	Easy to grow.
Leaf lettuce	35–40	40–80	55–65	0.5	4–6	Spring, Fall	Plant in full sun in cool weather but in partial shade in hot weather.
Chard	50	65–85	55–65	1	4–7	Spring, Fall	Can be used to make chard pesto.
Mustard	40–45	45–85	55–65	1	4–6	Spring, Fall	Spicy greens.
Kale	48	45–85	55–65	1	12	Spring, Fall	Can be harvested in 4 to 5 weeks if grown in flats.
Beets	55–60	50–85	60–65	1	4–6	Spring, Fall	Need to be thinned; greens are edible.
Carrots	60–88	55–75	60–65	0.5	2–3	Spring, Fall	Hard to germinate; need to be thinned.
Beans	54–65	65–85		Bush: 3–4 Pole: 6 beans/pole	Bush: 6 Pole: 3 beans/pole	Spring, Summer, Fall (Fava beans)	Easy to grow; can plant in pots and then transplant.
Peas	60	50–65	50–60	1	3–6, trellised	Spring, Summer	
Head lettuce	53–73	40–80		12–24, to allow for successive plantings	24–36, to allow for successive plantings	Spring, Fall	Can also use transplants.

<sup>1</sup>"Thin to" distances represent the space that a plant requires in all directions. For example, if you thin beets to a spacing of 6 inches, there should be 6 inches between beets planted in a row and 6 inches between rows.

## Appendix B

### Vegetables that may be suitable for educational gardens when grown from transplants.

Plants are listed according to maturation times (shortest to longest). Transplants may be started as seeds, started indoors, or purchased.

Plant	Days to maturity (from transplant to harvest)	Age of transplant (days)	Optimum air temperature for plant development (°F)	Planting distance (inches)	Planting season	Notes
Cucumbers (pickling)	30–40	14–21	75–85	6–8	Spring, Summer	Good cucumber for short growing seasons.
Cucumbers (slicing)	32–46	14–21	75–85	6, trellised 24–36, untrellised	Spring, Summer	For best flavor, harvest cucumbers early in the morning, and refrigerate immediately.
Summer squash (including zucchini)	40–50	14–21	65–75	36–48	Summer	Handle transplants gently to protect delicate roots.
Eggplants	55–80	42–70	70–85	18–24	Summer	Consistently warm weather throughout the growing season is necessary for good harvests.
Tomatoes	60–75	30–35	60–80	24–36	Summer	Cherry tomatoes are a good choice for short growing seasons; abundant producers.
Peppers	72–90	42–56	70–80	15–18	Summer	18 weeks if grown from seed.
Winter squash	70–100	14–21	65–80	36–48	Summer	Harvest before heavy frosts, when the rind is hard and firm or when the “ground spot” changes from white to a cream or gold.
Onions	110–120	Sets <sup>1</sup>	40–60 for plant development 60–75 for bulb development	4–6	Spring, Summer	Can grow scallions and chives for 8- to 9-week harvest.
Garlic	120–185	Sets <sup>1</sup>	40–60 for plant development 60–75 for bulb development	6	Fall, Spring	Can be harvested and used at any size; the longer garlic is allowed to mature, the bigger the bulbs.

<sup>1</sup>Onions and garlic are generally purchased as small bulbs, which are known as sets.

## Appendix C

### Gardening calendar for common garden plants in the Willamette Valley of Oregon.

This calendar is based on average weather; planting may need to be delayed depending on the actual weather in a given year. Use a soil thermometer to time planting. Gardeners in other growing regions (e.g., coastal, high desert, Rogue River Valley, Columbia Gorge, and Walla Walla Valley) should adjust planting dates as needed depending on local soil temperatures, frost dates, and other environmental factors that influence seed germination and transplant success.

Month	Sow seed directly outdoors	Start in flats indoors or with protection (cold frame or greenhouse)	Transplant from protected flats to an outdoor garden	Plant outdoors with the use of season extenders (greenhouse, cold frame, cloche, or row cover)
January		<ul style="list-style-type: none"> <li>• Leeks, onion sets</li> <li>• Lettuce, endive, cardoon, artichoke</li> <li>• Alpine strawberries</li> </ul> <p>Note: Sowing most seeds under protection in January and February requires bottom heat and supplemental light.</p>		
February	After 15th: <ul style="list-style-type: none"> <li>• Peas, fava beans</li> <li>• Arugula, radishes</li> <li>• Garlic, shallots, onion sets</li> </ul>	<ul style="list-style-type: none"> <li>• Parsley, cilantro, celery, celeriac</li> <li>• Broccoli, kale, greens</li> <li>• Lettuce, endive, dandelions</li> <li>• Chives, leeks, onion sets</li> <li>• Tomatoes, peppers, eggplants</li> </ul> <p>Note: Sowing most seeds under protection in January and February requires bottom heat and supplemental light.</p>		<ul style="list-style-type: none"> <li>• Peas</li> <li>• Parsley (T), cilantro</li> <li>• Greens, kale, turnips, radishes</li> <li>• Beets, spinach</li> <li>• Lettuce, endive</li> </ul>

(T) = transplant. (?) = success is questionable but worth a try in a pinch.

Month	Sow seed directly outdoors	Start in flats indoors or with protection (cold frame or greenhouse)	Transplant from protected flats to an outdoor garden	Plant outdoors with the use of season extenders (greenhouse, cold frame, cloche, or row cover)
March	<ul style="list-style-type: none"> <li>• Peas, fava beans</li> <li>• Parsley, cilantro</li> <li>• Broccoli, radishes, greens</li> <li>• Beets, spinach, chard, New Zealand Spinach</li> <li>• Bulb sets, scallions</li> </ul> <p>After 15th:</p> <ul style="list-style-type: none"> <li>• Jerusalem artichoke</li> <li>• Potatoes</li> </ul>	<ul style="list-style-type: none"> <li>• Parsley, cilantro, celery, celeriac</li> <li>• Cabbage, broccoli, cauliflower, kale, kohlrabi, greens</li> <li>• Leeks, onion sets</li> <li>• Tomatoes, peppers, eggplants</li> <li>• Mint-family herbs</li> </ul>	<p>After 15th:</p> <ul style="list-style-type: none"> <li>• Parsley, cilantro</li> <li>• Broccoli, kale, greens</li> <li>• Lettuce (?)</li> </ul>	<ul style="list-style-type: none"> <li>• Parsley, carrots</li> <li>• Greens, kale, kohlrabi, broccoli, cauliflower, cabbage</li> <li>• Beets, spinach, chard</li> <li>• Lettuce, endive</li> </ul>
April	<ul style="list-style-type: none"> <li>• Peas</li> <li>• Carrots, parsley, cilantro, parsnips</li> <li>• Cabbage, broccoli, cauliflower, kale, kohlrabi, turnips, radishes, Brussels sprouts</li> <li>• Beets, spinach (summer), chard</li> <li>• Scallions</li> <li>• Potatoes</li> </ul> <p>After 15th:</p> <ul style="list-style-type: none"> <li>• Scarlet runner beans</li> <li>• Celery, celeriac</li> <li>• Onion sets, leeks</li> </ul>	<ul style="list-style-type: none"> <li>• Parsley, cilantro</li> <li>• Cabbage, broccoli, cauliflower, kale, kohlrabi, greens</li> <li>• Lettuce</li> <li>• Leeks, onion sets</li> <li>• Tomatoes, peppers, eggplants</li> <li>• Summer squash, winter squash, cucumbers</li> </ul> <p>After 15th:</p> <ul style="list-style-type: none"> <li>• Tomatillos</li> <li>• Basil</li> </ul>	<p>After 15th:</p> <ul style="list-style-type: none"> <li>• Parsley, cilantro</li> <li>• Cabbage, broccoli, cauliflower, kale</li> <li>• Lettuce</li> <li>• Leeks, onion sets</li> </ul>	<p>After 15th:</p> <ul style="list-style-type: none"> <li>• Bush beans</li> <li>• Tomatoes (T)</li> <li>• Squash (T)</li> <li>• Basil (T)</li> </ul>

(T) = transplant. (?) = success is questionable but worth a try in a pinch.

Month	Sow seed directly outdoors	Start in flats indoors or with protection (cold frame or greenhouse)	Transplant from protected flats to an outdoor garden	Plant outdoors with the use of season extenders (greenhouse, cold frame, cloche, or row cover)
May	<ul style="list-style-type: none"> <li>• Peas</li> <li>• Carrots, parsley, cilantro, parsnips, dill</li> <li>• Cabbage, broccoli, cauliflower, kale, kohlrabi, turnips, Brussels sprouts, radishes</li> <li>• Beets, spinach (summer), chard, orach, quinoa, New Zealand Spinach</li> <li>• Lettuce, burdock</li> <li>• Scallions</li> <li>• Potatoes</li> <li>• Corn</li> </ul> <p>After 15th:</p> <ul style="list-style-type: none"> <li>• Snap beans, dry beans</li> <li>• Summer and winter squash</li> <li>• Corn (early), grain amaranth</li> <li>• Mint-family herbs</li> </ul>	<ul style="list-style-type: none"> <li>• Parsley, cilantro</li> <li>• Cabbage, broccoli, cauliflower, kale, kohlrabi, greens</li> <li>• Lettuce</li> <li>• Leeks</li> <li>• Summer squash</li> </ul>	<ul style="list-style-type: none"> <li>• Parsley, cilantro, celery, celeriac</li> <li>• Broccoli, kale</li> <li>• Lettuce</li> <li>• Leeks, onion sets</li> <li>• Tomatoes</li> <li>• Summer squash, winter squash, cucumbers</li> </ul>	<p>After 15th:</p> <ul style="list-style-type: none"> <li>• Tomatoes, tomatillos</li> <li>• Peppers and eggplants (T)</li> <li>• Summer squash, cucumbers (T)</li> <li>• Seed cucurbits and mint-family herbs</li> <li>• Basil (T)</li> </ul>

(T) = transplant. (?) = success is questionable but worth a try in a pinch.

Month	Sow seed directly outdoors	Start in flats indoors or with protection (cold frame or greenhouse)	Transplant from protected flats to an outdoor garden	Plant outdoors with the use of season extenders (greenhouse, cold frame, cloche, or row cover)
June	<ul style="list-style-type: none"> <li>• Peas, snap and dry beans</li> <li>• Carrots, parsley, cilantro, parsnips, dill</li> <li>• Cabbage, broccoli, cauliflower, kale, kohlrabi, turnips, radishes, greens, rutabagas</li> <li>• Beets, spinach (summer), chard</li> <li>• Lettuce, endive, radicchios</li> <li>• Scallions</li> <li>• Cucumbers, summer squash</li> <li>• Corn</li> </ul>	<ul style="list-style-type: none"> <li>• Parsley, cilantro</li> <li>• Cabbage, broccoli, cauliflower, kale, kohlrabi, greens</li> <li>• Lettuce</li> <li>• Leeks</li> </ul>	<ul style="list-style-type: none"> <li>• Parsley, cilantro</li> <li>• Broccoli, kale</li> <li>• Lettuce</li> <li>• Leeks, onion sets</li> <li>• Tomatoes, peppers, eggplants</li> <li>• Summer squash, winter squash, cucumbers</li> </ul> <p>After 15th:</p> <ul style="list-style-type: none"> <li>• Peppers and eggplants</li> </ul>	

(T) = transplant. (?) = success is questionable but worth a try in a pinch.

Month	Sow seed directly outdoors	Start in flats indoors or with protection (cold frame or greenhouse)	Transplant from protected flats to an outdoor garden	Plant outdoors with the use of season extenders (greenhouse, cold frame, cloche, or row cover)
July	<ul style="list-style-type: none"> <li>• Snap beans</li> <li>• Carrots, parsley, cilantro, parsnips</li> <li>• Cabbage, broccoli, cauliflower, kale, kohlrabi, turnips, radishes, greens</li> <li>• Beets, spinach (summer), chard</li> <li>• Scallions</li> <li>• Lettuce</li> </ul> <p>Before 15th:</p> <ul style="list-style-type: none"> <li>• Beets, parsnips, carrots, bush and snap beans, scallions</li> </ul> <p>After 15th:</p> <ul style="list-style-type: none"> <li>• Rutabagas, kale, winter beets, spinach, overwintering cole crops</li> </ul>	<ul style="list-style-type: none"> <li>• Cilantro</li> <li>• Cabbage, broccoli, cauliflower, kale, kohlrabi, greens</li> <li>• Lettuce</li> <li>• Leeks</li> </ul>	<ul style="list-style-type: none"> <li>• Parsley, cilantro</li> <li>• Cabbage, broccoli, cauliflower, kale, kohlrabi, greens</li> <li>• Lettuce</li> <li>• Leeks</li> </ul> <p>Before 15th:</p> <ul style="list-style-type: none"> <li>• Summer squash, cucumbers</li> </ul>	<ul style="list-style-type: none"> <li>• Summer squash, tomatoes, cucumbers for late harvest</li> </ul>
August	<ul style="list-style-type: none"> <li>• Cilantro</li> <li>• Spinach, chard</li> <li>• Greens, radishes</li> <li>• Lettuce, endive, escarole</li> </ul> <p>Before 15th:</p> <ul style="list-style-type: none"> <li>• Overwintering cole crops, lettuce, parsley, cilantro</li> </ul> <p>After 15th:</p> <ul style="list-style-type: none"> <li>• Bulb onions</li> </ul>	<p>For season extension:</p> <ul style="list-style-type: none"> <li>• Parsley, cilantro</li> <li>• Kale, greens</li> <li>• Lettuce</li> </ul>	<ul style="list-style-type: none"> <li>• Parsley, cilantro</li> <li>• Cabbage, broccoli, cauliflower, kale, kohlrabi, greens</li> <li>• Lettuce, endive, escarole, radicchios</li> </ul>	

(T) = transplant. (?) = success is questionable but worth a try in a pinch.



Month	Sow seed directly outdoors	Start in flats indoors or with protection (cold frame or greenhouse)	Transplant from protected flats to an outdoor garden	Plant outdoors with the use of season extenders (greenhouse, cold frame, cloche, or row cover)
September	<ul style="list-style-type: none"> <li>• Peas, fava beans</li> <li>• Cilantro</li> <li>• Spinach</li> <li>• Greens</li> <li>• Endive</li> <li>• Mache (sometimes called corn salad or lamb's lettuce)</li> <li>• Garlic, shallot</li> <li>• Cover crops (oats, rye, vetch)</li> </ul>			<ul style="list-style-type: none"> <li>• Parsley, cilantro</li> <li>• Spinach</li> <li>• Kale, greens</li> <li>• Lettuce, endive</li> </ul>
October	<ul style="list-style-type: none"> <li>• Fava beans and cover crops</li> <li>• Garlic</li> </ul>			<ul style="list-style-type: none"> <li>• Parsley, cilantro</li> <li>• Spinach</li> <li>• Kale, greens</li> <li>• Lettuce, endive</li> </ul>
November	<ul style="list-style-type: none"> <li>• Fava beans and cover crops (?)</li> <li>• Garlic (?)</li> </ul> <p>If needed, apply lime to raise pH (5 lb/100 ft<sup>2</sup>).</p>			
December				

(T) = transplant. (?) = success is questionable but worth a try in a pinch.

## Appendix D

The vegetable varieties listed below perform well in Oregon gardens. This list is organized by crop, and varieties are grouped as follows:

- **SPRING:** Plant in spring and harvest before students leave.
- **SPRING–FALL:** Plant in spring and harvest in fall when students return (as long as crops are watered and tended throughout summer).
- **FALL:** Plant in late summer and harvest in fall before seasonal frosts.

### Cool-Season Crops

#### Carrots

Carrots are a hardy, cool-season crop that can be direct-seeded in spring as soon as the garden soil can be worked. The optimal soil temperature for seed germination is between 55°F and 75°F. Carrots grow best with regular, uniform watering from germination through harvest.

**SPRING.** If you plant seeds early enough, you can harvest baby carrots before the school year ends.

- Scarlet Nantes, Mokum, Sugarsnax 54, Nelson, Kuroda, Sweetness III, Napoli, Yaya
- (white) White Satin
- (round, baby) Minicore, Parmex, Thumbelina

**SPRING–FALL.** If you provide regular water in summer (i.e., enough to moisten the soil to a depth of at least 6 inches), you can harvest these carrots in fall when students return.

- Red Core Chantenay, Danvers, Interceptor

#### Leaf lettuce

Lettuce varieties can be loosely grouped into four categories: crisphead, butterhead, leaf, and romaine. Leaf lettuce has an open growth form and does not form a head. It matures quickly and is easy to grow.

Plant in **SPRING** and again in **FALL** from seeds or transplants.

- (red leaf) Prizehead, Red Sails, Redina, New Red Fire, Merlot, Red Tide
- (green leaf) Salad Bowl, Grand Rapids, Slobolt, Pom Pom, Green Star
- (oak leaf) Oaky Red Splash, Cocarde, Mascara, Ferrari, Jamai, Cobham, Red Oak, Malawi

#### Peas

Peas can be direct-seeded as soon as soil temperatures are consistently above 40°F. When planted in soil that is 55°F to 65°F, pea shoots may emerge from the soil in as little as 7 to 10 days.

Plant in **SPRING** as soon as the garden soil can be worked.

- (shelling pea) Oregon Pioneer
- (snap pea, bush) Sugar Sprint, Sugar Ann

#### Radishes

Radishes are easy to grow and ready to harvest in as little as 4 weeks. To ensure an ongoing harvest, plant radishes every 1 to 2 weeks until warm weather arrives.

Plant in **SPRING** and again in **FALL**, if desired.

- (red) Fuego, Comet, French Breakfast, Cherry Belle, Champion
- (white) Burpee White, White Icicle

#### Spinach

Spinach comes in smooth, semi-savoy, and savoy varieties. The slightly curly leaves of semi-savoy and crinkly leaves of savoy varieties require extra attention when washing to ensure that garden soil and debris are completely removed.

Plant as seeds or transplants in **SPRING**. Harvest early for baby spinach.

- (smooth leaf) Bordeaux, 7 Green, Lombardia
- (semi-savoy) Tye

## Warm-Season Crops

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### Beans

Beans can be grown for immature pods (snap beans), immature seeds (shell beans), or mature seeds (dry beans). Plant seeds when the soil warms in summer; germination rates are poor when seeds are planted in soil below 60°F. Pole beans require vertical supports of up to 8 feet. However, pole beans yield two to three times more than bush beans in the same amount of ground space.

**FALL.** Beans planted in spring won't be ready for harvest before students leave. Beans planted in July will be ready to harvest as snap beans or shell beans in late September. Most varieties will work, except soybeans and lima beans.

- (green bush) Tendercrop, Venture, Slenderette, Oregon 91G, Oregon Trail, Provider, Jade, Oregon 54
  - (flat Italian) Roma II
  - (French filet) Nickel, Straight 'N' Narrow
  - (green pole) Blue Lake, Kentucky Wonder, Romano, Cascade Giant, Kentucky Blue, Oregon Giant
  - (wax bush) Goldenrod, Goldrush, Indy Gold, Slenderwax
- 

### Potatoes

Early season varieties can be planted as early as March or April. However, planting too early in damp, cold soil promotes rot. Plant potatoes from seed potatoes; cut larger seed potatoes into pieces with 2 to 3 "eyes."

**SPRING.** If soil conditions allow you to plant early in the season, you may be able to harvest new potatoes in 7 to 8 weeks.

- (red) Norland, Cranberry Red
- (white) Superior
- (yellow) Yukon Gold

**SPRING–FALL.** You can plant potatoes in spring and harvest them as full-size potatoes in fall when students return. However, this requires watering and weeding throughout summer. Potatoes are ready to harvest when plant stems and leaves naturally turn yellow.

- (yellow) Bintje
  - (purple) All Blue
  - (fingerling) French Fingerling
- 

### Summer squash

Summer squash produces many fruit and can be a great addition to an educational garden.

**SPRING–FALL.** Temperatures in most areas of Oregon aren't suitable for planting summer squash until at least mid-May. This crop requires regular watering and harvests during summer to keep plants producing into fall.

- (yellow) Early Prolific Straightneck, Multipik, Supersett, Fancycrook, Sunray, Yellow Crookneck, Goldbar, Gentry
  - (green zucchini) Ambassador, Seneca, Elite, Tigress, Aristocrat, Raven, Cashflow, Noche, Geode (round), Floridor (round)
  - (yellow zucchini) Gold Rush, Butterstick
  - (scallop) Sunburst
- 

### Tomatoes

Determinate tomatoes, sometimes called bush tomatoes, are a good choice for educational gardens. They are bred to grow in compact spaces, can be harvested early or in cool conditions, and don't require pruning. They produce all of their fruit in a 2- to 3-week period and then die. Indeterminate tomatoes, also called vining tomatoes, flower and fruit throughout the growing season. Pick ripe fruit often to keep these plants productive. Most heirloom tomato varieties are indeterminate.

You can sow seeds indoors or in a greenhouse 6 to 8 weeks before transplanting seedlings outside. Don't rush to transplant; wait until nighttime temperatures are consistently above 50°F. Use row covers, cloches, or other protection to keep plants warm in the early season, and remove these when temperatures warm to 85°F.

**SPRING–FALL.** Tomatoes can be planted in spring before students leave and harvested in fall when they return. However, this requires watering, weeding, and harvesting ripe tomatoes (particularly for indeterminate varieties) throughout summer.

- (very early) Oregon Eleven
- (early) Early Girl, Oregon Spring, Santiam, Oregon Pride, Oregon Star, Siletz, Legend
- (medium) Willamette, Pik Red, Celebrity, Sunleaper, Mountain Spring, Medford, First Lady II, Big Beef
- (late) Big Boy, Better Boy, Fantastic, BHN 444
- (cherry type) Sweet Million, Sun Gold
- (yellow) Jubilee
- (paste) Oroma, Saucy, Halley 3155, Viva Italia, Super Marzano, Macero II, Health Kick
- (heirloom) Brandywine (Sudduth's Strain or potato leaf strain), Seattle's Best of All

## General References and Resources

- Elliott, C., and R. Peterson. 2000. *Maritime Northwest Garden Guide*. Seattle, WA: Seattle Tilth.
- Ellis, B.W. 2008. *The Veggie Gardener's Answer Book*. North Adams, MA: Storey Publishing.
- McGee, R.M.N., and J. Stuckey. 2002. *The Bountiful Container*. New York, NY: Workman Publishing.

- Solomon, S. 2000. *Growing Vegetables West of the Cascades*. Seattle, WA: Sasquatch Books.
- Fall and Winter Vegetable Gardening (King County, Washington, Community Horticulture Fact Sheet #41): [http://king.wsu.edu/Gardening/documents/41FallandWinterVegetableGardening\\_000.pdf](http://king.wsu.edu/Gardening/documents/41FallandWinterVegetableGardening_000.pdf)

## OSU Extension References and Resources

The OSU Extension Service publishes many garden-related materials that educators may find useful. Many publications are available online. Visit the OSU Extension Publications and Multimedia catalog: <http://extension.oregonstate.edu/catalog>. Browse by topic, or search for the publication numbers listed here.

### General

- Fertilizing Your Garden: Vegetables, Fruits, and Ornamentals* (EC 1503)
- How to Build Your Own Raised-Bed Cloche* (EC 1627)
- Sustainable Gardening, The Oregon-Washington Master Gardener Handbook* (EM 8742)
- Growing Your Own* (EM 9027)
- Propagating Plants from Seed* (PNW 170)

### Vegetables

- Vegetable Gardening in Oregon* (EC 871)
- Short-Season Vegetable Gardening* (PNW 497)
- Fall and Winter Vegetable Gardening in the Pacific Northwest* (PNW 548)

### Small Fruit

- Growing Blackberries in Your Home Garden* (EC 1303)
- Growing Blueberries in Your Home Garden* (EC 1304)
- Growing Raspberries in Your Home Garden* (EC 1306)
- Growing Strawberries in Your Home Garden* (EC 1307)
- Blueberry Cultivars for Oregon* (EC 1308)
- Raspberry Cultivars for Oregon* (EC 1310)
- Blackberry Cultivars for Oregon* (EC 1617)
- Strawberry Cultivars for Oregon* (EC 1618)
- Selecting Berry Crop Varieties for Central Oregon* (EC 1621)
- Growing Table Grapes* (EC 1639)
- Growing Kiwifruit* (PNW 507)

### Tree Fruit

- Growing Tree Fruits and Nuts in the Home Orchard* (EC 819)
- Pruning to Restore an Old, Neglected Apple Tree* (EC 1005)
- Selecting Fruit Tree Varieties for Central Oregon Landscaping and Home Orchards* (EC 1622)
- Picking and Storing Apples and Pears* (FS 147)
- Training and Pruning Your Home Orchard* (PNW 400)

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