CHAPTER **TWENTY**

PRINCIPLES OF VEGETABLE CULTURE

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20 PRINCIPLES OF **VEGETABLE** CULTURE

Learning Objectives

- Learn the principles of planning a vegetable garden through a series of questions to help determine the needs of a gardener
- Learn how to choose the best varieties and to place and rotate crops
- Learn about the different vegetable production systems and garden designs
- Learn the techniques of buying, saving, and storing vegetable seeds
- Learn the basics of garden soil preparation, including soil testing, adding organic matter, fertilizing, and tillage
- Learn how to start and care for your own transplants and how to correctly plant them in the garden
- Learn the fundamentals of caring for your garden, including irrigation, weed, pest, and disease control

Introduction

Few things in life are more rewarding than savoring a meal of homegrown vegetables. Vegetable gardening can be enormously satisfying. However, there can be no argument that it also is complex and fraught with problems, requires hard work, and involves many personal decisions.

The most successful vegetable gardeners understand basic concepts of botany, plant growth and development, plant health, irrigation, soil fertility, and pest and disease control. Many of these principles are covered elsewhere in the *Idaho Master Gardener Handbook*. Detailed information about specific vegetable crops is found in the next chapter. Many good books about vegetable gardening are also available.

Planning the Garden

For some gardeners, planning a garden is an interesting and satisfying activity. If this is you, have fun with the process and take all the time you want. Get out the gardening books during the deep, dark months of winter, explore options for new crops and varieties, make a graph-paper map, and dream about summer harvests.

For others, planning seems to get in the way of accomplishment. If this describes you, cut the planning to a bare minimum and get on with buying seed. However, some planning is essential to success in vegetable gardening.

Planning can be broken into two phases: garden design and annual planning.

GARDEN DESIGN

Some decisions need to be made early in the planning process. A good approach is to take a few minutes to answer some fundamental questions. Here are a few (but surely not all) of the questions to consider.

How Much Time Do I Have for Vegetable Gardening?

This question may seem trivial, but it will affect everything else you do. Planting a garden and discovering you lack the time and resources to care for it properly leads to frustration. If you have only a few minutes a day to dedicate to gardening, plan a small garden that contains two or three of your favorite vegetables. You may opt to grow plants on your porch in pots or containers. At the other extreme, if you have plenty of time and energy, the garden can be more extravagant and include hobby activities such as testing unique varieties or growing unusual or marginally adapted crops. Or, if gardening is a life-sustaining activity, the scale of production may be quite large and your plans should be based on food-storage potential.

What Do I Like to Eat?

Plan to produce only crops that you and your family like and will prepare and consume. It's a waste of time and resources to grow produce that serves only as compost. Determine which vegetables you will consume fresh and which will be preserved and stored. Consider making room to experiment with small amounts of new crops or varieties. Over time, you may find a new favorite.

How Much Room Do I Have for Vegetable Gardening?

Sometimes the limitations for producing vegetables have less to do with time than with space. In this case, prioritize your goals and fit in only those crops you consider most valuable (your favorites). Plant crops that produce large quantities in limited space, such as tomatoes or cucumbers. Crops such as corn and squash require a lot of space; place them lower on the priority list.

Where Should I Locate My Garden?

This can be a difficult question to answer, as it is influenced by personal preference, impact on the appearance of the landscape, plant needs, and occasionally property ordinances. Public visibility creates a need for more intense design and maintenance. Selecting a warm microclimate, e.g., next to a south-facing fence or wall, may make it possible to grow crops, such as melons, that are otherwise marginally adapted.

Regardless of all other considerations, one requirement must always be met: sunlight. Almost all vegetable crops require full sunlight to grow and produce properly. Many books say that a vegetable garden should get at least six hours of sunlight per day. The origin of this recommendation is unknown, but it probably did not come from an experienced gardener. To maximize production and quality, a garden needs all-day sun, with the possible exception of an hour or two of shade at dawn and dusk; the more sunlight, the better.

Property features can place extreme limitations on garden placement. If options are available, here are a few tips to consider:

- Avoid placing the garden in a low swale, at the base of a hill, or at the foot of a slope bordered by a solid fence. Frost settles in these places because cold air naturally drains toward the lowest spot in the yard.
- Avoid windy locations (hard to do in Idaho!). If you must plant in a windy spot, build or plant a windbreak.
- Avoid planting near trees and shrubs that will compete for sunlight, nutrients, and water. Stay 10–20 feet outside of tree drip lines (an imaginary line on the ground at the edge of the tree canopy), if possible (Figure 1).
- Choose a spot near your home so it is convenient to work in the garden when you have a few minutes.
- Locate the garden near a good and easily accessible supply of water.
- Avoid contaminated areas. Water runoff from roads, sidewalks, or driveways can contaminate

the soil with salt, herbicides, or soil sterilants. Do not plant near chemical manufacturing or storage facilities without investigating safety issues. Sites where lead-painted buildings once stood may contain toxic amounts of soil lead. If you are unsure about your chosen location, check the lead (and other heavy metals) content by having the soil or leafy vegetable tissue analyzed.

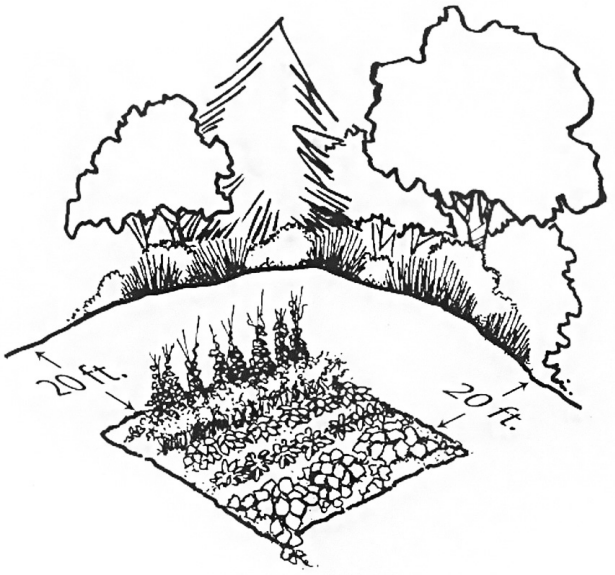

Figure 1. Locate vegetable gardens in full sun and at least 20 feet from the drip line of trees and shrubs to avoid competing roots.

What Type of Vegetable Production System Should I Use?

There are as many ways to lay out a vegetable garden as there are gardeners (Figure 2). Many people use some form of the traditional victory garden (straight, wide rows). Others use small beds, raised beds, trellis and stake systems, or containers. Part of this decision is based on garden size. Large gardens are usually best planted in rows so that tillers and other equipment can reduce the need for hand labor. Small gardens usually work best when laid out as intensively managed beds in order to maximize production in a limited space. Intensive production systems can also reduce the amount of work needed for weed and pest control. Common production systems are described later in this chapter.

Where Should I Place Perennial Beds?

Consider this question early in the design process. Some vegetables, such as asparagus, rhubarb, chives, and many herbs, are perennial; they regrow each spring and are a permanent part of the garden. Locate these crops where they will not interfere with annual garden operations. Perennials are typically grouped along one side or in one corner of the garden. Another technique is to use them as landscape features outside of the annually managed portion of the garden.

Figure 2. Productive vegetable garden designs range from the traditional open rows of a "victory garden" to space-saving containers.

ANNUAL PLANNING

Determination of gardening objectives, garden size, and production system needs to be done only once, although you probably will modify your plan in subsequent years. Good gardeners are never happy with the status quo. However, some planning must be done every year in order to maximize crop yield and quality.

Choose the Best Vegetable Varieties

Varieties differ not only in appearance and flavor, but also in earliness, adaptation, and many other characteristics that influence growth in a specific climate. In the short-season climates typical of much of Idaho, choosing the right varieties is critical to success. Information provided on seed packets, such as days to harvest and general descriptions of best production conditions, are typically inadequate for determining suitability, given Idaho's propensity for frost, cool nights, intense sunshine, low humidity, and/or alkaline soils. Obtain information about the best varieties from experienced gardeners, Master Gardener volunteers, local nurserymen, and county educators.

Place and Rotate the Crops

Deciding where to plant individual crops each year can be frustrating. However, these decisions are critical. Crop rotation, the practice of changing the location of crops to avoid disease and nutritional problems, is a sound agricultural principle. Many vegetable crops become weak and unproductive if they are planted in the same place every year.

You can simplify these decisions by taking the time to group plants into blocks based on genetic relatedness and growth habit. Plants in the same family often have the same needs and problems.

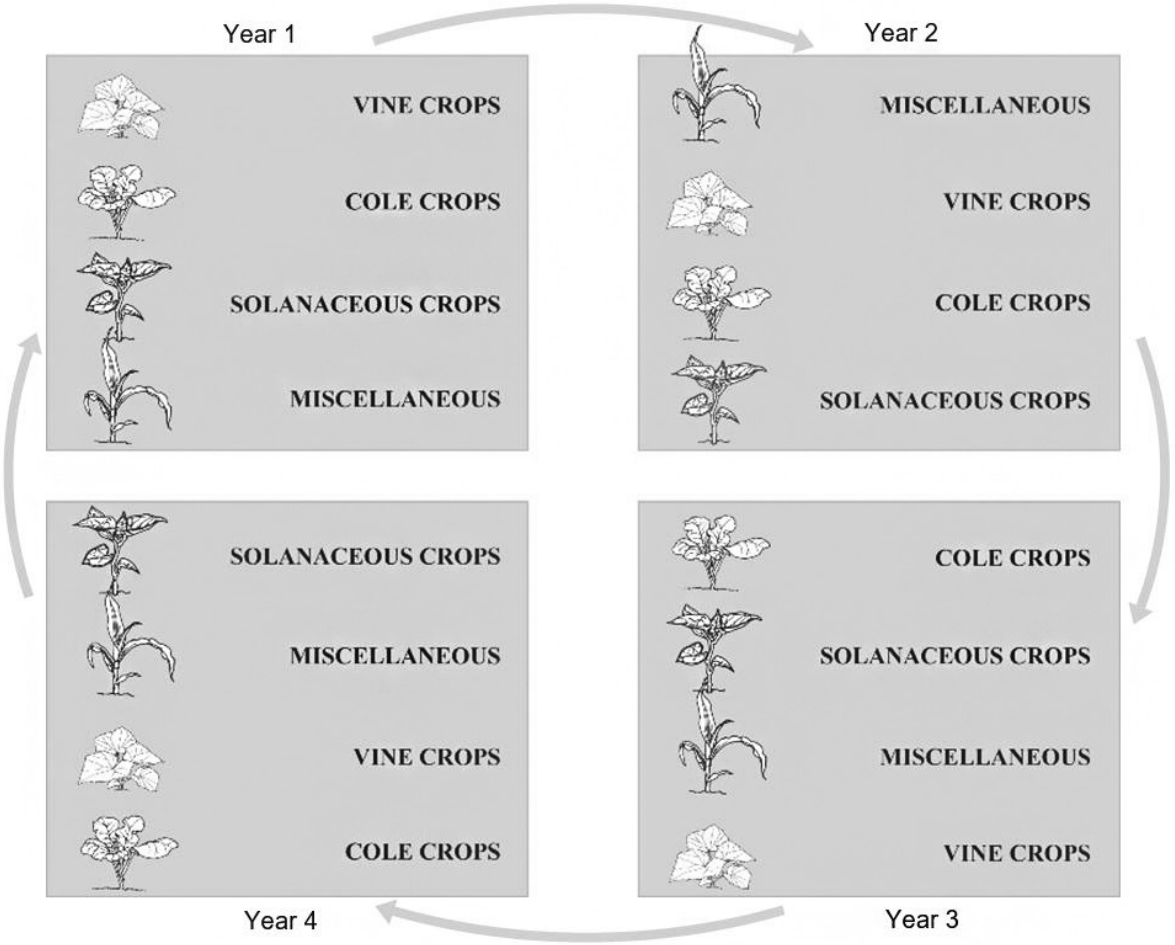

Figure 3. Example of crop rotation by grouping crops with similar growing requirements. Each shadowed square represents the garden in a given year. Categories within the squares represent crop groups that are rotated within the garden space. Cole crops include broccoli, cauliflower, cabbage, brussels sprouts, and all of the kales and mustards. Vine crops include melons, cucumbers, squash, and pumpkins. Solanaceous crops include tomatoes, potatoes, peppers, and eggplant.

Each year, keep the crops in their established blocks and simply rotate the blocks through the available space (Figure 3). If done properly, each block of similar plants should end up in the same plot of soil once every 3–5 years.

Rotation to prevent disease problems is more important for some crops than others. It is critical for the solanaceous crops (potatoes, tomatoes, peppers, eggplants, etc.), cucurbits (cucumbers, melons, squash, pumpkins, etc.), and cole crops (cabbage, broccoli, cauliflower, brussels sprouts, etc.).

Take into account plant height, spread, and growth habit. Don't plant tall or aggressive plants where they will overgrow or shade smaller plants.

Vegetable Production Systems

Vegetable gardening systems fall into two major categories: (1) low-intensity victory gardens planted in wide rows or hills and (2) intensive gardening systems planted in beds or containers. Victory garden layouts are best used in large gardens (more than 500 square feet) where simplicity of operations and use of motorized equipment is required. If space and/or time is limited, intensive garden designs are best. The production systems described here are only a sampling of the possibilities, but the concepts apply to most garden systems.

VICTORY GARDEN DESIGNS

The term *victory garden* originated during World War II and was used to describe a vegetable gardening system consisting of wide, straight rows running the length of a garden (Figure 4). It is the simplest design for a vegetable garden and the best method when large amounts of produce are needed for preservation, storage, or local sale. Any vegetable can be produced in a victory garden arrangement, but it is especially good for crops needed in large quantities, such as corn, peas, beans, potatoes, and broccoli.

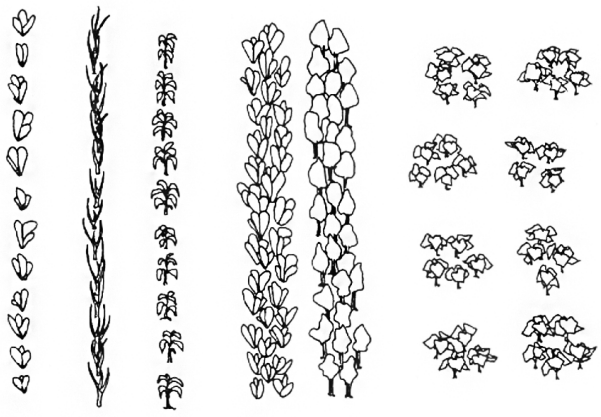

Figure 4. Possible row arrangements within a standard victory garden design.

There are many adaptations to the single-row planting design typical of the victory garden. The following are some common planting arrangements:

- **Row planting**. This arrangement consists of long, straight rows, usually 2 or more feet apart, with a single line of plants in each row (Figure 4, left). A string stretched between stakes or homemade row markers can provide a guide for straight rows. Use a hoe handle, a furrow hoe, or a grub hoe to make a furrow of the appropriate depth. Space the seed uniformly and at a distance suitable for the crop.
- **Broadcast row planting**. In the victory garden, broadcast planting usually involves placing seed in rows arranged as wide bands rather than single-wide plants (Figure 4, center). Many crops, especially root crops such as carrots, radishes, and beets, produce higher-quality vegetables when planted this way. Sow seed evenly across the planting band and rake it in. Lightly cover and press the soil over the seeds.
- **Hill planting**. Larger vegetables, such as melons, squash, corn, and cucumbers, may be planted in hills (Figure 4, right). The hills can be arranged in extra-wide rows to facilitate cultivation. Distance between hills is based on recommendations for individual crops. Mound soil a few inches high and a foot or so in diameter and plant in the center of the mound. Plant four to six seeds per hill, firming the soil well.

INTENSIVE GARDEN DESIGNS

Intensive garden designs require considerable effort to plan and install, but are relatively easy to maintain. Plans should include dimensions, construction materials, soil media, variety choice, and plant arrangement. Proven intensive garden designs include raised beds, vertical gardens, and container gardens. When combined with production techniques such as interplanting, succession planting, relay planting, and edible landscaping, these garden designs maximize the use of limited space.

Raised Beds

The typical "raised bed" garden consists of defined borders of wood or masonry filled with heavily amended soil to a level above the surrounding ground (Figure 5). Raising the bed above ground level accomplishes two very important things: it improves drainage and it allows the soil to warm up faster in the spring. Both factors can improve plant growth and production potential.

The actual garden design and the selection of border materials are personal choices. Typical beds are raised 6–8 inches, but they may be as much as 3 feet above grade. Borders may be permanent structures (made from concrete or other immovable materials) or temporary. Wood landscape timbers are a common choice. Redwood or cedar timbers will minimize deterioration due to constant exposure to moisture. Pressure-treated landscape timbers are commonly available. There is no evidence that the new generation of treated timbers are toxic or harmful to plants or consumers, but older timbers or railroad ties were commonly treated with creosote or pentachlorophenol (penta), both toxic to plants and people. If unsure, you may want to use only untreated wood.

There are no standard dimensions for raised bed gardens. Typically they are narrow enough to allow the gardener to reach to the center of the bed without stepping on the soil. The length is usually a function of the location; beds may be only a few feet long or stretch across the yard.

Soil preparation is an important aspect of raised bed gardening. The final soil mix commonly consists of one part native soil and one part compost or aged organic matter. Many other choices for soil components exist; for example, manure, peat, sand, vermiculite, or perlite may be added in various quantities. The simplest method for preparing the soil is to remove the top 12 inches of soil from the completed bed, place it in a pile, mix the pile with an equal amount of organic matter, and shovel the mixture back into the bed. At this point, the bed will be ready for plants.

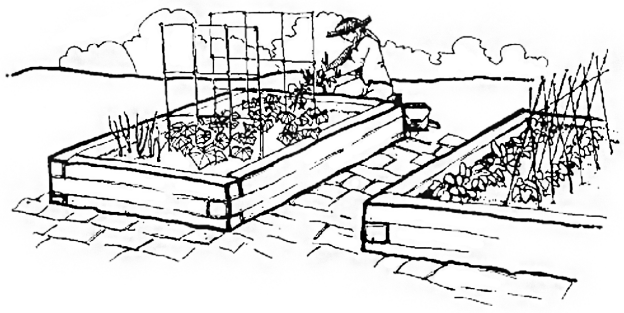

Figure 5. Example of a raised bed intensive-gardening system.

Plant arrangement should optimize the use of the limited space. Give each plant a square space large enough for it to grow properly. The goal is to space plants equidistant from one another on all sides so that, at maturity, plant leaves touch or slightly overlap. Spacing recommendations for raised beds are summarized in Table 1. The use of dwarf or bush-type varieties will minimize space needed for many crops, such as beans, cucumbers, tomatoes, and squash.

Table 1. Plant-spacing guide for raised bed or other intensive vegetable garden designs.

Plant	Spacing[a] (inches)	Plant	Spacing[a] (inches)
Asparagus	15–18	Leeks	3–6
Beans, bush	4–6	Lettuce, head	10–12
Beans, lima	4–6	Lettuce, leaf	4–6
Beans, pole	6–12	Melons	18–24
Beets	2–4	Mustard	6–9
Broccoli	12–18	Okra	12–18
Brussels sprouts	15–18	Onions	2–4
Cabbage	15–18	Peas	2–4
Cauliflower	15–18	Peppers	12–15
Chard, Swiss	6–9	Rutabaga	4–6
Chinese cabbage	10–12	Pumpkins	12–36
Collards	12–15	Spinach	4–6
Cucumbers	12–18	Radishes	2–3
Eggplants	18–24	Squash, summer	18–24
Endive	15–18	Squash, winter	24–36
Kale	15–18	Tomatoes	18–24
Kohlrabi	6–9	Turnips	4–6

Note: To determine spacing for interplanting, add the inches for the two crops to be planted together, and divide the sum by two. For example, if radishes are planted next to beans: 2 inches + 4 inches = 6 inches. Then, 6 inches ÷ 2 = 3 inches. Plant the radishes 3 inches from the beans.

The use of miniature varieties or vertical gardening techniques may allow closer spacing and increase the square-foot productivity.

[a] Arrange plants in square grid patterns. The indicated spacing is the distance to other plants in all directions. These recommendations for intensive gardening typically are for slightly closer spacing than the spacings suggested in the next chapter, which are based on recommendations for a traditional victory garden.

Vertical Gardening

The use of trellises, nets, strings, cages, or poles to hold plants upright and limit horizontal spread constitutes vertical gardening (Figure 6). Vining and sprawling plants, such as cucumbers, tomatoes, melons, and pole beans, are obvious candidates for this type of gardening. Tomatoes, for example, require about 10 square feet per plant when unstaked, but can be grown in 1 square foot of space if supported and trained upward. Vertical gardening can be used in victory gardens, raised beds, containers, or by itself.

Supports for plants can be simple or extravagant. They can take advantage of existing structures, such as buildings or fences, or can stand alone. The height of the support depends on the crop. Shorter plants, such as tomatoes, cucumbers, and pole beans, grow to a height of 5–6 feet. Squash may need 15–20 feet of vertical space or a structure that will allow some horizontal growth at the top (e.g., a high tunnel). In Korea, gardeners plant squash and other vine crops next to the walls of buildings, allowing them to climb a trellis and eventually set fruit on the roof.

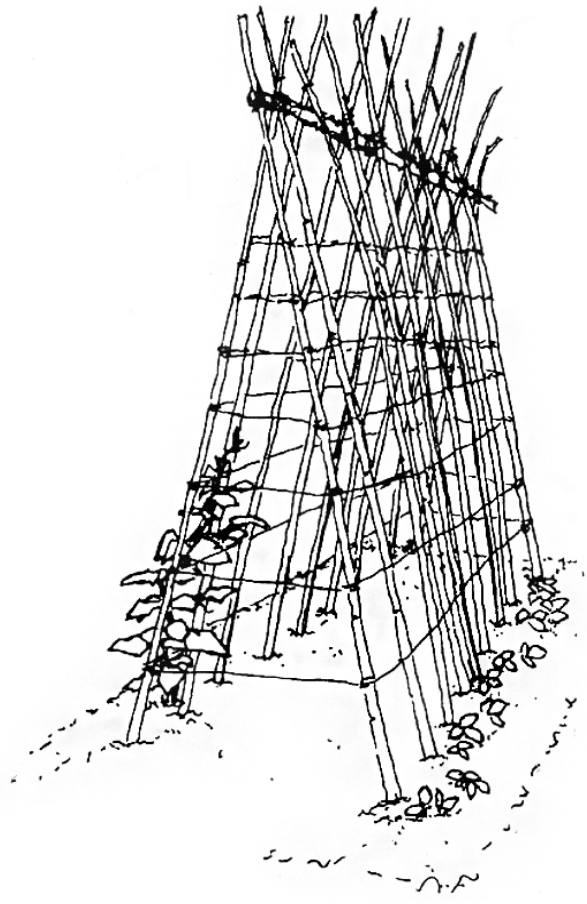

Figure 6. Example of a structure used for vertical vegetable gardening.

Vertical gardening saves considerable space but is labor-intensive. Staking, tying, pruning, and training new growth upward takes time. Most plants do not climb naturally, so simply planting next to a vertical structure will not necessarily convince plants to reach skyward.

Because vertically growing plants are more exposed, they dry out faster and may need to be watered more frequently than those allowed to spread over the ground. A vertical planting will cast a shadow, so be sure to locate the structures where they will not shade nonvertical parts of the garden.

Container Gardening

If you don't have yard space for a vegetable garden or if your garden is too small to produce everything you want, consider raising vegetables in containers (Figure 7). A windowsill, patio, balcony, or doorstep can provide sufficient space for a productive container garden. Container gardens can also make gardening simpler by reducing problems with weeds and many other pests.

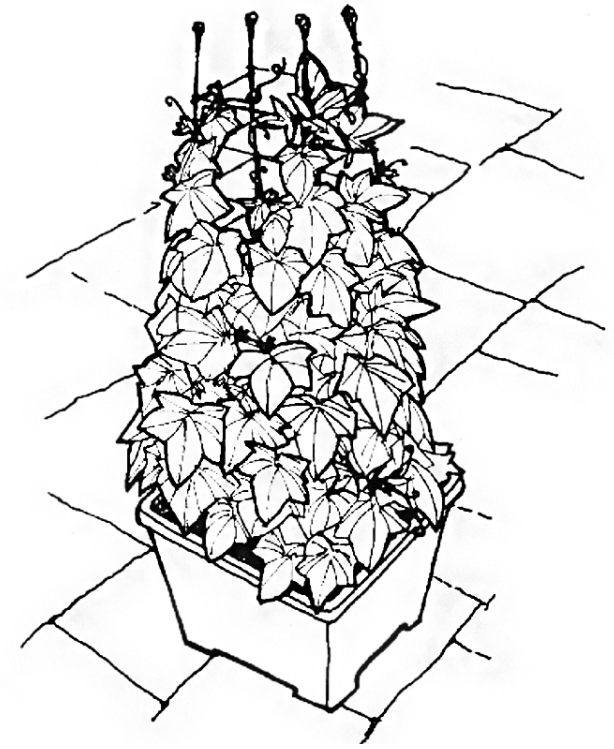

Figure 7. The ultimate in intensive vegetable gardening is container gardening. Tomatoes, peppers, cucumbers, and many other crops can be grown in containers.

Gardening in containers requires more attention to detail than any other gardening method. The plants have only a small amount of soil for root growth, meaning that water and nutrients are limited. Also, the plants are subject to heat and other stresses. As a result, care requirements are more stringent than in a traditional garden. In addition to the general vegetable gardening techniques discussed later in this chapter, the following considerations apply specifically to container gardens.

Choosing containers. Containers can be made of clay, wood, plastic, or metal. They can be purchased or homemade. It's best to use new containers to ensure that they are free from contamination (e.g., herbicide residue). The most important considerations are size, mobility, and drainage.

Selecting the proper container size is a balance between supplying adequate soil volume and making sure containers can be moved in case of inclement weather or for winter storage. Table 2 provides recommendations for minimum pot sizes for several common vegetable crops, as well as other information needed to make good container production decisions. Container depth is important because most plants need at least 6–8 inches of soil for proper rooting.

Wooden barrels make excellent vegetable pots. Wooden planting boxes also work well and can be purchased or constructed to preferred dimensions. Choose redwood or cedar, which resist breakdown and rot. Wood for container construction should not be treated with creosote (used to preserve railroad ties) or pentachlorophenol (penta) wood preservatives. These preservatives may be toxic to plants and harmful to people. Other options for homemade containers include vertical planters made out of wood lattice lined with black plastic or welded wire shaped into cylinders.

Regardless of whether you purchase or construct a container, be sure there are holes in the bottom of adequate size and number to allow drainage of excess water.

Choosing soil media. Native garden soil by itself does not make good potting soil because it does not provide adequate drainage or air exchange. The best soil media, ironically, are called "soilless mixes." These mixes usually are porous combinations of peat moss, perlite, and sand. Some contain wood chips or bark. Packaged potting soil (available at local garden centers) is relatively lightweight and makes a good container medium. It's much cheaper to make your own soilless mix, but a lot more work.

Soilless mixes are sterile and contain few nutrients. Manufacturers usually add major plant nutrients to mixes, but may not add trace elements that are necessary for good plant growth. This problem can be solved by using the soilless mix as a base and adding compost or a small amount of native garden soil (about 25% by volume).

Placing the containers. Providing adequate sunlight for the plants is the most important consideration when placing a container. Ideally, the container should be positioned where plants receive sun all day. However, in limited space situations, this is

Table 2. Growing vegetables in containers.

Vegetable	Light requirements[a]	Minimum container size (gallons)	Spacing between plants in containers[b] (inches)	Days from planting to harvest
Beans	FS	2	2–3	45–60
Beets	FS/PS	½	2–3	50–60
Cabbage	FS/PS	5	1 plant	65–120
Carrots	FS/PS	1	2–3	65–80
Cucumbers	FS	5	1 plant	70–80
Eggplants	FS	5	1 plant	75–100
Kale	FS/PS	5	10–15	55–65
Lettuce	PS	½	4–6	30–35
Mustard greens	PS	½	4–5	35–40
Onions	FS/PS	½	2–3	70–100
Peppers	FS	2	8–12	110–120
Spinach	PS	1	4–6	30–40
Squash	FS	5	1 plant	50–60
Swiss chard	FS/PS	½	4–6	30–40
Tomatoes	FS	5	1 plant	55–100
Turnips	FS/PS	3	2–3	30–60

a FS = full sun (10 or more hours of direct sun each day), PS = part shade (6 or more hours of direct sun each day).

b Any vegetable that produces large plants should have only one plant per container.

not always possible. Consequently, the amount of sunlight your container garden receives may determine which crops can be grown. Leaf crops generally can tolerate some shade, while vegetables grown for their roots or fruits need a minimum of 8–10 hours of direct sunlight each day. Available light can be concentrated somewhat by providing reflective materials around the plants (e.g., aluminum foil, white-painted surfaces, marble chips on the soil surface). Containers should also be placed to avoid frequent strong winds.

Choosing vegetable crops and varieties for containers. Almost any vegetable crop can be grown successfully in a container. However, the best container crops are those that allow you to make the best use of available space. Examples include many types of herbs, carrots, radishes, lettuce, and crops that bear fruits over a period of time, such as tomatoes, peppers, and cucumbers. Dwarf or miniature varieties of many crops are available, making them suitable for containers even if the standard varieties are too large. With increasing interest in container gardening, plant breeders and seed companies are working to develop vegetables specifically for container culture. These varieties may or may not be miniature or dwarf, but they do grow well in pots and produce as well as standard varieties if properly maintained.

Establishing plants in containers. Because containers can be moved indoors during frost or inclement weather, you can plant vegetables 2–3 weeks earlier than in the outdoor garden. Be careful not to plant too early, however, because plants that spend too much time indoors will not adapt well to outdoor conditions once the weather moderates. However, if a container is too large to move or is designated to remain permanently outdoors, plant the crops at the same time as you would in a traditional garden.

Make sure the potting soil is adequately moist. Plant the seeds as you would in the garden. Use the spacing recommendations listed in Table 2. It is a good idea to overplant and thin after emergence to the recommended spacing. If cages, stakes, or other supports are needed, install them just after planting or thinning to avoid root damage later.

Table 2 also provides information on the expected amount of time to first harvest. Your actual growing period may vary, depending on weather conditions and pot location.

Irrigating container gardens. Improper irrigation is the most frequent cause of failure in container gardens. Limited soil volume and extreme exposure results in a high demand for water. Inadequate or erratic irrigation will quickly reduce plant health and productivity.

However, overwatering is just as serious and may be the more common problem. Overwatered plants do not show immediate detrimental effects, but will eventually decline and die due to a reduction in root health. Overwatering is often caused by the presence of a water saucer or catch-pan under the pot. If the catch-pan is constantly full, water will wick back into the pot through the drainage holes and keep the soil too wet. Water only when the plants and soil indicate a need. The soil should never be soggy or have water standing on the surface.

Knowing when to water container plants is a little tricky, but there are a few techniques that may help. Check containers at least once a day (twice on hot or windy days). Use your fingers to feel the soil. It may be dry on top, but should be damp (not sopping wet) below a depth of about 1 inch. If the soil feels dry to a depth below the length of your finger, apply water until it runs out of the drainage holes in the bottom. Another trick is to watch the plants for the earliest signs of water stress — a change in color to dark green followed by mild wilt symptoms. Don't allow wilting to become severe.

In the hottest part of the summer, you may need to water daily or twice a day, depending on the size of the pot. In cool spring weather or on cloudy days, plants may need water only once every 3 or 4 days. If you must be away from the garden for long periods of time, consider installing an automatic drip irrigation system.

Clay pots and other porous containers allow evaporation through the sides of the pots. Plants grown in these types of containers require irrigation more often than those grown in impermeable containers.

To conserve water in containers, try the following techniques:

- Group containers so they shade one another and reduce evaporation.

- Place something impermeable, such as a plastic or rubber mat, under pots to prevent moisture from moving out of the pots and into cement or masonry surfaces.
- Use mulches and windbreaks.

Fertilizing containers. If you purchase a soil mix that includes fertilizer, your plants should have enough nutrients to last 8–10 weeks. If plants grow for a longer period of time, you will need to add water-soluble fertilizer, dry fertilizer (slow-release), well-aged manure, or compost at the rate recommended on the product label. Repeat every 2–3 weeks. An occasional dose of fish emulsion or compost will add trace elements to the soil.

Do not add more than the recommended rate of any fertilizer, because excess fertilizer may damage or kill the plants. Container soils do not have the buffering capacity provided by large volumes of soil and humus to protect them from overfertilization. Just because a little fertilizer is good for your plants does not mean that a lot will be better.

Pest control. Vegetables grown in containers can be attacked by the same insects and diseases that are common to any vegetable garden. They are more prone to damage from some pests, such as spider mites. Inspect plants periodically for foliage- and fruit-feeding insects as well as disease symptoms. Treat as needed. For insects, control may be as easy as spraying the plants with a hard stream of water. See "Controlling Pests" for more information.

Other Intensive Gardening Techniques

Interplanting. Growing two or more types of vegetables within the same space at the same time is known as interplanting (Figure 8). Interplanting has been practiced for thousands of years in Europe and Japan, but is just now gaining widespread support in this country.

Interplanting can be accomplished by alternating rows within a bed (for example, a row of peppers next to a row of onion), by mixing plants within a row, or by distributing various species throughout a bed. For the beginner, alternating rows may be the easiest system to manage.

To successfully plan an interplanted garden, consider these factors for each plant:

- Length of the plant's growth period and its growth pattern (tall or short, belowground or aboveground)
- Possible negative effects on other plants (e.g., sunflowers and Jerusalem artichokes produce chemicals that can inhibit the growth of nearby plants)
- Season of growth
- Light, nutrient, and moisture requirements

One of the best interplanting strategies is to combine an early crop, such as peas, radishes, or spinach, with a late crop, such as carrots, cucumbers, or squash. The early crop will be harvested by the time the late crop needs the space. Another technique is to plant smaller plants around larger plants (e.g., radishes at the base of beans or broccoli). Shade-tolerant species, such as lettuce, spinach, and celery, can be planted in the shadow of taller crops such as corn. Plants that require large amounts of nutrients, such as cabbage-family crops, can be interplanted with less gluttonous plants such as beans or beets.

Succession or relay planting. Succession planting involves growing multiple crops of the same or different plants in the same space by replanting as soon as harvest is complete. You may laugh at this idea if you live in one of Idaho's short-season climates, which limit the potential of this technique. However, some rapidly maturing crops are amenable to succession planting. Spinach, lettuce, kale, radishes, beets, and peas are good candidates. A fall

Figure 8. Interplanting — planting different crops together in the same space — is a good way to maximize production in limited space.

Figure 9. Relay planting can be used to extend the harvest season of many crops, such as corn. Plants on the right were planted first; those on the left planted later.

Relay planting is an effective option in cold-climate areas. This technique involves planting crops over several weeks to allow for continuous harvest (Figure 9). This method does not improve efficiency of land use, but does keep fresh vegetables available for a longer period of time. This method is especially effective for most salad crops and sweet corn.

Edible landscaping. Although not a new idea, edible landscaping has recently come into its own as an effective vegetable and fruit production technique. It consists of utilizing vegetable and fruit crops as landscape elements. For the vegetable gardener, it usually consists of planting edible crops among permanent elements of the landscape. Vegetables replace or are intermixed with flowers and other ornamental plants in annual and perennial beds.

Edible landscaping has much in common with the interplanting technique described above. You must consider compatibility among vegetables and other landscape plants. Because they are integrated into the landscape, the vegetable plants must not only be productive and healthy, but also must look good and contribute to the overall appearance of the property. They should enhance rather than detract from the landscape.

Vegetable crops are not all equal as edible landscape specimens. Appropriate edible landscape vegetables are those that can be planted in limited numbers, remain green for most of the summer, and provide unique and attractive visual appeal. Some of the best crops for use in edible landscapes include beets, cabbage, cauliflower, carrots, chard, collards, cucumbers, lettuce, onions, parsley, peppers, spinach, and tomatoes.

Maintenance of an edible landscape is similar to that of other intensive production systems. The processes of soil management, fertilization, irrigation, weed control, and pest management are similar to those described throughout this chapter. The unique part of edible landscaping is that the needs of vegetable crops must be balanced with the needs of permanent landscape elements.

Because no two edible landscapes have the same plants and situation, it is difficult to provide detailed instructions for installation and care. Experience will provide the best recipe for success.

Buying, Saving, and Storing Seed

BUYING SEED

Choose seed from a reputable seed company. Make sure the seed was grown and packaged the previous year, rather than stored by the seed company. The seed packet should show a package date.

After buying seed, keep a record of the seed company, variety names, plant performance, production problems (including diseases), and your personal feelings about the quality and flavor of the produce. This record will prove invaluable when selecting varieties in the future. Don't try to rely on memory to recall your favorite varieties; even the best minds create memories that may last a shorter time than the gardening season!

SAVING YOUR OWN SEED

Saving your own seed can create a sense of self sufficiency and save money. However, the true benefit is the ability to maintain a vegetable variety that is not available commercially. "Heirloom" or "heritage" varieties are fun to grow and can have a unique appearance and/or quality, but the seed is often hard to obtain. You can keep a steady supply of seed available by saving your own. Participation in a seed-saver's exchange can also be rewarding. You can trade extra seeds for unusual varieties not available through other sources.

Keep the following factors in mind when saving seed:

- Hybrid varieties (usually designated as "hybrid" or "F1 hybrid" as part of the variety name) produce seed that does not breed true. In other words, if you plant seed harvested from these plants, the resulting offspring will vary in appearance, productivity, and quality. Use only open-pollinated varieties (those that are not

hybrids) for home seed production. Some seed dealers have responded to the increasing interest in seed saving by clearly marking open-pollinated varieties in their catalogs.

- Seed can carry diseases into the next year's crop. This concern is minimal in most Idaho climates, but be safe by taking seed only from very healthy plants.
- Completely clean and dry the seed before storing it. A good method is to place the seed on a dry paper towel in a sunny window. Store the dried seed in a cool place (not more than room temperature) where it will remain completely dry.
- Some crops are self pollinated (they produce seed using their own pollen), while others are cross-pollinated (pollen is transferred from other plants). Self-pollinated crops include peas, beans, tomatoes, peppers, and eggplants. These are the simplest crops from which to save your own seed.
- Cross-pollinated crops include cucumbers, melons, squash, pumpkins, broccoli, lettuce, radishes, and sweet corn. If you want to save seed from cross-pollinated crops, you must isolate the plants or transfer pollen by hand. If you have ever saved squash seed and found the next crop to be full of unusual types, you know what can happen. You can isolate plants by growing only one variety of that crop, but only as long as there are no other varieties growing in gardens nearby (usually within about a quarter mile). The best way to ensure isolation is to cover the flowers with a paper bag before they open. Some plants have separate male and female flowers and both must be covered. When the flowers open, use a small artist's brush to transfer the pollen. Then cover the flowers again until they fade.
- For corn, save seed only from open-pollinated heirloom types.
- Some crops, such as beets, carrots, and onions, produce seed in their second year of growth. It is difficult to save seed from these crops, but you can do so by storing roots or bulbs over the winter in the refrigerator and replanting them in the spring.

Many books and web sites provide more detailed information about saving vegetable seed. For example, see seedsave.org (**http://seedsave.org/#**).

STORING SEED

Under proper conditions, seeds of some vegetable crops can be stored for several years. Table 3 lists common vegetables and the number of years that seed can be held. However, it can be difficult to provide proper storage conditions. If seeds are

Table 3. Number of years vegetable seeds will remain viable under proper storage conditions.

Vegetable	Average years seeds can be saved
Beans	3
Beet	4
Broccoli	3
Brussels sprouts	4
Cabbage	4
Carrot	3
Cauliflower	4
Celery	3
Chinese cabbage	4
Collard	4
Corn	2
Cucumber	5
Eggplant	4
Endive	5
Kale	4
Kohlrabi	3
Leek	2
Lettuce	1
Muskmelon	5
Mustard	4
Onion	1
Parsley	1
Parsnip	1
Pea	3
Pepper	2
Pumpkin	4
Radish	4
Rutabaga	4
Spinach	3
Squash	4
Tomato	4
Turnip	4
Watermelon	4

not stored properly, the length of time they can be held drops dramatically. To ensure plant vigor, the safest practice is to purchase or produce new seed every year.

Vegetable seed can be stored in the refrigerator or freezer inside a sealed container. It should at least be stored in a cool (below room temperature), dry place. A cool basement storage room can be ideal.

Preparing the Soil

Proper soil preparation is the basis for good seed germination and growth of garden crops. The ideal vegetable garden soil is deep, friable (easy to cultivate), well drained, and has high organic matter content. You may ask if such a soil exists! Only a few regions in Idaho have soils that naturally supply these conditions. Appropriate use of soil amendments can improve garden soil and provide the best possible conditions for your crops. Effective soil improvement begins with understanding the current status of your soil.

TESTING THE SOIL

Soil testing is the process of sampling soil and completing a laboratory evaluation to determine nutrient availability and chemical characteristics important for plant growth. At a minimum, have your soil tested for basic nutrient content and pH. Soil tests are especially critical in a new garden plot, but soil should be analyzed at least once every three years because conditions change over time. Soil tests are done for a nominal fee by the University of Idaho (UI) or by private laboratories. Contact your Extension office for instructions and sample bags.

One piece of information that comes from a soil test is pH. Soil pH is a measure of acidity or alkalinity. Vegetables differ to some extent in their response to soil pH, but most do well within a pH range of 6.2 (slightly acid) – 7.5 (slightly alkaline). If soil pH is too high or too low, poor crop growth may result, largely because of the effects of pH on the availability of nutrients.

Unfortunately, in most cases we are stuck with the soil we have regardless of whether pH is favorable. It is possible to raise the pH of low-pH soils (common in northern Idaho and some high mountain valleys) by liming. It is nearly impossible, however, to lower the pH of the alkaline soils common to much of southern Idaho. But you can partially compensate for the lack of nutrient availability in these soils by adjusting fertility practices. One of the best ways to improve nutrient availability is to increase the amount of organic matter in the soil.

ADDING ORGANIC MATTER

Organic matter is derived from decomposing plants. It is important because it improves tilth, increases water-holding capacity, improves fertility, and reduces problems with soil diseases. There is no replacement for organic matter in improving soil health and providing good growing conditions for vegetables.

Most Idaho soils are low in organic matter. It can be added in the form of plant waste (such as leaves or lawn clippings), composts, green manures, or aged animal manures. You'll need to add organic matter consistently (every year or two) because it breaks down rapidly in the soil.

Compost is one of the simplest, safest, and most effective organic amendments. You can purchase compost or make it from landscape or household plant-based waste. See chapter 8, "Backyard Composting," to learn the basics of this process. Apply compost by spreading a layer 3–6 inches deep on the soil surface. If possible, till it in to a depth of 10–12 inches.

Green manure is living plant material that is added to the soil. Effective green manure crops include oats, corn, vetch, clover, and mustard. Grow the green manure crop on the area you want to amend. Mow the crop while it is still green and till in the residue.

In short-season areas, planting a green manure crop may exclude planting a garden in that spot during the amending season. Regardless, this is still a very good practice in a new garden plot. A less disruptive method is to schedule green manure crops into the garden rotation system; reserve a different portion of the garden for a green manure crop each season.

Animal manures should be aged for a year or two or properly composted before application. Manures can be fairly high in salts and may be harmful in excessive amounts. Add 2–4 inches of manure and till it in to a depth of 10–12 inches. It's best to apply manure in the fall so it has time to completely decompose and salts can partially leach out of the root zone before spring planting.

FERTILIZING

Decisions related to fertilizing vegetable gardens can be complex. The type and amount of fertilizer needed depends on factors such as the natural fertility of the soil, soil texture, and amount of organic matter present. Thus, it is impossible to provide universal fertilizer recommendations that apply to every gardening situation.

Fertilizer requirements for individual vegetable crops vary widely, further complicating fertilizer-rate decisions. Some crops, such as peas, beans, and beets, need very little fertilizer. Most long-season crops, such as corn, potatoes, and melons, require fairly large amounts. Fertilizer application decisions for a vegetable garden should take into account these crop differences.

Nothing can replace a soil test for providing the information required to make good fertilizer application decisions. If soil test results are not available, you must base fertilizer decisions on reasonable assumptions about existing conditions. Three such assumptions are possible for most Idaho soils:

- Nitrogen (N) is the nutrient most likely to be in short supply. Base fertilizer application rates on the N requirement.
- Consistent applications of phosphorus (P) and potassium (K) are usually needed. Use a "complete" fertilizer — one that contains all three major nutrients (N, P, and K). The fertilizer should contain at least as much P and K as N. This assumption is not always true, however; hence, the value of an occasional soil test.
- Your garden soil is probably reasonably fertile to begin with and would grow a reasonable crop of vegetables even if you added no fertilizer. This last assumption can be validated only through experience.

If you feel these assumptions are reasonably valid for your garden soil, the following three-step process should work as a starting point for fertilizer applications. These recommendations are appropriate for a typical Idaho clay loam, silt loam, or sandy loam soil with average nutrient content and a low amount of organic matter.

1. Purchase a fertilizer that contains a moderate amount of N, high levels of P, moderate to high levels of K, and possibly some sulfur. Fertilizer labels list the content of these nutrients in the order N-P-K. Examples of appropriate fertilizer grades for vegetables are 4-10-6, 5-10-5, 5-10-10, 6-10-10, 10-20-10, 10-45-10, and 15-30-15. It's not necessary to use a product that matches one of these grades exactly, but do seek a product with a similar ratio of major nutrients.
2. Before planting, add fertilizer at the rate of 2–3 pounds of actual N per 1,000 square feet of garden area. (See chapter 5, "Soils and Fertilizers," for information on how to determine the nutrient content in fertilizers.) This will supply the full seasonal needs for crops that are considered to be light feeders (beans, beets, carrots, chard, lettuce, parsnips, peas, early harvested potatoes, radishes, rutabagas, spinach, tomatoes grown in a short-season area, and turnips).
3. After the crops are up and growing, side-dress the heavy feeders (broccoli, cabbage, cauliflower, celery, collards, corn, cucumbers, eggplants, kohlrabi, leeks, melons, onions, peppers, late-harvested potatoes, pumpkins, squash, and tomatoes grown in a long-season area) with an additional 2–3 pounds of N per 1,000 square feet. Apply this fertilizer just as the plants start their major growth phase — typically 3–6 weeks after planting or transplanting, depending on the crop. Apply the fertilizer near the base of the plants. For this application, you might use ammonium sulfate (20-0-0), which does not contain P or K.

If you use a lot of compost or manure, you can use less fertilizer. For example, if you apply 4–6 inches of manure or compost each year, you can reduce the amount of fertilizer applied by one-half to two-thirds.

The principles described above apply to both organic and chemical fertilizers. However, the fertilizer products used are different. Organic fertilizer products include bonemeal, blood meal, feather meal, etc. Organic gardeners often rely more heavily on consistent applications of composts, manures, and green manures to supply plant nutrients.

Sandy garden soils require some modification in fertilizer application practices. If your soil is sandy, apply less of the total fertilizer before planting. Instead, make frequent, small applications throughout the growing season. This will provide the plants with the nutrients they need, while reducing leaching losses. A soil test will help you determine your soil texture.

See chapter 5 for more about soils, soil fertility, fertilizer grades, and application methods.

TILLAGE

The final step in soil preparation is tillage. Ideally, soil should be tilled to a depth of at least 10 inches. This can be very difficult with small garden equipment, however. If you can't till deeply, it may be beneficial to occasionally fracture the soil to a greater depth. Push a long-tine garden fork deep into the ground and pull the handle backward to break up the hard lower layers.

It is important to avoid working soil when it is very wet. Tilling wet soil breaks down the soil structure, causing it to become cloddy and hard. The negative impact of tilling wet soil may last for years. You can tell if your soil is dry enough to work by taking a handful and squeezing it tightly into a ball. If the ball breaks into granular pieces when pressed lightly between your fingers, the soil is ready to work. If the ball remains intact and feels sticky when you squeeze it, wait a few days before tilling.

Planting

PLANTING VEGETABLE SEEDS OUTDOORS

No amount of care can rescue plants that get off to a bad start due to incorrect planting. In order to germinate properly, seed must be planted at the right depth and must remain moist.

As a general rule, vegetable seeds should be planted to a depth about three times their width (not their length). However, there are exceptions. Some seeds require light for germination and should be covered with no more than ¼ inch of soil. Most seed envelopes contain planting instructions.

You can cover shallow-planted seed with clear plastic film (such as plastic food wrap) or wet burlap to raise the soil temperature and hold moisture. Remove the covering immediately after the seedlings emerge to prevent burning or abnormal growth of the new plants.

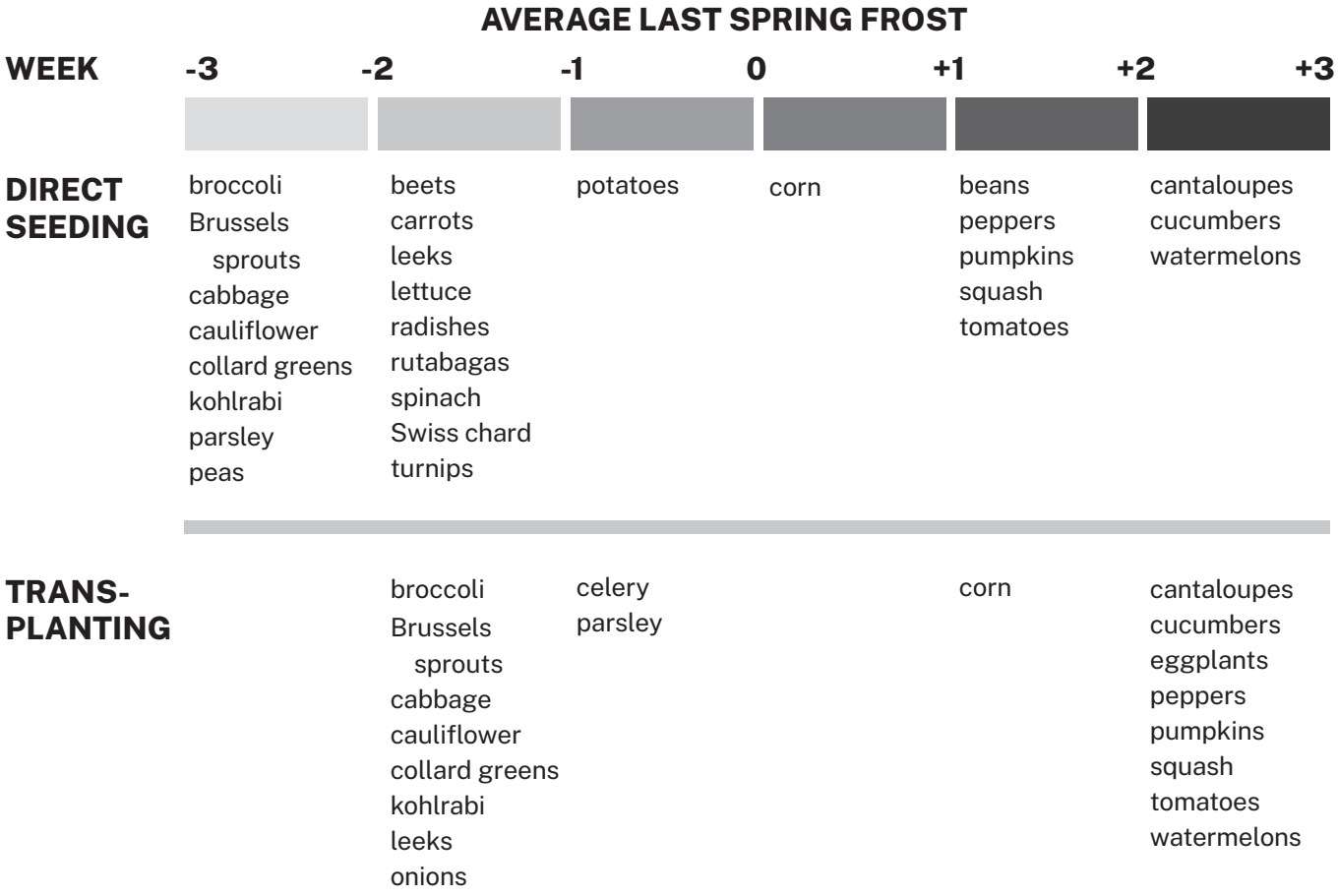

Figure 10. Planting and transplanting guide for vegetable crops based on the date of the last spring frost. On the bar, zero (0) is the date of the last spring frost, as determined for your locale. Each number to the right or left is the number of weeks before (-) or after (+) the average last frost. Crops listed under each number are those that typically can be successfully planted or transplanted during that time.

Optimal planting times vary from crop to crop. There is no "one time fits all" for vegetables. Some plants grow well in cool spring weather. Plant these crops well before the last frost. Other vegetables can be severely damaged by cold weather or light frost.

The first step in deciding when to plant is to determine the average date of the last frost in your area. This information can be found in many publications, websites, or from your local Extension office.

Next, schedule planting based on the frost hardiness of each crop (see Figure 10). Some general guidelines are

- **Three to four weeks before the average last spring frost**: Plant cold-hardy crops, including onions, peas, kale, cabbage, broccoli, and cauliflower. (The last three can be transplanted within the same time frame.)
- **A week to two weeks before the average last frost**: Plant moderately hardy crops, such as beets, carrots, spinach, Swiss chard, leeks, and lettuce. You can also plant sweet corn at this time if you are willing to take a chance on minor frost damage in order to get an earlier crop.
- **Within a week or two after the average last spring frost**: If the weather forecast does not call for cold weather, plant warm-season crops, including beans, cucumbers, eggplants, melons, squash, pumpkins, peppers, and tomatoes. If transplanting these crops, you may need to wait a few more days, depending on the weather forecast.

Bouts of cold temperatures and frost are not the only things that cause problems with emergence and early growth. Soil temperature also affects germination. In the spring, soil is often cold and seeds of some plants will rot before they have a chance to sprout. Even if the calendar indicates it's time to plant, it is wise to make sure the soil temperature is high enough to allow germination. For cold-hardy crops, the minimum daytime high soil temperature for planting is 50°F. Moderately hardy crops need soil temperatures of at least 55°F, and warm-season crops need 65°F. Table 4 outlines the minimum and optimal soil temperatures and expected time to emergence for common vegetable crops.

Once planted, you must keep the soil moist until the plants begin to emerge. In some years, spring rain and cool weather make irrigation unnecessary. However, in most years, frequent light watering is required to get seed off to a good start. You may need to water deeply seeded crops every two or three days and shallow-seeded crops as often as two times a day.

Table 4. Vegetable germination and emergence as related to soil temperature.

Crop	Days to emergence from seeding[a]	Optimal soil temperature for germination (°F)	Minimum soil temperature for planting (°F)
Beans	5–10	70°–80°	65°
Beet	7–10	50°–85°	50°
Broccoli	5–10	65°–75°	50°
Cabbage	5–10	65°–75°	50°
Carrots	12–14	70°–80°	55°
Cauliflower	5–10	65°–80°	55°
Celery	10–18	65°–75°	55°
Collards	5–10	65°–75°	50°
Corn, sweet	7–10	70°–80°	65°
Cucumbers	7–10	70°–85°	65°
Eggplants	8–12	70°–85°	65°
Endive	10–14	65°–75°	55°
Kohlrabi	5–10	65°–75°	50°
Leeks	10–14	65°–70°	50°
Lettuce	7–10	65°–70°	55°
Melons	5–10	80°–85°	65°
Onions	10–14	65°–70°	50°
Parsley	10–25	65°–70°	55°
Parsnips	14–21	65°–70°	55°
Peas	7–14	65°–70°	50°
Peppers	10–14	75°–85°	65°
Potatoes	10–18	65°–70°	55°
Pumpkins	7–10	65°–75°	65°
Radishes	5–7	65°–70°	50°
Rutabagas	7–15	65°-70°	50°
Spinach	7–14	65°–70°	55°
Squash	7–14	70°–85°	65°
Swiss chard	7–14	65°–75°	55°
Tomatoes	7–14	75°–80°	65°
Turnips	7–14	65°–70°	50°

[a] Emergence may take several days longer if soil temperatures are consistently below the optimum, as often occurs during spring in much of Idaho.

PRODUCING AND ESTABLISHING TRANSPLANTS

Many vegetable crops do better when transplanted rather than direct seeded in the garden. Transplanting makes weed control simpler, enhances the growth and quality of crops that prefer cool, spring weather (such as broccoli and cauliflower), shortens the time to harvest of many fruit-bearing crops (such as peppers and tomatoes), and allows us to grow many crops that are marginally adapted to short-season climates (such as melons).

Some vegetables are very difficult to transplant. (The length of this list varies, depending on the gardener's skill level.) Other vegetables fall into a middle category; they can be transplanted successfully, but only if proper precautions are followed. The last group includes vegetables that can be transplanted with minimal frustration. See Table 5 for a list of vegetables that can be successfully transplanted.

You can purchase transplants or grow them yourself from seed. It's easier to purchase plants and greenhouse-produced transplants are often healthier than those produced at home because they are grown under ideal conditions. However, growing your own transplants does have advantages. You can produce unusual varieties, save money, and ensure that your transplants are at the proper growth stage when you are ready to plant.

Growing transplants without good greenhouse facilities can be a challenge. The most important factors are light, soil mix, irrigation, proper size and growth stage, and hardening.

Table 5. Ease of transplanting vegetables.

Appropriate for transplanting and easy to handle	Appropriate for transplanting but require extra care for success	Inappropriate for transplanting or do not easily survive the process
Broccoli	Cantaloupes[a]	Beans
Brussels sprouts	Celery	Beets[b]
Cabbage	Corn	Carrots[b]
Cauliflower	Cucumbers[a]	Peas
Chinese cabbage	Pumpkins[a]	Radishes[b]
Collards	Squash[a]	Rutabagas[b]
Eggplants	Swiss chard	Spinach
Leeks	Watermelons[a]	Turnips[b]
Lettuce		
Onions		
Parsley		
Peppers		
Tomatoes		

[a] Transplant vine crops when seedlings are very young (one or two true leaves) and very vigorous. Cover transplants and protect them from wind and sunburn for about two weeks after transplanting.

[b] Root crops (beets, carrots, radishes, rutabagas, and turnips) are often easy to transplant, but the roots will branch or have other quality problems as a result of root disturbance.

Starting Transplants

It can be tricky to know when to plant seeds for transplants. The objective is to have the seedlings at the optimal stage of growth when it's time to transplant — assuming the unpredictable Idaho

Table 6. Number of weeks required to produce transplants from seed.

Crop	Weeks to produce transplants from seed[a]
Broccoli	5–7
Brussels sprouts	5–7
Cabbage	5–7
Cantaloupes	3–4
Cauliflower	5–7
Celery	8–10
Collards	5–7
Corn, sweet	3–4
Cucumbers	3–4
Eggplants	6–8
Endive	4–8
Kohlrabi	5–7
Leeks	4–6
Lettuce	3–5
Onions	6–8
Parsley	6–8
Peppers	6–8
Pumpkins	3–4
Squash	3–4
Tomatoes	5–9

[a] The number of weeks needed to produce transplants is based on growth at room temperature.

weather will be suitable for planting on the day you expect to transplant. It takes planning to ensure that transplants are neither too big nor too small when you are ready to move them to the garden.

You need two pieces of information in order to develop a planting schedule for vegetable transplants: (1) the date the transplants will be planted in the garden and (2) the amount of time needed to produce appropriate-sized transplants. You can calculate the transplanting date if you know the last average frost date for your locale. Use the following guidelines (also see Figure 10):

- **Cole crops (cabbage, broccoli, cauliflower, kale, brussels sprouts, etc.) and onions**: Transplant 2–3 weeks before the average last frost.
- **Most salad crops (lettuce, Swiss chard, spinach, etc.)**: Transplant a week or so before the average last frost.
- **Tender crops (tomatoes, peppers, eggplants, squash, melons, etc.)**: Transplant about 1 or 2 weeks after the average last frost if the weather forecast is for reasonably warm and stable conditions.

If you protect your transplants with hot caps, row covers, etc., you sometimes can move the transplant date forward by a week or two.

Once you know the anticipated date of transplanting, see Table 6 to find the number of weeks needed to produce transplants of your chosen crops. Then count backward from the transplanting date to find the date you should plant seeds.

It is best to use a soilless planting mix containing peat to start seedlings. Soilless mixes are usually free of disease organisms that can cause damping-off, a fungal disease that causes young seedlings to fall over and die. They also hold a large amount of water and maintain the integrity of the root ball when it is time to transplant. You can purchase premixed potting soil or mix your own. A mix of 50% vermiculite or perlite and 50% fine sphagnum peat (plus a little fertilizer) is excellent for starting seeds.

To save space, you can plant the seeds in flats and then transplant the small seedlings into small pots or other individual containers to complete growth in preparation for transplanting outside. An alternative is to plant the seed directly into individual containers such as small pots, six-pack trays, peat pellets, or peat pots. With this method, it is best to plant extra seed and thin the plants after emergence to the desired number in each pot (usually two or three).

Planted seeds and seedlings are extremely sensitive to drying out. If the air in your home tends to be dry, it may help to cover the flats (shallow, rectangular pans with no dividing lines) or pots with clear plastic in order to maintain uniform moisture. Do not keep the soil soaking wet, however, since excess moisture is conducive to damping-off. You can prevent or reduce damping-off by sprinkling a thin layer of milled sphagnum moss, which contains a natural fungicide, on top of the soil.

Caring for Transplants

More homegrown seedlings are lost to inadequate light than to any other factor. Vegetable seedlings grown under low-light conditions are likely to be spindly and weak. They frequently are killed by damping-off. If they survive the early growth phase, plants are often too tender to survive the move to the garden.

For these reasons, transplants should be grown under conditions that include or mimic at least 10 hours of sunlight each day. If you do not have a sunny room or back porch with a southern exposure, you will need supplemental lights. Grow lights supply a good spectrum of light. Mount the lights just above and nearly touching the plants.

Transplants must be healthy, growing rapidly, and adapted to outside conditions before they go to the garden. Thus, you must maintain optimum moisture and fertility conditions during growth. Never allow plants to dry out or run out of nutrients. Plants should be dark green and not lose any leaves. If growth is retarded, transplants may never recover sufficiently to produce a good crop.

Hardening Off

About a week before you plan to move transplants to the garden, you should "harden them off." Hardening off means to slowly adapt the plants to outside conditions. This process reduces transplant shock and the risk of transplant death. Harden off the plants over a one-week period by moving them outdoors for increasing amounts of time. Start with less than one hour the first day and eventually leave them outside for much of the day. Move them indoors at night (unless a warm night is forecast)

and during inclement weather (especially if it is windy). Transplants will use more water outside, so water accordingly.

Transplanting

Some vegetable transplants have specific requirements (Figure 11):

- Cole crops (cabbage, broccoli, cauliflower, Brussels sprouts) should not be too large when transplanted. If the stem diameter is larger than about ¼ inch, the plants likely will "button" or "bolt," meaning they will produce very small heads or go to seed after cold weather.
- Vine crops (cucumbers, melons, squash, pumpkins) should be very young when transplanted, having at the most only one or two true leaves. They should be very vigorous. Otherwise, they develop a root-hardening problem that makes them very slow at recovering from transplant shock. Also, newly transplanted vine crops are very susceptible to windburn and sunburn. Cover them with paper or plastic for about a week after transplanting.
- Tomatoes are relatively easy to transplant. Even very large plants establish with few problems, allowing you to get an early start on production.

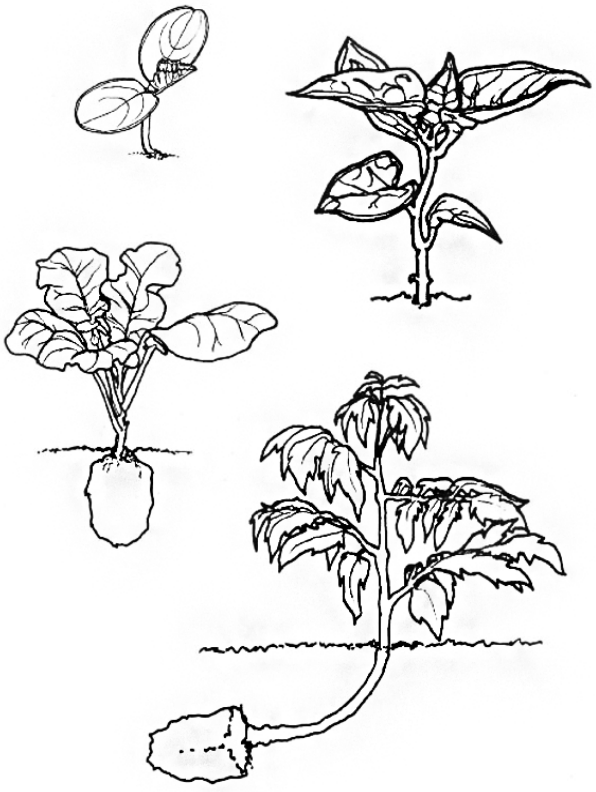

Figure 11. Optimal transplant size of vegetable crops. Transplant vine crops (cucumbers, melons, squash, and pumpkins) when very small. Plant them at the same depth as they are growing in the pot (top, left). Peppers, eggplants, and most other transplanted crops can be transplanted at a moderate size. Plant them slightly deeper than in the pots (top, right). Cole crops (cabbage, broccoli, cauliflower, Brussels sprouts, kohlrabi, and kale) should be relatively small and vigorous. Plant them at the same depth as they are growing in the pots (bottom, left). Tomatoes can be transplanted when quite large. Place tall tomato plants sideways in a trench and cover the stem to the lowest leaves (bottom, right).

Here are a few additional tips for successfully transplanting vegetables:

- Prepare garden soil before transplanting. Many soil amendments, such as aged manures, sulfur, limestone, rock fertilizers, and green manures, require time to break down. Mix these materials into the soil the fall before planting or at least several weeks before planting.
- Transplant on an overcast day, in late afternoon, or in early evening to minimize wilting. Water the potted plants thoroughly just before transplanting.
- Handle plants carefully. Avoid disturbing the roots or bruising the stems.
- Dig a hole large enough to hold the plant roots. Plant vegetables only very slightly deeper than they were growing in their pots. Tomatoes are an exception. They will develop roots all along the stems, and you can plant them deeply enough to leave only two or three sets of leaves exposed.
- Press soil lightly around the roots and water well. Pour a cup of liquid starter fertilizer solution around each plant, mixed at about half of the concentration recommended on the label.
- Protect plants from wind and sun for a few days after transplanting. Place newspaper or cardboard on the south side of the plants or cover them with commercially available devices, milk jugs, baskets, or upside-down flower pots (use clear plastic so the sunlight will pass through).
- Water the plants once or twice a day for about one week. Then water two or three times during the next week before going to a normal irrigation routine. Overwatering can cause transplants to suffer from root rots, so don't overdo it.

Caring for Your Garden

IRRIGATING

Under Idaho conditions, proper irrigation is essential for productive vegetable gardens. Watering maintains growth during the summer. It also can improve seedling emergence, reduce soil crusting, improve germination and plant establishment, and stimulate growth of transplants. Proper irrigation — exactly meeting your plants' water requirements — is the single most important factor in growing a high yield of good quality vegetables. See the "Soils and Fertilizers" chapter in this handbook for a discussion of general principles related to soil water and irrigation.

Garden water demands and irrigation scheduling are the result of complex interactions between climate, weather, soil type, plant species, and irrigation practices. Thus, no single recipe is suitable for all gardens. Taking the time to learn about proper irrigation in your own situation will pay dividends. The following principles can help you make good irrigation decisions for your vegetable garden:

- In most locations in Idaho, nearly all of a vegetable garden's water needs must be met through irrigation. Once they approach full size, most vegetable plants use ¼ inch of water per day or slightly more. Thus, a summer garden will need around 2 inches of water per week. Most soils will not hold this much water. In order to avoid plant stress, plan to irrigate twice each week, with the total of the two irrigations being about 2 inches.
- In the spring, when the weather is cool and plants are small, vegetable plants may use less than half the amount of water given. In the fall, when plants start to mature, water use also declines.
- You can measure the amount of water applied by a sprinkler by putting a can under it. If the water in the can is ¼-inch deep at the end of the irrigation, you have applied ¼ inch.
- Plants use the same amount of water regardless of soil type. However, sandy soils hold less water, so plants use the available water very quickly and then become stressed. If your soil is sandy, water more frequently but apply less water each time.
- Sprinkler irrigation is a simple method for applying water uniformly. However, sprinklers wet the leaves and encourage disease development. They also splash dirt on leaves, which may add some "grit" to your meals. If these are problems in your garden, consider using a bottom-up irrigation method such as soaker hoses or a drip system.

CONTROLLING WEEDS

Weeds are a constant source of frustration to vegetable gardeners. Weeds not only reflect negatively on the gardener's expertise (the neighbors are always watching!), but they also use water and nutrients, compete for available light, and reduce the yield and quality of vegetables.

Keeping the garden clean of weeds one year doesn't mean they won't be back the next. The old saying, "one year's weed, seven years' seed," contains more truth than myth. Although weeds will always be present, some control methods make them easier to live with.

Cultivation

Hand pulling and digging weeds is probably the best choice for small gardens and raised beds. You can make the task more pleasant with the use of kneepads. Hoeing is preferred in larger spaces. Hoeing can damage root systems of large plants, so push the blade of the hoe into the soil just deeply enough to sever weed roots. Stay several inches away from the base of vegetable plants. Manually powered rotary cultivators can supplement the use of a hoe. They do a good job on long rows and pathways if the soil is not too wet or dry and if the weeds are not too big.

A power tiller may be the tool of choice for large gardens that are arranged in wide rows. If you plan to use a power tiller for weed control, plant the vegetable rows far enough apart to till between the rows without damaging the plants. Make rows at least 8 inches wider than the tiller blades. Once plants are large enough to touch neighboring plants across the rows, stop power tilling in order to prevent damage to the roots or leaves.

Cultivation is best done when the soil is somewhat moist, but not wet. The best time to cultivate is 2 or 3 days after rain or irrigation. Working wet soil damages the soil structure, especially in the case of fine-textured soils, making the soil compacted and cloddy. However, when the soil is dry, weeds are difficult to pull and hoeing is a chore.

After hand pulling weeds, you can lay them on top of the soil to dry out and then turn them under (if they are not yet flowering). Turning under weeds provides organic matter to the soil. Avoid irrigating for a day or two to prevent the weeds from rooting and "coming back to life."

Some common weeds, such as purslane, nut grass, quack grass, and other rhizomatous grasses, will re-root with the first added water and continue to grow. It may be best to remove such difficult weeds from the garden. Also, if weeds are mature enough to produce seed, remove them from the garden to prevent seed dispersal.

Mulching

Mulching can reduce the need for weeding. A thick layer of organic mulch will prevent most annual weed seeds from germinating and those that do germinate are usually easily pulled. Organic mulches can include straw, grass clippings (make sure they are free of herbicides), bark (small enough to be tilled under at the end of the season), wood chips, or sawdust.

Mulching with black plastic film can also be very effective at reducing weed growth. Using black plastic mulch on the rows and an organic mulch between the rows will nearly eliminate annual weed problems. Mulches are less effective at controlling perennial weeds such as quack grass and bindweed. Elimination of these difficult weeds will probably require off-season (early spring or late fall) applications of herbicides over a period of years.

Close Spacing

When spaced close to each other, established vegetable plants shade the soil and prevent the growth of many weed seedlings. Close spacing is easily achieved in a well-planned raised bed, but it also works in victory gardens. Place plants closely enough together so that the foliage of adjacent plants forms a closed canopy when the plants are mature.

Other Practices

One unusual weed-control method is to plant grass between rows and keep it mowed throughout the summer (Figure 12). This grass is called "living sod" and is a good choice for controlling weeds between raised beds.

The use of a cover crop (such as alfalfa, clover, vetch, or rye) over several seasons or years can reduce weed problems. This method requires leaving the cover crop area uncultivated, which reduces gardening space. Cover crops should be mowed or harvested regularly, which can be time-consuming and difficult without appropriate tools.

A few herbicides labeled for use in home vegetable gardens can be applied over the top of growing vegetable plants. Most can be used safely and are moderately effective, but improper applications can damage crops. Herbicides are more effective when applied as a preventive measure before planting. First remove all existing weeds from the garden. Follow all label instructions.

CONTROLLING PESTS

In most Idaho vegetable gardens, you can ignore insect pests if you are willing to put up with a little damage and minor losses of edible produce. However, pests occasionally show up in numbers sufficient to be a serious problem.

The following five simple strategies will help you manage insects, slugs, and snails in a vegetable garden. The insect control chapter of this handbook includes more detailed information.

- **Be a sanitary gardener**. Insects often overwinter in garden refuse, so clean up dead plant material at the end of the year. If you want to return the organic matter to the soil, till or plow the garden after harvesting the last crops.

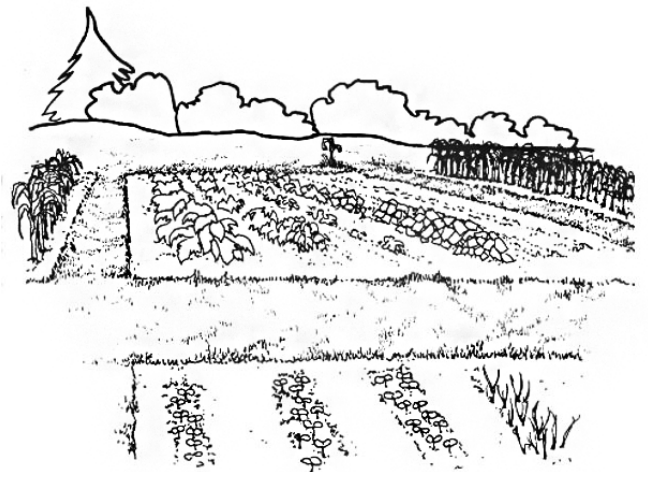

Figure 12. The use of living sod — the practice of planting and mowing grass between vegetable garden plots — is a good way to control weeds. This method is effective around both bordered or open blocks.

- **Maintain good plant health**. Healthy plants can often partially defend themselves from pests. Even if insects do some damage, the plants will have a good chance of recovering.
- **Use physical barriers and cultural controls**. You can keep some types of pests at bay by preventing access to your plants. For example, collars around the lower stems of small plants will foil cutworms. Wood ashes or sharp sand will discourage slugs and snails. Other methods include using colored plastic mulches and spraying insects with a hard stream of water.
- **Encourage or release beneficial insects**. A little patience will go a long way toward controlling many insects, such as aphids. Once pests show up, their predators will arrive and begin eliminating them. Purchasing and releasing beneficial insects such as ladybugs and lacewings may speed up the process. Two things will increase populations of predatory insects. One is to allow a few pest (prey) insects to be present. Predators will not come if there is nothing to eat, so allow a few pests to persist. The other strategy is to avoid using broad-spectrum insecticides. These products may kill pests, but they also eliminate many predators.
- **Judiciously use pesticides as a last line of defense**. Some insects become serious problems and do not respond to other control methods. For many insects, both organic and synthetic insecticide options are available. If you choose to use insecticides, direct the application to the problem rather than broadcasting an insecticide across the garden. Also, use products that target the specific pest you are trying to control. The goal is to control the pest without harming the beneficial insects that naturally reduce pest populations.

Insects and other pests that commonly infest Idaho gardens at damaging levels include the following:

Aphids

These soft-bodied insects are usually found crowded at the ends of succulent new growth. Insecticidal soaps or a hard stream of water that knocks them off the plant usually are sufficient to eliminate damage. Also, aphids will almost always be eliminated by predators if you are patient enough to let their natural enemies do their work.

Grubs and Wireworms

These soil dwellers often damage the roots and lower stems of plants. They are difficult to control and may require the use of a soil-applied insecticide before planting. Thus, you must know the garden's history and realize the problem exists before damage appears. Once damage is visible, it is hard to apply effective controls without damaging young plants.

Cutworms

This pest often kills seedlings and transplants by chewing through the stems at ground level. Cabbage, broccoli, tomatoes, and other soft-stemmed transplants are common victims. Placing cardboard collars around the base of plants is an effective way to prevent damage. Some insecticides are also effective.

Corn Earworm

This pest is common in the warmer regions of Idaho. Control usually requires the use of an organic or synthetic insecticide, applied once or twice while the plants are in silk. Begin control measures when the silks appear and continue as long as they are green and pliable.

Slugs and Snails

Slugs and snails are less of a problem in our dry climate than they are in wetter areas. In fact, if you have a slug problem, you may be watering too much and too often. Water less and the problem may be reduced. If reducing irrigation doesn't solve the problem, baits and traps can be partially effective.

Cabbage Looper

These slender green caterpillars infest all cole crops (broccoli, cabbage, cauliflower, kale, etc.). They chew holes in the leaves, deposit weblike material, and leave their frass (droppings) on the plants. They can be ignored in small numbers, but may require control with *Bacillus thuringiensis* (the organic pesticide sold as Bt) or another insecticide if they become very numerous.

Tomato Hornworms

These large, ferocious-looking caterpillars can be very damaging to tomato and potato plants. One large individual can defoliate a plant in a day or two.

Physical control is the best method for eliminating this occasional pest. Pick them off the plants and step on them or squeeze them between two rocks. For the squeamish, simply remove them from the garden.

Colorado Potato Beetles

These pests are a serious problem on potato plants and occasionally on tomatoes. If only a few are present, you can remove them from plants by hand. If numerous, they may require an insecticide. A hard stream of water may knock them from plants, but unless they are very small, they likely will climb back onto the plant and keep eating.

Mexican Bean Beetle

The bright-orange, prickly looking larvae of this beetle can quickly skeletonize leaves of bean plants. Heavy infestations may require an insecticide application.

CONTROLLING PLANT DISEASES

The dry climates common to Idaho limit the number of diseases in vegetable gardens. However, a few serious problems should be monitored.

Viruses

A number of common virus diseases occur on vegetable crops. Examples include zucchini yellows, cucumber mosaic, potato leafroll virus, tomato spotted wilt, and tomato mosaic. Viruses are difficult to control. Once a plant is infected, it cannot be cured. The only solution is to remove the affected plants to prevent its spread to healthy plants.

If you have recurring problems with any virus, you will need to identify it and learn about the disease and its vectors. **Vectors** are organisms, usually insects, that spread a disease. Develop a strategy to control them. You may need to seek help from a Master Gardener, Extension educator, nurseryman, or other qualified person.

Bacteria

Many fruit rots and some leaf spot diseases are caused by bacteria. There are no chemical products registered for control of bacteria in vegetable gardens. The best methods for controlling these diseases are cultural. Keep fruit off the ground and make sure to allow plant surfaces to dry between watering. Eliminate plant refuse from diseased plants.

Fungi

The most common plant diseases involve fungal pathogens. Some fungal diseases live in the soil and attack the plant through the roots; others directly attack leaves, stems, flowers, and fruits.

Crop rotation — moving each vegetable to a different place in the garden each year — is a good way to control soil fungi. Rotation is especially important for controlling verticillium wilt in potatoes, peppers, and tomatoes; club root in broccoli, cauliflower, and other cole crops; and vine wilts in the vine crops (squash, cucumbers, and melons).

Keeping fruit off the ground helps prevent fruit damage. Limit the impact of foliar fungi by allowing foliage to dry between irrigations. However, some fungi, such as powdery mildew, may still become a problem on many crops. Foliar fungal problems that return every year may require fungicidal applications. Most fungicides work best if they are applied before plants show symptoms. Thus, the decision to use fungicides may need to be based on past history.

Further Reading and Resources

WEBSITES

Many UI publications about gardening are available from your county's UI Extension office or online at **https://www.uidaho.edu/extension/publications**.

The UI maintains a gardening website that includes information on producing vegetables. It is called "Idaho Landscapes and Gardens" and can be accessed at **https://www.uidaho.edu/extension/landscapes**.

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