chapter 14

Vegetables

In a nutshell...

- Growing vegetables can be challenging but also rewarding. Helping people grow food can be one of the most rewarding aspects of gardening.
- You need to be especially careful when growing and harvesting plants for human consumption.
- Check the resources at **hort.extension.wisc.edu** for issues not covered in this chapter.

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Introduction

Home vegetable gardening contributes significantly to the world's food supply. Despite Wisconsin's relatively short growing season, vegetable gardening continues to grow in popularity. Home gardeners grow vegetables for various reasons: as a hobby, to supplement store-bought food with homegrown produce, to grow unique types or cultivars of vegetables, or as a source of income.

To grow vegetables successfully, it's helpful to understand plant development and the varied cultural practices for optimal production.

Learning objectives

1. Know what a vegetable is, how they can be grouped according to the plant part eaten, and why different types require different conditions for optimal growth.
2. Understand the significance of site selection, soil preparation, proper planting, and plant management for a successful vegetable garden.
3. Know what characteristics to consider when selecting types and varieties of specific vegetables.
4. Understand the different ways of planting vegetables and why some are more suitable for certain types than others.
5. Understand production techniques, including safe harvest and storage techniques, for common vegetables.

What is a vegetable?

Most people think of lettuce, tomatoes, or beans, but the immature frond of a bracken fern and the pads of a prickly pear cactus are vegetables too. A vegetable is officially defined as "any herbaceous (non-woody) plant or plant part that is eaten with the main course rather than as a dessert." Botanically, however, some edibles we call vegetables are actually fruits or seeds (which are the reproductive parts of a plant).

Vegetables can be classified in many different ways, including botanically by plant family, by plant part consumed, or by the season of growth and temperature limitations.

Classification by plant family

Although edible vegetables can be found in many plant families—especially considering the culturally diverse growing conditions and eating habits of the world's people—the majority of vegetables people commonly grow and eat can be found in 12 botanical plant families.

The **monocot** group of plants contains three families with common vegetables:

- Alliaceae (chive, garlic, leek, onion)
- Liliaceae (asparagus)
- Poaceae (sweet corn)

The **dicot** group of plants contains nine families with common vegetables:

- Apiaceae (carrot, celery, fennel, parsley, parsnip)
- Asteraceae (endive, Jerusalem artichoke, lettuce)
- Brassicaceae (broccoli, cabbage, cauliflower, collard, kohlrabi, mustard, radish, rutabaga)
- Chenopodiaceae (beet, chard, spinach)
- Convolvulaceae (sweet potato)
- Cucurbitaceae (cucumber, melon, pumpkin, squash)
- Fabaceae (bean, jicama, pea, peanut)
- Polygonaceae (rhubarb)
- Solanaceae (eggplant, pepper, potato, tomato)

Classification by plant part

Vegetables are often grouped according to whether we eat their leaves, stems, roots, or reproductive parts (fruits).

Leaves

Leafy vegetables such as lettuce and other salad greens, cabbage, spinach, and Swiss chard are eaten raw or cooked. They are generally very perishable and must be eaten or refrigerated to preserve quality. Brussels sprouts can be grouped with leafy vegetables, but technically the part we eat is an axillary bud, or compressed leaves and stem tissue.

Stems

We eat the stems of asparagus and kohlrabi. Celery and rhubarb are the leaf stalks, or **petioles**, of the plants. Asparagus is harvested as young shoots just emerging from the soil in spring, before the leaves have expanded, while the other vegetables are harvested when mature.

Roots

Root vegetables (tubers and bulbs as well as true roots) include beets, carrots, garlic, leek, onion, parsnip, potato, radish, sweet potato, and turnip. These parts develop below ground as storage organs for the plants and therefore need proper soil preparation for normal development. Many root vegetables store well for long periods of time, under the right conditions.

Reproductive parts

A wide range of vegetables falls within this group. The plant parts eaten may be:

- Highly immature reproductive parts harvested before flowering (broccoli).
- Flowers, either buds or fully open (squash, peas, nasturtium, any of the Brassicaceae).
- Immature fruit taken just after fruit set (green beans, pea pods, okra).
- Fruit that is partially to fully ripe (tomatoes, melons, summer and winter squash).
- Seeds that are fully mature (dry beans).

Classification by season of growth

Vegetable crops are also classified by when they grow best and how long they take to mature. By understanding the growth habits and limitations of each type of vegetable, you can better determine when to plant and when to harvest to maximize the growing season.

Cool season vegetables

Cool season vegetable crops are frost-tolerant—many will grow even when the soil is very cool in the spring, including most vegetables in the Brassicaceae family and English peas in the Fabaceae family.

Cool season vegetables can also be planted in late summer, when the soil is still warm, to be harvested in the fall chill for an especially sweet harvest. Plants that taste best when harvested in cold temperatures include Brussels sprouts, carrots, edible podded peas, and leafy greens. The short days and cool nights result in a higher sugar content in the vegetables, making them taste sweeter. Too much cold can damage some cool season crops; freezing temperatures can damage lettuce and prevent broccoli from forming heads.

To successfully plan a fall harvest of cool season vegetables, it is important to calculate the days to harvest. Use the information on the seed packet or plant label for each type and cultivar, and refer to the average first average frost in your area to determine when to plant (see chapter 9, General Gardening Practices).

Warm season vegetables

Warm season plants are those that cannot tolerate cold soil or air. These include most beans, tomatoes, eggplants, peppers, and all of the vegetables in the Cucurbitaceae family. When choosing cultivars of warm season vegetables to plant in your garden, be sure to find the days to harvest for that cultivar and make sure it matches the warm days available in your area for successful growth and harvest.

Also, know your soil temperature. Warm season crops grow best when soil is above 70˚F, and will not tolerate cold soil. A soil thermometer is a practical addition to your garden tool kit.

Most warm season vegetables require **pollination** in order to produce a crop.

Vegetable pollination

Pollination involves the transfer of pollen from male flower parts to female flower parts. With some vegetables (**dioecious** plants or cross-pollinated types), this requires more than one plant and occurs by different mechanisms, so you need to understand the biology of your plants before planting. Either the wind or beneficial insects can assist with pollination.

Corn is an example of a wind-pollinated crop.

- Corn is primarily cross-pollinated from the pollen from another plant.
- Pollen is windblown from the tassels (male flowers) at the top of the plant to the silks (**stigmas** of the female flowers) farther down on the corn stalks.
- Because of the physical separation of the different flower types, wind is not efficient in moving the pollen down a single row, so it's best to plant corn in blocks to maximize pollination.
- It is best to isolate sweet corn cultivars from other types of corn (field, popcorn, ornamental) or the flavor, color, and texture of the developing kernels will be affected.

Tomato, eggplant, and pepper are examples of vegetables with self-fertile flowers that technically do not need cross-pollination but are greatly helped in pollination by the vibration created from the wind or—even better—the buzzing of bumblebees visiting the flowers to collect pollen.

Because pollinators like bees and flies move freely in the garden, the way plants are arranged in the garden isn't as important. Certain garden practices, however, may interfere with pollination.

- Row covers used to exclude pest insects or keep the plants warm will also exclude pollinating insects. Remove covers when plants bloom or bees won't be able to get to the flowers.
- Don't use insecticides when pollinators are working in a crop. If you must use an insecticide, make applications late in the evening, when pollinators are less likely to be active. Bees will be out working as long as the sun is shining and the temperature is above 55˚F.
- Avoid applying insecticides directly to blossoms.

Native pollinators such as solitary bees, bumblebees, and some types of flies and wasps are the main pollinators of gardens and home landscapes. With the decline of honeybee and native pollinator populations, pollination may

be reduced. Wind, rain, and cold temperatures reduce insect activity and may also result in poor pollination and reduced fruit set.

Flowers and fruit set

With a few **monoecious** vegetables—cucumbers, melons, pumpkins, and squash—the sequence of flower production is important for fruit set. Early in the season, as day length increases, the first flowers produced are male. Once the days begin to shorten after the first day of summer, female flowers begin to appear. Female flowers are typically produced through July, and then male flowers predominate later in the season. Male flowers will also be produced in abundance during times of environmental stress or with disease or insect pressure, or if the plant has already produced a number of developing fruit.

Gynoecious plants, like some cucumber cultivars, only produce female flowers throughout the season, which means you need to plant a separate plant with male flowers for pollination. However, under moisture stress, cool temperatures, or crowded conditions, gynoecious plants will begin to produce male flowers and continue to produce male flowers even when conditions improve.

Planning a vegetable garden

Site selection & preparation

When selecting a location for a vegetable garden, consider the amount of light the site receives, the soil type, and the location's microclimate. Plant vegetables in a place that is sunny, level, and protected from frost pockets or excessive wind.

Light

Vegetable gardens should receive full sunlight for a minimum of 6 hours every day. Anything less will reduce the vigor and yield of most vegetable crops, especially fruiting-type vegetables. Don't locate a vegetable garden beneath a large tree or in the shade of a building or tall fence.

Soil

Obtain a **soil test** before planting a vegetable garden for the first time and routinely thereafter—at least once every 4 years.

- The best soil is a light, sandy loam with good drainage and a sufficient amount of organic matter. You can use compost or a cover crop to add organic matter to the soil, if needed.
- The level of essential soil nutrients is less important, since they can be amended with a wide variety of natural or synthetic fertilizers.
- Soil pH is not of much concern, as most vegetables do fine in soils with pH between 5.5 and 6.8. Some, like potato, sweet potato, rhubarb, and watermelon, tolerate pH as low as 5.0 very well. And most vegetables can tolerate a higher pH up to 7.6 if the soil is high in organic mater and well-drained. Some plant diseases are more severe when the pH is out of this range; if a soil test indicates this, the soil should be amended.
- If your soil is too sandy, add organic matter to improve its water-holding capacity. Clay soils can also be improved by adding organic matter to increase drainage.

See chapter 2, Soils, chapter 3, Composting, and chapter 9, General Gardening Practices for more information on compost and amending soils.

Few vegetable plants tolerate soggy soil, so good drainage is essential. If it isn't practical to alter your site's drainage, raised beds are a good alternative. Raised beds improve soil drainage and allow you to access the crop without causing soil compaction. Raised beds are typically 4 to 5 feet wide and may be as long as you desire. Leave at least a 2-foot aisle on either side of each bed to accommodate foot traffic. See chapter 9, General Gardening Practices.

Access

Locate your vegetable garden relatively close to access to water if irrigation is needed. Likewise, a vegetable garden near the house will encourage you to spend a few minutes here and there weeding, cultivating, and staking plants as needed. A garden near the house may also deter wildlife that may find your garden appealing, such as rabbits, raccoons, deer, woodchucks, various birds, and stray dogs and cats. In some cases, you may need to fence your garden to keep animals out.

Air drainage

Gardens located in low-lying areas are more subject to frost and waterlogged soils than sites in a higher location or on a gradual slope. A site with a south-facing slope is ideal—it will warm up more quickly in the spring, the dew on the foliage will dry more rapidly, and its soils will more readily drain.

You may need to provide wind protection, particularly in open sites where wind gusts can cause physical damage to plants. Plant shrubby windbreaks or locate the garden on the leeward side (the side away from the wind) of a building or fence. Windbreaks will also reduce the rate at which plants lose water through transpiration. Reducing transpiration will not only reduce the amount of water lost by plants, but also preserves the heat that would be lost during **transpiration**.

Proximity to trees & shrubs

When siting a vegetable garden, consider its proximity to trees or large shrubs. Trees not only produce shade, they compete for water and nutrients with nearby plants and their roots may make it difficult to work the soil. Therefore, it's a good rule of thumb to locate a vegetable garden at least 10 feet from the outermost branches of any tree or shrub.

Black walnut and related trees, such as hickory, are a special case—they impede the growth of many vegetables, particularly deep-rooted plants such as tomatoes, potatoes, eggplants, and peppers (as well as ornamentals such as lilacs, peonies, rhododendrons, and azaleas), because of the toxin **juglone** in their roots and leaves. Juglone interferes with plant metabolism and function, causing the plants to yellow and wilt. The greatest toxicity occurs under the canopy within the tree's drip line, but the toxic effects of a mature black walnut tree can extend as far as the roots grow, which can be two, three, or even four times the height of the tree out from the tree trunk.

Weed management

For vegetable crops to produce maximum yields, manage weeds to keep them from competing with crop plants for sunlight, water, nutrients, and space.

- Before you plant, eliminate any perennial weeds.
- After planting, use mulch and cultivate, hoe, or pull regularly to control annual weeds.
- Vegetables such as onions, carrots, radishes, and beets can more easily be overcome by weeds because of the relatively small canopy these crops produce, compared with bean, tomatoes, or vine crops. A quickly growing vine crop with large leaves can successfully inhibit germination of weed seeds just by shading the soil.

See chapter 7, Weeds, for more details on managing annual and perennial weeds.

Soil preparation

For early season crops on sites where erosion is negligible, prepare the planting site the previous fall. Preparing the soil in the fall will prevent any planting delays caused by cold, wet soils and will help reduce soil compaction associated with working wet soils. Compacted soils restrict root growth, reduce the amount of oxygen available to roots, and limit water penetration, all of which can reduce yield, especially of root crops. Work the beds 6 to 7 inches deep to promote good rooting and make sure the soil is free of large stones, clods, or plant debris. The development of root crops in particular can be impeded if the soil is not properly prepared.

For more information on preparing the soil, see chapter 9, General Gardening Practices.

Plant requirements

Various plants respond differently to their environment.

Day length

An increasing or decreasing day length, depending on the plant species, promotes development of reproductive structures—often in conjunction with other factors, such as temperature. Day length, or **photoperiod**, also affects other processes, such as bulbing in onions and tuber development in potatoes. The time of year when specific vegetables are planted can therefore influence whether the plants produce the appropriate edible parts (reproductive or vegetative). For more information on photoperiod, see chapter 1, Botany.

- Short-day plants, such as green onions, only flower when the day length is less than a critical amount.
- Long-day plants, such as lettuce, spinach, and radish, flower only when light exceeds a critical amount. These crops grow well in the fall when the days are getting shorter, because they develop well in cool temperatures and will not be stimulated to flower—or bolt—by the day length.
- For day-neutral plants, including cucumber, peas, beans, and peppers, flowering is not related to length of day or darkness.

Temperature

Temperature affects every plant's rate of growth, water and nutrient uptake, flowering and fruit set, and quality and yield. Certain plants do best under cool conditions, while others prefer warmer conditions.

- Cool season crops, such as peas, spinach, and cauliflower, grow best when temperatures are below 50˚F. They also tolerate frost and deteriorate quickly under warm conditions.
- Warm season crops, including beans, tomatoes, and sweet corn, do not grow well when temperatures are below 50˚F, are killed or severely injured by frost, and thrive under warm conditions. Temperatures above 85˚F, however, can cause pepper and tomato blossoms to abort.

Soil temperatures at planting greatly influence germination; some plants will develop at much cooler temperatures than others.

- Most cool season crops can be sown as soon as the soil is workable and will germinate and grow. However, cool season-type seeds planted in soil that is too warm may not sprout because of heat-induced dormancy. In the case of lettuce, soil temperature greater than 80˚F inhibits germination.
- If warm-season crops are sown when the soil is too cold, the seeds rot instead of sprouting. Wait until the soil temperature is above 60˚F to direct seed or transplant these crops.

Soil temperature can be artificially increased in order to plant earlier or later—see chapter 9, General Gardening Practices and "Using plastic" later in this chapter.

Frost tolerance varies among vegetable plants. Even a light frost (28 to 32˚F) can heavily damage warm season crops, while cool season crops can survive moderate frosts down to about 24˚F. Broccoli and cauliflower can be damaged in the early stages of growth by sub-freezing temperatures, but once the plants are mature they do well at those temperatures. Below this temperature, most non-dormant plants will be killed.

Variety selection

When deciding which vegetables to grow in a garden, start by thinking about who is going to consume them. If you are growing food for a food pantry, ask which vegetables are most popular. If it's for your own garden, consider what you and your family or friends like to eat. Experiment with new vegetables, too.

Another consideration when selecting which vegetables to grow is the size of the garden. If the garden is small, sweet corn and pumpkins may not have the space they need, while salad greens, carrots, and peas will do well in a confined space.

Once you have decided on the types of vegetables to grow, select specific cultivars based on the growth habit of the plant, characteristics of the plant part eaten, disease resistance, and how well they are suited to Wisconsin's growing conditions.

Size of the mature plant

Make sure to consider how much space you have when selecting types and varieties of vegetables. Also consider the planting technique that will be used.

- Standard variety vine crops can cover enormous spaces, while bush types are better suited to small gardens.
- Most vining crops can be **trellised**, which saves space in the garden and provides ample sunlight and air movement for the rapidly growing vines.
- Tomatoes come in many plant types and fruit types. Choose the plant type to meet your garden space; **determinate** varieties of tomatoes are smaller in plant size than their **indeterminate** relatives.

For small spaces, raised beds, and containers, consider cultivars that are specifically designated for containers. These plants typically are dwarf in stature and yet very productive.

Days to harvest

The length of Wisconsin's growing season varies greatly.

- Southern Wisconsin has an average of 120 to 180 frost-free days, with the higher end of the range closer to Lake Michigan.
- In northern parts of the state, the growing season is only 90 to 120 days.

Most vegetables will mature within this period, but some long-season crops, such as pumpkins and late-planted sweet corn, may require more time than this. Pay attention to the number of days to harvest listed on the package and in the seed catalogs. "Days to harvest" is the average number of days, given optimal growing conditions, that it will take for the plant to produce the first harvest.

- With some crops, such as tomatoes, it is the time from planting the transplants to the first harvest, so you will need to include the time to produce the seedling (if you are starting from seed) and the time from first harvest to the frost that will end your harvest.
- For other plants, such as beets, it is the time from seed to harvest of either the greens or the tap root and does not need to be adjusted.

When planting fall crops, count backward from the average date of first frost the number of days to harvest to determine when to plant these crops. Because of the cooler nights and shortening day length, you may need to add in additional days. As the temperatures decrease plant growth will slow, but developing fruits, foliage, or tap roots for harvest will be more flavorful in the cool temperatures.

Heirlooms

Heirloom plants are old-fashioned varieties that haven't been hybridized. Heirloom vegetables are often the ancestors of modern-day cultivars.

- Many of these varieties were selected hundreds of years ago for their flavor.
- Part of the charm of heirlooms is that they often come with a story (see box).
- Heirloom seed, which must be open pollinated, is available from several seed companies or it can be obtained from other gardeners.

Note that heirlooms may not produce as much, last as long on your counter, or be as uniform or disease-resistant as hybrid varieties.

Heirlooms

Heirloom plant varieties not only tend to taste better and look different, but they often have a story attached—one that connects people to food in a meaningful way.

Take, for instance, the story of the 'Beaver Dam' pepper, brought to Beaver Dam, Wisconsin in 1912 by the Hungarian immigrant Joe Hussli. The Hussli family liked its crunchy texture and mildly hot flavor and began using it in sandwiches.

Nowadays, seed banks consider varieties like the 'Beaver Dam' important because they can carry valuable genetic traits, such as heat tolerance. And growing the 'Beaver Dam' pepper is a fun way to connect with Wisconsin's colorful and tasty immigrant history.

Disease resistance

Many vegetable cultivars have been developed to resist specific plant diseases. Resistance is not immunity—these cultivars may still develop some disease, but their yield won't be greatly affected.

Note that no variety is resistant to all diseases. In many cases, using resistant varieties can reduce or eliminate pesticide use or allow the production of a crop that wouldn't otherwise be possible. Some seed catalogs mention disease resistance when describing varieties.

Planting vegetables

After the site is selected, the soil prepared, and the plants selected, you are ready to put your crops in the ground. Some vegetables can be direct seeded in the garden, while others will need to be transplanted.

Direct seeding

Many crops can be successfully planted directly in the ground as seeds. Place the seed in the soil at about the same depth as the width of the seed, at the prescribed intervals, and cover with an equal amount of fine soil. Keep the soil evenly moist until the plants germinate. Some seeds, such as lettuce, require light to germinate, so it's important to follow any special planting instructions on the seed packet.

Using transplants

Some species need to be started indoors, as our growing season is too short to allow them to develop from seed if planted outdoors when conditions are appropriate for germination. Start your seeds indoors several weeks before you want to move the transplants outside. For additional information on starting seeds, see chapter 19, Plant Propagation.

You need to **harden off** transplants before you plant them in the garden. Hardening off gradually acclimates the plant to the wind, more intense light, and fluctuating temperatures they will be exposed to outdoors. A sheltered location or cold frame provides some protection to the plants during this 1- to 2-week period. Gradually increase the exposure to sun during this time so the plants won't be sunburned. Move plants back indoors temporarily if frost or other adverse conditions are predicted. Reduce watering and withhold fertilizer while plants are being hardened off.

When you are ready to plant

Plant vegetables when the soil temperature is warm enough for the specific crop. Seeds planted too early are much more susceptible to **damping off**, root rot, and maggot damage because germination is slowed by cool soil temperatures. Some crops, such as onions and cole crops, should be planted at certain times to avoid pest problems.

Using plastic

Clear plastic is a good way to warm the soil and allow for much earlier planting, but weeds can grow under it. Spread the plastic over the prepared planting areas, anchoring the sides firmly using soil, rocks, or boards, and leave it in place to warm the soil for a week or two before planting. The plastic can be left on the bed all season for warm season crops such as melons or cucumbers. Slit the plastic to place transplants in the bed and cover it with an organic mulch, such as grass clippings, to suppress weed growth.

Black or dark-colored plastic warms the soil—not as much as clear plastic does—but it has the advantage of weed suppression. The dark color absorbs heat and radiates heat to the plants. For more information, see chapter 9, General Gardening Practices.

Soil mounds or trenches

A raised bed or mound of soil warms up more quickly than the surrounding area, allowing for much earlier planting. Plants can be also buried or mulched in trenches to temporarily protect them from adverse weather conditions.

Spacing

Direct seed or transplant crops at the recommended intervals listed on the seed package. Dense planting may promote plant disease.

Thinning

Seeds that have been planted directly into the garden may need to be thinned. This may not be the most pleasant activity as it is often viewed as destructive. However, small-seeded plants such as carrots, radishes, beets, and lettuce are often seeded closer together than recommended because of the difficulty in handling the small seeds and the lower germination rate.

With experience, you will be able to better gauge how to space the seeds and how many seeds to plant initially. Otherwise, you will need to thin. This may be done with your fingers or tweezers for small seedlings. If you aren't going to transplant the seedlings, you can simply pinch them off at ground level and discard or eat them. Some crops, such as carrots, do not transplant well.

Vegetable production & management

After planting, all vegetable crops require some maintenance to ensure a bountiful harvest. General practices of watering, mulching, and season extension are covered in chapter 9, General Gardening Practices.

Sequential or succession plantings

To extend the harvest season and not overwhelm you with a bumper crop of a given vegetable all at once, you can plant many crops at weekly intervals over several weeks. Bush beans are a good example of this. Many cultivars of bush beans have a "days to harvest" of 45 to 50 days, and at that time the majority of the fruit will be produced. By spreading out the planting dates you will succeed in spreading out the harvest as well.

In addition to repeated plantings of the same crop, succession planting is a term used to describe the planting of one crop after another in the same location. For example, early season lettuce that has finished production by early summer can be followed with a mid-season crop of a different vegetable, such as beans. If planned carefully, you could follow the beans with a late-season planting of kale or another cool season plant.

Crop rotation

Crop rotation, which involves varying the crop you plant in a given location, is a healthy practice whether you are large-scale farming or gardening in a raised bed.

- Rotating crops to different areas of the garden reduces the chance of insect or disease organisms building up in the soil.
- Crop rotation helps reduce nutrient demand on a given area.
- Rotating several short season crops over the course of one year helps keep the soil healthy also.

For home gardens, a three-year rotation is usually attainable. Plan ahead before planting—determine where vegetables were planted the previous season and make a plan to put each in a different location in the upcoming season. It may be beneficial to draw a map of your garden with the location of each crop and save this map to avoid planting the same crop in that location the next year.

Rotate plant families. Plants in the same plant family are susceptible to the same pests and problems and should not follow one another in a rotation. When mapping out your garden and planning your rotation, remember that potatoes, tomatoes, peppers, and eggplant are all in the Solanaceae family, cucumbers, melons and squash are all in Cucurbitaceae, and radish, cabbage, broccoli and turnip are all in Brassicaceae.

- A three-year rotation could be Fabaceae-Cucurbitaceae-Solanaceae, or beans-squash-tomatoes.
- If rotating vegetables on an existing permanent trellis, try a three-year rotation of pole beans-cucumbers-indeterminate tomatoes.
- Consider adding a **cover crop** of oats or buckwheat to your rotation. Cover crops grow quickly, help suppress weeds, and improve soil organic matter, in addition to adding nitrogen to the soil.

Try to plan the rotation so that successive crops benefit from their predecessor.

- Vegetable plants in the Fabaceae family are always good to rotate into an area, even if only for part of a season because of their nitrogen-fixing characteristic.
- For a year-to-year rotation of long season plants, consider planting tomatoes after pole beans. These represent two different plant families with different nutrient requirements.

Nutrition

Fertilizers can come from organic (natural) or inorganic (synthetic) sources. With adequate environmental conditions, soil microbes break down organic matter and supply the chemicals that plants need to their roots. Organic fertilizers can also improve soil **tilth** and health as well as fertility. Inorganic fertilizers can be used to quickly supply nutrients to plants. For more information on soil fertility and fertilization, refer to chapter 2, *Soils and Organic Soil Conditioners*.

Pest management

Pest scouting and management is an ongoing process whenever vegetables are grown. Insect pests can migrate into a garden unannounced; if you're not actively looking for them, you may not notice they have arrived before they reach damaging levels and your choice of management methods is limited. This also applies to plant diseases. Rainy weather or heavy dews provide ideal conditions for plant diseases. Check your plants carefully when weather conditions warrant. Similarly, the warmer the weather, the faster insects will develop. Refer to chapter 18, Phenology, for a discussion of the impact of temperature on insect growth and plant growth and health.

There are several management practices that can be used to manage vegetable pests. Regardless of what you choose, always use cultural practices as your first line of defense against insects, weeds, and plant diseases. Use chemical pesticides as a last option and only when pest numbers have reached damaging levels. For more information on general pest management, refer to chapter 4, Pest Management. For specific key disease and insect pests in each crop, refer to chapter 5, Entomology, and chapter 6, Plant Pathology.

Physiological disorders

Not all maladies that affect vegetables are the result of insects or plant diseases. In fact, some problems arise because of improper cultural practices or environmental conditions to which the crop is subjected. Because living organisms don't cause these problems—and because they disrupt the normal structure or functioning of the plant—such maladies are called "physiological disorders." Examples of such disorders include:

- **Blossom-end rot** of tomatoes caused by insufficient calcium uptake as a result of irregular rainfall or irrigation.
- **Forking** in carrots because of too much nitrogen in the soil or because of rocky soil.
- **Ricey curds** occur when cauliflower is exposed to excessive heat that causes the surface of the curds to separate into very small grains.
- **Sunscald** of tomato and peppers may result when a fruit is exposed to direct sunlight, for example when the plant is defoliated by disease.
- **Catfacing** is the development of deep indentations in the blossom end of tomatoes that occurs when the fruit is exposed to temperatures below 50˚F.

These are just some of the physiological disorders that affect vegetable crops. When trying to identify the cause of a problem, keep in mind that a plant disease or insect pest may not always be the culprit. Also remember that once a physiological disorder occurs, it can't be remedied. The blemish remains, and there are no pesticides that will correct or prevent the problem. In many cases, you can remove the blemish and safely consume the produce.

Harvest

Pick your vegetables at the appropriate stage of maturity to preserve the quality, flavor, tenderness, and texture. Eating and storage quality are reduced when produce is immature or over-mature. Remove any non-edible portion, such as carrot tops, to prevent excessive water loss.

Ideally, vegetables should be harvested in the morning while they are still cool and haven't absorbed the day's heat. The warmer the conditions are when harvesting and storing crops, the higher the rate of **respiration** and loss of water, the more rapidly quality deteriorates. To prevent the spread of plant diseases, however, it is best to wait until the plants are dry before performing any activity in the garden.

When harvesting, keep the following best practices in mind:

- Make sure your hands are clean before you pick, and avoid harvesting when you are sick. Protect the produce from coming in contact with animals and animal waste (including bird droppings) during and after harvest.
- Place just-picked vegetables in a clean harvesting basket in a cool, shady spot.
- Bring a 5-gallon bucket of clean, cold water to immerse leafy greens to cool them quickly. After a few minutes, when cool, remove them and drain them in a clean basket or tray that allows the water to drip and keeps them off the ground. Keep the greens in the shade to keep them from wilting.
- Remove any excess loose soil from vegetables before bringing them into the house; to prolong storage don't thoroughly wash them until just prior to use.
- Refrigerate vegetables that require cool storage conditions. Some vegetables, such as carrots, need to be stored near 32˚F or they will continue growing.
- Do not refrigerate tomatoes, potatoes, or sweet potatoes, as this will affect their quality.

Post-harvest care

Most perishable vegetables need cool temperatures and high humidity to prevent softening and wilting. Refrigerator storage provides the proper temperature, but it may be too dry if your vegetables aren't properly protected. Other vegetables may require different conditions.

Some vegetables should not be stored with other types of produce, because they may pick up odors (for example, celery will pick up onion odors) or suffer ethylene damage. Ethylene is a gas given off by some fruits as they ripen that can cause some vegetables to turn brown or bitter.

Conclusion

Growing vegetables is a popular and healthy activity. Whether you are growing them in a large community plot, a small raised bed, or a container by the back door, a few basics and some practice will help you become a better gardener in a short time. Understanding plant families, the difference between cool season and warm season crops, and using that soil thermometer will make you a good veggie gardener. Also, practices such as crop rotation, sequential planting, and season extenders can impress your community garden neighbors.

The edible nature of vegetable gardening and the need for annual replanting differentiates it from other types of gardening. Keeping food clean and safe is very important. Planting the vegetable garden every year gives you the wonderful opportunity to correct mistakes from the previous year and try new things.

Resources

Wisconsin Horticulture publications are available at hort.extension.wisc.edu.

FAQs

When can I plant my tomatoes?
Tomatoes are warm season plants that are very cold sensitive. Do not plant until after last frost date for your area—ideally the soil temperature should be above 60˚F. Tomatoes prefer soil temperatures in the 70˚F range, and moderately warm air temperature. Choose a cultivar that has a realistic "days to harvest" for your area, which for tomatoes is the time of transplanting to harvesting the first ripe tomato.

Can I use milorganite in my vegetable garden?
Milorganite is approved for use in a vegetable garden, but because it is a by-product of sewage sludge it is not certified organic. It is generally safe to use.

What do I do about the spots on my tomato leaves?
Spots are generally caused by fungal pathogens. They can be prevented or reduced by ensuring good air flow around plants to reduce humidity, keeping overhead watering to a minimum, mulching to prevent splash of spores from soil to leaves, and choosing resistant varieties. Some leaf spot diseases are more serious than others, so a sample should be submitted for an accurate diagnosis.

Why are the bottoms of my tomatoes turning black and mushy?
Blossom end rot is a common disease on tomatoes that forms, most often, when not enough calcium is moving into the developing fruit. In Wisconsin, where there's adequate calcium in the soil, blossom end rot is most often associated with irregular watering.

Vegetables, practice exam questions

1. **Which is the least useful classification scheme for vegetables?**
   a. Botanical plant family
   b. Part eaten
   c. Prefered season of growth
   d. Color
2. **Which is a cool season crop?**
   a. Broccoli
   b. Sweet corn
   c. Tomato
   d. Winter squash
3. **Why is it useful to know which vegetables belong to which botanical plant family?**
   a. Some families contain plants with poisonous parts as well as edible parts
   b. Prefered season of growth is often similar among vegetables in the same family
   c. Crop rotation strategies can be based off botanical plant families
   d. Vegetables in the same family are often prone to similar disease and pest issues
   e. All of the above
4. **Which of the following is/are true?**
   a. Adding organic matter will improve both sandy soils and clay soils
   b. Less than 6 hours of direct sunlight will result in reduced vigor of vegetables
   c. Juglone can enter the garden via leaves, roots, and compost
   d. Low lying areas are prone to waterlogging and unseasonable frosts
   e. All of the above
5. **Which of the following is a consideration for variety/cultivar selection?**
   a. Size of mature plant
   b. Days to harvest
   c. Disease resistance
   d. Taste
   e. All of the above
6. **Which of the following is not a transplanting technique?**
   a. Thinning
   b. Fluctuating day and night temperatures before transplanting
   c. Gradually increasing sunlight exposure before transplanting
   d. Using plastic or raised or mounded soil to warm soil
7. **Different varieties/cultivars of vegetables can have different days to harvests.**
   a. True
   b. False
8. **Which of the following is the most acceptable crop rotation strategy over a 4 year period?**
   a. Tomatoes-potatoes-beans-squash
   b. Beans-broccoli-radish-tomato
   c. Pumpkin-cabbage-cucumber-peas
   d. Tomatoes-beans-squash-tomatoes
9. **Which is not a recommend harvesting technique?**
   a. Washing hands before harvesting
   b. Storing vegetables in a cool, shady spot until finished harvesting
   c. Removing excess soil while in garden
   d. Washing produce right after harvest
10. **A frost of 30˚F is least likely to damage which vegetable?**
    a. Eggplant
    b. Pumpkin
    c. Winter squash
    d. Cauliflower
11. **Garden produce is so fresh that it is immune from carrying food-borne pathogens.**
    a. True
    b. False
12. **What conditions do most vegetables require for storage?**
    a. Low temperatures, low humidity
    b. Room temperatures, high humidity
    c. Low temperatures, high humidity
    d. Room temperatures, low humidity

Answer key
1. (d) 2. (a) 3. (e) 4. (e) 5. (e) 6. (a) 7. (a) 8. (d) 9. (d) 10. (d) 11. (b) 12. (c)