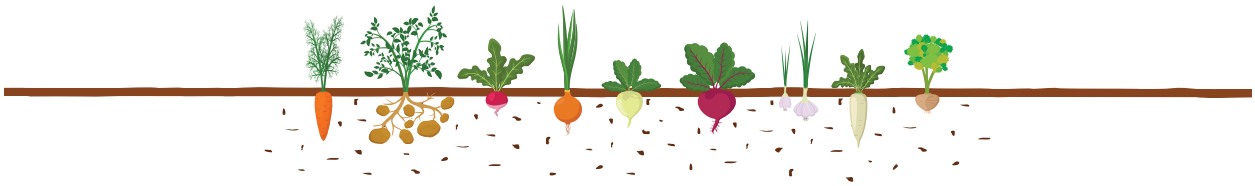
# Kansas Garden Guide



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# Kansas Garden Guide


**Rebecca McMahon,** *Horticulture Agent*
*K-State Research and Extension-Sedgwick County*

**Raymond Cloyd,** *Professor and Extension Specialist*
*Department of Entomology, Kansas State University*

**Megan Kennelly,** *Professor and Department Head*
*Department of Plant Pathology, Kansas State University*

**Londa Nwadike,** *Extension Associate Professor and Food Safety Specialist*
*Kansas State University/University of Missouri*



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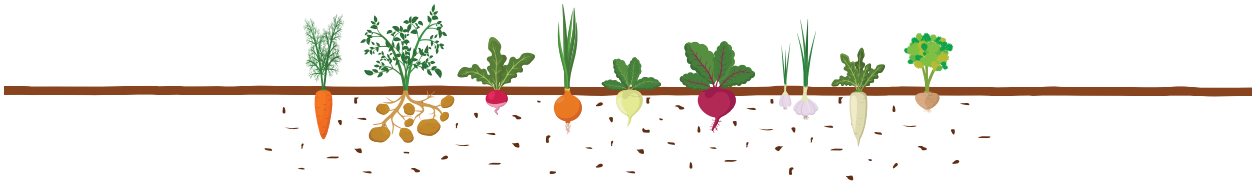
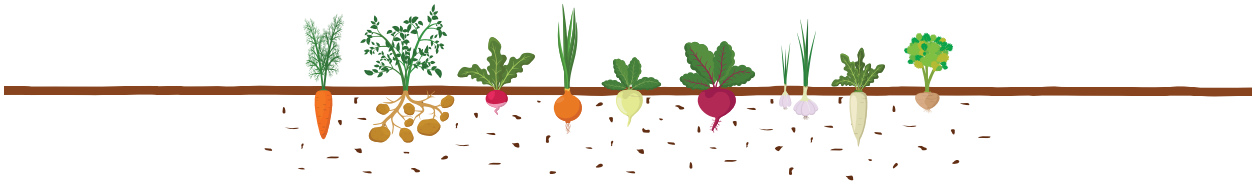


# Introduction



Vegetable gardening continues to capture the interest of millions of Americans each day. The vegetable gardener has evolved from the rural farmer to the urban city dweller. Metro areas around the United States are creating space for community gardens. Farmers markets continue to grow as the movement to eat locally grown food persists. Restaurants are adopting more local food items to appeal to the emerging menu trend. Grocery stores are stocking more local and organic inventory than ever before. The push to eat local is a leading factor to the recent growth in home gardening, and there are countless reasons why you should start growing your own food today.

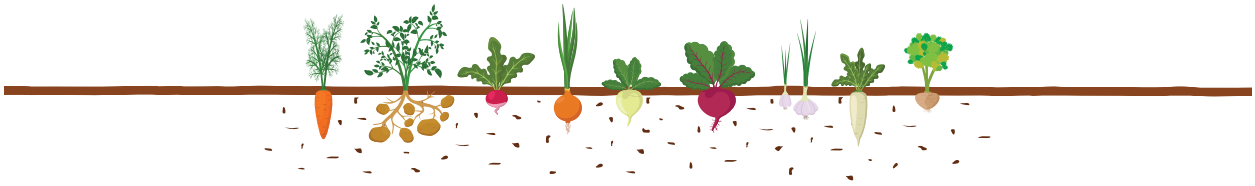
The investment of a home garden yields multiple appealing benefits: sustainable living, access to healthy food, and the pure enjoyment that goes along with gardening. In Kansas, home gardeners produce $20 to $25 million worth of vegetables every year. These vegetables not only provide food budget savings, but also make valuable contributions to overall nutrition and health. Most home gardeners agree that homegrown produce provides the ultimate in vegetable flavor as well as the satisfaction of knowing you grew it yourself. The food from a vegetable garden is only one of many benefits of home gardening. The relaxation and enjoyment derived from gardening is well known to many home gardeners. A garden can also provide therapy, education, and personal development.

Vegetable gardens have been incorporated into community centers, urban spaces, backyards, and many other settings through container gardens, raised beds, and in-ground gardens. Gardens can provide the opportunity to create therapy for people in need, such as those undergoing rehabilitation. Gardening is also an excellent 4-H or youth project. The garden is a wonderful laboratory for experimenting with plants. Everyone can learn something from simple experiments in the world of plant science. It can provide a sense of contentment, knowing that the food is cultivated over time and ultimately harvested as the result.

Successful gardens are the result of good planning, watchful care, and effective management. With a few simple tools, a little land (or a lot of containers), and a desire to nurture plant growth, anyone can become a home vegetable gardener. This guide will provide you with the advice and steps needed to achieve a successful home garden. Each chapter will focus on a different topic that will contribute to the overall scope of vegetable gardening. The *Kansas Garden Guide* combines knowledge gained from decades of gardening, making it an essential sourcebook to garden throughout communities in Kansas.

# Chapter 1

# Starting and Planning a Garden



The garden location should be selected with care before the first seed is planted. Preparation and planning are needed in advance of the first garden season.

## Choosing a Garden Location

When planning a location for the home garden, there are several factors that should be considered. Gardens should be placed in a sunny, level area away from large trees. Tree roots compete for soil nutrients and water, which would ultimately take resources from the garden area. A source of water should be accessible when irrigation is necessary. If irrigation is an option, this will be important to consider when planning the garden. In many Kansas locations, protection from wind is desirable. It is beneficial to take advantage of fences, small shrubs, or buildings that can provide a windbreak.

## Soil

Vegetables grow best in well-drained, fertile soil. Sandy loam soils are ideal for vegetables. Most home gardens, however, do not have this soil composition. Compost or manure spread over the garden and worked in with a garden tiller will improve not only fertility but also soil condition. Adding organic material such as manure or compost is an important practice in successful gardening.

## Water

Water is a necessary component to any home garden, and access to a reliable water source will be vital to growing healthy garden crops. In some instances, irrigation will need to be added to the garden site. Depending on the scale of the garden, hand-watering may be an option. Installing drip irrigation and/or sprinklers may be wise to maintain the vegetable garden. For more suggestions on different methods of applying water, see the section on Watering the Garden in Chapter 7, *Garden Maintenance*.

## Starting a New Garden

After a garden location has been selected, it may be necessary to prepare the site before gardening can begin. Assess the existing vegetation on the planned garden site to determine what weed control steps may be needed before the first planting. If the site primarily has fescue lawn grass or annual weeds (such as henbit, chickweed, or crabgrass), it is likely that either tilling the area or using tarps or mulch to smother the plants will be necessary for a good start to the garden. If the site has persistent perennial weeds or spreading grasses such as bindweed or bermudagrass, it will be necessary to spend several weeks to several months killing the existing plants and preparing to plant.

### Steps to Preparing a New Garden Site

| For non-persistent plants | | For persistent perennial plants | |
|---|---|---|---|
| **Option 1** | **Option 2** | **Option 3: Using herbicides** | **Option 4: Herbicide-free method** |
| 1. Mow or scalp existing vegetation.<br>2. Till and incorporate soil amendments.<br>3. Plant | 1. Mow or scalp existing vegetation.<br>2. Cover area with tarps, cardboard and mulch, or a biodegradable mulch for 3-8 weeks.<br>3. Plant | 1. Spray with glyphosate while plants are actively growing.<br>2. Repeat herbicide application as needed every 2-4 weeks for up to 3 months.<br>3. Mow or scalp dead vegetation.<br>4. Till and incorporate soil amendments.<br>5. Plant, taking care to maintain thick mulch on unplanted areas and around plants. | 1. Mow or scalp existing vegetation.<br>2a. Cover area with non-biodegradable tarps for 3-8 months to smother vegetation, OR<br>2b. Till area every 2-3 weeks for 3-8 months to kill vegetation, raking out plant material as needed.<br>3. Incorporate soil amendments.<br>4. Plant, taking care to maintain thick mulch on unplanted areas and around plants. |

## *Deciding Between an In-Ground or Raised Bed Garden*

There are many good reasons to choose to have your garden growing directly in the ground and many good reasons to consider a raised bed garden.

Raised beds may be a particularly good choice if you have a heavy clay soil with poor drainage characteristics. In that circumstance, a raised bed garden allows soil improvements to occur right away and provides an ideal soil for optimum plant growth. Raised beds can also be a good choice if you need a garden area that is more accessible due to physical limitations, such as the inability to kneel or bend significantly. Lastly, if you have limited space in which to have a garden, a raised bed garden can help you use space efficiently and maximize your harvest.

However, raised bed gardens are significantly more expensive to start, as the cost of the edging materials and all or part of the soil for each bed will need to be considered. Raised bed gardens will also dry out more quickly, making them less water-efficient and more challenging to keep moist during heat and drought.

For information on preparing and gardening in raised bed gardens, see the chapter on *Raised Bed Gardening*.

## Make a Sketch

Draw a scale diagram of your garden space and plan the garden using the information below. Allow everyone involved to participate by suggesting their favorite vegetables. The plan may need multiple revisions, but this process can help to identify whether there is sufficient space available. This plan can serve as a reference for this year and the years to come. It will also be a guide to obtaining the seeds and plantings for your vegetable garden.

## Optimizing Garden Space

A wide variety of vegetables can be grown in Kansas. Space available and individual preferences play an important part in deciding what to grow. Beans, beets, summer squash, peppers, tomatoes, lettuce, onions, radishes, and turnips are well adapted for growth when space is limited.

Sweet corn, vine squash, cucumbers, pumpkins, and melons require more space for growth and should be considered only if adequate space is available. Alternatively, consider using staking or trellising options to allow for vining crops in smaller garden areas. Don't be afraid to experiment with unfamiliar vegetables, but plan to be able to use most of the vegetables you produce.

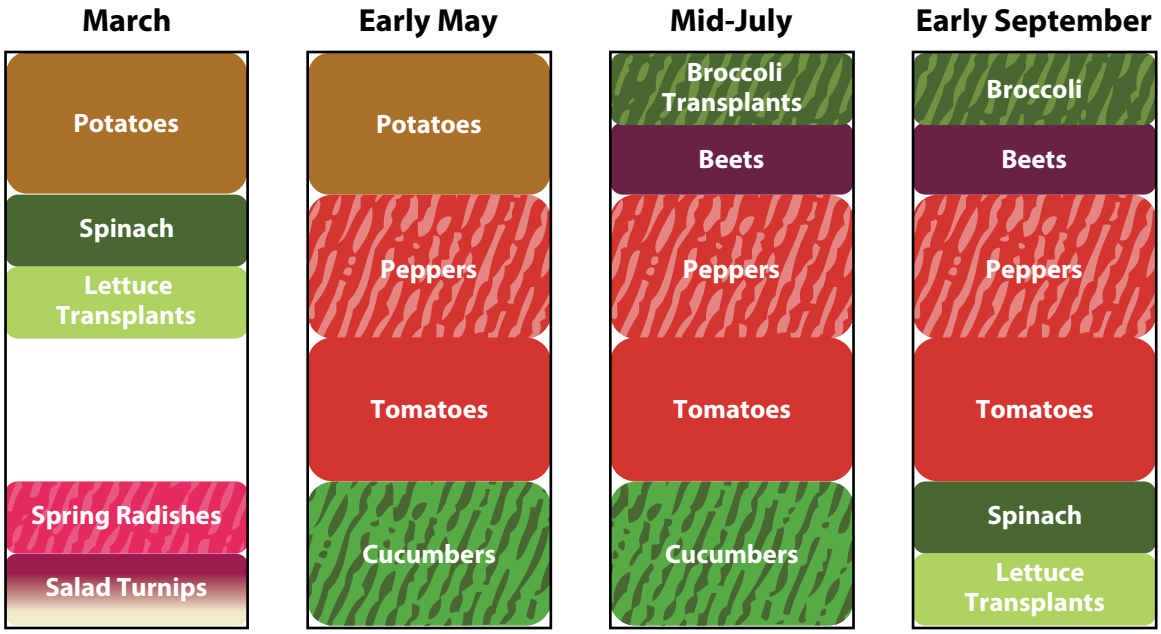
**Plant spacings.** Each vegetable crop has different spacings required to maximize its productivity. Planting too close together can reduce yield and increase disease problems. Planting too far apart can waste usable space and increase weed problems. Refer to the Vegetable Crop Information chart in the back of the book for information on plant spacings.

There are many ways to arrange a garden space. This is partly dependent on the overall size of the garden, the crops you want to grow, and the tools and equipment you have available. In addition, different crops may need different amounts of space between the planting rows to provide adequate space for maintenance and harvest. Refer to the Vegetable Crop Information chart in the back of the book for information on plant row spacings.

Very large gardens are often planted in rows with significant space between the rows to accommodate larger plants or tillage equip-

### Example of Optimizing Garden Space

In this sample garden plan, multiple crops are planted in the same space throughout the garden season in order to increase total garden yield. This is especially effective in small gardens. Depending on the year, this method may entail planting transplants into an existing planting of another crop or removing a crop that is not producing as much as earlier in the season to make room for a new crop.



ment. Medium sized gardens, small gardens, or gardens that use no-till techniques may arrange plants more closely together.

The publication titled *Garden Choices and Templates for Kansas School Gardens* (MF3590) includes a wide variety of plant descriptions and garden templates to help you think about plant choices and spacing. It is useful for home gardens, as well as school gardens.

**When to plant.** Use the Vegetable Garden Calendar in the back of this book to plan your garden space. Spinach, lettuce, radishes, peas, and green onions can be harvested early in the season. The same space is then available for late-season crops of beans, eggplant, tomatoes, or potatoes. Plant lettuce, radishes, or spinach between potatoes, cabbage, or other cole crops. (Cole crops include broccoli and other cabbage relatives.) Before the potatoes or cole crops get very large, the other vegetables will have been harvested.

Most home gardeners have too much produce maturing at the same time. This is desirable if you plan to can or freeze the vegetables. For table use, it is best to stagger plantings. Plant a few radishes every 4 to 5 days instead of all at once. This will provide a steady supply of radishes of ideal maturity over a longer time. Also stagger plantings of lettuce, beans, sweet corn, and peas.

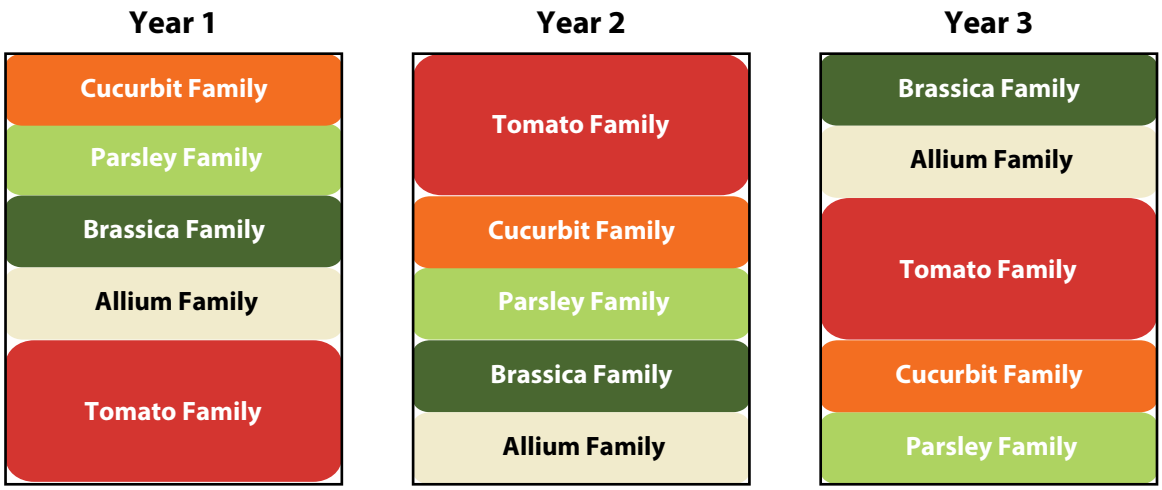
Select a place along one side of the garden for crops such as rhubarb, asparagus, strawberries, or bush fruits. These perennials will continue to grow next year without replanting. If planted in the garden, they will be in the way during tilling operations.

## Rotate Crop Location

Another factor to consider when planning your garden is crop rotation. Planting the same crop in the same spot every year can result in a buildup of insect and disease pressure. It can also result in the reduction of soil fertility and an increase in weeds. Planting vegetables from the same plant family in different areas each year will help support soil health and reduce insect and disease challenges. At least a 3-year rotation between different plant families is recommended.

In a larger garden, it can be simpler to move crop families to a different area each year, especially when it is possible to include cover crops in the rotations. (See Cover Crops in the *Improving Soil Health* chapter.) In a small or very small garden, including raised bed

### Example of 3-Year Crop Rotation



### Common Vegetable Crop Families

| Allium Family | Brassica Family | Cucurbit Family | Legume Family | Tomato Family |
|---|---|---|---|---|
| Chives | Arugula | Bitter melon | Dry beans | Eggplant |
| Garlic | Bok choy | Cantaloupe | Edamame | Garden huckleberry |
| Leeks | Broccoli | Cucumbers | Long beans | Ground cherry |
| Onions | Brussels sprouts | Gourds | Pole beans | Peppers |
| Shallots | Cabbage | Honeydew melon | Shelling peas | Potatoes |
| | Cauliflower | Pumpkin | Snap beans | Tomatillos |
| | Collards | Squash | Snap peas | Tomatoes |
| | Kale | Watermelon | Snow peas | |
| | Kohlrabi | | Southern peas | |
| | Mustards | | | |
| | Radish | | | |
| | Rutabaga | | | |
| | Turnip | | | |

| Aster Family | Grass Family | Amaranth Family | Mallow Family | Parsley Family |
|---|---|---|---|---|
| Endive | Corn | Amaranth | Okra | Carrots |
| Escarole | | Beets | | Celery |
| Jerusalem artichoke | | Chard | | Cilantro |
| Lettuce | | Spinach | | Dill |
| Sunflower | | | | Fennel |
| | | | | Parsnips |
| | | | | Parsley |

gardens, it is important to move plants from each crop family as much as is feasible each year — even if it is a short distance. If crop rotation is not very feasible due to the size of garden or crop selection, it becomes even more important to select disease resistant varieties and closely monitor soil health.

## Choosing Vegetable Varieties

In choosing varieties for the home garden, consider factors such as disease resistance, weather adaptability, yield, maturity date, size, shape, color, and flavor. Seed companies and state agricultural research stations are constantly developing and testing improved vegetable varieties and procedures. The following sources of information are useful when choosing varieties:

- Ask your local K-State Research and Extension agent for the publication, *Recommended Vegetable Varieties for Kansas*, L41 (*https://bookstore.ksre.ksu.edu/pubs/l41.pdf*)
- Use varieties that have performed well for you or other local gardeners.
- If you have a special use for a particular vegetable, such as freezing, exhibiting, or canning, check with your local extension agent or study seed catalog recommendations.
- Check with your local seed store or garden center for advice on what to plant.
- See the chapter *Vegetable Crops* for plant-specific, variety recommendations.

If you are unable to start seeds indoors before planting outdoors, you may want to buy vegetable seedlings to transplant to the garden. These can be obtained from local greenhouses or seed and garden centers. Again, make sure the varieties are what you want to produce.

After careful research and planning, purchase the seeds and plants you want so you will have them when you need them for your garden.

## Tools and Supplies

While several items are essential to raise a garden, it is not necessary to have a lot of equipment. If your friends have gardens, you might share equipment and supplies. Select supplies according to the size of garden you want. The lists below will help you get started. Other tools and supplies will likely be needed as your garden develops, but these are the minimum items needed to get started. Some garden tools are designed with accessibility in mind, with padded grips, longer handles, or other special features. The publication *Safety Tips for Farming with Arthritis* (MF3470) includes suggestions for tools and best practices that can be adopted by home gardeners. (*https://bookstore.ksre.ksu.edu/pubs/MF3470.pdf*)

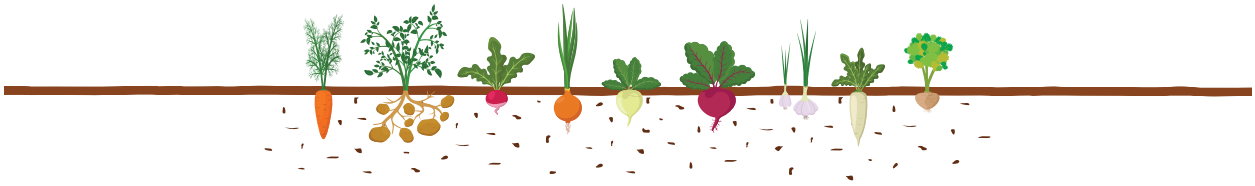
### General List of Gardening Supplies

(not size specific)

- Spading fork or shovel or tiller
- Hoe and garden rake
- Trowel
- Sprayer or duster
- Labels or row markers
- String and yardstick
- Fertilizer
- Fungicides and insecticides as desired
- Hose and other irrigation supplies
- Compost, manure, or peat moss
- Trellises, stakes, and cages as necessary

# Chapter 2

# Raised Bed Gardening



Raised bed gardening has become a popular gardening practice. Smaller home lots and families have led to the downsizing of planting areas and the amount of produce needed. Raised bed gardens offer several advantages over conventional gardening plots. Soil raised above ground level warms up more quickly in the spring, which allows for earlier planting dates. These beds are usually filled with high-quality soil, which improves drainage and increases yield.

Raised beds are smaller than traditional gardens, making them easier for most people to maintain. For example, the denser plantings help reduce weed infestations. Taller raised beds can make gardening accessible for those who are not physically able to bend or work close to the ground. The main disadvantage of this system is that elevated beds tend to dry out more quickly in the summer months, increasing the need for watering.

## Construction

The beds are usually raised off the ground 6 to 8 inches. The framework for this structure can be made from several types of materials. Some gardeners suggest not using a support but, instead, mounding the soil. This is the simplest method and works well.

Most gardeners use some sort of framing materials such as railroad ties, landscape timbers, planking, rock, manufactured blocks, or bricks. Do not use railroad ties that are still oozing sticky, black creosote or have a strong odor.

Naturally rot-resistant woods such as cedar and redwood are also a good choice. Other species of wood product used are often treated with wood preservative to increase the life of the structure because wood rot can become a problem over time.

Questions sometimes arise over the use of treated lumber in vegetable beds. The wood preservative ACQ (Alkaline Copper Quaternary) is the most widely available wood preservative for residential use. It may be used for raised bed construction. Some gardeners still prefer to line the sides of beds with polyethylene plastic so that roots do not touch treated wood. Do not use plastic on the bottom of the beds as this will prevent drainage.

## Size

The size of the raised bed varies depending on the gardener. A suggested size is either 4 by 8 feet or 4 by 10 feet. The 4-foot width is preferred because it allows for an easy reach

into the bed from either side to tend the plants. This keeps soil compaction from occurring because the garden soil is not walked on. Length of the bed can also vary depending on type of construction materials used and the space available for the bed.

A 6- to 8-inch depth of the bed at minimum is recommended because this will allow the added drainage and improved soil tilth needed to produce healthy plants. This depth is also where most of the main feeder roots of the vegetable crops will be located for nutrients and water uptake. Raised beds can also be as deep or high as about 30 inches if there is a need to accommodate larger perennial plants or a desire for a more accessible garden. A raised bed deeper than 30 inches will make it difficult to maintain taller plants.

## Location

As with any garden site, the bed should be in full sun for best production. If a full sun location is not available, pick a spot that will get at least a half day of sunlight — shady areas will result in poor production.

The bed should also be near a water source, as raised beds will require more water than conventional plantings. The best location also provides wind protection. Summer winds can take their toll on vegetable crops. A tree, shrub screen, or border of plants or fence will work if it is on the south or southwest side to protect the garden from harsh summer winds.

## Designing and Locating a Raised Bed Garden for Accessibility

Raised bed gardening can increase the accessibility of gardening activities for those with a variety of different physical needs. It may be necessary to make a raised bed narrower to accommodate a shorter reach. By selecting a wider edging material or constructing a wider platform on the top edge of a raised bed, seated gardening can be available. Adjusting the height of a raised bed can also accommodate different needs.

Special consideration should be given to the area surrounding a raised bed garden as well. A firm, level pathway around the garden will increase the usability of the space for those

in wheelchairs or with difficulty walking. A paved, brick, or concrete path around the garden is an option, but not the only choice. Well-packed and leveled dirt paths will also work, as will paths with finely crushed and packed rock material. Well-maintained turf-grasses may also be an option when a stable walking surface is the priority.

## Soil Mix

One of the greatest advantages to raised bed gardening is the ability to amend the soil. For instance, soils in some areas tend to have high clay content, which drain poorly and are hard to till when either too wet or dry. Soils in newly constructed areas are not always adequate. Raised beds are wonderful in this situation.

Several types of amended soil mixes can be used, but usually include good topsoil and organic matter, often in similar portions. This gives you a planting mix that drains well and is easy to till.

When incorporating the soil mix, several guidelines should be followed. It is best to loosen or spade the existing soil. This will improve drainage from the bed and prevent waterlogging. Spade or till 6 to 8 inches deep.

Next, blend a small amount of the amended soil mix into the existing soil. This will help avoid the problems that can arise from having two different soil layers. Incorporate about 2 inches of mix into the upper few inches of existing soil.

You are then ready to begin filling the raised bed. The result will be 10 to 12 inches of rich soil for plants to grow in. It is also important that a soil test be done on the mix. This will help you determine what fertilizer needs to be added.

## Plant Spacings

For a truly productive raised bed garden, the gardener must relearn many aspects of planting. Gone are the long straight rows and wide spacing between rows. Raised bed gardens use space more efficiently. In fact, rows may not even be used.

Small crops such as the leafy greens and root crops can be planted in wide rows or just by scattering the seeds over a small section of the

soil. Medium-sized vegetables such as snap beans, peas, or onions may be planted in rows with about 1 foot between each row. Or here again, a block planting with about 6 inches between plants can be used for highest return. Large crops, such as tomatoes, will need to be on 18- to 36-inch centers depending on their growth habit. Staking or caging the plants will allow for the highest plant density.

Other devices can be used to increase the capacity of the area. Trellises and other structures can be made to let vine crops and other plants grow up instead of sprawling.

## Efficient Space Use

A good gardener should be able to use the bed to its fullest potential. Careful planning must be used to achieve this. Group vegetables together based on the maturity time. Plant all short-season crops in one area so that when they finish producing they can be replaced by another crop. This is referred to as succession planting.

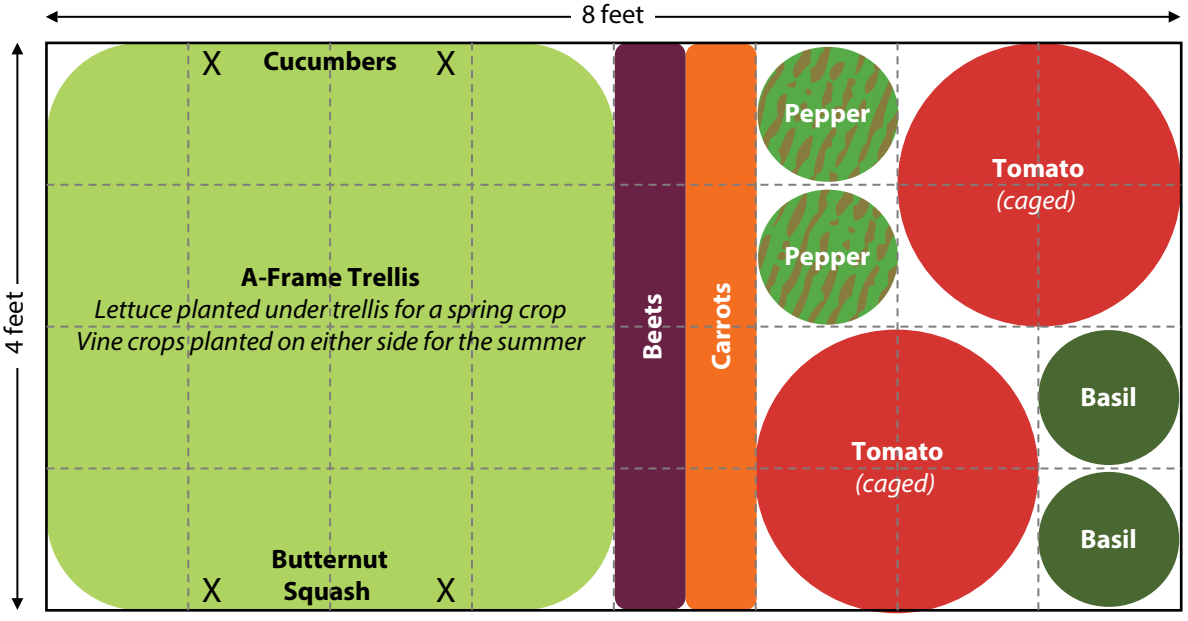
For instance, plant lettuce, spinach, radishes, and other leafy crops in one area so that the area can be replanted with beans, cucumbers, or some other warm-season crop after the first crop is harvested. Also, interplanting may be used. This method utilizes the empty row space. For example, between rows of onions, plant tomatoes or peppers. By the time the onions are harvested, the other plants will just be reaching a large size. Succession planting and intercropping will help you reach the full potential of the bed.

## Planting Dates

You may be able to plant a little earlier because raised beds warm up quicker in the spring. By using plastic mulches and row covers, it is possible to plant as much as two weeks earlier than a traditional garden. For a garden calendar with suggested planting dates, see the Average Expected Planting Calendar in the back of the book.

### Using Space in a Raised Bed Garden

It is often helpful to think about space in a raised bed in a grid rather than in rows with wide spaces between them. Crops can be planted closer together in this manner. Cages, stakes, and trellises are critical to using the space efficiently.



## Watering

It is best to water when the soil dries slightly. One or more inches of water per week is the general recommendation.

Many raised bed gardeners use drip irrigation. Drip irrigation allows you to use less water and apply it more efficiently. Drip tubing or a soaker hose may be purchased at local nurseries and garden centers. The tubes are then laid out over the bed, spaced about 2 to 3 feet apart depending on soil type. Using very low pressure (7 to 10 psi), the water slowly drips or oozes from the hose and filters down into the soil.

Pressure regulators are available for drip systems to drop pressure to the recommended range. Drip irrigation places the water at the root system, which reduces evaporation and prevents water from moving to nontarget areas such as the path. The drip tubing can also be buried below the soil surface for the most efficient delivery method.

## Fertilization

Fertilization needs of a raised bed garden are the same as a traditional garden. It is best to start with a soil test. If a soil test is not used, apply a general application of about 1 pound of 10-10-10 spread over 100 square feet of bed before planting in the spring. Incorporate the fertilizer into the soil. Sidedress the crops during the growing season based on needs of individual crops. Do not overfertilize as this will lead to poor production.

## Mulches

Summer mulches including straw help to conserve moisture, cool the soil, and control weeds. Apply a 2- to 4-inch layer over the soil after it has warmed; do not apply too early as you may keep the soil cool and slow the growth of warm-season crops.

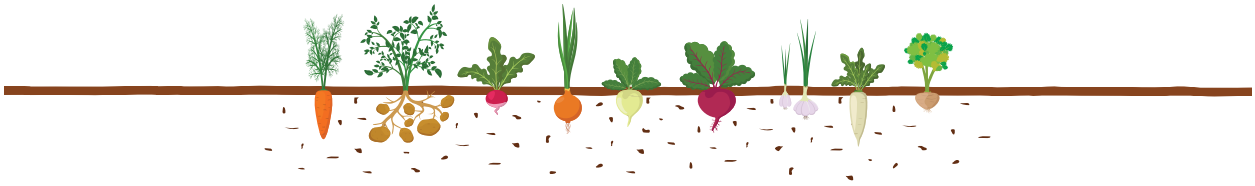
Plastic mulches can be used to warm the soil. Black plastic laid over the soil a month before the traditional planting date will allow the soil to warm earlier and may allow you to plant as much as 2 weeks earlier. This means harvest dates will arrive sooner, and in many cases, the yield will be greater.

## Conclusion

Raised bed gardens are a popular way for today's gardener to produce fresh, high quality, good tasting vegetables. It allows for more efficient use of space to maximize your investment of time, energy, and money. As with any gardening product, the fun and rewards come from your own experimentation and finding the techniques that work best for you.

# Chapter 3

# Container Gardening



Growing vegetables and herbs in containers is an option for persons with limited space, mobility, or time. In recent years, many new types and styles of containers have been developed, as well as vegetable varieties specifically adapted for growth in containers or compact spaces. This makes gardening much more productive, enjoyable, and easier for those who grow vegetables in containers.

Container gardening involves special considerations, especially in Kansas. A container plant growing in an exposed location is under more stress and requires more frequent watering. The effects of hot, dry winds may be more severe than in conventional gardens. Large containers can be expensive and are difficult to move when filled with potting mix. But the advantages far outweigh these considerations.

## Soil Mixes

When planting in containers, it is best to choose a soilless potting mix. The components of these mixes are lightweight and hold water and oxygen better than a garden soil. Soilless mixes will be free of weeds and diseases that can plague an in-ground garden. Many soilless mixes will also contain a slow-release fertilizer.

Sometimes soilless mixes can dry out very quickly in the heat of summer. Mixing in a good quality compost with the soilless mix, up to half of the volume of the pot, can help provide nutrients and additional capacity to hold water.

## Containers

Containers come in a variety of styles and sizes. Consider factors like pot depth, weight, durability, and good drainage when selecting containers. Larger pots hold moisture longer and aren't as susceptible to tipping over in the wind — two important considerations in Kansas. The smaller a pot is, the more susceptible the plants will be to heat and wind. Anything smaller than a 12-inch pot is probably too small.

One of the most important factors in selecting a container is the type and expected size of your plants. Small plants can be grown in small, shallow containers, while larger plants

need a larger container. For most larger vegetables, a pot that is 16 to 24 inches in diameter with a volume of at least 5 gallons is a good place to start. Even small pots can be used successfully, but they will require much more attention to watering and maintenance.

**Plastic.** Plastic containers are available in various sizes, shapes, and styles. They are relatively lightweight and much less expensive than other options. However, many plastics are breakable and may not hold up well over several seasons.

**Clay.** This old favorite is preferred by many gardeners for its earth-tone color. Clay pots are inexpensive and durable. However, they are also heavy and dry out quickly. Clay pots are breakable and may not hold up well if mobility is required.

**Glazed ceramic.** These pots are attractive, but also heavy and expensive. Some more decorative versions may lack drainage holes that are critical to gardening success.

**Fiberglass.** Fiberglass containers are available in a wide range of prices and configurations. Some types may be a durable, lightweight option.

**Fabric.** Containers made from fabric.

**Wood.** Wood containers, such as half whiskey barrels, are popular choices. Wood containers can also be built in a wide variety of sizes and styles.

**Self-watering containers.** Self-watering containers have become very popular in recent years. They can help conserve water and nutrients and reduce the frequency of watering. While purchased containers can be expensive, there are also many plans available for DIY self-watering containers.

**Repurposed containers.** It is possible to repurpose or recycle other containers or materials for a container garden. Repurposed containers should not have been used for toxic chemicals. It is also necessary to add drainage holes to any repurposed container before planting.

## Wheelchair Accessible Planters

Table height gardens or planters are good options for those that need to garden while seated. These elevated or table planters can be purchased as well as constructed. The planters should be treated like other containers with regards to gardening practices and maintenance.

There are two main types of these planters. Table style planters are on legs and have a planting box of uniform depth, usually only 4 to 6 inches deep so that the planting area is not too high for a seated gardener. These planters are often cheap and simple, but the shallow depth makes them best suited for growing root vegetables or leafy greens in the spring and fall. They typically dry out very fast and require significant watering. There are also barrel-style or V-shaped planters, which are shallower on the edges and deeper toward the center. These planters allow for larger, deeper-rooted plants and can support compact tomatoes or bush-type vine plants.

**Recommended Container Sizes**

| 1-3-gallon containers | 3-5-gallon containers | 5-15-gallon containers | 15+-gallon containers |
|---|---|---|---|
| May be shallow. | Not shallow or narrow. | Not shallow or narrow. | |
| Best for small, shallow rooted vegetables, such as leafy greens and root vegetables and some smaller herbs. | Best for medium-sized vegetables, highly dwarf or compact tomatoes, and herbs. | Best for large vegetables and herbs, such as tomatoes and vine crops. | Should be used for full-size indeterminate tomatoes, large vined varieties of cucumbers, melons, or squash. |

## Vertical Gardening Planters

Growing vertically to increase the available space for container gardening is attractive to many gardeners. Tower planters are available for purchase, and DIYers have developed many ways to reuse and repurpose materials to create vertical garden planters. When considering one of these planters, use the recommendations above for container characteristics.

One of the biggest challenges with many of these types of planter systems in Kansas is our hot, dry summers. Most plants do not perform well in outdoor vertical planters that are too small or do not have easy ways provide water and fertilizer. For many of these types of planters, drought-tolerant herbs may be the best choice for edible crops. Another option would be to plant leafy greens in the spring and fall, leaving the planter empty during the heat of summer.

## What to Grow

Vegetables require sunny locations and will vary in productivity depending on the type of crop. Check seed catalogs and garden centers for new varieties developed for container gardens. There are many new varieties of tomatoes and peppers that have been developed for container gardening. There are also some new types of melons and squash with very compact vines. If you want to try to grow larger-vined types of these vegetables, plan to add a staking system, trellis, or cage to your planting container.

Many leafy greens are well adapted to container production in the early spring or late fall. Lettuce is available in a variety of colors and leaf textures. Chard is another popular container plant because of its brightly colored stalks.

Many gardeners grow herbs in containers, and they are well-adapted to the slightly drier soil conditions. Basil, chives, marjoram, thyme, and many other herbs are all easy to grow in containers. Many gardeners keep mint in containers as it is an aggressive plant that spreads. Some herbs are perennial and can be moved indoors for winter use or held in the container until next year. Many gardeners dig a hole in the garden to store pots of perennial herbs until next season.


## Fertilizer

Soilless mixes drain water rapidly, causing nutrients to be washed out of the containers regularly. For successful container-grown vegetables, you will need to provide more nutrients throughout the growing season. If you added compost before planting, that would add nutrients that will support growth for at least the first part of the growing season. Likewise, if your potting mix had a slow-release fertilizer in it, additional nutrients may not be necessary right away.

There are many different fertilizer products, both organic and synthetic, that will work well in container gardening. For more discussion of fertilizer products, see the chapter on *Improving Soil Health*. Many gardeners prefer to apply a dilute fertilizer solution at every other watering. Several water-soluble fertilizers, both organic and synthetic, are available at garden centers. If you fertilize at every other watering, use only one-fourth the recommended rate unless the instructions state otherwise for continuous feeding.

Controlled-release or time-release fertilizers also are widely available. These are pellets designed to release fertilizer gradually over a long period of time. Use these according to label directions.

## Watering

Since containers are usually placed in an exposed location, water is lost from the containers quickly. Smaller containers have a smaller reservoir for holding water until needed. There is no rule of thumb on how often to water because it varies with the type of plant, potting mix, weather, and type of container.

You may find that daily watering is needed during hot, dry periods. One advantage of using a potting mix is that it is nearly impossible to over-water, as the water quickly drains from the container. Check your plants regularly and look for signs of wilting to indicate a need for water. Another method is to stick your finger into the upper inch or so of the potting mix to feel the dryness. Always apply sufficient water to allow a small amount to come out of the bottom drain hole. This indicates the container is thoroughly saturated with water.

If you have a large number of pots or find it difficult to water daily, setting up a small drip irrigation system with a timer can be an effective way to water containers. See the section on watering in Chapter 7, *Garden Maintenance* for more discussion of drip irrigation systems.

## Culture and Care

Plants need care and attention throughout the season. Insects and disease can be concerns because plants are growing under more stress and with limited root systems. Control measures are like those for conventional gardening (see page 33). Contact your local K-State Research and Extension office for additional information or publications dealing with garden pest problems.

## Varieties

Most common vegetable varieties will perform well in containers if the container is large enough and cages, stakes, or trellises are provided for larger plants. Below is a partial list of some specific varieties that have been developed for container cultivation.

**Cucumber** (12-18-inch spacing): Bush Pickle, Saladmore Bush, Bush Slicer, Patio Pickle, Patio Snacker, Spacemaster, Bush Champion

**Eggplant** (12-inch spacing): Fairy Tale, Hansel, Gretel, Patio Baby

**Cantaloupe** (12-18-inch spacing): Minnesota Midget, Honey Bun

**Squash** (1 per pot): Golden Nugget, Honey Bear Acorn, Gold Rush, Butterbush, Pinnacle Spaghetti, Honeybaby Butternut, Sugaretti Spaghetti, most bush-type zucchini

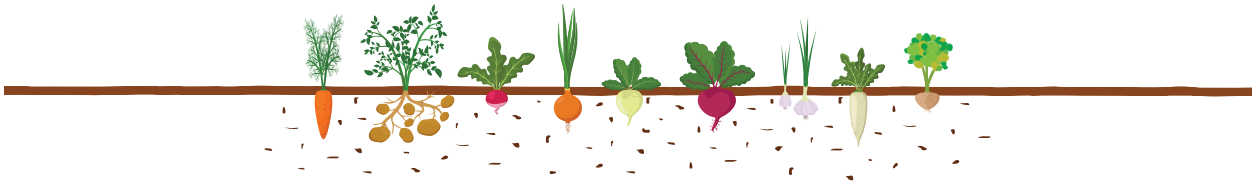
**Tomato** (Dwarf; 12-inch spacing): Patio Choice, Patio, Pixie, Tiny Tim, Geranium Kiss, Heartbreaker, Tumbling Tom, Micro Tom

**Tomato** (Small-Vined; 1 per pot): Early Resilience, Little Napoli, Amelia, Martino's Roma, Celebrity, most determinate tomato varieties

**Watermelon** (1 per pot): Sugar Baby Bush, Cal Sweet Bush, Mini Love

# Chapter 4

# Improving Soil Health



Soil health is one of the most important factors in the success of a garden. An understanding of your soil's texture, pH, nutrients, and biology will help you make decisions that will support the health of your soil and ultimately your plants. A healthy soil has a high level of organic matter that supports a diversity of beneficial microbes.

## Soil Components

Soil is made up of both mineral and organic components, and both are needed for a healthy soil.

The mineral part of the soil is comprised of some ratio of sand, silt, and clay. The ratio of these mineral components determines the soil texture, such as sandy loam or silty clay loam. The more sand a particular soil has, the faster water drains and the less it can hold nutrients. The more clay a particular soil has, the slower water will drain, but it will hold much higher levels of water and nutrients.

If you are not sure what type of soil texture you have, there are some simple at-home tests that you can try. You can also consult the Web Soil Survey. (*https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm*)

The organic part of the soil is made up of decomposing plant or animal detritus, stable humus, living plant roots and microorganisms. While it is tempting to assume that all soil organisms are harmful to plants, the vast

**Characteristics of Soil Types**

| Soil Characteristic | Sandy Soil | Loam Soil | Clayey Soil |
|---|---|---|---|
| Water-holding capacity | Low | Medium to high | High |
| Ability to store plant nutrients | Low | Medium to high | High |
| Capacity to supply plant nutrients | Low | Medium to high | High |
| Aeration | Good | Medium | Low |
| Drainage | Good | Slow to medium | Very slow |
| Organic matter levels | Low | Medium to high | High to medium |
| Compactability | Low | Medium | High |
| Susceptibility to wind erosion | Moderate | High | Low |
| Susceptibility to water erosion | Low | High | Low if aggregated, high if not |

majority are beneficial organisms that help plants access nutrients and water they need to grow. Maintaining a soil organic matter level of at least 5% is critical to keeping soil microorganisms alive and healthy to benefit your plants. In many cases, it is also recommended to keep growing plants in your soil as much of the year as possible through the use of cover crops.

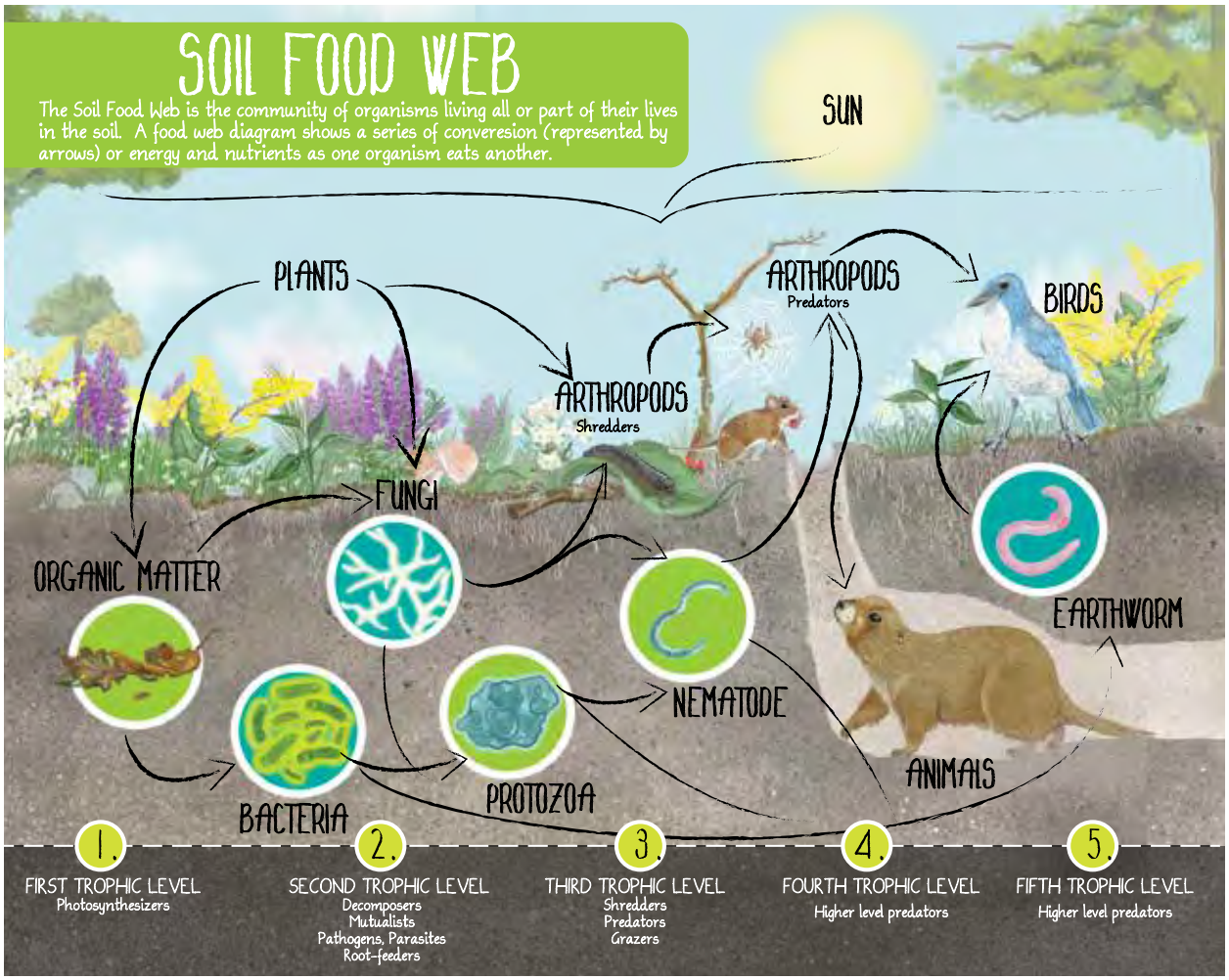
## Adding Organic Matter

Adding organic matter is an effective way of improving all kinds of soil. In almost every case, adding organic matter to the planned garden area is recommended. It is beneficial to add organic matter regularly, every 1-3 years. Organic matter serves the following purposes:

- It loosens tight clay soils to provide better drainage.
- It provides for better soil aeration, which is necessary for good root growth.
- It increases water-holding capacity especially of sandy soils.
- It makes soil easier to till and easier for plant roots to penetrate
- It provides nutrients for plant growth.

Most home gardeners prefer to add organic matter by using one of the following materials:

- **Stable manure.** Use 50–100 pounds per 100 square feet.
- **Poultry and sheep manure.** Use 10–20 pounds per 100 square feet.
- **Compost.** Compost is decayed plant material. Apply 50–100 pounds per 100 square feet of garden space. (See *Using Compost* on page 43.)



- **Cattle manure.** Use 10–20 pounds per 100 square feet.

If you use uncomposted manure, bear in mind that this is a potential source of microbial contamination that could lead to foodborne illness. Applying raw manure in the fall allows adequate time for decomposition before crop harvest the following summer.

Regular application of manures and composts can increase soil nutrient levels significantly over time. It is important to regularly test your garden soil to monitor nutrient and organic matter levels. It is common for excessive levels of organic matter and nutrients to reduce garden yields of some crops, especially tomatoes and related species. If you suspect these issues, be sure to request your soil organic matter and nitrogen levels when completing a soil test.

## Using Cover Crops in a Garden

Cover crops are plants grown to improve soil quality or to provide a benefit to the garden ecosystem. They are generally not grown with the intent to be harvested. Cover crops can benefit your garden soil in a variety of ways. They can help add organic matter and nutrients to your soil. They can help improve soil structure and drainage, reduce erosion, recycle nutrients, improve soil fertility, and reduce weed problems. Some cover crops can be food sources for pollinators and other beneficial insects.

For all their benefits, cover crops can also add an additional level of management and maintenance to a garden. Select cover crops that fit the needs of the garden, the correct planting time, and the availability of proper equipment and tools to terminate the cover crop when it is time to plant vegetable crops. A cover

crop that is left to grow too long or that is not properly managed can become a weed in the garden.

## Types of Cover Crops

Cover crops are divided into three main categories: legumes, non-legume broadleaves, and grasses. Legumes can collect nitrogen from the air and store it in the soil where it can be used by plants. Many non-legumes are grasses, although not all of them. It can be beneficial to plant a blend of cover crop species that includes at least one legume and one grass or a three way mixture that includes a legume, a grass, and non-legume broadleaf.

Cover crops can be planted at different times depending on the garden planting plan. Cover crops adapted for summer planting can be seeded after spring crops are harvested. Cover crops adapted for fall/winter growth can be planted after summer vegetable crops are finished. Some will grow through the winter while others will die during the winter cold.

When cover crops are chosen for a garden, consider how you will cut down and incorporate the plant material, as well as the time needed for good decomposition of the cover crop before you plant your vegetable crops. You may find that you need a tiller to readily incorporate a cover crop before planting. Some cover crops, such as sorghum sudangrass, are very common in commercial cropping systems, but may not be a good choice for a home garden due to the volume of plant material produced and the difficulty in removing or killing the plants to replant the garden.

## Termination of Cover Crops

Cover crops should be terminated 2-4 weeks before planting to allow adequate time for decomposition. Options for termination include: mowing, rolling/crimping, herbicides, rototilling, or a combination of these methods. In addition, some cover crops will naturally winter kill, either at frost or over the winter. Be sure to terminate a cover crop before it goes to seed to prevent unintended reseeding that can create weed concerns. A good guideline is to terminate the cover crop when about 50% of the crop is in bloom.

### Cover Crop Planting Seasons

| Cover Crop | Planting Season |
|---|---|
| **Legumes** | |
| Crimson clover | Spring, fall |
| Field peas | Spring, summer |
| Hairy vetch | Fall |
| Southern pea | Spring, summer |
| Sunnhemp | Summer |
| **Non-Legume/Broadleaves** | |
| Buckwheat | Spring, summer |
| Tillage radish | Fall |
| Mustard | Spring, fall |
| Field turnip | Spring, fall |
| **Grasses** | |
| Annual ryegrass | Early spring, fall |
| Winter wheat | Fall |
| Millets | Summer |
| Oats | Spring |
| Winter rye | Fall |

## Nutrients Needed for Plant Health

Nutrients most frequently lacking for growth are nitrogen (N), phosphorus (P), and potassium (K).

- **N (Nitrogen).** This nutrient element provides dark green color in plants. It promotes rapid vegetative growth. Plants deficient in nitrogen have thin, spindly stems, pale or yellow foliage, and smaller than normal leaves.
- **P (Phosphorus).** This nutrient promotes early root formation, gives plants a rapid, vigorous start, and hastens blooming and maturity. Plants deficient in this element have thin, shortened stems, and the leaves often develop a purplish color.
- **K (Potassium).** Potassium or potash hastens ripening of fruit. Plant disease resistance as well as general plant health depend on this element. It is also important in developing plump, full seeds. Plants deficient in this element have graying or browning on the outer edges of older leaves.


Nitrogen (N) – Phosphate ($P_2O_5$) – Potash ($K_2O$)

The content of N, P, and K is specified on fertilizer bags. The analysis or grade refers to the percent by weight of nitrogen, phosphate, and potassium in that order. Thus, a 10-10-10 fertilizer contains 10 percent nitrogen (N), 10 percent phosphate ($P_2O_5$) and 10 percent potassium ($K_2O$).

### *Other Plant Nutrients*

Ten other elements that plants require come from the soil. They include calcium, magnesium, sulfur, boron, chlorine, copper, iron, manganese, molybdenum, and zinc. The majority of Kansas soils naturally provide

**Fertilizer Sources with Concentrations of Specific Elements**

| | Analysis |
|---|---|
| **Nitrogen sources** | |
| Ammonium sulfate | 20-0-0 |
| Nitrate of soda | 15-0-0 |
| Nitrate of potash | 13-0-44 |
| Monoammonium phosphate | 11-48-0 |
| Diammonium phosphate | 18-46-0 |
| Urea | 45-0-0 |
| **Sulfur sources** | |
| Elemental sulfur | 98% sulfur |
| Copper sulfate | 20% sulfur |
| Ammonium sulfate | 24% sulfur |
| **Iron sources*** | |
| Iron chelate | 6%, 10%, or 12% iron for foliar or soil application |
| Iron sulfate | |
| **Zinc sources*** | |
| Zinc sulfate | 36% zinc |
| Zinc chelates | Variable |
| **Magnesium sources**** | |
| Epsom salts ($Mg SO_4$) | 10.4% Mg |
| **Boron sources*** | |
| Borax | 11.3% boron |

*Other commercial sources may be available. Consult the label for content.
** Some types of limestone (dolomitic) will also be sources of magnesium.

adequate amounts of these nutrients, unless the soil pH reduces their availability. A common micronutrient element found lacking in high pH soils is iron. The symptom of iron deficiency is a pale yellow color that develops in plants. This can be corrected by a foliar application of iron or by reducing the soil pH.

If you suspect a deficiency of one of these nutrients, you can request an additional test with your soil test. Work with your local Extension agent to identify the needed tests. Standard soil tests analyze for N,P, K and pH, while additional soil tests can be made for other fertilizer elements that may be required in unusual cases. Iron, zinc, magnesium, sulfur, or other elements are seldom required to correct a particular soil fertility deficiency. Some of these deficiencies might best be corrected with a foliar application as described.

## Soil Testing

The winter before you begin to garden, you will want to get a sample of your garden soil tested to determine pH and nutrient content. The soil test provides a starting place for a soil improvement program. Unless you know the deficiencies in your garden soil, you are only guessing when you apply fertilizer. The soil test will tell you how much fertilizer you must add to your garden initially. It is then much easier to maintain a high level of fertility as you garden year after year.

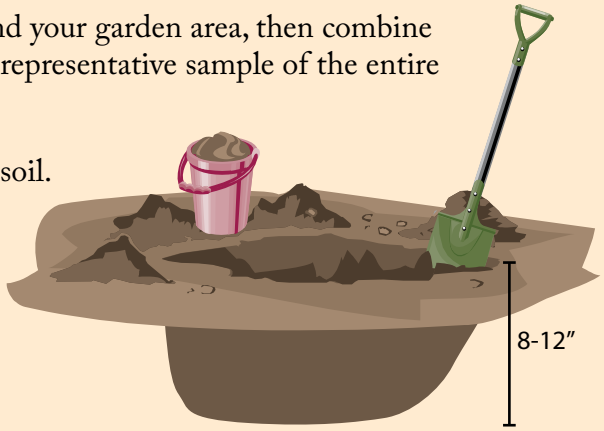
Check with your local K-State Research and Extension agent for soil testing information. Find your local extension office here: *www.ksre.k-state.edu/about/statewide-locations.html*

### *Taking a Soil Sample*

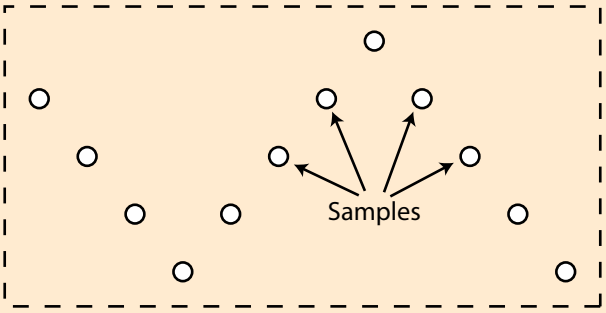
Use a soil probe, spade, or shovel to sample the soil profile to a depth of 8-12 inches. It is important to obtain a representative sample of the soil in the root zone rather than from the surface soil.

It is advisable to take at least 10 samples around your garden area, then combine these in a clean bucket or pail. This provides a representative sample of the entire garden area.

From the bucket or pail, select about a pint of soil. Special soil sample containers are available from your local K-State Research and Extension office or a fertilizer supplier. You may use a clean milk carton, ice cream container, or similar package. Label it with your name, address, and information on the garden to be grown. If you send more than one sample, be sure to label each plainly.




Slice for sample: 8-12 inches long by 1-1½ inches thick.



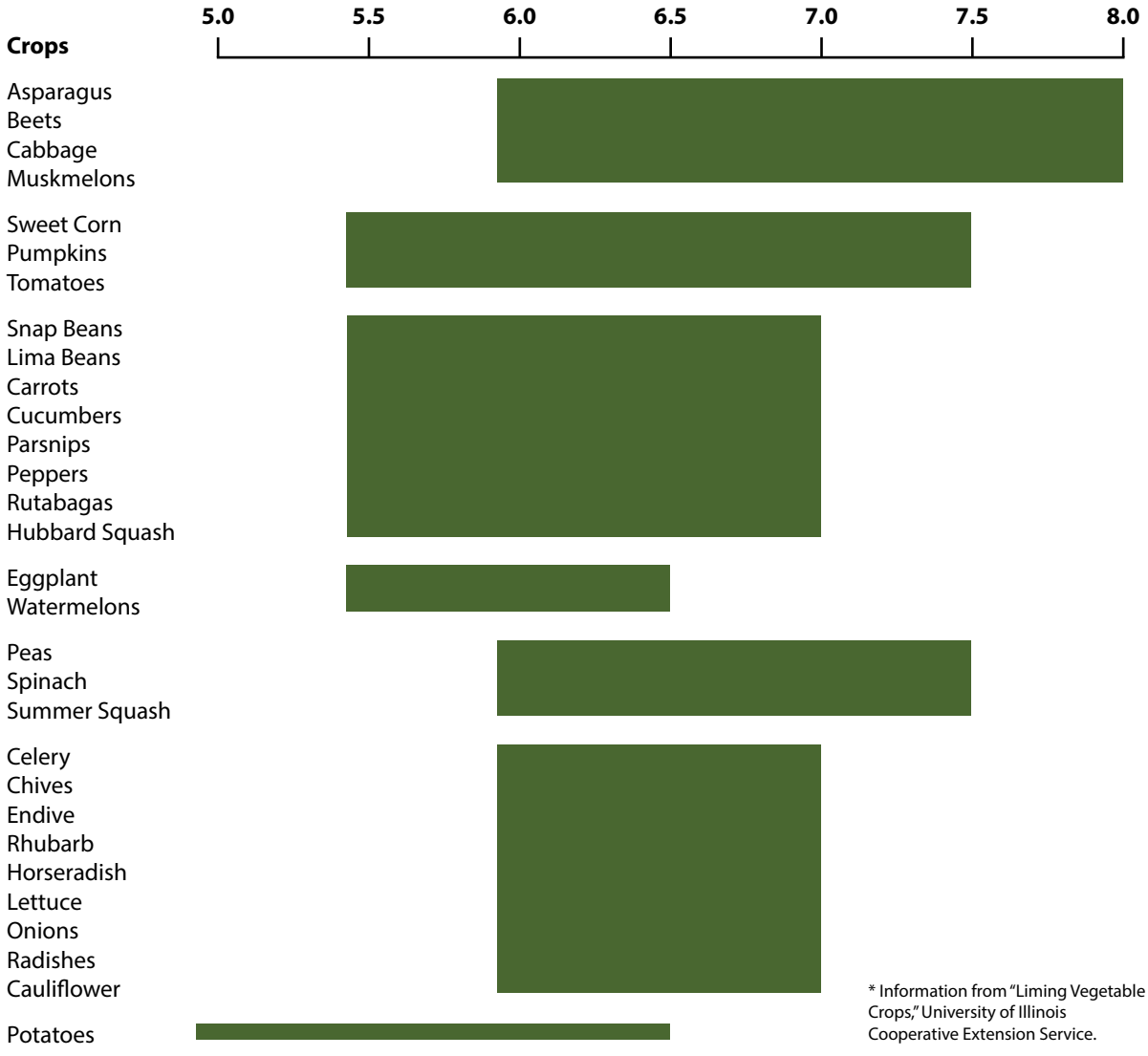

Your local agriculture or horticulture agent will either test the sample in the county soil lab or send it to the Kansas State University soil testing laboratory. The agent will make recommendations on the amounts of fertilizer to use on your garden. Rely on your local agent for information and advice concerning your garden.

## Controlling Soil pH

The pH of the soil is a measure of acidity or alkalinity. Most plants grow best in a soil that is neither too acid nor too alkaline. Extremes of acidity or alkalinity are possible in Kansas soils. These extremes may make the soil nutrients unavailable to plants. Because of the parent rock materials, previous fertilizer use, cropping sequence, or other factors, the pH of the soil may differ from the desirable range.

One part of the soil test is measurement of the pH. Most Kansas soils tend to be somewhat alkaline, although soils in certain areas and under certain cropping and fertilizer regimens may become acidic. Your local K-State Research and Extension agent can recommend the amount of sulfur, lime, or other material needed to correct the soil pH. Correcting soil pH can be as important in improving plant growth as adding fertilizers.

### Optimum pH Range for Vegetable Crops*




* Information from "Liming Vegetable Crops," University of Illinois Cooperative Extension Service.

### Materials to Add to Correct Soil pH

| Lime (to increase pH) | | | |
|---|---|---|---|
| pH level from soil test (increase to 6.5) | Lb Ground Limestone/100 sq ft | | |
| | Sandy Soil | Loam Soil | Clay Soil |
| 4.0 | 11 | 16 | 23 |
| 4.5 | 9 | 13 | 19 |
| 5 | 7 | 10 | 15 |
| 5.5 | 6 | 7 | 10 |
| 6 | 3 | 4 | 5 |

| Sulfur (to lower pH) | | | |
|---|---|---|---|
| pH level from soil test (decrease to 7.0) | Lb Sulfur (95%)/100 sq ft | | |
| | Sandy Soil | Loam Soil | Clay Soil |
| 7.5 | 1.5 | 2 | 3 |
| 8 | 3 | 4 | 5 |
| 8.5 | 5 | 6 | 7 |
| 9 | 8 | 8 | 8 |

Add all materials to soil and incorporate to a depth of 6 inches with soil tillage when no crops are growing in the garden area. Note: Specific recommendations by your local county agent may vary from these amounts based on local conditions and knowledge of specific soil factors. Use your local recommendations in preference to this table if available.

## Fertilizing the Garden

Fertilizing is an important practice, but it is not a cure-all. Fertilization cannot compensate for these problems:

- poor soil structure that does not allow for adequate drainage or aeration
- undesirable soil pH or salt content of the soil
- poor seeds, diseased or unhealthy plants
- shade trees or tree roots in or around the garden area.

The addition of organic matter will ensure that some fertilizer nutrients are in the soil. You may need to add additional fertilizer as well, especially if your soil has a significant deficiency. Most fertilizers are simply rock or mineral materials rich in nutrient elements.

### *Fertilizer Types*

The nutrient elements that plants require can be supplied by either organic or synthetic fertilizers. All plants require 16 nutrient elements for growth. Thirteen of these come from the soil. Regardless of the form of fertilizer — organic or synthetic — the plant makes no distinction as long as the nutrients are there.There are a wide range of different fertilizer products available for purchase. Bagged or bottled fertilizer products can be either organic or synthetic.

**Organic fertilizers** are typically derived from biological organisms, both plants and animals. Some organic fertilizers will also include minerals from mined rock sources. Organic fertilizers often have a lower nutrient analysis than synthetic fertilizers, requiring a larger volume to provide sufficient nutrients. This can make organic fertilizer significantly more expensive to use, especially if your soil has a severe nutrient deficiency.

**Synthetic fertilizers** are derived from a combination of mined rock and lab synthesized or purified nutrients. They are often cheaper and more efficient in providing a large amount of nutrients to the soil at once.

## Approximate Composition of Some Organic Fertilizers

| Material | Nitrogen (N) | Phosphorus (P) | Potassium (K) |
|---|---|---|---|
| | ---------- % ---------- | | |
| Bat guano | 3 | 10 | 1 |
| Blood meal | 12 | 1 | 1 |
| Alfalfa meal | 5 | 1 | 2 |
| Cottonseed meal | 5 | 2 | 1 |
| Feather meal | 12 | 0 | 0 |
| Coffee grounds | 2 | 0.5 | 1 |
| Cow manure, fresh | 0.5 | 0.1 | 0.4 |
| Cow manure, dried | 2 | 1 | 1 |
| Poultry manure, dried | 3 | 3 | 1 |
| Feedlot manure, dried | 2 | 1 | 1 |
| Bone meal | 2 | 14 | 0 |
| Worm castings | 1 | 2 | 1 |
| Wood ashes | 0 | 1 | 5 |

Other commercial or processed fertilizers may be available. Consult label for variation in nutrient content by brands/sources. Organic materials should be incorporated into the soil and allowed to decompose if full fertilizer value is to be available.

## Recommendations for Fertilizer Additions Based on K-State Soil Test Results

| | Soil test interpretation | | |
|---|---|---|---|
| | Low | Medium | High |
| Nitrogen* (Available nitrogen from lawn and garden soil test) | 0-25 ppm | 25-50 ppm | 50-80 ppm |
| Phosphorus* (P from soil test results) | 0-25 ppm | 25-100 pmm | 100+ ppm |
| Potassium* (K from soil test results) | 0-125 ppm | 125-250 ppm | 250+ ppm |

*If you do not have soil test results, follow recommendations for a medium application level.

## Pounds of Actual Element to Add per 100 sq ft

| | Nitrogen | | | Phosphorus | | | Potassium | | |
|---|---|---|---|---|---|---|---|---|---|
| | Low | Med | High | Low | Med | High | Low | Med | High |
| Intensive or small gardens with successive plantings from spring, summer, and fall | .2 | .1 | 0 | .2 | .1 | 0 | .1 | .05 | 0 |
| Standard or large gardens with wider row spacings | .1 | .05 | 0 | .1 | .05 | 0 | .1 | .05 | 0 |

### *Steps in Calculating Needed Fertilizer*

1. Measure the length and width of your garden and calculate the area of your garden.
   - For example, suppose your garden is 10 feet wide by 20 feet long. Your garden area is 10 ft x 20 ft = 200 square feet.
2. Determine the nutrients you need to add per 100 square feet from the tables below. Use your soil test results to determine whether your nutrient levels are low, medium, or high. Then use the next table to determine the amount of nutrients to add.
   - For example, suppose your test results indicate that you have medium levels of nitrogen, phosphorus, and potassium. Based on the tables, you will need 0.1 pound N, 0.1 pound P, and 0.05 pound K.
3. Determine the total amount of fertilizer you will need for each nutrient.
   - Multiply the amount you need by the number of hundred square feet units in your garden. For example, if your garden is 200 square feet, you would need two times the amount above or 0.2 pound N, 0.2 pound P, and 0.1 pound K.
4. Look for a fertilizer that will provide nutrients in the correct ratio that you need.
   - Because you need equal portions of N and P but less of K, look for a fertilizer that may have the ratio of nutrients in this range. You might not be able to find a fertilizer that provides exactly the ratio you need, so try to get as close as you can.
   - For example, if you find a fertilizer that has 10-10-5, this would provide the exact ratio you need.
5. To calculate how much of this material to add, divide the amount you need by the nutrient concentration or analysis of the fertilizer and multiply by 100 because the analysis represents a percentage or fractional value of 100:
   - 0.2 lb needed ÷ 10 x 100 = 2 lb of fertilizer material needed to provide the N you need. This amount of fertilizer will also supply the P and K you need.
   - Apply 2 pounds of 10-10-5 fertilizer to your 200-square-foot garden.

### Suggestions for Nutrients as Foliar Fertilizers

| Element | Material | oz/3 gal water per 100 sq ft | Remarks |
|---|---|---|---|
| Iron | Iron chelate | Follow package directions | Iron deficiency found when pH is above 6.8 |
| Magnesium | Magnesium sulfate (Epsom salts) | 4-5 | Use more than one application |
| Nitrogen | Urea | 2-3 | Most crops |
| Calcium | Calcium chloride | 2 | Direct at the growing point |
| Manganese | Manganese sulfate | 1-2 | May be needed in soils with high pH |

## Calculating the Amount of Fertilizer Needed

To calculate the amount of fertilizer needed for an area, consider the recommendation for the particular nutrient needed and the analysis.

The relationship of N, P, and K to each other, sometimes referred to as the ratio, indicates the proportion of each element. For example 1-1-1 means there are equal proportions of N, $P_2O_5$, and $K_2O$ as does 10-10-10. However, a 2-1-1 ratio means there is twice as much N as $P_2O_5$ and $K_2O$, as is true for 10-5-5. The ratio does not indicate the weight of the elements in the fertilizer bag, but only their relationship to each other.

If you need to add 0.1 pound of N per 100 square feet and you have 10-10-10 fertilizer, which contains 10 percent N, you will have to add 1 pound of this material per 100 square feet to achieve the needed amount of N.

Most fertilizers you find are complete fertilizers with proportions of each major fertilizer element. Some sources supply specific concentrations of a single element only. Some of these are listed in the table on page 33.

## Applying Fertilizers

**Row applications.** This provides the most efficient use of fertilizer for row garden crops. As a general rule, use about 1–2 pounds of the balanced analysis fertilizer per 100 feet of row. The best method of applying fertilizer is to dig a small trench 2–3 inches deep on either side of the row before planting. Sprinkle half the total amount of fertilizer in each trench. Cover the trenches and plant in the marked row. For tomatoes, cabbage, or other transplanted crops, as well as for melons or cucumbers planted in hills, use about 2 tablespoons of fertilizer placed 2–3 inches below the roots or seeds. Again, after placing the fertilizer, cover with soil and plant as usual.

**Broadcast applications.** An undesirable feature of row application is that it requires a lot of work. If you do not want to apply fertilizer to each row, you can broadcast or spread fertilizer throughout the garden area. Use 2–3 pounds of fertilizer per 100 square feet, spread uniformly over the surface, and incorporate into the soil before planting.

**Starter solutions.** For transplanted vegetables such as tomatoes, peppers, eggplant or cabbage, add a starter fertilizer to the water used in setting the plants to get them off to a faster start. Commercial starter fertilizers mix with water or are water soluble. Follow label directions, because mixing too much starter fertilizer can burn the plant roots.

**Sidedressing.** Nitrogen often leaches or washes out of the reach of plant roots, particularly in years when rainfall is abundant and in sandy garden soils. A sidedressing is simply an application of a nitrogen-containing fertilizer alongside the row of growing plants. Apply when corn is 12–18 inches high, after first fruits have set on tomatoes, or when plants lack a healthy, dark-green appearance.

It is possible to apply too much nitrogen; use fertilizer sparingly. Use ¼ pound of ammonium nitrate or ⅕ pound of urea per 100 feet of row. If these materials are not available, use an ordinary balanced fertilizer such as 5-10-10, 8-16-16, or others at the rate of 1–2 pounds per 100 feet of row. Don't put the material directly on the plant foliage and, when possible, water after applying the fertilizer.

**Foliar feeding.** In an emergency, it may be possible to add certain nutrients to a plant by applying to the foliage when nutrient deficiency symptoms develop. It is advisable to make every attempt to add the necessary nutrients to the soil before the symptoms develop because foliar application should be used only as an experimental or emergency treatment. Unless the soil conditions causing the symptoms are corrected, the symptoms will reappear soon.

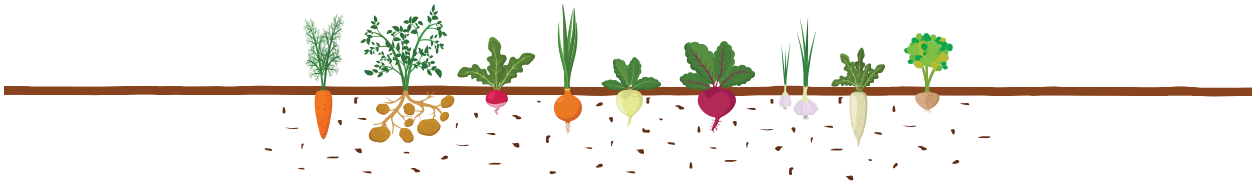
Using a commercial wetting agent or a few drops of detergent in the solution provides better coverage of foliage. Apply sprays in early morning or late afternoon on a cloudy day, or soon after a rain. Mixing these elements with one another or with a pest control spray may be difficult. Do not attempt to mix foliar nutrients with pest control sprays.

## Some Useful Measures

- 1 acre = 43,560 sq ft
- 100 lb/acre = approximately 2 lb/1,000 sq ft
- 3 tablespoons (level) = 1 oz
- 8 ounces = 1 cup
- 2 cups = 1 pint (equals 1 lb of most dried fertilizer materials)

# Chapter 5

# Composting



Compost is decayed organic matter that is dark and crumbly and has a pleasant earthy odor. It is used to improve garden and potting soil. Properly prepared compost is rich in nutrients and is free of weed seeds and offensive odors.

Compost is produced in piles or pits from organic waste such as leaves, grass clippings, manures, straw, hay, and garden refuse. It can be applied as a thin top dressing for lawns, as mulch around shrubs and young trees, or mixed into the soil in vegetable and flower gardens. One of the greatest benefits of making compost is recycling garden and yard waste into a useful product and reducing the amount of solid waste in the landfill to help improve the environment. Families can share a compost pile or contribute to a neighborhood composting facility. Composting small prunings and twigs and encouraging municipalities to shred large prunings and downed limbs allows for reuse of damaged or overgrown plants in the landscape.

## The Composting Process

The process of converting organic wastes to rich humus involves several types of bacteria and fungi. These organisms begin the process by breaking down cellulose and other complex molecules in the residue. Populations increase rapidly and the temperature inside the pile may reach 150 to 160˚F, killing weed seeds and disease organisms. After several months, the temperature decreases and fungi disappear. Millions of bacteria continue the gradual breakdown of organic materials into rich, dark, crumbly humus.

## Environmental Factors

Microoganisms and small invertebrates account for most of the decomposition that takes place within the compost pile. With the required oxygen and water, these organisms break down yard and food wastes, producing carbon dioxide, heat, water, and soil-enriching compost in the process.

One way to determine success is to monitor pile temperature. During composting, the pile warms to 150 to 160˚F. and gradually returns to ambient temperatures after organic materials decompose. Warm temperatures increase water evaporation. A decrease in the pile's weight and volume is another way to measure composting effectiveness.

Decomposing organisms include naturally occurring bacteria, fungi, and molds, and small invertebrate animals such as mites, millipedes, insects, and earthworms. With a wide range of organisms, there is a better chance that composted materials will be broken down completely. Aerobic bacteria, which require

oxygen, are the most important decomposers in the compost pile.

## Aerobic vs. Anaerobic Organisms

Aerobic organisms are preferred because they provide rapid and complete composting. Other organisms can operate without oxygen or in anaerobic conditions. This process, sometimes called fermentation, occurs more slowly. The biggest problem with anaerobic organisms is the tendency to produce offensive odors. They also generate acids and alcohols that can harm certain plants. A bad smell coming from the compost pile usually means it needs more oxygen, and it is time to turn or agitate the pile.

## Temperature

Aerobic bacteria vary in their ability to tolerate certain temperatures. Thermophilic bacteria survive at 140 to 150˚F. At the beginning of the composting process, bacteria adapted to lower temperatures predominate. When temperatures reach a certain level, these bacteria die, and thermophilic bacteria take over. Thermophilic bacteria, too, eventually succumb to the increasing temperatures. When this happens, the pile temperature begins to drop, and bacteria suited to lower temperatures take over. Bacteria die after most of the material has been composted. When energy has been depleted, the composting process is complete.

## Biological Activity

The complex web of life in the compost pile includes organisms that feed on organic materials or other organisms. Mobile organisms such as worms may move away from the excessive heat at the center of the pile, and then move back again when the pile cools. Most harmful organisms, such as disease organisms or persistent insect pests, as well as weed seeds, are killed in the composting process.

## Compost Activators

Decomposition of organic materials is carried out by bacteria and fungi that occur naturally in the environment. Soil can be added to the compost pile to increase the number of microorganisms. For populations to build, organisms need nitrogen, which can be supplied with an activator material. If you are trying to compost mostly brown materials such as leaves or wood chips, you should supplement with nitrogen from either a commercial fertilizer or a natural source. Natural materials containing nitrogen include blood meal, finished compost, fish meal, manure, or alfalfa meal.

**Application procedures.** The amount of activator to add depends on the concentration of nitrogen in the activator material. For concentrated materials such as commercial fertilizer, 1 to 2 cups of fertilizer per 10 square feet of compost bed area should be sufficient. If adding blood meal, alfalfa meal, or concentrated manure, add 1 to 2 pounds per 10 square feet of compost bed area. If using compost, 4 to 5 pounds per 10 square feet of compost pile area is recommended.

After applying the activator, continue to build the pile by adding 6 to 8 inches of organic material, a light sprinkling of ½ to 1 inch of soil, followed by another activator application. When finished, moisten the pile, blending contents with a pitchfork or rake to speed decomposition. The nutrient in the activator is absorbed into the bodies of the microorganisms as they build in large populations to break down organic materials in the compost. After the composting process is complete, these nutrients, plus any additional nutrients available in organic materials, are released back into the compost as the microorganisms die. This accounts for the high nutrient value of a well-made compost.

**Other considerations.** You can buy products known as compost activators, which contain the fungi and bacteria necessary to start the composting process. Purchasing these types of activators is not necessary if you can use

garden soil, which contains a wide range of these natural organisms. If you prefer to buy activators rather than adding soil, follow the label directions on how much activator to add per unit of compost volume or area.

## Location and Size of the Compost Pile

The compost heap should be located in an area that is not prone to standing water. Many gardeners choose an out-of-the-way, accessible location near the garden or refuse disposal site for convenience. It helps to have a water source nearby because compost piles need to be kept moist.

Compost can be made in a pit or with another method that does not require digging. Although it is possible to accumulate composting materials in a loose pile, an enclosure of some type is desirable. The following materials are suggested:

**Woven wire or wood slat fence.** Almost any type of wire, from fencing wire to reinforcing wire, can be used. Heavy gauge wire is preferred but finer wire can be used if supported by posts or rods.

**Cement blocks or bricks.** Blocks should be heavy enough to hold the pile in place without mortar.

**Scrap lumber.** Do not use good lumber because damp compost may ruin the boards. For a more permanent enclosure, use either redwood or cypress. Old pallets are often available for free. Strap four of them together to make a compost bin.

The size of the compost pile varies depending on availability of organic materials and how much compost is needed. Rectangular or square shapes are slightly easier to work with, but round wire enclosures will have less surface area and do not dry out as quickly. A


pile 5 feet wide by 5 feet long or a circular pile about 5 feet in diameter is sufficient for most households. The height of the pile fluctuates as organic material is added. Divide the pile or bin into two parts, or use two bins of the same size. Use one of the bins for last year's compost and accumulate this year's waste in the other one.

## Materials for Composting

The types of plant materials that can be added to the compost pile include leaves, grass clippings, weeds or garden refuse, fine hedge clippings, straw, corncobs, sawdust, old hay, and mulch removed from flower or vegetable gardens. Do not add plants that are severely diseased. Wood ashes should be avoided unless your soil is acidic, as they raise the pH. Most Kansas soils are alkaline, and adding wood ashes to the compost pile usually makes a bad situation worse.

Kitchen scraps such as eggshells, peelings, or plant residues can be added as long as the pile is kept covered to keep it from drawing flies. Avoid meat scraps or bones, which may attract dogs and other animals.

### *Grass Clippings*

Bagged grass clippings make excellent composting material, but research shows it may be more beneficial to leave them on the lawn. If grass clippings are added to the compost pile make sure lawn was not treated with a broadleaf herbicide or crabgrass killer.

Most crabgrass control products contain the active ingredient quinclorac. This can harm broadleaf plants, including vegetables, for up to 18 to 24 months after applying a compost made with treated grass clippings. Crabgrass preventers, on the other hand, should not harm plants after the clippings have gone through the composting process.

If your lawn has recently been treated with a broadleaf herbicide for weed control, it is best to avoid using the lawn clippings in compost or around garden plants for at least 3 mowings after the application to prevent residual herbicide damage to plants.

## Building the Compost Pile

Making compost from organic materials as they become available is a very slow process. The process can be accelerated by making hot compost. Start with a 6- to 8-inch layer of "brown" materials such as straw, old mulch, or tree leaves. Add a 2- to 3-inch layer of "green" materials such as grass clippings, coffee grounds, weeds, kitchen waste, or freshly harvested plant material. Alternate brown and green layers until the pile is 3 to 5 feet high. If green materials are in short supply, add a small amount of commercial garden fertilizer (about 1 to 2 cups per square yard) or an inch or two of manure. The fertilizer or manure provides nutrients that allow microorganisms to build up in the compost pile to ensure decomposition. Water after each layer. Brown materials can be difficult to find at certain times of the year. Stockpile leaves bagged in the fall and add them to the compost pile as needed.

The top of the compost pile should be dish-shaped, so it is slightly lower in the center than on the sides. This allows rainfall to soak into the pile instead of running off. In dry conditions, the pile should be soaked weekly so it stays moist. The compost pile eventually will reach 150 to 160°F before it begins to cool down. When this happens, it is time to turn the pile. Slice through the layers and turn the materials upside down. Move materials from the outside of the pile to the inside. After mixing, form the dish at the top and water. Let the pile heat up and cool down as before.

Compost should be ready four to six months after the pile is started. Most gardeners keep two piles or divide the pile into two sections, using one side to accumulate new material and storing last year's compost in the other.

As the compost pile progresses, check for signs the process is going well. The pile should shrink or sink in two to three weeks. If not, loosen it with a shovel or fork to aerate, adding moisture if compost is dry. A strong ammonia smell or other offensive odors may indicate overwatering or an imbalance in materials. Ammonia odors can occur when composting a lot of fresh, green plant material, especially grass clippings.

After four to five weeks the inside of the pile should be hot. This happens in less than a week using the quick composting procedures described in the following section. Push a wire or stick deep into the pile, pulling it out and touching it to check temperature. In three to four months, the pile should be about half its original height. Compost will be dark, moist, and crumbly and should smell like moldy leaves with a rich, earthy odor.

## Quick Composting

If you started a garden and want compost right away, consider making quick compost. With a supply of organic material, you can make compost in as little as 12 to 14 days.

For home gardeners, the minimum size of a compost pile is 3 feet by 3 feet by 3 feet. Any smaller and the pile may not heat correctly. The microorganisms that decompose the organic material require oxygen. It is important that you do not make the pile too large because oxygen only penetrates 18 to 24 inches in all directions. Below are the three requirements for quick composting.

### *Chopping or Shredding*

Shred or chop organic materials finely. This increases surface area and enables rapid decomposition.

### *Blending*

Microorganisms, nitrogen activator, and composting material should be blended completely to ensure contact among the major ingredients. You can do this by feeding the

raw materials through a chipper/shredder, or mixing them in a container, bag, or pile.

### *Frequent Turning*

Turn contents of the compost pile every 2 to 3 days to encourage rapid decomposition. The recipe for quick composting is similar to regular composting. Start with 4 to 5 parts of organic materials such as shredded leaves or grass clippings. In addition, you need about 1 part of garden soil, and a high-nitrogen fertilizer material such as commercial fertilizer, blood meal, or similar nitrogen source.

**Pulverize organic material.** If possible, blend in soil and fertilizer during the shredding process. Feed materials through a commercial shredder/chipper or a bagging-type lawnmower, catching shredded material in the bag.

**Blend composting material and moisten thoroughly.** Place in a plastic-lined container or pile and cover loosely with plastic to keep materials from drying out. Decomposing organisms need oxygen. To prevent anaerobic fermentation, which slows decomposition and creates off odors, do not cover or seal completely.

Using an implement such as a spading fork, turn or agitate the compost every 2 to 3 days. The compost should start heating to the center of the container immediately. The process should continue for the first 10 to 12 days. If you notice an off odor coming from the pile, open it up to aerate and agitate to incorporate oxygen into to the pile. Replace water as needed, keeping compost moist but not too wet or saturated.

In 12 to 14 days, you should notice a decrease in the temperature of the pile and volume reduced by about half. This means the quick composting process is essentially complete. The composting processes may continue over time, but the compost can be used safely as a garden additive or mulch.

The time required for quick compost depends on the fineness of materials and how often the

pile is turned. If you have difficulty getting the process to work quickly, try shredding materials to a finer texture and encourage thorough blending of the organic material, soil, and nitrogen activator.

## Using Compost

There are several ways to use compost in the home garden and landscape.

### *Fertilization and Soil Improvement*

The addition of organic material improves texture and workability of soil. Heavy, tight clay soils benefit from the loosening effects of organic materials. Sandy soils also benefit from the improved water-holding capacity and fertility organic materials provide. Compost contains nutrients plants require. Nutrient content varies based on the types of materials and the amount of water in the compost. A general recommendation is to apply compost at the rate of 50 to 100 pounds per 100 square feet. This translates to 1 or 2 bushels of material for every 10 square feet of garden area, or about ¼ inch of compost spread over the entire area.

The best time to apply compost is just before tillage in either the spring or fall. Tilling incorporates the compost throughout the plant root zone. In Kansas, gardeners typically till garden soils in the fall. Compost made early in the season should be ready for use by then. If you have a two-pile system, you can use compost prepared last year.

### *Compost at Planting*

Apply as a band in the bottom of a row trench or add several shovelfuls of compost to the bottom of planting holes. Single tomato plants, perennial flowers, trees, or shrubs all benefit from the "slow release" of compost nutrients through the early growth period. For seeded vegetables or flowers, use compost as a top-dressing over the row to prevent soil crusting. Compost can be mixed with water to form compost tea and applied as a substitute for soluble fertilizers or starter solutions. As a general rule, mix equal parts of compost and water. The leftover compost can be added to garden soil later.

### *Mulching*

Use of mulch is one of the most beneficial practices for summer gardening in Kansas. Mulches hold moisture in the soil, prevent weed growth, and reduce soil crusting and splashing. Mulches also help to keep the soil cooler in the summer. A mulch of compost 2 to 3 inches thick along the row of garden vegetables or flowers, or spread around perennial flowers, trees, or shrubs reduces moisture fluctuations and slows evaporation of water from the soil surface. At the end of the garden season, till the mulch into the soil as a source of organic material.

### *Common Problems*

Compost is not a cure-all for garden soils or problems. The benefits of composting outweigh limitations, but it is possible to overdo it. The high nutrient content of some composts can promote lush, rapid growth at the expense of fruit production if you apply too much. Compost that has not completely decomposed continues to break down. If added to the soil in large amounts, it can remove or tie up soil nutrients until decomposition slows. This is of particular concern with spring applications and where compost is incorporated into the soil.

When applied to the soil surface, certain types of compost pack to a dense, tight layer almost impervious to water. This may be sign of poorly made compost. To correct this, use more soil with the compost or mix the soil with compost before use. Creating a dark, cool environment at the soil surface provides ideal conditions for sowbugs, squash bugs, and other insect pests. Contact your local K-State Research and Extension office for specific control recommendations for each of these insects.

## Considerations in Acquiring Compost

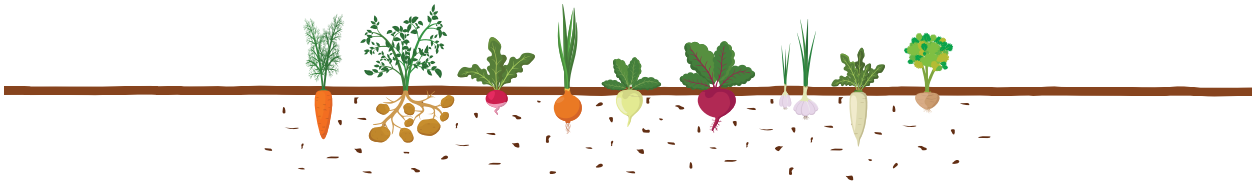
If you bring compost or manure in from an outside source, be aware of the possibility of residual herbicides still being present at very low levels. These herbicides were often used to treat a pasture and can persist in organic matter for a long time. Garden plants in areas where contaminated compost or manure was used will show signs of herbicide injury similar to 2,4-D drift. Usually, the residual affect will persist for 6 to 12 months before broadleaf plants can successfully grow in these areas again.

### Composting Troubleshooting Guide

| Problem | Possible Causes | Solution |
|---|---|---|
| Rotten odor | Excess moisture, lack of oxygen (anaerobic conditions) | Turn pile or add dry, porous material such as sawdust, wood chips, or straw. |
| | Compaction (anaerobic conditions) | Turn pile or make the pile smaller. |
| Ammonia odor | Too much nitrogen (lack of carbon) | Add high-carbon material such as sawdust, wood chips, or straw. |
| Low pile temperature | Pile too small | Make the pile bigger or insulate sides. |
| | Insufficient moisture | Add water while turning pile. |
| | Poor aeration | Turn the pile. |
| | Lack of nitrogen | Mix in materials that contain nitrogen such as grass clippings or manure. |
| | Cold weather | Increase pile size or insulate with an extra layer of straw or similar material. |
| High pile temperature (>140°F) | Pile too large | Reduce pile size. |
| | Insufficient ventilation | Turn the pile. |
| Pests: rats, raccoons, insects | Presence of meat scraps or fatty food waste | Remove meat and fatty foods from the pile. Cover with a layer of soil or sawdust. Build an animal-proof compost bin. Turn the pile to increase temperature. Source: Composting Troubleshooting Guide, MF3371 |

# Chapter 6

# Planting the Garden



Planting the garden is often one of the most exciting parts of the process for a gardener, and many gardeners want to plant everything as early as possible. Determining the best time to plant each crop and the best planting method can have season-long ramifications for the success of the garden.

## When to Plant

Planting date is determined by local weather conditions and the nature of the various garden vegetables. When determining what to plant and when, it is important to carefully consider the weather patterns of your part of Kansas. Warm season vegetables require warm soil and air temperatures, typically after the chance of frost is past. Cool season vegetables will grow in colder temperatures and may not tolerate the heat of summer. These vegetables are typically planted before the danger of frost has passed in the spring. The chart below lists some examples of vegetables in each category.

Use the Average Expected Planting Calendar at the back of this book as a general guide for when to plant various vegetables in your garden. These dates are based on estimated average temperatures in various locations. There may be unusual years that are either much warmer or much colder than the average. Each year is unique. Use your judgment in evaluating the weather each year.

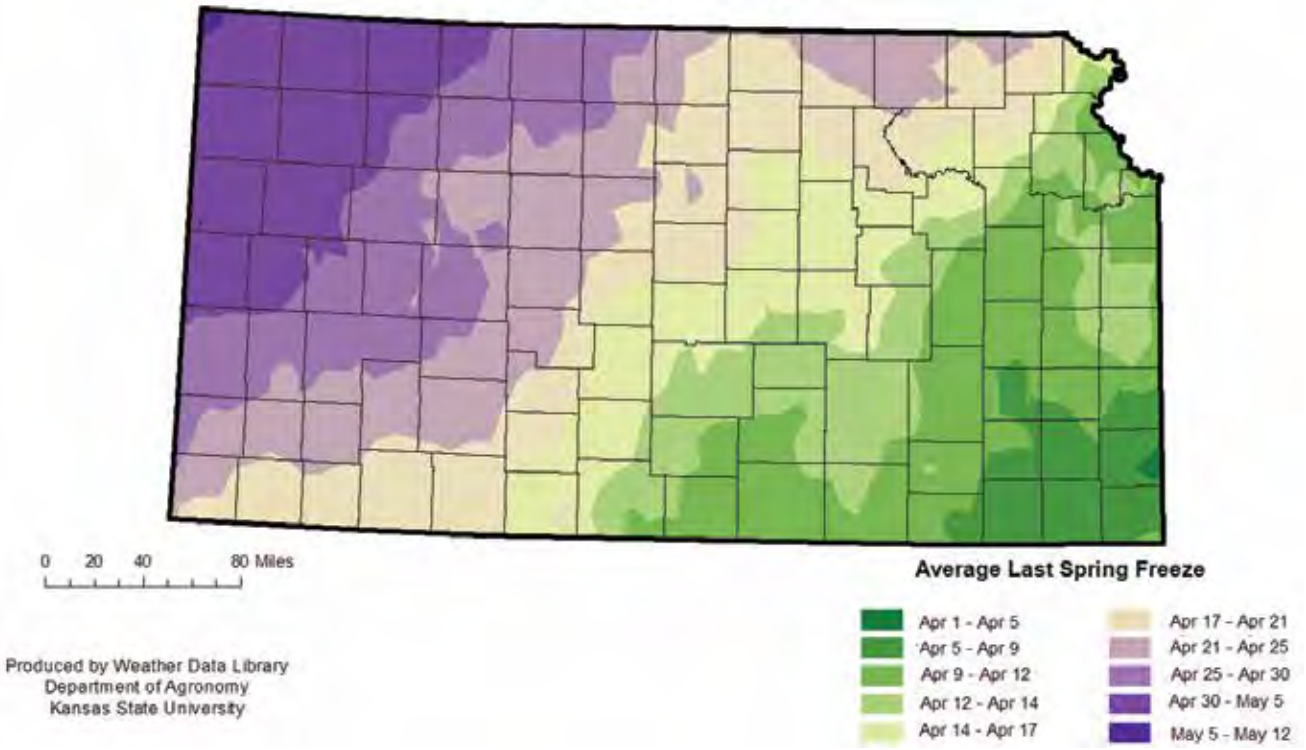
Weather conditions can vary widely across the state, making it necessary to use several pieces of information to determine the best planting window for each type of vegetable. The map (on the next page) shows expected first and last frost dates across Kansas. Warm season vegetables should usually not be planted until after the last frost date has passed, and sometimes later depending on local weather conditions in a given year. When planning fall plantings, keep in mind the average first frost in the fall to determine how early to plant.

**Warm and Cool Season Vegetables**

| Warm Season | | Cool Season | |
|---|---|---|---|
| Not frost tolerant, prefer soil temperatures of at least 55°F, if not warmer. | | Many are frost tolerant, will grow at soil temperatures as cold as 45°F, may not tolerate hot soil temperatures. | |
| Tomatoes | Sweet potatoes | Lettuce | Broccoli |
| Peppers | Corn | Spinach | Cabbage |
| Melons | Beans | Radishes | Beets |
| Squashes | | Carrots | |

## Average Last Spring Freeze

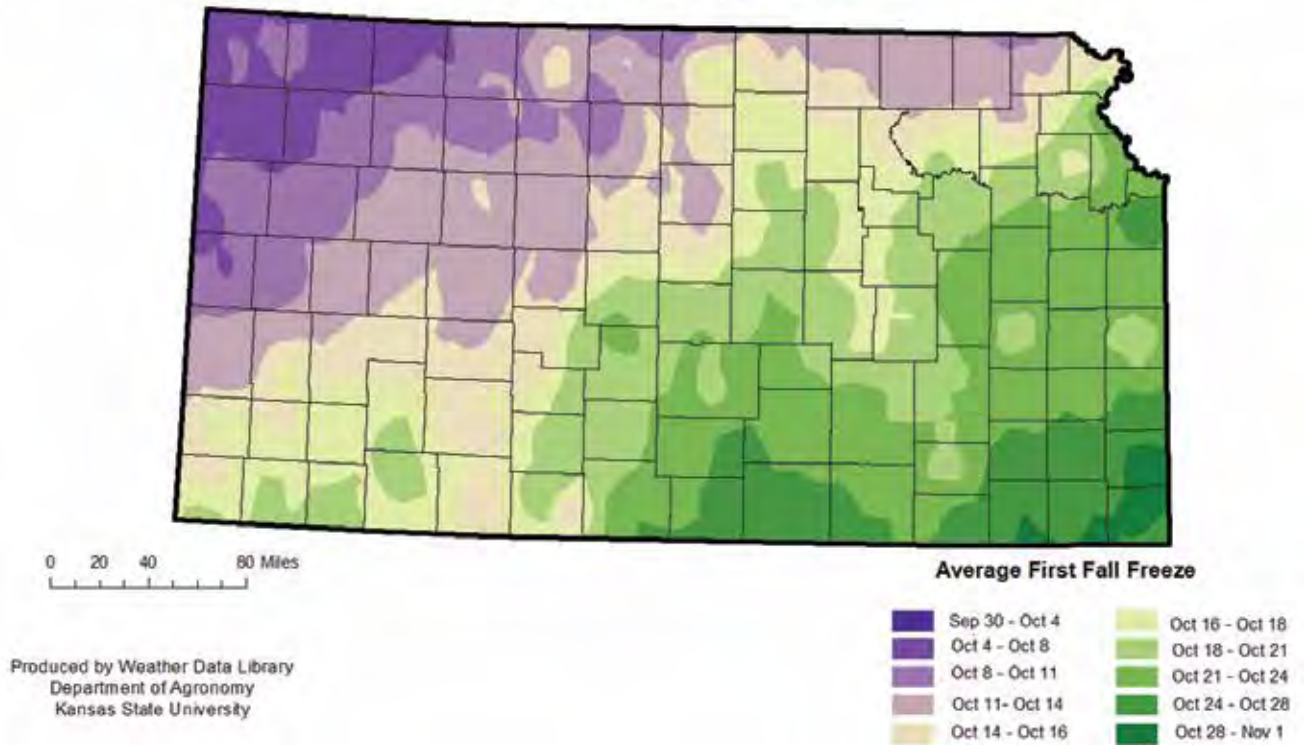
at 32 °F from 1991-2020 data




Produced by Weather Data Library
Department of Agronomy
Kansas State University

## Average First Fall Freeze

at 32 °F from 1991-2020 data

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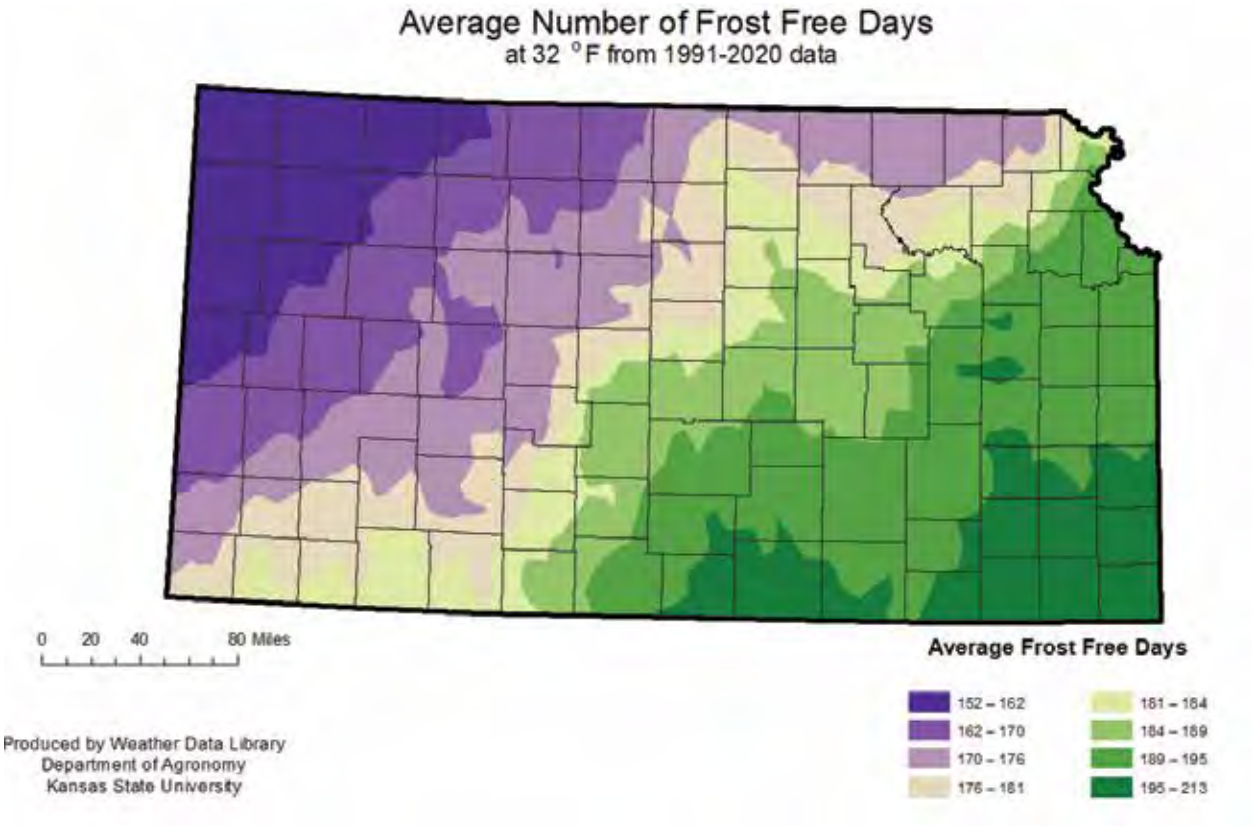
Kansas State University




Another helpful source of weather data and information that can guide your planting times each year is the Kansas Mesonet (*mesonet.k-state.edu*). The mesonet records the weather and soil temperature data from locations around the state. Checking the 7-day average soil temperature can be a helpful indicator as to whether it is safe to plant crops, especially in the early spring or late summer.

Soil temperature data: *http://mesonet.k-state.edu/agriculture/soiltemp/*

Because of the high level of weather variability across the state, you may also find it helpful to consult with your local Extension agent or an experienced gardener to help you better understand the planting windows that are generally successful in your area.

Many vegetables can be planted so they mature for use in the fall as well as in the spring. See the chapters on *Fall Gardens* and *Season Extension* for more discussion of this topic.

## Preparing the Seedbed

Seedbed preparation is meant to work the soil sufficiently so that when seeds are planted, there is good seed-to-soil contact. This facilitates the germination process and gives a better population of plants in the garden. An ideal seedbed has no large clods, is smooth and level, is free of weeds and large plant debris, and is moderately firm.

Many gardeners till or spade their soil in the spring. In some areas with heavy soils, it may be desirable to till in the fall to allow winter freezes to mellow the clods. Make sure the soil crumbles well as it is tilled. Working the soil when it is too wet will cause a poor seedbed and poor soil conditions throughout the season. As a rule, soil is too wet to work if you can press a handful of it into a muddy ball. After tillage, smooth or rake the soil to break up large clods and create a level seedbed for planting. Work the seedbed as little as possible but break up most of the larger surface clods.

If you use no-till gardening methods or a raised bed where the soil rarely needs tillage, first pull back any remaining mulch from the intended planting area. Mulch can be replaced after germination occurs, if needed. Next, it can be helpful to use a broadfork or pitchfork to loosen deeper soil to help improve drainage. Finally, use a garden or stirrup hoe or a tilther to loosen the top inch of soil, and a rake to create a smooth seedbed for planting.

For tiny vegetable seeds such as lettuce and carrots, it may be necessary to rake up a seedbed of very fine soil. For most vegetable seeds or plants, it is usually better to have some small surface clods.

## Seeds

Seeds should be obtained early in the year so you can get the varieties you want. The Vegetable Crop Information chart in the back of this book will guide you on how much seed to buy. Seeds can be obtained from local dealers and seed catalogs. Purchase high quality seed from reputable seed sources to ensure a good crop.

Avoid saving seed from your previous crops unless you have a special interest such as the continued propagation of an unusual variety. Saving seeds requires careful attention to cross-pollination contamination and seed harvesting practices. It is possible to get atypical plants when you save your own seeds, especially when the plants are cross-pollinated or originate from hybrid varieties. Commercially available seeds are often treated for disease and insect resistance and are selected, harvested, and stored under conditions that ensure health and vigor.

Before planting, carefully mark your intended planting areas. A measuring tape or yardstick, string, and stakes or plant labels may be useful. If planting in a raised bed or an intensively planted garden, measure and mark off the planting grid or rows. If planting in rows in a larger garden, use a string or similar method to mark straight rows through the garden. Use the Vegetable Crop Information chart to indicate proper spacing. If you have a mechanical tiller or cultivator, be sure to allow adequate space between rows for cultivating.

## *Seed Planting*

Seeds planted at the proper depth and spacing will have better success. Information on planting depth and spacing can be found in the Vegetable Crop Information chart at the back of this book. Most seed packets will also include a recommended planting depth and spacing information.

In a small or medium sized garden, it is possible to plant most seeds by hand. To plant, make a furrow the appropriate depth in the planting row or area. Place the seeds in the furrow at the correct spacing. Then cover the seeds with soil from the edge of the furrow and gently but firmly tamp the soil down. After seeding at the proper rate and depth, cover gently and water if the seedbed is very dry.

In a larger garden, seeds can still be planted by hand, but many gardeners find that investing in a push seeder is well worth it for planting larger areas in a short time. These seeders can often be adjusted for different seed spacings, making precision planting much easier.

## Thinning

Many small-seeded crops need to be thinned. For crops such as lettuce, spinach, other direct-seeded leafy greens, beets, carrots, radishes, and turnips, it is necessary to thin some young plants from the thickly seeded row. An advantage of this process is that you can select the best of several plants and remove the poorer ones. This should be done 1 to 2 weeks after emergence of the seedlings.

If seedlings are very tight or there is concern about disturbing the roots of nearby plants, seedlings can be removed by pinching them out at the soil line with your fingernails or snipping with small scissors. The average spacing between plants in a row is indicated in the Vegetable Crop Information chart. Also, many of these crops are edible at any stage of growth, including the tops of root vegetables, and as such can make a delicious early spring salad.

## Planting from Seedlings

Certain vegetables are most successfully transplanted into the garden as young plants. Reference the Vegetable Crop Information Chart for guidance on whether a vegetable should be transplanted. Most home gardeners obtain plants from local plant growers or suppliers. In areas where dealers are not available or where the desired varieties cannot be obtained, gardeners may need to grow their own plants.

## Selecting Transplants

When purchasing vegetable plants from a garden center or nursery, look for stocky, dark green plants that appear very healthy. There should be several sets of leaves on the transplants, and no evidence of insects or diseases on the leaves. As much as possible, avoid plants that are tall and gangly or have already started flowering or fruiting. If you purchase a plant with flowers or fruit, pinch them off before planting to encourage good root growth.

## Producing Transplants

Most vegetable transplants require 4 to 8 weeks from the time seeds are sown until plants are ready for transplanting to the garden. Use the Average Expected Planting Calendar to determine the expected garden planting date, and then count back the number of weeks required to determine when to start seedlings indoors. Most seed packets will provide guidance on the number of weeks of growth required before outdoor transplanting. Experience over time will also help refine the best timing for your particular planting environment.

Various types of containers — paper cups, milk cartons, clay pots, peat pots, flats, or other packages can be used. A container must have a drain hole.

Transplants can be started by seeding vegetables thickly in a small box or flat. To prevent diseases, a disease-free, soilless potting mix or seed starting mix should be used. If sowing into a small flat, sow thickly in rows 2 inches apart. Cover lightly with a thin layer of the planting medium and water gently. Place the box or flat under lights or in a sunny window and keep it moist until the seeds germinate.

After seedlings emerge and have 2 to 4 small leaves, they should be replanted in small pots and allowed to grow until transplanted to the garden. Lift the seedling plants from the flat and grasp the leaves, not the stem, of the small plants. Place one seedling in each pot. Water gently and place in a sunny window or under lights until transplanting time.

Seedlings can also be started directly into individual pots. Fill the pots with a soilless potting mix or seed starting mix and tamp down slightly. Seeds should be planted a rate of 1 to 2 seeds per pot. Cover lightly with a thin layer of the planting medium and water

gently. Place the pots under lights or in a sunny window and keep them moist until the seeds germinate. After seedlings emerge and have 2 to 4 leaves, any extra plants can be thinned out of the pots to encourage strong growth of a single plant in each pot.

Before transplanting to the garden, plants should be "hardened," or conditioned to outside temperatures, brighter sunlight, and wind. About 10 days before the transplanting date:

- Gradually withhold watering so the plants are not wilting but are getting less water than normal.
- Gradually expose plants to outside conditions by placing the plants in a protected location outdoors.
- Avoid fertilizing, especially with nitrogen.

If you have a cold frame or similar protected location, plants could be placed outside for the entire 10 days of the hardening procedure. If you do not have a cold frame or other protective structure outdoors, you may need to bring plants indoors overnight or during days with more extreme weather, such as high winds, very hot or cold temperatures, or heavy rain. By following this procedure, the plants will begin to grow soon after transplanting rather than suffer "transplant shock," which can drastically slow growth of transplants and increase their susceptibility to insects and diseases.

## Transplanting

When preparing to transplant the seedlings, first mark out the rows and planting locations at the optimum spacing. Refer to the Vegetable Crop Information chart for spacing recommendations. It is also helpful to have plant markers to label different varieties or make a planting map that can be referred to later.

When planting the seedlings, first dig a hole that is somewhat deeper and wider than the size of the pot. Most vegetable transplants can safely be planted slightly deeper than they are currently growing in the container. If the soil is very dry, it can be beneficial to put some water in the planting holes and let it soak

in before planting. It is also helpful to use a water-soluble starter solution in the planting holes or immediately after planting. The transplants themselves should also be watered thoroughly before transplanting to help remove them from the pots and to support their growth in transplanting.

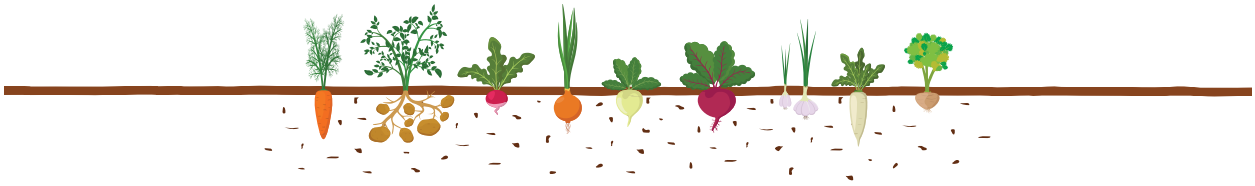
To plant the seedlings, gently remove the plants from the pots by holding them by the stem, close to the soil surface. As much as possible, try not to disturb the roots of the plant when planting. If the roots are very tight in the pot, especially near the bottom, it is beneficial to gently pull apart those lower roots to facilitate better root growth after transplanting. Place the plant in the hole and cover the entire root ball with soil, then tamp down the soil firmly, especially around the stem, to provide adequate support to the plant.

If peat pots or other biodegradable pots were used to grow the seedlings, the entire pot can be planted to lessen the transplanting shock. Make sure the pot is well covered, however, because the exposed peat pot acts as a wick to draw moisture from the soil around the transplant. It may also be beneficial to gently break or tear the bottom of the pot when planting.

Monitor the plants and the weather for the first few days after planting. New transplants may need extra water while becoming established. If the temperatures or wind are problematic, consider protecting the newly transplanted seedlings with row covers, milk jugs, or similar physical barriers for a few days.

# Chapter 7

# Garden Maintenance



Once a garden has been planned and planted, many other cultural practices will increase the quality and yield of the garden produce. Staking or trellising, watering thoughtfully, using mulch, and controlling weeds will help prevent diseases, support plant health and growth, and improve produce quality when implemented consistently and with care.

## Vertical Gardening

Most home gardeners have limited garden space, which makes larger, vining vegetables difficult to include in the garden plan. Many of these plants can be grown using trellises, cages, or stakes. In addition to using space more efficiently, these methods reduce disease and fruit rots by improving airflow and keeping fruit off the ground.

**Caging.** Tomatoes, peppers, and tomatillos often need cages for both support and to encourage a vertical growth habit. Cages available for retail sale are often good for peppers, tomatillos and compact tomato plants, but are frequently too short and flimsy for full-sized

tomato plants. A cage that is approximately 2 feet in diameter and 5 feet tall will perform well for most larger tomato plants. These cages can also be used for trellising cucumbers, pole beans, or similar crops.

**Staking.** Training plants to an individual stake can be effective for plants in very tight spaces or containers. Pole beans and snap peas can grow on individual stakes. Tomato and cucumber plants can also be trained to individual stakes with heavy and regular pruning of side shoots to maintain one main stem on the stake.

**Stake and weave.** Stake and weave is a training system that can be used for tomatoes, peppers, and tomatillos. This system involves using a stake for every 1 to 3 plants with twine or heavy string woven around the stakes to help train the plants to a more upright growth habit. For compact (determinate) tomatoes, 4- to 5-foot stakes can be used. For vigorous, tall (indeterminate) tomato varieties, use 6-foot or 8-foot stakes. Both wood and metal stakes can be used, although metal stakes have more strength and durability for use with large tomato plants.

*A stake and weave system to support vining plants.*

For peppers and tomatillos, this system can provide support to the branches that should prevent splitting and branch breakage as the plants get taller. For these plants, 3-foot wood or metal stakes are sufficient.

**Trellising.** Trellises come in a wide range of types and styles and can be made from a variety of materials, including recycled or found materials. Flat, vertical trellises made of string or twine can work well for lighter plants like beans and peas, while similar styles using wood or metal can work well for larger vines. A-frame trellises made of cattle panels or hog wire provide a strong trellis with a large surface area that is functional for many plants, including winter squashes and tomatoes. Arched or arbor trellises or pyramid-style trellises can be constructed from a wide range of materials and will support many types of plants.

*You can use different materials to make a trellis, such as this A-frame trellis made from a cattle panel.*

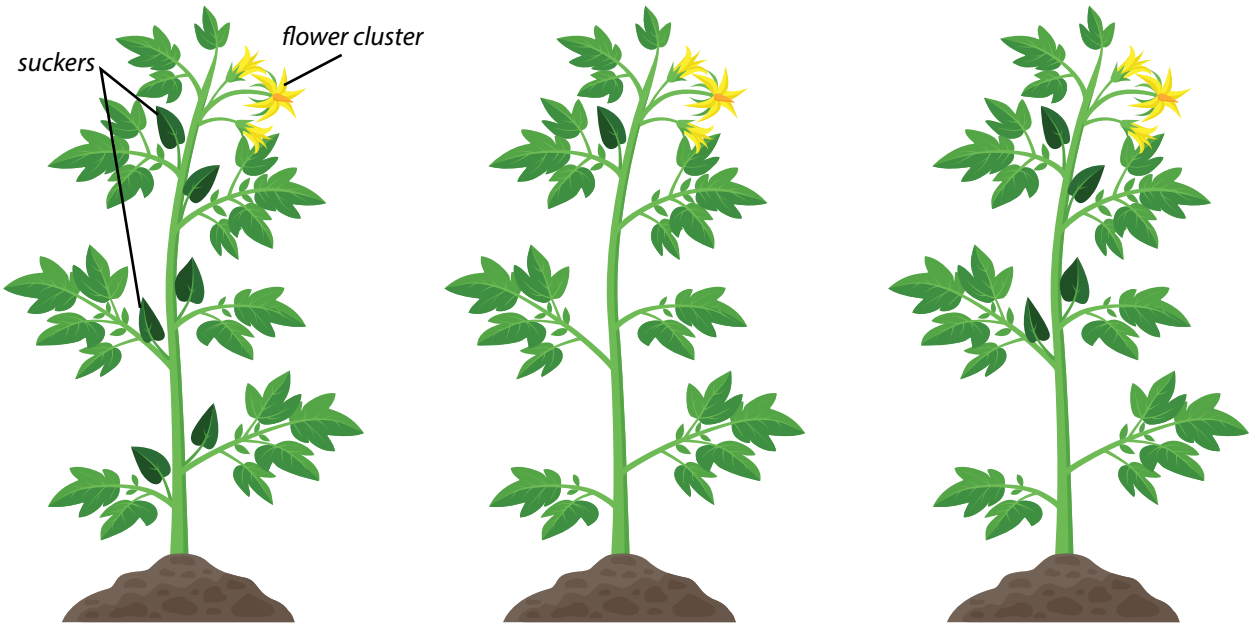
**Training plants in vertical gardens.** A few types of plants, such as beans and peas, will naturally climb trellises with minimal assistance. Most other plants, such as cucumbers, melons, squashes, and tomatoes, will need some training to get them started growing up the trellis. It can be beneficial to use string or twine or reusable clips or ties to help train plants to a trellis.

When attaching a clip or tie, do not tightly attach the plant to the trellis, which can girdle the plant and slow its growth. Use the clips or ties as guides or supports to encourage the plant to grow where you want it to be. As a plant grows, it may be beneficial to remove clips or ties from near the bottom of the plant to prevent girdling.

## Pruning

Removing some of the vegetative growth on certain plants will let more light into the plant, improve plant growth habit, and promote early fruit ripening. Pruning can be a valuable tool in small gardens to keep plants within their space or when you want to increase airflow to prevent disease. Pruning is commonly done with tomatoes. You could also prune vining crops, such as cucumbers, if you are training them to a stake or trellis with limited space.

*Plant clip to train vines to hold onto the trellis.*




***Nonpruned.*** *The suckers are darker colored for simplification and the first flower cluster on the main stem is labeled.*

***Pruned heavy (to the "fork").*** *Notice that the sucker immediately below the first flower cluster on the main stem has not been removed.*

***Pruned light.*** *Notice three additional suckers remaining on the plant.*

The most common type of pruning for vegetables, especially tomatoes, is to remove suckers or shoots that develop in the angle between the stem and branches. These suckers produce large side shoots if left to grow. Ideally, you should remove suckers as they form and before they are 1 to 2 inches long. If you need to remove larger suckers, use pruning shears or garden clippers to avoid damaging the plant.

For tomatoes, remove all the suckers from the bottom of the plant up to the first flower cluster. If you are pruning a cucumber or tomato plant while training it to a single stake, remove all the side shoots as the plant grows.

**Bottom pruning.** Bottom pruning is removing the leaves and branches from near the base of the plant. This is most frequently done with tomato plants to reduce the development and spread of foliar diseases during the growing season, but could be used on other plants judiciously. Removing the lowest leaves once the plants have put on significant growth will keep the leaves up and away from the soil, preventing some common diseases. Lower leaves that are yellowing or showing symptoms of disease can also be manually removed. Be sure not to remove so many leaves that the fruit will be exposed to the sun, increasing the risk of sunscald.

## Watering the Garden

Watering the garden can be an expensive and time-consuming task, especially in the heat of summer. When plants experience prolonged water stress, the yield, quality, and pest resistance will be reduced. Make the most of every drop of water with careful planning, proper soil preparation, efficient watering, and use of mulches.

### *Factors Affecting Water Needs*

The water needs of your garden will change over the course of the growing season. The amount of water needed at any given time will depend on your soil type, the size of the plants, and the weather conditions.

The type of soil you have influences its capacity for holding water. In general, sandy soils will not hold as much water and will dry out quickly. Heavy clay soils can hold higher

volumes of water and will dry out slowly. A loam soil will hold a moderate amount of water and will dry out at a moderate rate.

Plants need continuous access to water to thrive and grow. Water is necessary for both photosynthesis and the movement of nutrients throughout the plant. Water is absorbed through the roots and moves up through the plant where it evaporates into the atmosphere. As the size of the plant increases, there is a greater need for water. New seedling plants with shallow, poorly developed root systems may require regular shallow watering, while a mature plant with its extensive root system can use water from a larger area of the soil.

The temperature, humidity, and wind will all influence the amount of water needed by your garden. In hot, dry, windy conditions, water evaporates from the soil and is lost from the plant at high rates. When the weather is cool, humid, and calm, much less water evaporates or is used by the plant.

## General Garden Water Needs

Garden crops differ in the size and complexity of their root systems. Consider the type of plant root system when determining which water practice would be most efficient. The table on page 59 shows average effective rooting depths of selected vegetable crops. The development of the root system of garden crops is such that most of the water is absorbed in the upper half of the root system.

Some vegetables, such as lettuce and corn, have especially sparse, less developed root systems. Other crops, such as pepper and tomato, have fibrous root systems that more effectively remove water from a given area of soil.

As a rule, beds should be watered when the top several inches of soil are dry. Dig down 2 to 4 inches with a trowel to determine if soil needs additional water. Dry soil will not hold together to form a ball. If water is needed, thoroughly moisten the soil to a depth of 6 to 8 inches. In well-amended or prepared soil, this should take 1 to 2 inches of rain or irrigation. Check rainfall amounts to ensure that moisture is adequate. Consider watering after a light rain to take advantage of nature's contribution.

Cool-season vegetables, planted in spring or fall, generally root to a shallower depth than warm-season and perennial vegetables. These crops may need watering more frequently in stressful periods. Because fall and spring are usually characterized by cooler temperatures and more abundant rainfall, watering during these times is usually of less concern.

In many direct-seeded crops, you must be sure that adequate water is available in the root zone to encourage germination of seeds and allow for initial growth and development. It is often necessary to provide frequent shallow watering during dry seasons until the crop develops beyond the seedling stage. This is especially true of crops planted for fall production.

With transplanted garden crops, providing water at transplanting time is essential to support the plant until it can absorb water from surrounding soil. In general, apply ½ to 1 cup of water with each transplanted vegetable. Water slowly so it soaks into the area near the plant, or water at the bottom of the transplanting hole.

A garden crop needs water throughout its life cycle to survive and grow. There are several periods, however, when adequate water is critical. During these periods, the plant may respond to a lack of water by changes that are irreversible during the remainder of its life. See table on page 59.

When daytime temperatures average 85°F, unless rainfall is adequate, regular watering will be necessary. In those circumstances, start by watering clay soils once a week with 1 to 2 inches of water. If necessary, water in incre-

ments, applying ½ inch at a time and waiting 30 minutes between waterings. This allows clayey soils to absorb water without ponding on the surface. Trickle irrigation usually applies water slowly enough so it absorbs without ponding or running off. During warm weather, water loamy soils approximately every 5 to 7 days with 1 to 2 inches of water. Water sandy soils twice a week during similar conditions.

These recommendations are an average and vary depending on the site and environmental conditions. Watch plants and adjust amounts and frequency as needed. As the weather gets hotter and less humid in midsummer, the amount and frequency of watering will likely increase.

## *Methods of Applying Water*

Most gardeners use either drip/trickle irrigation or overhead sprinkler irrigation. Hand watering can be effective for very small gardens or container gardens but will be difficult to use for an entire garden season in most gardens.

### Drip or trickle irrigation

Drip systems are a common method of irrigating vegetable crops, particularly in small- to medium-sized growing spaces. These systems allow for the application of water directly to the plant root zone at a rate that can be absorbed by the soil without runoff. In addition to conserving water, drip irrigation benefits the plant by providing consistent soil moisture. Drip systems deliver water with precision, which reduces weed growth between rows and limits the spread of plant pathogens. It also allows for fertigation, the injection of fertilizers into irrigation water.

A disadvantage of drip irrigation is that filtration is required to keep particles from clogging emitters. Maintenance of low-pressure (drip tape) systems can be relatively high, and rodents, mowers, and weed trimmers can cause damage. Drip systems must be monitored for leaks and checked regularly to make sure they are functioning properly.

High-pressure and low-pressure are the two basic types of drip irrigation systems.

*High-pressure drip system with on/off valve and in-line timer. Using inexpensive timers helps conserve water and prevent over-watering.*

*This landscape-grade high-pressure drip system can last up to 10 years.*

High-pressure drip systems use pressure-compensating emitters that regulate the water flow at each emitter. Low-pressure systems use pressure regulators at the start of the system or where the system connects to the water supply. The flow of water dispersed at each emitter depends on the pressure of the system.

The use of "soaker hoses" is not the same as drip irrigation. Soaker hoses are effective in delivering water to the root zone, but typically do so at a much faster rate than a drip system. Soaker hoses require higher volumes of water than drip systems and may not provide consistent coverage over larger areas as compared to drip/trickle irrigation systems because they are not pressure-compensating systems.

**Low-pressure drip systems.** Low-pressure drip systems are the most commonly used for annual vegetable production by market gardeners and hobby farms. They are suitable for small plot gardening but can be very useful for mid-size to larger gardens or communal gardens. The components are inexpensive and simple to set up and tear down during the growing season.

Low-pressure systems utilize drip tape, or T-tape, with emitters installed at set spaces (4-, 12-, 18-inch, etc.) along the drip line. The spacing selected depends on the requirements of the crop and soil. A regulator must be used to control the water pressure in the system, which should range from 6 to 20 pounds

### Water-Holding Capacity and Availability in Different Soil Textures

| | Coarse Soils (Sand) | Mixed Coarse/ Fine Soils (Loam) | Fine Soils (Clay) |
|---|---|---|---|
| Water available (gal/cu ft) | ½ gal | 1 gal | 1½ |
| Depth 1" of water penetrates | 24" | 16" | 11" |
| Infiltration in 1 hour | 2" | ¾" | ¼" |

### Effective Rooting Depths of Selected Vegetable Crops (top 50% of root zone)

| Shallow (6-12") | | Moderate (18-24") | | Deep (over 24") | |
|---|---|---|---|---|---|
| Arugula | Lettuce | Beans | Kohlrabi | Asparagus | Squash |
| Bok Choy | Onions | Beets | Okra | Melons | Tomatoes |
| Celery | Radish | Broccoli | Peas | Pumpkins | Watermelon |
| Chives | Spinach | Cabbage | Peppers | | |
| Endive | Swiss Chard | Carrots | Potatoes | | |
| Fennel | | Corn | Sweet potatoes | | |
| | | Cucumbers | Turnips | | |
| | | Eggplant | Tomatillos | | |
| | | Kale | | | |

### Periods of Critical Water Needs in Crops' Life Cycle

| Stage | Crop |
|---|---|
| Germination | Seedlings, especially summer and fall crops |
| Transplanting | All transplanted crops |
| Pod enlargement | Beans, peas |
| Head development | Cabbage, broccoli, cauliflower |
| Root enlargement | Carrot, onion, potato, radish |
| Flowering to early fruit set | Corn, cucumbers, squash |
| Early fruit development | Melons |
| Uniform all season | Tomatoes, peppers, eggplant, lettuce |

per square inch (psi). The required psi is also dependent on the emitter and thickness of the drip tape.

When purchasing drip tape and/or pressure regulators, select the correct pressure regulator for the drip tape to ensure accurate operation. One advantage of drip tape is that it can be installed in long rows (>500 feet), and the same amount of water is delivered throughout the entire run. Drip tape can be reused for 1 to 2 years if stored in a rodent-free environment. Drip tape is connected into header (distribution) lines with simple connectors and terminated by using an end cap.

**High-pressure drip systems.** High-pressure drip systems use pressure-compensating emitters and are ideal for small plots and home gardens. They are also useful for perennial crops, such as small fruits, or in gardens where similar lengths of drip tube are used every year, such as in community garden plots. Pressure of the system/source can range from 30 to 50 psi, which is typical of city/county water supplies.

This type of drip system provides consistent water delivery at each emitter, regardless of the location, because of the pressure-compensating components. With this type of system, it is easy to have high-pressure water available throughout the garden for watering with hoses and/or overhead-type irrigation. Drip emitters can be installed into poly tubing or may come preinstalled. Since this type of drip operates at higher pressure than the low-pressure drip tape, this tubing is much thicker and is easily reused.

### Overhead sprinklers

Overhead sprinkler irrigation is inexpensive and can be used to water a diversity of crops in a relatively large area. Different types of sprinklers may be more effective for different garden layouts and types of crops.

Be sure that you assess the distribution of water applied to ensure that all areas get adequate water. Placing a few shallow cans in the area to check for uniformity of water application will give you an idea of the pattern of your sprinkler. Using catch cans will also help you measure the amount of water that you are applying to your garden.

One of the disadvantages of sprinklers is that they allow a considerable amount of water to evaporate into the air. Using coarse droplets and lower water pressure can reduce evaporation losses, especially on hot, windy days. Watering in cooler, less windy periods also helps to reduce wasted water.

When using overhead irrigation, be sure to apply water in a way that allows plant foliage to dry as soon as possible after watering. Thus, early morning and early evening watering is preferable to late evening watering.

## Mulching

Mulching is an important gardening practice that affects many gardening challenges, including:

- conserving water
- controlling weed growth
- managing soil temperature
- reducing disease spread

One of the most effective ways to reduce the need to apply water to garden plants and conserve natural rainfall is to use garden mulches. Mulches are most appropriately used on summer crops when periods of water use are greatest, as they provide a barrier that helps prevent moisture loss from the soil by evaporation.

**Organic mulches.** Common organic materials used in gardens include compost, straw, leaves, shredded newspapers, and grass clippings. Using coarse materials requires a 3- to 4-inch layer while fine materials can be applied in 1- to 2-inch layers. Carefully consider the quality of your organic mulch materials, as they can also introduce unwanted weed seeds, insects, or diseases into your

garden. Shredded newspapers or grass clippings can become matted down and prevent water infiltration.

Organic mulches help keep the soil cooler, reducing soil warming in the spring. You should wait to apply an organic mulch until late May or early June, once the soil is warm and the cooling properties will be beneficial. Mulches can be left in place and tilled into the soil during the fall as a source of organic matter. They can also be left in place to protect the soil over the winter. However, organic mulches can become a haven for pest insects to overwinter until the following season. You may want to assess the number of insect pests you had and your planned crop rotation when determining whether to leave or incorporate an organic mulch in the fall.

**Plastic mulches.** Plastic mulches are another option to consider. Black plastic mulch is preferred because clear plastic mulch promotes weed growth underneath it. Plastic mulch comes in a number of other colors, including clear (which can warm soil much faster, but also grows weeds), red (which tomatoes particularly like), infrared transmitting (which acts like clear mulch but won't allow weeds to grow), white (white on one side and black on the other to prevent weed growth; white mulch keeps soil cool and is often used for mid-summer plantings); and reflective, aluminized (which also cools the soil and is repellent to whiteflies and aphids).

Plastics usually are available in rolls 3 to 4 feet wide. They are placed over the row or bed, the edges covered with soil, and various sized holes cut for the different crops. In the home garden, plastic mulch can be laid by hand. It is important for the plastic mulch to be in direct contact with the soil to both maximize soil warming and minimize damage to the plastic during high winds.

The plastic surfaces absorb heat, warming the soil for earlier planting and crop production. Later, the foliage shades the plastic, reducing the heating of the soil. These mulches work

*Drip tape can be laid under plastic mulch in the garden. Prepare soil well to ensure good contact with mulch. Bury edges of mulch so it doesn't blow away.*

best with warm-season crops such as tomatoes, melons, peppers, and eggplant, which are usually established by transplant. Plastic mulches must be used with a drip irrigation system, as water will not penetrate the plastic.

**Disposal.** One problem with plastic mulch is cleanup and waste disposal. Biodegradable mulches made from modified starch or other bio-based polymers are also available and will probably become increasingly available in the future. These biodegradable mulches can be tilled in or left to decompose naturally after use.

Another option for soil covering is the use of weed barrier fabric, which can be reused from year to year. After preparing the soil, it can be placed in the garden where it will help warm soil for early planting while controlling weeds and conserving moisture. Best practices are to remove the weed barrier from year to year, or it will likely become covered with soil and become a messy nuisance.

## Weed Management

Weeds compete with vegetable plants for water, nutrients, and space. While there are a few herbicides that can be used in vegetable gardens, they are often tricky to use at the correct time when they will not impact the edible crops. In most cases, a combination of mulching, hand weeding, and cultivating will be necessary to control weeds in a garden. Overall, the goal of weed management should be to prevent weeds if possible. Once weeds start growing, the next goal is to prevent them from producing new seeds that will quickly multiply the weed challenges in future years.

The top priority in weed management is to minimize the weeds that are in the planting row or immediate vicinity of your desired garden plants. These weeds are in direct competition with your crops. The next priority is controlling weeds between the rows or planting beds. Weeds around the perimeter of the garden can be an eyesore but have less direct impact on the yields of your garden.

### Common Garden Weeds

Many different weeds can be found in a home garden and understanding their life cycles and growth habit can help you stay ahead of them before they become a problem. Most common garden weeds are annuals that can be controlled with good maintenance practices, mulching, and regular weeding or hoeing. However, if you have perennial weeds in your garden, especially bindweed or bermudagrass, you may need to develop a control plan that will last for several seasons.

**Annual weeds.** Annual weeds germinate from seed each year and complete their entire life cycle within a single growing season.

**Common Garden Weeds**

| Perennial Weeds | | | | Annual Weeds | | | |
|---|---|---|---|---|---|---|---|
| *Broadleaf* | | *Grasses* | | *Broadleaf* | | *Grasses* | |
| **Cool Season** | **Warm Season** | **Cool Season** | **Warm Season** | **Cool Season** | **Warm Season** | **Cool Season** | **Warm Season** |
| Clover | Bindweed | Orchardgrass | Bermudagrass | Bedstraw | Lambsquarter | Annual bluegrass | Barnyardgrass |
| Dandelion | Creeping oxalis | Quackgrass | Nimblewill | Chickweed | Morning glory | Bromes | Crabgrass |
| Dock | | Rough bluegrass | Silver beardgrass | Henbit | Oxalis | Cheat | Foxtail |
| Plantain | | Tall fescue | Windmill-grass | Knotweed | Pigweed | Little barley | Goosegrass |
| Thistles | | | | Shepherd's purse | Purslane | Wheat | Sandbur |
| | | | | | Ragweed | | |
| | | | | | Spurge | | |
| | | | | | Wild buckwheat | | |

Cool-season annual weeds typically germinate in the late fall or very early spring and will bloom and die by late spring. These weeds, such as cheat, chickweed, and henbit, are often not particularly problematic for a home gardener, as they are usually growing before spring planting begins. Simply till, hoe, or hand-pull these weeds when preparing the garden soil for planting each spring. Alternatively, covering the soil with either a thick layer of organic mulch or a black tarp in the late fall through early spring will prevent many cool season annual weeds from germinating.

Warm season annual weeds, such as crabgrass, foxtail, nutsedge, lambsquarter, and pigweed, can be much more problematic for the garden. These weeds will germinate when the soil is warm in the spring, at about the same time as you are planting many of your summer garden crops. They can also grow quickly and overtake slow-growing spring crops like carrots or beets. These annual weeds are most problematic in gardens with regular tillage and bare soil during the late spring and summer. These weeds are best controlled when they are very small by cultivating or hoeing. Weeds growing within the crop rows may need to be hand pulled. To minimize the amount of weeding, thick organic mulch, tarps, or weed barrier fabric could be used to prevent germination of weed seeds between rows and around larger plants.

Perennial weeds can be either cool season or warm season weeds. They can both germinate from seeds each year as well as continue growing from their roots, rhizomes, or stolons. This makes them particularly pervasive and difficult to control. If possible, spend several months eradicating perennial weeds from the garden area before the first growing season, and then work to prevent them from becoming re-established in the garden. If you have perennial weeds in an existing garden, you may need to use a combination of tactics to keep them under control, including mulches, tarps, hand weeding, cultivating, and herbicides.

## *Weed Prevention Strategies*

In general, it is far easier to prevent weeds from growing than it is to remove them. It is also easier eliminate very small weeds than it is to remove large weeds. Weed prevention strategies include mulching, occultation, minimizing tillage, using cover crops, and using pre-emergent herbicides.

**Mulching.** As discussed earlier in this chapter, there are a wide range of options and accompanying benefits and challenges of different types of mulches. When choosing an organic mulch for the purpose of weed prevention, it is critical to have a mulch that is largely free of weed seeds itself. Otherwise, the mulch can become a source of weed problems.

It is also necessary for an organic mulch layer to be thick enough to effectively shade the soil to prevent seed germination. In an organic garden, where mulching is a primary method of weed prevention, you may find it particularly beneficial to put down a layer of cardboard and then cover it with the organic mulch of your choice. This helps increase the shading and smothering capability of the organic mulch.

**Occultation.** Occultation is a relatively new practice in the United States and has become common on small vegetable farms that are minimizing tillage. This practice involves using black tarps, often silage tarps, to cover the soil when nothing is being grown in a particular area. The tarps are thick enough to prevent weed seed germination as well as smother any small, existing weeds. Typically, the area is watered, and then the tarp is laid across the area and secured at the edges. For best results, the tarp should be in place for at least 2 to 8 weeks. The tarp can be used for longer fallow (unplanted) periods as well, although you could also consider a cover crop for those times.

**Minimizing tillage.** Frequent tillage can contribute to annual weed problems by regularly bringing new weed seeds up to the

surface of the soil where they have the environment they need to germinate. Rather than using deep tillage multiple times a season, use shallow cultivation methods that only disrupt the top 1 to 2 inches of soil. Alternatively, till early in the season and then use mulches as mentioned above to reduce the need for additional tillage.

**Cover crops.** Cover crops can also be used to prevent weeds during periods when you do not have crops planted in your garden. Select a cover crop that grows quickly and is recommended for weed suppression. For example, buckwheat is often a good choice for home gardeners because it germinates and grows quickly in the summer after a spring crop is harvested, it effectively suppresses weed growth, and it is easy to terminate in a home garden.

**Pre-emergent herbicides.** Pre-emergent herbicides are products that are applied to the soil before weeds begin to grow and prevent them from growing. There is only one pre-emergent herbicide labeled for home garden use at this time, containing the active ingredient trifluralin. This product is primarily used against annual, broadleaf weeds. While this product is effective when used correctly, it is necessary to read the label closely and adhere to the application instructions for each different type of crop. Once applied, you must also avoid disturbing the soil as much as possible to maintain efficacy.

## *Weed Control Strategies*

Weeds that have already started growing in your garden area will need to be controlled in some manner. For many small gardens, hoeing and hand-pulling are the simplest and most effective methods of removing existing weeds. Weeds can also be controlled by cultivation or tillage and herbicides in certain cases.

**Hand weeding.** Removing weeds by hand remains one of the simplest and most effective weed control strategies. There are many different tools that can be helpful when hand weeding. Whether using your hands or tools, it is important to ensure that you remove all

of the root if at all possible, especially with larger weeds. This may require digging out a deep taproot on larger weeds. Hand weeding is easiest after a soaking rain or when the garden has been well watered. This will make it much easier to remove the weeds, root system and all.

**Tillage.** If your rows have been spaced to allow for a garden tiller, then you may opt for tilling between the rows to control weeds. As mentioned above, tillage can also bring up new seeds to germinate, so it is best to till just deep enough to remove the existing weeds.

**Hoeing and cultivation.** Hoeing and cultivating involve working the top 1 to 2 inches of soil to kill relatively young, small weeds. There are several different types of hoes and cultivator tools that may work for your garden situation. The goal of hoeing or cultivating is to uproot or cut off young weed seedlings from their roots. For weeds with more developed root systems, a narrow-bladed hoe with sharp, narrow corners is an effective option. For young weed seedlings, stirrup, circle, or scuffle hoes are all good choices.

Cultivation tools also come in a wide variety of types. In general, these tools will work best with loamy or sandy soils and when the weeds are very small. You may need to try several types of tools to find one that is the best fit for your garden situation and soil type.

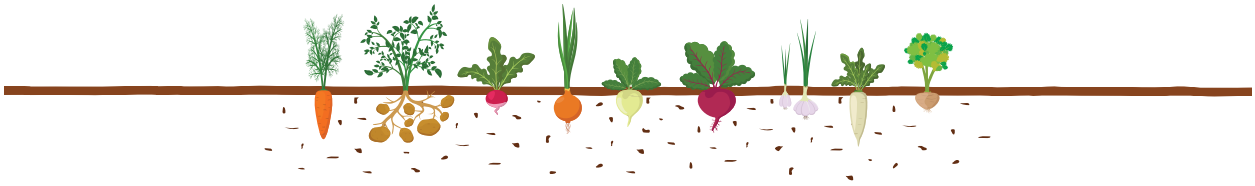
**Herbicides.** There are only a few herbicide options available for home gardeners to use in a vegetable garden. The first, sethoxydim, is primarily effective against young grass seedlings that are less than 6 inches tall. It also has a long pre-harvest interval for many crops. Pre-harvest intervals are the number of days between when you use a pesticide on a particular crop and when you can safely harvest the produce. It is critical to read the label closely before treating the garden with this product.

The other herbicide option for weed control is glyphosate. Glyphosate is a broad-spectrum herbicide that cannot be used directly on fruit or vegetables. During the growing season, it can be used around the perimeter of a garden or as a spot spray in aisles and walkways during the growing season. Take care to avoid spraying on windy days, and you may want to use a piece of cardboard as a shield to prevent overspray or drift onto desired plants. Applying the herbicide using a wick applicator is another option to keep the herbicide from impacting desired garden plants. Glyphosate can also be used to treat persistent perennial weeds either before or after the garden is planted. If spraying before planting, allow a few weeks for the herbicide to fully work on the weeds and dissipate.

There are few good options for organic herbicides that are also safe for the soil. Do-it-yourself mixes containing salt and other household chemicals are popular on the internet, but these products are not labeled for use in edible gardens, and table salt can harm your soil with regular use. The best option for an organic herbicide is horticultural vinegar, which is a 20% solution of vinegar. This product is broad-spectrum, meaning it will damage any plant it touches, including desired crops. It is also a "burn down" type herbicide. This means that the product will burn back the top growth of the weeds, but it will not kill the roots. It may be effective against annual weed seedlings, but it will provide only a very temporary solution for large weeds or perennial weeds.

# Chapter 8

# Fall Gardens



Fall is an excellent time for gardening in Kansas. This season is often overlooked in garden planning, and a successful fall garden requires preparations starting in the early summer. Fall gardens often have unique challenges due to both weather and pest pressure that have built up over the growing season.

A supply of fresh vegetables late in the year extends the gardening season, and the quality of many vegetables is better for fresh use and preserving. Vegetables maturing in the cool, crisp days of fall are often better flavored than those maturing in the hot, dry weather of late spring and summer. Many vegetables can be left in the garden and used as needed into the winter.

## What to Plant

Space available and preference will influence the choice of crops to plant for fall production. With attention to watering and pest control, many vegetables that are already growing in the garden will continue to produce into fall. Some of these crops are tomatoes, okra, peppers, New Zealand spinach, eggplant, and sweet potatoes.

Crops that are best adapted to fall culture are mainly cool-season crops, although cucumbers, summer squash, and beans can be grown as fall crops. Most spring vegetables are adaptable to fall gardening, but many Kansas gardeners report little success in growing fall peas. Peas require cool temperatures for germination and do not seem to adapt to the warmer temperatures of the summer planting period. You may want to try peas — particularly snow or sugar snap peas — in a mid- to late-August planting, but don't expect complete success.

Cabbage, broccoli, cauliflower, and Brussels sprouts can make excellent fall crops. Transplants may be difficult to find at the correct planting time in late July, so you may need to plan ahead to start your own transplants from seed. Allow 4 to 6 weeks to grow transplants indoors before setting the plants out in the garden. Depending on your location, the fall growing season may be too short for all varieties to mature successfully.

Beets, daikon radishes, turnips, and carrots perform well in the fall, but will require adequate moisture until they emerge. A light cover of compost over the row may prevent soil crusting and improve emergence. Larger daikons and other types of fall radishes as well as many heirloom and colored carrot varieties will perform better in the fall than in the spring, when the rapidly increasing temperatures can cause bolting and poor root quality.

Potatoes perform well in the fall in the northern part of Kansas. Soil temperatures in southern Kansas often remain too warm for fall potatoes to do well. Freshly cut potato seed pieces will rot easily in warm summer soils. Seed should be cut 3 to 4 days prior to planting and held at room temperature to heal over. This will prevent seed piece decay. Seed potatoes may be difficult to find in midsummer. Potatoes just harvested should not be used because they will not sprout readily. If you are without a source of seed potatoes, old potatoes from storage or a supermarket can be used.

Most lettuces will do well in the fall. If you are planting seeds directly in the garden, wait until late August when the soil is cooler. You can also start seeds indoors and transplant outside after about 4 to 6 weeks. Most lettuces will tolerate a frost down to about 28°F with minimal damage. Red lettuces develop beautiful color as the temperatures get colder in the fall.

A wide range of leafy greens can be grown in the fall, including spinach, kale, arugula, bok choy, mizuna, and more. Due to their rapid growth, many of these can be planted in late August to early September, for harvest in October or November. Spinach, in particular, should not be planted until late August or early September when the soil has cooled enough to ensure good germination.

Many gardeners report success in "overwintering" spinach and kale by using leaves in the fall without harvesting the entire plant. A light mulching through the winter should keep the plants alive to begin growth in the spring without replanting a new crop.

## When to Plant

Planting dates are influenced by how long it takes the crop to develop and how tolerant the crop is of first frosts or freezes. As mentioned above, some crops will also not germinate well if the soil temperature is too warm, which can further limit the length of the growing season. Crops such as potatoes or cabbage require a long period of development, thus a mid-July planting date, while crops such as lettuce or radishes can be planted in early September.

Although it is difficult to predict an exact date, the average first frost in the fall occurs in mid-October in most of central and eastern Kansas. It may occur several weeks earlier in northwestern Kansas and several weeks later in southeastern Kansas. The two calendars at the back of this book list suggested planting dates and estimated harvest periods for most of central and eastern Kansas. Northwestern Kansas gardeners may need to vary these dates about 10 days to 2 weeks earlier, southeastern Kansas gardeners 10 days to 2 weeks later.

## Fertilizing and Soil Preparation

Planting in space used for spring production may require additional fertilizer to support fall crops. Large quantities of fertilizer may damage tender young plants, so use it sparingly this time of year. In general, 1 to 2 pounds per 100 square feet of a low-analysis, all-purpose garden fertilizer should be sufficient to produce a successful crop.

Although adding organic matter is an excellent practice, it is not a good idea to add quantities before fall planting because this may loosen and dry out soils at a critical time. Save organic matter for a late fall application.

Extensive soil preparation probably will not be needed for fall planting. Avoid deep tillage

because it may dry out soil. A light surface cultivation will loosen soil to prepare the seedbed.

Additional amounts of fertilizer may be needed later in the season to ensure maximum plant growth and production. Cabbage, broccoli, cauliflower, collards, and kale, plus lettuce, mustard, spinach, and turnip greens will require about 4 tablespoons of a high-nitrogen, all-purpose garden fertilizer per 10 feet of row. It should be sprinkled along the row about 2 weeks after transplanting, or 4 weeks after sowing the seed. This will ensure lush vegetative growth before crop development during cooler fall weather. Other vegetable crops probably will not require any additional fertilization.

## Establishing Vegetables in Summer Heat

Fall gardeners will find that establishing a garden during the summer when soil temperatures are extremely high is difficult. One way to avoid seeding in extremely adverse conditions is to establish plants in containers or pots for transplanting to the garden later in the season as the weather begins to cool. Crops such as lettuce, cabbage, broccoli, cauliflower, Chinese cabbage, and collards can be grown in a cooler protected area, or under lights in a basement growing area for about 4 weeks prior to setting in the garden.

It is important to acclimatize crops for several days before transplanting directly in the garden. Place the flats in the direct sun, providing adequate water for 2 to 4 days to allow the plants to become accustomed to the stronger winds, hot sun, and the harsh environment of the summer garden.

Crops that are seeded directly should be planted slightly deeper than they would be for a spring garden. This has two benefits — it provides a slight cooling effect, as well as makes more moisture available at the deeper soil depth. It is probably wise to plant more seed than necessary and to do some thinning later to ensure an adequate stand. With frequent watering and heavy, tight soils, a crust may form in planting fall gardens. This can be overcome by a light sprinkling of peat moss, vermiculite, or compost directly over the row.

**Cooling the soil.** Because many fall crops prefer cooler soil temperatures to germinate and grow, it can be helpful to put a 3- to 6-inch layer of an organic mulch, such as straw, over the planting area a couple of weeks before planting to help cool the soil. When planting, pull back the straw in a narrow row to maximize the cooling effect in the surrounding soil.

**Shade cloth.** Another option for cooling the planting area for fall crops is to use shade cloth. Shade cloth can be stretched over the hoops of low tunnels during the summer to help provide some cooling.

## Watering

As in the usual gardening season, the availability of water can influence the success of fall gardening in Kansas. Many areas of the state receive adequate rainfall for successful gardening from late August through September and October. However, trying to establish young seedlings in high temperatures during July to mid-August is difficult without a readily available source of water. Many vegetables can develop a tolerance to a hot temperature, but they cannot tolerate a lack of sufficient soil moisture and cannot germinate without it.

**Seedlings.** Seeds need adequate moisture to germinate. Germination can be accelerated by soaking seeds overnight before planting. Until seedlings begin to emerge, it may be necessary to supply small quantities of water frequently, perhaps as often as several times a day. In warm summer soil, you will be surprised at how fast many seeds germinate and start to grow. The period of intensive watering lasts only several days.

Before planting a fall garden, apply water until the soil is moist to a 10- to 12-inch depth. This will require about 1 to 1½ inches of water — equivalent to 1½ inches of rainfall — immediately prior to planting. Water can be applied by overhead or drip irrigation.

As seedlings emerge, you can gradually reduce water because roots penetrate deeper into the soil. In fact, reducing water gradually will encourage deeper rooting of young seedlings, making them more drought-tolerant. In certain instances, a temporary wind screen or windbreak may reduce water loss from soil and protect tender seedlings.

Regardless of the system used, it is essential to provide adequate amounts of water deep into the soil for use by vegetables during the critical period of growth.

**Young plants.** When plants are small, they may require watering twice a week during dry periods. Try to allow the plants to show slight stress — become slightly limp — before applying water. This will encourage deeper rooting. As plants grow, they will require watering less frequently.

## Frosts and Freezes

The first frost in the fall will damage some frost-sensitive crops. Others may be slightly damaged but will continue to grow for several weeks until a severe freeze kills them. Other crops are hardy and will stand fairly low temperatures. These can be used into the winter months as needed.

From mid- to late October in most areas of Kansas, the weather forecast will indicate when a frost that will freeze tender vegetation is on the way. Many vegetables will have been producing vigorously for 2 to 4 weeks prior to this date; however, it may be possible to continue harvest for an even longer time.

Often, a few nights of low temperatures will be followed by warmer weather for several weeks. If you can protect tender vegetation during these few cold nights, you can continue harvesting vegetables. Some gardeners attempt to gain more days of growing time by covering plants with baskets, blankets, or plastic at the first frost warning. A further discussion of row covers and low tunnels can be found in the chapter on Season Extension.

Concentrate on saving only the tender vegetables which will be easily damaged by a slight frost such as bean, cucumbers, squash, peppers, eggplant, and tomatoes. Temporary coverings of polyethylene plastic, blankets, or tarpaulins may be stretched over the rows to provide frost protection. A small light bulb burning underneath such coverings can provide protection from freezes to around 25˚F. Coverings should be anchored so that they will not damage garden crops if a sudden wind develops. As little foliage as possible should come in contact with the surface of the covering because that foliage will freeze rapidly. After the danger of frost has passed, remove the coverings; be prepared to put them on again if a sudden frost is forecast later.

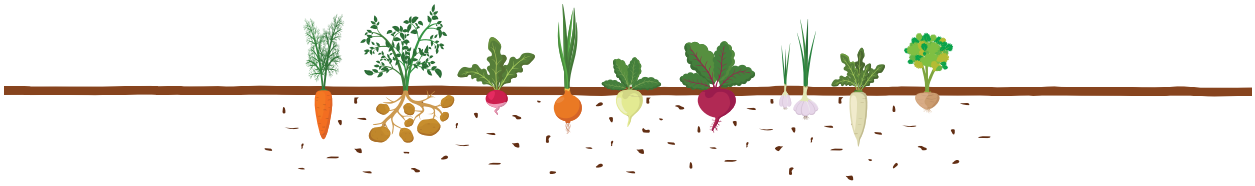
Semi-hardy vegetables should be harvested if temperatures in the mid- to upper 20s are forecast, and hardy vegetables harvested if temperatures in the low 20s seem imminent. Root crops such as beets, carrots, potatoes, and turnips may be mulched and used as needed until the soil begins to freeze, usually in late November to December.

**Sensitivity of Fall-Planted Vegetables to Freezing Temperatures**

| Tender crops | Semi-hardy crops | Hardy crops |
|---|---|---|
| Damaged by first frost | Can stand light frost down to about 28˚F | Can stand several frosts, but should be used before low 20˚F temperatures |
| Beans<br>Cucumbers<br>Irish potatoes<br>Summer squash | Beets<br>Bibb lettuce<br>Chinese cabbage<br>Leaf lettuce<br>Mustard<br>Radishes<br>Swiss chard | Broccoli<br>Brussels sprouts<br>Carrots<br>Cauliflower<br>Collards<br>Kale<br>Spinach<br>Turnips |

# Chapter 9

# Season Extension



Each crop in the garden has its production season when, if all goes well, gardeners enjoy abundant harvests and may have surplus to store or preserve. A number of techniques ensure continuous production of many crops beginning well before the usual production season, extending through the normal season, into the fall, and in some cases, continuing production year-round.

This chapter provides a brief overview of techniques that can be used for season extension, ranging from using appropriate varieties and planting dates, to selecting planting locations, to modifying the environment using materials such as mulches and floating row covers and structures such as cold frames and high tunnels.

## Crop and Cultivar Selection

Peak production for cool-season crops typically comes in the spring and fall. Warm-season crops, which are frost-sensitive, produce in the summer. The natural length of the harvest season varies by crop, with some crops, such as tomatoes, producing over many weeks, and others such as sweet corn, broccoli, and radishes, providing a relatively brief period of harvest from a planting. Cool-season crops vary in their capacity to tolerate temperatures below freezing, but some, including leafy greens, carrots, and beets, can easily be grown throughout the winter in an unheated cold frame or high tunnel. The season for warm-season crops can also be extended into the spring, fall, and winter, but these crops must be provided with the warmth they require for growth, and be protected from freezing.

Varieties (cultivars) of crops may vary in both the number of days to maturity (earliness) and tolerance to heat or cold temperatures. One way to ensure an extended harvest, particularly of crops that tend to produce during a brief harvest period, is to plant both earlier and later maturing cultivars at the same time.

Seed catalogs and packets almost always indicate the number of days to maturity. Seed catalogs may also identify cold or heat tolerant cultivars. For example, some lettuce and spinach cultivars are identified as slower to bolt (flower and produce seed), and these would be choices for growing into the hot summer. Cold tolerant cultivars of some warm-season crops, such as beans and sweet corn, would be choices for an early first planting.

## Maximize Yield

**Small, successive plantings.** Sequential planting is another way to ensure a continuous harvest of many crops, particularly those that produce only during a brief period. This

works well with quick cool-season crops, such as radish, lettuce, and spinach, and for warm-season crops, such as bush beans and sweet corn. The first planting of sweet corn will often include both early and later maturing, main season varieties, which will then be planted successively approximately every two weeks through the planting season.

The planting season for warm-season crops typically ends when there is no longer time for a crop to mature between the time of planting and the anticipated date of frost. If using structures such as cold frames or high tunnels, the planting season for cool season crops extends well beyond the normal season, but short days limit crop establishment and growth as winter approaches.

Well-established crops such as spinach, lettuce, and carrots can continue to produce throughout the winter, but they need to be planted early enough to give them time to grow before days become very short from November through January.

**Harvest promptly.** A timely harvest also helps ensure a long harvest period for many crops. Harvesting crops when they are ready can stimulate continued production by thinning the stand (for example, radishes, beets, green onions, lettuce), and removal of immature fruit (summer squash). Timely harvest also improves crop health through the removal of diseased, rotting, or overly mature fruits and other plant parts, and can contribute to air flow in the crop, reducing humid conditions favorable for disease development and spread.

**Use transplants.** Using transplants is a further way to ensure early production of many crops by allowing the gardener to take relatively large, rapidly growing plants to the field when conditions are favorable. Transplants of warm-season crops are produced in a controlled environment, such as a heated greenhouse, hot bed (see below), or under lights in the house so that they can be ready to plant out after danger of frost has passed. Care should be taken, particularly with the warm-season crops, such as peppers, to ensure they are planted in soil that is warm enough. It is a common error to plant peppers in soils that are cold (below 55˚F) and wet, resulting in root rots, which can kill the plant or delay production.

## Garden Site Selection

Various features of the garden can influence the potential for season extension. The orientation of the slope (the aspect) of land in the garden, as well as hedgerows and fences, which can act as windbreaks or sources of shade, can

have effects on the earliness and productivity of crops. Gardens in low lying areas or hollows called frost pockets are likely to be more prone to frosts than those on slopes, which allow for air drainage.

A garden with a northern aspect will warm up more slowly in the spring than will a southern facing garden. Western and southern facing slopes will capture the sun's warmth and may be advantageous for production early in the spring or late in the fall but may be too hot and dry when baking under the heat of the summer sun.

Northern facing slopes are often considered desirable for fruit production, as they warm up slowly and delay flowering till danger of frost has passed. Crops that require full sunlight need at least 6 hours of direct sunlight per day but may benefit from a bit of shade during the heat of the summer. A crop with an eastern exposure may benefit from the morning sun but be protected somewhat from the harsh afternoon sun. Gardeners in Kansas have reported an extended rhubarb harvest with plants receiving morning sun but afternoon shade.

**Wind protection.** Wind can be very damaging to vegetable crop productivity, resulting in damaged plants, both from the physical stress of the wind and from abrasion by sand particles being blown over the land. Hedgerows and fences can serve as effective windbreaks, protecting crops from prevailing winds and allowing for an extended season of production of higher quality vegetables in windy locations. Plants in a windbreak can compete with garden plants for water, so leave space between the garden and hedgerow or trees to avoid this.

## Raised Beds

Raised beds can help not only with season extension, but with general crop health, contributing to good drainage and soil aeration for healthy root growth. These can be permanent or made annually, with hoes or with an implement on a tractor or rototiller. Because they are raised above the surface of the soil, beds can warm up more rapidly in the spring than the rest of the garden, helping to produce earlier crops. Just as raised beds can warm up rapidly in the spring, they may also cool off rapidly in the winter. Thus, if poor drainage is not a concern, a flat surface or even a slight trench may help to conserve heat for crops grown in a protected structure such as a high tunnel or cold frame (see below) during the depths of winter. For more discussion of raised beds, see the chapter on Raised Bed Gardening.

## Mulches

Mulches are materials placed in the garden to cover the soil and can help with season extension by cooling or warming the soil and by conserving soil moisture and preventing the growth of weeds that can compete with crops. Mulches may be synthetic, including plastic films and weed barriers, or natural, including paper, straw, and wood chips. For further discussion on selecting and using mulches, please refer to the section on mulching in the Garden Maintenance chapter.

## Structures for Weather Protection

**Row covers.** Floating row cover is fabric, which as the name implies, can be placed directly over crops to protect them. It is usually made of spun-bonded polyester or polypropylene material, and comes in various thicknesses (for example, 0.55 or 1.5 oz per square yard), rated to provide varying degrees of frost protection to crops. It comes in widths ranging from 5 to 50 feet and a range of lengths and can be secured at the edges with weights such as sandbags or with metal sod staples.

Floating row covers can be useful in the garden, not only for short-term frost protection, but also to provide longer-term protection for overwintering crops such as spinach or strawberries. Row covers can provide a warm

and protected environment for many crops in the garden and provide protection from insect attacks.

While it is called floating row cover, it can be abrasive to some crops such as tomato, pepper, and zucchini, particularly in windy situations. Gardeners often fashion low tunnels (see page 77) using bent wire or plastic hoops placed over beds to keep the floating row cover from touching the crop.

Floating row covers can be particularly valuable for exclusion of serious insect pests such as cucumber beetles on cucurbits and flea beetles on eggplant or certain cole crops. It can be left to cover crops such as zucchini until they begin to flower, but then needs to be removed to allow for pollination. Floating row cover is often used to provide additional protection to crops grown in high tunnels during the winter. Hoops or other supportive structures are used to avoid damaging leaves that can freeze to the floating row cover when temperatures drop.

**Cold frames and hot beds.** Cold frames are typically low wooden boxes or frames with glass (often old storm windows), polycarbonate or polyethylene film covers, which are set in the soil or over beds in the garden. Cold frames may be used for winter production of cold tolerant greens such as spinach, for late fall and early spring production of a range of cool-season crops, and to harden off transplants before taking them to the open field for planting. Cold frames are often constructed with a sloping top and set facing the south to capture the most winter sun. Tops may also be peaked or arched with hoops that support a polyethylene film covering. Polyethylene film is the same thing as plastic sheeting, but for applications such as cold frames and high tunnels, special greenhouse film is used, which is typically 6 mils thick and treated with a UV blocking material so that it will last at least four years. Untreated polyethylene film will break down in less than a year and probably should not be used.

If the weather is at all mild and the sun is out, cold frames can heat up rapidly, and need to be vented. In the case of a cold frame with a hoop-type top, it is possible to replace the polyethylene film with floating row cover material when the season warms up, eliminating the need for manual venting, and providing a protected environment that may be used into the summer.

**Hot caps and cloches.** Hot caps, cloches, and other devices are used to protect individual plants in the garden. Like cold frames, these enclosed structures can heat up rapidly and cook plants in hot weather, so they need to be vented or removed during bright days. They are typically used for protecting transplants early in the season.

Paper hot caps are commercially available. Plastic hot caps can be made by cutting the bottoms out of milk containers, and placing the hot cap over the plant, with the base pressed into the soil. Glass bell jars called cloches were used in the past. They are rarely used today because they are expensive and cumbersome to handle.

Clear plastic, double-walled protectors that provide insulation from frost and a warm, protected sheltered environment for very early tomatoes are available through retail stores and garden suppliers. The space between the walls is filled with water, which provides great frost protection because it releases heat before freezing. In fact, commercial growers often use irrigation as emergency protection against unexpected freezes, particularly for fruit production.

## Low Tunnels

Low tunnels (above) are hoop-supported row covers, too low to walk in. Tunnels high enough to walk in are called high tunnels (see next section). Low tunnels may be covered with polyethylene film or floating row cover and may vary in width to span a single row or one or more beds in the garden.

Hoops to form the tunnel structure may be made of bent wire (usually 9- or 10-gauge galvanized wire), PVC (½-inch schedule 40 or flexible black pipe), galvanized electrical conduit (bent to form an arch), or other inexpensive materials. The length of hoops depends on the width of the bed, and typically varies between 5 and 10 feet. The distance between hoops can vary depending on the load tunnels may be expected to bear. Hoops are pressed firmly into the soil, which anchors them. If used to support floating row cover, and in a location protected from the wind, hoops may be spaced up to 10 feet apart. If polyethylene film is placed over hoops to protect crops from ice and snow in the winter, hoops should be spaced 3 feet apart.

Floating row covers of varying weights can be used during much of the year and can be replaced by polyethylene film during the

winter. Lighter row cover can be used during the spring and summer, and heavier row cover can be used in the late and early winter for freeze protection.

For covering in the winter, greenhouse polyethylene is preferred because it can be saved, and reused from year to year, but standard 6 mil polyethylene may be easier to obtain. Because it is not treated to resist ultraviolet radiation, it may only be expected to last one season.

The edges of row cover over low tunnels can be held in place using earth staples or similar anchors, or with sandbags, bricks, boards, or other weights. Polyethylene presents a greater challenge to keep in place, since it acts as a sail. A good approach is to secure the ends, bunching the plastic together and tying it off to a stake or t-post. Rope tie-downs running from stakes on either side of the low tunnel can then be used to hold the plastic in place between hoops. The edges of the polyethylene may be further secured with sandbags or other weights. On hot days, if venting is required, the edges of the plastic may be pushed up and held in place by the ropes. This same principle is used to keep the polyethylene on some types of homemade high tunnels.

## High Tunnels

High tunnels, also called hoop houses, are essentially unheated polyethylene-covered greenhouses. They are passively heated and ventilated and range from homemade field tunnels large enough to walk in (which distinguishes them from low tunnels), to more permanent structures, often sold by greenhouse manufacturers as high tunnels or cold frames.

Standard sizes of commercial high tunnels are typically too large for the home garden, but greenhouse manufacturers are increasingly targeting the home garden market as the benefits of high tunnels are recognized and demand for them increases. Rather expensive mini-greenhouses are commercially available to home gardeners, but do not exactly fit the description of high tunnels because crops in high tunnels are usually grown in the soil. Plans for homemade high tunnels are

available from various university extension services, including Kansas State University (*www.hightunnels.org*).

Crops, including vegetables, fruit, flowers, and herbs benefit in many ways from the protective environment provided by high tunnels and other structures. They often grow quicker, larger, and produce higher quality harvests than field grown crops. During the spring, fall, and winter, crops benefit from daily warming of the air and soil, leading to earlier and extended harvests.

High tunnels protect crops from severe weather, including wind, rain, hail, and snow. Because rain does not leach fertilizer from the soil in high tunnels, crops can make more efficient use of fertilizer. Also, sunlight reaching plants in high tunnels is diffused and lower in ultraviolet radiation, probably contributing to lush crop growth.

**Pests and diseases.** With adequate ventilation, and the exclusion of rain, fungal diseases on crops, such as foliar fungal diseases of tomatoes, tend to be reduced compared to the open field. The dry high tunnel environment can be favorable for a number of pests such as aphids, mites and whiteflies, but these may be controlled by natural enemies that may already be present or may be purchased and introduced.

Crop spacing and other cultural practices in high tunnels are similar to those used in the open field. Gardeners should avoid the temptation to plant crops such as tomatoes too densely because crops will grow more vigorously than in the open field, which can result in an impenetrable disease-prone mass of vegetation.

**Ventilation.** Ventilation in high tunnels is typically achieved by raising the sides to allow fresh air to enter. In structures with end walls, it is beneficial to be able to ventilate at the gable peak to let the hot air out. This can be done by installing a vent or by completely removing the end wall covering during the summer. There are numerous ways side venting can be done, including rolling up the plastic on a length of metal or PVC pipe, dropping down sides using a system developed for chicken houses, and simply tying up the sides at each hoop. For field tunnels, where the poly is held on by ropes over top of the plastic between bows, the poly can simply be propped open to vent the tunnel.

**Watering.** Because high tunnels exclude rain, crops grown in them must be watered. A simple garden hose and sprinkler wand is one option, as is sprinkler irrigation, which works well for some crops. Drip or other micro irrigation is the most efficient way to irrigate crops and provides moisture to the roots of crops without moistening foliage, which can contribute to disease development. Because high tunnels exclude rain, it is also possible for salts from fertilizer, animal manure, or irrigation water to build up in soil. Gardeners can monitor possible salt buildup in high tunnels by soil testing. If a salinity problem develops, salts can be leached through heavy irrigation or by removing the polyethylene cover for sufficient time to allow rainfall to leach out salts.

## Shade Cloth

Shade cloth is an underutilized tool for keeping things cool in the Kansas garden in the middle of summer. Shade cloth comes in a range of colors and percentages of shading. It can be used as a low tunnel covering or a high tunnel covering. It is commonly used over the polyethylene cover on high tunnels, thus providing cooling shade while maintaining the rain shelter benefit of the film covering.

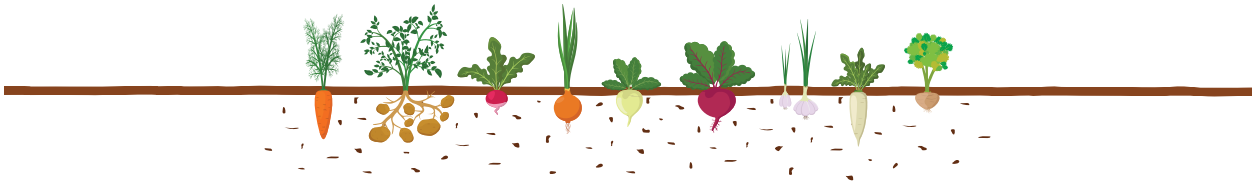
By limiting the amount of sunlight entering the tunnel and striking the soil, shade cloth helps to keep both the air and soil under it cool. Fifty percent shade cloth placed over a determinate tomato crop in a high tunnel when temperatures start to rise in May, stimulates the tomato crop to produce continuously throughout the summer and into the fall. Shade cloth can also be used prevent sunscald on colored peppers.

Another use for shade cloth is to extend the production of more heat tolerant types of lettuces or other leafy greens later into the summer from a spring planting. Shade cloth could also help cool the planting area when direct seeding or transplanting fall crops in the mid- to late summer.

*Shade cloth photos from "Summer Season Extension Using Shade Fabric for Cool Weather Crops," used with permission of Timothy McDermott, DVM, Assistant Professor and Extension EducatorAgriculture and Natural Resources, Franklin County, Ohio; The Ohio State University Extension*

# Chapter 10

# Insect and Mite Pest Management



Vegetable crops grown in gardens are susceptible to attack by a diverse array of insect and mite pests. Insect and mite pests vary in regards to when they are present and feed on plants, which depends on the time of year. Most insect and mite pests that attack vegetable garden plants have either chewing or sucking mouthparts. The different mouthparts result in distinct direct feeding damage to plants. For example, insect pests with chewing mouthparts feed on plant parts including: leaves, stems, flowers, fruits, and roots. They physically remove plant tissues during the feeding process. Insect and mite pests with sucking mouthparts feed on plant fluids within the vascular tissues of plants, causing stunting, wilting, leaf distortion, and leaf yellowing (starting with the lower leaves). In addition to the direct damage caused by insect and mite pests, some insects such as aphids, leafhoppers, thrips, and certain beetles cause indirect damage by transmitting diseases (e.g. fungi or viruses) when feeding or by creating wounds that allow for infection by disease-causing organisms (e.g. fungi or bacteria).

Some insect pests leave remainders ("leftovers") associated with their feeding and development. For example, caterpillars leave fecal deposits (frass) on plant parts (e.g., leaves and stems) while feeding, and sucking insects such as aphids and leafhoppers may leave a clear, sticky substance on leaves called honeydew. Aphids will also leave molting skins on plants as they develop, which may be mistaken for whiteflies. Furthermore, some insect pests such as caterpillars and beetles only feed at night — but the damage they cause will be evident during the day as well as any "leftovers."

## Insect and Mite Pest Development

Insects can undergo complete or incomplete metamorphosis (change in form). The life stages of insect pests that undergo complete metamorphosis include: egg, larva, pupa, and adult. Insect pests associated with complete metamorphosis include beetles and caterpillars. The life stages of insect and mite pests that undergo incomplete metamorphosis include: egg, larva or nymph, and adult.

*Fecal deposits (frass) on leaf associated with caterpillars.*

Insect and mite pests affiliated with incomplete metamorphosis include grasshoppers, harlequin bugs, leafhoppers, squash bugs, and twospotted spider mites.

## Insect and Mite Pest Life Cycles

It is important to understand the life cycle of insect and mite pests to determine the life stages (larva, nymph, and adult) that are most susceptible to pest management/plant protection strategies, the time of year (spring and summer) insect and mite pests are most abundant feeding on plants, and how insect and mite pests survive winter (overwinter). Some insect pests feed early in the growing season (e.g. striped cucumber beetle), whereas other insect and mite pests occur later on in the growing season (e.g. stink bugs and twospotted spider mite). Insect and mite pests can overwinter as eggs, larvae, nymphs, pupae, or adults depending on the specific insect and mite pest. Knowing how insect and mite pests overwinter will help determine when they are a problem during the growing season. For instance, insect pests that overwinter as adults (e.g. bean leaf beetle and squash bug) will be present earlier in the season than insect pests that overwinter as eggs (e.g. grasshoppers) or pupae (e.g., tomato hornworm, imported cabbageworm, and squash vine borer).

## Insect and Mite Pest Identification

Be sure to properly identify insect and mite pests in order to select the appropriate pest management/plant protection strategy. If you need assistance in identification, contact your state, regional, or university-based extension entomologist. Do not apply any pesticides until you have correctly identified a given insect or mite pest to avoid killing beneficial insects. The insect and mite pests that are commonly encountered in vegetable gardens and their host plants are presented in the table on pages 82-84.

### Insect and Mite Pests of Vegetable Gardens and Susceptible Host Plants

**Aphid**
***Susceptible host plants:*** Beans, celery, cole crops, corn, cucurbits, eggplant, lettuce, pea, pepper, potato, spinach, and tomato

*larva (left) and adult (right)*

**Colorado potato beetle**
***Susceptible host plants:*** Eggplant, pepper, potato, and tomato

**Asparagus beetle**
***Susceptible host plants:*** Asparagus

**Flea beetle**
***Susceptible host plants:*** Bean, carrot, celery, cole crops, corn, cucurbits, eggplant, lettuce, pea, pepper, potato, spinach, and tomato

## Insect and Mite Pests of Vegetable Gardens and Susceptible Host Plants

**Bean leaf beetle**
***Susceptible host plants:*** Beans and peas

**Grasshopper**
***Susceptible host plants:*** Bean, eggplant, and pea, pepper, and spinach

**Blister beetle**
***Susceptible host plants:*** Bean, carrot, cole crops, corn, cucurbits, eggplant, onion, pea, pepper, potato, spinach, and tomato

**Harlequin bug**
***Susceptible host plants:*** Beans, cole crops, corn, cucurbits, eggplant, lettuce, potato, and tomato

**Cabbage looper**
***Susceptible host plants:*** Bean, celery, cole crops, lettuce, pea, potato, spinach, and tomato

**Imported cabbage-worm**
***Susceptible host plants:*** Cole crops and spinach

**Corn earworm**
***Susceptible host plants:*** Bean, corn, lettuce, pea, pepper, and tomato

**Lace bug**
***Susceptible host plants:*** Eggplant, potato, and tomato

**Leafhopper**
***Susceptible host plants:*** Bean, carrot, celery, cucurbits, eggplant, lettuce, pepper, spinach, and tomato

**Striped cucumber beetle**
***Susceptible host plants:*** Cucurbits and tomato

## Insect and Mite Pests of Vegetable Gardens and Susceptible Host Plants

**Lygus bug/tarnished plant bug**
***Susceptible host plants:*** Bean, celery, cole crops, cucurbits, eggplant, lettuce, pepper, potato, and spinach

**Thrips**
***Susceptible host plants:*** Bean, carrot, celery, cole crops, cucurbits, onion, pea, and tomato

**Squash bug**
***Susceptible host plants:*** Cucurbits

*tobacco (top) and tomato hornworm (bottom)*

**Tobacco and tomato hornworm**
***Susceptible host plants:*** Eggplant, pepper, potato, and tomato

**Squash vine borer**
***Susceptible host plants:*** Cucurbits

**Twospotted spider mite**
***Susceptible host plants:*** Beans, cucurbits, eggplant, pea, pepper, and tomato

**Spotted cucumber beetle**
***Susceptible host plants:*** Beans, corn, cucurbits, pea, and potato

Cole crops: brussels sprout, cabbage, cauliflower, collards, kale, kohlrabi, mustard, and broccoli.
Cucurbits: cucumber, melons, pumpkin, squash, and zucchini

## Pest Management/ Plant Protection

### *Scouting*

Inspect plants in the garden on a weekly basis to detect insect and mite pest populations early, which will help avoid outbreaks that can result in plant damage. Be sure to focus efforts on leaf undersides where the life stages of insect and mite pests are located.

### *Cultural*

Plants that receive either too much or not enough water are less vigorous and consequently more susceptible to insect and mite pests. In addition, plants that receive too much fertilizer, especially water-soluble, nitrogen-based fertilizers, are more susceptible to insect and mite pests. Always conduct a soil test before applying any fertilizers to vegetable crops.

Remove old plant debris that can serve as overwintering sites for the adult stage of certain insect pests (e.g. bean leaf beetle and squash bug). In addition, remove all weeds from the vicinity as certain weeds host insect and mite pests (e.g. aphids, leafhoppers, and twospotted spider mite) and the plant diseases (e.g., viruses) that certain insects can spread. Moreover, many broadleaf weeds are susceptible to and serve as a refuge for insect pests such as aphids and leafhoppers. Weeds may also serve as overwintering sites for certain insect and mite pests.

### *Physical/Mechanical*

Hand-picking is an easy and quick method of removing certain insect pests such as caterpillars, beetles, and bugs from plants. Always wear rubber or leather gloves as certain beetles, such as blister beetles, will emit a substance that can burn skin. Place insects into a container with a 1:10 solution of soapy water.

Remove any plants that are heavily infested with insects or mites to prevent spread within the garden. Place infested plants in sealed garbage containers or place into debris piles located at least 30 feet from the garden. Do not incorporate plant debris into inactive compost piles. Infested plant material can also be burned.

*A floating row cover can be used to protect vegetable crops from certain insect pests.*

A forceful water spray can be directly applied to vegetable plants — especially the leaf undersides — to dislodge certain insect and mite pests. The force of the water spray is physically harmful to most soft-bodied insect (e.g., aphids) and mite (e.g., twospotted spider mite) pests.

Protective barriers or floating row covers can be placed on plants to protect them from different insect pests, including beetles and caterpillars. The barriers or row covers allow rain and sunlight to enter. Barriers or row covers need to be removed when vine crops such as cucumber are flowering to allow for pollination by bees. Be sure to firmly secure all edges of the row cover so that insect pests cannot crawl underneath.

Trap plants are plants that are attractive to insect pests. However, some trap plants produce chemicals that repel insect pests. It is important that trap plants are more attractive to insect pests than the main vegetable crop(s).

*Trap plants (marigolds) placed around vegetable plants.*

Trap plants can be placed around vegetable plants. Examples of trap plants include: dill, nasturtium, marigold, radish, and zinnia. 'Blue Hubbard' squash is an attractive trap plant to striped and spotted cucumber beetle, and squash bug and squash vine borer adults. Trap plants can be removed or sprayed with an insecticide. Trap plants will have to be removed occasionally because once trap plants are not a viable food source, insect pests will migrate onto the main vegetable crops.

## Pesticides

Pesticides (insecticides and miticides) are a component of a holistic pest management/plant protection program and should never be used indiscriminately. Pesticides that are commercially available for use in vegetable gardens are either contact or stomach poison. Insects must consume stomach-poison insecticides to be negatively affected. Contact insecticides or miticides kill insect or mite pests when they are directly exposed to applications or when insect or mite pests walk or crawl over a treated surface and encounter residues on the leaf. Most pesticides are broad-spectrum, killing a wide range of insect and/or mite pests. Unfortunately, broad-spectrum pesticides may also kill pollinators and beneficial insects. Insecticidal soaps (potassium salts of fatty acids) and horticultural oils (petroleum, mineral, or neem-based) are broad-spectrum pesticides. However, there are a number of pesticides that are narrow-spectrum or only kill select types of insect or mite pests. For example, *Bacillus thuringiensis* subsp. kurstaki (BtK), is a bacterium that only kills caterpillars.

Always read the label when purchasing and mixing any pesticide. Also, be sure to wear the appropriate personal protection equipment when applying a pesticide. Do not apply pesticides when the wind speed is greater than 5 miles per hour, to avoid drift.

Below are the ways to maximize pesticide effectiveness:

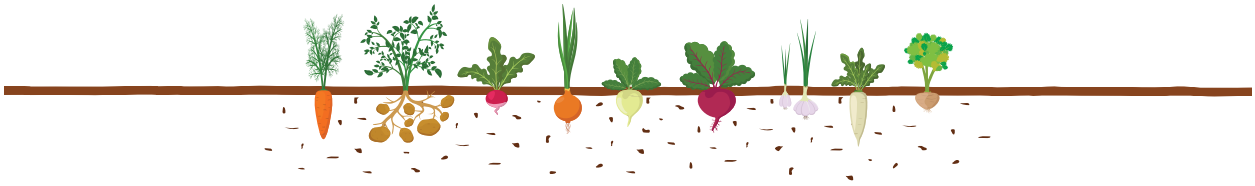
- **Timing.** Apply pesticides (insecticides and miticides) when the most susceptible life stages (larvae, nymphs, and adults) of a given insect or mite pest are present.
- **Coverage.** When spraying a pesticide, it is important to obtain thorough coverage of all plants parts, including leaves, stems, flowers, and fruits. Spraying leaf undersides is especially important as this is where the life stages (egg, larva/nymph, and adult) of most insect and mite pests are located.
- **Frequency.** Apply pesticides within timely intervals, which are dependent on the residual activity (persistence) of a given pesticide. Read the label for information associated with frequency of application.

## *Beneficial Insects*

There are a number of beneficial insects (and mites) that feed on insect and mite pests in the vegetable garden during the growing season. Some examples include: ladybird beetles, green lacewings, minute pirate bugs, big-eyed bugs, and hover flies. In addition, parasitoids or parasitic wasps attack insect pests such as aphids and caterpillars. Both predators and parasitoids can naturally regulate insect and mite pest populations during the growing season. For more information refer to the chapter on pollinators and beneficial insects.

# Chapter 11

# Pollinators and Beneficial Insects



There are a number of important pollinators and beneficial insects that contribute to the pollination and natural regulation of insect and mite pest populations associated with vegetable crops.

## Pollinators and Beneficial Insects

The primary pollinators of vegetable crops are honey bees and bumble bees. Beneficial insects are classified as consumers, decomposers, pollinators, and/or natural enemies. Natural enemies include parasitoids (for example, parasitic wasps) and predators. The two categories of natural enemies include: specialists and generalists. Specialists feed on only one insect or mite prey (host) or particular life stage (egg, larva, nymph, or adult) of prey. Most specialist natural enemies are parasitoids. Generalists feed on a wide variety of insect and mite prey (hosts) and also feed on different life stages (egg, larva, nymph, and adult) of a particular prey.

Parasitoids are beneficial insects that are usually difficult to see; however, they attack insect pests such as caterpillars and aphids. Females insert eggs into aphids using an egg-laying device known as an ovipositor. A larva hatches from the egg inside the aphid and begins feeding from within. Feeding leads to the formation of parasitized or mummified aphids.

Predators found in vegetable gardens include: ladybird beetles, green lacewings, insidious flower bugs, and hover flies. These predators feed on a wide range of insect and mite pests. In general, both the larvae/nymphs and adults are predaceous. However, this is not always the case, as adult green lacewings and hover flies do not feed on insect pests. Spiders are considered generalist predators; however, they typically do not consume enough prey to impact insect pest populations.

## Conservation Biological Control

The primary means of promoting pollinators and beneficial insects is referred to as conservation biological control. Conservation biological control is a practice that involves any activity designed to protect, attract, or maintain existing populations of natural enemies by incorporating plants into vegetable gardens that are attractive to beneficial insects (and butterflies), and supply pollen and nectar as a food source for adults. Plants that produce flowers that are attractive to pollinators and beneficial insects are listed in the table on this page.

Trap plants can be installed or incorporated into vegetable gardens. These are plants generally located either within or around the perimeter of the vegetable garden that attract insect pests; these insect pests then serve as a host or food source for natural enemies. Consequently, natural enemies migrate back and forth from the trap plants to the main vegetable crops. For example, sweet alyssum (*Lobularia maritima*), when interspersed among vegetable crops, serves as a trap plant for certain aphid parasitoids and hover flies. Flowering plants can differ widely in their attractiveness to pollinators and beneficial insects. In addition, flowering plants should bloom early to attract beneficial insects before pest damage occurs.

## Impact of Pesticides on Pollinators and Beneficial Insects

Pesticides (in this case, insecticides) can directly or indirectly harm pollinators and beneficial insects. Direct exposure is associated with wet sprays or dried residues on leaves and/or flowers that kill bees when foraging. Indirect exposure is affiliated with sublethal effects of pesticides affecting orientation, behavior, or reproduction, and the social interactions that occur resulting in sharing contaminated food sources (e.g. pollen and nectar).

For more information on the impact of pesticides on bees, refer to the following extension publication: Pesticides and Bees, MF3428, July 2018 (*https://www.bookstore.ksre.ksu.edu/pubs/MF3428.pdf*).

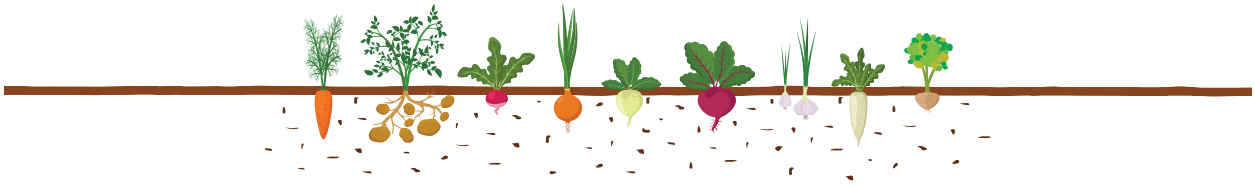
One of the ecological impacts of pesticide use on beneficial insects is called secondary pest outbreak or pest replacement. This occurs when populations of a major insect pest (e.g., aphids) are suppressed by routine insecticide applications, but are replaced in importance by populations of another insect or mite pest (e.g., twospotted spider mite) that was previously a minor or secondary pest. Consequently, the secondary pest becomes the primary pest, requiring additional applications of a pesticide (in this case, miticide). The cause of the secondary pest outbreak is the insecticide applications targeting a primary insect pest that also kill the natural enemies (parasitoids or predators) that were associated with a secondary pest. This results in the secondary pest becoming the primary pest and the initial primary pest is now the secondary pest.

### Plants Attractive to Pollinators and Beneficial Insects

| Common name | Latin name |
|---|---|
| Aster | *Aster spp.* |
| Black-Eyed Susan | *Rudbeckia hirta* |
| Buckwheat | *Fagopyrum sagittatum* |
| Coneflower | *Echinacea spp.* |
| Coreopsis | *Coreopsis spp.* |
| Dill | *Anethum graveolens* |
| English Lavender | *Lavandula angustifolia* |
| Fennel | *Foeniculum vulgare* |
| Garlic Chives | *Allium tuberosum* |
| Queen Anne's Lace | *Daucus carota* |
| Rosemary | *Rosmarinus officinalis* |
| Sage | *Salvia spp.* |
| Sweet Alyssum | *Lobularia maritima* |
| Sweet Clover | *Melilotus spp.* |
| Yarrow | *Achillea millefolium* |

# Chapter 12

# Plant Diseases



Plant diseases are caused by microscopic organisms including fungi, viruses, bacteria, and nematodes (microscopic worms). They reduce crop quality and yield. They cause symptoms such as leaf spots, fruit spots, moldy/rotten fruit, and root rots. These organisms are called plant pathogens, and they can grow, reproduce, and spread from plant to plant. Plants can also be affected negatively by non-living (abiotic) factors or environmental stresses such as drought, improper fertility, or too much water. Environmental stresses are covered in other chapters of this guide and in the crop-by-crop information in chapter 15. Not all microbes are bad, though; in fact, many are beneficial. For example, some good microbes help plants by cycling nutrients. However, plant pathogens can damage crops. This chapter focuses on the plant diseases caused by living, infectious organisms. Since plant diseases and environmental stresses can be difficult to distinguish, the table starting on page 94 includes photos.

## Plant Disease Development

There are many different kinds of fungi, viruses, bacteria, and nematodes that can cause plant diseases. Most plant pathogens infect a narrow range of plant species, such as only the tomato family or only the cucumber/melon family. In addition, plant pathogens do not infect people (with several rare exceptions).

Each plant pathogen has a unique life cycle, but there are common features as well.

**Fungi and bacteria** can cause leaf spots, fruit spots, wilts, fruit rots, stem dieback, root rots, and other problems. Fungi and bacteria tend to thrive in wet conditions. Most fungi and bacteria require water and/or humidity to reproduce and to infect plants. For example, fungal and bacterial leaf spots are much more common during wet seasons or in locations that receive frequent overhead irrigation. Root rots are much more common when soils are saturated. Many fungi and bacteria survive from season to season over winter on infected plant debris. Some can be introduced into a garden on infected seeds or transplants.

**Viruses** cause many symptoms including unusual colors and distortions, stunting, and decline. Viruses spread in different ways, including by insects, on infected seed, infected transplants, through grafting, or even on hands.

**Nematodes** are microscopic worms. They rarely cause problems in home gardens but can pop up from time to time. The main nematode problem in Kansas home gardens, which occurs only occasionally, is root knot nematode. The nematode feeds on and causes swellings in plant roots, which disrupt growth

and cause the plant to be stunted and eventually decline.

**Environmental/abiotic stresses.** As noted above, environmental stresses such as drought, improper fertility, or too much water can affect plants negatively. High temperatures and rapid temperature fluctuations frequently damage the vigor and quality of vegetable crops. In addition, environmental stresses can predispose plants to infectious diseases.

## Plant Disease Identification

Plant diseases cause many symptoms, including leaf spots, fruit spots, wilting, stem dieback, fruit rots, or root rots. Diagnosis can be difficult. Many diseases can be confused with environmental stresses, insect damage, or other factors. The table starting on page 94 includes both diseases and environmental stresses. Chapter 10 covers common insect problems. Your local K-State Research and Extension agent can assist you in identifying or recognizing specific problems in your garden. It is best to provide a large, representative sample along with information on the variety, when symptoms first appeared, unusual recent weather or growing conditions, and general condition of other vegetables in the garden. Your local agent may consult with the K-State Plant Disease Diagnostic Laboratory for further information or testing.

## Plant Disease Management/ Plant Protection

Integrated plant disease management is a piece of integrated pest management (IPM). IPM is an approach that focuses on long-term prevention of pest and disease problems through multiple methods that work together to build a healthy plant system. The Environmental Protection Agency states, "Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment." In terms of plant diseases, these IPM practices will help to (1) break the disease life cycles so pathogens cannot survive and spread; (2) make the plant more resistant or tolerant to disease; and/or (3) make the environmental conditions less favorable to disease. Keep in mind that there may be some damage from diseases, but you can still get a satisfying quality and yield. It is not practical to expect a perfectly clean garden. Integrated practices to use include:

**Choose a good garden location.** Garden fruits and vegetables need full sunlight and good soil drainage. Sunlight helps to dry foliage and reduce infection by many fungal and bacterial diseases, which thrive in wet conditions. Root-rotting diseases are more common in heavy soils or low areas that retain water. Choose a sunny, well-drained site.

**Select resistant varieties.** For some diseases, resistant varieties are available. Seed catalogs and plant tags often identify such varieties. For example, there are tomato varieties resistant to certain wilt-causing fungal diseases, and there are pumpkin varieties with resistance to powdery mildews.

**Rotate crops.** Planting the same crop family in the same place year after year can lead to a build-up of certain diseases, since some disease organisms survive on old, infected plant tissue. In general, follow a crop rotation of at least three years for the four major vegetable plant families — tomato family (tomato, potato, pepper, and eggplant); cucurbit (squash, melons, and cucumbers); cole crops (broccoli, cauliflower, cabbage, and Brussels sprouts); and allium (onion, garlic, and leeks).

**Start with "clean" plant material.** Some diseases can be introduced on transplants or seeds. Use high quality seed. Check foliage

and roots of transplants before purchasing. Select plants with healthy green foliage and a good root system.

**Plant at the proper time.** Seeds planted too early are more susceptible to rot. Follow planting timing guidelines for each crop.

**Scout and remove infected plants to keep the garden clean.** Inspect plants in the garden on a weekly basis to detect problems. Be sure to check the undersides of leaves as well as the tops. Remove infected plants during the season to prevent spread. Remove plant debris after harvest. Infected plant debris should be placed at a distance from the garden to prevent diseases from blowing or splashing back into the garden.

**Water properly.** Plants that receive either too much or not enough water are less vigorous and consequently more susceptible to plant diseases. In addition, many plant pathogens thrive in overly wet conditions.

**Provide good air circulation.** Overcrowding plants can result in weak growth and an increase in foliar diseases. Air circulation will dry plant tissue more quickly, reducing disease pressure. Proper spacing, stakes, trellises, cages, and pruning can all help increase air circulation.

**Fertilize properly.** Improper fertilizer rates can make plants more prone to diseases. Conduct soil tests when establishing a new garden and again every few years. Follow recommended amounts and timings for specific crops.

**Use mulch.** Mulch has several benefits. It helps reduce weeds, which can harbor diseases or disease-carrying insects. It helps prevent rot caused when fruit contacts bare soil. Mulch can prevent splash of pathogens from old crop residue up into the new canopy.

**If you use pesticides, use them carefully and judiciously, and apply them properly.** Many gardeners successfully grow crops without any disease-control products by focusing on the practices listed above. The section below discusses disease control products in more detail. Specific pesticide information is beyond the scope of this book.

## *Pesticides for Disease Control*

Disease control pesticides can be a component of a plant protection program but must be applied safely following all label instructions. Pesticides for disease control in home gardens include fungicides and bactericides. There are no products to control viruses. Nematicides are not available for homeowners. Some disease control products are labeled as organic products. For home gardens, there are both contact pesticides that stay on the leaf surface and systemic pesticides that have some movement within the plant. Some disease-control pesticides are broad spectrum, affecting multiple diseases. Other disease control pesticides have a more narrow spectrum, affecting a smaller range of diseases.

Always read and follow the label when purchasing and mixing any pesticide. Also, be sure to wear the appropriate personal protection equipment when applying a pesticide. Do not apply pesticides when the wind speed is greater than 5 miles per hour to avoid drift.

Below are the ways to maximize pesticide effectiveness for disease management:

- **Timing.** It is essential to first diagnose the problem and to have a basic understanding of the disease. For some diseases, if you spray at the wrong time you will not get any control because you have missed the phase in the life cycle that is vulnerable. In addition, some pesticides can injure plants at certain stages (like delicate flower structures). So, be sure to have an understanding of the disease problem and when and how to apply the chemical. As noted above, your local K-State Research and Extension agent can provide information on diagnosis and management.

- **Coverage.** Be sure to provide adequate coverage of all plant parts: leaves, stems, flowers, and fruits as instructed by the label.
- **Frequency.** For adequate disease control, some disease control pesticides may need to be applied more than once. Read the label for information associated with frequency of application.

## Biological Controls

There are some products that are composed of living beneficial organisms that control plant diseases. Just like traditional pesticides, you will need a correct diagnosis of the problem before using a biological control product. Apply the products at the right time and using the correct method. Follow all label instructions, including safety guidelines.

## Disease and Environmental Stresses

This table provides a summary of many common diseases and environmental stresses of vegetable crops in Kansas.

| Plant/Problem and causal agent | Symptoms/ identification | Conditions and management |
|---|---|---|
| ***Asparagus*** | | |
| Rust<br>Fungus: *Puccinia asparagi* | Raised, orange-red spots (pustules) on stems. Pustules eventually turn black. Repeated infection over multiple years can weaken plants. | Favored by wet conditions and heavy dew.<br>Plant rust-resistant varieties.<br>Manage leaf wetness and humidity. |
| Fusarium crown rot and root rot<br>Fungus: *Fusarium* species | Plants decline and show stunting. Plants may die. Interior of crowns and roots may be rotted and show red-brown color | Survives in soil and can be spread in seed and infected transplants.<br>Use resistant varieties and clean seed. Maintain overall plant vigor. Manage harvest to maintain plant vigor. |
| Phytophthora crown rot<br>Water mold: *Phytophthora* species | Lower shoots develop water-soaked lesions. Plants may collapse. Crowns may be discolored internally. | Disease thrives in wet conditions.<br>Avoid planting infected transplants. Select site with good drainage. Manage moisture to avoid soil saturation. |
| ***Basil*** | | |
| Downy mildew<br>Water mold: *Peronospora belbahrii* | Infected leaves turn yellow then purple/ black in blocky sections bordered by major veins. Fluffy, purple-gray growth (fungal spores) visible on the undersides of the spotted sections. | Favored by wet, humid conditions.<br>Plant downy mildew resistant varieties. Manage leaf wetness and humidity. |

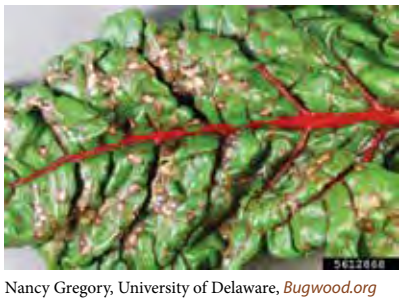
Rebecca A. Melanson, Mississippi State University Extension, *Bugwood.org*

## Disease and Environmental Stresses

This table provides a summary of many common diseases and environmental stresses of vegetable crops in Kansas.

| Plant/Problem and causal agent | Symptoms/ identification | Conditions and management |
|---|---|---|
| ***Beans*** | | |
| Bacterial blights — common blight and halo blight<br><br>Bacteria: common blight: *Xanthomonas campestris pv. Phaseolicola* (synonym *Xanthomonas axonopodis pv. phaseoli*); halo blight: *Pseudomonas savastanoi pv. phaseolicola* | Halo blight and common blight look and behave similarly. Small water-soaked spots turn brown and develop yellow halos. Water-soaked spots on pods | Favored by wet, humid conditions. Survives in plant debris. Can be introduced in seeds.<br><br>Rotate ≥2 years. Manage leaf wetness and humidity. Practice good sanitation. Till soil to bury infected debris. Start with clean seeds and/or transplants. |
| Broadleaf herbicide injury | Distorted, twisted, and/or stunted growth. May be confused with virus symptoms.<br><br>If damage is severe, reduced yield or plant death may result. | Beans are sensitive to several herbicides including 2,4-D, dicamba, and triclopyr. Some of these products can volatilize and drift onto plants from some distance.<br><br>Residual herbicides can also be present in soil amendments or mulches.<br><br>Avoid using herbicides that are known to cause damage in tomatoes. Avoid using mulches that may contain herbicide residues. |
| ***Beet*** | | |
| Cercospora leaf spot<br><br>Fungus: *Cercospora beticola* | Tan to off-white circular spots with reddish borders. Defoliation can occur if disease is severe. | Favored by wet conditions and high humidity. Also affects Swiss chard and spinach. Survives in crop residue.<br><br>Manage leaf wetness and humidity. Rotate to crops outside the beet family for 2 to 3 years. Till soil to bury infected debris. |

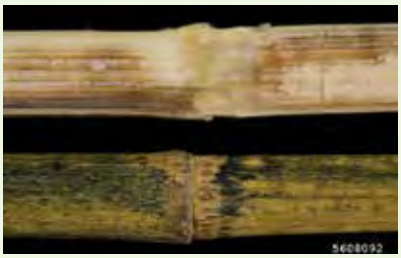
Howard F. Schwartz, Colorado State University, *Bugwood.org*



Nancy Gregory, University of Delaware, *Bugwood.org*

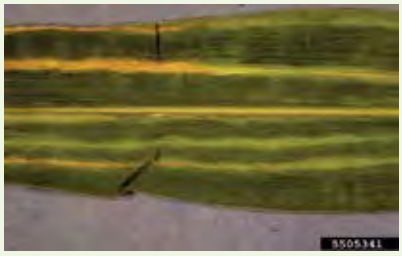
## Disease and Environmental Stresses

This table provides a summary of many common diseases and environmental stresses of vegetable crops in Kansas.

| Plant/Problem and causal agent | Symptoms/ identification | Conditions and management | |
|---|---|---|---|
| ***Carrot*** | | | |
| Root knot nematode<br><br>Nematode: *Meloidogyne* | Knobby, distorted growth on roots. Above-ground plant parts may be yellowed and/or stunted. | Crop rotation — Note: This is difficult because the disease affects many species and at least 6 years needed.<br><br>Avoid moving soils from infested areas into new areas. |  |
| Forked or split roots | Roots are forked or split one or more times. | Caused by heavy clay soil, rocky soil, or drought conditions.<br><br>Amend soil with organic matter or plant in raised beds. Provide adequate soil moisture during dry periods | |
| ***Corn (sweet corn)*** | | | |
| Anthracnose stalk rot/leaf blight<br><br>Fungus: *Colletotrichum graminicola* | Leaf spots with tan centers and brown borders. Spots may have a yellow or orange margin/halo.<br><br>Stalks exhibit shiny black areas on outer surface then develop internal rotting. | Favored by wet weather.<br><br>Choose resistant varieties. Rotate at least 1 to 3 years. Deep till to bury infected plant residue. |  <br>Courtesy Craig Grau and the University of Wisconsin plant pathology department teaching collection of images, *Bugwood.org* |
| Common rust<br><br>Fungus: *Puccinia sorghi* | Red to brown pustules on leaves and stalks. | Favored by cool, wet weather.<br><br>Plant resistant varieties. |  <br>Daren Mueller, Iowa State University, *Bugwood.org* |

## Disease and Environmental Stresses

This table provides a summary of many common diseases and environmental stresses of vegetable crops in Kansas.

| Plant/Problem and causal agent | Symptoms/ identification | Conditions and management | |
|---|---|---|---|
| ***Corn (sweet corn)*** | | | |
| Leaf blights (northern, southern)<br><br>Fungus: Northern corn leaf blight — *Exserohilum turicum*; Southern corn leaf blight — *Bipolaris maydis* | Elongated tan spots on leaves. | Use resistant varieties. Till soil to bury infected debris. Rotate at least 1 year. |  <br>Margaret McGrath, Cornell University, *Bugwood.org* |
| Poorly-filled ears<br><br>Physiological problem | Ear is missing kernels. | Hot dry conditions during pollination can reduce kernel development.<br><br>Insufficient pollination may occur when temperatures are too hot during the pollination window or when the planting is too small to provide consistent pollination.<br><br>Plant corn in blocks of at least 4 shorter rows rather than in long single rows to improve pollination.<br><br>Provide deep, thorough watering. Avoid frequent/shallow watering | |
| Smut<br><br>Fungus: *Ustilago maydis* | Smooth, round galls 1–4 inches in size develop on ears. Galls are filled with dark, powdery spores. | Overwinters in debris and soil. Spread by wind.<br><br>Plant resistant varieties. Maintain balanced fertility. Avoid leaf wetness. Avoid injuring plants. Remove galls while still small. |  <br>Daren Mueller, Iowa State University, *Bugwood.org* |
| Stewart's wilt<br><br>Bacterium: *Pantoea stewartii* (*Erwinia stewartii*) | Leaves develop long elliptical streaks that are initially yellow or pale green, later turning brown and dry. | Spread by corn flea beetles. Can be seedborne.<br><br>Manage corn flea beetles. Use pathogen-free seed. Partially resistant varieties available. |  <br>Margaret McGrath, Cornell University, *Bugwood.org* |

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| ***Cole crops (broccoli, Brussels sprouts, bok choy, cabbage, cauliflower, collards)*** | | |
| Bolting<br><br>Physiological problem | Development of flower stalks or loose heads that go to flower | Temperature fluctuations and hot weather during head development.<br><br>Plant during optimum planting windows. Select early maturing and heat tolerant varieties. |
| Buttoning<br><br>Physiological problem | Early development of small, button-like heads that do not develop further<br><br>Primarily cauliflower | Caused by stress, especially overgrown transplants, extreme temperature fluctuations, and cold temperatures after transplanting.<br><br>Manage planting to minimize temperature fluctuations. Plant transplants promptly. |
| Curd discoloration (cauliflower)<br><br>Physiological problem | Curd exhibits an off-white to tan color | Cauliflower heads exposed to sunlight will develop curd discoloration.<br><br>Plant self-blanching varieties. Tie leaves up over the head after head development starts to blanch the heads and prevent discoloration. |
| Hollow stems (cauliflower)<br><br>Physiological problem | Interior or heads and stems is brown and hollow. | Caused by boron deficiency.<br><br>Test soil for boron deficiency. Provide supplemental boron fertilizer. |
| Poor flavor<br><br>Physiological problem | All crucifers are prone to poor flavor due to hot temperatures. | Caused by hot temperatures and drought stress.<br><br>Provide consistent moisture. Plant during optimum planting window and select early maturing, heat tolerant varieties. |
| Poor or no head development<br><br>Physiological problem | All crucifers are prone to poor head development due to inconsistent moisture.<br><br>All crucifers especially cabbage are prone to no head development due to hot temperatures | Favored by hot, dry conditions during head conditions.<br><br>Provide consistent moisture. Plant during optimum planting windows. Choose early and heat tolerant varieties. |
| ***Cucumber — see "cucurbits"*** | | |

## Disease and Environmental Stresses

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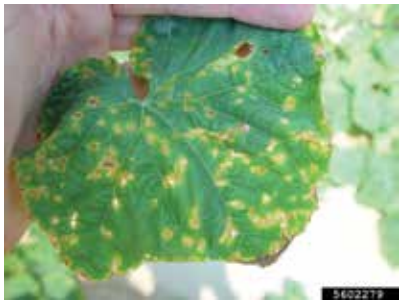
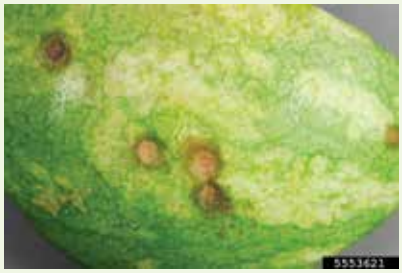
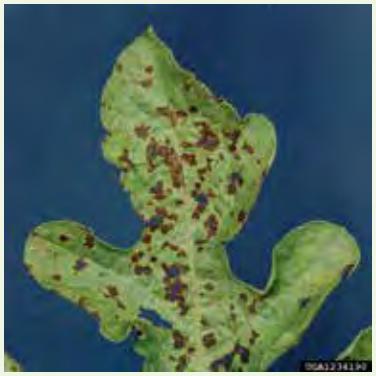
| ***Cucurbits (pumpkin, squash, melon, watermelon, cucumber)*** | | | |
| Alternaria leaf spot<br><br>Fungus: *Alternaria cucumerina* | Begins as small brown leaf spots which expand into larger brown lesions, often with concentric rings. Leaf drop may occur leading to sun damage on fruit. | Favored by wet conditions. Survives on plant debris. Most common on melon and watermelon.<br><br>Rotate ≥2 years. Manage leaf wetness and humidity. Practice good sanitation. Till soil to bury infected debris. |  <br>G. J. Holmes, Cal Poly San Luis Obispo, *Bugwood.org* |
| Angular leaf spot<br><br>Bacteria: *Pseudomonas syringae pv. lachrymans* | Small, angular tan or brown spots on leaves. Sticky ooze or crust may develop on leaf undersides. Spots dry and fall out leaving holes in leaves. Water-soaked spots on fruit which can lead to additional deeper rots. | Favored by wet, humid conditions. Survives in plant debris. Can be introduced in seeds.<br><br>Plant resistant varieties. Rotate ≥2 years. Manage leaf wetness and humidity. Practice good sanitation. Start with clean seeds. Till soil to bury infected debris. |  <br>G. J. Holmes, Cal Poly San Luis Obispo, *Bugwood.org* |
| Anthracnose<br><br>Fungus: *Colletotrichum orbiculare* | Watermelon — dark brown, irregular spots on leaves. Melon and cucumber — spots are more regular in shape. Infected leaf spots may drop leaving holes. Sunken brown, bruise-like spots may develop on fruit. | Primarily on watermelon, cucumber, melon.<br><br>Favored by wet, humid conditions. Survives in plant debris. Can be introduced in seeds or transplants.<br><br>Rotate ≥2 years. Manage leaf wetness and humidity. Practice good sanitation. Till soil to bury infected debris. |  <br>Nancy Gregory, University of Delaware, *Bugwood.org*<br>  <br>Clemson University – USDA Cooperative Extension Slide Series , *Bugwood.org* |

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| ***Cucurbits (pumpkin, squash, melon, watermelon, cucumber)*** | | | |
| Bacterial spot<br><br>Bacteria: *Xanthomonas campestris pv. cucurbitae* | Small, slightly-sunken round spots on fruit. Spots are tan with dark border. Spots may become large and cracked leading to additional deeper fruit rots.<br><br>Small dark lesions on leaves. | Primarily on pumpkin and winter squash. Can be severe.<br><br>Favored by wet, humid conditions. Survives in plant debris. Can be introduced in seeds.<br><br>Rotate ≥3 years. Manage leaf wetness and humidity. Practice good sanitation. Till soil to bury infected debris. Start with clean seeds. |  <br>Megan Kennelly, KSU Plant Pathology |
| Bacterial wilt<br><br>Bacteria: *Erwinia tracheiphila* | Plants exhibit wilting. Plants may recover at night. Leaves may turn yellow then brown. Plant eventually collapses. | Most common and most severe in cucumber and melon. Can occur in pumpkins and squash. Spread by striped and spotted cucumber beetles.<br><br>Prevent disease by managing cucumber beetles such as through exclusion practices including row covers. Remove infected plants to prevent further spread. |  <br>Jim Jasinski, Ohio State University Extension, *Bugwood.org* |
| Bitterness<br><br>Physiological disorder | Bitter flavor, often linked to plant stress. | Select varieties not prone to bitterness. Provide consistent moisture. | |
| Blossom end rot<br><br>Physiological disorder | The end of the fruit nearest where the blossom was develops a brown or decayed appearance. | Caused by calcium shortage in development fruit. Associated with water fluctuations.<br><br>Provide even soil moisture. Avoid overfertilization. Choose varieties less prone to blossom end rot. |  <br>G. J. Holmes, Cal Poly San Luis Obispo, *Bugwood.org* |

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| ***Cucurbits (pumpkin, squash, melon, watermelon, cucumber)*** | | | |
| Downy mildew<br><br>Water mold: *Pseudoperonospora cubensis* | Yellow spots on leaves. Spots on pumpkin and cucumber often angular in shape. Spots become brown over time. In humid conditions a dark fluffy growth may be visible on leaf undersides below the yellow spots. | Not common in Kansas but can occur in wet, humid conditions. Most likely in eastern KS. Survives in southern U.S. and spreads north during growing season with wind/storm activity.<br><br>Plant resistant varieties. Manage leaf wetness and humidity. |  <br>G. J. Holmes, Cal Poly San Luis Obispo, *Bugwood.org* |
| Fruit — poor pollination/poor fruit set<br><br>Physiological disorder | Lack of fruit<br><br>Poorly developed or misshapen fruit<br><br>Fruit that begins to develop and then wilts or fails to fully develop | Cucurbits have both male and female flowers on the same plant. Both types of flowers must be open at the same time for pollination to occur. Weather related stress can cause an imbalance in the types of flowers on the plant.<br><br>Provide consistent moisture during flowering and fruit set. Avoid spraying insecticides that can disrupt pollinators during bloom and fruit set. | |
| Fusarium wilt<br><br>Fungus: *Fusarium oxysporum* | Plants wilt and eventually collapse and die. Symptoms begin with leaf yellowing and mild wilting. A red-brown discoloration may be visible in the xylem when lower stems are cut open. | Causal fungus survives multiple years in soil. Can be spread through movement of infested soil.<br><br>Plant resistant varieties. Rotate ≥6 years. Start with clean seed. |  <br>G. J. Holmes, Cal Poly San Luis Obispo, *Bugwood.org* |
| Gummy stem blight/ black rot<br><br>Fungus: *Didymella bryoniae* | Leaves — round, tan-to-brown lesions. Tan to dark brown lesions can also develop on stems, sometimes with a gummy ooze. Infected fruit develop water-soaked spots that turn dark and may develop gummy ooze. | Favored by wet, humid conditions. Survives in plant debris. Can be introduced in seeds.<br><br>Rotate ≥3 years. Manage leaf wetness and humidity. Practice good sanitation. Till soil to bury infected debris. Start with clean seeds. |  <br>G. J. Holmes, Cal Poly San Luis Obispo, *Bugwood.org* |

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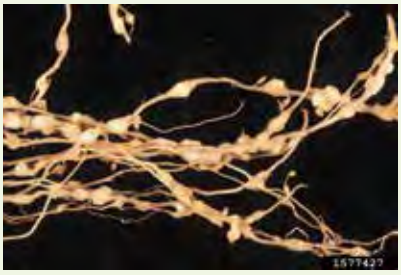
| ***Cucurbits (pumpkin, squash, melon, watermelon, cucumber)*** | | | |
| Powdery mildew<br><br>Fungi: *Podosphaera xanthii* and *Erysiphe cichoracearum* | White, powdery growth on leaves. Often starts on older, shaded leaves and undersides of leaves. Leaves may eventually die causing reduced fruit quality. | Favored by humidity, moderate temperatures, and shade. Spreads by wind. Does not require rain for spread.<br><br>Plant resistant varieties. Manage site to reduce humidity. Rotate ≥2 years |  <br>G. J. Holmes, Cal Poly San Luis Obispo, *Bugwood.org* |
| Phytophthora blight<br><br>Water mold: *Phytophthora capsici* | Can infect all plant parts. Infected crowns rot causing entire plant to die. Fruit develop water-soaked spots that develop a white, fluffy mold on the surface. | Favored by wet, humid conditions. Survives in plant debris and soil. Can affect many crop species.<br><br>Rotate ≥4 years. Manage soil moisture. Avoid moving infested soil to new plots. Carefully remove infected plants. Till soil to bury infected debris. |  <br>Elizabeth Bush, Virginia Polytechnic Institute and State University, *Bugwood.org* |
| Root-knot nematode<br><br>Nematode: *Meloidogyne* | Knobby, distorted growth on roots. Above-ground plant parts may be yellowed and/or stunted. | Crop rotation — Note: This is difficult because the disease affects many species and at least 6 years are needed.<br><br>Avoid moving soils from infested areas into new areas. |  <br>G. J. Holmes, Cal Poly San Luis Obispo, *Bugwood.org* |
| Verticillium wilt<br><br>Fungus: *Verticillium* | Yellowing of leaves, often on only one side of plant. Leaves wilt and die. Entire plant eventually wilts and dies. A red-brown discoloration may be visible in the xylem when lower stems are cut open. | Fungus can infect a very wide host range and survives up to 8 to 10 years in soil. Therefore crop rotation is difficult. | |

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| ***Cucurbits (pumpkin, squash, melon, watermelon, cucumber)*** | | | |
| Viruses — several<br><br>Cucumber mosaic virus, zucchini yellow mosaic virus, watermelon mosaic virus, and others | Leaves and fruits show mottled colors and sometimes distortion or stunting. Plants may decline. | Spread by insects<br><br>Adjust planting timing to avoid insect pressure. Manage insects. Resistant varieties available for some. |  <br>William M. Brown Jr., *Bugwood.org*<br>  <br>5614532<br>Rebecca A. Melanson, Mississippi State University Extension, *Bugwood.org* |
| ***Eggplant*** | | | |
| Verticillium wilt<br><br>Fungus: *Verticillium* | Yellowing of leaves, often on only one side of plant. Leaves wilt and die. Entire plant eventually wilts and dies. A red-brown discoloration may be visible in the xylem when lower stems are cut open. | Fungus can infect a very wide host range and survives up to 8 to 10 years in soil. Therefore crop rotation is difficult. | |

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|---|---|---|
| ***Onion/garlic*** | | |
| Botrytis leaf blight<br><br>Fungus: *Botrytis squamosa* | Small, oval spots sometimes with light-colored, water-soaked halo. Tips of leaves die back. Entire leaves may die back. Severe disease can lead to reduced bulb yield. | Favored by wet, humid conditions. Survives in plant debris. Can be introduced in contaminated bulbs.<br><br>Rotate ≥3 years. Manage leaf wetness and humidity. Practice good sanitation. Till soil to bury infected debris. Start with clean seeds.<br><br>  <br>Lindsey du Toit, Washington State University, *Bugwood.org* |
| Fusarium basal crown rot<br><br>Fungus: *Fusarium* | Leaves yellow and dieback. Bulbs, roots, and stems develop reddish brown discoloration. Bulbs and roots eventually rot. | Soilborne fungus.<br><br>Rotate at least 4 years. Select resistant varieties. Avoid physical injury to bulbs. Store bulbs appropriately. |
| Purple blotch<br><br>Fungus: *Alternaria porri* | Small, brown, elliptical-shaped spots on leaves, sometimes with yellow rings. Spots may turn purple. Entire leaves may blight/collapse. Bulbs can also become infected. | Favored by wet, humid conditions. Survives in plant debris. Can be introduced in seeds or sets. Associated with damage by thrips.<br><br>Rotate ≥3 years. Manage leaf wetness and humidity. Practice good sanitation. Till soil to bury infected debris. Start with clean seeds and/or transplants. Harvest in dry weather and cure properly.<br><br>  <br>Howard F. Schwartz, Colorado State University, *Bugwood.org* |
| Small bulbs or poor bulb development | Bulbs either fail to develop or are small. | Small bulbs can be due to dry soil conditions or low fertility during bulb development. Maintain even soil moisture and monitor soil fertility regularly.<br><br>Small or non-existent bulbs can be caused by planting at the wrong time or by selecting varieties that are not well adapted to Kansas. |

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| ***Peas*** | | |
| Damping off<br><br>Multiple fungi and water molds including *Rhizoctonia*, *Fusarium*, and *Pythium* | Seedlings fail to emerge from soil, or seedlings collapse and fall over. Roots and stems rotted. | Common in cold, wet soils.<br><br>Avoid planting into overly cold, wet soil. |
| ***Pepper*** | | |
| Bacterial spot<br><br>Bacteria: *Xanthomonas* species | Small brown leaf spots with yellow halo. Leaf spots sometimes have a water-soaked appearance in early stages. Severe infection can cause defoliation and sun damage to fruit. Small, slightly-raised brown spots on fruit. | Favored by wet, humid conditions. Survives in plant debris. Can be introduced in seeds or transplants.<br><br>Plant resistant pepper varieties. Rotate ≥2 years. Manage leaf wetness and humidity. Practice good sanitation. Till soil to bury infected debris. Start with clean seeds and/or transplants.<br><br>  <br>Megan Kennelly, KSU |
| Blossom end rot<br><br>Physiological disorder | Blossom-end of fruit turns watery then a dry tan/gray. Secondary rotting fungi sometimes colonize the area. | Caused by calcium shortage in developing fruit. Associated with water fluctuations.<br><br>Provide even soil moisture. Avoid overfertilization. |
| Sunscalded fruit<br><br>Physiological disorder | Light-colored areas appear on fruit surfaces exposed to direct sun. These areas can turn dry, papery, and wrinkled. Damaged areas may be invaded by rot fungi. | Can occur in plants where leaves are lost due to foliar disease or other damage.<br><br>Manage foliar disease. Avoid physical injuries.<br><br>  <br>Don Ferrin, Louisiana State University Agricultural Center, *Bugwood.org* |

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| ***Pepper*** | | | |
| Virus — several: tomato spotted wilt virus, cucumber mosaic virus, tobacco mosaic virus, and others | Mottling, streaking, distortion on leaves and/or fruit<br><br>Can be confused with herbicide injury or nutritional disorders. | Some viruses are spread by insects (aphids, whiteflies, thrips). Manage insect pests.<br><br>Remove infected plants to prevent further spread. Resistant varieties available for some viruses. |  <br>G. J. Holmes, Cal Poly San Luis Obispo, *Bugwood.org* |
| ***Potato*** | | | |
| Black scurf<br><br>Fungus: *Rhizoctonia solani* | Small, black, hard growths develop on tuber surfaces. Disease can also cause death of young sprouts before or after emerging from soil. | Disease is favored by cold, wet conditions<br><br>Start with healthy seed tubers. Plant into warm soil. Rotate at least 3 years. |  <br>G. J. Holmes, Cal Poly San Luis Obispo, *Bugwood.org* |
| Common scab<br><br>Bacteria: *Streptomyces scabies* | Rough, corky patches on tuber surfaces. May become sunken/ pitted. | Use resistant varieties. Start with clean tubers. Avoid moisture stress. Rotate crops at least 3 to 4 years |  <br>Clemson University - USDA Cooperative Extension Slide Series |
| Early blight<br><br>Fungus: *Alternaria solani* | Dark brown spots on foliage, usually starting on lowest leaves. Spots often develop dark concentric rings in a target pattern. | Favored by wet conditions. Fungus survives in plant debris.<br><br>Rotate crops at least 3 years. Manage leaf wetness and humidity. Practice good sanitation. Till soil to bury infected debris. Start with clean planting material. |  <br>Howard F. Schwartz, Colorado State University, *Bugwood.org* |

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| ***Potato*** | | |
| Hollow heart — also called brown heart or sugar center<br><br>Physiological problem | Hollow open cavity in center of tuber. May have brown discoloration. | Associated with stresses in weather and growing conditions such as abrupt water fluctuations.<br><br>Provide even soil moisture.<br><br>  <br>Ben Phillips, Michigan State University, *Bugwood.org* |
| Silver scurf<br><br>Fungus: *Helminthosporium solani* | Light brown or gray leathery spots develop on tuber surface. Affected tubers may decay. | Fungus survives in infected tubers and plant debris.<br><br>Plant disease-free tubers. Rotate 2 to 3 years. Practice good sanitation when storing tubers. |
| Low yield of tubers or lack of tuber development | No tubers or few tubers present at harvest. | Tuber development is inhibited by both hot soils and excessive soil nitrogen.<br><br>Plant potatoes during the optimum planting window. Select early maturing varieties.<br><br>Monitor soil fertility and do not over-fertilize. |
| Tuber greening | Green skin on tubers | Caused by tubers being exposed to sun.<br><br>Hill up soil or use mulch to cover developing tubers. |
| Cracked or misshapen tubers | | Caused by moisture fluctuations or dry conditions.<br><br>Maintain even soil moisture. |
| ***Rhubarb*** | | |
| Crown rot<br><br>Multiple organisms including *Phytophthora* and soft rotting organisms | Leaf dieback. Plant collapse. Soft, mushy brown roots and crowns. | Favored by wet conditions.<br><br>Plant in well-drained soil. Consider "hilling" to improve drainage. Start with healthy new crowns. |
| Seed stalks<br><br>Physiological issue | Plant produces stalks and flowers, reducing vigor of the plant. | Remove seedstalks as soon as they appear |

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| ***Tomato*** | | | |
| Adventitious roots (Aerial roots)<br><br>Physiological disorder | Bumpy, fleshy roots on above-ground stems. | Condition itself does not affect overall plant health. May be caused by stress such as high humidity, physical damage, or overwatering.<br><br>Note: Some diseases can also cause this condition. | |
| Anthracnose<br><br>Fungi: *Colletotrichum* species | Sunken bruise-like spots on the surface of ripening fruit. Concentric rings of tiny black specks develop. | Favored by wet conditions. Survives in plant debris.<br><br>Avoid overhead irrigation. Use mulch to prevent rain splash. Improve airflow with spacing and staking. Rotate crops 3 to 4 years. |  <br>Clemson University – USDA Cooperative Extension Slide Series , *Bugwood.org* |
| Bacterial canker<br><br>Bacterium:<br><br>*Clavibacter michiganensis* subsp. *michiganensis* | Yellowing and dieback of leaves. Fruit spots with white halo. Rotting in the stem may be visible when stem is cut. | Favored by wet conditions. Can be introduced on infected seed or transplants.<br><br>Start with clean plant material. Rotate away from tomato family at least 3 years. Use mulch to prevent rain splash. Avoid working with plants under wet conditions. Avoid overhead irrigation or other practices that cause leaf wetness. Improve airflow with spacing/staking. |  <br>Mary Ann Hansen, Virginia Polytechnic Institute and State University, *Bugwood.org*<br><br>  <br>G. J. Holmes, Cal Poly San Luis Obispo, *Bugwood.org* |

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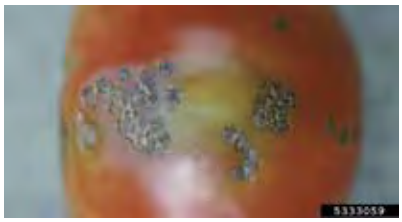
| ***Tomato*** | | | |
| Bacterial speck and bacterial spot<br><br>Bacteria: *Pseudomonas* (speck) and *Xanthomonas* (spot) | Small (1/16–1/8 inch for speck, 1/8 to 1/4 inch for spot) black spots on leaves and fruit | Favored by wet conditions<br><br>Avoid leaf wetness and high humidity. Do not work in tomatoes when garden is wet. Start with clean seeds and transplants. Mulch underneath plants. Remove infected debris in fall. Rotate crops 3 to 4 years. Deep till to bury infected material. |  <br>G. J. Holmes, Cal Poly San Luis Obispo, *Bugwood.org*<br>  <br>Mary Ann Hansen, Virginia Polytechnic Institute and State University, *Bugwood.org*<br>  <br>Clemson University – USDA Cooperative Extension Slide Series , *Bugwood.org* |
| Blossom-end rot<br><br>Physiological disorder | Fruits develop sunken, water-soaked lesion that expands and turns black. Often followed by secondary rot. | Caused by calcium shortage in developing fruit. Associated with water fluctuations.<br><br>Provide even soil moisture. Avoid overfertilization. Choose varieties less prone to blossom end rot. |  <br>M.E. Bartolo, *Bugwood.org* |
| Cracking<br><br>Physiological disorder | Fruit cracks in concentric circles or in a star-like pattern. | Occurs when fruit expands too quickly. Most common in nearly-ripe fruit.<br><br>Provide even water and balanced fertility to avoid overly lush growth. Select varieties less prone to cracking. |  <br>Megan Kennelly, KSU Plant Pathology |

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| ***Tomato*** | | |
| Early blight<br><br>Fungus: *Alternaria* | Round, brown leaf spots up to about ½ inch in size. Spots may have concentric rings. Severely infected leaves may fall. | Favored by wet, humid conditions. Survives in plant debris. Can be introduced in seeds.<br><br>Plant resistant (tolerant — not fully resistant) varieties. Rotate ≥3 years. Manage leaf wetness and humidity. Practice good sanitation. Till soil to bury infected debris. Mulch to prevent rain splash of infected debris. |
| Fruit — poor setting<br><br>Physiological disorder | Lack of flowering or blossom drop resulting in no fruit set. | Can occur due to excessive nitrogen fertilization resulting in vigorous vegetative growth and no flowering.<br><br>Manage nitrogen fertilization carefully and avoid side-dressing before fruit set occurs.<br><br>Can occur due to high temperatures during bloom, causing flowers to abort and fall off without setting fruit.<br><br>Select early maturing varieties that are more likely to bloom before high summer temperatures occur. |
| Fruit — hard core<br><br>Physiological disorder | White discoloration and hard flesh inside ripe tomato fruit | Caused by a combination of genetic, fertility, and weather factors, especially high temperatures.<br><br>Maintain good soil fertility and select varieties less prone to this disorder. |
| Fruit — yellow shoulders | Yellow coloration on the top (shoulders) of otherwise ripe tomato fruit. Yellow area is often firmer than surrounding fruit. | Caused by a combination of genetic, fertility, and weather factors, especially high temperatures.<br><br>Maintain good soil fertility and select varieties less prone to this disorder. |
| Fruit — slow ripening<br><br>Physiological disorder | Green fruit that has reached mature size is slow to ripen. | Can occur when the plant growth and fruit development has outpaced root growth and development, especially when coupled with a change in weather to hotter, drier conditions.<br><br>Support fruit ripening with adequate moisture and fertility throughout the growing season. |

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## Disease and Environmental Stresses

This table provides a summary of many common diseases and environmental stresses of vegetable crops in Kansas.

| Plant/Problem and causal agent | Symptoms/ identification | Conditions and management | |
|---|---|---|---|
| ***Tomato*** | | | |
| Fruit — sunscald<br><br>Physiological disorder | Light-colored areas appear on fruit surfaces exposed to direct sun. These areas can turn dry, papery, and wrinkled. Damaged areas may be invaded by rot fungi. | Can occur in plants where leaves are lost due to foliar disease or other damage.<br><br>Manage foliar disease. Avoid physical injuries. | |
| Fusarium wilt<br><br>Fungus: *Fusarium oxysporum* f. sp. *lycopersici* | Plants wilt and eventually collapse and die. Symptoms begin with leaf yellowing and mild wilting. A red-brown discoloration may be visible in the xylem when lower stems are cut open. | Causal fungus survives multiple years in soil. Can be spread through movement of infested soil.<br><br>Plant resistant varieties. Grafted plants with resistant rootstocks are also available. Rotate ≥6 years. Avoid moving infested soil into new plots. |  <br>Clemson University – USDA Cooperative Extension Slide Series , *Bugwood.org* |
| Gray mold<br><br>Fungus: *Botrytis cinerea* | Fuzzy gray mold develops on leaves, stems, and fruit. Stems may become girdled causing plant collapse and death. | Primarily in high tunnels and greenhouses. Rare in field. Favored by wet, humid conditions and cool/moderate temperatures. Survives on infected plant debris and infection often begins on dead/dying tissue.<br><br>Manage humidity and moisture and improve airflow through proper spacing and ventilation of high tunnels and greenhouses. Avoid irrigation practices that cause leaf wetness. During season remove infected plant debris and place immediately in plastic bag to avoid spread spores. Clean up all debris at end of season. |  <br>G. J. Holmes, Cal Poly San Luis Obispo, *Bugwood.org* |

## Disease and Environmental Stresses

This table provides a summary of many common diseases and environmental stresses of vegetable crops in Kansas.

| Plant/Problem and causal agent | Symptoms/ identification | Conditions and management | |
|---|---|---|---|
| ***Tomato*** | | | |
| Herbicide injury<br><br>Chemical/ physiological | Distorted, twisted, and/or stunted growth. May be confused with virus symptoms.<br><br>If damage is severe, reduced yield or plant death may result. | Tomatoes are sensitive to several herbicides including 2,4-D, dicamba, and triclopyr. Some of these products can volatilize and drift onto plants from some distance.<br><br>Residual herbicides can also be present in soil amendments or mulches.<br><br>Avoid using herbicides that are known to cause damage in tomatoes. Avoid using mulches that may contain herbicide residues. |  <br>Megan Kennelly, KSU |
| Leaf mold<br><br>Fungus: *Passalora fulva* | Infected leaves develop light green to yellow color on upper surface. Olive-green to brown moldy growth develops on leaf undersides. Leaves eventually die. | Primarily in high tunnels and greenhouses. Rare in field. Favored by wet, humid conditions.<br><br>Manage humidity and moisture and improve airflow through proper spacing and ventilation of high tunnels and greenhouses. Avoid irrigation practices that cause leaf wetness. During season remove infected plant debris and place immediately in plastic bag to avoid spread spores. Clean up all debris at end of season. Clean and sanitize stakes, trellises, and other greenhouse or high tunnel structures that contacted plants. |  <br>Rebecca A. Melanson, Mississippi State University Extension, *Bugwood.org* |
| Leaf roll<br><br>Physiological disorder | Leaves roll during dry weather.<br><br>Physiological condition | Provide even soil moisture and avoid cultivation that damages roots. |  <br>Megan Kennelly, KSU Plant Pathology |

## Disease and Environmental Stresses

This table provides a summary of many common diseases and environmental stresses of vegetable crops in Kansas.

| Plant/Problem and causal agent | Symptoms/ identification | Conditions and management | |
|---|---|---|---|
| ***Tomato*** | | | |
| Root-knot nematode<br><br>Nematode: *Meloidogyne* | Knobby, distorted growth on roots. Above-ground plant parts may be yellowed and/or stunted. | Select resistant varieties.<br><br>Crop rotation — rotate at least 6 years to plant species that are not susceptible to root knot. This is difficult because the disease affects many species. |  <br>G. J. Holmes, Cal Poly San Luis Obispo, *Bugwood.org* |
| Septoria leaf spot<br><br>Fungus: *Septoria lycopersici* | Small tan leaf spots with dark borders. Tiny black flecks may be visible inside spots. Heavily infected leaves may turn yellow and drop off. | Most common tomato leaf spot in Kansas. Favored by wet, humid conditions. Overwinters in fallen leaf debris.<br><br>Rotate crops at least 2 to 3 years. Reduce moisture and humidity through spacing, staking, and good irrigation practices. Use mulch underneath plants. Deep till to bury infected debris. |  <br>Nancy Gregory, University of Delaware, *Bugwood.org* |
| Southern blight<br><br>Fungus: *Sclerotium rolfsii* | Brown-to-black lesions on the lower stem leading to girdling. Plants may wilt or collapse. White fungal growth may develop on affected areas. Small (1–2 mm) red-brown hard structures (sclerotia) may develop within the moldy fungal growth. | Not common. Favored by moisture and hot weather. Fungus infects a very wide host range. Fungus survives multiple years in host debris in the soil.<br><br>Rotate crops at least 6 years. Deep till to bury debris. Avoid spreading infested soil to new plots. |  <br>Clemson University – USDA Cooperative Extension Slide Series , *Bugwood.org* |
| Verticillium wilt<br><br>Fungus: *Verticillium* | V-shaped lesions on leaves. Plants yellow and wilt, often on one side. Inside of stem develops brown discoloration. | Causal fungus infects many plant species and survives multiple years in soil. Can be spread through movement of infested soil.<br><br>Plant resistant varieties. Grafted plants with resistant rootstocks are also available. Rotate ≥6 years. Avoid moving infested soil into new plots. | |

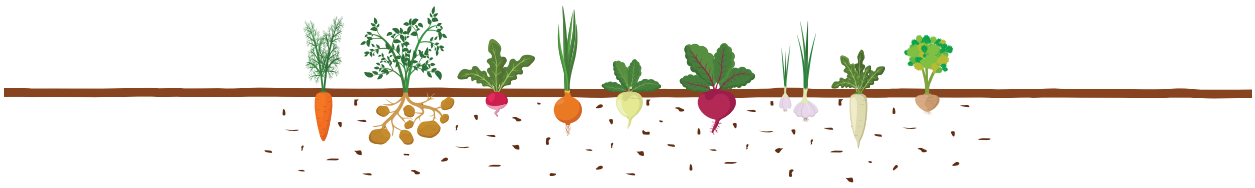
## Disease and Environmental Stresses

This table provides a summary of many common diseases and environmental stresses of vegetable crops in Kansas.

| Plant/Problem and causal agent | Symptoms/ identification | Conditions and management |
|---|---|---|
| ***Tomato*** | | |
| Viruses — several including tobacco mosaic virus, beet curly top, cucumber mosaic virus, tomato spot wilt virus | Viruses cause many symptoms including distortion, twisting, ringspots, mottled colors on fruit and foliage.<br><br>May be confused with herbicide injury, which is much more common. | Some viruses are spread by insects.<br><br>Remove infected plants to prevent further spread. Manage insects that may spread the disease. Manage weeds that may harbor insects.<br><br>Resistant varieties are available for some viruses.<br><br>  <br>Whitney Cranshaw, Colorado State University, *Bugwood.org* |
| Walnut wilt<br><br>Physiological problem | Tomatoes near trees in the walnut family (walnut/butternut/ pecan) abruptly wilt and die, usually in early to mid summer. | Caused by root uptake of juglone, a chemical produced by trees in walnut family.<br><br>Avoid planting tomatoes near problematic trees. |
| Warty stems – See adventitious roots and herbicide injury | | |
| ***Vine crops – see "cucurbits"*** | | |
| ***Watermelon – see "cucurbits"*** | | |

# Chapter 13

# Harvesting and Storing



Vegetables from home gardens have the benefits of being harvested at the peak of ripeness and just before use. If produce is not going to be used immediately, providing conditions to slow deterioration in quality after harvest is important. Please note that all the information listed is for whole, intact produce. Once produce has been cut or peeled (beyond normal harvesting), then produce must be kept below 40°F for safety.

## When to Harvest

Because vegetables include many different parts of the plant — leaves, roots, stems, fruits, flowers, seeds — it can be challenging to identify the correct time to harvest each vegetable. Additionally, some vegetables can have different harvest times depending on the cultivar being grown. When planning the garden and choosing cultivars, make notes on expected days to maturity, harvest size and color, and any other characteristics that may indicate ripeness for each cultivar. You can refer to these notes as harvest time approaches.

Refer to the chart for harvest guidelines for different types of vegetables.

## Vegetable Harvest Indicators

| Vegetable | Size | Color | Comments |
|---|---|---|---|
| Asparagus | ½ inch diameter and 8-10 inches long | Green, purple | Cut or snap at ground level |
| Bean, shelling | Seeds fully developed | Pods faded to tan | To use fresh, harvest when seeds are still moist. To store, harvest when pods are fully dry. |
| Bean, snap | Pods should be smooth and seeds not yet fully developed | Green, purple, yellow | |
| Beets | 2-3 inches diameter | Red, varies with cultivar | Beet foliage can be harvested for greens |
| Bok choy | Varies with cultivar | Green, purple | Individual leaves can be harvested starting at about 3 inches long |
| Broccoli | 6-7 inches across | Dark green | Harvest before yellow flower buds begin to open |
| Brussels sprouts | 1-2 inches diameter sprouts | Dark green, purple | Harvest after a freeze for best flavor. Harvest when sprouts are firm. |
| Cabbage | Varies with cultivar | Green, red | Harvest when heads are large and solid |
| Cabbage, Chinese | Varies with cultivar | Green, often light green | Harvest heading types when heads are large and solid; harvest non-heading types as desired starting when leaves are about 3 inches long |
| Carrot | Varies with cultivar | Orange, varies with cultivar | Note expected root shape and length when choosing cultivars. |
| Cauliflower | 6-8 inches across | White, varies with cultivar | Blanch heads when 2-3 inches across by tying leaves over heads |
| Chard | Any size as desired | Dark green, bright stems | Cut or pinch stalk near the soil |
| Collards | Any size as desired; Leaves less than 10 inches long have the best flavor | Dark green, varies with cultivar | Harvest individual leaves starting from the bottom of the plant, moving up over time. |
| Cucumber | 2-4 inches long, pickling<br>6-12 inches long, slicing | Dark green, before yellow color develops, varies with cultivar | Diameter should be less than 2 inches |
| Eggplant | Varies with cultivar | Purple, white, green, varies with cultivar | Fruit should have glossy sheen to skin. Dull, matte skin indicates fruit is overmature and seedy, may be bitter. |
| Endive, escarole | Any size desired | Green, varies with cultivar | |
| Fennel, bulb | 3-4 inches across; any size desired | White | |
| Garlic | 1.4-3 inches diameter | White, reddish-purple | Harvest when tops fall over or when about 5 lower leaves have dried. |

## Vegetable Harvest Indicators

| Vegetable | Size | Color | Comments |
|---|---|---|---|
| Herbs | Varies with type | Varies with type | Harvest before bloom; keep trimmed to prevent blooms |
| Horseradish | Harvest large roots in the fall | White | Harvest in late October or November after roots are large. |
| Kale | Any size desired, before flower buds appear | Varies with cultivar | Harvest individual leaves starting from the bottom of the plant, moving up over time. |
| Kohlrabi | 2-3 inches diameter, varies with cultivar | Green, purple, white | Harvest before the bulb becomes woody |
| Leek | ½-2 inches diameter | 3 inches or more of white stalk | Can be harvested at various sizes |
| Lettuce | 4-8 inches long, varies with cultivar | Green, red, varies with cultivar | Harvest outer leaves or cut at soil level; hot weather causes bitterness |
| Melon, cantaloupe | 5-10 inches diameter | Yellow-tan between the netting | When mature, stem separates easily from the melon |
| Melon, honeydew | Varies with cultivar | Creamy white with yellow accents, no green color to peel | Peel should be waxy, sweet aroma, blossom-end is slightly soft. |
| Okra | 3 inches long | Green, red | Harvest regularly to maintain productivity; larger pods will become tough and fibrous |
| Onion, dry | Varies with cultivar | White, red, yellow | Harvest when tops fall over and begin to dry |
| Onion, bunching | ¼-½ inch diameter | White stalk | |
| Parsnip | 8-18 inches long; 1-3 inches diameter | White or cream | Can overwinter in the ground, mulch and dig in early spring; newer cultivars can be harvested in the fall |
| Pea, shelling | 3-inch long pods | Green | Harvest when peas in pods are full size |
| Pea, sugar snap | 3-inch long pods | Green, purple, varies with cultivar | Harvest when peas are nearly full size and flavor is sweet |
| Pea, snow | 3-inch long pods | Green, purple, yellow, varies with cultivar | Harvest when pea seeds are just beginning to develop and pods are still flat |
| Pepper, hot | 1-3 inches long, varies with cultivar | Red, yellow, orange, purple, green, varies with cultivar | Fruit should be firm with thick walls appropriate to the cultivar |
| Pepper, sweet | 2-4 inches diameter, varies with cultivar | Green, red, yellow, orange, purple, varies with cultivar | Can be harvested when green or left on the plant to mature to red, yellow, or orange. Fruit should be firm with thick walls appropriate to the cultivar |
| Potato | Varies with cultivar | Varies with cultivar | Dig when tops turn brown and die |
| Pumpkin | Varies with cultivar | Orange, white | Harvest when uniformly orange and rind is hard. |

### Vegetable Harvest Indicators

| Vegetable | Size | Color | Comments |
|---|---|---|---|
| Radish, spring | ½-2 inches diameter | Red, white, pink, purple, varies with cultivar | Radishes larger than 2 inches are usually pithy |
| Radish, fall | 2-5 inches diameter | Varies with cultivar | Pull and twist near the base of the stalk. |
| Rhubarb | ½ inch diameter or larger stalks; 10 inches long or more | Green, red | Leaves are toxic; Do not remove more than ⅔ of the fully developed stalks at one time. |
| Spinach | 4-8 inches tall | green | Crop will bolt when weather is too warm |
| Squash, Summer | 3-12 inches long | Yellow, green | Harvest while skin is still soft |
| Squash, Winter | Varies with cultivar | Varies with cultivar | Harvest when rind is hard and difficult to puncture with fingernail |
| Sweet corn | 5-12 inches long; varies with cultivar | Yellow, white, bicolor | Harvest when silks are golden brown, kernels are plump and exude a milky sap when punctured |
| Sweet potato | Varies with cultivar | Varies with cultivar | Harvest in September or October, when roots have reached desired size |
| Tomato | Varies with cultivar | Varies with cultivar | Harvest when fully ripe for best flavor. Harvest when fruit begins to develop color and ripen at room temperature to prevent cracking. |
| Tomatillo | Varies with cultivar | Green, purple | Harvest when fruit is firm and fills the husk to the point where it bursts |
| Turnip | 2-3 inches diameter | White, purple, red, varies with cultivar | Foliage can be harvested for greens |
| Watermelon | Varies with cultivar | Varies with cultivar; light to dark green, striped | Harvest when underside turns yellow; harvest when tendril nearest stem is partially or completely brown |

## Preventing Foodborne Illnesses During Harvest

Some commonsense guidelines can prevent the risk of foodborne illness from garden produce. Even though on a very small scale compared to a commercial farm, there is a risk of foodborne illnesses due to wildlife, personal hygiene, or cross-contamination from dirty harvest tools or containers.

Wildlife frequently find their way into a home garden, lured by tasty plants and access to water. While it is unreasonable and impractical to expect all wildlife to be excluded from the garden, it is wise to be aware of the signs of animals in the garden. Most critically, any produce that has been either fed upon by an animal or where feces are on the part to be harvested should be discarded rather than consumed or mixed with other produce. Washing the feces off the produce does not guarantee that any pathogens are removed from the vegetable.

It is also common in a home garden that tools and containers are used for more than one purpose. Before harvesting, wash your hands thoroughly and clean and sanitize any tools or containers to be used. If possible, avoid

using the same buckets or bins that you use for hauling compost, manure, fertilizers, weeds, or other garden-related materials. Consider bringing a clean bowl or container and shears from your kitchen to harvest your produce.

For root vegetables, remove as much dirt as possible during harvest. Depending on your usage and storage plans for the root vegetables, you may want to wash them before bringing them into the kitchen. Otherwise, store them with as little dirt on them as possible.

## Short Term Storage of Vegetables

After harvesting, it is important to store any vegetables that will not be used immediately in a manner that will maintain their freshness for as long as possible. The table below shows the recommendations for short term storage of vegetables in a home kitchen. The majority of garden vegetables that will be consumed or preserved within several days can be stored in a refrigerator with a temperature between 35 and 41˚F. In most cases, placing the vegetables in a plastic bag or container will help maintain the high humidity conditions needed to prevent water loss and withering.

Certain vegetables should be stored at room temperature for the few days before use. See table below.

## Curing Vegetables for Storage

Certain vegetables need to be cured before storage and use. The curing process typically helps thicken or harden the skins or rinds to help reduce water loss and lengthen storage. Potatoes, sweet potatoes, and winter squashes are the most commonly cured vegetables for a home gardener. Curing typically involves holding the vegetables at a warm temperature and high humidity for 1 to 2 weeks. See the table below for curing conditions. Under less-than-ideal curing conditions, the curing process will take longer than described.

### Curing Vegetables

| Vegetable | Temp. | Humidity | Length of Time |
|---|---|---|---|
| Potatoes | 60-75˚F | 95% | 2 weeks |
| Pumpkins and winter squash | 80-85˚F | 75-80% | 1 week |
| Sweet potatoes | 85-90˚F | 80-95% | 1-2 weeks |
| Onions, garlic, and shallots | 85-90˚F | Dry, with good airflow | 2 weeks |

### Short Term Storage of Vegetables

| Refrigerator | | Room temperature | |
|---|---|---|---|
| Asparagus | Herbs (not basil) | Basil (in water) | Peppers* |
| Green beans | Leafy vegetables | Cucumbers* | Pumpkins |
| Beets | Leeks | Dry onions^ | Sweet potatoes^ |
| Broccoli | Lettuce | Eggplant* | Tomatoes |
| Brussels sprouts | Mushrooms | Garlic^ | Winter squashes |
| Cabbage | Peas | Ginger | |
| Carrots | Radishes | | |
| Cauliflower | Spinach | | |
| Cut vegetables | Summer squashes | | |
| Green onions | Sweet corn | | |

* Cucumbers, eggplant, and peppers can be stored in the refrigerator for 1 to 3 days if used soon after removing from the refrigerator.

^ Store garlic, onions, potatoes, and sweet potatoes in a well-ventilated area in the pantry. Protect potatoes from light to avoid greening.

## Long Term Storage of Vegetables

Many vegetables can be stored for longer periods of time — up to several months in the case of many root vegetables and hard squashes. To achieve these longer storage windows, it is critical that the vegetables be stored at the correct temperature and with as close to the recommended level of relative humidity as possible. When storing vegetables for later use, follow recommendations in the Vegetable Storage Conditions table on the next page.

## Storage Condition Groups

While there are always exceptions, most crops can be categorized into one of the following groups of temperature and humidity for storage. When seeking to store vegetables for as long as possible, the closer you can get to the listed storage conditions, the longer the vegetables will last with high quality.

**32 to 36°F and 90 to 98% humidity:** Many vegetables keep best if storage temperatures are low (between 32 and 36°F) and the humidity level is very high (90 to 98%). These vegetables often need to maintain crispness by preventing water loss. Most leafy greens and root vegetables are in this category.

**32 to 36°F and 85 to 95% humidity:** Some crops need low temperatures and high humidity. Many of these crops are fruits, such as apples or cantaloupe.

**45 to 50°F and 85 to 95% humidity:** Some crops suffer internal damage if the storage temperatures are too low. They are best kept in a cool storage location with high humidity. A colder storage temperature in the 30s may shorten the storage life of the crop, resulting in discoloration of the product and disagreeable flavors.

**40 to 50 and 60 to 70% humidity:** These crops will tolerate storage temperatures between 40 and 50°F. Onions and garlic are the best examples. They are often best stored in open mesh bags so that excess humidity does not build up near the product.

**55 to 65°F and 85 to 95% humidity:** These crops will lose flavor or quality if stored at colder temperatures, but will have the longest storage life if stored in a high humidity location to prevent water loss.

**55 to 65°F and 65 to 70% humidity:** Crops such as sweet potatoes, winter squash, and pumpkins store best at cool basement temperatures, between 50°F and 60°F, with about 60 to 70% humidity. These crops are subject to internal injury when storage temperatures drop too low. The damage, called "chilling injury," is as serious as many other types of physical damage.

## Select the Best

Nothing improves in storage, and defective produce should be discarded or used immediately so only the best quality, soundest products are stored. Produce must be handled carefully to avoid surface damage, skinning, or bruising. All these types of injury provide entry points for bacteria or fungi that may rot the produce and reduce storage intervals.

## Check Storage Areas Regularly

Frequently check on vegetables in storage and discard any that are starting to rot or discolor by gently removing them from the basket or box. Areas that are used for storage, including boxes or baskets used to hold produce, should be cleaned and disinfected prior to use. Wiping them with a dilute bleach/water solution using about 1 part laundry bleach to 10 parts water can disinfect effectively. Allow containers or racks to dry thoroughly before using. Individual harvesting and storage suggestions are provided in the text for individual crops.

### Recommended Vegetable Storage Conditions

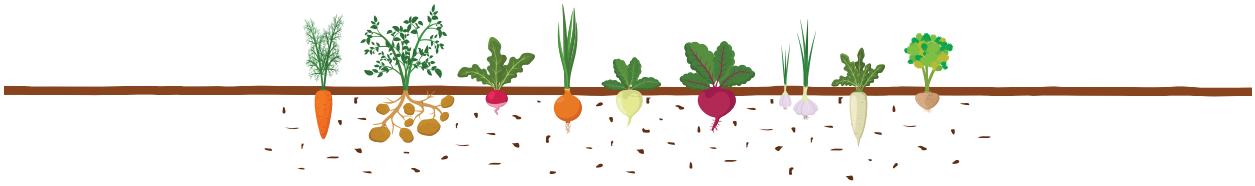
| Vegetable | Storage Temperature | Relative Humidity | Storage Period |
|---|---|---|---|
| Asparagus | 36°F | 95-98% | 2 weeks |
| Beet (tops removed) | 32°F | 98% | 1-3 months |
| Bok choy | 32°F | 95-98% | 3 weeks |
| Broccoli | 32°F | 95-98% | 3 weeks |
| Brussels sprouts | 32°F | 95-98% | 1 month |
| Cabbage | 32°F | 95-98% | 2-3 months |
| Cantaloupe, other netted melons | 36-41°F | 95% | 2-3 weeks |
| Chinese cabbage | 32°F | 95-98% | 2-3 months |
| Carrot (tops removed) | 32°F | 98% | 4-6 months |
| Cauliflower | 32°F | 95-98% | 2-3 weeks |
| Chard | 32°F | 95-98% | 1-2 weeks |
| Collards | 32°F | 95-98% | 1-2 weeks |
| Endive, chicory | 32-36°F | 95-98% | 2-4 weeks |
| Fennel, bulb | 32-36°F | 90-95% | 2-3 weeks |
| Herbs (except basil) | 32°F | 95-98% | 2-3 weeks |
| Horseradish | 32°F | 98% | 10-12 months |

## Recommended Vegetable Storage Conditions

| Vegetable | Storage Temperature | Relative Humidity | Storage Period |
|---|---|---|---|
| Kale | 32°F | 95-98% | 1-2 weeks |
| Kohlrabi | 32°F | 98% | 2-3 months |
| Leafy greens | 32°F | 95-98% | 1-2 weeks |
| Leek | 32°F | 95-98% | 2 months |
| Lettuce | 32°F | 95% | 2 weeks |
| Melons, other than cantaloupe | 45-50°F | 85-90% | 2-4 weeks |
| Okra | 45-50°F | 90-95% | 7-10 days |
| Onion, green or scallion | 32°F | 95% | 2-3 weeks |
| Parsnip | 32°F | 95-98% | 4-6 months |
| Peas, in pods | 32°F | 90-98% | 1-2 weeks |
| Southern peas (cowpeas) | 40-41°F | 95% | 6-8 days |
| Radish, daikon | 32-34°F | 95-98% | 2-3 weeks |
| Radish, spring | 32°F | 95-98% | 1-2 months |
| Rhubarb | 32°F | 95-98% | 2-4 weeks |
| Spinach | 32°F | 95-98% | 1-2 weeks |
| Sweet corn | 32°F | 95-98% | 4-8 days |
| Turnip, greens | 32°F | 95% | 2-3 weeks |
| Turnip, roots | 32°F | 95% | 4-5 months |
| Bean, snap or lima | 40-45°F | 90-95% | 1 week |
| Basil | 50°F | 90% | 7 days |
| Garlic | 32°F | 65-70% | 6-7 months |
| Cucumber | 45-55°F | 85-90% | 1-2 weeks |
| Eggplant | 45-50°F | 90% | 1 week |
| Pepper | 45-50°F | 90-95% | 2-3 weeks |
| Potato | 45-50°F | 95-98% | 4-6 months |
| Squash, summer | 45-50°F | 95% | 1-2 weeks |
| Sweet potato (after curing) | 55-60°F | 85-90% | 4-6 months |
| Tomatillo | 45-55°F | 85-90% | 3 weeks |
| Tomato (firm, colored) | 46-50°F | 85-90% | 1-2 weeks |
| Tomato (mature, green) | 50-55°F | 90-95% | 2-5 weeks |
| Watermelon | 50-60°F | 90% | 2-3 weeks |
| Onion, dry | 32-35°F | 60-70% | 2-8 months |
| Shallot | 32-36°F | 60-70% | 6-8 months |
| Pumpkin | 50-60°F | 50-70% | 2-3 months |
| Squash, winter | 50-60°F | 50-70% | 2-4 months |

# Chapter 14

# Herbs



Herbs are plants that are used as flavoring agents. Herbs used in cooking are called "culinary" herbs. Mild or savory herbs impart a delicate flavor to foods, while stronger or pungent herbs add zest. A number of additional herbs are used for teas, medicinal, aromatic, or ornamental purposes. Still other herbs are grown in the garden to support beneficial insect and pollinator populations.

For culinary herbs, the leaves are the part of the plant that is most commonly used, although the flowers, seeds, or roots of some herbs also can be used. Both the leaves and flowers may be used in teas, with some herbs grown for the use of their flowers in tea. Of course, flowering herbs are prized for the benefits of pollinator populations. Herbs can be interplanted in both vegetable and ornamental beds.


## Types of Herbs

Similar to vegetables, herbs fall into different categories that are helpful to know when determining what to plant and when. Most herbs are either annuals or perennials, although a few are categorized as biennials.

**Annuals.** Annual herbs need to be replanted in the garden every year. They will complete their entire life cycle in one growing season. Many of these herbs can be direct-seeded in the garden if desired, although it may give them a head start to plant seeds indoors or purchase plants and transplant them outdoors after they have grown for a few weeks. Often, annual herbs can be successfully grown from seed.

**Biennials.** Biennial herbs will over-winter and grow for part of a second year while they develop flowers and seed. For culinary purposes, you may find it easier to plant biennial herbs like annuals each spring.

**Perennials.** Perennial herbs will grow for several years once established in the garden, usually re-growing from the roots each year. Some perennials will develop woody stems and will put on new growth from those stems. Most perennial herbs must be propagated from cuttings or division rather than seeds if you want the new plant to come true to type.

It is also important to note that some popular herbs are perennials, but will not reliably over-winter in Kansas. Some of these, like rosemary, may overwinter in some years but not others. Other herbs, such as lemon verbena, are not winter hardy at all and must be replanted each year.

## Site Selection

Many herbs are versatile, tough plants that will grow well in a variety of situations. Often, herbs are more drought tolerant than other garden plants, and can be planted in locations that do not get as much water. Many herbs are well-adapted to growing in raised beds or containers.

Because the leaves are most commonly used, many herbs will grow well in part-sun and part-shade locations. Herbs grown for the flowers should be planted in full sun, or the flowering may be reduced.

## Getting Started

Most annual and biennial herbs can be established by planting the seed directly in the garden or starting seed indoors for transplanting to the garden. Refer to the chart below for recommended propagation methods and planting times for herbs.

Perennial herbs can be propagated by cuttings or division. Divide plants every 3 to 4 years in the early spring. The plants should be dug up and cut into several sections. You can also cut 4- to 6-inch sections of the stem and root them by placing the cuttings in moist sand in a shady area. In 4 to 8 weeks, roots should form. Herbs such as sage, winter savory, and thyme can be propagated by cuttings. Chives, lovage, and tarragon can be propagated by division of the roots or crowns.

## Aggressive Herbs

Some herbs can become a problem in a home garden due to either spreading by rhizomes or by reseeding freely. Other herbs have deep taproots that can make it difficult to eradicate the plants if desired. Mint and oregano, in particular, can spread easily in a garden if left unchecked. You should consider planting these herbs in containers rather than directly into the garden. Herbs that spread or reseed are noted in the chart below.

## Maintenance

Care for the herb garden will be similar to that of a vegetable or flower garden. Refer to specific chapters in this guide for more detailed information on various maintenance topics. The main difference is that many herbs do not require as much fertilizer as vegetables, nor do they require as much water. This is important to remember if you want to interplant herbs with your vegetables, as some herbs may experience more problems with crown or root rot if watered and fertilized at the same level as vegetables.

**Deadheading.** Because most culinary herbs are prized for their foliage rather than their flowers, it is ideal to keep the plants trimmed back when they begin to flower. If you want to provide a food source for pollinators, you may choose to let the herbs bloom, but then you will want to remove the flowers as they begin to fade to rejuvenate the foliage. Leaving the flowers on to develop seed will reduce the quality of the foliage for culinary purposes. The only herbs that you should not deadhead are those that you are growing for seed.

## Harvesting

Most culinary herbs are grown for their foliage, although in some cases the flowers are also flavorful. Certain herbs are also grown for the seeds. Herbs grown for foliage should be harvested when the foliage is full size but stems are still tender. Herbs grown for seeds are typically harvested when the seeds are fully mature and have turned brown.

When harvesting foliage for fresh use, cut a 3- to 6-inch tender stem and strip the leaves. In some cases, individual leaves can be harvested. Herbs, such as parsley, that form a rosette near the ground should be harvested by individual leaves, starting with the oldest, outermost leaves.

When harvesting foliage herbs to dry or freeze for later use, it is best to harvest most herbs just before the buds open, as this is when the essential oils are at their strongest.

## Drying

After harvesting, hang herbs in loosely tied bundles in a well-ventilated room. You can also spread the branches on a screen, cheese-cloth, or hardware cloth. For herbs where leaves only are needed, the leaves can be spread on flat trays.

Dehydrator drying is a fast and easy way to dry high quality herbs because temperature and air circulation can be controlled. Pre-heat the dehydrator with the thermostat set to

95˚F to 115˚F. In areas with higher humidity, temperatures as high as 125˚F may be needed.

When the leaves are crispy dry and crumple easily between the fingers, they are ready to be packaged and stored. Dried leaves may be left whole and crumpled as used, or coarsely crumpled before storage.

## Storage

When herbs are thoroughly dry, they should be put in airtight containers such as sealed fruit jars and stored in a cool dark location. Any sign of moisture accumulating in the jars indicates the herbs are not thoroughly dry.

## Growing Herbs Indoors

Some herbs can be placed in pots and grown indoors during the winter. Herbs can either be dug up toward the end of the growing season and placed in pots or started from seed indoors. Some herbs can be propagated from cuttings and rooted for growing over winter. They should be placed in a sunny south window and given care similar to house plants. A grow light may be beneficial if your house does not have good sunlight.

If bringing mature plants indoors, adjust the water and fertilizer levels to the amount of light available. Most herbs will not need as much water and may need minimal fertilizer under lower light conditions. Expect that the herb plants will drop some leaves when brought indoors, due to the lower light.

For some herbs that can be grown from seed indoors, such as basil, parsley, and cilantro, it may be easier to harvest the entire plant once it is 3 to 6 inches tall and then reseed, rather than trying to grow larger, mature plants.

## Perennial and Biennnial Herbs

| Herb | Height (in.) | Ideal Planting Range | Propagation and Culture | Harvest | Use |
|---|---|---|---|---|---|
| **Anise Hyssop** *Agastache foeniculum* | 24-36 | April – June after last frost | Direct seed or transplant. Reseeds freely. | Harvest young leaves. Clip seed heads and shake out in a paper bag | *Leaves* — salads, teas *Seeds* — sprinkle in baked goods |
| **Chives** *Allium schoenoprasum* | 12 | April – June | Can be grown in containers or outdoors in spring. Divide to increase. Space 5 inches. | Clip leaves as needed. | *Leaves* — omelets, salads, soups, sauces, dips. |
| **Garlic Chives** *Allium tuberosum* | 12-16 | | Same as chives. | Same as chives. | Substitute for garlic flavor. |
| **Horseradish** *Armoracia rusticana* | 18-36 | February – April | Transplant a small plant or a root cutting. Easily spreads through root divisions. | Harvest roots in late winter or early spring | *Roots* — Used to make a pungent condiment that compliments beef, roasts and hearty stews |
| **Lavender** *Lavandula angustifolia* | 18-36 | April – June | Transplant plants. Do not prune plants except for right after flowering. Slow to break dormancy. | Harvest flower buds just as they begin to open. Use sparingly — a little goes a long way. | *Flower Buds* — used in pastas, salads, dressings, desserts and baked goods. *Leaves* — flavor meats and vegetables. |
| **Lemon Balm** *Melissa officinalis* | 24 | April – June | Space 12 inches. Prefers full sun. Reseeds freely! | Harvest mature leaves. | *Leaves* — soups, meats, teas, summer drinks. |
| **Lovage** *Levisticum officinale* | 24-36 | April – June or crown divisions in Autumn | May start indoors and move to sunny location. Space 12-15 inches. | Harvest mature leaves. | Substitute for celery flavor. |
| **Monarda** *Monarda didyma* | 12-40 | March – June | Dig and divide clumps or easily started by seed. Member of the mint family. Spreads easily by seeds and root rhizomes. | Harvest the leaves before it flowers and dry, then harvest and dry the flowers. | *Tea* — used in Earl Grey blends. *Leaves* added to bread doughs or pastries. *Flowers* can be scattered on salads. Great substitute for oregano or thyme. |

## Perennial and Biennnial Herbs

| Herb | Height (in.) | Ideal Planting Range | Propagation and Culture | Harvest | Use |
|---|---|---|---|---|---|
| **Oregano** *Origanum vulgare* | 24 | April – June | Plant in rich soil. Space 8-10 inches. Start in protected location and move to full sun. | Harvest mature leaves. | *Leaves* — soups, roasts, stews, salads. |
| **Parsley** *Petroselinum crispum* Biennial | 5-6 | April – May | Seed in early spring. Space 6-8 inches. May be slow to germinate Will also self-seed in the fall. | Harvest mature leaves as needed. | *Leaves* — garnishes, pesto |
| **Peppermint** *Mentha piperita* | 18 | March – June | Transplants or root cuttings. Prefers rich, moist soil. Space 8-10 inches. Spreads extremely easy! | Harvest young or mature leaves. | *Leaves* — soups, sauces, teas, jelly. *Sprigs* — teas, sauces, summer drinks. |
| **Rosemary** *Rosmarinus officinalis* | 36 | April – June | Start cutting in early spring. Space 24 inches. | Harvest mature leaves. | *Leaves and sprigs* — meats, sauces, soups. *Dried leaves* — sachets to hang in closet with garments. |
| **Saffron crocus** *Crocus sativus* | 4-5 | August | Bulbs are planted in August and flowering is in the fall. | Harvest the crimson stigma called threads and dry. | High in antioxidants, flavors rice and risotto, fish, bouillabaisse. |
| **Sage** *Salvia officinalis* | 16 | April – June | Plant in well-drained location. Space 30 inches. | Harvest leaves before flowering. | *Leaves* — meats, teas, fish, dressings, stews. |
| **Spearmint** *Mentha spicata* | 18 | March – June | Same as peppermint. | Same as peppermint. | *Leaves* — summer drinks, teas, mints, sauces. |
| **Thyme** *Thymus vulgaris* | 8-12 | April – June | Start seeds indoors. Prefers full sun and well-drained soil. Space 10-12 inches. | Harvest leaves and flower clusters before first flowers open. | *Leaves* — soups, salads, dressings, omelets, gravy, breads, vegetables. |
| **Winter Savory** *Satureja montana* | 8-15 | Late April – May | Start seeds indoors 4-6 weeks before last frost or as transplants. | | Strong peppery flavor — excellent with beans, potatoes, and green beans. |

## Annual Herbs

| Herb | Height (in.) | Ideal Planting Range | Propagation and Culture | Harvest | Use |
|---|---|---|---|---|---|
| **Basil**<br>*Ocimum basilicum* | 20-24 | Late May – early June; night time temps above 50's | Start seed indoors in early April or seed in early spring. Space 12 inches. Prefers protected sunny location. | Harvest leaves just before flowering begins. Cut plants 7-8 inches above ground. | *Leaves* — soups, stews, omelets, salads, meats, sauces. |
| **Borage**<br>*Borago officinalis* | 20-24 | May – June | Seed directly in early spring. Space 12 inches apart. Seeds may be slow to germinate. Self-seeding annual. | Harvest the young leaves and dry, or cook fresh like spinach. | *Leaves* — salads, greens<br>*Flowers and leaf tips* — pickles, soups.<br>*Tea* |
| **Calendula**<br>*Calendula officinalis* | 12-36 | May – June | Transplant or seed directly outside just before last frost or start indoors 6-8 weeks before last frost. | Harvest new leaves and petals once the flowers are fully opened. | *Leaves* — bitter addition to salad greens<br>*Flowers* — petals are used as a garnish, seasoning<br>*Other* — dye for fabrics or foods, and cosmetics. |
| **Chervil**<br>*Anthriscus cerefolium* | 18 | April – May | Sow seed in moist, partially shaded location. Space 6 inches. | Harvest mature leaves and dry or use fresh for garnishes. | *Leaves* — salads, soup, meat, poultry, garnishes. |
| **Cilantro**<br>*Coriandrum sativum* | 24-36 | April – May<br>Fall | Sow seeds in full sun, thin to 10 inches. Grow slow-to-bolt varieties to prolong harvest. Direct seed in fall for a 2nd crop. | Harvest leaves by trimming repeatedly until the flower stalk emerges | *Leaves* — delicate leaves are used in Mexican, Spanish, Latin American, Middle Eastern and Asian dishes.<br>*Seeds* — see Coriander |
| **Coriander**<br>*Coriandrum sativum* | 24-36 | April – May | Sow seeds in full sun, thin to 10 inches. | Harvest seeds when they begin to turn brown. Seeds are generally used crushed. | *Seeds* — pastries, sauces, pickles, liquors.<br>*Leaves* — see Cilantro |
| **Cumin**<br>*Cuminum cyminum* | 12-24 | May – June | Transplants are delicate. Seeds started indoors 4-8 weeks before last frost. Direct sow outdoors 1 to 2 weeks after last frost. | Harvest feathery foliage but mostly grown for seeds harvested when dry. | *Leaves* — added to salads<br>*Seeds* — commonly used whole or ground up, grind only when you are ready to use them. |

## Annual Herbs

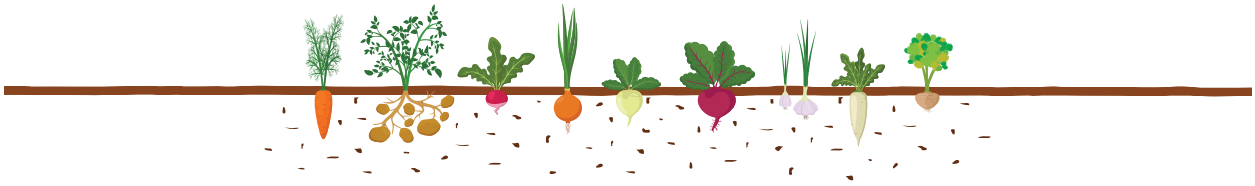
| Herb | Height (in.) | Ideal Planting Range | Propagation and Culture | Harvest | Use |
|---|---|---|---|---|---|
| **Cutting Celery** *Apium graveolens* | 18 | May – June | Direct seed after last frost. Sow seeds shallowly. Transplants can be planted out after last frost. | Harvest leaves about ¾ way down the plant. New leaves will continue to grow. | *Leaves* — great addition to soups, stocks and salads. Little stronger taste that of stalk celery. |
| **Dill** *Anethum graveolens* | 24-36 | Late March – May | Seed directly and thin to 12 inches. If seeds mature and fall, they come up again next year as a self-seeding annual. | Harvest mature seed before it drops. May use small leaves as well. | *Sprigs of seed head* — pickles, sauces, meats, salads, vinegar. |
| **Fenugreek** *Trigonella foenum-graecum* | 18 | May – September | Direct seed after last frost until late summer for fast growing leaves. Direct seed May-June for seed harvesting. | Leaves and seeds impart a flavor and aroma of maple syrup. Leaves can be dried or used fresh. | *Leaves* — used to finish dishes like sauces, curries, vegetable dishes and soups. *Seeds* — Whole or ground used in spice blends such as garam masala. |
| **Ginger** *Zingiber officinale* | 24-48 | Tropical — container grown as a houseplant — outside it does best with afternoon shade | Choose ginger rhizomes in the late spring and plant in container large enough to expand the rhizomes. Temps must be above 55°F! | Harvest the rhizomes in early fall if you are not overwintering. | *Root/rhizome* — used peeled, grated or sliced and used in dressings, Asian dishes, soups, meats, curries, desserts and cookies. *Syrup* — used in jams, sauces and beverages. |
| **Sweet Marjoram** *Majorana hortensis* | 12 | May – June | Difficult to start from seed. Start seedlings in shade. Mature plants prefer full sun. Space 8-10 inches. | Harvest mature leaves. | *Leaves* — salads, soups, dressings. |
| **Lemongrass** *Cymbopogon citratus* | 36-48 | May – June | Lemongrass stalks can be rooted in water before planting in containers or the ground. | Cut or twist or break off a stalk that is at least ¼ inch thick close to the ground. | *Stalks* — sliced into stir fries, herbal teas, and meat, poultry, seafood and vegetable soups and dishes. |
| **Lemon verbena** *Aloysia citrodora* | 12-36 | May – June | Container or garden. | Harvest leaves frequently but take no more than ½ at a time. Dries excellently. | *Leaves* — salads, seafood, desserts, ice cream, fruit salads, syrups, teas |

## Annual Herbs

| Herb | Height (in.) | Ideal Planting Range | Propagation and Culture | Harvest | Use |
|---|---|---|---|---|---|
| **Nasturtium** *Tropaeolum majus* | 6-12 | April | Direct seed 2-4 weeks before your last frost date. Transplants are very fragile. They do best in poor soil. | Leaves and flowers can be harvested at any time. Harvest seedpods before seeds mature and harden. | *Leaves and flowers* have a peppery flavor — salads. *Seedpods* — pickled, use like capers. |
| **Perilla/Shiso** *Perilla frutescens* | 6-18 | May – June | Start seeds indoors 4-6 weeks before last frost. Transplant after all danger of frost. Reseeds freely. | Start harvesting leaves after the plant is at least 8 inches tall. Snip leaves and flowers as needed. | *Green leaves* — salads, sushi, chopped into hot and cold noodle dishes. *Red leaves* — cooked dishes and pickling. |
| **Scented Geranium** *Pelargonium crispum* or *tomentosum* | 6-18 | May – June Can overwinter as a houseplant | Transplanting plants is best. Container or garden. Very slow to germinate from seed. | Harvest leaves and use fresh as needed. | *Leaves* — line your cookie sheet or baking pan and bake on top of them. Also flavor sangria, fruit punch, lemonade and sorbet. Jellies, flavored sugars, teas. |
| **Summer Savory** *Satureja hortensis* | 18 | April | A tender annual; direct sow in spring or transplant after danger of frost. | Harvest mature leaves. | *Leaves* — salads, soups, dressings, poultry. |
| **Chamomile** *Matricaria chamomilla* (German) or *Chamaemelum nobile* (Roman) | 24 | April – June | Start seeds indoors 6-8 weeks before last frost. Transplant outdoors after last frost. German variety can self-seed. | Pinch off blossoms throughout the growing season to use fresh or dry. | *Flowers* — teas, jams, candies and ice cream. Also savory dishes like risotto and salads. |
| **Lavender** *Lavandula stoechas* (Spanish) or *Lavandula dentata* (French) | 24 | April – May | Transplant in containers or garden. Trim plants by ⅓ after first flush of blooms | Harvest flowers early in their bloom cycle for maximum fragrance and essential oil | *Flowers* — cleaning products, potpourris, lotions, tinctures. |
| **Sage, Pineapple** *Salvia elegans* | 24-36 | Late April – May | Transplant cultivars are more common that planting seeds. | Harvest leaves throughout the season. Harvest flowers in the fall. | *Leaves* — summer fruit salads, chicken dishes, breads, cakes, fruit smoothies. *Flowers* — Vinegars, fruit dip, ice cubes, flavored sugar, tea. |

# Chapter 15

# Vegetable Crops



Most vegetables are similar enough that we can generalize many of their growing practices to have a successful garden. However, there are always exceptions to the rules. Each vegetable has something about it that makes it unique and can present specialized challenges for the gardener. In this chapter, each vegetable will be addressed individually or with other very similar vegetables to provide additional insights for garden success.

Each vegetable addressed will include information on variety considerations, planting time, spacing, crop rotation, care, harvesting, and common concerns. For each crop, guidelines are provided for making good choices in variety selection, but no specific recommendations. This is because there are more new varieties available each year than we can test and determine their value for Kansas gardeners.

The common concerns section lists the most common insect and disease problems for each crop. It also includes plant problems or reasons for poor yield or quality due to environmental conditions. In many cases, more information on the common concerns can be found in the chapters on insect and disease management.

## Asparagus

Asparagus is a hardy perennial that will last for 30 years or more in the garden. Plant asparagus near the side or edge of the garden where it will not interfere with annual tillage. Asparagus is one of the first crops harvested in the spring.

**Variety considerations.** Select newer, hybrid male varieties with good disease resistance, vigor, and high yield. These varieties are typically planted from crowns rather than from seed. Seed planted varieties have a higher percentage of female plants, which reduces the yield.

**When to plant.** Asparagus can be planted in early spring (mid-March to mid-April) or in the fall (early October to mid-November). Purchase fresh plump crowns from a local garden center or plant seedling transplants.

**Spacing.** Plant crowns or transplants so buds of the crown are 7 to 8 inches below ground level. Place the crowns 18 to 24 inches apart. Cover with a few inches of soil initially and add soil as the season progresses. After the trench is filled and the soil settles, crown buds should be about 6 inches below soil level.

**Care.** Asparagus produces a large, vigorous root system and is fairly resistant to stress conditions. Well-drained soil and a full sun location are necessary. Soak the area well in very dry weather. Spear production in the spring depends on vigorous growth the previous season. Spears begin to emerge in early April and may be damaged by a few spring freezes. Cut and destroy frozen spears, and the plant will rapidly send up new spears to replace them. Do not harvest the first year. In subsequent years, harvest until the spear size decreases to thinner than a pencil, usually 6 to 7 weeks in a mature planting. Fertilize in the early spring so that fertilizer can be carried into the root zone with spring rain. Weeds are a particular concern in this perennial plant. Control weeds with mulching, hoeing, or spot chemical treatment because weeds can invade over time. In the fall, you can remove dead ferns after they are completely brown or leave them in place through the winter to catch moisture and prevent soil loss.

**Harvesting.** Snap spears at the breaking point ½ to ¾ inch above the soil level or cut slightly below the soil level with a sharp knife. When spears are more than 10 to 13 inches long, they become tough and woody. Heat will cause the tips of the spears to open and become loose — called "feathered tips" — later in the season unless harvested frequently. Asparagus deteriorates rapidly after harvest; store in a cold, moist location and use quickly.

### Common concerns

- Asparagus beetles
- Asparagus rust
- Weed management

## Beans

Beans are a tender, warm-season crop that is popular in Kansas gardens as either a spring crop or a fall crop.

- ***Bush snap.*** Snap, or green beans, are grown for their tender, immature pods. They can be green, yellow (sometimes called "wax"), and purple. Bush types grow on short plants typically up to 24 inches tall and do not require trellising.
- ***Pole beans.*** Pole beans have a climbing growth habit and will require a trellis. Pole beans often perform best when planted for a fall crop in Kansas. Pole beans can be either shelling or snap beans.
- ***Shelling.*** Shelling beans are grown for the mature bean seeds in the pod. They require a longer growing season and dry weather to cure the pods. Blossoms may drop if heat occurs too early in the growing season, making them difficult to grow in Kansas. These include lima beans as well as French horticultural types, cranberry, pinto, great northern, red kidney, and similar varieties.

- ***Long beans.*** Long beans are relatives of Southern peas (cowpeas) and are vigorous climbers requiring a trellis. The bean pods can grow to 3 feet long, although best eating quality for snap beans is usually 12 to 18 inches.
- ***Southern peas.*** Also known as cowpeas, field peas, or black-eyed peas, southern peas are actually beans that are grown throughout the south and originated in Africa. They are very heat and drought tolerant, which makes them a good choice for a low maintenance summer crop. Some varieties are more bush-type and others are more vining.

**Variety considerations.** Choose early maturing varieties, because beans may not set as well in the heat and have problems with spider mites in the middle of summer. Many newer cultivars of snap beans produce large yields at one time, whereas older cultivars may spread the harvest over a longer time period. Some cultivars have larger pod diameter, whereas others have been developed for more slender, filet beans. Look for varieties resistant to bacterial blight and that are heat tolerant.

**When to plant.** Beans are sensitive to cold temperatures. Soil temperatures should be 55 to 60°F with danger of freezes well past before planting. Fall beans can be planted in late July or early August. You can have a continuous supply by planting at intervals several weeks apart. However, beans planted to bloom in hot, dry weather frequently will be of poor quality.

**Spacing.** Plant seeds about an inch deep. A plant every 3 to 5 inches is desirable, so drop seed about every 2 to 4 inches. Plant pole beans 6 to 12 inches apart.

**Crop rotation.** If possible in your garden space, do not plant beans in an area where peas, beans, or soybeans have been planted in the previous 3 to 4 years.

**Care.** Do not soak bean seed before planting. Moisten the soil to provide moisture for germination, but do not water to form a tight crust. Beans have a shallow root system and require careful cultivation, good weed control, and water in dry periods. Beans are sensitive to soil salts; avoid alkali spots or "salty" locations. Excessive nitrogen in the soil can delay flowering, so take care not to overfertilize.

**Harvesting.** Harvest snap beans when the pod is crisp, smooth, and before the seeds enlarge significantly. Do not harvest in early morning when dew is on the plants as this may spread bacterial blight. Harvest lima beans and horticultural beans when the pods are fully formed and seeds have enlarged to the degree you desire. To use fresh, harvest when the pods are thin and tough, but not dry. To store, harvest when pods are fully dry and the beans inside rattle.

## Common concerns

- Anthracnose
- Bacterial blight
- Bean leaf beetle
- Broadleaf herbicide injury
- Delayed flowering due to excessive nitrogen
- Flower drop/poor pod set due to heat
- Poor stands from salt injury or soil crusting
- Poor stands due to cold soil temperatures
- Spider mites

## Beets

Beets can be grown as a spring or fall crop in Kansas. Commonly grown for the roots, the tops can also be used as a cooked green.

**Variety considerations.** Red, round beets are by far the most common, but you can now easily find gold, white, red and white striped, and cylindrical types as well. Some non-red varieties are not as vigorous and have lower germination rates. Monogerm varieties only grow one plant per seed, whereas most varieties will produce 2 to 6 plants per seed. Look for varieties that mature quickly and produce uniform roots..

**When to plant.** Beets are fairly frost hardy and can be planted from late March to mid-April in many areas of Kansas. Irrigate carefully to avoid soil crusting, which prevents good germination. Plant fall beets in late July to early August.

**Spacing.** The beet "seed" is actually a cluster of seeds in a dried fruit, resulting in 2 to 6 plants per seed. Plant the seeds about an inch apart and about ½ inch deep. Hand thinning is usually necessary to provide a uniform stand of beets properly spaced 2 to 3 inches apart. Poorly thinned stands will have an abundance of tops with few or small roots.

**Crop rotation.** If possible in your garden space, do not plant beets in an area where Swiss chard, beets, spinach, amaranth, or other root vegetables have been planted in the previous 3 to 4 years.

**Care.** Beets compete poorly with weeds, so frequent shallow cultivations are necessary. Beet plants require a fertile well-watered location. Hand thin the plants when they are 1 to 2 inches tall to avoid damage to surrounding plants.

**Harvesting.** Select beets of the diameter you prefer. Roots larger than 2 to 2½ inches in diameter are often tough and woody. Beets for baby beets or whole canning should be harvested smaller. Trim the tops of beets to ½ to 1 inch above the roots and store in plastic bags in a refrigerator before use. Mulch fall-planted beets to prolong the fresh harvest season but use them before they freeze.

### Common concerns

- *Cercospora* leaf spot
- Wireworms

## Bok Choy

Bok choy, also known as pac choi, is a cool season vegetable that can be grown in both spring and fall in Kansas. The vase-shaped plants have thick crunchy stems and spoon-shaped leaves. The crunchy stems can be eaten like celery, and the young leaves are often used fresh in salad mixes.

**Variety considerations.** You can find varieties that have green or white stems and green or red leaves. Variety options also range from 4 to 6 inches tall to 15 to 18 inches tall. Varieties that have good heat tolerance or bolt resistance would be good choices.

**When to plant.** Bok choy can be direct-seeded or transplanted. Transplanting allows for an earlier harvest and mitigates the impact of hot temperatures, especially in the fall. Plant seeds or set plants in the garden in late March to early April, before the danger of frost has passed. Plant fall plants in early August or direct seed in late July.

**Spacing.** Depending on the variety, bok choy should be spaced between 4 and 12 inches apart to allow for full size head development. If planting from seed, thin seedlings to the desired spacing and use the seedlings for salads.

**Crop rotation.** If possible in your garden space, do not plant bok choy in an area where turnips, mustards, kale, cabbages, or other leafy greens have been planted in the previous 3 to 4 years.

**Care.** Bok choy requires consistent moisture and temperature for a good quality crop. If temperatures fluctuate, the plant is more likely to bolt, especially in the spring. You can use clean straw mulch to help maintain even soil moisture and temperature around the plants. If insects are a problem, try using a row cover to protect the plants.

**Harvesting.** It can be harvested young for salad greens or harvested at full size for cooking. If harvesting leaves, remove the oldest, outermost leaves first, cutting the stalk near the base of the plant. If harvesting the whole plant, cut below the main rosette of leaves, just at the soil level.

### Common concerns

- Aphids
- Bolting or poor flavor due to hot temperatures
- Cabbage worms
- Flea beetles

## Broccoli

Broccoli is a cool season vegetable that can be grown in both the spring and the fall. Common broccoli forms a large head of immature flower buds. Other types of broccoli develop smaller shoots of buds.

- ***Sprouting broccoli.*** Sprouting broccoli is another type of broccoli that produces lots of smaller side shoots rather than one large central head. In most cases, it is recommended to pinch out the central floret/head when it appears to induce more side shoots. There are both green and purple varieties. There are also some varieties that are designed for winter harvesting in mild areas, which may not perform well in Kansas. Look for varieties with shorter days to maturity.
- ***Broccoli rabe.*** Broccoli rabe is also called broccoli raab or rapini. This vegetable has florets that look like broccoli, but does not form a large head. It is more closely related to turnips than to traditional broccoli, and has a stronger, more pungent flavor. It is fast-maturing and not very heat tolerant.
- ***Chinese broccoli.*** Chinese broccoli is also called Gai Lan or Kailaan. While it develops small flower buds, similar to sprouting broccoli or broccoli rabe, it is usually harvested for the thick, fleshy stalks and tender leaves that grow around the buds.

**Variety considerations.** For a spring crop, look for varieties that are fast maturing and maintain good head quality in hot weather. For a fall crop, look for early maturing varieties that also have good cold tolerance. Some varieties will produce side shoots after the main head is harvested.

**When to plant.** For a reliable crop, it is best to use transplants rather than direct-seeding. Set plants in the garden in late March to early April, before the danger of frost has passed. Early planting is essential so that plant heads can develop before the onset of hot weather. Plant fall broccoli plants in late July.

**Spacing.** Broccoli should be planted 18 to 24 inches apart. If planting in rows, allow 36 inches between rows.

**Crop rotation.** If possible in your garden space, do not plant broccoli in an area where Brussels sprouts, cabbage, cauliflower, collards, broccoli, kale, or turnips have been planted in the previous 3 to 4 years.

**Care.** Select broccoli plants that are small and stocky. Avoid tall, spindly plants. Weak, tall plants often "bolt" or produce a premature head, which will never enlarge. Broccoli requires a lot of fertilizer to produce a large plant and a large head. Fertilize at planting. Sprinkle additional fertilizer — side dress — along the row every 2 to 3 weeks as the crop develops. Provide adequate water as the head starts to develop, as insufficient water can cause poorly flavored, bitter heads. If insects are a problem, try using row covers over the plants.

**Harvesting.** Harvest the head with a sharp knife before the flowers start to open or before yellow centers of the flowers start to show. Usually 4 to 5 inches of the stem is also tender and can be used with the head. Continue to cut small side heads until hot weather causes them to be strongly flavored or until a hard freeze kills the plant. Broccoli will continue to grow even after light frost in the fall.

### Common concerns

- Aphids
- Cabbage worms and loopers
- Harlequin bug
- No head development due to hot weather
- Poor flavor due to hot temperatures
- Poor head development due to inconsistent moisture

## Brussels Sprouts

Brussels sprouts are a close relative of cabbage, broccoli, and cauliflower, but slower growing. Best success in Kansas is to grow the "sprouts" — small heads that grow along the stem and resemble small cabbage heads — in the fall season by planting in early July.

**Variety considerations.** Select early maturing varieties to maximize the potential for a good yield before frost. Heat tolerance and large sprout size are also desirable characteristics.

**When to plant.** Start the seeds indoors in early to mid-June, for transplanting out into the garden in early to mid-July. Plant to allow 90 to 100 days before first frost.

**Spacing.** Set plants about 18 to 24 inches apart. If planting in rows, allow about 36 inches between rows.

**Crop rotation.** If possible in your garden space, do not plant Brussels sprouts in an area where broccoli, cauliflower, cabbage, kale, turnips, or Brussels sprouts have been planted in the previous 3 to 4 years.

**Care.** Like cabbage and broccoli, Brussels sprouts require regular watering and fertilizing. Some gardeners remove the leaves from the side of the plant after the sprouts start to develop, but this is not necessary. Topping or cutting the terminal bud from the plant when the plant is 2 to 2½ feet tall will speed the development of sprouts. Sprouts developing in hot weather will often be loose and of poor quality.

The plant is quite freeze hardy and can be left in the garden until late November or even early December in many years for continued harvest, as long as temperatures remain above 20°F. The flavor becomes sweeter after experiencing freezing temperatures.

**Harvesting.** Snap or cut the sprouts from the stem when they are 1 to 1½ inches in diameter. More sprouts will develop on the stem above.

### Common concerns

- Aphids
- Cabbage worms
- Poor sprout development or flavor due to heat or inconsistent moisture

## Cabbage

Cabbage is a heading vegetable that requires about half of a growing season to fully develop. It can be grown in the spring or fall in Kansas. There are both red and green varieties. Heads can be round, flat, or pointed. Cabbage is intolerant of our summer heat.

**Variety considerations.** Select a variety with shorter days to maturity and heat tolerance for best success.

**When to plant.** Set cabbage plants in late March to early April or in late July or early August for a fall planting. If there is not a local source of transplants for a variety that meets the needs of your garden, it will be necessary to start seeds indoors in February to be planted out in March. For a fall garden, transplants should go in by at least the 3rd or 4th week of July, if not slightly earlier. This means that seeds would need to be started indoors in mid-June at the latest.

**Spacing.** Cabbage plants should be spaced 12 to 18 inches apart. Closer spacing will result in smaller, but more numerous heads.

**Crop rotation.** If possible in your garden space, do not plant cabbage in an area where broccoli, Brussels sprouts, cabbage, cauliflower, collards, kale, or turnips have been planted for the last 3 to 4 years.

**Care.** Fertilize cabbage with a starter fertilizer when setting out plants, and side dress every 2 to 3 weeks during the growing season. Cultivate carefully to avoid damaging shallow roots. Irrigation is critical when heads are small and enlarging.

It may also be helpful in the spring to use row covers to keep the air and soil around the plants warmer and encourage faster growth. Row covers can also help reduce insect problems in both spring and fall. Cabbage will withstand temperatures as low as 20˚F without damage.

**Harvesting.** Cabbage is ready for harvest when the head is fully formed and dense. This can be judged by pressing or squeezing the head to indicate firmness. Waiting too long may result in heads that split, especially after rainfall or irrigation. The size of the head will vary with variety, soil fertility, and plant spacing.

### Common concerns

- Aphids
- Black rot
- Blackleg (choose resistant varieties)
- Cabbage yellows (choose resistant varieties)
- Cabbage worms
- Flea beetles
- Harlequin bug
- Poor head development due to heat or inconsistent watering
- Split heads due to delayed harvest

## Carrot

Carrots are a hardy, cool-season crop that grows in the spring or fall in Kansas. Carrots harvested in cooler weather will be tender and sweet. The roots grow best in loose or sandy soils, so long slender varieties are not well adapted to growing in our heavier, tighter soils.

**Variety considerations.** Carrots come in a wide variety of sizes and shapes. While the long, slender, Imperator types are very popular, they are not a good choice in heavy clay soils. Chantenay types have short roots with wide shoulders and are a good choice in heavy soils. Danvers types are longer, but also have broad shoulders. Nantes types are medium length with a blunt tip and a straighter shape. All three types can grow well in heavier soils. There are also round carrots that will do well. Nantes types are also fast-maturing and have excellent flavor, which can be helpful for spring plantings when the weather can get hot quickly.

There are many different colored carrot varieties available, including yellow, white, red, and purple. Many colored varieties will not perform well in the spring when the weather is warming rapidly, causing them to bolt. For best success, plant colored varieties in the fall.

Beyond shape and color, look for varieties that are bolt-resistant, heat tolerant, and early maturing for spring planting. If you want to overwinter or store carrots in the fall, look for cold-tolerant varieties that are developed for overwintering.

**When to plant.** Plant spring carrots in late March to mid-April. Make sure the soil is well tilled or loosened to an 8- to 9- inch depth before planting. Fall carrots should be planted in late July to early August.

**Spacing.** Plant seeds ¼ to ½ inch deep — deeper for fall planting — in moist soil. Rows may be as close as 12 inches apart with plants every 1 to 2 inches in the row. Thin carrots to the desired spacing when the plants are small.

**Crop rotation.** If possible in your garden space, do not plant carrots in an area where parsnips, celery, fennel, or other root vegetables have been planted for the last 3 to 4 years.

**Care.** Until carrots germinate, avoid heavy watering that could form a crust on the soil surface. Sowing radish seeds along with the carrots may help prevent soil crusting. Germination may be slow and uneven in early spring. When planting in late summer for a fall crop, keep the soil evenly moist until germination. Consider using an organic mulch to help keep the soil cool and evenly moist.

Young carrot plants are weak and spindly. Weeds compete with young plants, so careful weeding is necessary. Water is required as roots are enlarging. Carrots that develop in hard, compacted soils will be misshapen or forked. If possible, consider planting carrots in a raised bed amended with compost. This will yield higher quality roots and allow planting of a wider variety of carrot types.

**Harvesting.** Dig or pull the roots when they are the desired diameter. Most carrot varieties require 55 to 60 days from seeding to maturity. After harvesting, cut the tops to within ½ inch of the root top and store in plastic bags in a refrigerator until ready to use. Carrots can be stored for long periods.

Fall-planted carrots can be mulched with straw and harvested as needed until the ground freezes solid in mid- to late December. Carrots can be overwintered under heavy straw mulch or with a couple of layers of row cover fabric. The tops will die back with freezing temperatures, but the roots can be dug throughout the winter with only minor loss of quality. In the spring, the tops will begin to regrow, but will likely bolt quickly with warmer temperatures. Harvest any remaining carrots before significant regrowth occurs, or the roots will become woody and bitter.

## Common concerns

- Aster yellows
- Carrot weevil
- Forked or split roots due to rocky or heavy soil or drought
- Poor root development due to crowding or excessive nitrogen
- Root knot nematodes
- Wireworms

## Cauliflower

This cool-season vegetable is a close relative of broccoli and cabbage. However, cauliflower is more difficult to grow in Kansas because it takes longer to develop and is neither as cold hardy nor as heat tolerant. It may not develop heads or may produce poor quality heads under stressful conditions.

**Variety considerations.** Select an early maturing variety with good heat tolerance for best success. Self-blanching varieties are preferred by many gardeners. There are also green, orange, and purple varieties available, but many are not early maturing enough to perform reliably in Kansas.

**When to plant.** Set transplants in late March to mid-April for a spring crop or in late July to early August for a fall crop. If starting your own transplants, start seeds indoors 4 to 6 weeks before the desired transplanting date. Heads will not develop if planting occurs too late.

**Spacing.** Space plants 1½ to 2 feet apart. The plant is larger than cabbage or broccoli and needs more space. Planting too close will reduce head size.

**Crop rotation.** If possible in your garden space, do not plant cauliflower in an area where broccoli, Brussels sprouts, cabbage, cauliflower, collards, kale, or turnips have been planted for the last 3 to 4 years.

**Care.** Use starter fertilizer when setting plants and provide additional fertilizer every 2 to 3 weeks during the growing season. Provide consistent moisture for best results.

When the heads are about the size of a quarter, blanch them by pulling a few leaves over the head to shade them from the hot sun. Secure the leaves with a rubber band, clothespin, or string. Check the development of the head by peeking through the leaves. Do not blanch colored cauliflowers.

Cauliflower is very susceptible to environmental stress, especially during the transplant stage. "Buttoning" is when young plants develop very small, 1-inch heads that do not further develop. This can be initiated by excessive temperature fluctuations to either too hot or too cold, moisture stress, nutrient deficiencies, or plants getting too large before transplanting into the garden.

It may also be helpful in the spring to use row covers to keep the air and soil around the plants warmer and encourage faster growth. Row covers can also help reduce insect problems in both spring and fall.

**Harvesting.** Cut heads when they are fully formed but before they are overmature, as indicated by a rough spiny appearance of the curds. This condition — called riciness — indicates that the head will be strong flavored and tough. In cool conditions, a slight purplish color may prevail in the heads and is normal. Some varieties also may produce a few leaves that will protrude through the head. Cauliflower will not produce side shoots after the head is cut. Store cauliflower in a cold, moist location for 2 to 3 weeks.

### Common concerns

- Aphids
- "Buttoning" due to environmental stress, overgrown transplants, or excessive temperature fluctuations
- Cabbage worms and loopers
- Discoloration of curds due to lack of blanching
- Flea beetles
- Harlequin bug
- Hollow stems due to boron deficiency
- No head development due to hot weather
- Poor head development due to inconsistent moisture

## Chicories

Chicories are relatives of lettuce and grow in similar ways. Chicories include endive, escarole, radicchio, and Italian dandelion. These greens all have mild to strong bitter flavors,

- ***Endive.*** Endive is a hardy, leafy vegetable similar to lettuce in growth habit and use. Endive has a crinkled leaf and can sometimes be found called "frisee." Belgian endive requires a special growing procedure to produce the blanched heads.
- ***Escarole.*** Escarole is a type of endive that has a broad, flat leaf.
- ***Radicchio.*** Radicchio is a head-forming chicory. It can be difficult to grow these heads in Kansas, as we do not have a long enough period of cool, mild weather in most years.
- ***Italian dandelion.*** This leafy green has leaf shapes similar to the common dandelion, but with an upright growth habit and larger leaves with a thicker midrib. It can have a strong bitter flavor.

**Variety considerations.** Most chicory varieties will do well if grown for salad leaves. If you are planning to try growing a head forming variety, look for a fast-maturing variety that is bolt-resistant and heat-tolerant.

**When to plant.** These leafy green vegetables do not like hot weather and must be planted early in the spring. Starting seedlings indoors and setting out transplants in late March or early April is advisable. Direct seeding in mid-July or setting out transplants in early August is suitable for growing fall crops.

**Spacing.** Spacing varies depending on the desired harvest size. For baby salad leaves, 2- to 3-inch spacings are sufficient in most cases. For larger leaves or heads, space plants 6 to 12 inches apart.

**Crop rotation.** If possible in your garden space, do not plant in the same area where lettuces or other leafy greens have been planted in the last 3 to 4 years.

**Care.** Germination rate on some of these greens can be lower than other vegetables. It may be beneficial to start the seeds indoors and transplant them into the garden to ensure a good stand of plants if you desire full size heads.

These leafy crops are hardy and can withstand freezes in the fall. Like most leafy greens, they require consistent watering and are fairly shallow-rooted. They also require fairly rich or well-fertilized soil.

Blanching endive will cause the interior leaves to be white and milder in flavor. About 4 to 6 weeks after planting, tie the outer leaves up around the center of the plant with string or rubber bands. After about two weeks, the center will be blanched and ready for harvest.

**Harvesting.** Pinch smaller, baby leaves when a desired size for eating. To harvest the entire plant, cut at ground level and discard the dark-green outer leaves. The most desirable parts of the plant are the bleached light green/yellow leaves near the center. Store leaves in plastic bags in a refrigerator for several weeks.

### Common concerns

- Aphids
- Bolting due to hot weather or weather fluctuations
- Excessive bitterness due to hot weather
- Flea beetles

## Chinese Cabbage

Chinese cabbage is a cool season vegetable that can be planted in both spring and fall. It can be either heading or looseleaf. Heading types may be more familiar to American gardeners as "napa" cabbage and have thinner, more tender leaves than common cabbages. Looseleaf types are faster growing and are more similar to Bok choy or leafy greens grown for salads.

**Variety considerations.** Select early maturing, heat tolerant, and bolt resistant varieties of heading Chinese cabbage for planting in the spring. Most varieties will be successful for fall plantings. Looseleaf varieties grow fast enough that any type will perform well in spring or fall.

**When to plant.** Heading types of Chinese cabbage are difficult to plant in the spring because of a tendency for transplanted crops to bolt or go to seed. Select small, stocky plants and set them in mid-April, or direct seed by planting in the garden at the same time to prevent bolting. Young plants are prone to bolting if they are exposed to frost or cold overnight temperatures.

Looseleaf types of Chinese cabbage can be direct seeded or transplanted from late March to mid-April.

Fall is an excellent season for growing all types of Chinese cabbage in Kansas. Direct seed in early to mid-July, or transplant in late July to early August.

**Spacing.** Space head-forming plants 12 to 18 inches apart. If you are direct seeding, plant seeds about ½ inch deep. Plant looseleaf types 6 to 12 inches apart, depending on desired harvest size.

**Crop rotation.** If possible in your garden space, do not plant Chinese cabbage in areas where bok choy, cabbage, kale, or turnips have been planted in the past 3 to 4 years.

**Care.** Like its cabbage family relatives, Chinese cabbage needs a starter fertilizer at transplanting and regular fertilizing every 2 to 3 weeks during the growing season. Critical periods when water is necessary are during head formation and enlargement. Row covers can help reduce insect problems in both spring and fall.

**Harvesting.** Heads of Chinese cabbage will be looser than cabbage and is more open on top. Feel through the leaves and cut it above the outer leaves when the head is firm and dense. Once seed stalks start to appear, all head development ceases; if bolting occurs, harvest and salvage what you can of the crop.

Looseleaf Chinese cabbage can be harvested at whatever size you prefer, starting at about 3 inches tall through mature size. Harvest individual leaves from the outside of the plant. If you want to harvest the entire plant, cut the plant at the soil level.

### Common concerns

- Aphids
- Bolting due to spring temperatures
- Cabbage worms
- Flea beetles
- Harlequin bug

## Collards

Collards are a cool season vegetable that tolerates both heat and cold, and hence can be grown most of the year in Kansas. However, flavor and quality will be better in the spring and fall than during the heat of summer. Collards are members of the cabbage family, but do not form heads and are grown for their leaves.

**Variety considerations.** For spring planting, look for bolt resistant cultivars. Most cultivars are acceptable for planting in the fall.

**When to plant.** Set transplants in late March to mid-April for a spring crop or in early August for a fall crop. Collards can also be direct-seeded into the garden if desired.

**Spacing.** Space plants 1½ to 2 feet apart if growing for full sized plants. Collards can become quite large if grown through the summer. If direct seeding, thin the plants as they grow until the desired spacing is achieved.

**Crop rotation.** If possible in your garden space, do not plant collards in areas where cabbage, cauliflower, broccoli, Brussels sprouts, collards, kale, or turnips have been planted for the last 3 to 4 years.

**Care.** Use starter fertilizer when setting plants and provide additional fertilizer in 4 to 6 weeks if the foliage appears to be pale or growth is poor. Provide water during dry periods. Row covers can help reduce insect problems. Once the plants are mature, collards can tolerate temperatures down to 20°F without significant damage, and their flavor becomes sweeter after experiencing freezing temperatures.

**Harvesting.** Cut lower leaves close to the stalk, starting with the oldest leaves. Harvest only a few leaves from each plant at a time. This allows the plant to continue producing more leaves as it grows. The entire plant can also be cut at the soil level and the leaves stripped off for use.

### Common concerns

- Aphids
- Black rot
- Cabbage worms and loopers
- Harlequin bugs

## Cucumber

Cucumbers are warm-season crops that traditionally have required a lot of garden space. With a trellis or newer compact varieties, cucumbers may be grown in small spaces and even in containers. An increasing diversity of cucumber types are available to a home gardener. Some types of cucumbers are best grown in a greenhouse or high tunnel, but many will grow well in a regular garden.

- ***Pickling.*** These varieties are short and blocky in shape, with a firm flesh that makes a crisp pickle. They frequently have very prickly skin.
- ***Slicing.*** Slicing cucumbers are long and slender, with a dark-green skin. They are usually not as prickly as pickling cucumbers.
- ***Asian cucumbers.*** These cucumbers are also long and slender with relatively thin skin but can have prickles. They have been bred to be both burpless and bitter-free.
- ***English or greenhouse.*** English cucumbers are very long with very thin, tender skins. They are usually grown in a greenhouse and may not be as heat tolerant.
- ***Armenian.*** This long, light green fruit is actually more closely related to melons than cucumbers but is typically used like a cucumber.
- ***Beit alpha (Persian).*** These cucumbers are relatively short with very thin, smooth skins, similar to English cucumbers. They typically have few seeds.

**Variety considerations.** There are many types of cucumbers with range of plant characteristics to consider when selecting varieties. There are certain varieties that have a more bush-type growth habit and would not need trellising. The majority of cucumbers will need some sort of trellis or lots of space to grow.

Be aware that some heirloom and older hybrid varieties can be more susceptible to developing bitterness during the heat of summer or due to other stress on the plants. Look for varieties that are bitter-free for best eating qualities during a hot summer. Choose varieties that are resistant to powdery mildew and other diseases.

If planting cucumbers for a fall crop or for early season harvest in June, be sure to look for varieties that have fewer days to maturity. It may also be helpful to look for types that are more likely to perform well under cooler conditions.

**Standard or monoecious.** Both male and female flowers are produced on this plant.

**Gynoecious.** These plants have only female flowers and tend to produce earlier. A pollinator is needed to ensure fruit set.

**Parthenocarpic.** These plants produce only female flowers but will produce seedless fruit without pollination. These varieties can also be grown under row covers or in hoophouses where pollinators are not present.

**When to plant.** Cucumbers require warm conditions with no danger of frost for best results. Soil temperatures should be approaching 60°F, which occurs in early May in most of Kansas. Using black plastic mulch to warm soil is a way of producing cucumbers earlier.

**Spacing.** Cucumbers are usually spaced 2 feet apart in rows 5 to 6 feet apart. However, bush types may be spaced 2 feet apart in rows 3

feet apart. If planting on a trellis, space plants about 2 feet apart along the trellis.

**Crop rotation.** If possible in your garden space, do not plant cucumbers in an area where melons, squashes, pumpkins or cucumbers have been planted in the past 3 to 4 years.

**Care.** Cucumbers may be transplanted by starting seeds in large containers and moving them carefully to the garden area, taking care not to disturb the roots. Do not let transplants get larger than one or two sets of true leaves or start to vine before planting.

Cucumbers are fairly shallow-rooted and require caution at initial cultivation. One application of fertilizer along the row when the vines are 6 to 12 inches long will improve production into the bearing season. Cucumbers can be grown on a trellis or cage, but you may have to help the vines get started up the trellis. Avoid areas where strong winds may damage vines on the trellis.

Cucumbers have separate male and female flowers on the same plant. Male flowers predominate and usually appear before female flowers start to develop. Many newer cucumber varieties are of the gynoecious type or have a larger number of female flowers for higher yields. Bees are required to transfer pollen from male to female flowers for the fruit to develop.

**Harvesting.** Select firm, dark-colored cucumbers developed before the seeds have a hard seed coat and while the skin is tender. Small cucumbers may be harvested for pickles at any stage. Removing large, overgrown fruits will keep vines productive longer.

## Common concerns

- Anthracnose
- Bacterial wilt
- Bitterness due to heat, stress, variety
- Cucumber beetles
- Melon aphids
- Poor fruit set due to lack of pollination
- Powdery mildew
- Spider mites

## Eggplant

Eggplant is a close relative of pepper and tomato. It requires warm weather to grow well and will not tolerate cold soils or temperatures. Many newer small-fruited or elongated varieties are now available. Compact varieties perform well in containers or landscape plantings.

**Variety considerations.** There are many different types of eggplant, most of which perform well in the long, hot summers in Kansas. Small-fruited types and long, slender Japanese types are usually more productive on a per plant basis than the larger fruited Italian types, although the yield by weight may be similar. Orange and red eggplants, while unique, often have a bitter flavor that is popular in other parts of the world.

**When to plant.** Eggplant is sensitive to cold temperatures and will not grow well in cool conditions. Wait to plant until low temperatures are consistently above 50°F. Eggplant is usually transplanted about the time peppers are set into the garden — 1 to 2 weeks later than tomatoes or in early to mid-May in most of Kansas.

**Spacing.** Eggplant is usually set 18 to 24 inches apart in rows at least 2 to 3 feet apart.

**Crop rotation.** If possible in your garden space, do not plant eggplant where tomatoes, peppers, potatoes, or eggplant have been grown in the past 3 to 4 years.

**Care.** Eggplant will thrive in hot dry conditions better than many of its relatives. However, a good soaking in hot weather is beneficial to keep it productive. A strong plant is necessary to support fruit and to protect it from sunburning. Short cages or staking may help keep plants upright and prevent branches from breaking as they get larger.

Insects are especially damaging to eggplant foliage. Many leaf-feeding insects will nearly defoliate the plants in a short time; regular inspection and insect control measures are usually necessary. The use of row covers in the spring can help encourage faster growth and protect against flea beetles and other insects.

**Harvesting.** Select firm, fully sized fruit that have a slightly soft touch with a bright and glossy skin. Because the stem that attaches the fruit to the plant is tough and woody, use pruning shears to cut the fruit loose. Pick off and discard overgrown fruit to keep plants productive.

### Common concerns

- Colorado potato beetles
- Eggplant lacebug
- Flea beetles
- Poor growth and cold injury due to temperatures below 50°F
- Spider mites
- Sunscald of fruit due to poor foliage cover

# Fennel

Fennel is a close relative of dill, carrots, and parsley. Many gardeners are most familiar with growing fennel as an herb for the foliage, flowers, or seeds. Bulbing fennel, also called Florence fennel or finocchio, produces a large, swollen stem at the base of the plant that is eaten as a vegetable.

**Variety considerations.** Most herb varieties will perform well in Kansas. For the vegetable types, look for varieties that are fast maturing and bolt resistant.

**When to plant.** Sow seeds in mid-March to early April for a spring crop or late July to early August for a fall crop. The bulbing types will thrive only in cooler periods of the year. Fennel can also be started from seed indoors and transplanted, although the seedlings can be delicate and tricky to transplant.

**Spacing.** Plant seeds 2 to 3 inches apart and thin to a plant every 4 to 6 inches for best results. Rows can be 12 to 15 inches apart for vegetable types. Foliage types grown for seed can get much taller and may need to be spaced further apart.

**Crop rotation.** If possible in your garden space, do not plant in the same areas where dill, fennel, carrots, or parsley have been planted in the past 3 to 4 years.

**Care.** Once established, fennel plants are fairly drought tolerant. However, too much heat or drought stress for bulbing types will result in the plant flowering and losing quality of the bulbs. Fennel will tolerate light frost if planted for a fall crop.

**Harvesting.** Fennel foliage can be harvested at any time during the growing season. Fennel seed should be harvested after it has turned brown and then dried completely before storage.

Fennel bulbs can be harvested at any size but are at peak quality when they are about 3 inches across. Bulbs larger than 4 inches may be of lower quality. Bulbs on plants that have bolted (flowered) will be woody and poorly flavored. Cut the plant below the bulb, at the soil line to harvest the bulbs. Trim the tops near the bulb and store in plastic bags in the refrigerator for several weeks.

## Common concerns

- Aphids
- Bolting due to heat or drought stress
- Parsleyworm (Swallowtail caterpillars)

## Garlic

There are hundreds of varieties of garlic, which are divided into two broad classifications, softneck and hardneck.

- ***Hardneck garlic.*** Hardneck varieties have sturdier stalks, often have larger cloves, and a wide range of flavors from spicy to mild. Most hardneck types put on flower stalks, called "scapes" in the late spring. Hardneck varietal groups include: Porcelain, Purple Stripe, Marbled Purple Stripe, Glazed Purple Stripe, Rocambole, Creole, Asiatic, and Turban.

- ***Softneck garlic.*** Softneck varieties do not produce the flower stalks or "scapes" that give the firmer necks to the hardneck types. These varieties often require milder growing conditions. They also have a longer storage life than hardneck varieties.

**Variety considerations.** Each variety group has a large number of varieties to choose from.

In general, some of the variety groups are more adapted to long, cold winters, followed by cool, moist springs and warm summers. Other varieties prefer mild winters and warm springs. Some types will not tolerate hot, dry spring weather. Because of this, it can be difficult to determine what varieties do best here in Kansas, because all different types of weather can occur in different combinations each year. It is often best practice to try varieties from several different variety groups over several years to see what performs best for your conditions.

Many Kansas gardeners find that Silverskin and Artichoke softneck types and Purple Stripe and Porcelain hardneck varieties are the most reliable. Rocambole varieties do not perform as well because they need colder winters. Creole, Asiatic, Turban, and some softneck types may not be cold hardy enough for parts of Kansas in some years.

**When to plant.** Garlic should be planted in the first part of October and overwintered for harvest the following summer. It can be planted later in the fall, but yield may be reduced. Spring planted garlic will have significantly smaller bulbs and lower overall yield.

**Spacing.** Individual cloves should be planted 2 inches deep with the blunt end down and the tip pointing up. Plant cloves 6 inches apart in rows 12 inches apart. In a raised bed, rows need only be about 6 to 8 inches apart.

**Crop rotation.** If possible in your garden space, do not plant garlic in the same area where onions, leeks, shallots, or garlic have been planted in the past 3 to 4 years.

**Care.** Garlic grows best in fertile, loam soils. Tilling and amending the soil with compost can improve success in heavier soils, as will planting on a berm or raised bed. Test soil regularly and add phosphorus as recommended to ensure good growth of bulbs.

To plant, break the bulbs into individual cloves. Do not remove the papery skins from the cloves. Plant within 5 days to prevent the cloves from drying out.

Mulching with straw or leaves is recommended over the winter. Put the mulch down in the late fall or early winter after there have been a few frosts or freezes. Mulch should be removed in mid-spring to allow soil to warm.

Garlic does not compete well with other plants for water and nutrients, so keep the area weed free and well-watered.

***Garlic scapes.*** In late spring or early summer, hardneck varieties will send up their flower stalk, called a "scape." These scapes should be removed because they will take energy away from the growing bulbs and reduce the bulb size by as much as 30%. The removed scapes can be used in stir-fry or other recipes similar to how you would use green onions.

**Harvesting.** Most varieties will be ready to harvest in late June to mid-July. The best indicator of time to harvest is when the 5 lowermost leaves have yellowed and died. When 3 to 4 leaves have turned brown, you should discontinue watering. Dig the whole plant with a spade or garden fork and gently remove dirt, taking care to keep the wrapper intact. Let dry in a shady location with good air circulation for a day or two. Brush off any remaining dirt and tie in bunches. Hang in a shady, dry, cool, and well-ventilated location for 4 to 6 weeks to cure the bulbs. Once dry, trim stalks to about 1½ inches above the bulb. To maximize storage life, store bulbs at 32 to 25°F and 65 to 70% relative humidity, such as in a refrigerator. Bulbs can be stored at room temperature, but storage life may be shortened if the bulbs begin to sprout due to the warmer temperatures.

## Common concerns

- Bulb and neck rots
- Thrips

## Kale

This relative of cabbage is one of the most cold-hardy vegetables and can withstand very low temperatures while maintaining its characteristic dark green to purplish color. It is also quite heat tolerant and can sometimes provide harvests through most of the summer in Kansas, although the leaves will have a stronger flavor.

**Variety considerations.** There are several different types of kale, including curly types, flat-leaf types, and lacinato kale. All types of kale will perform well in Kansas during the spring and fall. Different types will be more appropriate for different cooking applications, so consider intended uses when selecting a variety.

**When to plant.** Kale is cold tolerant and can be direct-seeded in mid-March for a spring crop or in early August for a fall crop. Kale can be started indoors and transplanted outside for an earlier harvest.

**Spacing.** Plant seeds ¼ to ½ inch deep and thin seedlings to one plant every 8 to 12 inches in the row. Rows can be up to 15 inches apart. For small salad leaves, plants can be grown more closely together.

**Crop rotation.** If possible in your garden space, do not plant in areas where you have grown cabbage, cauliflower, broccoli, collards, Brussels sprouts, mustards, or turnips for the past 3 to 4 years.

**Care.** For best flavor, provide consistent moisture throughout the growing season. If leaves become bitter in the summer, replant in the fall for a continued crop. Mulch to help maintain even soil moisture. Row covers can help reduce insect pressure from cabbage worms and loopers.

**Harvesting.** For salad leaves, harvest individual leaves when they are 3 to 6 inches long. For larger, more mature leaves, cut older, lower leaves when they are full sized and tender. Cold weather improves the flavor. Kale can be left in the garden and used until a severe freeze damages the crop, usually in early December.

### Common concerns

- Aphids
- Cabbage worms and loopers
- Flea beetles
- Harlequin bugs
- Strong or bitter flavors due to heat and drought stress

## Kohlrabi

Kohlrabi is a close relative of cabbage and broccoli. It produces a large, swollen stem resembling a turnip, with leaves protruding like spokes.

**Variety considerations.** Most varieties will perform well in Kansas if planted at the correct time. There are both purple and green varieties that do well. Most kohlrabi is best in the 2- to 3-inch size, but there are also varieties that have been developed to be of good quality at larger sizes.

**When to plant.** Kohlrabi can be direct-seeded in mid-March to early April for a spring crop or in late July to early August for a fall crop. It also can be started indoors and transplanted outside for an earlier harvest.

**Spacing.** Plant seeds 2 to 3 inches apart and thin to a plant every 4 to 6 inches for best results. Rows can be 12 to 15 inches apart. Large varieties may need to be spaced 12 inches apart to reach their full size.

**Crop rotation.** If possible in your garden space, do not plant kohlrabi in areas where turnips, radishes, cabbage, kale, mustards, Brussels sprouts, collards, broccoli, or cauliflower have been planted in the last 3 to 4 years.

**Care.** Like most other cool season crops, kohlrabi requires consistent cool, moist conditions for peak quality. Mulch to help maintain even soil moisture. Row covers can help reduce insect pressure from cabbage worms and loopers.

**Harvesting.** The flavor is best when the kohlrabi is small to medium sized — less than 2 to 3 inches in diameter. Larger ones often become tough or woody. Cut the plant below the bulb, near the soil line. Trim off the leaves close to the bulb and store in a plastic bag in the refrigerator for a few weeks.

### Common concerns

- Aphids
- Cabbage worms and loopers
- Bitter, fibrous, or cracked bulbs due to heat or moisture stress
- Bolting due to high temperatures
- Bolting due to temperatures below 45°F
- Flea beetles

## Leeks

Leeks are related to onions, but do not develop a bulb. They are characterized by a long, straight white sheath that is the desirable part for consumption. Leeks require a much longer growing season than onions, making them more challenging to grow to peak quality and maturity in Kansas.

**Variety considerations.** Leeks require a long, cool growing season, which means that in most cases, choosing fast maturing varieties will be best. For spring planted leeks, look for varieties that are early maturing and heat tolerant. For leeks planted in the late summer to fall, look for varieties that are early maturing and cold tolerant. Fall planted leeks that will be overwintered for a spring crop can be later maturing and should be selected for overwintering quality and bolt-resistance.

**When to plant.** In most cases, leeks are transplanted rather than direct-seeded. Leek transplants can be difficult to find, which means you may need to grow your own transplants. Leek seeds should be started indoors about 10 to 12 weeks before the expected transplant date, with a goal of having plants that are between a pencil lead and pencil width in diameter before planting.

Leeks for summer harvest should be transplanted in mid-March. Leeks for fall harvest should be transplanted in late July to early August.

Another strategy may be to direct seed the leeks in mid- to late March and thin the seedlings to the desired spacings as they grow, with the expectation of a fall crop. This may be more successful in some years than others.

**Spacing.** Leek plants should be spaced 6 inches apart in rows 12 to 15 inches apart. For larger leeks, you may want to space the plants and rows further apart.

**Crop rotation.** If possible, in your garden space, do not plant leeks in an area where onions, garlic, shallots, or leeks have been planted in the past 3 to 4 years.

**Care.** Leeks require specialized care to develop the desired long white sheaths. Transplants should be planted 3 to 6 inches deep, provided the plants are tall enough to have the growing point above the soil line at that depth. One way to easily plant leek seedlings is to use a 1-inch diameter stick or dowel to make holes your desired depth, then drop the plants in. Do not fill in the holes but let the soil wash in over time. If you are not able to plant the seedlings deep enough, you can also hill up the leeks later in the growing season, again taking care not to bury the growing point, which will cause dirt to be stuck in between the layers of the sheath.

Leeks have a shallow root system and need regular watering and fertilizing for best results. They compete poorly with weeds and other

crops. Weed control is essential to reduce competition. Mulching with straw or leaves will help both minimize weed competition and keep the soil evenly moist.

Some leeks may hold through the summer in Kansas and continue growth without significant loss of quality when temperatures cool in the fall. This may be more successful in some years than others and will require excellent weed and water management.

Leeks have exceptional cold tolerance and can often be overwintered successfully with heavy mulching or the use of thick row covers.

**Harvesting.** Leeks can be harvested and used at any stage of growth. The expected mature size will vary with growing conditions, spacing, and variety selected. Most leeks are mature between ¾ and 1½ inches in diameter. Summer leeks are typically smaller than fall or overwintering leeks.

Harvest with a garden fork to carefully loosen the roots while gently pulling on the top. Take care to avoid breaking the stalk by pulling too hard without loosening the roots sufficiently.

Trim the tops in a V shape, so the tougher outer leaves are short and the younger inner leaves are longer. Remove any dead, damaged or otherwise inedible outer layers, and trim the roots to about ¼ inch. Leeks can be stored in plastic bags in the refrigerator for as long as 2 to 3 months.

## Common concerns

- Bulb and neck rots
- Thrips

## Lettuce and Other Leafy Greens

Lettuce is a cool-weather crop that is fairly cold tolerant. However, the thin, fragile nature of the leaves makes them susceptible to freezes and drought. Lettuce is best grown as a spring or fall crop. There are several different types of lettuce.

- ***Leaf types.*** On leaf types of lettuce, leaves are loosely arranged. Leaf lettuce matures rapidly and is the most reliable type of lettuce to grow in Kansas, especially from seed. Many leaf lettuce types are more heat-tolerant than other types. In addition to more traditional leaf shapes, this group also encompasses oakleaf and lolla types. Oakleaf lettuces have heavily lobed leaves that look much like an oak leaf. Lolla lettuces have highly curled or frilled edges, making them high yielding and attractive.
- ***Romaine or cos.*** This lettuce forms a loose, upright head with thick mid-ribs and stronger flavored, crisp leaves. Most romaines take longer to reach maturity than leaf lettuces. Many romaine lettuces have better bolt-resistance than other types.
- ***Butterhead or Bibb.*** Tender, rounded leaves that form into a loose or soft head are characteristic of this succulent lettuce. The center of the heads often develop a light yellow, buttery appearance. It takes longer to grow than leaf lettuce.
- ***Head or crisphead.*** Head lettuce takes nearly twice as long as leaf lettuce to develop. It is most reliably grown using transplants, and the fall season is the best time to grow head lettuce in Kansas.
- ***Summer crisp or Batavian.*** These lettuces are a type of crisphead, with thick, crisp leaves, but have been developed to have more heat-tolerance than other lettuces. They do not develop firm heads but are typically harvested as looseleaf or soft heads. Some of these types also germinate better in hot weather than other varieties.

- ***Other leafy greens.*** A wide range of other leafy greens can be grown in addition to lettuce. Mixtures of lettuce and other greens are often sold as mesclun. General culture of most leafy greens is similar to lettuce. Some require long periods of cool weather, making them difficult to grow in many years in Kansas, but many are quick growing and will produce well both as baby salad greens or as larger greens for cooking. Greens crops include cress, mizuna, tatsoi, arugula, komatsuna, orach, and sorrel.

**Variety considerations.** Lettuces come in a wide range of colors, from various shades of green, red and green variegated, and light to dark reds. Red varieties can be more strongly flavored and more prone to developing bitterness as the weather gets hot in the early summer.

For spring planting, select varieties that have good heat tolerance and bolt resistance. For fall planting, select varieties that have strong cold hardiness. Early maturing varieties are always beneficial due to our variable spring and fall weather. You may also choose to stagger plantings of different types of lettuces throughout both the spring and fall planting seasons to extend the harvest.

**When to plant.** Lettuce can be direct-seeded and transplanted successfully. Doing both can extend the harvest season in spring and fall. For a spring crop, sow lettuce seed or set plants in mid-March to early April. For a fall crop, sow seeds or set plants in mid- to late August for leaf or Bibb types, or in late July to early August for head or romaine types.

If starting seeds indoors for transplanting, plant 4 to 6 weeks before the desired transplant date. Transplants should have 4 to 6 true leaves when set in the garden.

**Spacing.** Sow seeds thinly ¼ inch deep, and water consistently until the lettuce emerges. Thin to a plant every 6 to 8 inches or set transplants at this spacing. Rows may be as close as 12 to 15 inches apart.

**Crop rotation.** If possible in your garden space, do not plant lettuces in the same location where chicories, other leafy greens, or lettuces have been grown in the past 3 to 4 years.

**Care.** Lettuce seed needs light and warmth to germinate, so take care not to plant seeds too deep. Seeds planted in cool soil will germinate slowly, but seeds planted in soil that is warmer than about 85°F will not germinate at all. Starting seeds indoors for transplanting can help ensure a reliable crop if the weather is too cold in the early spring or too hot in the late summer.

Lettuce is shallow rooted, and the root system is fairly spindly. Therefore, it will require careful cultivation so as not to damage roots. Regular watering and fertilizing are necessary. Overwatering in heavy soils can cause root or head rots. Mulching in the late spring can help keep the soil cool and evenly moist, which may extend the growing season.

**Harvesting.** Lettuces can be harvested at any stage of growth. For baby leaf lettuce, harvest leaves when 3 to 4 inches long. Thinned seedlings can also be used as baby leaf salads. For full-size plants, cut the heads slightly above ground level and remove damaged, dirty, or excess leaves. Select full-sized leaves of leaf lettuce individually so that the plant will continue to produce. Store lettuce in a plastic bag in a refrigerator immediately after harvest because it will become limp quickly.

## Common concerns

- Aphids
- Bitterness due to heat and drought stress
- Bolting due to heat and drought stress
- Tipburn (brown, dead edges of the leaves)

## Melons

Melons are tender, warm-weather vegetables that require culture similar to other vine crops. There are many different types of melons, most of which perform well in Kansas. Most melons are large-vined plants, although there are some newer, more compact varieties.

- ***Muskmelon and cantaloupe.*** Despite common usage, muskmelons and cantaloupe are two slightly different types of melon. The vast majority of what are commonly called cantaloupes are muskmelons. These are orange- or green-fleshed melons that have netted skin. They also "slip" from the vine when ripe, as discussed below under harvesting. True cantaloupes do not have netting on the rinds and are not very common in the United States.
- ***Winter melon.*** Other melons such as honeydew, crenshaw, and casaba are considered winter melons. They have smooth rinds, minimal odor, and do not "slip" from the vine like muskmelons.
- ***Oriental melon.*** This type of melon, sometimes called Korean melon, has become more common in the United States in local farmers markets, although it is still fairly uncommon. These melons typically have yellow skin and white, crunchy flesh with a mildly sweet, sometimes floral taste. These are the earliest maturing melons.
- ***Watermelon.*** See the later section on Watermelon.

**Variety considerations.** There are many types of melons and melon varieties available. For home gardeners, considerations such as desired fruit size and desired vine size will often take precedence over other factors. Disease resistance, especially powdery mildew resistance, will be helpful for many gardens. Newer hybrid varieties will typically have smaller seed cavities and higher sugar levels, while heirloom varieties may have much larger seed cavities. Many newer varieties will have a longer window of high eating quality around the ideal harvest window, while older varieties may not be as good if picked too early or too late.

**When to plant.** Melons are injured by light freezes; all danger of frost should be past before planting seeds or setting plants. Consistent soil temperatures of at least 60°F are necessary to encourage good germination, and warmer soil temperatures will speed up germination. Early to mid-May is a standard planting date throughout most of Kansas, but planting can be done later as well, allowing about 100 days until the expected first frost date. Melons can be transplanted, but this is a challenge in windy conditions due to the very fragile stems.

**Spacing.** Cantaloupe vines spread 6 to 8 feet wide, so row spacings of 6 feet are necessary, with individual plants spaced every 18 inches to 2 feet in the row. Types with compact vines may be able to grow in a 2-by-2- or 3-by-3-foot space. Many melons can be successfully grown on a trellis, with one to two plants per trellis.

**Crop rotation.** If possible in your garden space, do not plant melons in the same area where cucumbers, melons, squashes, or pumpkins have been planted in the past 3 to 4 years.

**Care.** Melons usually do not require heavily fertilized soil. Normal maintenance fertilizers

should produce an adequate crop. Mulching with black plastic warms soil, improves early season growth, and makes weed control easier. Row covers may be useful to reduce cucumber beetle damage in the early season but must be removed once the plants start flowering. Row covers can also help increase the success of transplanting due to protection from the wind.

Melons produce separate male and female flowers and require bees to pollinate them. Male flowers are more abundant and are present 1 to 2 weeks before female flowers begin to develop.

Melons need plenty of water during early growth, flowering, and early fruit development. Once the melons have reached full size but have yet to ripen, watering should be minimized to encourage sweet, flavorful fruit with high sugar content.

**Harvesting.** Muskmelons are ready for harvest when the stem slips easily and cleanly away from the end of the melon, leaving a clean dish-shaped scar. They should be slightly soft and have a pleasant aroma. Honeydew melons typically turn a creamy color rather than have a green cast when ripe, and may develop a more waxy texture to the rind. They do not slip. Casaba, crenshaw, and Oriental melons do not slip from the vine but do develop a yellow rind color and exhibit a slight softening at the flower end opposite the stem. Melons will not ripen off the vine, although they may improve in flavor somewhat if left at room temperature for a few days.

## Common concerns

- Angular leaf spot
- Anthracnose
- Aphids
- Bacterial wilt
- Cucumber beetles (transmit bacterial wilt)
- Mosaic viruses
- Powdery mildew
- Spider mites

## Mustard

Mustard greens are a cool-season crop. They mature quickly and are easy to grow. Although cooking greens are popular in the South, many people recognize their high nutritional value, and greens are becoming more popular for use in light cooking and stir frying. Newer varieties of mustards have been developed for harvest as baby leaf salad greens rather than larger cooking greens.

**Variety considerations.** Most mustard varieties will perform well in Kansas if planted during the spring or fall. Look for varieties that are slow to bolt, especially when planting in the spring. Be sure to pay attention to whether a variety is intended for cooking or for fresh use, as many fresh use types do not grow larger leaves.

**When to plant.** Mustard is normally direct-seeded in late March to early April or can be direct-seeded in early August for a fall crop. Fall is a preferred season for growing greens because of the long, cool, harvest season.

**Spacing.** Seeds should be planted ½ inch deep and plants thinned to a plant every 2 to 4 inches. Rows may be as close as 15 inches apart, or you can plant mustard in a wide row by scattering seeds in a band 5 to 6 inches wide.

**Crop rotation.** If possible in your garden space, do not plant mustards in areas where turnips, radishes, cabbage, kale, kohlrabi, Brussels sprouts, collards, broccoli, or cauliflower have been planted in the last 3 to 4 years.

**Care.** Mustard requires water during dry periods to keep the tender foliage from becoming limp. Mustard that produces a large plant too early may bolt or produce a seedstalk with bright yellow flowers instead of producing only foliage. Once seedstalk development starts, leaves should be quickly harvested and used.

**Harvesting.** Cut the leaves when they are young and tender. You can cut the entire plant or individual leaves to allow the plant to continue to grow and produce more leaves. Leaves harvested in hot weather will be strong flavored and tough. Store leaves in a plastic bag in a refrigerator for 2 to 3 weeks.

### Common concerns

- Aphids
- Flea beetles
- Strong, bitter flavors due to heat or drought stress

## Okra

Okra is a tall-growing, warm-weather vegetable that is easy to grow in Kansas gardens. The edible parts of the plant are the young tender pods that develop following flowering. The plant will continue to bloom and produce pods up the stalk as the season progresses.

**Variety considerations.** Most varieties of okra will perform well in Kansas. Most gardeners prefer spineless varieties. There are also varieties that will remain tender even with larger pods. Some varieties are more likely to produce side branches, which can increase yield in a small garden space.

**When to plant.** Okra requires warm weather, and mid-May is a desired planting time, once all danger of frost is past. Soil temperatures should be at least 65˚F, and germination will occur more quickly with warmer soil temperatures. Soaking the seed overnight can also speed germination. Okra may be transplanted or direct-seeded.

**Spacing.** Plant seeds an inch deep and thin to one plant every 12 to 18 inches in the row, with rows no closer than 3 feet apart.

**Crop rotation.** Okra does not have any close vegetable garden relatives, so there are no major crop rotation concerns. This can make okra a good choice for interplanting with other crops. Other related plants include hollyhock and hibiscus.

**Care.** Okra will grow well in a wide variety of soil types and requires only minimal levels of fertilizer. Excessive nitrogen results in excessive vegetative growth and poor production.

Okra does fairly well in hot, dry seasons with periodic, thorough watering. Later in the season after the plant is tall, you can cut it off about 12 inches from the ground. Use pruners or a saw because okra stalks are very tough. The plant will send up a new stem for pod production into the late summer or fall season.

**Harvesting.** Cut the pods from the plant when they are no longer than your finger to ensure that they will be tender, not woody. Harvesting every other day might be necessary. Some people are sensitive to the small spines on the okra leaves, which cause itching or rashes. Wear long sleeves and gloves to prevent this during harvest. Okra can be stored for 7 to 10 days at temperatures of 45 to 50˚F. Storing at colder temperatures will result in pod discoloration, although they will still be edible.

### Common concerns

- Aphids
- Root knot nematodes

## Onions and Onion Relatives

Onions are cool season plants that need to be planted at specific times to have good growth. Bulbing and green onions are biennial plants that are grown as annuals in the cool, spring growing season. Other types of onions, including Egyptian walking onions, multiplier onions, and shallots are hardy perennials that are either planted as perennials (walking onions) or are planted in the fall for harvest the following summer (multiplier onions and shallots).

**Variety considerations.** Onions can be yellow, white, or red and vary in sweetness and pungency. Some varieties are better for long storage than others.

The most important consideration when selecting onion varieties is knowing the latitude of your location. Onion varieties are categorized into "long day," "intermediate," and "short day" varieties. Long day varieties develop bulbs when there are 15 to 16 hours of sunlight and are adapted for more northerly areas (latitudes 37 to 47). Intermediate day varieties perform best in latitudes 32 to 42. Short day varieties perform best in latitudes 25 to 35.

This means that intermediate day varieties are best for all of Kansas, while some long day varieties may do well in the northern parts of the state. Gardeners along the southern edge of Kansas could try short day varieties as an experiment, but they likely will not produce large onions in most years.

**When to plant.** Onion plants or sets need to be planted in mid- to late March so that the majority of growth occurs before the onset of hot, dry weather. If starting from seed, they should be started

indoors about 10 to 12 weeks before the expected transplant date, with a goal of having plants that are between a pencil lead and pencil width in diameter before planting.

**Spacing.** Onions may be grown in rows as close as 15 inches, with individual plants spaced 2 to 4 inches in the row, depending on the expected size of the bulb. Plant sets 1 to 1½ inches deep, and plant transplants about the same depth.

**Crop rotation.** If possible in your garden space, do not plant onions where leeks, onions, garlic, or shallots have been planted in the past 3 to 4 years.

**Care.** Onions are grown from sets, plants, or seed. Sets are small onion bulbs that are planted in the spring to produce green onions or bulbs later in the season. Most onion sets for sale in garden centers are often poorly identified by variety, so they may not reliably produce a bulb but can be a good choice for green onions. Plants or transplants are typically sold in bundles and usually are identified

by variety. Choose healthy, fresh plants with good green color.

Onions have a shallow, inefficient root system and need regular watering and fertilizing for best results. Dry soils will result in small bulbs, and additional water may be necessary during the bulbing phase. Watering may be reduced near the harvest period, but regular timely watering until the tops begin to fall over is needed. Large, vigorous plants are essential for large bulbs with high yields. Onions compete poorly with weeds and other crops. Weed control is essential to reduce competition.

**Harvesting.** Onions are ready for harvest when the tops begin to weaken and naturally fall over. This is a signal that the bulbs are as big as they will get. Pull or dig the onions and store in a warm, dry, shaded location for 2 to 4 weeks until the tops and necks are completely dry. After the tops are dry, cut them, trim the roots, and store in a cool dry location. Onions need cool storage, but they should not be stored in a tight plastic bag. An open mesh bag is best for storage. Mild-flavored onions keep for only a month or so. Stronger flavored or more pungent onions keep 3 to 4 months.

## Common concerns

- Bolting due to temperature fluctuations.
- Bulb and neck rots
- Small bulbs due to dry soils, low fertility
- Small or non-existent bulbs due to poor variety selection or incorrect planting time.
- Thrips

## Parsnip

Parsnip is a hardy, cool-season crop that is grown for its white, carrotlike root. Roots are most flavorful when dug late in the season, as sugars accumulate in the root.

**Variety considerations.** Most varieties will perform well in Kansas. Some varieties are intended for overwintering, while others can be dug for a late fall or early winter harvest.

**When to plant.** Sow seed in mid-March to early April as beets or carrots are planted. Using fresh seed is important, as the seed loses viability quickly.

**Spacing.** Plant seeds ½ inch deep with 2 to 4 inches between plants. Rows may be 15 inches apart.

**Crop rotation.** If possible in your garden space, do not plant parsnips in an area where carrots, parsnips, parsley, dill, or fennel have been planted in the past 3 to 4 years.

**Care.** Parsnips may be slow to germinate — as much as 21 days — so be patient for the crop to emerge. Avoid heavy watering that would create a crust and interfere with good germination or sprinkle some peat moss or sand

over the row to prevent crusting. Planting some radish seeds in the row with the parsnips can help mark the row as well as help prevent crusting. Be sure to pull the radishes carefully so as not to disturb the young parsnip seedlings.

Parsnips need care similar to that for beets or carrots. Prevent weed competition and water during stressful periods. Allow the crop to stand until late fall to early winter before digging.

**Harvesting.** Dig the roots in late November to early December before the ground starts to freeze. Parsnips can also be mulched and left to overwinter in the ground and be dug in early spring or whenever the ground is thawed during the winter.

### Common concerns

- Forked or split roots due to rocky, heavy, or compacted soil
- Poor germination due to soil crusting, old seed, or inconsistent moisture during germination.
- Poor root development due to drought, excessive nitrogen, or crowding.

## Peas

Peas are one of the most cold-tolerant plants grown in Kansas gardens. They can be planted about as early as soil can be prepared in the spring.

- ***Shelling peas.*** Sometimes called English or garden peas, these varieties must be shelled and the seeds are eaten.
- ***Sugar snap peas.*** These peas have fleshy, edible pods and are consumed when the seeds are developed and the pods are full. They have a very sweet flavor.
- ***Snow peas.*** These edible-podded peas have thin, tender pods that are typically eaten when the seeds are still very small and immature.
- ***Southern peas.*** Also called cowpeas, these are more closely related to beans and are discussed in the bean section.

**Variety considerations.** Many varieties are good choices in Kansas, although early maturing varieties may be more consistent, especially in the southern half of the state. Varieties that are resistant to powdery mildew may also be a good choice.

For most gardeners, the two primary considerations are vine height and pod length. Some peas have shorter, dwarf vines that will not need any staking or trellising. Others have much taller vines — as tall as 5 feet — and will need a trellis for best production.

Pod length typically has a direct impact on yield, with longer pods having more seeds. Larger podded snow and snap peas also will often yield more per plant. However, gardeners may find that they prefer the flavor and tenderness of smaller podded varieties.

**When to plant.** Plant seed in early to mid-March when soil is dry enough to work. Peas will germinate when soil conditions are favorable. Peas planted later in the spring may not produce before the weather gets too hot. Peas are not well adapted for fall gardens because seed usually fails to germinate well in warm soil.

**Spacing.** Plant seed 2 to 4 inches apart with rows 12 inches apart. Peas usually do best where 2 to 3 rows can be planted 4 to 6 inches apart to allow the weak, spindly vines to support each other.

**Crop rotation.** If possible in your garden space, do not plant peas in an area where peas or beans have been planted in the past 3 to 4 years.

**Care.** Peas prefer cool soil and need water during stressful periods. They grow best in moderate- to well-fertilized soil. A trellis may be needed to support the flimsy vines; short wire mesh or string trellis works well.

**Harvesting.** When the shelling pea pods are swollen so that seeds within are full sized but tender and not yet starchy, pick and shell the peas. Harvest sugar snap peas when the pods are succulent and tender, but the seeds are mostly enlarged. Harvest snow peas when the pods are crisp and tender but before the seeds begin to enlarge significantly. Tasting a pea or two is also helpful in determining if they are ready to pick. Edible-podded peas should be tender and sweet at optimum harvest.

Store peas in a refrigerator in a plastic bag for up to a week. Edible-podded types should be picked and used immediately after harvest as they tend to dry out readily. Peas are easily frozen for later use.

### Common concerns

- Failure to set or poor pollination due to hot weather
- Powdery mildew
- Root rots

## Peppers

Peppers are generally classified as sweet or hot, with the most common sweet peppers being large, blocky bell, banana, and Italian roasting varieties. Hot peppers vary in shape and size as well as degree of hotness. Heat level is measured in Scoville Heat Units (SHU), which ranges from about 1,000 SHU for Anaheim peppers to well over 1.5 million SHU for specialty hot peppers like the bhut jolokhia (ghost) pepper or Carolina Reaper. Common hot peppers include anaheim, jalapeno, serrano, and habanero peppers. Some peppers, such as paprika or cayenne, are commonly grown to be dried and ground into chili powders for seasonings rather than for fresh eating.

Peppers can be eaten either when the fruit is full sized but immature or when it changes to its mature color. A variety of colors from green to red, yellow, orange, purple, white, and brown (dull purple) are available.

**Variety considerations.** Many types of peppers will perform well in Kansas, and gardeners have many choices for size, shape, color, and heat level. For an earlier harvest, consider early maturing varieties. Many hot peppers have long days to maturity and will not produce until late summer.

When possible, select varieties that have a compact, bushy growth habit that will withstand wind and heavy fruit set without breaking branches. For colored peppers, look for varieties that have vigorous foliage growth that will provide good shading to the ripening fruit in order to prevent sunscald.

Large-fruited, sweet, bell peppers produce relatively few fruit per plant. If high yields are desired or space is limited, smaller fruited sweet peppers or Italian roasting peppers may be a better choice. Most home gardeners find that 1 or 2 plants of a particular type of hot pepper are sufficient to meet their needs unless a large volume is desired for food preservation purposes.

**When to plant.** Peppers are usually set as transplants in the garden and should be planted 1 to 2 weeks after setting tomatoes. Peppers exposed to cold temperatures early in the season will often drop their fruit, resulting in a large, unproductive plant. Mid-May is a safe time to plant peppers in most of Kansas. It is better to wait to plant if the soil and air temperatures are still consistently below 55°F.

If starting peppers from seed indoors, plant the seeds 6 to 8 weeks before the desired transplant date. Planting large, overgrown plants that have already started to flower will reduce the overall productivity of the plants. The rate of germination and transplant growth will vary widely depending on the type of peppers and the warmth of your growing area. Heat mats will provide faster, more consistent germination, especially for hot pepper varieties.

**Spacing.** Set plants 1 to 2 feet apart in rows 2 to 3 feet apart. Another option is to plant a staggered, double row in a 2-foot-wide bed. This is an efficient option if you have limited space or are looking for a high yield of a sweet pepper variety. Many hot peppers produce a larger, more sprawling plant and may require more space.

**Crop rotation.** If possible in your garden space, do not plant peppers in the same area where tomatoes, peppers, eggplant, potatoes, or tomatillos have been planted in the last 3 to 4 years.

**Care.** Peppers thrive in well-drained fertile soil. Water is required in dry periods. Even, consistent watering is preferred as peppers can develop blossom end rot, a brown leathery patch at the base of the fruit. Peppers require a slightly more fertile spot than tomatoes, but gardeners should avoid over-fertilization.

While support is not strictly necessary for peppers, using short tomato cages or a stake and weave system can help support the plants and prevent breakage during high wind or when the plants have many fruit set. This may be particularly beneficial when planting varieties that are taller and less bushy.

Poorly shaded fruit may be subject to sunburning in hot summer conditions. If high quality, colored sweet peppers are desired, the use of low tunnels covered with shade cloth will help reduce the incidence of sunburn on the fruit.

It is very common in Kansas for peppers to produce a small number of fruit in the early to mid-summer, but for the bulk of the harvest to occur in late summer through fall.

**Harvesting.** Harvest fruits when they are the desirable size, with firm, thick walls. Regular harvests will keep the plants producing more. Carefully pick or cut peppers from the plants. Avoid pulling on the fruit as you can easily break the plant. Peppers that have begun to turn color may continue to turn after harvest. Hot peppers produce an oil that will penetrate the skin and cause discomfort if you get it in your eyes or other sensitive areas of the body. Use rubber gloves to harvest very hot peppers.

## Common concerns

- Aphids
- Bacterial spot
- Blossom end rot
- Corn earworm
- Poor fruit set due to early season cold injury
- Poor fruit set due to excessive nitrogen fertilization
- Poor fruit set due to hot weather
- Spider mite
- Sunburn or sunscald due to poor foliage cover, exposure of fruit to direct sunlight
- Tobacco mosaic virus (distorted, misshapen leaves; transmitted by aphids)

## Potatoes

Potatoes, often called Irish potatoes, are tubers, or swollen underground stems that form as a storage location for starch. Tubers form best at temperatures of 60 to 70°F; therefore, early spring planting or fall planting is preferable in Kansas. Potatoes are grown from cut pieces of tubers grown in the previous season, usually referred to as seed potatoes.

**Variety considerations.** Always purchase certified disease-free tubers from a reputable seller. Potatoes purchased from the grocery store or saved from previous harvests will result in reduced yield compared to certified seed potatoes.

Potato skin color can be white, red, yellow, or russet (brown). Flesh color is usually white or creamy yellow. There are newer varieties that have purple skin and flesh or pink flesh. Varieties differ in texture as well. The russet varieties are particularly good for baking as they have a mealy, crumbly texture when baked. White, yellow, or red varieties are usually preferred for boiling or mashing.

Because tuber development is best when temperatures are mild and cool, selecting early maturing varieties will be more successful, especially in southern parts of Kansas. This ensures that tuber development occurs before the soil is too hot. Most russet-skinned varieties require a longer growing season and do not perform as well as red, yellow, or white varieties.

**Cutting and preparing seed.** Select firm, solid seed potatoes. Cut the tubers into 1½- to 2-ounce pieces. An average-sized potato is cut into four pieces, while a large potato is cut into six. Store the cut seed pieces in a warm, humid location for 2 to 3 days to allow the freshly cut surface to "heal." This prevents the seed piece from rotting when planted.

**When to plant.** Mid-March to early April is the best time to plant spring potatoes in Kansas, with soil temperatures of at least 45°F for best success. Early to mid-July is the time to plant for a fall harvest. Fall planting is much more successful in the northern half of Kansas and can be inconsistent at best in southern Kansas.

**Spacing.** Plant seed 12 inches apart in rows 3 feet apart. Plant the seed 2 inches deep in the spring, and 4 to 5 inches deep for a fall planting.

**Crop rotation.** If possible in your garden space, do not plant potatoes in an area where tomatoes, peppers, eggplant, potatoes, or tomatillos have been grown in the past 3 to 4 years.

**Care.** Potatoes develop along the main stem of the plant, above the seed piece. To encourage large yields and to prevent sunburning or greening, potatoes should be hilled or ridged, pulling loose soil along the row as the crop is growing. This ridge or hill eventually should be 8 to 12 inches tall. Thick straw mulch can also be used in place of soil, particularly in locations where a high soil pH contributes to potato scab.

Potato vines are sensitive to frost, so plan to cover the plants if there is a late freeze expected after growth has developed above ground. If the vines are killed due to frost, the plant will not be able to continue growing.

Potatoes like a fertile well-drained location with loose, friable soil. Potatoes need regular, consistent watering, especially during development when the plants are 6 to 12 inches tall. Irregular watering lowers yields and may result in rough knobs on the tubers. Mulches can be useful in holding moisture near the plant.

**Harvesting.** Early or new potatoes can be harvested as the plants are growing by gently removing some plants in the row. Begin digging potatoes when the vines are about half dead. Remove excess vines and carefully dig the tubers. Allow them to surface-dry out of the sun for a day or more to toughen the skin. Alternatively, wait until a week after the vines have died to harvest, which allows the skins to toughen before harvest. Sort out any damaged tubers for use first and store only the best quality potatoes. Then move potatoes into a cool, dark location for storage. Ideal storage temperature is 45 to 50°F.

## Common concerns

- Cracks or misshapen tubers due to too much or too little water
- Colorado potato beetles
- Early blight
- Greening or sunburn due to inadequate hilling or mulching
- Leafhoppers
- Poor tuber development due to hot soils
- Poor tuber development due to excessive nitrogen
- Scab (use certified seed)

## Pumpkins and Winter Squash

Pumpkins and winter squashes are warm-season crops that are grown using similar methods. The term "pumpkin" is often used for anything that is round and orange, while the term "squash" is used for an edible fruit of some other shape or color. The term "gourd" is used for various shapes and sizes of fruit used for decoration. Most pumpkins are either *Cucurbita pepo* or *Cucurbita maxima* species, while most squashes are *Cucurbita pepo*. Some winter squashes are *Cucurbita moschata* or *Cucurbita argyrosperma*. Most pumpkins have been developed for their ornamental qualities, although some varieties have been developed for pies or for hull-less seeds. Winter squashes are primarily for culinary purposes, although many have attractive ornamental characteristics as well.

**Species of Squash and Pumpkins.** Pumpkins, squash, and gourds are closely related crops that are members of the Cucurbit or vine crop family. There are four species of the genus *Cucurbita* used as vegetables, and crossing can occur within species only. Cross pollination, however, will only influence the crop if you save your own seed for next year's crop.

The four species are listed below with some common varieties for each species. Only varieties within species will cross with each other.

- ***Cucurbita pepo.*** Most jack-o-lantern pumpkins, zucchini, yellow summer squash, scallop or patty pan squash, acorn squash, most small, yellow-flowered gourds.
- ***Cucurbita maxima.*** Large pumpkins (Big Max, Atlantic Giant), hubbard squash, buttercup squash, delicata squash, Turk's Turban squash.
- ***Cucurbita moschata.*** Dickinson field pumpkin, Kentucky field, butternut squash.
- ***Cucurbita argyrosperma.*** (formerly *Cucurbita mixta*) Green-striped cushaw, sweet potato squash, Japanese pie pumpkins.

**Variety considerations.** Pumpkins produce large, sprawling vines that take up a lot of space in the garden. Some pumpkin varieties are bush or semi-vining types that take less space but still spread. Numerous varieties exist that range widely in size, color, shape, eating quality, and other characteristics. Most decorative types are not flavorful for eating purposes.

For winter squashes, *Cucurbita moschata* and *Cucurbita argyrosperma* types are often more resistant to squash bugs and squash vine borers than other types and can be a good choice if insect pressure is a concern. Many types of winter squashes have newer varieties with smaller fruit size that make a meal for one or two people. Newer varieties include a few bush-types of winter squash that are good for small gardens.

Powdery mildew can be a serious disease for pumpkins and winter squashes. Choosing a variety that is highly resistant to the disease will increase the chances of a successful crop with minimal fungicide treatment needed.

**When to plant.** Pumpkins and winter squash can be safely planted after all danger of frost is past in early to mid-May and the soil temperature is at least 60°F. For pumpkins, most growers prefer to plant in early to mid-June to ensure that pumpkins do not mature too early. June-planted pumpkins are ready for harvest in early October.

**Spacing.** Pumpkin vines need 50 to 60 square feet per hill — 1 to 2 plants — and standard vining types should be planted about 4 to 5 feet apart in 12-foot rows. Small or semivining pumpkins and winter squashes can be planted 3 to 4 feet apart in 6-foot rows. Plant seed about an inch deep.

**Crop rotation.** If possible in your garden space, do not plant pumpkins and winter squash in the same area where cucumbers, melons, watermelon, squashes, or pumpkins have been planted in the previous 3 to 4 years.

**Care.** Provide shallow cultivation to keep weeds from developing in areas where vines will spread, because weeds will be difficult to remove later. Water thoroughly during flowering and early fruit development.

Pumpkins and squashes have both male and female flowers. Only female flowers develop into fruit; male flowers outnumber female flowers and appear first. Bees transfer pollen from male to female flowers. Use care in application of pesticides that may kill bee populations.

Some smaller fruited gourds and pumpkins can be grown on a trellis or cage, although they will need help to start climbing. Most winter squashes, even larger fruited types, can do well on a trellis due to their strong stems and vines. However, not all varieties of squashes and pumpkins will perform well when trellised.

**Harvesting.** Pumpkins and winter squash are ready for harvest when the skin is tough and hard and the stem no longer "leaks" when cut from the vine. Check the development by trying to penetrate the skin with your fingernail. Cut the stem with a sharp knife or pruning shears.

Immediately after harvesting, allow winter squash and pumpkins to further dry by storing them at 70 to 80°F in a dry location for 2 to 3 weeks before moving them to storage areas such as a basement where temperatures are 50 to 60°F. This "curing" process allows the squash rind to toughen. Winter squash can be stored for 4 to 8 months. Storage temperatures of 50 to 60°F in a dry location out of direct sunlight will maintain pumpkins' bright color.

## Common concerns

- Aphids
- Cucumber beetles
- Fusarium wilt, especially with no crop rotation
- Phytophthora blight
- Poor fruit set due to lack of pollination
- Powdery mildew
- Squash bugs
- Squash vine borer

## Radishes

Radishes are cool season vegetables that are divided into spring and fall types. Spring radishes are typically smaller and quick to mature. Fall radishes, which include daikons, require a longer growing season and are typically milder in flavor. Radishes need a sunny location and can be grown in early spring and as a fall crop. As the weather gets hot, however, the flavor of radishes becomes strong and hot.

**Variety considerations.** Most radish varieties will perform well in Kansas if planted at the correct time.

- ***Spring radishes.*** Most spring radishes are round, although some are more oblong. Spring radishes are most commonly red, although there are white, pink, purple, yellow, and multicolored types. Some varieties are longer-maturing, which should be considered if another crop will be planted after the radishes.
- ***Fall radishes.*** Fall radishes, including daikons, are typically much larger than spring radishes. Many fall radishes are oblong or carrot-shaped and can be 2 to 3 inches in diameter. These radishes require a longer growing season and are best planted in the fall. For spring planting, choose early maturing varieties that are slow to bolt.

**When to plant.** Plant spring radishes in mid- to late March for a spring crop or early September for a fall crop. Make successive plantings so that you will have a continuous supply over a longer period of time. Plant fall radishes in mid- to late March for a spring crop or early August for a fall crop.

**Spacing.** Radishes can be grown in narrow 15-inch rows, and in bed or wide-row plantings. Spring radishes need 1 to 2 inches to enlarge the root, so thin out thickly planted seedlings to this spacing. Fall radishes are much larger and should be thinned to 4- to 6-inch spacings to allow for mature roots. Plant seeds ¼ to ½ inch deep.

**Crop rotation.** If possible in your garden space, do not plant radishes in an area where turnips, radishes, cabbage, kale, mustards, Brussels sprouts, collards, broccoli, or cauliflower have been planted in the last 3 to 4 years.

**Care.** Radishes require loose, well-drained soil and need regular frequent watering for a good crop. Excessive nitrogen fertilizer can encourage lush tops with poor-sized radishes. Control weeds while they are small and be careful not to damage the shallow root system of this spring crop.

**Harvesting.** In loose soil, radishes can easily be pulled, especially if the soil is moist. For elongated radishes in heavy soil, a spading fork may be necessary. Store excess radishes by removing the tops and placing in plastic bags in a refrigerator. Spring radishes will remain good for a week or more. Fall radishes can be stored for a few months.

### Common concerns

- Cabbage maggots
- Flea beetles
- Misshapen roots due to heavy clay soil or inadequate thinning
- Poor root development due to excessive nitrogen fertilization
- Poor root texture or cracking due to drought stress
- Strong flavor due to hot, dry weather or insufficient watering
- Wireworm

## Rhubarb

Rhubarb is a perennial crop grown for its green or red stalks that have an acid flavor. Rhubarb often is mixed with fruits. It is among the first vegetables ready for use in spring. Because your planting may last a number of years, locate plants in full sun at the edge or end of the garden area to avoid damaging them with annual tillage.

**Variety considerations.** Rhubarb stalk colors range from pure green to bright red, with many types in between. Different varieties have different levels of vigor and heat tolerance, with green varieties typically being the most vigorous. Some varieties are also more sour or more fibrous than others.

**When to plant.** Rhubarb is best established in early spring — March to April — by planting a plump, healthy "crown" consisting of a portion of the woody root system with some buds in a shallow trench. Dig an old plant and divide the root into 4 to 8 pieces for replanting, or purchase rhubarb roots from a garden center.

**Spacing.** Plant rhubarb about 2 feet apart in rows at least 3 feet apart. The crowns should be planted in a well-drained location with a slightly raised bed to encourage good drainage away from the center of the plant. The roots should be planted 1 to 2 inches deep.

**Crop rotation.** As a perennial crop, there are few crop rotation concerns for rhubarb.

**Care.** Fertilize rhubarb plantings in the spring so that spring rainfall will carry fertilizer into the root system, encouraging early summer growth. Rhubarb survives by producing vigorous leaves that produce food reserves stored in the root system, especially in the fall season. Rhubarb thrives in cool locations and is fairly hardy in severe winters. A location with light afternoon shade may prove beneficial during establishment. Always provide good drainage; never allow water to stand over the row.

In some seasons, rhubarb will produce seed stalks. These should be cut and discarded immediately as rhubarb that produces seed also produces less foliage, resulting in less vigorous crop the next year. Seed stalks may also be an indicator that the plant is crowded and may need to be divided.

If you have difficulty finding an appropriate planting location, planting in a raised bed or large container may help resolve challenges of poorly drained soil.

**Harvesting.** Rhubarb must be established for at least one season before it can be harvested. Pull the stalks as soon as they are large enough to use in the spring and continue the harvest as long as the leaf stalks are large and thick — up to 7 to 8 weeks in the spring. After late May to early June, it is time to stop harvesting and allow the plant to produce summer growth for continued bearing the following season.

Rhubarb dries out quickly. Trim the large leaves and place the leafstalks in plastic bags in a refrigerator to store for a week or more. The leaves are toxic and should be discarded. Excess rhubarb can be frozen easily for later use.

### Common concerns

- Crown rot
- Rhubarb curculio

## Spinach

Spinach is a hardy, cool-season crop that is relatively easy to grow and well-adapted in small garden areas. It will grow in spring or fall seasons, but long, hot days in late spring cause spinach plants to bolt or produce a seed stalk.

**Variety considerations.** Spinach varieties vary as to the degree of "crinkle" in the leaves — called savoy. There are smooth leaf, semi-savoy, and savoy-leaf types. Spinach varieties also differ in whether the leaves exhibit more upright growth or more flat growth. Both of these characteristics can impact how dirty the leaves get and how well they tolerate cold weather conditions.

For spring-planted spinach, look for varieties that are quick to mature and that are heat tolerant and slow to bolt. For fall-planted spinach, varieties that are heat tolerant during germination are helpful. If the spinach will be grown into the early winter or overwintered, choose varieties that have strong cold tolerance or were developed for overwintering.

See the next section for a discussion of hot weather spinach alternatives.

**When to plant.** Spinach can be planted very early as it is cold hardy. Mid- to late March is a common planting time. Fall spinach can be planted in mid-August to early September. Fall-planted spinach will usually overwinter if lightly mulched and will vigorously re-grow in the spring.

**Spacing.** Plant seeds about an inch apart in rows as close as 5 to 6 inches, or you can scatter seed uniformly about an inch apart in a wide row or bed planting. Because spinach germinates and grows early in the season, weed control is easier in this crop than in many other crops planted this way.

**Crop rotation.** If possible in your garden space, do not plant spinach in the same area where Swiss chard, beets, or amaranth have been planted in the past 3 to 4 years.

**Care.** Spinach needs a fertile, well-drained location. Because production occurs early in the season, watering during stressful weather is not normally a concern. Additional nitrogen may be required to keep the spinach dark green and growing vigorously.

To overwinter, cover the planting with mulch or row cover in late November and uncover early in the spring. In southern parts of Kansas, mulching or row cover may not be necessary for plant survival, but there will be less cold injury to the leaves. You will usually get an additional early spring crop of spinach; however, this overwintered crop produces seed stalks early in the season.

**Harvesting.** Clip spinach leaves as soon as they are big enough to use. If you clip individual leaves, the plant will continue to develop and produce more leaves. If you want to harvest mature plants, cut the plant at the soil level. This will be necessary as hot weather approaches. Fall-planted spinach will often overwinter; clip individual leaves for fall harvest but allow the plants to remain. Store spinach in a plastic bag in a refrigerator for about a week.

### Common concerns

- Aphids
- Bolting due to hot weather, long days
- Poor germination due to high temperatures in the fall

## Spinach Substitutes for Summer

Many gardeners that love spinach want to grow it throughout the summer, which is not possible in Kansas due to the summer climate. There are several different plants that can be grown for leafy greens that have flavors similar to spinach and will tolerate the summer heat.

- New Zealand Spinach
- Goosefoot
- Amaranth
- Orach
- Malabar Spinach

**Variety considerations.** Each type of these spinach alternatives may have a few different variety choices, but there are relatively few. In general, look for varieties that have been selected for culinary quality over ornamental qualities. Goosefoot and amaranth varieties are selections closely related to common garden weeds, lambsquarter and pigweed respectively.

**When to plant.** All of these plants are warm season plants, so the ideal time to plant is in the late spring, around the same time you would plant tomatoes or peppers. Most can be direct-seeded, although they could be transplanted if desired.

**Spacing.** Plant spacing will vary a bit between each type of spinach alternative. Most of these plants will get quite large by the end of the summer and develop flowers, which will impact the quality of the leaves for salad purposes. Most of these plants can be planted quite thickly and then thinned out to a 12 inch spacing, while using the thinned plants as salad greens. If allowing the plants to grow to maturity, most will require about 12 to 24 inches of space between plants and 2 to 3 feet between rows.

**Crop rotation.** New Zealand spinach and Malabar spinach do not have near relatives that would require crop rotation. If possible

in your garden area, do not plant goosefoot, amaranth, or orach in the same areas where spinach, Swiss chard, and beets have been planted in the past 3 to 4 years.

**Care.** Most of these plants are relatively low maintenance once established. Sufficient watering will help keep leaves more lush and flavorful. Malabar spinach is a vining plant and will best be grown on a trellis.

Goosefoot, amaranth, and orach can become weedy nuisances in a garden if they are allowed to flower and go to seed. It may be preferable to terminate the planting when they show signs of flowering to prevent this. Malabar spinach can also reseed itself, but not at a rate that will be difficult to control in a home garden.

**Harvesting.** The eating quality for most of these greens is best when the leaves are young and tender. When plants are young, any leaves can be harvested. On older plants, harvest young shoot tips or individual leaves from near the top of the growing plant for best quality. Older leaves will be best used for cooked greens. Regular harvesting will keep plants producing more new, tender leaves.

### Common concerns

- Aphids
- Weediness due to letting plants flower and go to seed

## Squash, Summer and Zucchini

Summer squash, which include zucchini, are used in their young or immature stage and usually grow on compact, nonsprawling vines. Zucchini are a subset of summer squash, and typically have thicker, smooth skin. Other types of summer squash include crookneck, straightneck, and patty pan types. Some pumpkins and winter squash can be harvested at the immature stage and eaten as a summer squash, although they may not be as flavorful.

**Variety considerations.** Most types of summer squash will perform well in Kansas. Varieties that are resistant to powdery mildew may be beneficial. Early maturing varieties may be helpful in providing a crop before insect pressure causes damage to the plants.

Most summer squashes are very susceptible to squash bugs and squash vine borers. Related plants such as Tromboncino (a *Cucurbita moschata* squash), luffa gourd, or snake gourd are more tolerant of squash bugs and vine borers. These plants can be grown and harvested at young stages and consumed as summer squash, although the flavor is somewhat different. These plants also have vigorous vines that benefit from trellising.

**When to plant.** Squash are warm-season crops that are damaged by freezes. Plant seeds directly in the garden after all danger of frost has passed; early May is a traditional planting time, although squash can be planted at any point during the summer. Regular re-planting can help circumvent insect problems and provide a more consistent yield. A planting of summer squash for a fall harvest can be made in July to early August.

**Spacing.** Summer squash can be planted 2 feet apart in rows at least 3 feet apart.

**Crop rotation.** If possible in your garden space, do not plant summer squashes in an area where cucumbers, melons, watermelon, pumpkins, winter squash, or gourds have been grown in the past 3 to 4 years.

**Care.** Squash benefit from the soil-warming and weed-control properties of black plastic mulch. Light weight row covers on hoops can be used over young squash plantings to help prevent insect damage, especially from squash vine borer. The row covers also provide a warmer environment that increases the growth rate in the early season. Apply the row covers immediately after planting and remove when the plants begin to bloom to facilitate pollination. This is most effective when squash are planted in a different area each year, as squash vine borers overwinter in the soil near where squash plants were growing.

Once full vine spread is achieved, little additional care is necessary. When plants are established, squash are fairly tolerant of drier soil conditions, although consistent moisture during fruit development will help prevent blossom end rot problems. Weeds compete with squash plants, making shallow cultivation essential, especially early in the season.

Squash, like other relatives such as cucumber, cantaloupe, and watermelon, have separate male and female flowers on the same plant. Bees are required to transfer pollen from flower to flower. Male flowers usually appear first, and there are more male than female flowers.

**Harvesting.** Summer squash are harvested at an immature stage — before the skin and seeds have toughened. Usually harvesting when they are 6 to 10 inches long is preferable. Squash develop quickly, and regular harvesting is important to encourage continued production. Summer squash should be stored in a refrigerator for only a short time because they are prone to drying out.

### Common concerns

- Aphids
- Blossom end rot due to irregular watering or drought stress
- Cucumber beetles
- Poor fruit set due to lack of pollination
- Powdery mildew
- Squash bugs
- Squash vine borer

## Squash, Winter

See the section on Pumpkins and Winter Squash.

## Sweet Corn

Sweet corn is a popular summer vegetable but requires a significant space investment to have a good yield. Sweet corn does not adapt well to small garden areas because closely spaced plants will produce only 1 to 2 ears. Sweet corn is also wind-pollinated, and different varieties can easily cross in small spaces and impact the quality of ears. Types of sweet corn are categorized based on their genetic types.

- ***Normal sugary (su types).*** This is the oldest, traditional type of sweet corn. It is tender and creamy but will quickly become starchy. These varieties must be isolated from sh2 and sy types.
- ***Sugary enhanced and Triplesweet (se types).*** These types have an increased sugar level and even more tender kernels. The sugar turns to starch more slowly than su types. These varieties must be isolated from sh2 types.
- ***Supersweet (sh2 types).*** Supersweet varieties have up to 50% more sugar than regular sugary types. They have a crisp, crunchy texture to the kernels and will keep their sweetness for a week in the refrigerator. The shriveled seeds do not germinate well in cold soil. This variety must be isolated from other sweet corn types.
- ***Synergistic (sy types).*** Synergistic types of sweet corn have a combination of the above genes. They have at least one se gene and may have a combination of sh2 or su or both. They combine the beneficial traits of all the other genes to have improved sweetness, texture, and storage life. Isolation requirements must be determined for each variety, or plan to isolate from all other types.
- ***Augmented supersweet (sh2 with some se characteristics).*** This type of corn is a supersweet that also has the se trait in the kernels, resulting in a corn with high sugar, tender texture, and good storage life.

**Variety considerations.** Many new hybrid varieties of sweet corn are available in all of the genetic categories previously discussed. The colors range from yellow to white to bicolor, yellow and white kernels together on the same ear. Early varieties that require 65 to 75 days to mature produce smaller stalks and ears, while later varieties requiring 75 days or longer produce larger plants and larger ears. Varieties are available with resistance to several common diseases such as maize dwarf mosaic, smut, and bacterial wilt. For early season planting, choose a type that is adapted to cold soils.

**When to plant.** Sweet corn is a warm-season crop and should be planted in mid- to late April. The sh2 varieties and other newer varieties that have a smaller, more shriveled seed will rot in cold soil; do not plant these types until early May. Soil temperature should be at least 60˚F when planting corn seed.

Successive plantings of corn are important to spread the harvest over a longer period. Make additional plantings when the previous planting is ½ to ¾ inch tall.

**Spacing.** Plants should be 8 to 12 inches apart in rows at least 3 feet apart. Do not crowd plantings, as weak, spindly, unproductive plants will result. Plant the kernels an inch deep. If many seeds fail to germinate, do not attempt to replace missing plants; replant the entire planting. Plant corn in blocks of at least four rows to ensure adequate pollination.

**Crop rotation.** There are no major crop rotation concerns for sweet corn planted in a home garden. Do not plant sweet corn in the same location in successive years.

**Care.** Sweet corn requires wind to transfer pollen from the tassel (male) to the ear (female). Plant corn in small blocks or several short rows rather than a single row to encourage better pollination. Sweet corn pollinates poorly in 100-degree weather, and ears with missing kernels or gaps may result.

Sweet corn may be cross pollinated by other types of corn such as field corn that pollinates at the same time. If there is a danger of cross pollination, a space of 40 to 50 feet may be needed as cross pollination can affect flavor. If there are field corn acreages nearby, you may need as much as 300 feet of separation due to the large volume of pollen.

Another option for isolating sweet corn varieties is by time. One way to do this is to plant multiple varieties with significant differences in days to maturity (about 2 weeks) so that pollen production does not occur at the same time. You can also plant one variety earlier than another variety to ensure the time differential in pollen production.

Sweet corn is a member of the grass family and needs considerably more nitrogen fertilizer than other garden plants. A sidedressing of additional fertilizer sprinkled along the row every several weeks is important. Sweet corn needs regular watering as well because its sparse, inefficient root system does not reach to deep soil water. Apply 1 to 1½ inches of water per week. Weed control is necessary, especially in young plantings.

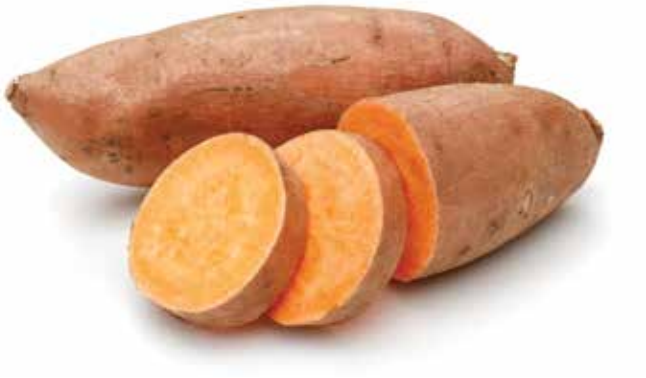
**Harvesting.** Sweet corn is ready for harvest when the juice in the kernel appears milky as you puncture a kernel with your finger. The ear should be well filled to the tip. This ideal harvest stage lasts for only a few days in hot weather, and regular checking for maturity is important. The silks of mature ears are generally completely dry and brown. Twist and pull the ear from the plant by bending the ear down sharply. Use corn immediately or store it in a cold place immediately after harvest. Pick corn early in the morning when it is cool outside. Store corn for only a few days in a refrigerator before using. Corn is easily frozen for later use.

### Common concerns

- Corn earworm
- Poor ear fill due to insufficient pollination
- Smut

## Sweet Potato

Sweet potatoes are a warm-season crop that requires a long growing season with plenty of heat, making the crop a good choice for Kansas gardens. They are often called "yams" in the United States, although yams are a completely different species.



**Variety considerations.** Most common varieties popular in the United States are dark orange, moist, and sweet with tan or red skin. There are also varieties with white flesh and tan or purple skin that are typically drier and less sweet. More recently, purple fleshed varieties have been developed, although they are not readily available commercially.

If planting in heavy soils, look for a variety that is tolerant of heavier soils or plant on a raised bed or berm. If planting in an area where root knot nematodes have been a concern, select a variety with resistance to nematodes.

**When to plant.** Sweet potatoes can be injured by any degree of cold weather. Wait until mid- to late May before attempting to plant but the planting date can be as late as the end of June.

Sweet potatoes are grown from young plants, usually called "slips," that can be purchased in bundles from your local garden center. You can also grow your own by placing a sweet potato root in a container filled with moist sand and allowing it to sprout in a warm location for about six weeks before cutting the slips and planting them in the garden.

**Spacing.** Plant about 12 inches apart in rows at least 3 feet apart. Vines may spread to 6 to 8 feet wide.

**Crop rotation.** There are no major crop rotation concerns for sweet potatoes. If possible in your garden space, do not plant sweet potatoes in the same location in successive years.

**Care.** Sweet potatoes need to be planted on a ridge or mound of loose soil about 8 to 12 inches high to provide a bearing area for the fleshy roots to develop later in the season. Planting on this ridge will also help provide adequate drainage in heavy soils.

Avoid planting sweet potatoes in excessively rich soils or highly fertilized soils. The plants grow best in moderately fertile soil. Excessive fertilization can result in heavy foliage growth and minimal production of sweet potatoes.

Sweet potatoes are adapted to grow well in drier weather, but thorough watering is important while the slips are initially being established. Occasional, deep watering in the summer during dry periods will improve yields. Hoe as needed early in the season to prevent weeds from developing; later in the season, the dense vine growth will suppress weeds.

**Harvesting.** Sweet potatoes continue to develop throughout the season and do not deteriorate in quality if they get too large. It usually takes until mid-September to mid-October for the fleshy roots to enlarge to a harvest stage. Dig before freezing weather occurs. Cut or chop the vines a few days before digging to make digging easier. After digging,

break the roots from the vine and allow them to air dry for a few hours before picking them up. Gently place roots in baskets or boxes to avoid injury to the tender skin. Sweet potatoes must be "cured" in a warm, humid location for 1 to 2 weeks to improve keeping quality and flavor. Place the baskets in an 85 to 90°F environment with high humidity for 7 to 10 days. Then lower the temperature to around 55°F for long-term storage. Never allow temperatures to drop below 50°F as poor keeping quality, flavors, and dark colors will result. If sweet potatoes are washed before storing, make sure they are handled carefully and dried before curing.

## Common concerns

- Cracking or distortion due to drought stress or moisture fluctuations
- Low yield due to excessive fertilization
- Scurf
- White grub
- Wireworm

## Swiss Chard

Swiss chard is a close relative of the beet and produces large, glossy green leaves with thick, brightly colored stems rather than an enlarged root. In many years, Swiss chard will grow through the entire season, as it is both heat and cold tolerant.

**Variety considerations.** Most cultivars of Swiss chard will perform well in Kansas. Multicolored mixes are the most common, but varieties with single-colored stems can also be grown.

**When to plant.** Chard is fairly frost hardy and can be planted in late March to mid-April in many areas of Kansas. Irrigate carefully to avoid soil crusting, which prevents good germination. Plant fall chard in early August if needed. Swiss chard can also be started indoors 4 to 6 weeks before the desired planting date for an earlier crop.

**Spacing.** Plant the seeds about an inch apart and about ½ inch deep. Hand thinning is usually necessary to provide a uniform stand.

**Crop rotation.** If possible in your garden space, do not plant Swiss chard in the same area where Swiss chard, beets, or amaranth have been planted in the past 3 to 4 years.

**Care.** Hand thin the plants when they are 1 to 2 inches tall to avoid damage to surrounding plants.

Swiss chard can develop severe *Cercospora* leaf spot in the late summer. In those cases, it is better to remove the planting and reseed a fall crop if continued harvests are desired.

**Harvesting.** Trim the chard leaves to ½ to 1 inch above the roots and store in plastic bags in a refrigerator before use.

Cut the outer leaves of chard when they are young and tender or about 8 to 10 inches long. The inner leaves will continue to grow for additional harvests until hot weather (for spring crop) or a severe freeze (for fall crop) stops the plant growth.

### Common concerns

- Blister beetles
- *Cercospora* leaf spot
- Grasshoppers

## Tomatillos

Tomatillos (*Physalis ixocarpa*) are relatives of tomatoes that are native to Mexico. They have leafy husks around the fruit and are much firmer than tomatoes with a tart flavor. There are also related species called husk tomatoes and ground cherries that are grown in similar ways, but have smaller, sweeter fruits.

**Variety considerations.** Most tomatillos will grow in Kansas, but the productivity can be variable. There are both green and purple fruited varieties, and fruit size ranges from 1 to 3 inches in diameter. Some varieties have a more upright growth habit, while others are more sprawling.

**When to plant.** Plant tomatillos after all danger of frost is past in early to mid-May. Growth is poor when temperatures are below 60°F, so it is better to wait to plant until later if the spring is cool. Either purchase plants from a garden center or start seeds indoors 6 to 8 weeks before planting outdoors.

**Spacing.** Tomatillos are fairly bushy plants and should be planted 3 feet apart in the row. Allow 3 to 5 feet between the rows. Ground cherries are somewhat smaller and can be planted 2 feet apart in the row.

**Crop rotation.** If possible in your garden space, do not plant tomatillos in an area where tomatoes, peppers, eggplant, potatoes, or tomatillos have been grown in the past 3 to 4 years.

**Care.** Tomatillos are grown much like tomatoes and peppers. One significant difference is that tomatillos do not self-pollinate well, unlike tomatoes. Many types of tomatillos need two or more different varieties to set fruit, especially large amounts of good quality fruit. If there is poor fruit set or unfilled husks, it is possible that lack of pollination is the culprit.

Staking or caging is recommended to support the branches of upright varieties, which can be prone to breakage. Support is also recommended for the more sprawling types to help keep the fruit off the ground and improve harvest quality. Tomatillos will also root down when the stems touch the soil, so caging or staking can help prevent this.

Tomatillos are more drought tolerant than tomatoes but will still benefit from consistent moisture throughout the growing season. They do not need much fertilizer, so it is best to avoid applying a nitrogen fertilizer if the plants are growing well.

**Harvesting.** Tomatillos are best harvested when fruits fill their husks but are still firm and bright green. Colored varieties often do not develop color until after the husk is split. Store tomatillos at temperatures between 45 and 55°F for up to 3 weeks. Temperatures below 45°F can cause cold injury after a couple weeks of storage.

### Common concerns

- Aphids
- Fruit worms or hornworms
- Poor fruit set due to high temperatures
- Poor fruit set due to excessive nitrogen fertilization
- Poor fruit set or development due to insufficient pollination.
- Spider mites

## Tomatoes

Tomatoes are the most popular vegetable grown in Kansas gardens. They are easy to grow, productive in small garden areas, and used in a wide variety of ways. Tomatoes require a location that is fairly fertile, well-drained, and sunny, getting at least a half day of sun or more. Smaller vine tomatoes can be grown in containers.

**Variety considerations.** Tomatoes are available in a wide range of colors, shapes, sizes, and growth habits. Most modern tomato varieties are hybrids with disease resistance, although there is also a strong interest in heirloom varieties. Increasingly, new varieties are being developed that combine desirable characteristics of heirloom varieties with increased disease resistance and yield of hybrid varieties. Not all varieties will perform well in Kansas, and some varieties that perform well in one year will not perform well in another year. Small-fruited tomato varieties, such as cherry, grape, cocktail, and paste tomatoes will often perform more reliably during extremely hot and dry years than larger slicing tomatoes. Very large-fruited varieties, especially large-fruited heirlooms, can be challenging in Kansas due to low yield and late fruit set.

There are dozens of characteristics that could be considered when selecting a good variety for your garden. In general, varieties that exhibit good crack resistance and are relatively early maturing (less than 75 days to maturity) are good choices for most of Kansas. Early maturing varieties are more likely to set fruit before the summer heat reduces fruit set. Many gardeners, especially those who are not able to rotate their planting locations or those whose gardens have a history of disease problems, will benefit from choosing varieties with strong disease resistance characteristics.

- ***Determinate types.*** These tomatoes are sometimes called "bush-type" or "compact" plants. They typically stop growing at about 3 feet tall and produce a larger number of fruit during a more concentrated time period. They can be a good choice if you have a very small garden, plan to use containers, or want a large harvest at one time for canning.

- ***Indeterminate types.*** These tomatoes continue growing for the entire season, which can result in a very large, tall plant that is 5 feet tall or more. Because of this vining growth habit, cages, stakes, or trellises are necessary. The plants will set fruit on side branches along the stem throughout the growing season, with smaller numbers of fruit ripening at one time.

**When to plant.** Plant tomatoes after all danger of frost is past. Early May is the common spring planting time. For a later

harvest, tomatoes can be planted as late as early June, although high summer temperatures can reduce fruit set until later in the season on late planted tomatoes. Tomato plants are typically set in the garden. If you want to start your own transplants from seed, start the seeds indoors 4 to 8 weeks before the desired planting date.

**Spacing.** Most garden tomatoes should be spaced at least 18 inches to 2 feet apart in rows 3 to 5 feet apart. Dwarf varieties can be spaced closer. Large, heirloom varieties should be spaced further apart — about 3 feet — in rows.

**Crop rotation.** If possible in your garden space, do not plant tomatoes in an area where tomatoes, peppers, eggplant, potatoes, or tomatillos have been grown in the past 3 to 4 years.

**Care.** Tomatoes are usually grown from transplants. Choose a strong, healthy transplant that has a dark green color. Plants that are overgrown and have already started flowering or setting fruit will not perform as well later in the season. Set the plant slightly deeper than the container and firm the soil well around the root system.

Tomatoes need consistent soil moisture so plan to water regularly and thoroughly. Deep watering will encourage deep root development and increase tolerance to heat and drought later in the season Fluctuations from dry to wet soil conditions can increase problems with blossom end rot. Take care to keep water off the leaves to help prevent leaf blight diseases.

Tomatoes benefit from mulching for several reasons. All types of mulch help provide even soil moisture, weed suppression, and reduce the spread of leaf diseases. Black plastic mulch encourages early growth, while organic mulches are excellent for summer when applied 2 to 3 weeks after planting.

Tomatoes need lots of nutrients to be productive, but excess fertilizer can also cause problems. Do not apply more fertilizer than a soil test recommends. If plants have been very vigorous with lots of foliage and little fruit, delay fertilization until after initial fruit set occurs. A sidedressing of fertilizer when the first fruits on the plant are about the size of a walnut usually will improve yields and lengthen the harvest period.

Caging, staking, or trellising is recommended for tomatoes in most circumstances in Kansas. These practices use garden space more efficiently, keep the fruit off the ground, improve airflow, and reduce problems with fruit and leaf diseases. More information on these practices can be found in the Garden Maintenance chapter of this guide.

Many gardeners growing indeterminate types of tomatoes find that pruning the sideshoots early in the growing season, up to the first flower cluster, benefits the overall health and growth of the plant. Pruning can be a valuable tool in small gardens where you want to keep plants within their space or when you want to increase airflow to prevent disease. (This is also in the Garden Maintenance chapter in more detail.)

**Harvesting.** Tomatoes will ripen on or off the plant when the fruit are full sized and starting to show a slight tinge of color. Harvest early to reduce the chances of cracking, fruit rot, and other damage. Store ripening fruit at 55°F

for maximum storage life or place them in a warmer location for quicker ripening. Do not store unripe tomatoes at temperatures less than 50˚F for best flavor development. Fully ripe fruit can be stored at temperatures as cool as 46-50˚F for up to 2 weeks.

Red pigments do not form in temperatures of 95˚F or above; therefore, deeper red color will result from ripening off the vine in summer heat.

At the end of the season, harvest all full-sized fruit and store them in a cool basement for ripening to enjoy fresh tomatoes 1 to 2 months after the last freeze. Fruit that has not yet started turning color but that has a faint white star on the bottom of the fruit will usually ripen successfully.

## Common concerns

- Aphids
- Blossom drop and poor fruit set due to high temperatures
- Blossom end rot
- Broadleaf herbicide injury due to drift or mulching with contaminated materials
- Catfacing of fruit due to poor pollination, cold weather, or other environmental factors
- Fruit worms or hornworms
- Growth cracks due to high temperatures and moisture fluctuations
- Leaf blight diseases
- Mites
- Physiological leaf curl due to weather fluctuations
- Poor fruit set due to excessive nitrogen fertilization
- Sunscald due to leaf loss or excessive sun exposure on fruit
- Yellow shoulder or white core due to a combination of environmental factors, including genetics, hot weather, and potassium deficiency.

## Turnip and Rutabaga

Turnip is a cool-season vegetable that can be grown as a spring or fall crop in Kansas. Turnips are easy to grow and can be used for the root, top, or both. Rutabagas are a relative of turnips that require considerably more time to develop. Rutabagas are best grown as a fall crop in Kansas.

**Variety considerations.** Most varieties of turnips will do well in Kansas if planted at the correct time. There are both traditional, large-rooted turnips that are typically cooked. There are also newer, smaller-rooted turnips that are more commonly used for fresh eating. For rutabagas, early maturing varieties will perform better when grown for fall planting.

**When to plant.** Plant spring turnips in mid- to late March to allow roots to develop before intense summer heat. Plant fall turnips in late July to early August. Rutabagas should be planted in mid-July.

**Spacing.** Plant seed about ½ inch deep and about 2 to 4 inches apart in rows at least 15 inches apart. Thin turnips to 3 to 6 inches, depending on the desired mature root size. You can also plant turnips in a bed or wide row planting by scattering seed to produce a plant every 2 to 4 inches in each direction. Rutabagas should be thinned to 6 to 8 inches between plants.

**Crop rotation.** If possible in your garden space, do not plant turnips or rutabagas in an area where turnips, radishes, cabbage, kale, mustards, Brussels sprouts, collards, broccoli, or cauliflower have been planted in the last 3 to 4 years.

**Care.** Turnips need regular watering during their early development to ensure emergence and rapid growth. Weeds compete with small plants and must be removed early, using care to avoid damaging young, tender, turnip plants.

**Harvesting.** When roots are 2 to 4 inches in diameter, pull and trim the tops. Store turnip roots in plastic bags in a refrigerator for 2 to 3 weeks. Harvest the tops when they are young and tender. Overmature tops or roots will be strong flavored, and roots may be tough.

Rutabagas will be slightly larger — about 3 to 5 inches in diameter at harvest because the plant is larger. The roots have a yellow interior. Rutabagas can be stored for months in cold storage.

### Common concerns

- Aphids
- Flea beetles
- Wireworm
- Woody, fibrous, bitter, or strong-flavored roots due to overmature roots, heat, or drought stress

## Watermelon

Watermelon is a warm season crop that grows well in the warm, dry days of Kansas summers. The plant grows best in deep, sandy soils; however, small icebox-type watermelons can be grown on upland shallow soils. Most watermelons require a lot of room and are not well adapted to small backyard gardens.

**Variety considerations.** There are a wide range of watermelon varieties, with many different fruit characteristics that will perform well in Kansas. Fruit shape and size, rind color, and flesh color can all be taken into consideration. Varieties with good disease resistance are also beneficial. For gardeners with small spaces, newer varieties with more compact vines have been developed.

- ***Seedless watermelon.*** Seedless watermelons are produced by growing a specially developed cultivar that is cross-pollinated by a regular cultivar or a provided pollinator variety. Because two varieties are required to produce the seedless fruit, the amount of space needed is not practical for most home gardeners. The seedless cultivars are also less vigorous and more finicky than regular seeded watermelons.

**When to plant.** Watermelons thrive in warm soils and warm air temperatures. Plant after all danger of frost is past in early to mid-May, when soil temperature is at least 60˚F and air temperatures are consistently above 70˚F.

**Spacing.** Standard watermelons require about 50 square feet per plant or hill — 4 to 5 plants together, then thin to the strongest 2 plants after two true leaves have developed. Plant 4 to 5 feet apart in rows 10 to 12 feet apart. Small-vined icebox varieties can be spaced closer together, using 2 to 3 feet between hills in rows 5 to 6 feet apart. Closer spacing of large-vined, large-fruited melons will likely reduce the overall fruit size but may be a good option if garden space is limited.

**Crop rotation.** If possible in your garden space, do not plant watermelons in the same area where cucumbers, melons, squashes, or pumpkins have been planted in the past 3 to 4 years.

**Care.** Watermelons need a warm, sunny, well-drained growing area. If your garden soil is heavy, plant on ridges or raised beds to improve the soil drainage. Black plastic mulch can help warm the soil, conserve water, and suppress weeds in watermelon plantings. If straw mulch is used, do not apply it until the soil is warmer than 75˚F.

Watermelons can be grown as transplants and transferred to the garden. Use a fairly large transplant or peat pot container for best results to avoid disturbing the roots when transplanting.

Row covers may be useful to reduce cucumber beetle damage in the early season but must be removed once the plants start flowering. Row covers can also help increase the success of transplanting due to protection from the wind.

Weeds are difficult to control in sprawling vines, making early season weed control essen-

tial. Scrape weeds using shallow cultivation close to the plants.

Like cucumbers, cantaloupe, squash, and pumpkin, watermelons have separate male and female flowers on the same plant. Bees are necessary to transfer pollen from the male to female flowers.

Watermelons need plenty of water during early growth, flowering, and early fruit development. Once the melons have reached full size but have yet to ripen, watering should be minimized to encourage sweet, flavorful fruit with high sugar content.

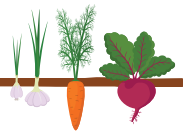
**Harvesting.** Watermelons are ready for harvest when the underside of the fruit turns a bright buttery yellow color and when the small, curled tendril where the fruit attaches to the vine has turned brown and died. Thumping larger fruited varieties produces a dull, hollow sound when ripe; however, small icebox types are difficult to thump to determine ripeness.

## Common concerns

- Anthracnose
- Aphids
- Bacterial wilt spread by cucumber beetles
- Cucumber beetles
- Gummy stem blight
- Poor fruit set or misshapen fruit due to insufficient pollination
- Powdery mildew

## Vegetable Crop Information

| Crop | Type of Planting | Days to First Harvest | Plants Per 10' Row* | Days to Germinate | Optimum Temp. (°F) | Depth of Planting (in.) | Avg. Spacing Within Row (in.) | Avg. Spacing Between Rows (in.) | Frost Resistance |
|---|---|---|---|---|---|---|---|---|---|
| Asparagus | Perennial: Crowns | 2nd season | 5-7 | — | — | 8 | 18-24 | 48 | Hardy |
| Asparagus | Seed: Transplant | 4th season | 150 | 10 to 20 | 65-75 | 1 | 3 | 6 | Hardy |
| Rhubarb | Perennial: Crowns | 2nd season | 3 | — | — | I | 36 | 35-48 | Hardy |
| Beans, bush | Seeded | 50-60 | 30 | 5-8 | 70-85 | 2 | 3-5 | 36 | Tender |
| Beans, pole | Seeded | 55-70 | 10-20 | 5-8 | 70-85 | 2 | 6-12 | 48-60 | Tender |
| Beets | Seeded | 50-65 | 40 | 7-10 | 50-60 | ½ | 2-3 | 18 | Half-hardy |
| Bok choy | Seed or Transplant | 40-55 | 10-30 | 6-8 | 50-60 | ½ | 4-12 | 18-24 | Half-hardy |
| Broccoli | Transplant | (60-80) | 5-7 | (6-8) | (50-60) | (½) | 18-24 | 36 | Hardy |
| Brussels sprouts | Transplant | (85-110) | 5-7 | (6-8) | (50-60) | (½) | 18-24 | 36 | Hardy |
| Cabbage | Transplant | (65-100) | 7-10 | (6-8) | (50-60) | (½) | 12-18 | 36 | Hardy |
| Chicories | Seed or Transplant | 45-75 | 10-40 | 10-21 | 55-68 | ⅛-¼ | 3-12 | 18-24 | Half-hardy |
| Chinese cabbage | Seed or Transplant | 48-80 | 7-10 | 5-7 | 55-70 | ½ | 12-18 | 36 | Half-hardy |
| Carrots | Seeded | 54-80 | 60 | 10-12 | 55-70 | ½ | 1-2 | 18 | Half-hardy |
| Cauliflower | Transplant | (45-80) | 5-7 | (6-8) | (55-70) | (½) | 18-24 | 36 | Half-hardy |
| Collards | Seed or Transplant | (50-60) | 5-7 | 6-8 | 55-70 | ½ | 18-24 | 36 | Hardy |
| Cucumbers | Seed or Transplant | 45-65 | 5 | 5-8 | 75-85 | ½-1 | 24 | 48-72 | Very tender |
| Eggplant | Transplants | (50-75) | 5-7 | (8-12) | (75-85) | — | 18-24 | 36 | Very tender |
| Fennel | Seed or Transplant | 80-90 | 20-30 | 6-12 | 50-70 | ¼ | 4-6 | 12-15 | Hardy |
| Garlic | Sets | 140-160 | 20 | — | — | 1 | 6 | 18-36 | Hardy |
| Horseradish | Roots | Fall | 7-10 | — | — | 3-4 | 12-18 | 36 | Hardy |
| Kale | Seed or Transplant | 55-65 | 10-15 | 6-8 | 50-60 | ½ | 8-12 | 36 | Hardy |
| Kohlrabi | Seed or Transplant | 40-80 | 20-30 | 6-8 | (50-60) | (½) | 4-6 | 18-24 | Hardy |
| Leeks | Seed or Transplant | (75-120) | 20 | 7-10 | (50-75) | (¼) | 6 | 12-15 | Hardy |
| Lettuce | Seed or Transplant | 45-65 | 10-30 | 6-8 | 50-70 | ¼ | 4-12 | 18-24 | Half-hardy |
| Melons | Seed or Transplant | 60-90 | 2-3 | 7-12 | 75-85 | 1-1½ | 18-24 | 48-72 | Very tender |
| Mustard | Seeded | 40-60 | 30 | 6-8 | 50-60 | ½ | 2-4 | 18-24 | Hardy |
| Okra | Seeded | 50-60 | 7-10 | 6-12 | 75-85 | ½ | 12-18 | 36 | Very tender |
| Onion, sets | Sets | 90-120 | 30 | — | — | 1½ -2 | 3-4 | 12-24 | Hardy |
| Onion, plants | Transplants | (90-120) | 30 | — | — | 1½ -2 | 3-4 | 12-24 | Hardy |
| Parsnip | Seeded | 100-120 | 30 | 10-21 | 55-70 | ¼-½ | 2-4 | 18-24 | Hardy |
| Peas | Seeded | 50-80 | 30 | 7-10 | 50-65 | 2 | 2-4 | 12-24 | Hardy |
| Peppers | Transplants | (50-110) | 6-10 | (10-14) | (75-85) | (½) | 12-24 | 36 | Tender |
| Potatoes | Tuber Pieces | 70-90 | 10 | — | 50-60 | 2-3 | 12 | 36 | Half-hardy |
| Pumpkin | Seeded | 85-130 | 2 | 7-10 | 75-85 | 1 | 48-60 | 72-90 | Half-tender |
| Radish, spring | Seeded | 25-40 | 40-60 | 4-6 | 50-60 | ½ | 2-3 | 12-18 | Hardy |



## Vegetable Crop Information

| Crop | Type of Planting | Days to First Harvest | Plants Per 10' Row* | Days to Germinate | Optimum Temp. (°F) | Depth of Planting (in.) | Avg. Spacing Within Row (in.) | Avg. Spacing Between Rows (in.) | Frost Resistance |
|---|---|---|---|---|---|---|---|---|---|
| Radish, fall | Seeded | 35-60 | 20-30 | 4-6 | 50-60 | ½ | 4-6 | 12-18 | Hardy |
| Rutabaga | Seeded | 90-120 | 20-30 | 5-10 | 50-60 | ½ | 4-6 | 18-24 | Hardy |
| Spinach | Seeded | 25-40 | 20-40 | 7-12 | 55-70 | 1 | 3-6 | 12-18 | Hardy |
| Squash, summer | Seeded | 45-55 | 5 | 7-10 | 75-85 | 1 | 24 | 48-72 | Very tender |
| Squash, winter | Seeded | 80-105 | 2 | 7-10 | 75-85 | 1 | 48-60 | 96 | Very tender |
| Sweet corn | Seeded | 68-90 | 10-18 | 6-8 | 70-80 | 2 | 8-12 | 36 | Tender |
| Sweet potatoes | Slips | 90-105 | 10 | — | — | — | 12 | 36-48 | Very tender |
| Swiss chard | Seed or Transplant | 40-65 | 15-20 | 7-12 | 55-70 | ½-1 | 6-8 | 18-24 | Half-tender |
| Tomatillo | Transplants | (60-75) | 3-4 | (7-14) | (75-85) | (½) | 36 | 36-60 | Very tender |
| Tomato | Transplants | (52-120) | 3-5 | (7-10) | (75-85) | (½) | 24-36 | 36-48 | Tender |
| Turnips | Seeded | 40-50 | 30-60 | 5-10 | 60-70 | ½ | 2-4 | 12-18 | Hardy |
| Watermelon | Seed or Transplant | 65-90 | 2 | 8-12 | 80-90 | 1-2 | 48-60 | 72-90 | Very tender |

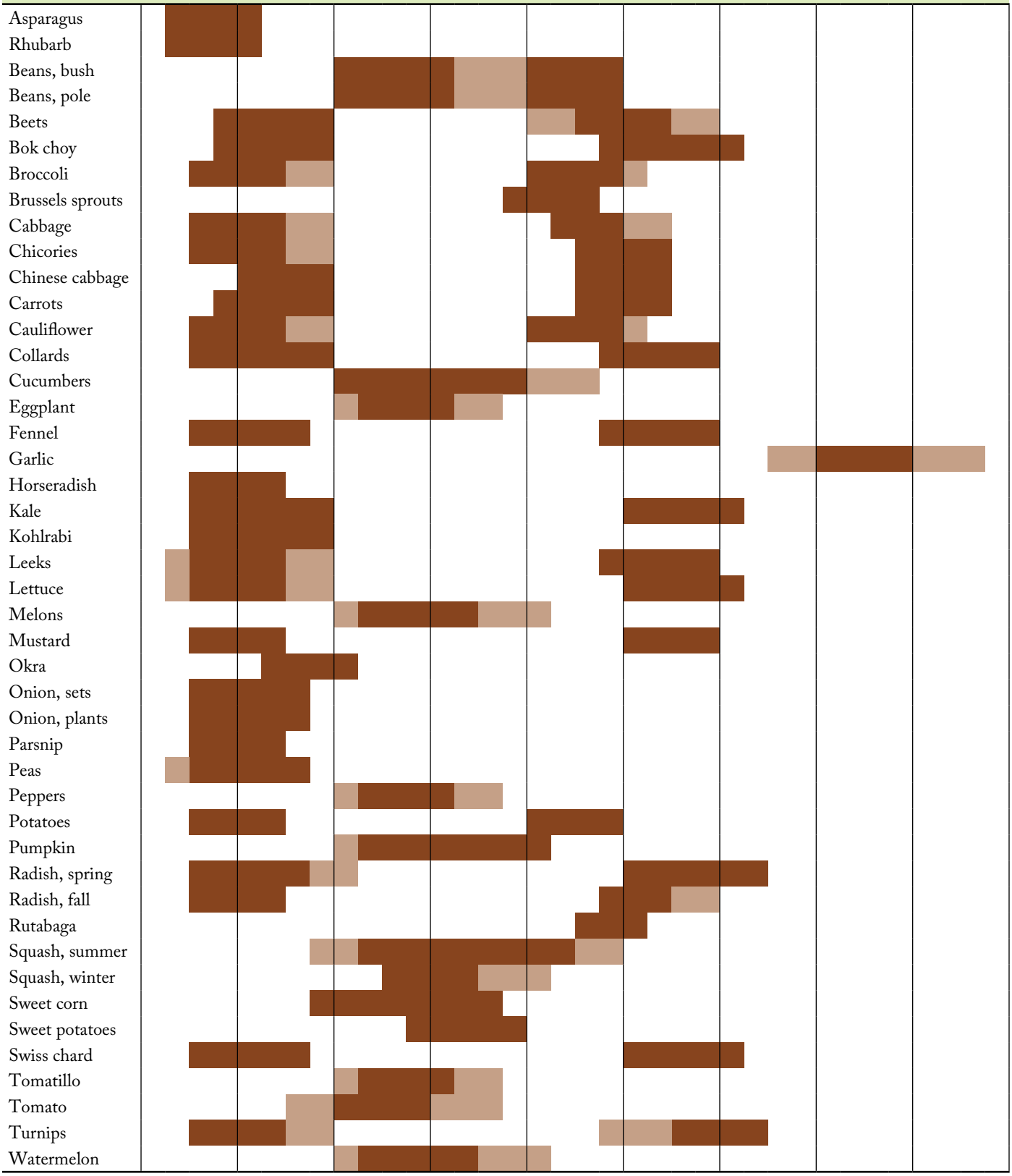
( ) = Seeding information for indoor seed starting; allow for 4-8 weeks indoors.
* For seeded crops, you will usually need to plant more seeds than the final number of plants per row and thin the seedlings after germination.

## Average Expected Planting Calendar

All planting windows are approximate and may need to be adjusted earlier or later depending on the weather each season, varieties chosen, preferred harvest quality, and your location in Kansas.

Primary expected planting window for most of Kansas

Marginal possible planting window depending on conditions



## Average Expected Harvest Calendar

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Primary expected harvest window for most of Kansas

Marginal possible harvest window depending on conditions

**Rebecca McMahon,** *Horticulture Agent*
*K-State Research and Extension-Sedgwick County*

**Raymond Cloyd,** *Professor and Extension Specialist*
*Department of Entomology, Kansas State University*

**Megan Kennelly,** *Professor and Department Head*
*Department of Plant Pathology, Kansas State University*

**Londa Nwadike,** *Extension Associate Professor and Food Safety Specialist*
*Kansas State University/University of Missouri*

*The authors gratefully acknowledge the work of the previous authors of the Kansas Garden Guide:* **Charles W. Marr and Ted Carey.**

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