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Vegetable Gardening

Topics covered:

Learning Objectives

- Know site, soil, and environmental conditions for optimal home garden production
- Know how to plan for, plant, and maintain healthy vegetable plants
- Understand the difference between cool and warm season crops

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Introduction

Sustainable gardening means growing plants in an environmentally friendly way. In the vegetable garden, this may include using cover crops to improve soil tilth and nutrition, rotating crops to prevent disease, and choosing an irrigation system that conserves water and reduces disease pressure. Also, making the right choices regarding types of crops and varieties to grow will enable you to produce a healthy crop while reducing the need for pesticides. Many of the practices that we will discuss in this chapter are the same practices that are used in organic gardening. Our goal is to grow a healthy, productive vegetable garden while minimizing outside inputs such as purchased fertilizer and pesticides. In addition, by recycling plant debris through composting you will be able to reduce the amount of waste that your garden produces.

In this chapter we will discuss common cultural practices and techniques to use in your vegetable garden. Some topics such as soils, fertility, and composting are covered in detail in separate chapters in this manual.

Getting Started

Establishing a new vegetable garden that will be successful requires some advance assessment and planning similar to implementing any landscape design. There are decisions to be made about exactly where the garden will be for best sun access and wind protection, what that site needs in terms of soil enhancement, what sort of beds will be set up, what methods of irrigation will be used, what types and quantities of vegetables will be grown, and so on. Some of these issues are ongoing and can be addressed or modified throughout the growing season or between seasons. Others, such as where the garden sits, are not so flexible. Also keep in mind your own needs as a gardener: if the garden is not where and what you want it to be, you will be less inclined to give it the attention it needs to be sustainable and successful.

Choosing a Vegetable Garden Site

The first step to growing a healthy and productive vegetable garden is selecting a site that has these four important elements:

1) Full sunlight.
2) Easy access to water.
3) Protection from heavy winds.
4) Soil with good tilth.

Sunlight. Most summer vegetable crops need at least eight hours of direct sunlight a day. If trees or shrubs are shading your garden, prune branches to allow in more light. If a solid fence is the source of the shade, consider replacing it with a post and rail fence that will let in more light. Light can be improved by painting nearby walls or fences white so they are more reflective. Areas receiving less sunlight may make a good composting site or work area. If the only garden site you have is shady, start by growing crops with low light requirements, such as leafy green crops like lettuce, or asparagus, garlic, and leeks. If these do well, expand into medium light-needing crops such as beans, radishes, and peas.

Water. Regardless of where you live in Washington, if you are going to grow summer vegetables you will need a steady supply of clean water for irrigation all summer long. The easiest way to irrigate is from a water spigot located in or near your vegetable garden. If the spigot is in an inconvenient place, you may want to extend the line and put a spigot closer to the garden. In climates that freeze, bury the pipe deep enough (below the **soil frost line**) to prevent it from bursting. Check with your local water company and county building department to learn how deep the soil frost line is in your area, and to determine if there are any required permits or procedures for extending a water line. See the Watering section to learn more about how and when to irrigate your vegetable garden to conserve water and optimize crop production. If your garden is very wet during the winter, it will require drainage if you plan to grow winter vegetable crops. Use raised beds and deep pathways to create a drier growing area for winter crops (see the section on Raised Beds).

Wind Protection. Vegetables tend to be very easily damaged by winds. Not only can plants be blown over, but if there are particles of soil in the wind, these will abrade leaves and stems, thereby sand blasting them. If your site is exposed to wind, plant or build a windbreak so that it protects the garden but does not shade plants. See "Trees Against the Wind" listed in Further Reading for details on planting a wind break.

Soil Tilth. A deep, loose garden soil that is high in organic matter is ideal, but few gardens start out this way. If you are lucky enough to have such good soil, maintain it by adding compost each year. If your soil is poor quality to begin with, or if you cannot dig more than a few inches deep, or if it is full of rocks, you can slowly improve the soil by adding organic matter several times a year. See the section on Soil Management for suggestions on building soil tilth.

Access and Convenience. It is best to plant your garden in an area where you have easy access for maintenance. Vegetables usually require care several times a week so choose a location that is convenient. You will also need to move things in and out of the garden such as wheelbarrows of compost. If you will be adding compost by the pickup load, make sure the garden gate area is large enough for this.

Site Protection. Another primary consideration for your vegetable garden is fencing. Deer can be a nuisance throughout the state and they may feed in your garden year-round. If you know there are deer in your area, be prepared to construct an 8-foot deer fence. Neighborhood dogs can also be destructive pests—digging, rolling and leaving droppings—so fencing them out as well is often necessary. See Chapter 18: Vertebrate Pest Management, for methods of dealing with other large pests.

Design

Once you have decided where your vegetable garden will be located, your next step is to design the garden layout. Committing your design to paper helps you plan quantities of seed, mulch, and other materials. It also serves as a record of what was done, to help with future design changes or rotational plantings.

Many gardens often look like smaller versions of farms: long, single rows of vegetables with wide alleys between the rows. If you have lots of land and a rototiller, you may choose this system. If you have limited space or would like to maximize space usage, you may choose to use raised beds. See the Raised Beds section for information on how to make a raised bed.

Pathways. Whether you choose to plant in rows or beds, make the main pathways in your garden at least 3 feet wide so that you can easily use a wheelbarrow. If you use a garden tractor, make sure you have room to drive in and out of the garden and to turn around if needed. If you plant vegetables in long, single rows, allow enough space to walk between the rows for weeding and harvesting. If your garden is arranged in raised beds, pathways between the beds should be wide enough for you to work. For example, if you work on your knees, measure the distance between the front of your knee and the toe of your shoe, then allow at least this much space for the width of your pathway. Do not make the beds or rows too wide: plan to plant, weed, water and harvest by reaching into the bed while standing or kneeling on the pathway to avoid compacting the soil within the bed.

Cover all pathways with mulch or a cover crop to control weeds in the alleys and to keep your feet clean and dry year-round. For mulch, use wood chips, straw, pine needles, or any other product that is readily available in your area. To make the mulch more effective, first lay down heavy cardboard and then cover with mulch. If you use degradable mulch such as woodchips or straw, scrape the decomposed mulch off the pathways and into the rows or beds every 2 to 3 years and add new, fresh mulch to pathways.

If you plant a cover crop in the alleyways, mow it several times a year to keep it from getting too tall and setting seed. If you use this technique, make sure your alleys are wide enough for your lawn mower. See the Cover Crop section for information about different cover crops that can be used. The major disadvantage with this technique is that the cover crop will grow into the beds and will require edging or weeding several times a year. If you use framed beds, this may not be an issue.

Raised Beds. Raised beds have some important advantages that make them very popular for many vegetable gardeners including gardeners with mobility issues. For example, raised beds have improved water drainage that results in increased soil temperatures, especially in the spring months. It is possible to work a drier soil earlier and it is possible to plant a warmer soil earlier, so, raised beds lead to an earlier garden. An added benefit of warmer, drier soil is decreased incidence of root rot, a common disease problem of many vegetable crops. Raised beds are usually semi-permanent or permanent, and although they may require more labor to start with, they are generally easier to maintain.

While a raised bed can be of any dimension, they are usually 6 inches to 1 foot high, 3 to 4 feet wide, and 10 feet long or longer. It is best to custom-fit the width and length of your beds to suit your needs. First, make sure you can easily reach the middle of the bed while squatting, kneeling, or sitting on either side of a bed. If a bed is against a wall or a fence and you only have access from one side, make sure you can reach all the way across the bed without stepping into the bed. Make the beds short enough so that you can easily get from one place to another in the garden without going too far out of your way. If children assist you in the garden, place stepping stones across the beds every 10 feet or so for easy crossing over. Do not walk on beds—avoiding foot traffic will minimize soil compaction and will result in better soil tilth in the bed.

For more information about the design and use of raised beds for people with limited mobility, refer to the publication "Gardens for All," listed in Further Reading at the end of this chapter. Typically, when used for this purpose, raised beds are built 2 to 3 feet high and are spaced far enough apart to allow wheelchair access.

If you are starting a new garden or redesigning your garden space, use string to mark off the beds and pathways. Make sure to leave enough space in pathways for a wheelbarrow, garden tractor, or other equipment that you commonly use. A primary objective will be to build a loose, rich, deep soil throughout the bed. If you are able to dig about a foot deep in your soil, consider using the double digging method to build raised beds. Double digging is an old, traditional gardening technique that is used to build soil for permanent raised beds and is discussed below.

Double Digging. Double digging is an old, labor-intensive technique used to prepare raised beds and is generally only done once for each bed. Double digging is most popular in areas where the soil is easy to dig, as the recommended depth for double digging is about 1 foot. The basic concept of double digging is to add compost deep at the bottom of a bed to improve rooting potential, water drainage, and soil nutrition. Here are the steps for double digging a bed (Figure 1):

1. Outline your bed with string or mark the outline in the soil.
2. Dig a trench across the width of the bed at one end. The trench should be approximately 1 foot deep and 1 foot wide, but a few inches more or less is just fine. As you remove the soil, pile it into a wheelbarrow and dump it at the far end of the bed—not on the bed, but next to the far end.
3. Fill the trench at least half full with compost, but not to overflowing. You will likely only double dig each bed once, and the compost you add here will play a key role in the health of the soil you are building, so add enough to make it worth your while. Also, the compost will settle and decompose the first year, losing about half its volume, which will cause the bed to lose half its height.
4. Dig another trench across the width of the bed, right next to the first trench, and place all the soil from this second trench on top of the compost in the previous trench.
5. Repeat steps 2–4 until the entire bed has been dug and the trenches have all been filled with compost and topped by soil. When you dig the final trench, fill it with the soil from the first trench that you piled at the far end of the bed (Step 1). Spread any remaining soil across the entire bed.
6. Rake the surface of the bed to smooth it out and break up any large clods.

Soil Management

Establishing and maintaining a healthy, fertile soil is the foundation of a healthy, productive vegetable garden. A healthy soil will have air, organic matter, nutrients, and good water-holding capacity. Organic matter is a good source of plant nutrients and will also increase water-holding capacity. Do not dig in the garden when the soil is too wet, as this will destroy soil structure. If your garden tends to be very wet until late spring, use raised beds to increase soil drainage and to enable you to plant earlier.

Air. Plants are living, breathing organisms and require air in their root zones as well as around their foliage to thrive. Because roots are buried in soil, it is easy to think that air is not an essential part of a healthy soil system. On the contrary, air in the root zone is as necessary to plant growth as water and nutrients. Soil organisms such as worms, bacteria, and fungi also need air to survive and do their jobs of breaking down organic matter and making nutrients available to plants. Air is added to the soil

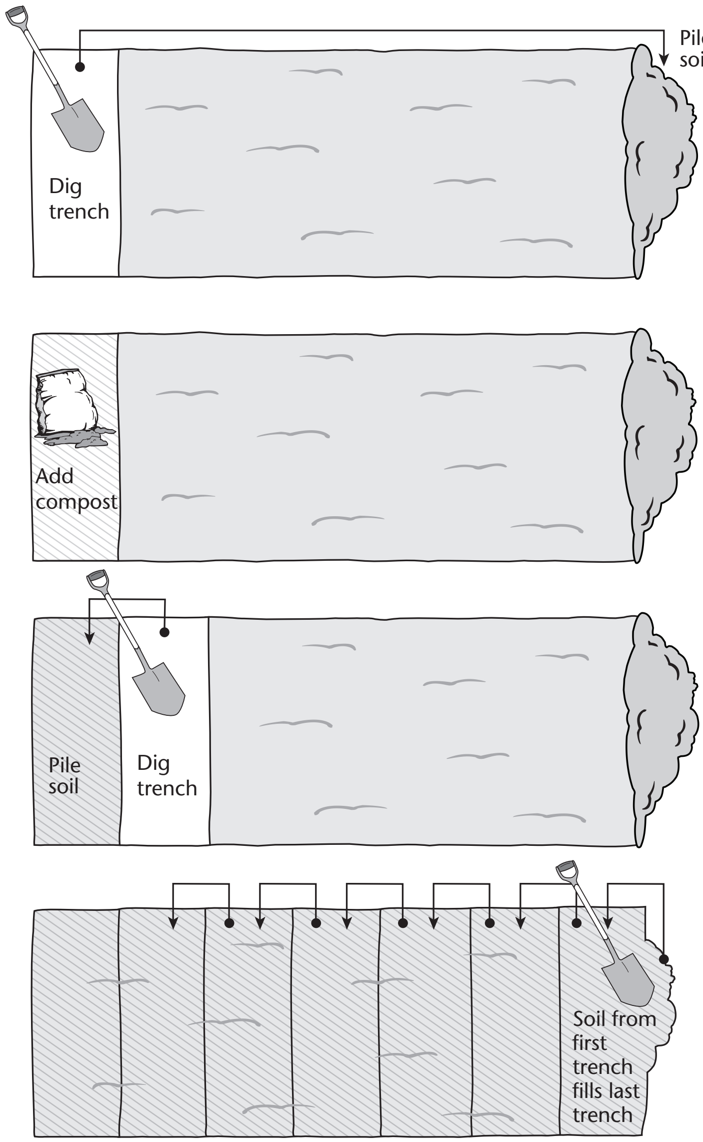


Figure 1. Steps for double-digging a garden bed.

when you cultivate for planting, when you incorporate compost, or when you till in plant residue after harvest. A rototiller will generally turn the top 5–6 inches of soil, while hand digging can reach a foot or more deep. Worm tunnels and decomposing deep plant roots will create channels several feet deep in the soil for aeration and water drainage. Soil that has high organic matter content will have large pore spaces that can be filled with air.

A well-aerated, deep soil allows plants to establish a deep rooting system. Plants with deep root systems are more drought tolerant and more effective at capturing soil nutrients. It is especially important to have deep, well-aerated soils in intensive beds where plants are spaced close together and there is greater potential for competition for water and nutrients.

Organic Matter. Plant residues such as fallen leaves, grass clippings, vegetable crop debris, and compost are all sources of organic matter for your vegetable garden. Naturally occurring bacteria and fungi in the soil decompose organic matter, turning it into humus, which is generally seen as the dark brown or black layer at the top of the soil. Soil organic matter generally accounts for only 1–5% of the total soil weight, whereas the majority of soil is made up of mineral particles in the form of sand, silt or clay. Soil organic matter improves soil tilth (soil health and structure), water-holding capacity, nutrient retention, nutrient availability, and aeration. Soil organic matter helps to improve soil structure by binding mineral soil particles together into larger soil aggregates. Large soil aggregates result in larger pore spaces that are available for air and water retention, and for root growth.

Whether your soil is too heavy due to high clay content or too light due to high sand content, adding organic matter regularly is the best thing you can do to improve it. Soil that is high in organic matter is easier to work and generally is more productive than soil that lacks organic matter. To increase soil organic matter, add 2–3 inches of compost to the beds or rows each year. In addition, you can grow cover crops or use composted animal manures from local farms to build a healthy, productive soil.

Building the soil. If your garden soil is very rocky or compacted, it is easiest to build the soil up over the course of several years rather than trying to dig deep the first year. To build your soil up, apply a 4–6 inch layer of compost uniformly over beds the first year. After you have applied the compost the first year, remove the top few inches of good soil from the paths and place it on top of the compost in the beds. This increases the depth of good soil in the beds and discourages weed growth in the poorer soil left in the paths. Apply a 2–3 inch layer of compost to the beds each year after.

You can leave compost on the surface of the bed or you can turn it into the soil. Compost left on the surface will act as mulch and will help retain soil moisture and smother weeds. By incorporating the compost, you are placing nutrients where they are needed most—in the rooting zone. Whether you choose to leave the compost on top of the bed or turn it in, rake the beds to level them and to break up any large clods. Your decision may be based on how easy it is to turn the soil in your garden and you should do what is easiest for you. If your soil is compact and difficult to dig, plant deep-rooted vegetables such as tomatoes, winter squash, and melons for the first 2–3 years. Decomposing deep roots will create channels for water drainage and aeration, which will, in turn, enable medium- and shallow-rooted crops to grow and be more productive in following years.

Compost. Compost is decomposed plant material and is easily made from plant residues from your garden and kitchen. Homemade compost is the easiest and least expensive way to provide your garden soil with fresh organic matter each year. In general, you should think of your compost pile as a place to recycle garden debris and kitchen vegetable scraps. Do not compost food wastes such as meat that might attract rodents or other animals. Be cautious when composting problem weeds such as quack grass, morning glory, and comfry because roots of these weeds can be very resistant to decomposition and may begin to grow again when incorporated back into garden soil. Also, some plant seeds may not be killed unless you are very diligent about turning the compost pile to ensure that high enough temperatures have been reached for the necessary time period. Diseased plants with infections such as club root or late blight should not be be put in your compost pile because the disease organisms can survive the composting process. There are several techniques and "recipes" for making compost effectively, and to learn more, refer to Chapter 22: Composting.

Cover Crops. Cover crops are planted to protect the soil from erosion, control weeds, trap or add nutrients, add organic matter, break up a pest cycle in the soil, improve soil moisture retention, and increase soil drainage. When the primary purpose of planting a cover crop is to add nutrients, then the crop is often referred to as a "green manure crop." Cover crops and green manure crops are the same crops—they are just referred to differently depending on the primary purpose for planting them. In this chapter, these crops will be referred to as cover crops. If you have unplanted areas in your garden in the summer, or are not growing a winter vegetable crop, consider planting a cover crop. Cover crops are usually legumes or grain crops such as wheat, oats, or barley.

Cover crops improve soil nutrition by taking up nutrients from the soil that would otherwise be lost due to leaching or erosion. Nutrients are held in the green, living tissue of the cover crop and are not available for the vegetable crop until the cover crop is killed and it has decomposed in the soil. Mowing is generally a good method to kill annual grass cover crops while light tillage generally works well for most legume crops. If the legume crop has a lot of top growth, you may mow it first and either remove the tops and add them to your compost pile or leave them on the surface for a few weeks and then till. Note that legume plants will not form an association with *Rhizobium* bacteria if the plants have received sufficient nitrogen fertilizer to meet their needs. Therefore, to take advantage of nitrogen fixation by a legume cover crop, only use a small amount of nitrogen fertilizer for legume plants.

Wait at least two weeks after killing or tilling the cover crop before planting a new crop. As the cover crop breaks down during these two weeks, nutrients are not available for new plant growth, and any new seedlings will suffer from nutrient deficiencies during this period. Mow or kill the cover crop before it sets seed. If it does set seed, it will likely become a weed in the next season.

Cold-tolerant crops can be planted as summer or winter cover crops, while tender crops should only be planted in the summer (Table 1). Depending on the minimum winter temperatures in your area, somewhat cold tolerant crops may also be suitable for both winter and summer planting. Plant your summer cover crop before the rains end, as soil moisture is needed for good germination. Although some cover crops can survive all summer long without irrigation, they generally will not be very productive. If you want a vigorously growing cover crop it may be necessary to irrigate it during the summer.

Table 1. Cold hardiness of cover crops commonly grown in Washington.

Cold Tolerant	Somewhat Cold Tolerant	Not Cold Tolerant
Hairy vetch (annual)	Annual ryegrass (annual)	Buckwheat (annual)
Red clover (-30 to -20°F)	Barley (annual)	Alfalfa (-10 to -5°F)
Subterrandean clover (-30 to -20°F)	Crimson clover (annual)	Mustard (canola, rapeseed) (annual)
White clover (-30 to -20°F)	Fava beans (annual)	Oats (annual)
Winter wheat (annual)	Field peas (annual)	Sundangrass & sorghum (annual)

Plant a winter cover crop by mid-September. Winter temperatures vary around the state and some cover crops listed in Table 1 as cold tolerant may not be winter hardy in your area. The best way to determine which cover crops will do best in your area is to experiment. Start by planting 2 or 3 cover crops and discard those that do not do well. Each year test another crop until you can identify several that do well. You may also consult with your area Extension agronomist for suggested cover crops.

If you would like to plant a cover crop earlier than mid-September but have not finished harvesting the summer vegetable crop, simply broadcast the cover crop seed around and under the vegetable plants and rake in the seed. The cover crop will germinate under the vegetable crop and will be ready to take off when the vegetable crop is harvested. Cut the spent vegetable plants at the soil surface and place the tops in your compost pile. Leave the roots in place in the garden and they will decompose, adding organic matter where it is needed most—deeper in the soil.

To avoid contamination of your vegetable crops by E. coli and Salmonella, do not use fresh livestock manure in your garden.

Livestock Manure. Livestock manure can be rich in organic matter and crop nutrients, but must be handled safely to avoid problems due to potential pathogen contamination. The two major pathogens of concern are *E. coli* O157 and *Salmonella*. To avoid potential contamination of your vegetable crops with these pathogens, do not use fresh livestock manure in your vegetable garden, only use composted livestock manure. High temperatures achieved in a well-managed, aerobic compost pile can kill most harmful pathogens. See Chapter 22: Composting, for more details on composting.

If you are receiving fresh or aged livestock manure for your garden, store it as far away as practical from areas where fresh vegetables are grown and handled. If necessary, erect physical barriers to prevent runoff and wind drift of manure onto vegetable crops. If you are using aged manure in your vegetable garden, apply it in the fall, preferably when soils are still warm and unsaturated. Incorporate aged manure immediately after application and wait two weeks before planting winter vegetable crops or cover crops. The 2-week wait is to allow for organic matter decomposition that ties up soil nutrients, which can result in severely stunted crop plants. Do not harvest vegetables until 120 days after aged manure application. Therefore, do not apply aged manure to short season crops such as lettuce.

Do not harvest vegetables until 120 days after aged manure application.

Also be aware that using manure in gardens may result in the addition of weed seeds and, in some cases, herbicides to the garden. Seeds and some herbicides can pass unaltered through the digestive system of a grazing animal.

Variety Selection

Select crops and varieties that are likely to do well in the climate of your local area. Washington State is known for its cool nights that result in relatively mild average daily summer temperatures. In Central and Eastern Washington, the average temperature on a summer day can be quite warm (80–90°F), whereas in Western Washington summer temperatures are quite a bit cooler (65–75°F). Throughout the state, night temperatures are quite low all summer long (50–60°F). The maximum and minimum daily temperatures impact plant growth, and vegetable crops are classified based on how cold hardy or tender they are (Table 2).

Table 2. Classification of vegetable crops according to their adaptation to warm and cold temperatures (Adapted from: Knott's Handbook for Vegetable Growers; Vegetable Production, Nonnecke).

Warm-season Crops			
Tender		Very Tender	
Cowpea	Soybean	Cucumber	Pepper
New Zealand spinach	Sweet corn	Eggplant	Pumpkin
Snap/green bean	Tomato	Lima bean	Squash
		Muskmelon	Sweet potato
		Okra	Watermelon
Cool-season Crops			
Hardy		Half-hardy	
Artichoke	Kohlrabi	Carrot	Chinese cabbage
Asparagus	Leek	Cauliflower	Endive
Beet	Mustard	Celery	Lettuce
Broad bean	Onion	Chard	Potato
Broccoli	Parsley		
Brussels sprouts	Radish		
Cabbage	Rhubarb		
Chive	Spinach		
Collards	Turnip		
Garlic	Parsnip		
Horseradish	Salsify		
Kale			

Wait to plant tender crops until all danger of frost has passed, and do not set very tender crops in the garden until temperatures are quite warm. Hardy crops can be grown during the winter months with some protection (see the Winter Gardening section), while half-hardy crops are suitable for fall and spring production.

Growing Degree Days. Plants grow in response to the amount of heat they accumulate above a base temperature. Warm season crops have a higher base temperature than cold season crops. Table 3 is a summary of the base temperatures for many common vegetable crops. When the temperature is below a plant's base temperature, that plant does not actively grow.

The equation that measures heat accumulation is referred to as **growing degree days**. Growing degree days (GDD) for a given crop on a single day are calculated by:

(Average daily temperature) [minus] (the base temperature)

where the average daily temperature equals:

$$\frac{(\text{Maximum daily temperature}) + (\text{Minimum daily temperature})}{2}$$

Table 3. Growing degree day (GDD) base temperatures for some common vegetable crops (Source: Knott's Handbook for Vegetable Growers).

Crop	Base Temperature (°F)
Asparagus	40
Bean, snap	50
Beet	40
Broccoli	40
Carrot	38
Collards	40
Cucumber	55
Eggplant	60
Lettuce	40
Muskmelon	50
Onion	35
Okra	60
Pea	40
Pepper	50
Potato	40
Squash	45
Strawberry	39
Sweet corn	48
Sweet potato	60
Tomato	51
Watermelon	55

It is important to know the minimum and maximum temperatures in your area because they will determine which crops or varieties you are able to grow. Table 4 provides monthly average maximum and minimum temperatures for some locations in Washington. To find a summary of temperatures year-round for your area, one source is the Western Regional Climate Center, http://www.wrcc.dri.edu/summary/climsmwa.html.

In Washington, the average number of GDD for the summer growing season (June through August) at a base temperature of 50°F (the base temperature for most summer crops) varies considerably depending on your location. For instance, in Western Washington, GDD range from700 (Long Beach) to 1350 (Vancouver), whereas in Eastern and Central Washington they range from 1200 (Pullman) to 2000 (Richland). In comparison, in the mid-western U.S. there are, on average, 1800–2300 GDD for the summer growing season (50°F base temperature). You can see that in some areas of Washington there is less than one-half the heat for crop growth in the summer than in the mid-western U.S. This is the essential reason why it is necessary to select early maturing varieties, especially for cooler areas of the state.

Table 4. Average maximum and minimum temperatures (°F), average precipitation (inches), and Growing Degree Days (GDD) for some locations in Washington State. (Source: Western Regional Climate Center)

Location															GDD[1]	
Eastern Washington		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	J-A	M-S
Ellensburg	Ave. Max. Temp	34.3	41.5	53.1	61.7	69.4	76.1	84.2	83.4	74.7	62.3	45.7	35.6	60.2		
	Ave. Min. Temp	18.6	22.8	28.6	34	41.6	48.2	52.8	51.4	43	33.9	26.9	21	35.2		
	Ave. Total Precip	1.27	0.92	0.68	0.51	0.55	0.65	0.28	0.27	0.45	0.59	1.24	1.45	8.87		
GDD[2]						170.5	364.5	573.5	539.4	265.5					1477	1695
Ephrata	Ave. Max. Temp	34.3	42.2	54.1	65	74.7	81.9	90.2	88	79.3	64.8	46.7	37.3	63.2		
	Ave. Min. Temp	21.2	26.5	33.2	40.5	48.4	55.6	61.6	59.9	52.6	42.1	31.3	25	41.5		
	Ave. Total Precip	0.98	0.71	0.6	0.62	0.68	0.77	0.22	0.27	0.42	0.64	1	1.16	8.04		
GDD						358.1	562.5	802.9	742.5	478.5					2108	2526
Prosser	Ave. Max. Temp	38.2	46.1	56.3	64.9	73.3	80.3	88.1	86.8	78	65.1	48.7	40	63.8		
	Ave. Min. Temp	23.9	27.7	32.5	37.6	44.3	50.2	54	53	46.7	38.6	30.9	26.2	38.8		
	Ave. Total Precip	0.97	0.73	0.61	0.58	0.62	0.66	0.2	0.28	0.39	0.72	0.98	1.12	7.86		
GDD						272.8	457.5	652.6	616.9	370.5					1727	2049
Pullman	Ave. Max. Temp	34.7	40.6	47.3	56	64.4	71.4	81.7	82	72.9	59.9	43.7	36.1	57.5		
	Ave. Min. Temp	22.7	27	30.7	35.5	41.3	46.3	49.7	49.7	44.3	37.2	30.3	25	36.7		
	Ave. Total Precip	2.76	2.06	2	1.61	1.66	1.43	0.59	0.79	0.99	1.69	2.84	2.85	21.26		
GDD						88.35	265.5	486.7	491.4	258					1244	1417
Richland	Ave. Max. Temp	40.4	48.5	58	66.6	75.2	82.6	90.3	89.2	80.6	66.9	50.9	41.9	65.9		
	Ave. Min. Temp	26.2	30.3	35.1	40.9	48.2	54.8	59.5	58.8	50.7	41	33.8	28.6	42.3		
	Ave. Total Precip	1.01	0.71	0.6	0.49	0.56	0.5	0.21	0.25	0.27	0.51	0.94	1.04	7.09		
GDD						362.7	561	771.9	744	469.5					2077	2493
Spokane	Ave. Max. Temp	34.5	42.5	49.6	59.2	68.8	76.8	85.8	84.5	74.4	60.3	44	37.1	59.8		
	Ave. Min. Temp	23.9	28.8	31.2	36.8	44.3	51.2	56	54.7	47.2	38.4	31.5	27.2	39.3		
	Ave. Total Precip	2.24	1.65	1.56	1.25	1.52	1.33	0.56	0.79	0.86	1.13	2.16	2.58	17.62		
GDD						203.1	420	647.9	607.6	324					1676	1939
Walla Walla	Ave. Max. Temp	39.6	46.4	56.6	66.8	74.8	81.3	91.3	88.8	79.8	66.1	49.8	43.3	65.4		
	Ave. Min. Temp	25.8	30.1	34.9	40.3	46.3	51.8	57.4	55.7	48.3	40.9	32.7	30.3	41.2		
	Ave. Total Precip	1.73	1.46	1.53	1.29	1.47	1.2	0.25	0.33	0.82	1.48	1.72	1.73	15		
GDD						327.1	496.5	754.9	689.8	421.5					1941	2315
Wenatchee	Ave. Max. Temp	34.6	42.4	54.4	64.7	73.1	79.9	87.9	86.8	78.1	63.6	46.6	36.7	62.4		
	Ave. Min. Temp	22.1	25.8	32.7	40	47.9	54.8	60	58.6	50.2	39.8	31.3	25.6	40.7		
	Ave. Total Precip	1.26	0.91	0.62	0.54	0.55	0.72	0.21	0.39	0.37	0.6	1.21	1.47	8.85		
GDD						325.5	520.5	742.5	703.7	424.5					1967	2342
Yakima	Ave. Max. Temp	37.3	45.9	55.5	63.9	72.6	79.8	87.5	86.1	77.8	64.2	48.2	38.2	63.1		
	Ave. Min. Temp	20.8	25.7	29.9	34.8	42.3	49	53.2	51.8	44.2	34.8	27.7	22.8	36.4		
	Ave. Total Precip	1.27	0.77	0.65	0.52	0.52	0.68	0.19	0.33	0.34	0.55	1.01	1.32	8.15		
GDD						231	432	630.9	587.5	330					1650	1931

[1] GDD are calculated for June through August (J-A) and for May 15 through September 15 (M-S).
[2] GDD are calculated for a base temperature of 50°F.

Table 4. (continued) Average maximum and minimum temperatures (°F), average precipitation (inches), and Growing Degree Days (GDD) for some locations in Washington State. (Source: Western Regional Climate Center)

Location															GDD	
Western Washington		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	J-A	M-S
Bellingham	Ave. Max. Temp	43.2	47.7	51.1	56.4	62.3	66.7	71.2	71.3	67.1	58.4	49.6	44.5	57.4		
	Ave. Min. Temp	31.4	33.9	35.9	39.9	45.2	50.4	53.2	53.1	48.1	42	36.7	33.1	41.9		
	Ave. Total Precip	4.56	3.45	3.02	2.65	2.16	1.8	1.24	1.37	1.83	3.43	5.02	4.82	35.36		
	GDD					116.3	256.5	378.2	378.2	228					1013	1185
Centralia	Ave. Max. Temp	46	50.4	55.2	61.6	68.1	72.9	78.5	78.4	73.2	62.4	51.9	46.6	62.1		
	Ave. Min. Temp	33.9	35	36.6	39.6	44.4	49	52.2	52.2	48.6	43.2	38.3	35.3	42.4		
	Ave. Total Precip	6.7	5.27	4.79	3.13	2.16	1.85	0.76	1.17	1.93	4.28	6.91	7.51	46.45		
	GDD					193.8	328.5	475.9	474.3	327					1279	1539
Goldendale	Ave. Max. Temp	37.7	44.8	52.6	61.3	69.8	76.3	85.7	84.2	76.9	63.6	48	39.6	61.7		
	Ave. Min. Temp	23.7	26.9	30.3	33.8	39.6	45.3	49.6	48.3	42.6	35.4	30	26.8	36		
	Ave. Total Precip	3.06	1.94	1.64	0.9	0.82	0.74	0.19	0.27	0.57	1.47	2.62	3.22	17.44		
	GDD					145.7	324	547.2	503.8	292.5					1375	1594
Long Beach	Ave. Max. Temp	48.3	51.1	52.2	55.6	59.7	63.3	65.9	66.5	66.9	61.8	54.3	50	58		
	Ave. Min. Temp	35.8	37	36.2	39.8	43.6	48.3	50.4	50.3	47.1	43.7	39.2	37.2	42.4		
	Ave. Total Precip	12.91	9.46	8.38	6.01	3.09	2.87	1.33	2.2	3.05	7.86	12.07	11.91	81.15		
	GDD					51.15	174	252.7	260.4	210					687	818
Mt. Vernon	Ave. Max. Temp	45.5	49.2	52.8	57.7	63.9	68.6	73.2	73.8	68.6	59.4	50.7	45.9	59.1		
	Ave. Min. Temp	33.6	35.1	37.1	39.9	44.7	48.8	50.6	50.9	47	41.9	37.8	34.6	41.8		
	Ave. Total Precip	4.02	2.84	2.73	2.43	2.21	1.83	1.16	1.49	1.84	3.23	4.43	4.08	32.3		
	GDD					133.3	261	368.9	382.9	234					1013	1196
Olympia	Ave. Max. Temp	44.5	49.2	53.4	59	65.7	71	77.1	77.1	71.6	60.6	50.5	44.8	60.4		
	Ave. Min. Temp	31.6	32.4	33.8	36.5	41.5	46.6	49.4	49.5	45.2	39.6	35.5	32.8	39.5		
	Ave. Total Precip	7.95	5.82	5.12	3.35	1.98	1.57	0.72	1.2	2.04	4.74	8.1	8.18	50.76		
	GDD					111.6	264	410.8	412.3	252					1087	1269
Port Angeles	Ave. Max. Temp	45.1	47.7	50.5	55.3	60.6	64.7	68.4	68.4	65.7	57.4	50	45.9	56.6		
	Ave. Min. Temp	34	35.5	36.9	40.1	44.7	49	51.6	51.6	48.8	43.3	38.1	35.2	42.4		
	Ave. Total Precip	4.02	2.75	2.19	1.34	0.96	0.86	0.55	0.8	1.11	2.64	4.19	4.25	25.66		
	GDD					82.15	205.5	310	310	217.5					825.5	975.3
Puyallup	Ave. Max. Temp	46.3	50.5	54.8	60.9	68.1	72.6	78.2	78	72.2	62.3	51.9	47	61.9		
	Ave. Min. Temp	32	33.6	35.3	38.5	43.1	47.9	50.3	50.1	46.5	41.6	36.1	33.4	40.7		
	Ave. Total Precip	5.59	4.5	4.01	2.84	1.94	1.78	0.82	1.1	1.87	3.55	5.67	6.16	39.84		
	GDD					173.6	307.5	441.8	435.6	280.5					1185	1412
Seattle	Ave. Max. Temp	44.7	50.1	53.4	59.4	66.7	71.2	76.9	76.3	71	61.3	52	47.1	60.8		
	Ave. Min. Temp	34.2	37.1	38.2	41.6	47.1	52.2	55.1	55.6	52.1	46.1	40.5	37.1	44.7		
	Ave. Total Precip	4.94	4.23	3.52	2.3	1.5	1.5	0.96	1.08	1.92	3.24	4.89	5.79	35.86		
	GDD					213.9	351	496	494.5	346.5					1341	1622
Vancouver	Ave. Max. Temp	44.7	49.8	55.4	61.4	67.4	72.7	78.9	79.1	73.9	63.6	52.4	45.9	62.1		
	Ave. Min. Temp	34.2	34.4	37.4	40.7	45.6	50.5	53.7	53.4	49.2	43.4	38.1	34.3	42.7		
	Ave. Total Precip	5.71	4.48	3.79	2.67	2.2	1.65	0.6	0.87	1.82	3.17	5.94	6.31	39.23		
	GDD					201.5	348	505.3	503.8	346.5					1357	1631

Our summers do not provide enough heat for rapid crop growth, and as a result, it can take varieties longer to mature in Washington than in warmer regions of the country. It may be necessary to add days to the "days to maturity" numbers that are given in seed catalogs or on seed packets from warmer parts of the country. Add 10 days for short-maturing varieties (40–50 days to maturity) and add 30 days for long-maturing varieties (100 or more days to maturity). Seed companies that are located in mountain states or in the Pacific Northwest tend to provide days-to-maturity numbers that better match what we can expect in Washington.

Experiment with varieties and note how many days they take to mature in your garden. It takes 3 or more years to determine an average number of days to maturity. In order to grow long-maturing varieties, start seeds indoors in mid-spring and transplant them when appropriate in early summer. In this way, you can get a 4- to 6-week jump on the growing season.

Disease resistance. When selecting varieties to grow, it is also important to select those varieties that are resistant to the most common diseases that affect your area. Table 5 is a summary of the primary diseases affecting vegetable crops. If you know a particular disease is a problem in your area, select a variety with resistance whenever possible. Seed catalogs can be a good source of information regarding the disease resistance of particular varieties.

Table 5. Vegetable crop rotation recommendations to avoid soil-borne diseases.

Crop	Disease	Rotation Recommendation
Asparagus	Fusarium Wilt, Root & Crown Rot	Indefinite; use transplants grown from treated seed, plant on clean ground in raised beds; rotate with grasses and cereals
Basil	Fusarium Wilt	Indefinite; plant disease-free seed in disease-free soil or potting mix
Bean, Dry	White Mold (Sclerotinia Rot)	8–9 years of non-host crops
Bean, Green	Fusarium Root Rot	5–6 years, rotate with grass or small grain crops
	Gray Mold	2 years, rotate with cereals and corn
	White Mold (Sclerotinia Disease)	2–3 years; avoid tomato, potato, lettuce, cabbage, celery, carrot, peas
	Bacterial Blight	2 years; eliminate overhead irrigation
Beet, Red	Cercospora Leaf Spot	3 years
	Root Rots	3 years; rotate with grain crops and sweet corn
Cabbage and Cauliflower	Blackleg	5 years; no adjacent crucifer crops for this time period
	Black Rot	2–3 years, no crucifer crops
	Club Root	6+ years; no crucifer crops; adjust pH to 6.8 or above
	Damping-off and Wirestem	3 years; rotate with cereals
	Leaf Spot	3 years
	Phytophthora Root Rot	3 years, rotate with nonsusceptible crops such as grass or grains
	Water Soft Rot (White Blight)	3 years, rotate with nonsusceptible crops such as grass or grains
	White Mold (Scelerotinia)	3 years, rotate with grains and sweet corn
Cabbage	Nematode (Sugar Beet Cyst)	2 years for slight infestations, 5-6 years for severe infestations; avoid crucifers. Rotate with beans, clover, corn, grains, peas, potatoes, and tomatoes annually. Alfalfa is suitable for a long rotation period.
Cantaloupe	Fusarium Wilt	4+ years; no cucurbit crops; avoid soil with a history of this disease
	Leaf Blight	2+ years; do not plant other cucurbits
	Leaf Spot, Gummy Stem Blight, & Scab	2+ years; do not plant other cucurbits
Carrot	Alternaria Leaf Spot & Leaf Blight	1–2 years
	Bacterial Leaf Blight	2–3 years
	Black Rot	1–2 years
	Cavity Spot	6–7 years; avoid fields with a recent history of cavity spot
	Cercospora Leaf Spot, Leaf Blight	1–2 years
	Cottony Soft Rot (White Mold)	2 years; rotate onions, grasses, cereals; do not rotate with beans, lettuce, parsnips, crucifers; do not grow early or late crops in fields with a history of this disease as heavy rains can cause severe losses
	Nematode (Root-knot)	4–5 years; rotate with a nonhost crop such as corn or cereals
	Violet Root Rot	4–5 years, rotate with cereals and grasses
Celery	Fusarium Yellows	2–3 years, rotate with corn, crucifers, cucurbits, or onions
	Late Blight	2 years
	Leaf Blight	2 years
	Sclerotinia Pink Rot	2–3 years, rotate with corn, cereals, beets, onions, and spinach

Crop	Disease	Rotation Recommendation
Corn	Leaf Spots and Blights	2–3 years
	Seed Rot and Seedling Blight	2–3 years
	Smut (Head)	3–4 years
	Stalk Rots	2–3 years
Cucumber	Alternaria Leaf Spot	2 years
	Powdery Mildew	2-year, plant no cucurbits during this time
	Scab (Gummosis)	2–3 years, plant no cucurbit crops during this time
	Sclerotinia Stem Rot (White Mold)	2–3 years, do not follow potato or tomato crops
Eggplant	Anthracnose	Rotate crops
	Cercospora Leaf Spot	Rotate crops
	Root Rot	Practice light irrigation and crop rotation
	Verticillium Wilt	4–5 years, rotate with grasses and grains, no solanaceous crops, strawberry or brambles
Garlic	Leaf Blight	2–3 years
	Nematode (Stem & Bulb)	2 years
	White Rot	6–7 years; plant only disease-free cloves in disease-free soil
Ginseng	Verticillium Wilt	3–4 years; rotate with alfalfa or cereal crops
Lettuce	Anthracnose	4–5 years
	Bottom Rot	3 years, rotate with sweet corn or onions
	Drop (Watery Soft Rot)	3 years; rotate with corn, cereals, grasses, onions, table beets, spinach; avoid tomato, potato, beans, cabbage, celery, carrots
	Varnish Spot	2–3 years
Onion	Basal Plate Rot	4 years
	Botrytis Leaf Blight	2–3 years, no allium crops
	Downy Mildew	3–4 years
	Nematode (Stubby-root)	5–6 years, do not plant after a mint crop
	Pink Root	3–6 years
	Purple Blotch	5–6 years, no allium crops
	White Rot	6–7 years, plant only disease-free matierial in disease-free soil
Parsley	Damping-off	3 years
Parsnip	Leaf Spot and Root Canker	2 years
Pea	Aphanomyces Root Rot	4–5 years
	Ascochyta Blight (Basal Stem Rot or Black Stem)	4 years; do not include vetch or alfalfa in the rotation
	Downy Mildew	2–3 years, do not rotate with legumes
	Nematode (Pea Cyst)	4 years for slight infestations, eliminate peas if high infestation
	Powdery Mildew	1 year
	Root Rots	5 years
	Seed Rot and Damping-off	3 years
	Wilt and Near-wilt	5 years
Pepper	Anthracnose	3 years
	Cercospora Leaf Spot	3–4 years
	Phytophthora blight	3 years; avoid tomato, eggplant, cucurbits
	Root Rot	3–4 years
	Verticillium Wilt	3 years, rotate with grass and grain crops

Crop	Disease	Rotation Recommendation
Potato	Black Dot	2–3 years
	Early Blight	2 years; do not plant tomatoes
	Fusarium Wilt	4–5 years
	Nematode (Potato Rot)	2–3 years, rotate with cereals and corn
	Nematode (Root-knot)	2–3 years, rotate with cereals or sweet corn
	Nematode (Root-lesion)	2–3 years, rotate with cereals or sweet corn
	Powder Scab	3–4 years; avoid planting on previously contaminated ground
	Pythium Leak, Pink Rot	4 years
	Rhizoctonia Canker (Black Scurf)	3 years; best with cereals or grass
	Scab	2–3 years; no root crops; adjust pH to 5.2 or below
	Sclerotinia Stalk Rot	4 years, avoid tomato, lettuce, beans, cabbage, celery, carrot, beans
	Silver Scurf	3 years
	Verticillium Wilt (Potato Early Dying)	3–4 years, do not solanaceous, cucurbits, mint, or nursery maple crops; rotate with alfalfa or cereals
Radish	Black Root	3–4 years
	Clubroot	7 years; do not plant crucifers; adjust pH to 6.8
Spinach	Downy Mildew & White Rust	2–3 years
Tomato	Anthracnose	1–2 years; alternate every other year with nonsolanaceous crop
	Bacterial Canker	3–4 years
	Bacterial Spot	2 years; do not plant peppers
	Early Blight	3–4 years
	Wilt	4–6 years
Turnip and Rutabaga	Black Root Rot	3 years, do not plant any crucifers during this period
	Club Root	6–7 years; do not plant crucifers; adjust pH to 6.8
	Powdery Mildew	1 year
Winter Squash & Pumpkin	Alternaria Leaf Blight	2–3 years, do not plant any cucurbits during this period
	Angular Leaf Spot	2 years
	Crown and Foot Rot (Fusarium Root Rot)	3–5 years, plant no cucurbits
	Gummy Stem Blight (Black Rot)	2–3 years, plant no cucurbits
	Phytophthora Blight	3 years; do not plant tomato, pepper, eggplant, or cucurbits
	Pythium Root Rot	2 years
	Scab (Gummosis)	2–3 years, plant no cucurbits
	Sclerotinia Stem Rot	2–3 years, do not plant potatoes

Table 5 courtesy of Debra A. Inglis and Babette Gundersen, WSU-Mount Vernon REC Vegetable Pathology Program, and Carol Miles, WSU-Vancouver REU Agricultural Systems Program. Based on crop rotation recommendations listed in the 2000 PNW Plant Disease Control Handbook. Adapted from A.A. McNab and T.A. Zitter, Do Rotations Matter Within Disease Management Programs, Cornell Cooperative Extension of Oswego County.

Rotating Vegetable Crops. The primary reason to rotate vegetables in the garden is for disease prevention. As a general rule, rotate crops based on family, as many crops in the same family are often hosts to the same diseases. For example, potato and tomato, both in the Solanaceae family, are affected by *Phytophthora infestans*, commonly called Late Blight. Therefore, do not plant potatoes in the bed or area where the previous year you had tomatoes. The families of common vegetable crops are presented in Table 6.

Table 6. Families of common vegetable crops.

Family Name	Common name, *Genus and species*
Aizoaceae	
	New Zealand spinach, *Tetragonia expansa*
Apiaceae	
	carrot, *Daucus carota* var. *sativa*
	celeriac, *Apium graveolens* var. *rapaceum*
	celery, *Apium graveolens* var. *dulce*
	dill, *Anethum graveolens*
	fennel, *Foeniculum vulgare*
	parsley, *Petroselinum crispum*
	parsnip, *Pastinaca sativa*
Asteraceae	
	artichoke, *Cynara scolymus*
	cardoon, *Cynara cardunculus*
	chicory, *Cichorium intybus*
	dandelion, *Taraxacum officinale*
	endive, *Cichorium endivia*
	Jerusalem artichoke, *Helianthus tuberosus*
	lettuce, *Lactuca sativa*
Brassicaceae/Cruciferaceae	
	broccoli, *Brassica oleracea* var. *italica*
	bok choy, *Brassica chinensis*
	Brussels sprouts, *Brassica oleracea*, var. *gemmifera*
	cabbage, *Brassica oleracea* var. *capitata*
	cauliflower, *Brassica oleracea* var. *botrytis*
	Chinese cabbage, *Brassica chinensis* or *pekinensis*
	collard, *Brassica oleracea* var. *viridis*
	cress, *Lepidium sativum*
	horseradish, *Armoracia rusticana*
	kale, *Brassica oleracea* var. *viridis*
	kohlrabi, *Brassica oleracea* var. *gongylodes*
	mustard, *Brassica juncea*
	radish, *Raphanus sativus*
	rutabaga, *Brassica campestris* var. *napobrassica*
	turnip, *Brassica rapa*

Family Name	Common name, *Genus and species*
Chenopodiaceae	
	beet, *Beta vulgaris*
	chard, *Beta vulgaris* var. *cicla*
	spinach, *Spinacia oleracea*
Cucurbitaceae	
	cucumber, *Cucumis sativus*
	gherkin, *Cucumis anguria*
	muskmelon/cantaloupe, *Cucumis melo*
	pumpkin, *Cucurbita pepo*
	summer squash, *Cucurbita pepo* var. *melopepo*
	watermelon, *Citrullus lanatus*
	winter squash, *Cucurbita maxima* or *moschata*
Fabaceae	
	bean, broad *Vicia faba*
	bean, dry *Phaseolus vulgaris*
	bean, Lima *Phaseolus limensis*
	bean, scarlet runner *Phaseolus coccineus*
	bean, snap *Phaseolus vulgaris*
	edamame, *Glycine max*
	pea, *Pisum sativum*
Liliaceae	
	asparagus, *Asparagus officinalis* var. *altilis*
	chive, *Allium schoenoprasum*
	garlic, *Allium sativum*
	leek, *Allium porrum*
	onion, *Allium cepa*
	shallot, *Allium ascalonicum*
	Welsh onion, *Allium fistulosum*
Poaceae	
	sweet corn, *Zea mays* var. *rugosa*
Solanaceae	
	eggplant, *Solanum melongena*
	husk tomato, *Physalis pubescens*
	pepper, *Capsicum frutescens*
	potato, *Solanum tuberosum*
	tomato, *Solanum lycopersicum*
Valerianaceae	
	corn salad, *Valerianella olitoria* or *locusta*

Planting

Seeds can be sown outside directly in the garden or started earlier inside to be set out as transplants. Table 7 provides recommended plant spacing information for many vegetable crops. In row cropping, the between-row spacing is generally quite a bit wider than the in-row spacing. In raised beds, plants are grown with the same spacing between the rows as within the rows. This results in more plants per square foot in a raised bed, compared with row cropping, and this is the reason why raised beds are commonly used for intensive gardens.

Table 7. Recommended planting depth and spacing, days to germination, and germination light requirements of common vegetable crops.

	Seeds		Seeding Distance			
Vegetable	Depth to Plant (inch)	No. to Sow (per ft)	Within Row (inch)	Between Rows (inch)	No. Days to Germinate	Needs Light to germinate
Asparagus	1 1/2		18	36	7–21	–
Beans: snap bush	1 1/2–2	6–8	2–3	18–30	6–14	–
snap pole	1 1/2–2	4–6	4–6	36–48	6–14	–
Lima bush	1 1/2–2	5–8	3–6	24–30	7–12	–
Lima pole	1 1/2–2	4–5	6–10	30–36	7–12	–
Fava (broad bean) Winsor bean	2 1/5	5–8	3–4	18–24	7–14	–
Garbanzo (chick pea)	1 1/2–2	5–8	3–4	24–30	6–12	–
Scarlet runner	1 1/2–2	4–6	4–6	36–48	6–14	–
Soybean	1 1/2–2	6–8	2–3	24–30	6–14	–
Beets	1/2–1	10–15	2	12–18	7–10	–
Black-eye cowpea (Southern peas)	1/2–1	5–8	3–4	24–30	7–10	–
Yardlong bean (Asparagus bean)	1/2–1	2–4	12–24	24–36	6–13	–
Broccoli	1/2	10–15	14–18	24–30	3–10	–
Brussels sprouts	1/2	10–15	12–18	24–30	3–10	–
Cabbage	1/2	8–10	12–20	24–30	4–10	–
Cabbage, Chinese	1/2	8–16	10–12	18–24	4–10	–
Cardoon	1/2	4–6	18	36	8–14	–
Carrot	1/2	15–20	1–2	14–24	10–17	–
Cauliflower	1/2	8–10	18	30–36	4–10	–
Celeriac	1/8	8–12	8	24–30	9–21	–
Celery	1/8	8–12	8	24–30	9–21	Yes
Celtuce-Asparagus lettuce	1/2	8–10	12	18	4–10	–
Chard, Swiss	1	6–10	4–8	18–24	7–10	–
Chicory-Witloof (Belgian endive)	1/4	8–10	4–8	18–24	5–12	Yes
Chives	1/2	8–10	8	10–16	8–12	–
Chop suey greens (Shungiku)	1/2	6	2–3	10–12	5–14	–
Collards	1/4	10–12	10–15	24–30	4–10	–
Corn, sweet	2	4–6	10–14	30–36	6–10	–
Corn salad	1/2	8–10	4–6	12–16	7–10	–
Cress, garden	1/4	10–12	2–3	12–16	4–10	Yes
Cucumber	1	3–5	12	48–72	6–10	–
Dandelion	1/2	6–10	8–10	12–16	7–14	Yes

Vegetable	Seeds: Depth to Plant (inch)	Seeds: No. to Sow (per ft)	Seeding Distance: Within Row (inch)	Seeding Distance: Between Rows (inch)	No. Days to Germinate	Needs Light to germinate
Eggplant	1/4–1/2	8–12	18	36	7–14	–
Endive	1/2	4–6	9–12	12–24	5–9	–
Fennel, Florence	1/2	8–12	6	18–24	6–17	–
Garlic	1		2–4	12–18	6–10	–
Ground cherry husk tomato	1/2	6	24	36	6–13	–
Horseradish: division			10–18	24		–
Jerusalem artichoke: tubers	4		15–24	30–60		–
Kale	1/2	8–12	8–12	18–24	3–10	–
Kohlrabi	1/2–1	8–12	3–4	18–24	3–10	–
Leeks	1/4–1/2	8–12	2–4	12–18	7–12	–
Lettuce: head	1/4–1/2	4–8	12–14	18–24	4–10	Yes
leaf	1/4–1/2	8–12	4–6	12–18	4–10	Yes
Muskmelon	1	3–6	12	48–72	4–8	–
Mustard	1/2	8–10	2–6	12–18	3–10	Yes
Nasturtium	1/2–1	4–8	4–10	18–36		–
Onion: sets	1–2		2–3	12–24		–
plants	2–3		2–3	12–24		–
seed	1/2	10–15	2–3	12–24	7–12	–
Parsley	1/4–1/2	10–15	3–6	12–20	14–28	–
Parsnips	1/2	8–12	3–4	16–24	15–25	–
Peas	2	6–7	2–3	18–30	6–15	–
Peanut	1 1/2	2–3	6–10	30		–
Peppers	1/4	6–8	18–24	24–36	10–20	–
Potato: tubers	4	1	12	24–36	8–16	–
Pumpkin	1–1 1/2	2	30	72–120	6–10	–
Radish	1/2	14–16	1–2	6–12	3–10	–
Rutabaga	1/2	4–6	8–12	18–24	3–10	–
Salsify	1/2	4–6	2–3	16–18		–
Salsify, black	1/2	8–12	2–3	16–18		–
Shallot: bulb	1		2–4	12–18		–
Spinach:	1/2	10–12	2–4.	12–14	6–14	–
Malabar	1/2	4–6	12	12	10	–
New Zealand	1 1/2	4–6	18	24	5–10	–
Tampala	1/4–1/2	6–10	4–6	24–30		–
Squash: summer	1	4–6	16–24	36–60	3–12	–
winter	1	1–2	24–48	72–120	6–10	–
Sunflower	1	2–3	16–24	36–48	7–12	–
Sweet potato: plants			12–18	36–48		–
Tomato	1/2		18/–36	36–60	6–14	–
Turnip	1/2		1–3	15–18	3–10	–
Watermelon	1	14–16	12–16	60	3–12	–

There are several planting schemes or designs for vegetable beds (Figure 2). A single row is generally used for large crops such as corn and tomatoes, but a double row can also work well for these crops and can save space. In bed planting, offset the rows so that the maximum number of plants are fitted into the bed and the bed space is fully utilized.

There are several other ways you can maximize your garden space usage. First, interplant a slow-growing crop such as tomatoes, broccoli, or peppers with a fast-growing crop such as radish or lettuce. After you harvest the fast-growing crop, the slow-growing crop will fill the space. Second, when you direct seed or transplant crops such as lettuce, beets, or spinach, you can plant heavily and later thin plants to their final spacing after they have become established. The thinned plants can be eaten rather than discarded. And third, you can maximize your garden space by interplanting shallow-rooted crops with deep-rooted crops (Table 8).

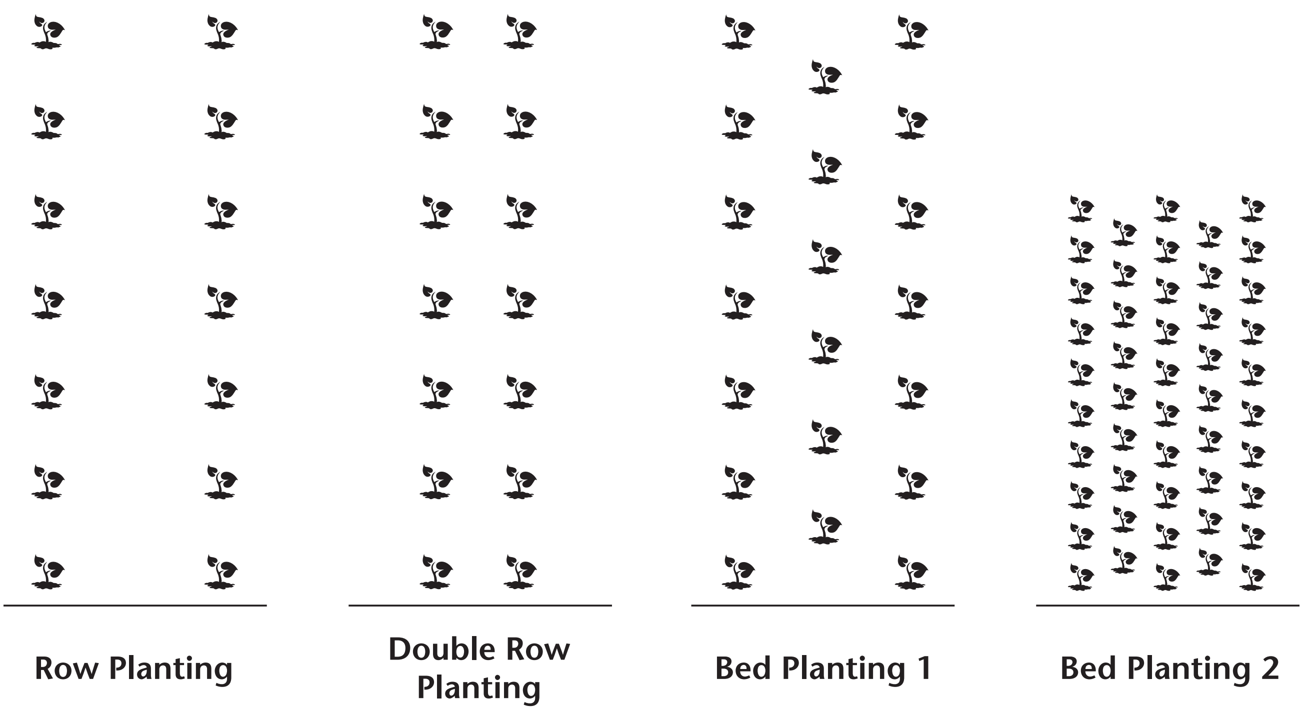


Figure 2. Row and bed planting designs for vegetable crops. Bed Planting 1 is used for larger crops such as tomatoes and broccoli while Bed Planting 2 is used for smaller crops such as radishes, lettuce, and onions.

Table 8. Average rooting depth of some common vegetable crops.

Shallow Rooting (1 ft or less)	Medium Rooting (1–3 ft)	Deep Rooting (3–6 ft or more)
Broccoli	Bean (bush & pole)	Artichoke
Brussels sprout	Beet	Asparagus
Cabbage	Carrot	Lima bean
Cauliflower	Chard	Muskmelon
Celery	Cucumber	Pumpkin
Chinese cabbage	Eggplant	Squash (winter)
Garlic	Honeydew melon	Sweet potato
Leek	Mustard	Tomato
Lettuce	Pea	Watermelon
Onion	Pepper	
Potato	Rhubarb	
Radish	Rutabaga	
Spinach	Squash (summer)	
Sweet corn	Turnip	

Direct Seeding. Plant seeds of your vegetable crops directly into the ground when soil temperatures are within the optimum range for good germination (Table 9). Some crops such as cabbage, carrot, cauliflower, lettuce, pea, radish, and spinach will germinate when soil temperatures are quite low (40–45°F), but all crops germinate best when soil temperatures are quite warm (around 75°F). All cucurbit crops (cucumbers, melons, and squash) and solanaceous crops (tomatoes, peppers, eggplants) will not germinate well unless soil temperatures are warm (at least 65–70°F). Regardless of the crop, do not seed into cold, wet soil because the disease incidence under these conditions can be quite high. Some crops such as carrots and turnips do not transplant well and so it is always best to direct seed them.

All vegetable crops germinate best when soil temperature is warm, about 75°F.

Table 9. Minimum, maximum, and optimum soil temperatures for vegetable seed germination (Source: Knott's Handbook for Vegetable Growers).

Vegetable	Minimum (°F)	Optimum Range (°F)	Optimum (°F)	Maximum (°F)
Asparagus	50	60–85	75	95
Bean	60	60–85	80	95
Bean, Lima	60	65–85	85	85
Beet	40	50–85	85	95
Cabbage	40	45–95	85	100
Carrot	40	45–85	80	95
Cauliflower	40	45–85	80	100
Celery	40	60–70	70	85
Chard	40	50–85	85	95
Corn	50	60–95	95	105
Cucumber	60	60–95	95	105
Eggplant	60	75–90	85	95
Lettuce	35	40–80	75	85
Muskmelon	60	75–95	90	100
Okra	60	70–95	95	105
Onion	35	50–95	75	95
Parsley	40	50–85	75	90
Parsnip	35	50–70	65	85
Pea	40	40–75	75	85
Pepper	60	65–95	85	95
Pumpkin	60	70–90	90	100
Radish	40	45–90	85	95
Spinach	35	45–75	70	85
Squash	60	70–95	95	100
Tomato	50	60–85	85	95
Turnip	40	60–105	85	105
Watermelon	60	70–95	95	105

As a general rule, the planting depth for most seeds is equal to twice the size of the seed. The planting depth for most small-seeded crops is $^1/_8$ to ½ inch, while large-seed crops are generally planted 1–2 inches deep. Refer back to Table 7 for recommended planting depths for many specific vegetable crops. Seed large crops in rows, and place 2 seeds per planting hole (thinning one if both emerge) to ensure that you attain the correct plant stand (number of plants in a given area). Small crops such as radish can be sown close together in rows or broadcast seeded.

Growing Transplants. Using transplants enables you to get a jump on the season and perhaps try some varieties and crops that might not otherwise mature in our relatively cool summer climate. Many small-seeded crops such as lettuce, tomatoes, basil, etc., do better as transplants than when direct seeded because they tend to be susceptible to adverse environmental conditions and seedling diseases.

Plant seeds for transplants 4 to 6 weeks prior to the date when you plan to set them out in the garden. Refer to Table 7 for more specific information regarding the number of weeks needed to produce transplants of specific crops. Sow large-seeded crops directly into the final transplant pot. Sow small-seeded crops very close together in seeding trays to conserve space and "prick out" seedlings into larger transplant pots after the cotyledons have fully emerged. Do not allow transplants to become root bound, especially cucurbits (melons, cucumbers, and pumpkins) as plants can become permanently stunted.

Use a disease- and weed-free potting medium to grow transplants. Although it is possible to use garden soil or compost to make your own potting mix, it is generally not recommended. Garden soil and compost tend to contain weed seeds, insects, and diseases, and soil forms a crust and drains poorly under transplant growing conditions.

Use disease-free seed to prevent seedling disease problems. If you wish to use seed that you have saved from your own garden, only save seed from healthy, disease-free, and non-hybridized plants.

If you are using recycled or previously used seeding trays or pots, first wash them in a 10% bleach solution and scrub them clean. Rinse in clean water to remove bleach residue.

Fill transplanting trays or pots with potting medium and press down the medium so that it is compact. Saturate the potting medium with water and allow any excess moisture to drain out. Plant seeds at the recommended depth, and place trays or pots into a clear plastic bag. Close the bag with a clothespin to conserve moisture, and in this way you will not need to water the trays or pots as long as they are in the bag (Figure 3).

Observe germination through the clear bag, and when 50% of the seedlings have emerged in any pot or tray, remove that tray or pot from the bag. If seedlings are left in the moist, humid environment of the sealed bag, they will likely develop foliar and root disease problems. After you have removed the trays or pots from the bag, water lightly once a day or as needed to maintain moist, but not saturated, soil conditions.

To optimize time to emergence and plant vigor, grow transplants at the appropriate temperature for each crop type. Cooler temperature will result in greater incidence of disease, while hot temperatures can result in spindly seedlings.

Transplant seedlings after 2–4 true leaves have emerged.

Figure 3. A simple "conservatory" made from a clear plastic bag: planting medium is well moistened first, pots are seeded with 1 variety each (up to 6–8 seeds per pot), and bag is sealed with a clip to conserve moisture.

Hardening Off. Before transplanting, "harden" transplants to better enable them to withstand transplant shock that results from new exposure to outdoor growing conditions: low temperatures and drying winds, plus the root injury and moisture stress that occurs during transplanting. Plants that are hardened off have a temporarily decreased growth rate, which enables the plant to store energy. Common hardening treatments include reduced watering and exposure to cold temperatures, and a combination of these two is better than either one alone.

In the one to two weeks prior to transplanting, gradually reduce watering, but do not allow plants to dry out suddenly or develop severe wilting. Set plants outside during the day in the first week and for the entire day and night in the second week—make sure plants are covered at night to avoid cold damage. Hardening temperatures should be just 5–10°F less than the inside growing temperatures. Do not apply fertilizer immediately before or during hardening. At transplanting, water and fertilize plants well to encourage quick plant establishment and growth.

Planting Schedule. Recommended dates for direct seeding and transplanting vary across the state and depend on minimum temperatures and type of vegetable crop. See Table 10a for a suggested planting schedule for Western Washington, and Table 10b for recommended planting schedule for Eastern Washington. As always, the best way to determine what dates work best in your area is to experiment and talk with other gardeners.

Table 10a. Suggested planting calendar for vegetable crops in Western Washington. Specific dates will vary by location and microclimate.

Table 10a. (continued) Suggested planting calendar for vegetable crops in Western Washington. Specific dates will vary by location and microclimate.

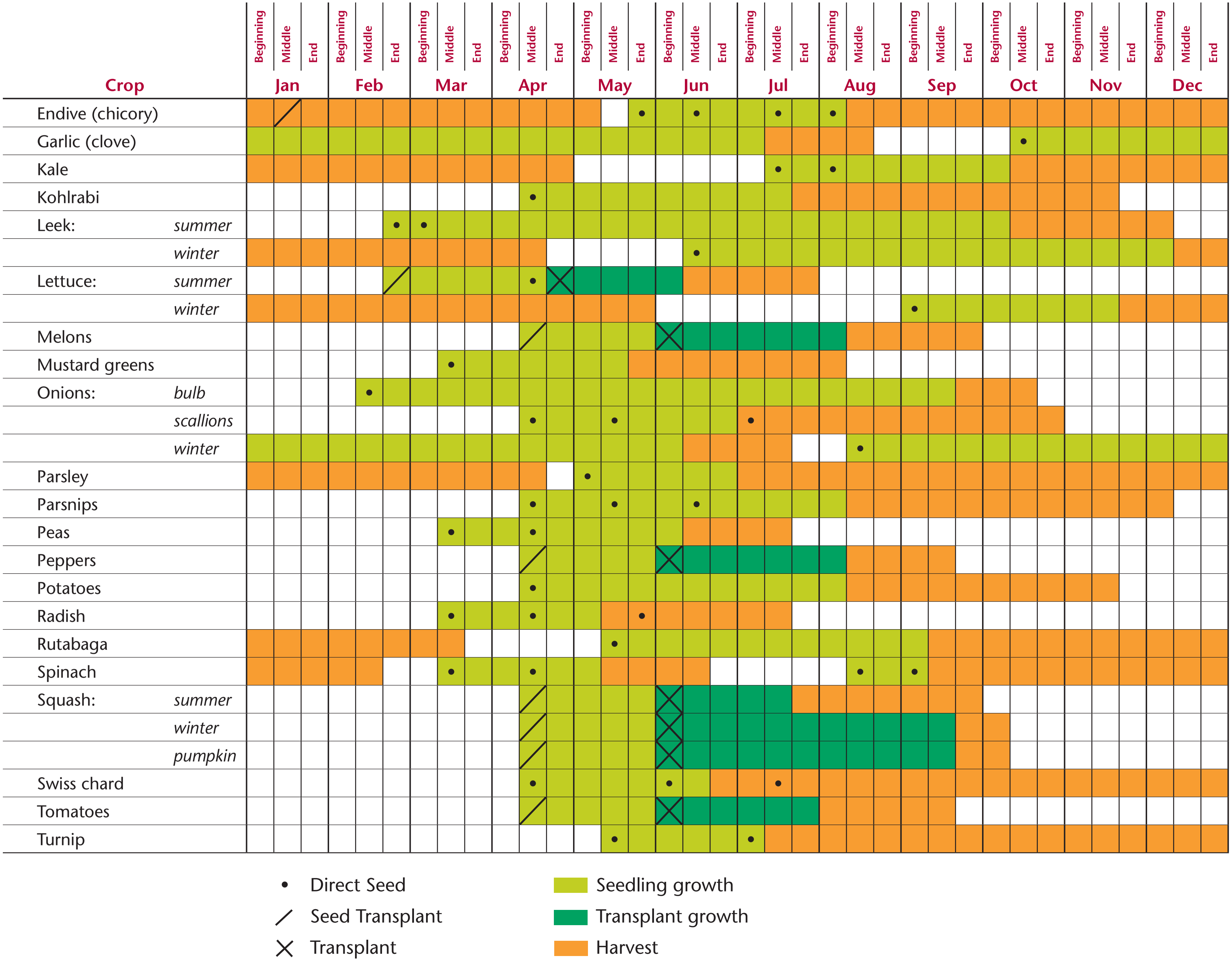


Table 10b. Suggested planting calendar for vegetable crops in Eastern Washington. Specific dates will vary by location and microclimate.

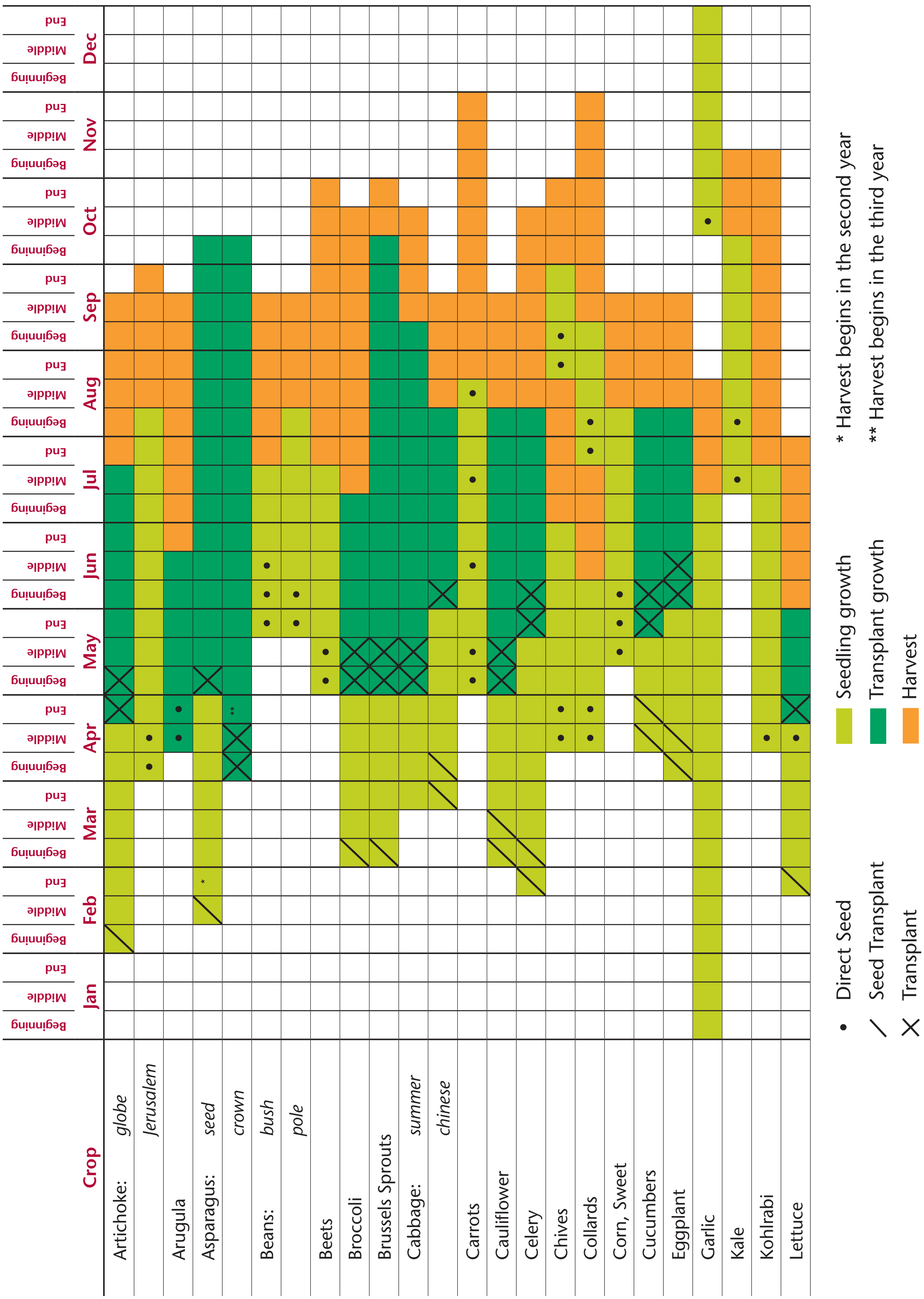
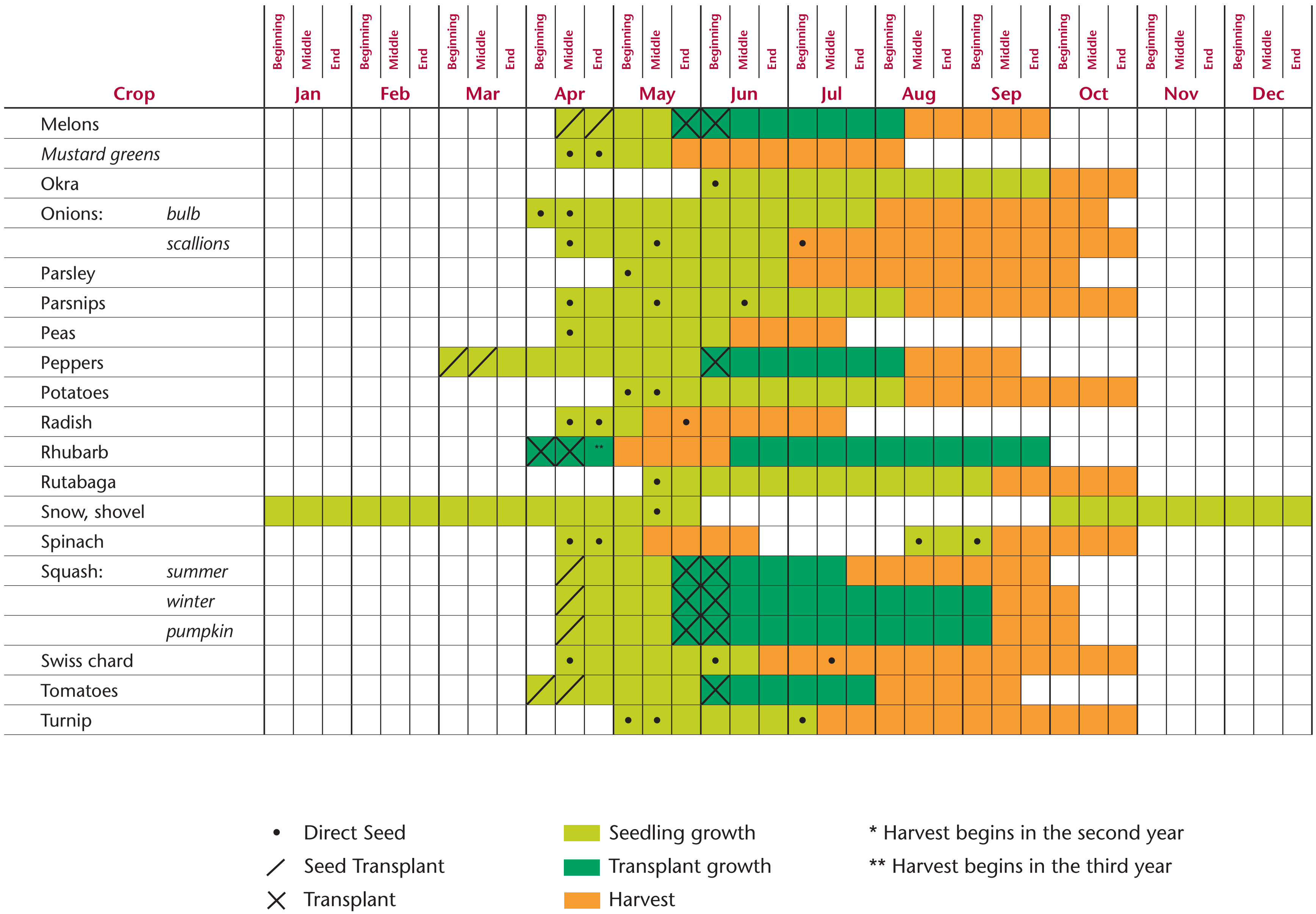


Table 10b. (continued) Suggested planting calendar for vegetable crops in Eastern Washington. Specific dates will vary by location and microclimate.



Maintenance

Plant Nutrition

Plants require macro- and micronutrients to grow well and be productive. For fertilizer information and application methods, refer to Chapter 5: Plant Mineral Nutrition and Fertilizer.

If you are adding compost to your garden each year, you may be adding sufficient levels of most macro- and micronutrients for adequate crop growth. To determine if your soil has appropriate nutrient levels to meet the needs of your vegetable crops, have your soil tested every 3 to 4 years. If your soil is low in one or more nutrients, add the appropriate fertilizer at the recommended rate to meet your crop needs. If the level of any nutrient in your soil is above the recommended level, reassess your practices so that you do not continue to add that nutrient. For example, compost made from dairy manure tends to be high in phosphorus (P) while compost made from poultry manure tends to be high in potassium (K).

Remember that soil pH affects nutrient availability. In acid soils (at low soil pH), nutrients are not readily available for uptake by most vegetable crops. To increase nutrient availability, maintain a soil pH between 6.0 and 7.0. If you are adding compost to your garden each year, the organic matter will act slowly to increase soil pH. If your soil pH is still too low, add agricultural lime at the rate of about 6 pounds (12 cups) per 100 square feet for most soils. For clay soils, add 8 pounds of lime, and for sandy soils add 4 pounds. Lime does not react quickly in the soil and it takes at least half a year to be effective. In addition, water is needed to activate the lime; therefore it is best to apply lime in the fall. Lime is rarely needed in Eastern Washington.

Watering

Summers are quite dry throughout Washington, and you need to be prepared to water your vegetable garden from May through September. The amount of water and method of irrigation you use will often determine the success of your vegetable garden. The following is a guide to help you determine how best and how frequently to water.

Timing. If you are using an overhead sprinkler, irrigate in the early mornings so that foliage can dry off before cool evening temperatures occur. Disease potential is increased when foliage remains wet during the night. If you use soaker hoses or drip irrigation, irrigate in the late afternoon or evening. By watering at the end of the day, more water will be absorbed into the soil and less water will be lost due to evaporation and transpiration, thereby increasing irrigation efficiency. Regardless of your irrigation method, do not irrigate in the heat of the day (11 am to 2 pm), as excessive evaporation loss and foliage burn will occur. Windy weather is also a poor time to water due to increased evaporation rates.

Sprinkler Irrigation. Sprinkler irrigation is generally the least expensive and the simplest irrigation method for home vegetable gardens, but unfortunately it is also the least efficient. With a sprinkler, the entire garden area is watered and thus the total amount of water used to irrigate is much greater. Evaporation loss is also larger when the water is broadcast into the air. Weeds are also being watered, which leads to greater weed growth. In addition, diseases are encouraged by wet foliage and can be transferred to neighboring plants by splashes of water.

Soaker Hoses. Soaker hoses are much more efficient than sprinkler systems and can reduce water use by up to 50%. Soaker hoses can be flat or round, and they have tiny holes through which water leaks or seeps out. Evaporation, runoff, and weed growth are reduced by nearly a half, while water application to the vegetable crop is optimized. The occurrence of foliar plant diseases is also substantially reduced with the use of soaker hoses.

Drip Irrigation. The water efficiency and plant health benefits of drip irrigation are quite similar to those of soaker hoses, but drip lines tend to be more complex and expensive to install and operate. Depending on the size of the irrigation system, gauges and water-pressure reducers may be required. When selecting drip lines for your garden, it is important to choose ones with the appropriate emitter spacing. The emitter is the hole in the tape or hose where the water comes out. Use an emitter spacing of 9 inches for a continuous row (as with radishes, beans, peas). Choose a wider emitter spacing to match the plant spacing for those crops that are spaced far apart; for instance, 18 inches for tomatoes, peppers, broccoli and 36 inches for squashes, cucumbers, melons.

Frequency. Water seedlings and transplants in the garden gently and frequently (every 2 to 3 days, depending on rainfall) for the first week or two. Apply approximately ¼ inch of water in each application. Thereafter, irrigate once a week or as needed and apply 1 inch of water at each application. Shallow watering encourages shallow root growth, resulting in plants that are inefficient in water uptake and are less drought tolerant. To determine the amount of water applied, see Calculating Amount to Irrigate, below.

Rate. Irrigation is most effective when applied at approximately ½ inch or less of water per hour. A faster rate will cause runoff. If you begin to see runoff or puddling, turn off the irrigation and resume watering in about an hour.

Rain Gauges. Observe and note any rainfall that your garden receives. Adjust irrigation accordingly so that rainfall plus irrigation equals 1 inch per week.

Calculating Amount to Irrigate. The amount of water that vegetable crops need is usually given in inches. For example, most vegetable crops require 1 inch of water (per square foot) every week. You can use indicators such as depth of soil moisture to determine if you have applied the right amount of water or you can measure and calculate the actual amount of water you apply.

The easiest method for determining how long to irrigate is to simply use a shovel to check the depth of moisture in the soil, and adjust your watering schedule accordingly. For most clay and loam soils, 1 inch of water will penetrate about 6 inches deep. Measure the amount of time it takes for your first irrigation to wet the soil to a depth of 6 inches, and this is the amount of time it takes to apply 1 inch of water. Irrigate again for this same amount of time when the top 1–2 inches of soil is dry. After several weeks of irrigation, the soil should be moist throughout the root zone. At this point, you will only need to check the top 4–6 inches to see the soil moisture level.

1 inch of water per square foot equals 0.62 gallons

It is helpful to know that 1 inch of water per square foot equals 0.62 gallons. If you are watering by hand, apply 0.62 gallons per plant per week for those plants that are spaced more than a foot apart, or apply this same amount of water per linear foot of row for those crops that are spaced close together.

To measure the amount of water you are applying with a sprinkler, place a bucket near one of the vegetable plants. Measure the depth of the water in the bucket after one hour; this will be the amount in inches that the plant received in that hour. Or, measure the volume of water in the bucket, and this will be the amount in gallons that the plant received. Use this measurement to determine how long to keep your sprinkler system on so that plants receive 1 inch of water.

If you are using a sprinkler, measure the area (in square feet) of the garden that will be reached by the sprinkler. Multiply this number by the number of inches of water needed (1 inch in most cases), and then multiply by 0.62 (1 inch of water per square foot = 0.62 gal). This will give you the total number of gallons you need to apply. Divide the total number of gallons that you need to apply by the gallons-per-hour rate of your irrigation system to determine the irrigation time.

Soaker hoses vary slightly in the amount of water they deliver, but in general they emit approximately 0.1 gallon per linear foot per hour. Soaker hoses generally wet an area of 6 inches on either side of the hose, or a 1-foot total width. You would need to irrigate six hours in order to apply the amount of water that is needed (0.62 gallon per square foot). You can measure the amount of water delivered by your soaker hose or drip tape by placing a container under the hose or tape. The volume of water in the container at the end of an hour tells you the number of gallons of water the plant is receiving. Or you can place the entire hose or tape in a small wading pool to measure the total amount of water applied.

Winter Gardening

In Western Washington, crops listed as hardy (refer back to Table 2) can be grown without cold protection while crops listed as half-hardy do best with protection. In Central and Eastern Washington, cold protection is needed for most vegetable crops.

The two most common materials used for cold protection to extend the growing season are fabric row covers and clear plastic. Fabric row covers come in different weights and can increase day temperatures by 4–8°F. Lighter fabric row covers (0.45–0.55 oz/sq yd) are generally promoted as insect barriers and are not recommended for winter use. Heavier fabric row covers (0.9–1.5 oz/sq yd) are used for frost protection.

Day temperatures under greenhouse-grade clear plastic (6 ml) can be 10–20°F greater than outside temperatures on a clear, sunny day. Night temperatures under bug-shield row covers and plastic tend to be equal to outside temperatures. Do not place row cover or plastic so they are touching plants, because frost damage can occur where the fabric or plastic comes into contact with the plant. Construct a cloche by shaping metal or PVC hoops and laying the row cover or plastic over these hoops (Figure 4).

Figure 4. Movable garden winter cloche (a small "hoop house") made from PVC hoops and greenhouse-grade plastic.

Saving and Storing Vegetable Seeds

When saving seeds from your own garden, choose seeds from healthy non-hybridized plants. Seeds from hybrid cultivars do not produce plants with the same traits as the parent plants. Also, for open-pollinated plants, unless you can control cross-pollination, the seeds you collect may produce hybridized plants.

If you plan to dry and store vegetable seeds, you will need to control the seed moisture and to store seeds at moderate temperatures. High moisture and temperature cause rapid seed deterioration and loss of seed viability. The longer seeds are stored, the more important moisture and temperature conditions become.

An ideal method of drying seed is a food dryer/dehydrator at a very low temperature setting. It is essential that a fan blows air away from the seed to prevent heat from building up around the seed. To reduce seed moisture, dry seed at temperatures of 110–120°F. For small seeds, drying time may be 1 hour while large seeds may require 3 hours. Drying time will depend on the starting seed moisture content, the thickness of seed being dried, whether or not the seed is still in the pod, and the volume and dryness of the air.

Once the seed is dried, seed moisture will reach equilibrium with the surrounding atmosphere in a few weeks: 3 weeks for small seeds and up to 6 weeks for large seeds. To maintain low seed moisture, store dried seed in an airtight container with desiccant such as calcium chloride or silica gel. Re-dry the desiccant as needed.

Ideally, seed moisture should be maintained at around 12%, and storage temperatures should be about 50°F. Under these conditions, seed of most vegetable crops can be stored for several years (Table 11).

For much more in-depth information regarding saving and storing seed, we recommend the publication "Seed to Seed" (listed in the Further Reading section at the end of this chapter).

Table 11. Approximate life expectancy of vegetable seeds stored under favorable moisture and temperature conditions.

Vegetable	Years	Vegetable	Years
Asparagus	3	Kohlrabi	3
Bean	3	Leek	2
Beet	4	Lettuce	6
Broccoli	3	Muskmelon	5
Brussels sprouts	4	Mustard	4
Cabbage	4	New Zealand spinach	3
Cardoon	5	Okra	2
Carrot	3	Onion	1
Cauliflower	4	Parsley	1
Celeriac	3	Parsnip	1
Celery	3	Pea	3
Chard, Swiss	4	Pepper	2
Chervil	3	Pumpkin	4
Chicory	4	Radish	5
Chinese cabbage	3	Rutabaga	4
Collards	5	Salsify	1
Corn, sweet	2	Sea Kale	1
Corn salad	5	Sorrel	4
Cress, garden	5	Southern pea	3
Cress, water	5	Spinach	3
Cucumber	5	Squash	4
Eggplant	4	Tomato	4
Endive	5	Turnip	4
Fennel	4	Watermelon	4
Kale	4		

Further Reading

WSU Extension Publications available at: http://cru84.cahe.wsu.edu/

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