MASTER GARDENER
COLORADO STATE UNIVERSITY
EXTENSION

Vegetables

Learning Objectives

At the end of this unit, the student will be able to:

- Describe block style layout in a raised bed garden design.
- Describe garden planning and planting times.
- Describe soil preparation and fertilization for the vegetable garden.
- Describe routine garden care including mulching, irrigation, and water conservation.
- Describe routine care for tomatoes.
- List hints for growing other vegetables.
- Describe frost protection and microclimate modification.

Vegetables Curriculum developed David Whiting (CSU Extension, retired), Carol O'Meara (CSU Extension, Boulder County) and Carl Wilson (CSU Extension, retired)

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- Extension programs are available to all without discrimination.
- No endorsement of products named is intended, nor is criticism implied of products not mentioned.

Revised October 2014

References / Reading

Colorado State University Cooperative Extension

CSU Extension Fact Sheets

- Eggplants – Peppers and Eggplant – #7.616
- Flea Beetle – #5.592
- Grasshopper Control in Yards and Gardens – #5.536
- Herbs – Growing, Preserving and Using Herbs – #9.335
- Horticultural Oils – #5.569
- Insects – Flea Beetle – #5.592
- Insects – Grasshopper Control in Yards and Gardens – #5.536
- Insects – Greenhouse Whitefly – #5.587
- Insects – Potato or Tomato Psyllids – #5.540
- Insects – Squash Bug Management - #5.609

- Peppers and Eggplant – #7.616
- Potatoes Seeds – Saving Seeds – #7.602
- Preventing E. coli From Garden to Plate – #9.369
- Psyllids – Potato or Tomato Psyllids – #5.540
- Seeds – Growing Plants from Seed – #7.409
- Seeds – Home Storage of Vegetable and Flower Seeds – #7.221
- Storage of Home-Grown Vegetables – #7.601
- Tomatoes – Recognizing Tomato Problems – #2.949
- Vine Crops – Cucumbers, Pumpkins, Squash, and Melons – #7.609

Review Questions

1. Describe how adding organic matter improves a sandy garden soil. A clayey garden soil.

2. List techniques to manage soil compaction in the vegetable garden.

3. What are the limitations on using manure and compost made with manure in the vegetable garden?

4. Describe the pros and cons of homemade compost, of commercial compost.

5. Describe the standard application rate for compost. How does it change with incorporation depth and potential for salts in the product?

6. If the soil is low in organic matter, will a routine application of compost and/or manure supply the nitrogen needs for crops? Explain why.

7. How the fertilizer application rate change based on soil organic content?

8. What is the purpose of a starter fertilizer? List examples of common fertilizers that could be used as a starter fertilizer.

9. What is nitrogen side dressing? List examples of common fertilizers that could be used for side-dressing.

10. In Colorado, what types of soils will likely have deficiencies of phosphorus and potassium?

11. Why are the advantages of a block style garden layout? Of raised bed gardens?

12. Describe how to design a garden in block style layout.

13. Describe how to make a raised bed garden. How high should the beds be raised? In routine raised bed gardening, where are the crop's roots?

14. Explain "double digging".

15. Describe how to set up a soaker hose drip irrigation system in a raised bed garden.

16. Describe procedures and limitations on using grass clipping mulch in the vegetable garden.

17. Can wood/bark chip mulch be used in the vegetable garden? Explain.

18. List gardening techniques to conserve water in the vegetable garden. What happens to vegetable quality with inadequate water supplies?

19. What is the critical water period for various vegetables?

20. Describe the ideal tomato transplant. How should tall, leggy transplants be planted?

21. What are the advantages of trellising tomatoes? How far apart should tomatoes be spaced? Give examples of trellising methods.

22. What are the advantage and limitations on using black plastic mulch on tomatoes, peppers, eggplants and vine crops? Describe techniques for using plastic mulch.

23. Tomatoes are often referred to as being a "low nitrogen" crop. More correctly stated, they are fussy about nitrogen levels. Explain the fertilizer needs at planting and as the crop nears harvest.

24. Explain the management option for early blight on tomatoes. Will a fungicide stop the disease when leaves have turned yellow late summer?

25. Why will vine crops bloom but not set fruit?

26. When should beans be planted?

27. Beans have a higher water use than other vegetables. What happens when they get a little dry? How can you tell when bean plants need irrigation?

28. Explain the growing techniques for quality cole crops.

29. *Bacillus thuringiensis*, *Bt*, is the standard biological control approach for worms in cole crops. Describe the criteria in using *Bt*. (See fact sheet #5.556.)

30. What is isolation required in growing Super Sweet corn varieties?

31. Gardeners often list "poor quality" as the reason most don't grow leafy vegetables. What are the keys to great quality lettuce, spinach, chard, and other leafy vegetables?

32. What cultural practices are needed to compensate for the onion family's poor, inefficient root system?

33. What is the difference between English peas, snow or sugar peas, and snap peas?

34. Describe how to get potatoes off to a great start.

35. What are the different temperature requirements of hardy, semi-hardy, tender, and very tender vegetables?

36. How does a gardener know when to plant various crops?

37. In covering plants for frost protection, what is the heat source, i.e., where is the heat stored?

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CMG GardenNotes #711

Vegetable Gardens:

Soil Management and Fertilization

Outline:

In the garden, managing soils to improve ***tilth*** and garden ***fertilization*** are related but not necessarily the same process. For example, compost or manure may be added as a soil amendment to improve tilth; however, they may add nominal amount of plant nutrients. A manufactured fertilizer may be added to supplement soil fertility levels, but it will not improve a soil's tilth. For optimum yields and quality, gardeners need to pay attention to both soil management for improving tilth and soil fertilization.

> ***Tilth*** is a term related to the suitability of a soil to support plant growth. Technically speaking, tilth is "the physical condition of soil as related to its ease of tillage, fitness of seedbed, and impedance to seeding emergence and root penetration".

Soil Amendment or Fertilizer

The term ***soil amendment*** refers to any material mixed into a soil. By law, soil amendments make no legal claims about nutrient content or other helpful (or harmful) properties. Compost and manure are common soil amendments used to improve soil tilth. They may also supply nominal amounts of plant nutrients. Some of the nutrient effect seen from adding soil amendments is likely due to their effect on soil microorganisms. The organic material in soil amendments is a food source that allows microorganisms to multiply. The larger numbers increase the conversion of nutrients in the soil to plant usable forms.

Mulch refers to a material placed on the soil surface.

By law, the term ***fertilizer*** refers to a material that guarantees a minimum percentage of nutrients of nitrogen, phosphate, and potash. An ***organic fertilizer*** is

derived from natural sources and guarantees the minimum percentages of nitrogen, phosphate, and potash.

Soil Amendments

In the vegetable garden, the routine addition of organic soil amendments such as compost will optimize potential yields and quality. The goal in soil management is to increase the organic content to 4-5%, over a period of years.

Common amendments include compost, manure, compost made with manure, fall leaves, straw, and peat moss. Home compost has the advantage that the gardener controls what goes into the compost, reducing problems with salts, weed seeds, and plant diseases.

In climates with long growing seasons, another method to add organic matter is to grow green manure crops in between the vegetable growing season. In some areas, this would be a winter crop, in hot areas of the south this would be a summer heat crop. In areas like Colorado, where the entire growing season is used for vegetable production, a green manure is less practical. For additional information, refer to *CMG GardenNotes* #244, **Cover Crops and Green Manure Crops**.

How Organic Amendments Improve the Soil

On clayey soil, organic matter (over a period of years) glues the tiny soil particles together into larger aggregates, increasing pore space. This increases soil oxygen levels and improves soil drainage, which in-turn increases the rooting depth thereby allowing roots to reach a larger supply of water and nutrients.

On sandy soils, organic matter holds over ten times more water and nutrients than sand.

Organic matter also encourages the beneficial activity of soil organisms and helps remediate soil compaction.

Application

General application rates for compost or other organic soil amendments are based on the salt content of the materials and soil and on the depth to which it is cultivated into the soil. Ideally, cultivate the soil amendment into the top six to eight inches of the soil. On compacted/clayey soils, anything less can lead to a shallow rooting system with reduced plant growth, lower vigor, and lower stress tolerance.

Table 1 gives the standard application rate for compost. Compost made solely from plant residues (leaves and other yard wastes) is basically free of salt problems, and higher application rates are safe.

Compost, which includes manure or biosolids as a component, has a potential for high salt. Excessive salt levels are common in many commercially available products sold in Colorado. In compost made with manure or biosolids, the application rate is limited unless a soil test on that batch of product shows a low

salt level. An amendment with up to 10 dS/m (10 mmhos/cm) total salt is acceptable if incorporated six to eight inches deep in a low-salt garden soil (less than 1 dS/m or 1 mmhos/cm). Any amendment with a salt level above 10 dS/m (10 mmhos/cm) is questionable.

Note: dS/m or mmhos/cm is the unit used to measure salt content. It measures the electrical conductivity of the soil.

Table 1. Routine Application Rates for Compost

Site	**Incorporation Depth**[2]	**Depth of Compost Before iIncorporation**[1]	
		Plant Base Compost and other compost known to be low in salts[3]	**Compost Made with Manure or Biosolids** for which the salt content is unknown[4]
One-time application—such as lawn area	6-8 inches	2-3 inches	1 inch
	3-4 inches	1-1½ inches	½ inch
Annual application to vegetable and flower gardens – **first three years**	6-8 inches	2-3 inches	1 inch
	3-4 inches	1-1½ inches	½ inch
Annual application to vegetable and flower gardens – **fourth year and beyond**	6-8 inches	1-2 inches	1 inch
	3-4 inches	1 inch	½ inch

1 3 cubic yards (67 bushels) covers 1,000 square feet approximately 1 inch deep.
2 Cultivate compost into the top 6-8 inches of the soil. On compacted/clayey soils, anything less may result in a shallow rooting depth predisposing plants to reduced growth, low vigor and low stress tolerance. The 3-4" inch depth is shown as an illustration of how application rates need to adjust when the deep cultivate is not practiced.
3 Plant based composts are derived solely from plant materials (leaves, grass clippings, wood chips and other wards wastes). Use this application rate also for other compost known, by soil test, to be low in salts.
4 Use this application rate for any compost made with manure or biosolids unless the salt content is known, by soil test, to be low. Excessive salts are common in many commercially available products sold in Colorado. Based on soil tests of commercially available compost, this application rate may be too high for products extremely high in salts.

Compost needs to be thoroughly mixed into the upper six to eight inches of the soil profile. Do not leave compost in chunks, as this will interfere with root growth and soil water movement.

As the soil's organic content builds in a garden, the application rate should be reduced to prevent ground water contamination issues. A soil test is suggested every four to six years to establish a base line on soil organic matter content.

If using a green manure cover crop, till the cover crop in before it reaches four inches in height.

In the vegetable garden, do not plow in woody materials such as bark or wood chips. They may interfere with seedbed preparation and may result in soil nitrogen depletion.

Precautions When Using Compost and Manure

Manure, compost made from manure, and bio-solids may be high in salts that will interfere with crop growth. Do not add more than one inch per season without conducting a soil test to evaluate potential salt build-up.

Due to a health issue (*E coli* contamination), fresh manure additions should be made at least four months prior to the harvest of any edible crops. In other words, apply fresh manure only in the fall after crops are harvested.

Fresh manure or unfinished compost products may be high in ammonia. Avoid application of products with an ammonia smell; they could burn roots and leaves. Manure and compost may be source of weed seeds.

Nutrient Release Rates from Compost and Manure

Gardeners need to understand that the nutrient release from compost and manure is slow, taking years. Adding compost or manure to improve soil tilth is not the same as fertilizing.

The typical nitrogen release rates from manure is only 30 to 50% the first year (fresh manure), 15 to 25% the second year, 7 to 12% the third year, 3 to 6% the fourth year, and so on. With compost and composted manure, the release rate is even slower, 5 to 25% the first year, 3 to 12% the second year and 1 to 6% the third year.

Because the nitrogen percentage of compost and manure products is typically only 2 to 4%, the amount of actual nitrogen release to support crop growth is very small.

For soil with 4 to 5% organic matter, the mineralization (release) of nitrogen from soil organic matter will likely be sufficient for crop growth.

For soils with 2 to 3% organic matter, the mineralization of nitrogen from soil organic matter will not likely be sufficient for heavy feeding vegetable crops. Supplement with 0.1 pound nitrogen fertilizer per 100 square feet.

For the typical garden soil with 1% organic matter or less, the mineralization of nitrogen for soil organic matter will be minimal. Add 0.2 pounds of nitrogen fertilizer per 100 square feet.

Fertilization

Soil fertilization is the addition of soil nutrients to support crop growth. While some soil amendments add small amounts of nutrients, amending the soil to improve soil tilth is not the same as amending the soil to provide nutrients.

Manufactured fertilizers are popular with gardeners because they are readily available, inexpensive, easy to apply, and generally provide a quick release of nutrients for plant growth. Application rates for any fertilizer depend on the content and the amount of nutrient to be applied. **In products containing multiple nutrients, the application rate is always based on the nitrogen content.**

Nitrogen Applications

Nitrogen is the nutrient needed in largest quantities by plants and the one most frequently applied as fertilizer. It is annually applied in the form of manufactured fertilizer, organic fertilizers, and/or organic soil amendments. **Application rates are critical, because too much or too little directly affects crop growth**.

The standard annual application rate for home vegetable gardens is 2 pounds actual nitrogen per 1,000 square feet (0.2 pound actual nitrogen per 100 square feet). When organic matter is supplied, adjust the rate accordingly to account for nitrogen released by the organic matter. [Table 2]

Table 2. Standard Nitrogen Fertilizer Application Rates for Gardens

	Soil Organic Content		
	Typical garden soil low in organic matter (<2% organic matter)	Moderate level of organic matter (2-3% organic matter)	High level of organic matter (4-5% organic matter)
Nitrogen needed	**0.2 lb. actual N per 100 sq. ft.**	**0.1 lb actual N per 100 sq. ft**	**0**
Fertilizer examples			
Ammonium sulfate 21-0-0	1 lb. fertilizer per 100 sq. ft (approx. 2 cups)	0.5 lb. fertilizer per 100 sq. ft (approx. 1 cup)	0
OR			
Ammonium nitrate 34-0-0	0.6 lb. fertilizer per 100 sq. ft. (approx. 1 1/3 cups)	0.3 lb. fertilizer per 100 sq. ft (approx. 2/3 cup)	0
OR			
Urea, 45-0-0	0.4 lb. fertilizer per 100 sq. ft. (approx. 1 cup)	0.2 lb. fertilizer per 100 sq. ft (approx. ½ cup)	0

Manufactured nitrogen fertilizer can be broadcast and watered in, or broadcast and tilled into the top few inches of soil. It can be banded 3-4" to the side of the seed or plant row. Do not place the fertilizer in the seed row or root injury will occur. Some soluble types are applied in the irrigation water. "Organic" nitrogen fertilizers are typically tilled in or some can be applied in irrigation water.

Starters Fertilizers

In setting out transplants, starter solutions often promote early growth. Because transplants have been hardened-off (growth slowed to prepare the plant for movement to the exposed, windy, outdoor environment), the nitrogen in the starter solution gives the signal to resume active growth. Because phosphorus is less available in cold soils, phosphate may also be helpful in spring and before soils have thoroughly warmed.

A starter fertilizer is any water-soluble fertilizer added to the irrigation water. Common examples include MiracleGro, Peters, Schultz Plant Food, Fertilome Root Simulator, and Plant Starter Solution, etc. They generally contain ammonium nitrate since it is readily usable by the plant. Some products claim that vitamins or hormones promote plant growth. These claims are not supported by research findings.

Nitrogen "Side Dressing"

Plant need for nitrogen varies. Beans, peas, tomatoes, and vine crops (cucumbers, squash, pumpkins, and melons) are examples of vegetables with a lower need for nitrogen. High nitrogen promotes excessive growth of the plant at the expense of fruiting.

Crops such as potatoes, corn, and cole crops (broccoli, cauliflower, cabbage, and kale) use large amounts of nitrogen and need supplemental applications during the growing season (referred to as ***side dressing***). For example, home garden potatoes often show nitrogen deficiency from August into fall. Symptoms start as a yellowing of lower leaves and progress into a general browning and dieback of the vine. When nitrogen stress hits, potatoes become more susceptible to diseases, including early blight and Verticillium wilt. [Table 3]

Fertilizers commonly used in the home garden for side dressing include ammonium sulfate, ammonium nitrate, and water-soluble fertilizers such as MiracleGro, Peters, etc. Phosphate and potash fertilizers are best added in the spring or fall, when they can be cultivated into the soil.

Table 3. Nitrogen Side Dressing of Vegetable Crops				
Vegetable	**Timing**	**Application Rate** (Based on rate of 0.1 lbs. actual N per 100 square feet)		
		Ammonium sulfate 21-0-0	Ammonium nitrate 34-0-0	Water soluble fertilizers
Asparagus	1) Early spring 2) At end of harvest season	0.5 lbs. fertilizer per 100 sq. ft. (approximately 1 cup) Sprinkle over soil and water in, OR place in furrow to side of plant. CAUTION: an over application will burn roots, stunting or killing plants.	0.3 lbs. fertilizer per 100 sq. ft. (approximately 2/3 cup) Sprinkle over soil and water in, OR place in furrow to side of plant. CAUTION: an over application will burn roots, stunting or killing plants.	See label of specific product. Water soil with fertilizer added to water. Low burn potential, but significantly more expensive.
Sweet Corn	1) 12 inches tall 2) One month later			
Leafy green vegetables	3-4 weeks after emergence			
Onions	3-4 weeks after emergence			
Potatoes	Late-July to early-August			
Tomatoes, peppers, and eggplants	First fruits 1" diameter			
Cole crops (broccoli, cabbage, cauliflower)	1) 2-3 weeks after transplanting 2) 4-5 weeks after transplanting			See label for specific product.

Phosphorus and Potassium Applications

A soil test is the best method to determine the need for phosphate and potash. With a fertilizer containing nitrogen and phosphate and/or potash, the application rate is always based on the nitrogen percentage because nitrogen is most critical to plant growth.

Phosphate and potash fertilizers are best applied in the spring or fall, when they can be tilled into the soil

Phosphorus

Phosphorus levels are adequate in the majority of established Colorado soils. Deficiencies are most likely to occur in new gardens where the organic matter content is low and in soils with a high pH (7.8 to 8.3). Excessive phosphorus fertilizer can aggravate iron and zinc deficiencies and increase soil salt content.

Routine application of compost or manure will supply the phosphorus needs in most Western soils.

Where phosphorus levels are believed to be low, the standard application rate without a soil test is ¼ to 1-pound triple super phosphate (0-46-0) or ammonium phosphate (18-46-0) per 100 square feet.

Potassium

Potassium levels are naturally adequate to high in most Colorado soils. Deficiencies occasionally occur in new gardens low in organic matter and in sandy soils low in organic matter. Excessive potash fertilizer can increase soil salt content.

Routine applications of compost or manure will supply the potassium needs for most Western soils.

Where potash levels are believed to be low, the standard application rate without a soil test is ¼ to ½ pound potassium chloride (0-0-60) or potassium sulfate (0-0-50) per 100 square feet.

Managing Soil Compaction

On clayey soils, soil compaction is a common problem limiting crop growth potential. Soils are typically compacted in the construction process. Walking on wet soils, cultivating wet soils, and the impact of rain are other common forces compacting soils.

The following are suggested to help minimize soil compaction in the garden:

- Add organic matter to clayey soils.
- Avoid cultivating or working a clayey soil when wet. To evaluate, squeeze a handful of soil. Then try to crumble it. If it will crumble, it can be worked. If it will not crumble but stays in mud balls, it is too wet to be worked.
- Avoid cultivating other than to prepare a seed bed or till in organic matter and fertilizers. For weed control, use a mulch, hand removal, or shallow cultivation only.
- Use a raised bed with established walkways, and avoid walking on the growing bed.
- Mulch the soil, year round, to minimize the compaction forces of rain and sprinkler irrigation. Winter rains on bare soil are a major compaction force. This also helps manage weeds and reduces irrigation need.

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CMG GardenNotes #712

Sample Vegetable Garden Seed Catalogs

Baker Creek Heirloom Seed
2278 Baker Creek Rd.
Mansfield, MO 65704
417-924-8917
www.rareseeds.com

Burpee Seed
300 Park Ave.
Warminster, PA 18974
800-888-1447
www.burpee.com

Gurney Seed
110 Capital St
Yankton, SD 57079
513-354-1492
www.gurneys.com

Harris Seed
P.O. Box 24966
Rochester, NY 14624
800-544-7938
www.harrisseeds.com

Irish-Eyes Garden Seed
5045 Robinson Canyon Rd.
Ellensburg, WA 98926
509-933-7150
www.irisheyesgardenseeds.com

Johnny's Selected Seeds
955 Benton Ave
Winslow, Maine 04901
1-877-564-6697
www.johnnyseeds.com

Jung Seed
335 S High St
Randolph, WI 53956
800-247-5864
www.jungseed.com

Park Seed
3507 Cokesbury Road
Hodges, S.C. 29653
800-845-3369
www.parkseed.com

Stokes Seed
Box 548
Buffalo, NY 14240-0548
800-396-9238
www.stokeseeds.com

Territorial Seed
PO Box 158
Cottage Grove, OR 97424
800-626-0866
www.territorialseed.com

Twilley Seed
121 Gary Road
Hodges, SC 29653
800-622-7333
www.twilleyseed.com

Tomato Growers Supply
PO Box 60015
Ft. Meyers, FL 33906
888-478-7333
www.tomatogrowers.com

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GMG GardenNotes #713

Block Style Layout in Raised Bed Vegetable Gardens

Outline:

Block Style Garden Layout

Block style garden layout (also called ***close-row*** or ***wide-row*** plantings) ***increase*** yields five fold compared to the traditional row-style garden layout, and 15-fold for the smaller kitchen garden vegetables. The compact design reduces weeding and is ideal for raised bed gardening.

The basic technique used in close-row, block planting is to eliminate unnecessary walkways by planting vegetables in rectangular-shaped beds or blocks instead of long single rows. For example, plant a block of carrots next to a block of beets, followed with a block of lettuce and so forth down the bed area.

Plant crops with an equal-distance space between neighboring plants in both directions. For example, space a carrot patch on 3-inch by 3-inch centers. It may be easier to visualize this plant layout as running rows spaced 3 inches apart across the bed, and thinning the carrots within the row to 3 inches. A 24-foot long "traditional" row of carrots will fit into a 3 foot by 2-foot bed. [Figure 1]

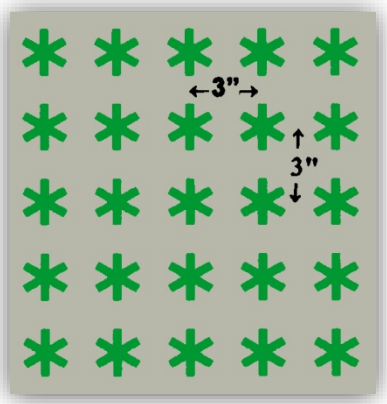

Figure 1. Carrots planted on 3-inch centers

Design the planting beds to be 3 to 4 feet wide and any desired length. This width makes it easy to reach into the growing bed from walkways for planting, weeding and harvesting.

Limiting foot traffic to the established walkways between planting beds reduces soil compaction. Design walkways to 18-24 inches wide. Mulch walkways with dry grass clippings, wood chips, or other organic mulch.

As the vegetable foliage grows together, the shade cast suppresses weed germination.

After harvesting a row of radishes, beets, lettuce, or spinach, replant for continual summer production.

Due to the higher plant density, block plantings require a weed-free, fertile, well-drained soil that is rich in organic matter. Give extra attention to watering and frequent, light fertilization to nourish the dense plant population. Avoid over-crowding vegetables; the reduced air circulation can increase disease problems.

Figure 2. Kitchen garden in block-style layout with (top to bottom) spinach, assorted lettuce varieties) and Swiss chard. Note that rows run across the four-foot wide bed. As a row of lettuce is harvested, it is replanted for continual production or neighboring crops fills in the space.

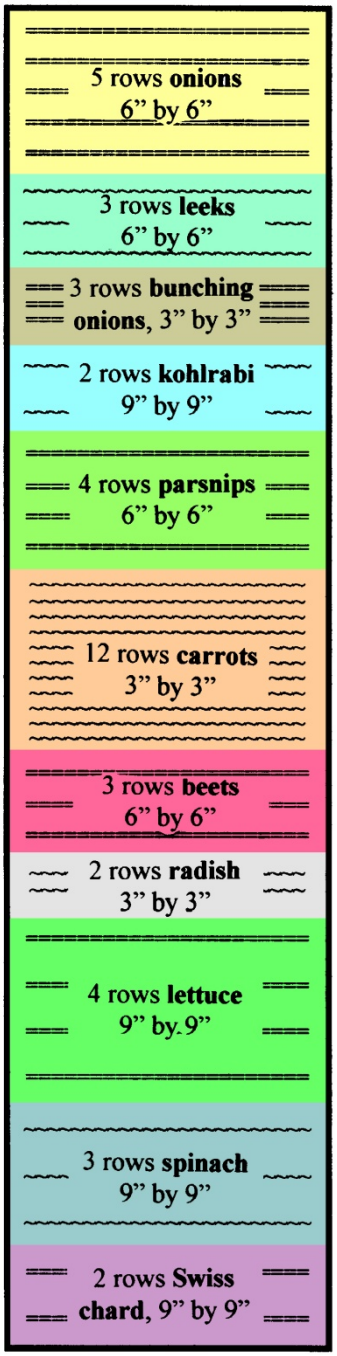

Figure 3. Sample layout of kitchen garden vegetables.

Suggested Spacing

Suggested spacing for kitchen garden vegetables: (Start with the wider spacings, reducing spacing with experience and as soil improves in fertility and tilth.)

- Beets: 4-6” by 4-6"
- Carrots: 2-3" by 2-3"
- Celery: 7-9" by 7-9"
- Garlic: 4-6” by 4-6"
- Kohlrabi: 7-9" by 7-9"
- Leeks: 4-6” by 4-6"
- Lettuce, head: l0-l2” by 10-12"
- Lettuce, leaf: 7-9" by 7-9"
- Onions, bunching” 2-3" by 2-3"
- Onions, dry: 4-6" by 4-6”
- Parsnips: 5-6” by 5-6"
- Radishes: 2-3" by 2-3"
- Spinach: 4-6” by 4-6”
- Swiss chard: 7-9” by 7-9”
- Turnips: 4-6”by 4-6"

Other vegetables suited to block planting

Cole crops (broccoli, cabbage, Brussels sprouts and cauliflower) – Spaced at 18 by 18-inches', or three plants across a 4-foot bed.

Corn – Always plant in a block to facilitate pollination. Five rows wide is recommended for the best "pollen shower" to maximize kernel set; three rows wide is minimum. Space at 12" by 24" or four rows across two, four-foot wide beds.

Eggplant – Space at 18-24 by 18-24 inches (or two or three plants across a four-foot wide bed).

Peppers – Space at 15 by 15 inches (or three plants across a four-foot wide bed).

Potatoes – Space at 12-15 by 12-15 inches (or three plants across a four-foot wide box).

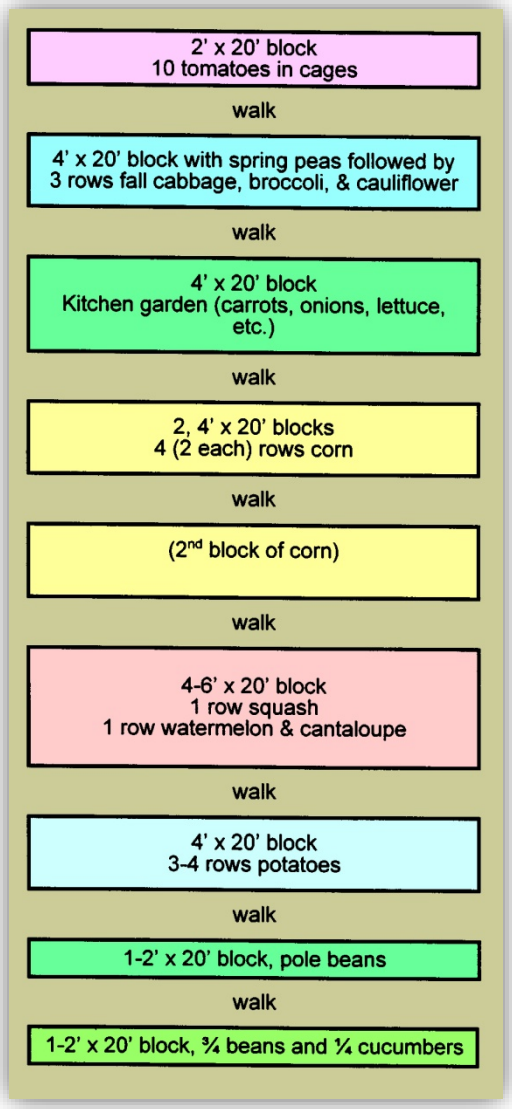

Figure 4. Sample block-style garden

Vine crops (squash, cantaloupes, pumpkins, and watermelons) – Place a single row down the center of a 4-foot wide box. They may also be planted in larger blocks, several rows wide. Place the winter squash and pumpkins in the center of the block and cantaloupes, watermelons, and summer squash around the edge where they can be reached for summer harvest.

Trellis tomatoes and cucumbers to save space and make harvest easier. The increased air circulation around trellised tomatoes helps suppress tomato blight. Space trellised tomatoes a minimum of 24 inches apart down a single row, in a block two to three feet wide. Plant cucumbers along a trellis at 9-12 inch spacings.

Beans and peas may be easier to pick and are less disease-prone if planted in single or double rows, rather than block style planting. Space beans 12 inches between rows and 4 inches between plants. Plant a double row down a block 2 to 3 feet wide.

Figure 5. Raised bed garden with chard, lettuce varieties, spinach, beets, and onions. Because even water distribution is needed for this bed with a heavy plant population, the drip irrigation hose is run up and down the bed four times on a 12 inches spacing. The bed will be mulched with dry grass clippings to conserve water and control weeds in summer. Wood chips make an excellent mulching material for the walkways.

Raised Bed Gardening

Raised bed gardens with block style layout have many advantages, including the following:

Higher yields and less area to weed – The block style layout, eliminating unnecessary walkways increases yields by five-fold over the traditional row-path-row garden layout.

Reduced soil compaction – Established walkways keep foot traffic off the growing bed, reducing soil compaction.

Earlier planting – The raised bed facilitates better runoff and drainage allowing soil to warm faster in the spring. Beds can be covered with plastic during spring rains, allowing for early planting even in rainy years.

Frost protection – The block-style layout is easy to cover for spring and fall frost protection. It can also be shaded in the hot summer.

Soil improvement – The raised bed is a clearly defined area where the gardener can concentrate on soil improvement techniques, (e.g., the addition of soil organic matter). In situations where the soil is poor, and limits plant growth, good planting soil may be added to the box.

Architectural interest – Raised beds become an architectural feature of the landscape design.

Accessible gardening – The raised bed is ideal for enabling persons with limited mobility to garden.

Constructing a Raised Bed Garden

Size – A bed 4 feet wide is ideal for most vegetable crops, allowing the gardener to reach the entire bed from the side without ever stepping on the soil in the growing bed. Length can be whatever works for the space.

Tomatoes are well suited to a bed 24 to 36 inches wide, with one row of plants down the middle. Beans and peas are easier to pick in a single or double row down a bed rather than in the block-style planting. Here a bed 24 inches wide would be ideal.

Depth / Height – The height of the beds is generally of no consequence, assuming that crops can root down into the soil below the bed. For most home garden situations, the role of a raised bed is to define and separate the growing bed from the walkway. Here a four-inch height would be adequate. Variations in heights (4", 6", 8", and 10") among different beds may help create an appealing landscape feature.

In situations where the soil below is not suitable for crop growth, 8 to 12 inches of soil is considered minimal. Deeper beds would make management easier.

To accommodate gardeners with special needs, bed height may be raised to minimize bending or to allow gardening work from a chair or wheelchair. Plan walkway space between beds wide enough to accommodate specialized equipment or mobility.

For ease of irrigation, beds should be reasonably level, both across and lengthwise.

Orientation – For frost protection, an east-west orientation has a slight advantage of collecting heat. For summer crop growth, a north-south orientation has a slight advantage of sunlight on both sides of the plant row each day. Because there is no clear advantage, orient the beds in whatever direction work best for the landscape design. Often beds are best arranged to be an appealing landscape feature of the property.

Construction materials – A simple way to construct a raised bed garden is to use construction lumber (2 by 4s, 2 by 6s, 2 by 8s, and 2 by 10s). Untreated lumber will last for several years, except in high salt areas or wet sites. Treated lumber will last longer. Simply cut two pieces the width of the bed (typically 4 feet) and two others to the desired bed length. Using 3½ to 4 inch decking screws, screw the corners together to make a four-sided box. Place the box-like frame on the soil and fill.

Various landscaping timbers may also be used in like fashion. Cooper treated lumber is safe for garden boxes. However, do not use railroad ties (creosote cancer concerns) or CCA pressure treated lumber (removed from the market several years ago due to arsenic concerns). Brick or other building materials may also be suitable.

Raised beds may also be made without sides. Here, organic matter is mixed as the garden is tilled. Walkways are dug down with the soil thrown up on the bed. Beds are 4 feet wide at the base and three feet wide at the top. The entire bed is covered with organic mulch like dry grass clippings to prevent soil erosion and reduce compaction from rain and sprinkler irrigation. [Figure 6]

Figure 6. Raised bed garden without sides. Beds are 4 feet wide at the base and t3 feet wide at the top. Walks were dug down with soil placed on the beds.

Adding soil – In the typical garden setting where crop roots will spread down into the soil below the bed, it is best to use similar soils. It may be beneficial to double-dig the beds. In ***double-digging***, the top 6 inches of soil is moved from one side of the bed to the other side of the bed. Mix organic matter into the soil below the excavated side. Return the soil to the top, mixing in organic matter. Then repeat the process for the other side of the bed.

When adding soil, avoid creating a situation where one type of soil ends and another begins. This creates a line between soil types that impedes water and air infiltration and slows, or even stops, root penetration. If the soil being added to the bed is different from the soil below, mix some of the two together before adding the remainder to avoid a distinct line of change.

In situations where the entire rooting zone will be in the raised bed, a soil on the sandy side with 4-5% organic matter would be preferred.

When purchasing soil, be aware that there is no legal definition of topsoil or planting soil. Just because it is commercially available in bulk or sold in bags, does not necessarily mean that it is good for gardening. Many bagged and bulk soils and soil amendments are prepared with compost made with manure and may be high in salts.

Figure 7. A recently planted raised bed garden. Corn boxes to left, kitchen garden in center, strawberry patch on right, tomato patch in back with black plastic mulch. Growing beds are mulched with grass clippings; wood chips were used between beds.

Gardening in a Raised Bed

Due to the high plant population, raised beds require better than average soils, and more frequent irrigation and fertilization. Concentrate on improving soils with routine applications of organic matter. For details on soil improvement and fertilization, refer to the various *CMG GardenNotes* #711, **Vegetable Garden: Soil Management and Fertilization**.

Mulching – Mulch beds to control weeds, conserve soil moisture, and regulate soil temperatures. Grass clippings make great mulch when applied in thin layers (up to ¼ inches thick). Allow each layer to dry between applications. Do not use clippings from lawns treated with weed killers or other pesticides for at least four weeks after application. Wood/bark chips are great for mulching between the beds. Three to four inches of chips will minimize the compaction forces of foot traffic. However, do NOT mix wood/bark chips into the growing bed, it will interfere with seedbed preparation. For additional information on mulching, refer the to the *CMG GardenNotes* #715, **Mulches for the Vegetable Garden**.

Watering a raised bed – Drip irrigation is well suited to raised bed gardening. It is rather easy and inexpensive to add a water tap at the end of each box. Alternatively, simply move a garden hose in turn to each box and connect the drip hose. Sprinkler irrigation is also suitable, but less desirable due to potential disease problems. For details on irrigation, refer the *CMG GardenNotes* #714, **Irrigating the Vegetable Garden**.

As a point of clarification, raised bed gardening is a water conservation technique. It does require more frequent irrigation due to the higher plant density. However, it is more efficient resulting in higher yields for the amount of water applied compared to the larger areas watered in traditional row-walkway-row culture. Raised beds become even more efficient when watered with drip irrigation or soaker hoses on timers.

Frost protection – An advantage of raised bed, block style layout is that the bed is easy to cover for protection from springs rains and frost, allowing for early planting.

Figure 8. Frost protection covering adds two to six plus weeks to the growing season.

This picture illustrates a Quonset-type cold frame covering made of concrete reinforcing mesh covered with plastic. This style of frost protection adds two to six plus weeks on both ends of the growing season for cool season vegetables. Any type of covering must be opened during the day to prevent overheating.

Authors: David Whiting (CSU Extension, retired), Carol O'Meara (CSU Extension, Boulder County), and Carl Wilson (CSU Extension, retired). Artwork by David Whiting; used by permission.

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MASTER GARDENER
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CMG GardenNotes #714

Irrigating the Vegetable Garden

Outline:

Garden Irrigation

In vegetable production, an adequate supply of water during the growing season is directly related to produce quality and yields. Many vegetables become strong-flavored or stringy with water stress.

Several gardening techniques (including soil preparation, mulching, and efficient irrigation) help conserve water in the vegetable garden.

As a rule of thumb, vegetables use around ¼ inch of water per day during typical summer weather. If the garden is watered every four days, apply one inch of water per irrigation. Hot, windy weather will increase water demand significantly. Beans and corn will be significantly higher in water demand during blooming or tasseling/silking.

Checking Soil Moisture Content

Check soil moisture regularly. Irrigate when the top two to four inches of soil is dry to the touch. This is especially important if using mulch, where surface evaporation is reduced.

Evaluating when the soil needs irrigation is rather subjective. The "stick" method (judging moisture by the relative easy or difficulty of pushing a stick or screwdriver into the soil) is an old farmer's standard. It will be easier when wet than when dry. However, this very subjective method is specific to soil types and can be misleading to the novice. On compacted clayey soils, it may be somewhat difficult when moist and very difficult when dry. On sandy soils, it may be somewhat easy wet or dry.

To check moisture levels, a soil probe is a useful tool to pull up soil samples from the rooting zone at a six to eight inch depth. A small garden spade could be used.

Houseplant watering meters are helpful in evaluating the soil moisture content under mulch. Realize however, that these inexpensive meters are somewhat inaccurate. If the fertility level is high, the meter will read on the wet side. If the fertility is low, the meter will read on the dry side. Learn to interpret the meter reading for a specific soil by trial and error. [Figure 1]

Figure 1. Although somewhat inaccurate, a houseplant water meter is a tool to evaluate water needs in the garden.

Automate the System with Controllers

Sprinkler or drip systems can be easily automated with a multi-zone controller like the lawn. A small garden could be connected to the lawn's controller as a separate zone and run on a different program. However, do not have the lawn and vegetable garden on the same zone, as water needs are not the same.

Single zone controllers connect to the garden hose. Some simple models are manually turned on and automatically turn off after the set number of minutes or gallons. More elaborate battery operated models turn the water on and off at the day and time interval set by the gardener. [Figure 2]

Figure 2. Single zone controllers connect to the hose line. Left: This style is manually turned on and automatically turns off the water flow after the set number of minutes. Right: This battery powered controller turns water on and off at the day and time intervals set by the gardener.

Furrow Irrigation

For gardeners who have irrigation water from a ditch, furrow irrigation in the traditional row-style garden layout may be most practical. As a rule of thumb, adjust water flow for the furrow so that the water reaches the end of the row 1/3 of the time into the irrigation period. For example, if the irrigation period is 15 minutes, the water should reach the end of the row in five minutes. Soil erosion and runoff are major disadvantages of furrow irrigation.

Sprinkler Irrigation

Sprinkler irrigation is considered more efficient in water delivery than furrow irrigation. It is easy to measure the amount of water applied and easy to manage. Because it wets the entire soil surface, weed seed germination may be high.

Sprinkler irrigation is discouraged on vegetables prone to foliar diseases such as Early Blight (tomatoes, peppers, and potatoes). The splashing water spreads disease organisms and water on the leaves creates favorable conditions for disease development. Tall crops, such as corn and pole beans may interfere with water delivery patterns.

As a rule of thumb, vegetables use around ¼ inch of water per day, depending on temperature, wind, and stage of crop development. For example, if the garden is watered every four days, apply one inch of water per irrigation. The gardener can quickly learn how long to run the sprinklers by measuring the amount of water in several straight-sided cans placed around the garden.

Delivery rates depend on the type of sprinkler heads used, pressure, and the spacing of heads in the garden. For example, pop-up spray heads deliver around 1½ inches per hour and would typically run 40 minutes to apply 1-inch of water. Rotor type heads deliver around 1/2 inch per hour and would typically run for 120 minutes to apply 1-inch of water.

Because the water needs of the vegetable garden are different from a lawn, it should be on a different irrigation zone than the lawn. Water use will be low in the spring when crops are small and temperature are cool and will increase as the temperatures rise and crops come into bloom.

Drip Irrigation

Drip irrigation is well suited for the block-style garden layout and raised beds. Several different types of drip systems are available including:

- **In-line drip tubing** – Emitters are found in the tubing every 6, 12, or 24 inches; 12 inches is most common in the home garden trade.
- **Soaker hose** and **soaker tubing** – Emits water along the entire length of the hose.
- **Bubblers** and **drippers** – Emitter or drippers are placed to water individual plants.

A disadvantage of a drip system is that they require relatively clean water. Systems readily plug with dirt, algae, or salts in the water. This is generally not a problem when using drinking quality municipal water supplies. Depending on water quality, drip irrigation may not practical for many non-potable water sources. The filtering system required may be expensive and high maintenance.

Ideally, an in-line drip hose or soaker hose is placed on the soil surface under the mulch. The soaker hose may also be buried a couple of inches into the soil to protect the hose from breakdown by sunlight.

On a raised-bed box, space the drip line/soaker hose at 12-inch spacing. A four-foot wide box would have four runs of the drip line/soaker hose up and down the box (as illustrated in Figure 1). For larger vegetables like corn, squash, and cole crops (three plants across a four-foot wide bed) make three runs up and down a four-foot wide box. On a two-foot wide raised bed box for tomatoes or beans, the drip line/soaker hose runs down and back. [Figure 3]

Figure 3. On this four-foot wide box, the drip line or soaker hose makes four runs up and down the box at 12-inch spacing. Carrot rows are running across the box.

Drip systems are designed to run on low pressure. High pressure may split the hose and pop connections. The desired low pressure is easy to achieve with pressure regulators that have hose-end fitting (found with the drip system supplies). If the garden has changing elevations, a pressure regulator will be needed for every couple of feet change in elevation. [Figure 4]

Figure 4. With irrigation pipe, it is easy to plumb a tap at each raised bed box. Here a pressure regulator with hose-end fittings reduces pressure to 25 psi. It is connected to a ½-inch soaker hose.

Determine the run time by examining the soil moisture content. Run time will vary with the brand of hose, water pressure, and spacing.

Soaker Hose and Soaker Tube

The soaker hose and soaker tube type of drip system allows water to seep out the entire length of the hose. It is easy to use in traditional row style or raised-bed gardens. [Figure 5]

Figure 5. Soaker hose seeps water out along the length of the hose.

It can be connected by manually connecting the garden hose to each line at each irrigation session or by connecting a series of dedicated garden hoses to a series of lines. On raised-bed gardening, it is easy to run a water line with a tap to each box. Several small boxes may run together on the same zone. [Figure 4]

For uniform water delivery, keep runs short, generally 25 feet or less. With long lengths, water delivery will be higher at the top of the hose line and less at the bottom. The ground must be reasonably level. On slopes, run several short lengths.

Several brands and styles are available in the home garden trade.

- **Half-Inch Soaker Hose** – Some brands (like *Swans Soaker Hose*) are a ½-inch hose that connects with standard hose fitting. These are found the garden hose section. It can be cut to any length and connected with garden hose fittings.

  A small plastic disc fits inside the female hose connection as a pressure regulator (actually a flow regulator). With the reduced water flow, it may need to run for around an hour to adequately water the garden. It works better to use the pressure regulators with hose-end fittings found with the drip irrigation supplies (figure 4). With this type of regulator, the drip line runs 10-20 minutes to adequately water the garden. Without a pressure regulator of some type, the soaker hose tends to rupture sending out steams of water at spots rather than dripping along the line.

  This half-inch hose style is more tolerant of small amounts of dirt, algae, or salts in the water than other types of drip systems, and may be successful on some nonpotable water sources. Periodically, open up the end of the hose and flush out soil deposits.

- **Quarter-inch Soaker Tubing –** A ¼ inch soaker tubing is availble in the drip irirgaiton section at garden stores. Cut the soaker tubing to desire length and connect with drip system components. An in-line pressure regulator (figure 4) is required; otherwise, the fitting may pop or leak.

  Because the soaker tubing has a higher delivery rate, it can not be on the same zone as other in-line drip hoses, button emitters, or bubblers.

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MASTER GARDENER
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CMG GardenNotes #715

Mulches for the Vegetable Garden

Outline:

Benefits

The benefits of mulch depend on the material used and depth to which it is applied. In general, mulching minimizes evaporation of water from the soil surface, reducing irrigation need by around 50%. It helps stabilize soil moisture levels, thereby improving vegetable quality and encouraging the beneficial activity of soil organisms.

Mulching helps reduce soil compaction forces from rain and traffic. Some may later be plowed into the garden as a soil amendment, adding organic matter to the soil. Mulching may cool or warm soil temperatures. It may control weeds.

Grass Clippings

Grass clippings make excellent mulch for the vegetable garden. Apply fresh clippings in thin layers (up to 1/4 inch thick) and allow each layer to dry before adding more. The clippings quickly dry down and additional layers can be added weekly. A few layers will stop weed seed germination. Do not place fresh clippings in thick piles, as they will mat, reducing water and air infiltration, stink, and may become hydrophobic. Do not use clippings from lawns that have been treated with herbicides or other pesticides in the past month. [Figure 1]

Figure 1. Grass clippings being applied to garden directly from lawn mower bag. Apply only in thin layers, allowing the grass layers to dry between applications.

Around lettuce and other leafy vegetable, mulch by carefully hand placing the grass at the base of the plants. Grass sticks to wet lettuce, creating a problem in food preparation.

A couple of sheets of newspaper may be used under the clippings to help control weeds. The newspapers blow away with a light wind. It must be covered immediately with grass to hold it in place. It shuts out the light preventing seed germination. Do not apply newspapers more than a couple of sheets thick or a soil carbon to nitrogen imbalance may occur. Do not use glossy print materials; their inks may not be soy-based like newspapers. The grass and newspaper mulch may be cultivated into the soil in the fall adding small amounts of organic matter. [Figure 2]

Figure 2. Corn bed being mulched with newspapers (only a couple of sheets thick) covered with grass clippings.

Wood or Bark Chips

Do not use wood or bark chips in the growing beds since they will interfere with future seedbed preparation. It takes several years for chips to decompose in the soil.

In a raised-bed garden, wood or bark chips make excellent mulch between the boxes. Apply three to four inches deep to control weeds. At this depth, chips also prevent soil compaction from foot traffic, allowing crop roots to spread out under the walkways. [Figure 3]

When placed on the soil surface as mulch, wood/bark chips do not tie-up soil nitrogen. Does not use fine sawdust for mulch because it could create carbon to nitrogen imbalance.

Figure 3. Wood or bark chips make excellent mulch between raised-bed boxes.

Do NOT put wood or bark chips on the growing bed. The chips take years to breakdown and will interfere with seedbed preparation.

Black Plastic

Black or colored plastic mulch is extensively used in commercial tomato, pepper, and melon production in Colorado. It merits consideration for the tomato family (tomatoes, peppers, eggplant) and the vine crops (cucumbers, summer and winter squash, pumpkins, watermelons, cantaloupes and other melons). Because it warms the soil, it is undesirable for other crops.

Put the plastic on the growing bed early in the season to start the soil warming. **Crops must be planted early so plant growth shades the plastic before summer heat arrives.** Otherwise, the plastic can be too hot for crops and must be removed.

The plastic warms the soil allowing for earlier crop growth. Along the Colorado Front Range, crops average 2-3 weeks earlier production and produce higher yields. In cooler locations, crops could be three to over four weeks earlier in production.

The black plastic mulch also controls weeds and reduces the need for irrigation. Because there is no surface evaporation of water, it is easy to over-irrigate crops.

Applying plastic mulch

1. Prepare the soil and irrigation system. Drip irrigation with a soaker-type hose works well. Slightly mound the soil so the plastic makes direct contact with the ground.
2. Cover the growing bed with the plastic. Bury all edges two to four inches. On a raised-bed box made with lumber, staple the plastic on the sides of the box.
3. Cut holes to plant or transplant into. Do not cut "X's"— the hot plastic touching tender plants can burn.

Figure 4. Tomatoes planted down a 30-inch wide raised-bed box. Plastic mulch is stapled to side of box. Plants are spaced at 24 inches in the center of 24-inch wide cages.

Figure 5. Trellised tomatoes in raised-bed box with black plastic mulch.

With plastic mulch, crops must be planted early so plant growth shades the plastic before summer heat arrives.

The plastic fluttering in the wind pumps air into the soil. However, covering the plastic with organic mulch like grass clippings or chips could reduce soil oxygen levels.

In the fall, do NOT plow in the plastic, rather remove and put it in the trash. Polyethylene plastic will never decompose in the soil. Because it breaks down with sunlight, it generally can be used only for a single season. Chemists are working on biodegradable plastics for horticultural uses. It will be a few years before they are available.

Some gardening magazines talk of colored plastics. For example, red plastic is reported to increase tomato yields in cloudy climates. It also makes the fruits softer in texture. With Colorado's high light intensity, color is insignificant.

Warming the soil for other crops – Plastic may also be used to warm the soil for other crops, being applied early and **removed prior to planting**. For maximum soil warming, clear plastic is most effective. However, it will also encourage weeds to grow under the warm, greenhouse-like covering.

Straw

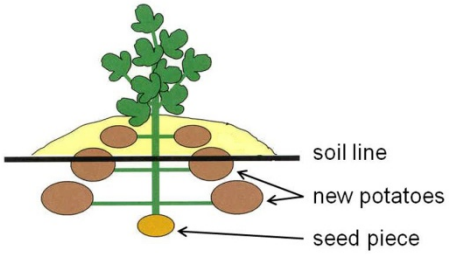
Weed free (seed free) straw makes excellent mulch for potatoes. When purchasing straw, look for certified weed (seed) free products. Otherwise, the potato patch may be thick with oats!

The straw protects tubers growing near the surface from sunlight, so the potato plants do not have to be mounded. (When a potato tuber is exposed to sunlight, it turns green, becoming mildly poisonous.) [Figure 6]

Certified weed (seed) free straw is also a good organic source for clayey soils. After using it as a summer mulch, thoroughly cultivate it into the soil as a soil amendment in the fall.

Figure 6. The new crop of potatoes grows above the seed piece.

To shield growing tubers from sunlight (which turns them green), soil is "hilled" (mounded) around the base of the plant. Straw mulch may be used as an alternative to hilling.



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MASTER GARDENER
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CMG GardenNotes #716

Water Conservation in the Vegetable Garden

Outline:

In vegetable production, an adequate supply of water during the growing season is directly related to produce quality and yields. Many vegetables become strong flavored with water stress. Unlike bluegrass and other landscape plants, vegetables cannot go dormant when the water supply is inadequate. However, there are several techniques that will significantly reduce the water requirements of the home vegetable garden.

Always follow efficient irrigation practices. The following practices will allow gardeners to have a productive vegetable garden and still reduce water consumption.

Water Conserving Techniques

Amend Garden Soil with Coarse, Decomposed Organic Matter

In the vegetable garden, the routine addition of organic soil amendments, such as compost, will optimize potential yield- and produce quality. The goal in soil management is to increase the organic content to 4-5%, over a period of years.

On sandy soils, organic matter holds over ten times more water and nutrients than the sand. On clayey soil, organic matter glues the tiny soil particles together into larger aggregates, increasing pore space. This process takes place over time. This increases soil oxygen levels and improves soil drainage, which in turn increases the rooting depth allowing roots to reach a larger supply of water and nutrients.

Organic matter also encourages the beneficial activity of soil organisms and helps remediate soil compaction

Manure and compost made from manure may be high in salts that will interfere with crop growth. The standard application rate for plant-based compost (free of salts) is two to three inches per year, cultivate into the soil six to eight inches deep. After a few years, the application rate should be cut back to avoid excessive soil salts, phosphorus, and potassium.

Manure and manure-based compost may be high in soil salts. The standard application rate is one-inch maximum per year, cultivated into the soil six to eight inches deep. Do not add more unless a soil test on the specific batch indicates low soil salt levels. Soil testing on many commercially available products available in Colorado markets found extremely high salt levels in some products. For high salt products, the one-inch application rate may be too high.

Be sure that the organic matter is thoroughly cultivated into the soil. Leaving chunks of organic matter will interfere with seeding, root spread, and water movement through the soil profile.

In the vegetable garden, do not plow in woody materials such as bark or wood chips, as they may interfere with seedbed preparation and may result in soil nitrogen depletion. Wood chips take several years to decompose in the soil.

Due to a health issue (*E coli* contamination), fresh manure additions should be made at least four months prior to the harvest of any edible crops. In other words, apply fresh manure only in the fall after crops are harvested.

Another method to add organic matter is to replant the fall garden with a green manure crop such as winter rye or Austrian peas. For details, refer to *CMG GardenNotes* #244, **Green Manure and Cover Crops.**

For additional details, refer to *CMG GardenNotes* #711, **Vegetable Garden: Soil Management and Fertilization**.

Reducing Water Need with Drip Irrigation and Mulching

Use of a drip system on a mulched garden reduces water need by around 50%.

Other Water Saving Techniques

Plant in blocks, rather than rows. This creates shade for roots and reduces evaporation. For details, refer to the *CMG GardenNotes* #713, **Block Style Layout in a Raised Bed Garden**.

Control weeds that compete with vegetables for water.

Group plants with similar water needs in the same section of the garden for easy irrigation. Cucumber, zucchinis, and squash, for example, require similar water applications.

Protect plants and soil from wind with windbreaks to reduce evaporation.

Critical Water Periods for Vegetables

You can target the timing and amount of water to add. As a rule of thumb, water is most critical during seed germination, the first few weeks of development, immediately after transplanting, and during flowering and fruit production. The critical watering periods for selected vegetables follow:

Asparagus needs water most critically during spear production and fern (foliage) development. Less water is needed after ferns reach full size.

Cole crops (broccoli, cabbage, cauliflower, collards, Brussels sprouts, kale, and kohlrabi) need consistent moisture during their entire life span. The quality of cole crops is significantly reduced if the plants get dry anytime during the growing season. Water use is highest and most critical during head development.

Beans have the highest water use of any common garden vegetable. During blossoming and fruit development, beans use 0.25-inch to over 0.50-inch of water per day (depending on temperature and wind). Blossoms drop with inadequate moisture levels and pods fail to fill. On hot, windy days, blossom drop is common. When moisture levels are adequate, the bean plant is a bright, dark, grass-green. As plants experience water stress, leaf color takes on a slight grayish cast. Water is needed at this point to prevent blossom drop.

Carrot and other root crops require consistent moisture. Cracking, knobby, and hot flavored root crops are symptoms of water stress.

Corn water demand peaks during tasseling, silking, and ear development. Water stress delays the silking period, but not tasseling. Under mild water stress, the crop may tassel and shed pollen before silks on ears are ready for pollination. The lack of pollination may result in missing rows of kernels, reduced yields, or even eliminate ear production. Yield is directly related to quantities of water, nitrogen, and spacing.

Lettuce and other leaf vegetables need water most critically during head (leaf) development. For quality produce, these crops require a constant supply of moisture.

Onion family crops require consistent moisture and frequent irrigation due to their small, inefficient root system.

Peas need water most critically during pod filling.

Potato tubers will be knobby if they become overly dry during tuber development.

Tomato family (tomatoes, peppers, and eggplant) needs water most critically during flowering and fruiting. Blossom end rot (a black sunken area on the bottom of the fruit) is often a symptom of too much or too little water. The tomato family has a lower water requirement than many vegetables and plants are often over-watered in the typical home garden.

Vine crops: cucumbers, summer and winter squash, and assorted melons need water most critically during flowering and fruiting. Vine crops use less water than many vegetables and are often over-watered in the typical home garden.

Vegetable Gardening When Irrigation Interval Is Restricted

- Restrictions that allow for thorough watering only twice a week should not have a major effect on the vegetable garden. With adequate soil organic content, a standard in vegetable production, the garden should be able to go two to seven days between irrigations. Follow recommendations listed above.

- Avoid heavy water use crops such as beans and sweet corn.

- Grow only what you need. Consider that one tomato plant can yield over 20 pounds of fruit.

Vegetable Gardening When No Watering Is Allowed

- When water restrictions prohibit outdoor watering, do not plant a vegetable garden. Vegetables do not go dormant like Kentucky bluegrass lawn. If water restrictions allows, consider planting containers with vegetables and consider planting non-irrigated or minimally-irrigated cover crops in the vegetable garden area.

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MASTER GARDENER
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CMG GardenNotes #717

Growing Tomatoes

Outline:

Variety Selection

There are over 2,000 cultivars of tomatoes grown worldwide. Ask neighbors, local gardeners, and garden center staff about local favorites.

Hybrid tomatoes are popular in the United States to reduce problems with *Verticillium* and *Fusarium* wilt, common soil-borne pathogens. Early hybrids were developed for their yields and disease resistance. Flavor became a driving factor in the breeding of newer hybrids. Some gardeners prefer to trade off the disease protection of hybrids for the rich "tomato-ey" flavors of heirloom varieties.

For early production, *Early Girl* is a popular variety with mid-size fruits. *Celebrity*, *Big Boy*, and *Better Boy* are examples of popular main season varieties. Many gardeners prefer the rich tomato flavor of heirloom *Brandywine* or the large beefsteak types. Pear tomatoes and yellow types are gaining popularity.

Cherry and the new grape-type tomatoes are popular for salads and snacking. Many, but not all, have small size vines suitable for container gardening. [Figure 1]

Figure 1. ***Sweet 100*** is the most popular home garden cherry-type tomato. On a large vine, it produces hundreds of sweet, cherry sized fruits with very tender skins.

Requiring less time to cook down, paste types such as *Roma* and its descendents are preferred for making salsa, chili sauce, and other tomato products. Be aware that paste types and standard varieties are not directly interchangeable in recipes.

Where the growing season is short, select *Early Girl* and other cultivars that will mature in 50 days or less. In many mountain communities, tomatoes may only be successfully grown in a structure or adjacent to the south side of a building to provide frost protection and warmer growing temperatures.

Whatever type you prefer, VFN resistant hybrid varieties are recommended. The abbreviation VFN indicates resistance to *Verticillium* wilt, *Fusarium* wilt, and nematodes. Verticillium and Fusarium wilts are common soil-borne fungal diseases. Nematodes are not an issue in Colorado due to cold soil temperatures. Researchers have found multiple strains of *Verticillium* and *Fusarium*, so if you are having problems with these diseases, try other VFN varieties.

Vine types – There are two types of vines: *indeterminant* and *determinant*. Most popular home garden varieties are indeterminant. The vine keeps growing through the growing season, extending fruit production until frost kills the vine. Plant size is typically large. Determinant types are common in commercial production as vine growth stops when flowering begins; plants will typically be moderate in size. Determinant types put on a large single crop. They may be suitable for container planting where trellises are not possible.

Planting

Planting Time

For optimal growing, tomatoes need warm temperatures: above 52ºF at night and above 60ºF during the day at transplant. They are readily killed by a light frost. A week of cool daytime temperatures (below 55ºF) will stunt plants, reducing yields.

With these warm temperature requirements, planting time along the Colorado Front Range is typically late May. Do not plant tomatoes out into a cold spell and make sure soil temperatures are warm.

To get a head start on the season, gardeners use a variety of frost protection techniques. The Wall-of-Water® provides protection into the mid teens, or lower. Cool soil temperatures also inhibit early growth. When using a Wall-of-Water, also use black plastic mulch to help warm the soil. Be cautious in filling the Wall-of-Water not to splash water around, as a wet soil will be slow to dry and warm in the spring. [Figure 2]

Figure 2. Wall-of-Water protects individual plants down to the mid-teens.

Notice that black plastic mulch was also used to warm the soil. Cool soil temperatures are also a growth-limiting factor with early plantings.

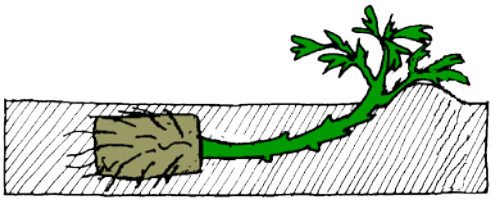
Selecting the Ideal Plants

The ideal tomato transplant is dark grass green and six to eight inches tall. The stem is about pencil size in diameter and the plant has not been pruned or cut back. Transplants are hardened-off (growth rate slows so the plant is more tolerant of the move the greenhouse environment to the bright, windy outdoors) by withholding water and/or nutrients or by exposure to cooler temperature.

Plant leggy transplants horizontally – When gardeners are shopping for transplants in the warm greenhouse conditions of May, tomato plants quickly grow from ideal size to tall and leggy. The white bumps along the leggy tomato stem are roots beginning to form.

Plant these taller leggy transplants horizontally. Dig a trench a two to three inches deep. Place the plant horizontal with only the top two to three sets of leaves showing above the soil. Pinch off other lower leaves below the soil line before planting. These leggy plants readily root out along the stem in the warm soil near the surface, supporting rapid growth. [Figure 3]

Figure 3. Plant tall leggy tomatoes horizontal in a shallow furrow.



Space and Trellis Plants

To minimize Early Blight, space and trellis plants to allow for good air circulation and promote rapid drying. Trellised tomatoes are easier to pick and less preferred by tomato psyllid insects. Trellising eliminates problems with fruit rotting where they touch the ground.

The minimal spacing for trellised tomatoes is two feet apart in a hedgerow. Research has demonstrated that crowding plants will not increase yields, but will increase disease problems.

Cages – The American Society for Horticultural Science suggests a trellis two feet in diameter by four to five feet tall. It is easy to make from a 6½-foot length of concrete reinforcing mesh. Cut off the bottom ring of wire so the cages can be pushed into the ground. When a branch sticks out of the cage, simple tuck it back in. [Figure 4]

For the smaller-vined, determinant types, two cages may be made from a 6½-foot length, cutting the height in half. Cages will be two feet diameter but only 3-feet tall.

Commercially available cages are too small for most popular tomato varieties grown on good soils.

Figure 4. Tomatoes planted in a raised bed with black plastic mulch and cages made from concrete reinforcing mesh.

Cages are six feet around, two feet across, and five feet tall. On improved soils, tomato vines will loosely fill the cage, allowing for good air circulation and easy picking.

Tender transplants are rather sensitive to cool winds. Wrapping the cages with a plastic sheet or newspapers to provide wind protection for the first week helps plants acclimate.

Figure 5. Wrapping the tomato cage with plastic or newspapers protects tender plants from cold winds.

Single pole trellis – Some gardeners prefer to trellis tomatoes on a single pole or stake. To do this, prune plants to a single trunk by removing all side shoots. This requires constant removal of side shoots.

Figure 6. Tomatoes trellised to a single pole.

Fan trellis – Another method, which produces larger fruit, is to trellis to a three-trunk, fan shape, removing all other side shoots. This requires a sturdy frame to support the weight of the vine and fruit.

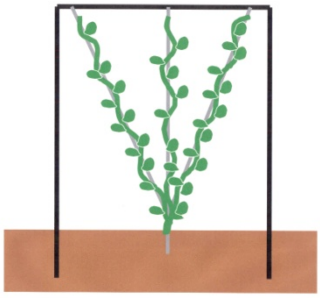


Figure 7. Tomatoes trellised into a fan shape.

Mulching

As with any crop, surface mulch is recommended to conserve soil moisture and manage weeds. Mulching helps reduce the splashing of Early Blight fungal spores from the soil onto the leaves. It also helps stabilize soil moisture levels, reducing the incidence of blossom end rot.

Black plastic mulch is popular for tomatoes, warming the soil and pushing production two to three weeks earlier. When using black plastic mulch, crops must be planted early so plant growth covers and shades the plastic before summer heat sets in. .

Irrigation

Avoid overhead sprinkling on tomatoes. Fungal spores are easily water-splashed from one leaf to another, and water on the leaves creates a favorable environment for disease development. Watering in the morning, allowing plants to dry before nighttime, may also be helpful.

Fertilization

Tomatoes have a low nitrogen requirement. Under high nitrogen conditions, vines grow excessively large at the expense of fruit production. More correctly stated, tomatoes are a fussy nitrogen feeder. On soils low in organic matter, tomatoes typically run out of nitrogen in mid-summer, reducing yields and predisposing the plants to Early Blight.

At transplanting, apply one to three applications (depending on soil organic content) of a water-soluble, "plant starter" fertilizer. This includes any of the water-soluble products like MiracleGro, Peters, RapidGro, Schults, etc. Transplants would have been "hardened off" (growth slowed) in the greenhouse. Water-soluble fertilizers stimulate renewed growth.

If the weather turns cold late spring after tomatoes are out (that is a week with daytime temperatures below 55ºF), use water-soluble fertilizers to stimulate growth when warm temperatures return. A week with daytime temperatures below 55 ºF stunts tomato growth, reducing yields.

Mid-summer – On low organic matter soils, tomatoes typically run out of nitrogen in mid to late summer. Yellowing of the foliage, starting with lower leaves, is the typical symptom of nitrogen stress. Low nitrogen in the plant allows Early Blight disease to spread like wildfire. Keeping nitrogen levels up in mid to late summer is a primary means of Early Blight control and significantly improves yields.

Fertilize tomatoes lightly as the first fruits reach two-inches in diameter. Water-soluble fertilizers (such as MiracleGro, RapidGro, and Peters) used according to label directions make a good summer fertilizer supplement. Make applications every two to four weeks, depending on soil organic content.

If using a dry granular fertilizer, apply 21-0-0 (ammonium sulfate) at the rate of one level tablespoon per plant. Sprinkle the granular fertilizer in a wide circle 12 to 20 inches out from the plant, and water in. Dry granular fertilizers can easily kill tomatoes if over-applied.

Pollination and Summer Temperatures

Tomato pollination is temperature dependant. If nighttime temperatures drop below 55ºF, pollen fails to develop and flowers that open the following morning will not set fruit. Cool nights often interfere with fruit set for early tomatoes and in higher elevations. Blossom set sprays help set fruit even with cool nights.

If the daytime temperature reaches 90ºF by 10 a.m., blossoms that opened that morning abort. Blossom set sprays are not effective under high temperatures.

In July and August along the Colorado Front Range, night temperatures have a 50/50 probability of staying above 55ºF any given night. In unusually warm seasons, tomato fruit set may be unusually high. When poor soil conditions and/or watering problems limit plant growth potential, fruit may ripen while small. With good soil tilth and water conditions, fruit size may be unusually large.

Garden Sanitation

Control weeds. Common weeds harbor many garden insect and disease problems. Volunteer potatoes and tomatoes could be a source of Early Blight infection. [Figure 8]

For Early Blight management, some references suggest removing lower leaves showing symptoms. Symptoms start as tiny black spots on lower leaves. Spots enlarge to light and dark target-like rings. Leaves yellow and the disease progresses from lower leaves up the plant.

If removing lower leaves, focus on leaves with the tiny black spots. Removing just the lower yellow leaves will not be adequate. Wash hands with soap and water immediately after touching diseased leaves to prevent spreading spores to other plants. Avoid working with the plants when they are wet.

Another disease, tobacco mosaic virus (TMV) can readily spread from tobacco smoke residues on the hands and clothing to tomatoes. Prevent TMV infections by washing hands after smoking or handling tobacco products.

Figure 8. Early blight leaf spots [Photo: USDA]

Rotation

Since the common tomato diseases (Early Blight, Verticillium and Fusarium wilt) are soil borne, crop rotation is an effective management tool. However, this may not be practical in most home garden situations, particularly since rotation allows no tomatoes, peppers, potatoes, eggplants, vine crops (cucumbers, squash, pumpkins, and melons), strawberries, or raspberries in the same growing area for at least four years. In a garden bed, moving the tomatoes a few rows to the left or right is not an effective rotation.

Fall Clean Up

Remove all tomatoes and potato debris in the fall. Dispose of debris in municipal trash or by burial. Do not compost unless the compost heats to at least 145ºF and the pile is turned occasionally. Most home compost piles do not heat adequately to kill pathogens.

Common Disorders

- CSU Extension fact sheet #2.949, **Recognizing Tomato Problems**

Figure 9. Blossom end rot on tomato is caused by water imbalance between the fruit and soil. The soil could be too wet, too dry, or root could be cut by cultivation. It could be aggravated by soil compaction and poor soil preparation.

Ripening Fruit at the End of the Season

To speed fruit ripening in the fall, hold back slightly on watering.

Ripening Fruit Indoors

With the forecast of a light frost, tomatoes may be protected by covering. If heavy frost is forecast and covering is not practical, harvest fruit before the frost event and carry indoors.

Pick ripening fruit and green tomatoes with a glossy green appearance that have reached about three-fourths of their full size. Remove stems. Wash fruit under a stream of water and allow to air dry on a clean towel. Save only blemish-free fruits for ripening indoors.

As for humidity, fruit shrivel if it is too low. If the humidity is too high, fruit mold. A gardener will have to learn by trial and error what works for their home. Some gardeners simply hang the whole plant upside down in a dark cool barn or basement to let the fruits ripen gradually. In Colorado's dry climate, fruit tend to shrivel from the low humidity.

Other options include placing tomatoes, one or two layers deep, in a covered box for ripening. Some people find better success by individually wrapping fruit in newspaper or wax paper and placing them in a covered box. Placing a few fruit together in a vegetable storage bag has been effective for others. For higher humidity, place tomatoes up to two layers deep in a blanching pan or strainer inside of a covered pan with some water in the bottom. Make sure the fruit does not touch the water.

Ethylene gas produced by ripening tomatoes is a ripening hormone. To speed the ripening process, place a ripe tomato in the container with the fruit. To slow the ripening of green tomatoes, routinely remove ripening fruit from the container.

Green fruit will ripen in about two weeks at 65ºF to 70ºF, and in about three to four weeks at 55ºF. Storage below 50ºF will give fruit a bland, off-flavor. Ripe tomatoes may be stored in the refrigerator for a few days.

Authors: David Whiting (CSU Extension, retired), with Carol O'Meara (CSU Extension, Boulder County), and Carl Wilson (CSU Extension, retired). Artwork by David Whiting; used by permission.

- Colorado Master Gardener *GardenNotes* are available online at www.cmg.colostate.edu.
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Revised October 2014

MASTER GARDENER
COLORADO STATE UNIVERSITY
EXTENSION

CMG GardenNotes #718

Tomato Early Blight

Outline:

Early Blight, caused by the fungus *Alternaria solani*, is common on garden tomatoes and potatoes, and occasionally infects eggplants and peppers.

Symptoms

Symptoms appear soon after fruit set- on the lower leaves- as tiny dark brown spots. The spots enlarge to over 1/2 inch in diameter and develop a grayish-white center with a darker border. As the spots enlarge, they develop concentric, target-like rings. Spots may also develop on fruit and stems.

As the disease progresses, leaves turn yellow, brown and drop off. Black *pycnidia* (fungal fruiting bodies that appear as pinhole sized black dots) form in the center of the spots as they mature.

Figure 1. Yellowing and halo target marking from Early Blight.

When the pycnidia become wet, fungal spores ooze out. The spores are spread by splashing water, insects, wind, and human contact. During rainy weather or overhead irrigation, spores quickly spread the disease through the planting.

The disease is favored by warm wet weather, overhead irrigation, and where heavy foliage delays the drying of leaves. A moist 48-hour period is required for infections to occur. It is not necessary that this be a continuous period, but may be cumulative over several days.

In the garden, the fungus can over-winter on diseased plant debris and in perennial weeds such as horse nettle and nightshade. These serve as sources for inoculum and for primary infections in the spring.

Management

Control measures center around reducing the amount of inoculum (spores) available, and promoting rapid drying of wet leaves.

Spacing and Trellising Plants

Space and trellis plants to allow for good air circulation that promotes rapid drying. Minimal spacing for trellised tomatoes is two feet apart. Crowding plants will not increase yields and increases disease problems.

Trellising also increases the distance of the upper leaves from the sources of inoculum on the soil and lower leaves.

Mulch

Use a mulch (such as black plastic) to help protect the plant from inoculum splashing from the soil onto lower leaves. Removing leaves in the lower 8 to 12 inches of the plant (as the plant grows) also helps protect lower leaves from infections splashing from the soil.

Irrigation

Avoid overhead irrigation on tomato crops. Fungal spores are easily water-splashed from one leaf to another, and they depend on standing water on the plant surface to cause infections. It may also be helpful to water in the morning in order that plants dry quickly. Plants that remain wet all night from evening watering are prime targets for disease infection.

Fertilization

A mid-summer loss of plant vigor from inadequate moisture or fertilizer will leave the plant more susceptible to the fungi. In home gardens, Early Blight frequently erupts due to low nitrogen levels in mid to late summer.

Fertilize tomatoes at planting, flowering and fruiting (as the first fruits reaches two inches in diameter). An additional application can also be made to ensure the plants are not nutrient deprived. Avoid heavy applications of nitrogen that can over- stimulate vine growth at the expense of fruiting.

Water-soluble fertilizers (such as MiracleGro, RapidGro, and Peters) applied according to label directions can be used as summer fertilizer supplements.

If using a dry granular fertilizer (such as 21-0-0, ammonium sulfate), apply one level tablespoon per plant. Sprinkle the granular fertilizer in a wide circle 12 to 20 inches out from the plant, and water in. Dry granular fertilizers can easily kill the tomatoes if over-applied

Weed Control

Keep the garden weed-free. Common weeds harbor many garden diseases. Volunteer potatoes and tomatoes can also be a source of inoculum for Early Blight.

Remove Infected Leaves

Remove infected leaves as soon as noticed. Wash hands with soap and water immediately after touching diseased leaves to prevent spreading spores to other plants. Avoid working with the plants when they are wet.

Rotation

Since fungal spores can be found on plant debris in the soil, crop rotation is a management tool. However, this may not be practical in most small, home garden situations because a rotation plan allows no tomatoes, potatoes, eggplants, vine crops, strawberries, or raspberries in the same growing area for at least four years. In a garden bed, moving the tomatoes a few rows to the left or right is not an effective rotation.

Fall Clean Up

Remove all tomatoes and potato debris in the fall. Dispose of debris in municipal trash or by burial. Do not compost unless the compost heats to at least 145° and the pile is turned occasionally. Most home compost piles do not adequately heat to kill pathogens.

Fungicides

During years with frequent rains, supplementing the above cultural practices with fungicide applications may be necessary to protect the plants. Start spraying at the first sign of spotting on lower leaves, typically in July. Once the disease begins to cause yellow leaves, fungicides lose effectiveness.

Complete coverage, including the lower leaves, is essential for control. Repeat applications at 10 to 14 day intervals as needed. Under moist conditions, reapplication may be needed at seven-day intervals.

Effective fungicides include Chlorothalonil (Daconil 2787, Ortho Multi-Purpose Fungicide) and EBDC fungicides (such as Mancozeb and Maneb).

The use of these fungicides calls for protective clothing, including rubber gloves, long sleeved shirt, and long pants.

These fungicides are toxic to fish and aquatic life. Do not apply directly to water (lakes, streams, ponds, or wetlands). Do not use on lands adjacent to water or wetlands, where drift or runoff could become hazardous to aquatic life.

Authors: David Whiting (CSU Extension, retired), with Carol O'Meara (CSU Extension, Boulder County), and Carl Wilson (CSU Extension, retired). Revised by Mary Small, CSU Extension

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MASTER GARDENER
COLORADO STATE UNIVERSITY
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CMG GardenNotes #719

Vegetable Garden Hints

Outline:

Harvesting quality and quantity from a vegetable garden starts with the gardener's ability to provide nearly ideal growing conditions for individual crops. Central to all highly productive gardens is a rich soil, high in organic matter, created with annual additions of compost and/or other organic materials. The following home gardening hints summarize a variety of research projects focusing on quality in vegetable production. Crops are grouped by families that have similar cultural practices.

Asparagus

Soils – Asparagus tolerates a wide range of soils as long as they are well drained. It prefers soil high in organic matter, and full sun (eight hours/day minimum).

Fertilizing – Asparagus is a heavy feeder. Fertilize in spring as growth starts and again in mid-summer after the harvest period.

Mulching – Asparagus competes poorly with weeds and other crops for water, nutrients, and space. Organic mulch is recommended. Mulch also provides winter cold protection for the roots.

Harvesting – The asparagus bed can be weakened or destroyed by over harvesting. The harvest period for an established bed is only four to six weeks (May into mid-June). Harvest only larger spears. Stop harvesting if spears decrease to pencil size or smaller. Leave the ferns (foliage) to grow until fall or let stand through the winter, finally cutting before new growth begins in spring.

Planting – Extra efforts in plantings new beds pay off with increased production.

1. Thoroughly work in four inches of well-composted and aged organic matter through the soil to a 12 inch depth.
2. Before planting, soak roots in warm water for a couple of hours.
3. Dig a trench four to five inches deep and wide enough to accommodate the spread-out roots. Space roots, typically 18 inches apart, covering with only two inches of soil.
4. Add additional soil during the growing season, as plants grow. Asparagus roots are easily smothered if initially covered too deep. (Many texts talk of planting six to eight inches deep for better protection from cold winter soil temperatures. However, this deep planting will decrease yields.)

When planting from seed, start seeds indoors 12 weeks prior to transplanting outdoors. Harden off seedlings before transplanting outdoors.

Beans

Soils – Beans are tolerant of a wide range of soils, as long as they are well drained. Beans are rather sensitive to soil salt. A soil rich in organic matter (to hold water and nutrients for growth) is preferred.

Planting – Research clearly demonstrates that early growth sets potential yield.

- Avoid planting too early in the spring. Soil temperature should be above 50ºF, measured at 8 a.m., six inches deep. For example, along the Colorado Front Range, this is typically early May for well-drained sandy soils to late May for clayey soils.
- Rich soil fertility should push early growth of plants. However, heavy nitrogen fertilization will lead to excessive plant growth at the expense of fruiting and increased disease problems.

Spacing affects yields – The potential for disease explodes once the plant canopy grows to cover over the patch; avoid over-crowding! Crop research suggests the following optimum spacings:

- 24 inches between rows with two inches between plants
- 18 inches between rows with three inches between plants
- 12 inches between rows with four inches between plants – (gives 20% higher yield than 24 inches × 2 inches spacing, but may increase disease pressure.)
- Six inches between rows with six inches between plants (this block style spacing will predispose the patch to foliage diseases.)

High water demand – During flowering and fruit production, beans have the highest water use of any vegetable crop. If the water supply is optimum, most varieties will produce until frost. If the water supply is low, beans will respond by:

1. Dropping blossoms
2. Producing pinched, pollywog-shaped fruit

Depending on temperature and wind, water use during fruiting will be ¼-inch to over ½-inch of water per day. Frequent watering in the right amount is essential for bean production.

Figure 1. Beans have a high water use. With inadequate water, blossoms drop, reducing yields. When beans need water, plant color changes slightly from a dark grass green to a grayish green. Windy weather significantly increases the water demand.

Cole Crops: Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Kale, and Kohlrabi

Quality is dependent on the weather and the grower's ability to provide conditions for rapid growth.

Soils – Being shallow rooted, cole crops require a fertile, moist, well-drained soil that is rich in organic matter and nitrogen.

Fertilizer – Cole crops are heavy feeders of nitrogen, phosphorus, and potassium. Apply a plant starter fertilizer (solution of water-soluble fertilizer like MiracleGro, Peters, and Rapid Grow) at planting, three weeks and five weeks. Starter fertilizers increase yields by 20%

Mulch – Because cole crops are poor competitors, mulch to stabilize moisture and control weeds. For early spring plantings, black plastic mulch helps warm cold soils. However, plastic becomes too hot when warm weather arrives. During warm weather, a grass clipping mulch cools the soil and microenvironment.

Irrigation – Cole crops are intolerant of drying. Dry soils quickly lead to strong flavors.

Temperature – Cole crops prefer growing temperatures between 65ºF and 80ºF. Hot weather reduces sweetness. Because seeds do not like cold soils, use transplants for spring planting. For a superior quality fall crop, direct seed the main planting in early-July (Front Range area).
Both broccoli and cauliflower tolerate some frost (down to lower 20's) on maturing plants.

Using Bt – For cabbageworm and looper control, treat with *Bacillus thuringiensis, Bt*, (a biological control product). Because *Bt* is rapidly broken down by sunlight, treat in the evening. *Bt*, a living organism, has only a two-year shelf life and cannot survive storage under extreme heat or cold.

Transplants –

- Preferred growing temperature for transplants is 60ºF to 70ºF. High temperatures result in too rapid growth, and tall, weak plants that are easily broken off in transplanting.

- The ideal transplant is about four inches tall and about four weeks old. Avoid transplants older than six weeks. Quick maturing varieties should be transplanted within four weeks of seeding.

Heading – Yield is based on plant size as the head (curd) starts to develop.

- **Bolting** (rapid head formation)

    - Broccoli and cauliflower are prone to bolting when exposed to cool weather before three to four pair of true leaves develop.
    - Long days and hot weather in the summer cause broccoli to bolt and go to seed, and cause cauliflower curds to develop a red-purple discoloration.
    - Cabbage bolts if exposed to two to three weeks below 50ºF Avoid planting too early in the spring.

- **Buttoning** (development of small heads or curds [buttons] on immature plants) – Factors that restrict early plant growth (including nitrogen deficiency, cold temperatures, shock to young transplants, and drought stress) lead to buttoning. Follow practices that will result in rapid vegetative growth.

- **Blindness** (plants having lost their terminal growing points produce no head) – Damage to the terminal growing point due to low temperatures, cutworms, damage or rough handling of transplants, will result in blind plants. Handle transplants carefully, control cutworms, and avoid planting in low temperatures.

Figure 2. For quality, broccoli, cabbage, and cauliflower need cool temperatures. In warm summer climates (like the Colorado Front Range) plant mid-July for harvest in the cooler temperatures of fall. They will tolerate fall frost down to the mid-20s.

Corn

Variety types –

- Normal sugary, (su) – standard varieties
- Sugar Enhanced, (se) – Sugar Enhanced (se) genes increase the original level of sugar in the kernel and slow the conversion of sugar

into starch. Isolation is helpful, but not required

- Super Sweet, (sh) – Super Sweet (sh) genes increase sugar content two to three fold. Delay planting until soil temperatures reach 70ºF, in June. Isolation from non-super sweet types by 300 to 500 feet or 14 plus day differences in maturity is required.

Yield = water + nitrogen + space

- Water stress will reduce overall plant growth reducing yields. In particular, water stress will delay silking beyond the time when tassels shed pollen, thereby preventing kernel formation.
- Side dress with nitrogen fertilizer frequently (every three to four weeks) through the summer to maintain a dark grass-green color. Sprinkle one cup 21-0-0 (or equivalent) per 50 feet of row, and water in.
- Spacing affects yields. Crowding decreases sunlight to the leaves, reducing the number and size of ears. Optimum spacing is 36 inches between rows with nine inches between plants or 30 inches between rows with 12 inches between plants. Allow side shoots to develop, but do not plant in clumps.

Plant in Blocks – Corn is wind pollinated, so plant in blocks at least three rows wide, preferably four to five rows wide. Single blocks may include only a portion of the row length, with the remainder of the row being part to a block of another variety that matures at different times.

Pollination – Corn is wind pollinated, but bees collecting pollen also frequently visit it. When applying insecticides, use caution to protect pollinating insects. Do NOT spray tassels with insecticides.

Figure 3. Corn needs to be planted in blocks for wind pollination. For pollination, two side-by-side four-foot wide beds are used. Each bed has two rows going down the bed. This makes the block four rows wide. To extend the harvest season, the top of the bed could have an early planting with a later planting at the bottom.

Leafy Vegetables and Salad Crops: Lettuce, Spinach, Swiss Chard, etc.

Quality lettuce, spinach, chard, and other salad crops is the mark of a great gardener. Quality is based on the gardener's ability to match ideal conditions for rapid growth, including water, fertilizer, space, and temperature.

Soils – A rich soil, high in organic matter, is necessary for quality.

Mulch – Organic mulch (like dry grass clippings) reduces summer soil temperatures producing sweeter produce, conserves moisture, and controls weeds. Weeding by cultivation will damage surface roots.

Irrigation – Keep soil moist with 1 to 1½ inches of water per week (including rain). If the crop gets dry, it will become tough and stringy.

Spacing – Thin the crop to reduce competition for nutrients, moisture, light, and space.

Planting for fall harvest – Plant lettuce and spinach in mid to late summer to produce exceptional harvest quality during cool fall weather. It can also be planted mid-fall for extra-early spring crops. Cover the small seedlings with organic mulch for winter protection.

Figure 4. For quality, leafy vegetables need a constant supply of water, rich soils. For best quality, thin plants when crop is tiny. Here a variety of leaf vegetables are in a raised bed, going across the box. As one row is harvested, immediately replant for a continual harvest of young tasty produce.

Onion Family: Garlic, Leeks, Onions, Shallots, etc.

Soils – The onion family has a poor, inefficient root system, making the crop intolerant of poor soils and competition from weeds. The plants are heavy feeders. Quality produce arises from a well-drained, fertile soil, rich in organic matter.

Mulch – The onion family thrives with organic mulch (like dry grass clippings), which cools the soil, conserves moisture, and controls weeds.

Photoperiod sensitivity – The onion family is sensitive to the length of night, which triggers bulb development. In Colorado, plant only long day varieties that start bulbing with day lengths of 14 to 16 hours and temperatures above 65ºF. Plant size at the time conditions trigger bulb development determines the size of the bulb. Plant onions as soon as soil conditions allow in the spring.

Seed head – Keep seed heads picked. They pull plant resources away from bulb development.

Seed, Sets, or Transplants – Onions can be planted from seed, sets, or

transplants. If planted from sets, sort sets larger than a dime from smaller ones. Plant small and large sets separately. Harvest from larger sets first because they do not store as well as onions grown from small sets.

Figure 5. Onions have a shallow inefficient root system. For quality they need an even moisture supply and rich soils.

Peas

Soils – Peas grow best in a rich soil, high in organic matter. They require a well-drained soil.

Types of peas –

- English Pea – standard, shelled pea
- Edible Pod Pea, Sugar Pea or Snow Pea – edible pod, pick before seeds swell
- Snap Pea – edible pod and plump sweet pea fruit

Plant as early as possible –

- Peas are sensitive to the photoperiod (length of night), influencing yields. At Colorado's latitude, an April 1st planting will have a 50% higher yield than a May 1st planting.
- Plant when soil temperatures reach 40ºF. Avoid planting in wet soils.

Planting for fall harvest – Peas may be planted in mid-summer for harvest during cooler fall weather. Sweeter peas develop in cooler temperatures. However, yields of the fall crop are reduced due to photoperiodism and the vines are prone to powdery mildew in the fall.

Figure 6. *Snap peas* are edible pod types eaten with plump peas filling the pod. *Edible pod peas*, *sugar peas* or *snow peas* are edible pod types eaten before the pod fills with peas.

Potatoes

Soils – Potatoes thrive in a soil rich in organic matter that provides water and nutrient holding capacity, and improved drainage. However, avoid heavy applications of fresh manure or compost, as it will make the tuber surface rough and increase the occurrence of scab.

Certified Seed – The use of certified seed helps reduce disease problems.

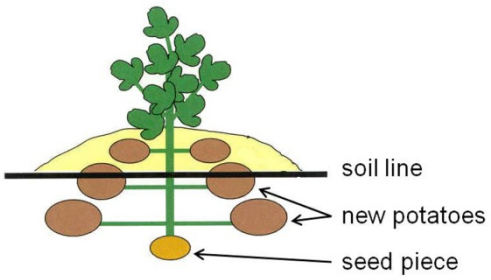
Give the plants a vigorous start –

- Plant when soil temperatures rise above 50°F, four inches deep at 8 a.m.
- Avoid using too small of a seed piece. Cutting seed pieces to 1½ to 2 inches in size provides for early plant vigor. Many gardeners prefer to use seed pieces that require no cutting to reduce decay potential.

Spacing – Plant spacing determines tuber size. Learn by experience the optimum spacing for the variety in a particular garden soil. A starting point is an equal-distant spacing of 12-15 inches between plants and between rows (or three plants across a four-foot wide raised bed). Spacing that allows the plants to close in and shade the soil yields sweeter spuds. However, thick foliage and reduced airflow can also increase the occurrence of disease.

Mulch – Transplants are hardened-off (growth rate slows so the plant is more tolerant of the move the greenhouse environment to the bright, windy outdoors) by withholding water and/or nutrients or by exposure to cooler temperature.

Figure 7. The new crop of potatoes grows above the seed piece. To shield the growing tubers from sunlight (which turns them green) soil is "hilled" (mounded) around the base of the plant. Straw mulch may be used as an alternative to hilling.



Fertilizer – Potatoes are heavy feeders of nitrogen, phosphorus, and potassium. Running out of nitrogen by August is the most common potato problem. Symptoms are a general yellowing of leaves that starts with lower interior leaves. Nitrogen stress pre-disposes the crop to Early Blight.

Moisture – If the soil is too wet or has poor drainage, tubers will rot. If the soil becomes overly dry, tubers will develop knobs.

Rhubarb

Soils -- Rhubarb thrives on any soil that is high in organic matter and well drained.

Yields – Yield is based on the plant's ability to store food reserves in the roots for the next year's crop.

- Keep seed stalk picked off.

- Stop harvest when temperatures rise above 85°F.
- Remove oldest stalks at the base when plants grow crowded, giving room for new stalks to grow. Never remove more than 1/4 of the stalks at one time.

Mulch – Rhubarb is a poor competitor for water and nutrients. Keep mulched with organic mulch.

Sun – It prefers full sun but grows poorly with reflected heat.

Coloration – Poor coloration of stalks develops from too much shade, too much heat, overly wet soils, or an inferior variety.

Re-planting – Reset when stalks become slender and the center of plant dies out, about every eight years. Rhubarb is best transplanted in the fall.

Root Crops: Beets, Carrots, Parsnips, Radish, Rutabagas, Turnips, etc.

Soils – Root crops need a rich, well-drained soil, high in aged organic matter.

Mulch – Use an organic mulch (like dry grass clippings) to cool the soil in summer, stabilize soil moisture, and control weeds.

Irrigation – Consistent soil moisture is a must!

Carrot disorders –

- Strong flavor – Many varieties have a high oil content (and the oil can turn rancid); change varieties.
- Hairy or rough root surface develop from too much <u>fresh</u> organic matter in the soil. Use old, well-aged compost or manure in the root crop section.
- Stubby, knobby, or cracked roots arise from uneven moisture supply, hot soil temperatures, or poor, rocky, or compacted soil conditions.
- Green shoulders result from root crowns exposed to sunlight and reduce sweetness. Mulch with dry grass clippings to shade the crown of the root.
- Failure of seedlings to emerge may arise from soil crusting, planting too deep or high soil temperatures.

Radishes –

- Hot and/or pithy radishes arise from hot weather, hot soil, and/or plants that are past maturity.
- Thin plants as soon as they pop through the ground!

Replanting of root crops for fall harvest – For tender young root crops, replant in mid-summer (Front Range area) for fall harvest.

Winter storage of roots – Some varieties of carrots store well in the garden soil or in a root cellar for year-round use. Other carrot varieties become strong-

flavored as the oil becomes rancid. Two useful options for winter storage include:

- Leave undisturbed where growing in the garden and mulch the bed with straw or other organic materials. Dig as needed.
- Place harvested carrots in straw in a garbage can storage pit.

Figure 8. Burpee white radish: for quality, root crops need an even moisture supply and rich soil.

Tomato Family: Tomatoes, Peppers, and Eggplants

Mulch – Use black plastic mulch for earlier production and higher yields. The mulch also helps controls weeds, conserves water, and protects the foliage from disease spores splashing from the soil.

Trellis – Trellis or cage tomatoes to allow for easier picking and suppress Early Blight (the most common tomato disease) and psyllids. Trellising allows plants to dry quickly following rains. An ideal trellis is two feet wide and four to five feet tall. It can be easily made from a six and half-foot length of concrete reinforcing wire coiled in a circle.

Spacing – Avoid crowding plants. Crowding will not increase yields, but will promote disease problems. The minimum spacing for trellised tomatoes is two feet.

Watering – Avoid overhead irrigation, which promotes leaf diseases. A soaker hose type of drip irrigation works well under plastic mulch. Tomatoes can also be furrow irrigated with water running in furrows under the plastic mulch.

Transplanting – Except for avid gardeners who use extra protective efforts to realize a few early tomatoes, avoid early plantings. Plant the main tomato crop when the threat of frost has passed and daytime temperatures are consistently above 60°F. A week of daytime temperatures below 50°F degrees stunts growth.

Fertilizer –

- Over-fertilization causes excessive vine growth at the expense of fruiting.

- However, starter fertilizer at planting and a couple of weeks later will encourage early growth. (MiracleGro, Peters, and Rapid Grow are examples of water-soluble fertilizers that make great starter fertilizers.)
- An additional light fertilization as the first fruits color also will increase yields and resistance to Early Blight.

Blossom drop – Hot, dry summer winds can cause blossoms to drop. Inconsistent watering contributes to this condition. Mulch plants.

With night temperatures below 55°F, blossoms that open the following morning will not have pollen, and blossoms will drop. For example, there is a 50/50 probability along the Colorado Front Range that any given summer night will too cool for pollen development. For early production and in cool locations the "blossom set sprays" effectively improve yields. If daytime temperatures rise above 90°F by 10 a.m., blossom opening that morning will abort.

Blossom end rot – Irregular watering and over-watering causes development of a dark, leathery area on the blossom end of fruits. Water consistently in a deep, improved garden soil and mulch will help prevent this condition.

Figure 9. Sweet 100 Tomato - Over 2,000 cultivars allow the gardener lots of options in flavor, fruit size, and disease management.

Vine Crops: Cucumbers, Melons, Pumpkins, and Squash

Soils – Vine crops thrive in well-drained soils high in organic matter. Yearly applications of compost will likely supply needed nutrients.

Mulch – Use black plastic mulch for earlier production and higher yields. It also controls weeds and conserves water.

Planting time – Do not plant too early. Daytime temperatures should consistently be above 55°F. Protect young, tender plants from cool winds.

Seeds or Transplants – Direct seeding is reported to give higher yields. If using transplants, they should be small, never more than two to four weeks old.

Blossom Drop –

- Vine crops have male flowers and female flowers (small fruit behind the flower). Male flowers develop first, and generally predominate.

Young fruits that are not pollinated will abort.

- When bee activity is limited, increase yields by hand pollination. Pick a male flower, remove petals, and touch the center of the female flowers with the male flower.
- Any form of stress (like too much or too little water, poor soil conditions, extreme heat, and wind) can reduce flowering and lead to abortion of fruits.

Figure 10. Vine crops have female flowers (left blossom) and male flowers (right blossoms). The female blossom has a tiny fruit at the base of the petals. For production, bees or the gardener must move the pollen from the male flower to the female flower.

Authors: David Whiting (CSU Extension, retired), with Carol O'Meara (CSU Extension, Boulder County), and Carl Wilson (CSU Extension, retired). Photographs and line drawings by David Whiting; used by permission.

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MASTER GARDENER
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CMG GardenNotes #720

Vegetable Planting Guide

Outline:

Cool Season Vegetables

These vegetables prefer cool growing temperatures (60°F to 80°F) and lose quality in hot weather. They are often replanted mid-summer for fall harvest.

Hardy Vegetable

Crops: broccoli, cabbage, kohlrabi, onions, lettuce, peas, radish, spinach, turnips

Temperatures: Hardy vegetables grow with daytime temperatures as low as 40°F and may survive a frosty nip.

When to plant:

- Based on soil temperatures, refer to Table 1.
- Plant as soon as soil adequately dries in the spring.
- These crops may be planted as early as 2-4 weeks before the date of the average last spring frost.

Semi-Hardy Vegetables

Crops: beets, carrots, cauliflower, parsley, parsnips, potatoes, and Swiss chard

Temperatures: Semi-hardy vegetables grow with minimum daytime temperatures of 40°F to 50°F, but are less tolerant of a frosty night.
When to plant:

- Based on soil temperature, refer to Table 1.
- Plant as soon as soil adequately dries in the spring.
- These crops may be planted as early as 0-2 weeks before the date of the average last spring frost.

Warm Season Vegetables

Warm season vegetables prefer summer-like weather with temperatures between 70°F and 95°F. They are intolerant of frost and may be sensitive to cool spring winds.

Tender Vegetables

Crops: beans, celery, corn, cucumbers, New Zealand spinach, summer squash

Temperatures: Tender vegetables grow with a daytime temperature above 55°F, and are intolerant of frost.

When to plant:

- Based on soil temperature, refer to Table 1.
- Soil is adequately dry to work.
- These crops may be planted (from seed) around the date of the average last spring frost. Transplants of cucumbers and summer squash without frost protection should be delayed until frost potential is over.

Very Tender Vegetables

Crop: lima beans, cantaloupe, eggplant, pepper, pumpkin, winter squash and pumpkins, tomato, and watermelon

Temperatures: Very tender vegetables are not only intolerant of frost, but also cool spring winds. They need daytime temperatures above 60°F, and prefer temperatures of 70°F to 95°F. A week of daytime temperatures below 55°F, may stunt the crop.

When to plant:

- Based on soil temperature.
- Soil is adequately dry to work.
- These crops are typically planted two plus weeks after the average last spring frost date.
- Weather is becoming summer-like, (i.e., consistently above 55°F (daytime) and breezes should have lost any cool nip).

Table 1 – Vegetable Planting Guide

Vegetable	Germination Temperature[1] Min.	Optimum	Max.	Plant Spacing[2]	Planting Depth	Days to Germination	Typical Days to Harvest	Age of Transplant (weeks)
Cool Season Crops[3]								
Beets	40°	80°	90°	4-6”	¾-1”	7-10	60	
Broccoli[4]	40°	80°	90°	18”	½”	3-10	65T[4]	5-7
Cabbage[4]	40°	80°	90°	18”	½”	3-10	85T[4]	5-7
Carrots	40°	80°	90°	2-3”	¼”	10-17	70	
Cauliflower[4]	40°	80°	90°	18”	½”	3-10	65T[4]	5-7
Kohlrabi	40°	80°	90°	7-9”	½”	3-10	50	
Leeks	40°	80°	90°	4-6”	¼”	7-12	120	
Lettuce (leaf types)	35°	70°	70°	7-9”	¼”	4-10	60	
Onion, green	35°	80°	90°	2-3”	¼”	7-12	60	
Onions, dry (seed)	35°	80°	90°	4-6”	¼”	7-12	110	
(sets)				4-6”	1-2”			
Parsnips	35°	70°	90°	5-6”	½”	15-25	70	
Peas	40°	70°	80°	4-6” or 3”×8”	1”	6-15	65	
Potatoes	45°			12-15”	4-6”		125	
Radish	40°	80°	90°	2-3”	½”	3-10	30	
Spinach	40°	70°	70°	4-6”	½”	6-14	40	
Swiss Chard	40°	85°	95°	7-9”	1”	7-10	60	
Turnips	40°	80°	100°	4-6”	½”	3-10	50	
Warm Season Crops								
Beans, snap	55°	80°	90°	6” or 4” x 12”	1-1½”	6-14	60	
Cantaloupe[5]	60°	90°	100°	36-48”	1-1½”	3-12	85	2-3[5]
Corn	50°	80°	100°	12” x 30”	1-1½”	5-10	60-90	
				9” x 36”				
Cucumbers	60°	90°	100°	6” trellised	1”	6-10	55	2-3[5]
				24-36” untrellised				
Eggplant	60°	80°	90°	18-24”	¼”	7-14	60T[6]	6-9
Pepper	60°	80°	90°	15-18”	¼”	10-20	70T[6]	6-8
Tomato	50°	80°	100°	trellised: 24”	¼”	6-14	65T[6]	5-7
				between plants				
Squash, Summer	60°	90°	100°	36-48”	1-1½”	3-12	50	2-3[5]
Squash, Winter	60°	90°	100°	36-48”	1-1½”	6-10	100	2-3[5]
Watermelons	60°	90°	110°	36-48”	1-1½”	3-12	85	2-3[5]

1 **Germination temperature –** Soil temperature is one of the best methods to determine spring planting time. Plant when soils reach minimum temperature measured at 8 a.m., 4 inches deep. Beans are an exception, being measured at 6 inches deep. Optimum temperatures listed in the table are useful for starting seeds indoors. Maximum temperatures are listed in regards to high soil temperatures that may interfere with seed germination in the summer.

2 **Plant Spacing –** Spacings given are equal-distance spacing for crops grown in block or close-row style beds. For example, beets, with a spacing of six inches are thinned to six inches between plants in all directions. In other words, beets are thinned to six inches between beets in the row and six inches between rows. The closer spacing listed should be used only on improved soils with 4-5% organic matter.

Close-row or block style planting works well for raised bed gardening, with blocks/beds 4 feet wide (any length desired) and 2-foot wide walkways between blocks/beds.

3. **Cool Season Crops** – Cool season crops prefer a cool soil. Lawn clipping and newspapers make an excellent mulch for these crops by cooling the soil, preventing weed germination, and conserving water. Apply fresh grass clippings only in thin layers (less than ½ inch) and allow it to dry between applications. Thick layers will mat and smell. Do not use clipping from lawns treated with weed killers or other pesticides. Several layers of newspapers covered with grass clippings also work well between rows. Do not use glossy print materials.

4 **Transplanted Cole Crops –** Since cole crops (cabbage, cauliflower, broccoli, and Brussels sprouts) germinate better in warmer soil, they are typically started from transplants in the spring. Days to harvest are from transplants. In the warmer areas of Colorado, these crops produce the best quality when direct seeded mid-summer (early July for the Front Range area) for harvest during cooler fall weather. Before planting out, harden off seedlings.

5 **Transplanting Vine Crops –** Vine crop (cucumbers, squash, melons) roots are extremely intolerant of being disturbed, and perform best when grown by direct seeding rather than by transplants. With the use of black plastic to warm the soil, direct seeded crops germinate rapidly. If using transplants, select small, young plants, not more than 2-3 weeks from seeding.

6 **Tomato family transplants** – The tomato family is traditionally planted from transplants. In warmer areas of Colorado, they can also be direct seeded with minimal delay. Days to harvest are from transplants.

Authors: David Whiting (CSU Extension, retired), with Carol O'Meara (CSU Extension, Boulder County), and Carl Wilson (CSU Extension, retired).

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CMG GardenNotes #721

Sample Planting Guide for Raised-Bed Garden

The following table is a guide for planting a family vegetable garden in a block-style layout. It is based on a raised bed system with boxes four feet wide and rows typically running across the bed (four feet long).

Planting times are based on May 10 and October 10 average frost dates, typical of Colorado's Front Range. In other areas, adjust the planting dates using local average frost dates.

Estimated planting for fresh use and *projected yields* are estimates on what a family of four may consume in fresh use during the harvest period. Actual plantings should be adjusted to the family's likes for various vegetables and desire for canning, freezing, and storage.

Authors: David Whiting (CSU Extension, retired), with Carol O'Meara (CSU Extension, Boulder County), and Carl Wilson (CSU Extension, retired).

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Cool Season Planting Groups	Crops	Block Style Spacing	Estimated Planting for Fresh Use amd Projected Yield	Planting Time	Harvest Period
Cole Crops	Broccoli, cabbage, and cauliflower	3 plants across a 4-foot wide block (row) with 18 inches between rows	1-2, 4-foot rows each per planting 1 head per plant = 3 heads per 4-foot row	Spring planting for summer harvest: 1. Early April – Broccoli and cabbage from transplants 2. Early May – Broccoli, cabbage, and cauliflower from transplants	Spring plantings/summer harvest in June to early July (1-3 weeks per plantings, depending on temperatures) In warm weather crops come on rapidly with reduced quality (sweetness). Check every couple of days for harvestable stage, and store crops in fridge. Crops over-mature rapidly in warm temperatures.
			2-3+ 4-foot rows each. 1 head per plant = 3 heads per 4-foot row	Summer planted for fall harvest: Broccoli, cabbage, and cauliflower by direct seed, mid-July for fall harvest	Summer planting/fall harvest – 4-8+ weeks with excellent quality due to cool fall temperatures. Harvest crops as needed. They tolerate a mild frost into the mid to low 20s and can be stored in fridge or pit for winter use.
Leafy Vegetables & Salad Crops (Kitchen garden)	Lettuce (leaf and soft head types)	Thin to 7-9 inches, with rows 7-9 inches apart	1-3, 4-foot rows, with assorted varieties per planting ~ 6 heads per 4-foot row ~ 3 lbs. per 4-foot row	1. Early April	May-June
				2. Early May	June-July (depending on temperatures)
				3. Late July	Early September+
				4. Mid August	Late September+
	Spinach	Thin to 4-6 inches, with 6 inches between rows	1-3, 4-foot rows per planting ~8 bunch per 4-foot row ~2 lbs. per 4-foot row	1. Early April	May-June
				2. Early May	June-July (depending on temperature)
				3. Late July	Early September+
				4. Mid August	Late September+
	Chard	Thin to 7-9 inches, with 7-9 inches between rows	1-2, 4-foot rows ~ 4 lbs. per 4-foot row	Late April to early May	Harvest by cutting off leaves, plants grow back, for summer long harvest
	Kohlrabi (a cole crop)	Thin to 7-9 inches, with 7-9 inches between rows	1-2, 4-foot rows per planting ~ 6 heads per 4-foot row	1. Early April	June
				2. Early May	Mid June to early July (depending on temperatures)
				3. Mid to late July	September+

Cool Season Planting Groups	Crops	Block Style Spacing	Estimated Planting for Fresh Use and Projected Yield	Planting Time	Harvest Period
Onion Family (Kitchen garden)	Dry onions	4-6 inches, with 4-6 inches between rows	2-5, 4-foot rows ~ 10 bulbs per 4-foot row ~ 3 lbs. per 4-foot row	Early April to early May Onions are sensitive to photoperiod, the early the planting the larger the bulbs.	Mid summer through fall
	Green onions	2-3inches, with 2-3inches between rows	1-2, 4-foot rows ~ 4 bunches per 4-foot row	Early April to early May	Early summer through fall
	Leeks (soup onion)	4-6 inches, with 4-6 inches between rows	1-2, 4-foot rows ~ 10 bulbs per 4-foot row	Early April to early May	Fall into winter (for winter harvest leave in garden and mulch to protect from extreme cold, dig as needed.)
Peas	Peas	Thin to 3-4 inches, with 8 inches plus between rows Note: Peas are easier to pick in a single or double row rather than in the block-style plantings	20' double row ~ 12 lbs per 20' double row	1. Early April to early May, as soon as soil temperature reaches 40ºF. Peas are sensitive to photoperiod, early plantings give higher yields.	June
			20' double row ~ 6 lbs. per 20' double row	2. Mid July	September Note: fall plantings are prone to powdery mildew and have lower yields, making them questionable.
Potatoes	Potatoes	3-4 plants across a 4-foot wide bed, with 15 inches between rows	A 16-foot by 4-foot bed of potatoes would produce around 72 pounds.	Early May	July+ Mulch with straw

Cool Season Planting Group	Crops	Block Style Spacing	Estimated Planting for Fresh Use and Projected Yield	Planting Time	Harvest Period
Root Crops	Carrots	Thin to 2-3 inches, with rows 3 inches between rows	6-18+, 4-foot rows ~ 4 lbs. per 4-foot row	Early May	July through fall; can be left in the garden and mulched for winter harvest.
	Beets	Thin to 4-6 inches, with 4-6 inches between rows	1-2, 4-foot rows per planting ~ 4 lbs. per 4-foot row	1. Early May	June-July – Thin for beet greens. Harvest roots while young (small) for best quality
				2. Mid July	September-October – Thin for beet greens. Harvest roots while young (small) for best quality
	Parsnips	Thin to 5-6 inches, with 5-6 inches between rows	2-6, 4-foot rows ~ 4 lbs. per 4-foot row	Early May	For late fall to winter harvest, after soils cool, mulch for harvest through the winter.
	Radish	Thin to 2-3 inches, with 2-3 inches between rows	1-2, 4-foot rows per planting ~ 4 bunches per 4-foot row	1. Early April	Early May
				2. Early May	Early June
				3. Early August	Early September
				4. Late August	Late September
	Turnips	Thin to 4-6 inches with 4-6 inches between rows	1-2, 4-foot- rows per planting ~ 4 lbs. per 4-foot row	1. Early May	June-July -- Thin for greens. Harvest roots while young (small) for best quality
				2. Mid July	September-October – Thin for greens. Harvest roots while young (small) for best quality

Warm Season Planting Group	Crops	Block Style Spacing	Estimated Planting for Fresh Use and Projected Yield	Planting Time	Harvest Period
Beans	Pole beans	Thin to 4 inches in a single row	10-20' row ~ 10 lbs. per 10 foot row	Mid May	July till frost, with adequate water
	Bush beans	Thin to 4 inches , in double row. Beans are easier to pick in a single or double row rather than block-style planting.	10-20' row ~ 10 lbs. per /10 foot double row	Mid May	July till frost, with adequate water
Corn		For pollination, corn must be planted in block with 4+ rows wide. In a block-style garden, plant 4 rows with 2 rows each going the length of the box, in 2 boxes side by side. Space plant 9 inches in the row.	A block of 4, 6-foot rows will give ~60 ears	1. Mid May 2. Mid June	Late July to October – Harvest period on any variety is only 10 to 20 days. For continual harvest of fresh corn plant varieties with 20+ days difference till harvest OR make second planting 20-30 after the first.
Eggplant		3 plants across a4 foot row, with rows 18-24 inches apart	1, 4-foot rows ~ 12 fruit per 4-foot row (4 fruit per plant)	Late May, temperatures consistently above 60 ºF	August till frost (A Wall-Of-Water can be used for earlier production.)
Peppers		3 plants across a 4-foot row, with rows 18 inches apart	1-4, 4-foot rows, depending on family use Yields vary with variety ~ 18 bell peppers/4-foot row (6 fruit per plant)	Late May, temperatures consistently above 60 ºF	August till frost (A Wall-Of-Water can be used for earlier production.)
Tomatoes		Trellis in single row, plants spaced 24 inches apart.	3-6 plants, depending on family use ~ 26 lbs. (½ bushel) per plant	Late May, temperatures consistently above 60 ºF	August till frost (A Wall-Of-Water can be used for earlier production.)

Warm Season Group	Crops	Block Style Spacing	Estimated Planting for Fresh Use and Projected Yield	Planting Time	Harvest Period
Vine Crops	Cucumbers	Trellis in single row, plants spaced at 6 inches.	2-4 plants, depending on family use ~ 1 lb. per plant	Mid May for direct seeding OR late May for transplants	Mid July till frost For maximum yields, do not let fruit get large on the vine.
	Zucchini and other summer squash	Single row down center of 4-foot box; two plants take 4-foot by 8-foot	2 plants	Mid May for direct seeding or late May for transplants	Mid July till frost (A Wall-Of-Water can be used for earlier production)
	Cantaloupes, Watermelon, Pumpkins, and Winter Squash	1-3 plants per type, as desired by family 2-6 fruit per plant	Single row down center of 4 inches wide box with 2-3' between plants. Makes a great ground cover for garden areas. ~ 3-4 fruit per plant	Late May, temperatures consistently above 60ºF	September-October

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CMG GardenNotes #722

Frost Protection and Extending the Growing Season

Types of Frost

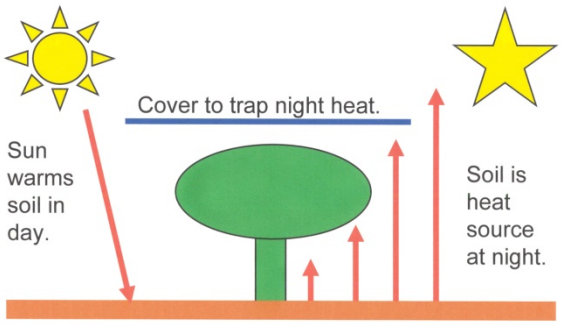
Advective frosts occur when a cold front moves into the area. Temperatures may drop significantly below critical levels thereby making crop protection questionable.

Radiation frosts occur on calm clear nights that lack cloud cover to hold in heat. Radiation frosts at the beginning and end of the growing season are typically only a few degrees below critical levels, making crop protection worthwhile.

Heat Source at Night

Soil, warmed by the sun in the daytime, is the source of heat for frost protection at night. Moist, smooth soil absorbs more heat. To trap heat from the soil around young vegetables at night, place a covering that is low to the ground and spreading. To recharge the heat source for the next night, any covering must allow sunlight to shine through to the soil or must be removed in the daytime. [Figure 1]

Figure 1. The sun warms the soil in the daytime. Heat from the soil keeps crops warm at night. A covering traps heat from the soil around the crops.



Coverings

Blankets and Sheets

Grandma's old method of covering the garden with blankets and sheets works well as long as the fabric remains dry. If the fabric absorbs water, evaporative cooling can lead to colder temperatures adjacent to the blanket. To recharge the heat stored in the soil, the blankets and sheets must be removed in the daytime.

Floating Row Covers

Floating row covers are lightweight fabrics that lay directly over crops. Because they transmit light, they provide crop protection over an extended period of time without being removed. They provide 2°F to 4°F of frost protection, cut wind on tender plants, and screen out some insects. On insect pollinated crops, covers must be removed for pollination to occur. [Figure 2]

Floating row covers are popular in commercial vegetable production where crops planted in large blocks are easily covered with row covers. Many brands and fabric types are commercially available.

Figure 2. Floating row cover on broccoli and cabbage, protecting crops from cabbageworms moths.

Clear Plastic Covering on Frame

When plastic is used as a covering over a growing bed, it must be held up off the plants. Plants will freeze where the plastic touches them.

Tunnel Gardening – Gardening catalogs carry wire hoops for use in "tunnel" or cloche gardening. Hoops are placed at three to five foot intervals depending on the wind exposure of the site. The wire hoops hold up a strip of plastic forming a tunnel-shape covering down the growing bed. Bury the edges of the plastic a few inches into the soil on all sides. On a raised-bed box made with lumber, staple the plastic to the sides of the box. Two-inch holes cut in the sides of the plastic tunnel at two to three foot intervals are essential to reduce overheating.

This type of covering is popular with commercial tomato, pepper, and melon growers for an early start to the growing season. It provides 2°F to 4°F of frost protection, protects tender plants from cold spring wind, and provides warmer

growing temperatures inside the tunnel. Tunnels are removed when warm weather arrives and the danger of frost is past.

Plastic Covered Cold Frame Made with Concrete Reinforcing Mesh

An easy cold frame structure for a growing bed is made with 4-mil clear plastic (polyethylene film) draped over concrete reinforcing mesh. The structure is easily opened during warm days and closed for cold nights. It works well with a 4-foot wide, raised-bed garden system. [Figure 3]

Figure 3. Cold frame for a raised bed garden made from concrete reinforcing mesh covered with 4-mil plastic. Notice the belt-like plastic straps, which hold the covering in place. The covering is slid between the straps and mesh to open and close. Pictured open for ventilation on a warm day.

The frame is concrete reinforcing mesh, available at hardware and lumber stores. This stiff wire mesh typically comes five feet wide, in 50 and 100-foot rolls. A six-foot length is required to make a Quonset-type frame over a four-foot wide growing bed. In trials, the low and spreading shape was ideal for trapping heat from the soil during a frosty night.

Cover the frame with clear, 4-mil polyethylene plastic. It typically is sold in 10' by 25' rolls. For a four-foot wide raised bed box, place a 3½-foot wide section on each side, overlapping at the top. On a raised bed box, staple the plastic to the sides of the wood box. In soil bed applications, bury the plastic a few inches along the sides.

Hold the plastic onto the frame with small clips available at local hardware stores. Clothespins do not hold in the wind. Another method is to use a series of 6-inch wide, belt-like plastic straps arching over the frame (above the plastic cover) and stapled onto the box. Open and close the cover by sliding it between the frame and the belt-like straps. Hold the plastic closed at the ends with a rock or brick. [Figure 4]

Figure 4. Clip holds plastic on frame.

During the day, the covering MUST be opened, at least a slit, to prevent overheating. With just an hour of sun, temperatures under a closed cover can quickly rise to over 130°F! [Figure 5]

On cool days, open the top a crack to prevent excessive heat build-up. On a warm day, the plastic can be slid down the side, ventilating and providing crops exposure to the outdoors. On freezing nights, close the cover completely. On warm nights, the covers may be left open a crack. On stormy days with full cloud cover and no direct sun, the cover may remain closed. [Figure 5]

Figure 5. Left: Cover must be opened at least a slit to prevent over-heating. Right: Cold frame pictured closed for a cold night.

Not only will the covers provide frost protection, they also increase growing temperatures for early crop growth and provide protection from cold winds.

In trials in Fort Collins, Colorado, a plastic cover on a frame typically provides 3°F to over 6°F of frost protection. It works well for cool season crops that are somewhat tolerant of frosty nights, and adds two to six weeks or more on both ends of the growing season. For warm season tomatoes and summer squash crops (being intolerant of a frosty nip), adding a small light inside the cold frame provides even better frost protection.

Adding Space Blankets

On extra cold nights, placing an aluminum space blanket over the plastic on the frame significantly adds to the frost protection. With the aluminized side placed down (towards the plants), a space blanket reflects 99% of the heat. They are readily available where camping gear is sold. [Figure 6]

In trials in Fort Collins, topping a plastic-covered, concrete mesh cold frame with a space blanket prevented freezing when outside temperatures dipped to 0°F following a sunny spring day. The space blanket must be removed each day to recharge the soil's stored heat

Figure 6. Aluminum space blanket covering a cold frame for extra protection on cold nights.

Lights for Additional Heat

Christmas tree lights – For additional protection, add Christmas tree lights inside the cold frame. In Fort Collins trials, one 25 light string of C-7 (mid-size) Christmas lights per frame unit (four feet wide by five feet long) gave 6°F to over 18°F frost protection. Lights were hung on the frame under the plastic and turned on at dusk and off at dawn. Christmas lights work better than a single, large light bulb in the center by eliminating cold corners and edges. [Figure 7]

Figure 7. Cold frame with Christmas tree lights for additional warmth.

Space blanket with Christmas tree lights – For the gardener really wanting to extend the growing season, try Christmas lights plus a space blanket. One 25 light string of C-7 (mid-size) Christmas lights per frame unit (four feet wide by five feet long) with a space blanket on top gave 18°F to over 30°F frost protection in Fort Collins trials.

Wall of Water®

The Wall-of-Water® is a cone-shaped ring of connected plastic tubes filled with water that surrounds a single plant, like a tomato, pepper, or summer squash. [Figure 8]

This device works on the chemistry principle of heat release in a phase change; there is a significant amount of heat released as water freezes (changes from the liquid phase to the solid or ice phase). A Wall-of-Water provides frost protection typically down to temperatures in the mid-teens. It also provides wind protection for tender plants and growing temperatures may be slightly warmer inside a Wall-of-Water.

They are helpful to get a few extra weeks head start on vine ripe tomatoes. However, an extra early tomato may out-grow the protection and the tops may be nipped back by frost.

Both cold air temperatures and cold soil temperatures are limiting factors in early crop production. When using a Wall-of-Water to start early crops, warm the soil with black plastic mulch.

In filling the Wall-of-Water, be careful not to splash excessive water onto the soil. A wet soil will be both slow to warm and dry in the spring. Moderately moist soils are best.

Figure 8. Tomato in Wall-of-Water. Notice use of black plastic mulch to warm the soil, another limiting factor of early production. Also, note the plant has grown beyond the device and is now less protected from frost.

Authors: David Whiting (CSU Extension, retired), with Carol O'Meara (CSU Extension, Boulder County), and Carl Wilson (CSU Extension, retired). Photographs by David Whiting; used by permission.

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MASTER GARDENER
COLORADO STATE UNIVERSITY
EXTENSION

CMG GardenNotes #723

Growing Vegetables in a Hobby Greenhouse

Outline:

Extending the Growing Season

Off-season vegetable production in the hobby solar greenhouse is an enjoyable way for year-round gardeners to extend the harvest season of fresh vegetables. However, without the expense of a greenhouse, gardener can extend the growing season weeks to even months with cold frames and plastic tunnel gardening

Winter vegetable production in a greenhouse is only cost effective with an energy efficient greenhouse structure, a well-designed solar collector, and optimum management. Winter vegetables have a slow growth rate due to low light intensity. Crops should be planted to obtain a near harvestable size by mid-October. The use of artificial light for vegetable production (except for starting transplants) is generally not cost effective.

A gardener's success is dependent on the greenhouse design and construction to conserve energy and on the management care given the greenhouse crops.

Before investing in a greenhouse, carefully consider your real interests in extending the gardening season. Are you only interested in adding a few weeks to the harvest season? Are you interested in year-round gardening in a solar greenhouse OR do you need a winter break?

Passive Solar Greenhouse

For the gardener considering a passive solar hobby greenhouse, here are a few key points to consider. Refer to other greenhouse references for additional details.

For solar collectors, any area with direct sun, but not blocking solar illumination of plants, is a potential location. For a hobby greenhouse, solar collectors are typically built into an insulated north wall.

A solid brick wall on the north makes a good solar collector. Brick absorbs 30 to 35% of the solar radiation. With a brick storage wall, the greenhouse quickly heats on a sunny winter day and ventilation will be needed by mid morning. [Figure 1]

Figure 1. Brick storage wall in passive solar hobby greenhouse – Thermal storage mass is a wall made with two layers of brick filled with concrete. In this well-built structure, nighttime temperatures dropped to 35°F with no supplemental heat when outside temperatures dropped to -17°F. Note young crops in raised-bed style garden with drip irrigation.

Water storage using plastic milk jugs makes a great storage system. Water jugs absorb 90% of the solar radiation, holding three times more heat than brick or rock. This increased heat storage holds night temperature higher longer into the night, resulting in slightly improved crop growth compared to brick storage. [Figure 2]

Figure 2. Milk jug water storage wall in a passive solar hobby greenhouse. Disposable milk jugs on left and returnable milk jugs on right are spray painted flat black. In this well-built structure, nighttime temperatures dropped to 39°F with no supplemental heat when outside temperatures dropped to -17°F.

With milk jug storage, spray the milk jugs with flat black paint, and add one tablespoon of liquid bleach per jug (to prevent algae growth in the warm water). Secure the cap back on the jug with a ring of caulk. Place the milk jug on a bookcase type frame not more than two jugs high.

Disposable milk jugs develop leaks over time and require routine replacement. Heavier weight jugs (like returnable plastic milk jugs) last longer. Other types of containers may be used. Keep the size two gallons or smaller or water will stratify with hot water on the top and cooler water on the bottom, reducing efficiency.
A passive solar hobby greenhouse is only effective when built to optimum energy specifications. Because the major heat loss is through the glazing, double-glazing (which reduces heat loss by 25 to 35%) is required. Double glazed patio door glass is great for glazing a hobby greenhouse. Glass suppliers sometimes have recycled

(used) patio door glass available at minimal prices. Night curtains may add an additional 30 to 50% energy conservation. On a passive solar hobby greenhouse, the north, east, and west walls are typically insulated to an R-value of R38. The foundation and floor are insulated from heat loss to the ground. [Figure 3]

Figure 3. Hobby greenhouse being constructed with double glazed patio door glass.

Cold air infiltration is the second major source of heat loss. For passive solar to be effective, minimize cold air infiltration with good design and construction techniques. Insulative vent covers help reduce cold air infiltration at night, but must be removed daily to allow thermostats to maintain proper temperature.

A passive solar hobby greenhouse requires an east to west orientation. In northern Colorado latitudes, an east to west orientation receives 25% more solar energy than a north to south orientation. Sometimes the hobby greenhouse may be oriented slightly to the east for faster morning warming. An orientation 20º off east to west will cut 4 to 5% of the solar potential, while an orientation 45º off east to west will cut 18 to 20% of the solar potential. At northern Colorado latitudes in January, a north to south orientation cuts 25% of the solar potential.

A poorly constructed greenhouse cannot be retrofitted into an efficient passive solar unit.

Cool Season Vegetables

Cool season vegetables do well in the greenhouse or cold frame. High temperatures are not desirable, and an occasional near freezing dip will not harm crops. High light intensity is not as critical for cool season crops as for warm season crops. [Figure 3]

Figure 4. Lettuce in solar greenhouse raised bed.

General temperatures for cool season crops

Daytime: 50ºF to 70ºF Short-term temperature extremes: 35ºF to 90ºF
Nighttime: 45 ºF to 55 ºF Germination: 40ºF to 75ºF

Vegetable	Minimum Container Size*	Minimum Equal-Distance Spacing	Remarks
Beets	8” deep	6”	• Grow in fall and hold in cool greenhouse for winter use. • Properly thin.
Broccoli Cabbage Cauliflower	10” deep 5 gallons/plant	18”	• High yield for space used. • Avoid long-term temperature extremes. • Heads split with warm humid conditions.
Carrots	12” deep	3”	• Extremely sweet with adequate water and cool temperatures. • Use short varieties, like Short & Sweet or Scarlet Nantes • Questionable use of greenhouse space.
Chard	8” deep	9-12”	• Does exceptionally well.
Kohlrabi	8” deep	9”	• Does exceptionally well.
Leaf lettuce	4” deep	9”	• Easy to grow in fall, winter and spring in solar greenhouse. • Use softhead or leaf types. • Keep temperatures under 70 ºF.
Green onions	6” deep	3”	• Never let onions get dry. • Sensitive to photoperiod (length of night). With short days (long nights), growth goes into leaf production. With long days (12-16 hours) energy goes into bulb production.
Peas	8” deep	6”	• Use dwarf, edible-pod or snap types for salads and stir-fry. • Avoid temperature extremes. • Questionable use of space. • Do not transplant well, not well suited to container gardening.
Radish	5” deep	2-3”	• Avoid water and heat stress. • Must have 12 hours of light to root. • For fall and spring crops in greenhouse.
Spinach	8” deep	6”	• Needs cool greenhouse (45ºF to 50ºF) for best quality. • Avoid temperature fluctuations.
Turnips	8” deep	6”	• Good for fall and spring crops.

Many oriental vegetables are also suited for greenhouse production.
*A larger container size will make crop easier to care for, providing a larger supply of water and nutrients.

Warm Season Vegetables

Warm season vegetables require high light intensity and moderate night temperatures. They cannot be cost effectively grown during the winter in a hobby greenhouse without solar heat collectors. Greenhouse climates control is critical for these fruiting crops to produce. Warm season crops are not compatible with cool season crops due to differing temperature needs.

General temperatures for warm season crops

Daytime – 60ºF to 85ºF	Short-term temperature extremes – 50ºF to 95ºF
Nighttime – 55ºF to 65ºF	Germination – 60ºF to 85ºF

Vegetable	Minimum Container Size	Minimum Equal-Distance Spacing	Remarks
Beans	8” deep	6”	• Not a common greenhouse crop. • Good production with adequate light and spacing in spring and fall. Poor winter production. • May be questionable use of greenhouse space.
Cucumbers	8” deep 3-4 gallons/plant	18”	• Requires high humidity, high light intensity, and good moisture. • Needs 75ºF to 80ºF day temperatures and 50ºF minimum nights. • Avoid temperature fluctuations greater than 20ºF. • Poor mid-winter production. • Plant gynecious greenhouse types. • Needs good air circulation to minimize powdery mildew.
Eggplant	8” deep 4-5 gallons/plant	24”	• Hand pollination required.
Muskmelon	8” deep 5 gallons/plant	24”	• Uses lots of space for yield, try trellising. • Needs 80ºF day temperatures. • Requires hand pollination. • Needs good air circulation to minimize powdery mildew.
Peppers	8” deep 2-5 gallons/plants	15”	• Minimum night temperatures of 55ºF. • Hand pollination required.
Summer Squash	8” deep 5 gallons/plant	24”	• Hand pollination required. • Needs good air circulation to minimize powdery mildew. • Productive with good sunshine.
Tomatoes	12” deep 2-5 gallons/plant (depending on cultivar/plant size)	24”	• Minimum night temperature of 55 F. • Hand pollination required. • Productive with good sunshine.

*A larger container size will make crop easier to care for, providing a larger supply of water and nutrients.

Figure 5. Beans in solar greenhouse raised bed

Figure 6. Raised bed in solar greenhouse.

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MASTER GARDENER
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CMG GardenNotes #724

Vegetable Gardening in Containers

Container vegetable production is somewhat more demanding than growing flowers and other ornamentals in containers. Quality of most vegetables is based on the soil's ability to provide a constant supply of water and nutrients. Vegetables become strong flavored, stringy, and tough under dry or low fertility conditions. With the limited root spread in a container, the gardener must frequently and regularly supply water and fertilizer. In growing container flowers, minor lapses in daily care may interrupt flower production, but flowering eventually resumes with returned quality care. With container vegetables, minor lapses in daily care may significantly reduce produce quality.

Warm Season Vegetables

Warm season vegetables prefer warmer summer temperatures (70ºF to 95ºF) and are intolerant of frost. They are typically planted after the average spring frost date as summery weather moves into the area. Along the Colorado Front Range, planting time would be mid-May to early June. Warm season crops need full sun.

Cool Season Vegetables

Cool season vegetables prefer the cool growing temperatures (60ºF to 80ºF) of spring and fall. Most are intolerant of summer heat. They do tolerate light frosts. Leafy and root vegetables prefer full sun, but are tolerant of partial shade. They are intolerant of reflected heat during the summer season.

Spring crops are typically planted two to four weeks before the average spring frost date. Along the Colorado Front Range, spring planting times are mid-April to early-May. Most are replanted in mid-July to mid-August for a fall harvest.

The quality of these vegetables is directly related to their ability to grow rapidly in a good soil mix under frequent light fertilization and a constant supply of water. Crops become strong flavored if they become dry.

Warm Season Vegetables

Vegetable	Minimum Container Size*	Minimum Direct Sunlight Per Day	Remarks
Beans	8” deep	full sun	• In a long box 12 inches wide, plant bush beans or trellis pole beans. • Beans have a high water requirement during blossoming. • Beans drop blossoms with dry soil or excessive wind.
Cantaloupes Muskmelons	5+ gallons/plant	full sun	• May be trellised to conserve space. • Compact varieties preferred for container gardening. • With male and female blossoms, may need hand pollination. • Needs good air circulation to minimize powdery mildew.
Cucumbers	8” deep 3+ gallons/plant	full sun	• Grow bush-types in hanging baskets or on a trellis (vines grow 18-24 inches long). • Grow strong vining-types on trellis. • Needs good air circulation to minimize powdery mildew. • Young plants are very sensitive to wind burn.
Eggplant	8” deep 4-5 gallons/plant	full sun	• One plant per container. • Needs night temperatures above 55ºF for pollen development.
Peppers	8” deep 2-5 gallons/plants	full sun	• One plant per container or space to 14 to 18 inches in row. • Needs night temperatures above 55ºF for pollen development. • Decorative, attractive plant with fruit.
Summer Squash (Zucchini)	36” by 36” space 8” deep 5 gallons/plant	full sun	• Compact varieties more suited to container gardening. • Great in a whiskey barrel size container. • One plant will produce six or more fruit per week. • Has male and female blossoms. May need hand pollination. • Needs good air circulation to minimize powdery mildew. • Keep fruit picked for continued production.
Tomatoes	12” deep 2-5 gallons/plant depending on variety (plant size)	full sun	• Varieties vary in mature plant size from determinate (bush) types to large, indeterminate vines over 6 feet tall. • Patio types (small vines) are great for container gardening and may be grown as hanging baskets or trellised. • Standard garden types require a larger container (like a whiskey barrel) and trellising. • Needs night temperatures above 55ºF for pollen development. • Crowding cuts yields and increases disease potential. • Blossom end rot (black sunken area on bottom of fruit) is a symptom of inconsistent watering or a soil that does not have enough water storage.

* Larger container sizes will make crop easier to care for, providing a bigger supply of water and nutrients.

Cool Season Vegetables

Vegetable	Minimum Container Size*	Minimum Direct Sunlight Per Day	Remarks
Beets	8” deep	8 hours	• Best in cool temperatures, grow a spring and fall crop. • To give space for root development, thin greens to 3”. • A consistent supply of water and nutrients promotes the rapid growth essential for quality produce.
Broccoli Cabbage Cauliflower Kale Collards	10” deep 5 gallons/plant	8 hours	• Best in fall production (e.g., plant mid July for fall harvest along the Colorado Front Range). • Minimum spacing per plant is 18 by 18 inches. • A consistent supply of water and nutrients promotes rapid growth and is essential for quality produce. • Heavy feeder, requiring frequent light fertilization. • Crops develop a strong flavor if the soil gets dry.
Carrots	12” deep	8 hours	• Best in cool temperatures, grow a spring and fall crop. • Use short root varieties. • Roots will crack and be strong flavored if the soil gets dry. • Thin early to two to three inches apart. • Foliage is rather decorative.
Chard	8” deep	6 hours	• Space to six plus inches between plants in a row. • Harvest outer leaves allowing plants to continue to grow. Makes an excellent “cut and grow again” crop. • Colored varieties are very decorative. • Responds to frequent light fertilization. • A consistent supply of water and nutrients promotes the rapid growth essential for quality produce.
Kohlrabi	8” deep	8 hours	• Best in cool temperatures, grow a spring and fall crop. • A consistent supply of water and nutrients promotes the rapid growth essential for quality produce. • Never allow soil to become dry. • Kohlrabi is a heavy feeder, requiring frequent, light fertilization.
Lettuce (leaf)	8” deep	6 hours	• Grow as a spring or fall crop; avoid hot summer temperatures. • Use softhead or leaf types. • As the young crop grows, thin to 9” spacing; crowding (competition for space, water and nutrients) reduces quality. • A consistent supply of water and nutrients promotes the rapid growth essential for quality produce. • Responds to frequent light fertilization. • Lettuce become strong flavored if the soil become dry, during hot weather, and with crowded plants

Vegetable	Minimum Container Size*	Minimum Direct Sunlight Per Day	Remarks
Onions (green)	6” deep	8 hours	• Onions require a consistent supply of water. Never allow soil to become dry. • Thin the crop by harvesting young plants. • Plant in early spring. • A consistent supply of water and nutrients promotes the rapid growth essential for quality produce.
Peas	8” deep	Full sun	• Not well suited to container gardening. • Best in cool temperatures, grow a spring and fall crop. • Use dwarf, edible-pod or snap types for salads and stir-fry. • May be grown in hanging baskets or trellised. • Needs good air circulation to avoid powdery mildew.
Radish	8” deep	8 hours	• Best in cool temperatures, grow a spring and fall crop. • A consistent supply of water and nutrients to promote rapid growth is essential for quality produce.
Spinach	8” deep	6 hours	• Best in cool temperatures, grow a spring and fall crop. • A consistent supply of water and nutrients promotes the rapid growth essential for quality produce.
Turnips	8” deep	8 hours	• Best in cool temperatures, grow a spring and fall crop. • When large enough to make greens, thin to four inches allowing roots to develop. • A consistent supply of water and nutrients promotes the rapid growth essential for quality produce.

* Larger container sizes will make crop easier to care for, providing a bigger supply of water and nutrients.

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