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Water Wise
Vegetable and Fruit Production

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Water management guidelines are provided to help growers maximize vegetable and fruit production.

Water Management Crucial in Vegetable and Fruit Production

Water management is crucial to vegetable and fruit crop management since water is an essential component of photosynthesis and plant development. With reduced water uptake, carbohydrate production, the building block of plant nutrition, is significantly decreased. This limits plant growth and vigor.

Impact of Drought on Production Quality and Quantity

Less than optimal soil moisture causes a chain reaction of plant responses. Minimal root, stem, and leaf development takes place, ultimately causing the plant to take in less than adequate amounts of water and nutrients to carry out growth and reproduction functions. This overall reduction of vigor is seen as reduced growth and smaller leaves, resulting in reduced photosynthesis and carbohydrate production. This reduction equates to less food production in the plant and, ultimately, reduced potential for crop reproduction and fruiting.

Crops and Water Needs

Distinction Between Shallow, Moderate, and Deep-Rooted Crops

Crop rooting depth is categorized as shallow, moderate, or deep. Shallow-rooted crops root to a depth of 12 to 18 inches. Moderate-rooted crops develop roots to a depth of 18 to 24 inches. Deep-rooted crops develop a root system to a depth of 24 or more inches. Please refer to *Table I* for rooting depth for various crops.

Water stress on fruit and vegetable crops can be extremely disruptive to the plant's development. Less than optimal soil moisture results in reduced:

- seed germination,
- plant growth, and
- potential crop yield.

Table I. Effective root zone moisture depth in unrestricted soils (top 50 percent of root zone).

Truck Crops	*Effective Root Zone Depth (Inches)*	*Truck Crops*	*Effective Root Zone Depth (Inches)*
Asparagus	36	Melons	24
Beets	18	Okra	18
Broccoli	18	Onions, bunch	6
Cabbage	18	Onions, dry	12
Carrots	18	Parsnips	24
Cauliflower	18	Peas	18
Celery	12	Peppers	18
Chives	6	Potatoes	18
Collards	18	Pumpkins	24
Corn (sweet)	24	Radish	6
Cucumbers	18	Rutabagas	18
Dandelion	6	Shallots	12
Eggplant	18	Snap beans	18
Endive	6	Spinach	6
Escarole	6	Squash	24
Fennel	6	Sweet potatoes	18
Horseradish	18	Swiss chard	12
Kale	18	Tomatoes	24
Kohlrabi	18	Turnips	18
Lettuce	6	Watermelons	24
Lima beans	24		
Fruits, Berries, and Orchards	*Effective Root Zone Depth (Inches)*	*Fruits, Berries, and Orchards*	*Effective Root Zone Depth (Inches)*
Apples	30	Grapes	36
Blueberries	30*	Peaches	24
Cane fruits	24	Pears	24
Cranberries	6	Strawberries	6

*For water table restrictions in blueberries, use 18 inch depth.
Source: USDA NRCS, New Jersey NRCS Irrigation Guide.

Allowing moisture stress to reach the point of leaf wilt can cause irreversible damage by affecting the absorption of moisture through the roots and conductive tissue. This level of stress does not allow the plant to grow at a normal rate and forfeits the plant's ability to transition from a vegetative to a productive state. Crop production and quality will be greatly reduced or completely eliminated.

Critical watering periods vary from crop to crop. *Table II* shows the critical moisture period for some common crops.

Table II. Critical periods for irrigation of vegetables, tree fruits, and small fruits.*

Vegetable Crops	Critical Period(s)
Asparagus	Spear growth, fern growth
Broccoli	Transplanting, flower bud production
Cabbage	Transplanting, head development
Carrot	Root enlargement
Cauliflower	Transplanting, curd development
Cucumber	Pollination, fruit enlargement
Eggplant	Transplanting, flowering, fruit development
Lettuce	Throughout growth
Lima bean	Blossom and pod development
Muskmelon	Pollination and fruit enlargement
Onion	Transplanting and bulb enlargement
Pea	Pod development
Pepper	Fruit development
Potato	Tuber development
Rhubarb	Petiole formation for harvest
Snap bean	Blossoming and enlargement
Spinach	Throughout growth
Sweet corn	Silking and tasseling ear development
Sweet potato	When slips are set in the field
Tomato	Transplanting, early flowering, fruit set, enlargement
Turnip	Root enlargement
Watermelon	Pollination and fruit enlargement
Tree Fruits	**Critical Period(s)**
Apple	Early fruit set, flower formation, final fruit swell
Pear	Early fruit set, flower formation, final fruit swell
Peaches	Early fruit set, flower formation, final fruit swell
Plums	Early fruit set, flower formation, final fruit swell
Nectarines	Early fruit set, flower formation, final fruit swell
Cherries	Early fruit set, flower formation, final fruit swell
Small Fruits	**Critical Period(s)**
Blueberries	Berry swell to end of harvest and bud formation for next year's crop (late July and August)
Raspberries	Bloom and as berries are sizing before first picking
Blackberries	Bloom and as berries are sizing before first picking
Strawberries	At planting, during runner formation, during flower bud formation before harvest, and at renovation

*Used with permission from Dr. William Lamont, Pennsylvania State University Extension.

Irrigation Timing

When to Irrigate for Different Crops

Irrigation requirements vary between individual crops based on whether they are direct seeded or grown as transplants. It is important for direct-seeded crops to have an evenly moist seedbed from germination through the development of the first two true leaves. Irrigation is important when the root system is the least developed. Sufficient moisture is crucial for the roots on developing plants.

In the case of transplants, it is important that water is available to reduce plant stress created by moving plants into the field. Not providing adequate moisture increases the acclimation time needed by transplants to adapt to field conditions. The added time needed for acclimation does not allow plants to grow, develop, and produce a crop as quickly or efficiently.

Water needs for small fruit crops are unique to each crop. For example, strawberry and other small fruit should be watered immediately after planting. They need 1 to 1½ inches of water per week, either through rain or supplemental irrigation, throughout the growing season. Moisture levels are especially critical during the fruiting period and times when temperatures exceed 70°F to 80°F.

For all fruit trees, the fruit development period is a time of very high moisture use. Water stress during this period can result in small or dropped fruit, as the tree compensates for inadequate soil moisture levels.

Young apple trees need to have adequate moisture available for the first 100 days of the growing season. It is during this time the majority of the branch growth takes place. For established apple trees, the first 50 days of the growing season is the most critical period for branch growth and flower bud initiation for the next year's crop. A second critical period for watering apple trees is when fruit sizing and maturing is taking place. After the fruit development stage, moisture needs gradually reduce as the growing season progresses.

Moisture Stress Indicators

Wilting is the classic indicator of moisture stress. Prior to the point of wilting, the growth of roots, stems, and leaves are reduced. A reduction of photosynthetic activity also takes place. These deficits negatively impact overall growth and production of the plants. In extreme cases, plant death will occur.

Preseason Preparation

Cover Crop Benefits and Implementation

Cover crops serve a variety of purposes related to moisture conservation in fruit and vegetable production. They reduce soil moisture loss and soil erosion, increase organic matter levels through incorporation in the soil, and, in some cases, can act as a nutrient enhancer. Examples of cover crops can include annual rye, wheat, barley, alfalfa, chick peas, and field peas. Cover crops are planted after the harvest of annual crops. For perennial crops, a cover crop should be in place between rows and beds at all times.

Water Fallow — Preparing Adequate Soil Moisture Levels Before Planting

Planting a cover crop is one way to help maintain moisture levels. Getting water into the ground will help provide moisture for production in the next growing season. The amount and depth of the water penetration for each crop will vary. Please refer to *Table I* to determine the moisture depth needed.

Moisture levels in soils can be determined in several different ways. The most common method is to install a tensiometer that measures available moisture. A more basic technique is to learn about your soil type and its characteristics at different moisture levels. *Figure 1* illustrates soil types and how those soil types feel and act to the touch at different levels of moisture.

Organic Matter

Organic Matter Types

Soil organic matter plays a vital role in the water holding capacity of soil. Organic matter comes in many different forms:

- Green manure, essentially a cover crop that has been tilled into the soil and allowed to decompose
- Livestock or poultry manure and livestock bedding

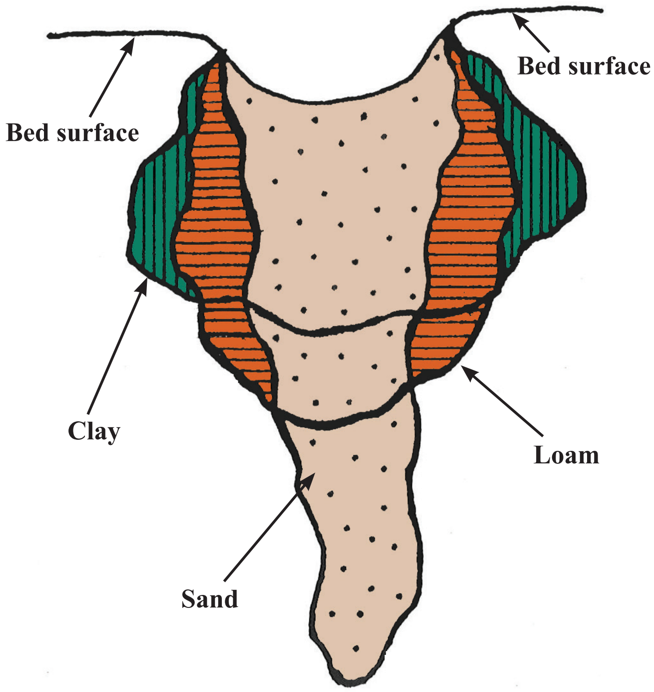

Figure 1. Water moves through sandy soils in a deeper and narrower pattern than it does through loam or clay.

- Grass clippings, garden debris, compost, rotted hay and straw

All can be incorporated into the soil. Decomposition of these materials increases soil organic matter.

Application and Incorporation

Organic matter should be evenly distributed across the entire planting area, and incorporated in the soil. This can be achieved using a manure spreader for larger areas, or for smaller areas, by broadcasting it manually by hand with a shovel or garden fork. Incorporate organic matter to a depth of 8 to 12 inches in the soil.

Avoid working the soil to the point that the tilled area becomes powdery or abnormally fine in texture. This can destroy the soil's structure and profile, possibly leading to an artificial hardpan layer in the rooting zone. This level of destruction can lead to loss of air pores in the soil, hindering the oxygen and carbon dioxide exchange in the soil for the crop roots.

Use of Manure

Livestock manure can be an excellent soil amendment that can increase the level of organic matter and add nutrients. Using aged or composted manure that is at least several months old is preferable to raw manure. If raw manure is used, apply it to a cover crop as part of a crop rotation system. Allow as many months as possible between the manure application and the next crop. Raw manure can burn plants and can carry pathogens and parasites that can be transferred to humans through the consumption of produce.

Types. The primary types of livestock manure are dairy, beef, horse, poultry, and sheep. Each of these vary in nutrient content. Dairy manure has a higher and more predictable nutrient content due to the consistent feeding and nutrient regime the cattle receive. Horse manure may contain more weed seed when compared to cattle manure. Horses have a single-stomach digestive system, compared to the four-stomach digestive system found in cattle, and may not break down weeds as thoroughly. Poultry manure can be very high in nitrogen since it contains urine.

Swine, dog, and cat manure should never be used as a fertilizer source on fruits and vegetables because it contains pathogens harmful to human health.

Pre-plant interval ahead. Incorporate livestock manure in the fall prior to spring planting of fruit and vegetable crops. USDA guidelines state that manure should be applied and incorporated 180 days prior to harvest for crops with edible parts that are in direct contact with soil.

For crops with edible parts that do not come in contact with the soil, manure should be applied and incorporated 90 days prior to harvest. These guidelines are in place to protect consumers from accidentally ingesting parasites and disease organisms that may be harmful to them.

Mulches

Mulch is an integral component of water conservation in fruit and vegetable production. Several mulch types can be used, such as natural, organic, or plastic mulch. Mulch acts as a physical barrier, reducing moisture from the surface of the soil. It also helps moderate soil temperature and retention of soil moisture when compared to bare ground.

Natural: Dense Plantings Reduce Weed Pressure and Evaporation

Dense plant populations with plants touching leaf to leaf create a natural canopy that acts as a natural much, protecting the soil surface from moisture loss through wind and solar evaporation.

Organic

Many types of organic mulch are available. These include, but are not limited to, leaves, straw, hay, newspaper, compost, pesticide-free grass clippings, and wood chips.

Wood chips contain more carbon than the other forms of organic mulch and use up nitrogen in the soil through decomposition. Additional fertilization may be needed. Avoid using wood chips from walnut trees, which contain the compound juglone that will inhibit the growth and development of a number of vegetable crops.

Plastic Mulches

Plastic mulches are a very effective way to reduce water loss from the soil while inhibiting the growth of weeds that rob moisture from the intended crop. Plastic mulches warm soils earlier in the season, allowing for early planting, and enabling growers to take advantage of early season rainfall.

In larger production areas, plastic mulches are applied to the soil surface through the use of a mechanical mulch layer. At the end of the season, plastic mulch is removed with a mulch lifter. For smaller areas, once soil preparation has been accomplished, plastic mulch can be rolled out and held in place with garden soil along the edges.

Plants are placed in the ground through holes cut in the plastic mulch, making this mulch particularly adapted for use with transplant crops. New plastic mulch should be applied each growing season.

One drawback of plastic mulches is disposal at the end of the growing season since the plastic cannot be recycled.

Application of Mulches

In general, applications of organic mulch should be no deeper than 3 to 4 inches; however, pesticide-free grass clippings should be applied no deeper than 2 inches at any given time. If applied too thick, grass clipping mulch can heat up and damage the crop. To reduce the chance of damage to plant stems, do not apply mulch right up to the base of the plants.

Cooling the Crop

Cooling Ground and Crops With Row Covers and Shade Cloth

Besides using mulches to reduce the water requirements of crops, shade can be used during periods of high temperatures. Protecting the crop from direct sunlight using floating row covers or shade cloth reduces the leaf temperature and plant water needs. In extreme situations of high temperatures, syringing or misting the crop may be necessary to save the crop from loss.

Floating row covers are spread over the crop loosely and weighted along the edges to stabilize the material during windy conditions. Row cover fabric is lightweight, allowing both water and sunlight to reach the crops beneath.

Shade cloth requires a simple support structure consisting of PVC or metal bows that span one or more rows. The bows support the shade cloth over the crop, providing cooling shade and reducing water needs.

Understanding the light requirements of each crop may allow you to plant some crops in a naturally shaded environment. Lettuce, currants, gooseberries, and other crops can grow in conditions with less than full sun. Under these conditions, water use needs will be reduced due to the natural cooling of the plant.

Water Placement

Reducing Water Loss

One of the most effective means of conserving water in a production system is through the placement of irrigation water. The least efficient method of applying water is through the use of overhead sprinkler systems. Water applied this way leads to high rates of water evaporation, allowing water to be lost to the atmosphere before plant roots are able to absorb it.

Directly applying water to the plant's roots through furrows and flood irrigation saturates the soil in the root zone of the plant. This method still lends itself to water loss through evaporation from the water surface, though the evaporation rate is less than for overhead irrigation.

Drip irrigation is by far the most efficient water application method in fruit and vegetable production. Water is transported throughout the field in enclosed tubing with emitter holes that deposit water at a slow rate directly to the base of the plant. This method greatly reduces the amount of water lost to evaporation. For more information about drip irrigation installation and maintenance, refer to *Drip Irrigation for Home Gardens* from Colorado State University Extension, *www.ext.colostate.edu/pubs/garden/04702.pdf*.

Water Infiltration

Not all soil types have the same water holding capacity and drainage ability. Growers need to know and understand their soil type to match the watering methods, distribution, and rates to efficiently utilize water resources.

Water movement and infiltration varies between soil types. Water moves much quicker through a sandy soil compared to a clay soil due to the number and size of air pore space between the particles. Sandy soils contain large pore spaces that facilitate infiltration and drainage. Clay soils have much smaller pore spaces, which reduces the amount and rate of water flow through the profile.

Figure 1 shows how water is distributed through different soil types. In this illustration water moves through sandy soils in a deeper and narrower pattern compared to a clay soil that moves water in a shallower, broader pattern through the profile.

Conclusion

Growers should know the water requirements for the crops they are growing, the types of soil the crops are growing in, and maximum production potential in order to use water efficiently. Understanding this relationship will influence the difference between success and failure in the production, yield, and economics of fruit and vegetable production.

Resource

"Managing Cover Crops Profitability," 3rd Edition, *www.sare.org/Learning-Center/Books/Managing-Cover-Crops-profitably-3rd-edition.*

This publication has been peer reviewed.

UNL Extension publications are available online at *http://extension.unl.edu/publications*.

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