

cucumber, carrot, spinach, lettuce, celery, cabbage, turnip, radish, and other crucifer seed. Improper treatment can injure seed. Hot-water treatment can severely damage cucurbit seed.

Warm seed in a loosely woven cotton bag (not over half full) for 10 minutes in 100°F water. Place the warmed seed in a water bath that will constantly hold the water at the recommended temperature (see Water Bath Temperatures and Treatment Lengths below). The length of treatment and temperature of the water must be exact. After treatment, dip bags in cold water to stop heating action, and then spread seed out to dry. Always apply a protective seed treatment fungicide to hot-water-treated seed.

This treatment can injure old seed. Always test a small sample of any seed lot more than a year old by treating it, and testing for germination to determine the amount of injury, if any, that might occur.

Water Bath Temperatures and Treatment Lengths

The water bath temperatures and treatment lengths should be followed exactly.

Seed	Temperature (°F)	Minutes
Brussels sprouts, cabbage, eggplant, spinach, tomato	122	25
Broccoli, cauliflower, cucumber, carrot, collard, kale, kohlrabi, rutabaga, turnip	122	20
Mustard, cress, radish	122	15
Pepper	125	30
Lettuce, celery, celeriac	118	30

Chlorine Treatment

Chlorine treatment effectively removes bacterial and fungal pathogens on the seed surface. Chlorine treatment is recommended for pepper, tomato, cucurbits, and other vegetables if the seeds have not been treated by another method.

Agitate seeds in a solution of 1 quart of household bleach, 4 quarts of water, and 1 teaspoon of surfactant for 1 minute. Use 1 gallon of this disinfectant solution per pound of seed and prepare a fresh solution for each batch. After placing seed in this solution, remove, and rinse thoroughly in running tap water for five minutes. After that, spread out seed to dry. Dust the seed with Thiram 75WP® at 1 teaspoon per pound of seed.

Treat the seed near planting time, as viability may be reduced over time. Before you treat all seed, we recommend that you test a small sample of each seed lot first. Treat 50-100 seeds and see how they germinate. If they germinate well, treat the rest of the seed lot.

If you treat coated seed or seed treated with fungicide with hot water or bleach, always dispose of wastewater in an environmentally sound manner.

For more information, see *Hot Water and Chlorine Treatment of Vegetable Seeds to Eradicate Bacterial Plant Pathogens*, Ohio State University Extension Fact Sheet HYG-3085-05, ohioline.osu.edu.

Fungicide Seed Treatment

Thiram is the most common seed-protectant fungicide. Other fungicides are recommended for specific crops. These fungicides are often combined with insecticides, and these combinations may be superior to fungicide treatment alone. Purchase treated seed, or dust seed lightly with fungicide according to label directions.

Do not use treated seed for food or feed.

Using Plastic Mulch

Black plastic mulch laid before planting helps control weeds, reduce root pruning, and give profitable increases in early yields of warm-season crops. Wavelength-selective and clear mulches typically lead to greater early yields than black plastic, but weed growth under these mulches may be a problem. This is particularly true for clear mulch. Because leaching is retarded, less fertilizer is lost, and nitrogen sidedressing is often unnecessary with the plastic mulch. If nitrogen needs to be added, it can be applied later through the irrigation system.

Try to lay plastic mulches as early in the season as possible. Mulches should be laid as soon as the ground can be worked after a heavy rain. Irrigate the field if soil moisture is not adequate prior to laying the mulch. Plastic mulches should be laid over moist soil. If the plastic is laid over dry soil, it will actually delay subsequent transplant growth. It is better to lay out plastic at midday so it can be stretched tight. However, do not overstretch the plastic because cool nights may actually cause it to tear.

The seedbed should be as fine as possible in order to get a good covering. The plastic is laid by burying about 6 inches of each edge. Black plastic mulch is most effective in warming the soil when it is in direct contact with the soil.

A disadvantage of plastic mulch is disposal at the end of the season. Many landfills do not accept plastic mulches. Photodegradable plastic mulches, which degrade into small pieces of plastic that remain in the environment, are available. Biodegradable plastic mulches that break down completely are available.

Yields of pepper, eggplant, and summer squash are higher most years, and harvest can be up to seven days earlier than unmulched plantings. Clear plastic mulch is common in early sweet corn production. Growers can plant sweet corn in hills, single rows, or double rows, and apply herbicides before laying the plastic. Clear plastic mulch warms the soil and contributes to early harvest and quality produce.

Herbicides that were applied before the mulch was laid may break down before the crop matures. Unless otherwise advised, never apply herbicides over the top of plastic mulch. An alternative to the clear mulch/herbicide system is the IRT or *wavelength selective mulch* system. IRT mulches provide similar soil warming to clear film while controlling most weeds like black plastic.

Apply all fertilizer before laying the plastic, but reduce the total amount applied by 10-15 percent. Mulch layers are available in various widths. They also can be adapted for raised beds and for the laying of trickle irrigation tubes all in one operation.

Trickle irrigation combined with plastic mulch offers several advantages: it uses water economically, requires less energy for pumping, wets leaf surface less, allows for easy fertilizer application, provides a uniform moisture supply, and allows the application of certain insecticides and fungicides.

Irrigation and Water Management

Vegetables require an adequate supply of moisture throughout their entire growth. While the frequency and amount of water varies according to individual vegetable crop, its age, current soil moisture, soil type, and weather conditions, generally 1 to 1.5 acre inches of water are required each week.

Effective Rooting Depth of Selected Vegetables

Shallow (6-12 inches)	Moderate (18-24 inches)	Deep (> 36 inches)
Beet	Cabbage, Brussels sprouts	Asparagus
Broccoli	Cantaloupe	Lima bean
Carrot	Cucumber	Pumpkin
Cauliflower	Eggplant	Sweet potato
Celery	Pea	Watermelon
Greens & herbs	Potato	Squash, winter
Onion	Snap bean	
Pepper	Squash, summer	
Radish	Sweet corn	
Spinach	Tomato	

Vegetable Crops and Growth Period Most Critical for Irrigation Requirements

Crop ¹	Most Critical Period
broccoli, cabbage, cauliflower, lettuce	head development
carrot, radish, beet, turnip	root enlargement
sweet corn	silking, tasseling, and ear development
cucumber, eggplant, pepper, melon, tomato	flowering, fruit set, and maturation
bean, pea	flowering, fruit set, and development
onion	bulb development
potato	tuber set and enlargement

¹For transplants, transplanting and stand establishment represent a most critical period for adequate water.

The total available water holding capacity (AWHC) for a given location depends on soil texture, organic matter, and rooting depth. AWHC estimates are best obtained from the county soil survey or the local Soil and Water Conservation District office. Available Water Holding Capacities for Several Soil Types shows AWHC estimates for some typical soil textures in the upper Midwest. Irrigation should be initiated for most crops before 50 percent of the available water is removed by the plants in the active root zone. In most vegetable crops, the majority of the roots are usually within the top 6 to 18

inches of soil. When using a trickle irrigation system on shallow-rooted, water sensitive crops (lettuce, peppers, etc.), the allowable depletion is generally 20 to 25 percent of AWHC and the system is run more frequently. With deeper rooted, more drought-tolerant crops (tomatoes, melons), a higher depletion allowance can be used without loss of yield or quality.

Available Water Holding Capacities for Several Soil Types

Soil Texture	Available Water Holding Capacity	
	In Inches per Inch of Soil	In Inches per Foot of Soil
Loamy fine sand	0.08-0.12	0.96-1.44
Sandy loam	0.10-0.18	1.20-2.16
Loam	0.14-0.22	1.68-2.64
Silt loam	0.18-0.23	2.16-2.76
Clay loam	0.16-0.18	1.92-2.16

Soil Water Monitoring

Two common ways of estimating soil water deficit to assist irrigation scheduling are:

1. Measuring soil water tension with soil moisture sensors.
2. Measuring the feel and appearance of soil with a soil probe.

Soil water tension can be monitored at a given point in the active root zone by electrical resistance moisture blocks or tensiometers. Soil tension or suction is a measurement usually expressed in centibars that describes how tightly water is held to the soil particles.

Tensiometers directly read soil tension between 0 and 80 centibars and work best in sandy loam or lighter textured soils. Resistance blocks work in a wider range of soil textures, and some types, such as Watermark sensors, work as well in lighter textured soils, as do tensiometers. If the soil texture is known, use the Soil Water Deficit Estimates for Different Soil Textures and Selected Tensions table (below) to estimate the inches of soil water deficit for a given tension reading; use the Soil Tension Values for Different Soil Textures For Use in Scheduling Trickle Irrigation table (page 30) to estimate the point of 20 to 25 percent depletion.

For example, let's say you have a sandy loam soil that has an AWHC of 1.5 inches per foot. A tomato crop would be irrigated when 50 percent (or about 0.7 inch) has been depleted in the upper foot of soil, or when a 6-inch tensiometer reads 45 centibars (Soil Water Deficit Estimates for Different Soil Textures and Selected Tensions). If we use the same soil for another example, a trickle-irrigated pepper crop would be irrigated when 20 to 25 percent (or 0.3 inch) has been depleted in the upper foot soil, or a 6-inch tensiometer reads 22 centibars (Soil Tension Values for Different Soil Textures For Use in Scheduling Trickle Irrigation).

To obtain representative soil tension readings with any sensor, the sensors should be left installed throughout the irrigation season and preferably at two or more locations in the field. Two depths are generally desired at each location. These depths should be about one-third and two-thirds of the active root zone, or about 6 and 12 inches.

Your local Extension office will have more information about in-field soil moisture monitoring tools.

Soil Water Deficit Estimates for Different Soil Textures and Selected Tensions

Soil Texture	Soil Tension in Centibars						
	10	30	50	70	100	200	1,500 ¹
	Soil Water Deficit — Inches per Foot of Soil						
Coarse sands	0	0.1	0.2	0.3	0.4	0.6	0.7
Fine sands	0	0.3	0.4	0.6	0.7	0.9	1.1
Loamy sands	0	0.4	0.5	0.8	0.9	1.1	1.4
Sandy loam	0	0.5	0.7	0.9	1.0	1.3	1.7
Loam	0	0.2	0.5	0.8	1.0	1.6	2.4

¹1,500 cbs refers to the permanent wilting point and the soil deficit value is equal to the soil's total available water capacity.

Soil Tension Values for Different Soil Textures For Use in Scheduling Trickle Irrigation

Soil Texture	0% Depletion of Available Water Holding Capacity (Field Capacity) ¹	20-25% Depletion of Available Water Holding Capacity ²
	Soil Tension Values (in centibars)	
Sand, loamy sand	5-10	17-22
Sandy loam	10-20	22-27
Loam, silt loam	15-25	25-30
Clay loam, clay	20-40	35-45

¹ At field capacity the soil contains 100 percent of AWHC; any excess water in the rootzone has drained away.

² Start trickle irrigation for shallow-rooted crops at this point.

Information adapted from *New Jersey Commercial Vegetable Production Guide*, New Jersey Ag Expt. Station, Rutgers; and *Water Management in Drip-irrigated Vegetable Production* by T.K. Hartz, UC-Davis, Calif., Vegetable Research and Information Center.

Frost Control

Irrigation can help protect vegetable crops, although it is not a common practice in the Midwest. With the proper equipment, growers must begin sprinkling as soon as the temperature reaches 34°F. Place a calibrated thermometer at the lowest elevation in the field at plant level, facing skyward. Continue sprinkling plants until the air temperature is greater than 30°F and the ice has melted from the plants.

To be effective, you need approximately 0.1 inch of water per hour, the sprinkling must be continuous, and the sprinklers should rotate at least once per minute. If conditions become windy and temperatures drop, it may be necessary to increase the amount of water to as much as 0.5 inch per hour. It is the process of the water freezing that gives off the heat to protect the crop. Therefore, liquid water must be present during the freezing period to protect the plants.

Bees and Pollination

Pollination is the transfer of pollen from the male portions of the flower (stamens) to the female portions of the flower (pistils). This process is vital to the production of many vegetable crops, including cucumber, cantaloupe, pumpkin, squash, and watermelon. Some crops (such as tomato) are self-fertile, but wind or bees must vibrate the flowers to release pollen for fertilization.

Honeybees are often thought of as the most prevalent pollinator for vegetable crops, but studies show that many species of native bees — including bumble bees and squash bees — play a vital role in pollinating many vegetable crops. Tomato, for example, benefit from the “buzz pollination” that bumble bees can provide. Honeybees are unable to buzz pollinate, and therefore do not play a role in tomato pollination. The squash bee, a North American native, is an important pollinator of pumpkins and other squash crops. Native bees are often active earlier in the day and at cooler temperatures than honeybees.

To ensure pollination, many vegetable growers rent honeybee hives rather than manage their own hives. Since honeybee colonies are occasionally in short supply, growers should communicate frequently with their bee providers.

In addition to renting honeybee hives, growers can improve the pollination services of native and non-native bees by increasing on-farm habitats. The Xerces Society for Invertebrate Conservation (www.xerces.org) and Pollinator Partnership (www.pollinator.org) offer guides, plant lists, and other resources about building on-farm bee habitats.

At least 90 crops grown in the United States depend to some extent upon bees as pollinators, either for seed or fruit production. The exact number of honeybee hives needed to pollinate a crop depends on a number of factors, including the strength and condition of colonies, magnitude of the natural pollinator community, amount of wild flower material competing with the crop, attractiveness of the crop to bees, projected yield, and weather.