Drought Advisory for Vegetable Production

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Efficient conservation, management, and use of irrigation water are critical to successful vegetable production, especially under drought conditions. Frequently, extremely hot and dry conditions can reduce production over large areas of the region, thereby limiting vegetable supplies and driving prices up. Profit opportunities exist for the producer with a well-organized water management plan when these conditions occur.

Crop Requirements and Responses

Vegetable crop water requirements range from about 6" of water per season for radishes to 24" for tomatoes and watermelons. Precise irrigation requirements can be predicted based on crop water use and effective precipitation values.

Lack of water influences crop growth in many ways. Its effect depends on the severity, duration, and time of stress in relation to the stage of growth.

Nearly all vegetable crops are sensitive to drought during two periods: during harvest and two to three weeks before harvest. More than 30 different vegetable crops are grown commercially. Although all vegetables benefit from irrigation, each class responds differently.

- **Leafy vegetables.** Cabbage, lettuce, and spinach are generally planted at or near field capacity. Being shallow rooted, these crops benefit from frequent irrigation throughout the season. As leaf expansion relates closely to water availability, these crops, especially cabbage and lettuce, are particularly sensitive to drought stress during the period of head formation through harvest. Overwatering or irregular watering can result in burst heads.
- **Broccoli and cauliflower.** Although not grown specifically for their leaves, broccoli and cauliflower respond to irrigation much as the leaf vegetables do. They are both sensitive to drought stress at all stages of growth, responding to drought with reduced growth and premature heading.
- **Root, tuber, and bulb vegetables.** Sweet potato, potato, carrot, and onion crop yields depend on the production and translocation of carbohydrates from the leaf to the root or bulb. The most sensitive stage of growth generally occurs as these storage organs enlarge. Carrots require an even and abundant supply of water throughout the season. Stress causes small, woody, and poorly flavored roots. Uneven irrigation can lead to misshapen or split roots in carrots, second growth in potatoes, and early bulbing in onions.
- **Fruiting vegetables.** Cucumbers, melons, pumpkins and squashes, lima beans, snap beans, peas, peppers, sweet corn, and tomatoes are most sensitive to drought stress at flowering and as fruits and seeds develop. Fruit set on these crops can be seriously reduced if water becomes limited. An adequate supply of water during the period of fruit enlargement can reduce the incidence of fruit cracking and blossom-end rot in tomatoes. Irrigation is often reduced as fruit and seed crops mature.

Plant growth stage also influences the susceptibility of crops to drought stress. Irrigation is especially useful when establishing newly seeded or transplanted crops. Irrigation after transplanting can significantly increase the plant survival rate, especially when soil moisture is marginal and the evapotranspiration rate is high. Irrigation can also increase the uniformity of emergence and final stand of seeded crops. For seeded crops, reduce the rate of application and the total amount of water applied to avoid crusting. If crusting is present, use low application rates and small amounts of irrigation water to soften the crust while seedlings are emerging.

The periods of crop growth when an adequate supply of water is critical for high-quality vegetable production are shown in **Table 1.**

Basic Irrigation Principles

Supplemental irrigation is beneficial in most years since rainfall is rarely uniformly distributed, even in years with above-average precipitation. Moisture deficiencies occurring early in the crop cycle may delay maturity and reduce yields. Shortages later in the season often lower quality as well as yields. However, overirrigating, especially late in the season, can reduce quality and post-harvest life of the crop.

Applying the proper amount of water at the correct time is critical for achieving the optimum benefits from irrigation. The crop water requirement, termed evapotranspiration, is equal to the quantity of water lost from the plant (transpiration) plus that lost from the soil by surface evaporation. The evapotranspiration rate is important in effectively scheduling irrigations. Numerous factors must be considered when estimating evapotranspiration. The amount of solar radiation, which provides the energy to evaporate moisture from the soil and plant surfaces, is the major factor. Other factors include day length, air temperature, wind speed, and humidity level.

Plant factors that affect the evapotranspiration rate are crop species; canopy size and shape; leaf size, shape, and orientation; plant population; rooting depth; and stage of growth and development of the crop. The plant canopy size and shape influence light absorption, reflection, and the rate at which water evaporates from the soil. Leaf architecture affects the transpiration rate from individual leaves. Rooting depths vary with crop species and may be affected by compaction or hardpans that may exist. Rooting depth determines the volume of soil from which the crop can draw water and is important when determining the depth to which the soil must be wetted when irrigating.

Table 1. Critical Periods of Water Need (by crop)

CROP	CRITICAL PERIOD
Asparagus	Brush
Beans lima	Pollination and pod development
snap	Flowering and pod enlargement
Broccoli	Head development
Cabbage	Head development
Carrots	Root enlargement
Cauliflower	Head development
Corn	Silking and tasseling, ear development
Cucumbers	Flowering and fruit development
Eggplants	Flowering and fruit development
Greens	Continuous
Lettuce	Head development
Melons (musk melons & watermelons)	Flowering and fruit development
Onions (dry)	Bulb enlargement
Peas	Seed enlargement and flowering
Peppers	Flowering and fruit development
Potatoes white	Tuber set and tuber enlargement
sweet	Root enlargement
Radishes	Root enlargement
Spinach	Continuous
Squash (summer)	Bud development and flowering
Tomatoes	Early flowering, fruit set, and enlargement
Turnips	Root enlargement

Cultural practices also influence evapotranspiration. Cultivation, mulching, weed growth, and method of irrigation are factors to consider. Cultivation generally does not reduce evaporation significantly, but if crop roots are pruned by cultivating too close, water uptake and thus transpiration may be reduced. Shallow cultivation may help eliminate soil crusts and therefore improve water infiltration. Weeds compete with the crop for water and increase the amount lost through transpiration. Sprinkler irrigation wets the entire crop area and thus results in a greater evaporation loss than does drip irrigation, which wets only the area in the immediate vicinity of the plants.

Table 2. Relationship of Available Water-holding Capacity and Soil Texture

SOIL TEXTURE	INCHES OF WATER PER INCH OF SOIL
Coarse sand	0.02 to 0.06
Fine sand	0.04 to 0.09
Loamy sand	0.06 to 0.12
Sandy loam	0.11 to 0.15
Fine sandy loam	0.14 to 0.18
Loam and silt loam	0.17 to 0.23
Clay loam and silty clay loam	0.14 to 0.21
Silty clay and clay	0.13 to 0.18

Soil factors must also be considered. Soils having high levels of silt, clay, and organic matter have greater water-holding capacities than do sandy soils or soils that are compacted **(Table 2).**

[Editor's note: It is estimated that for each percent of organic matter in the top 12" of soil, moisture-holding capacity is increased by about 16,500 gallons per acre. Soils with high water-holding capacities require less frequent irrigation than those with low water-holding capacities. However, when soils are irrigated less frequently, a greater amount of water must be applied per application to meet crop needs.]

Another soil factor that influences irrigation practices is the infiltration rate. Water should not be applied at a rate greater than the rate at which the soil can absorb it. **Table 3** lists typical infiltration rates of several soils.

Factors to Consider in Scheduling Irrigations

There is no simple method for scheduling irrigations accurately because all the above factors interact to determine water loss. Research is currently under way to develop improved methods in scheduling irrigations. The following factors should be kept in mind when deciding when and how much to irrigate.

- Soils vary greatly in **water-holding capacity** and **infiltration rate,** as previously discussed.
- Water loss from plants is much greater on **clear, hot, windy days** than on cool, overcast days. During periods of hot, dry weather, ET rates may reach 0.35" per day or higher. The evapotranspiration rate can be estimated by the use of a standard evaporation pan.
- Recently, researchers have found that **maintaining soil moisture levels in a narrow range** *[Editor's note: Apply water when 30-40% of the available water has been used and bring soil to field capacity.]* maximizes crop response. This may mean that more frequent application of smaller amounts of water is better than delaying irrigations until the

Table 3. Relationship of Soil Infiltration Rates and Texture

SOIL TEXTURE	INCH PER HOUR RATE
Coarse sand	0.75 to 1.00
Fine sand	0.50 to 0.75
Fine sandy loam	0.35 to 0.50
Silt loam	0.25 to 0.40
Clay loam	0.10 to 0.30

soil moisture reaches a lower level — 40-50% soil moisture — and then applying a large amount of water.

- **Plastic mulches** reduce evaporation from the soil but also reduce the amount of water that can reach the root zone from rains. Thus much of the natural precipitation should be ignored when scheduling irrigations for crops grown under plastic mulch.
- In general, for **overhead irrigation** apply 0.25" of water or more in each irrigation, except when establishing crops. This rule does not apply with drip irrigation. When using **drip irrigation** and plastic mulch, applying as little as 0.08" of water per day may be sufficient during periods of low evapotranspiration.

Irrigation Practices and Strategies

Water is a precious and costly resource. It must be managed properly. Efficient irrigation demands applying the correct amount of water at the correct time. A number of irrigation practices and strategies are recommended for vegetable crops to make every drop of water count.

Reduce area planted. Reducing irrigation below the level required for best production can reduce yield and quality of vegetable crops greatly. No advantage is gained in trying to spread a given water supply over too large an area. When irrigation water is in short supply, it may be necessary to take some land out of production or stop irrigating some fields. If you have a choice, plant the most productive land.

Select less sensitive crops and cultivars. Commercial growers weigh economic factors heavily in selecting crops. However, during periods of anticipated drought, water requirements assume increased importance. Certain crops and cultivars are less sensitive to short periods of water stress than others. These are not necessarily the highest-yielding selections and may not have greatest market demand. Short-season cultivars also can require less water.

Begin the season with adequate soil moisture. Preplant irrigation benefits many vegetable crops by building subsurface soil moisture and promoting a deeper root system. Avoid over-irrigation, which wastes water and can leach fertilizer and chemicals into groundwater.

Establish the proper plant stand. Rapid emergence and a uniform plant stand make the most efficient use of soil moisture. Wet soil exposed to sunlight has greater evaporation loss than does soil shaded by a crop. Once a full canopy has developed, differences in evapotranspiration per area due to plant population are negligible. Reducing the plant population in vegetable crops saves little water.

Consider transplants. Proper germination and emergence in the field require careful water management. Often, less water can be used and more precise control can be obtained by using transplants. However, once in the field, transplants generally develop shallower root systems than direct-seeded crops and may require more frequent irrigation.

Use mulches and row covers. Mulches and plastic or spunbonded row covers will increase temperatures for more rapid plant growth. Mulches also can save water by reducing surface evaporation.

Consider drip irrigation. Drip or micro-irrigation is an expensive but efficient system of irrigating high-value crops, such as vegetables. Combine use of such systems with mulches and row covers for added efficiency.

Improve irrigation scheduling. Good irrigation scheduling is essential for all irrigation systems if growers are to apply the correct amount of water at the correct time. Irrigation scheduling requires careful attention to soil moisture, climate, and crop growth. The use of tensiometers or moisture blocks can increase the precision of irrigation scheduling.

Maintain proper soil structure and fertility. Proper soil structure permits optimum infiltration and water holding. Proper soil fertility encourages the best plant growth and use of available soil moisture. Adopting tillage methods, such as minimum or no tillage, that maintain or enhance soil organic matter will improve the water-holding capacity of droughty soils. Not all vegetable crops lend themselves to minimum tillage or no-tillage systems.

Achieve good weed control. Weeds compete with crops for soil moisture and decrease yields. In particularly weedy fields, weeds can use more water than the crop. Good weed control reduces competition for soil moisture and increases water-use efficiency.

Maintain good plant health. Insect and disease damage restrict the growth and water-use efficiency of vegetable crops, reducing both yield and quality. Maintaining good plant health is especially important in regard to diseases classified as wilts, which reduce the ability of the crop to absorb and translocate water. Plant parasitic nematodes damage or stunt the development of plant roots, thereby worsening drought damage. Good nematode control is essential for healthy root systems.

Careful attention to irrigation is always an essential part of vegetable production and will pay off through improved crop quality, a more reliable product, and greater profit. As production costs rise, so does the need to safeguard investments in seed, fertilizer, labor, and land against losses resulting from weather conditions.

References

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