ALABAMA COOPERATIVE Extension SYSTEM

ANR-1169

ALABAMA A&M AND AUBURN UNIVERSITIES

Basics of Vegetable Crop Irrigation

Vegetables are 80 to 95 percent water. Think of them as sacks of water with a small amount of flavoring and some vitamins. Because vegetables contain so much water, their yield and quality suffer rapidly when subjected to a drought. Thus, for good yields and high quality, irrigation is essential to the production of most vegetables. If water shortages occur early in the crop's development, maturity may be delayed and yields reduced. If a moisture shortage occurs late in the growing season, quality is often reduced even though total yields may not be affected.

Most vegetables are rather shallow-rooted. Even short periods of two to three days of moisture stress can damage marketable yields. Irrigation is likely to increase the size and weight of individual fruit and to prevent defects, such as toughness, strong flavor, poor tip-fill and pod-fill, cracking, blossom-end rot, and misshapen fruit. On the other hand, too much moisture reduces soluble solids in muskmelons (cantaloupes) and capsaicin (what makes the peppers hot) in hot peppers when it occurs during fruit development.

Growers often wait too long to begin irrigation, thinking, "It will rain tomorrow." This often results in a severe stress for that portion of the field that dries out the quickest or receives irrigation last. Another common problem is trying to stretch the acreage that reasonably can be covered by the available equipment. Both of these practices result in all or part of the field being water stressed. It is better to do a good job on some of the acreage rather than a halfway job on all the acreage.

Drought stress can begin in as little as three days after a 1-inch rain or irrigation in such crops as tomatoes in soils like those in the Piedmont of Alabama. Thus, frequent irrigation is necessary to maximize yields. Soil moisture requirements differ with each crop and with each particular stage of crop development. Soil moisture availability varies with the amount of water in the soil and with the type of soil. Knowing your soil type is essential in planning for and in using an irrigation system. The critical stage and irrigation needs of various vegetable crops are listed in the table.

Up to 1.5 inches of water is needed each week during hot periods to maintain vegetable crops that have a plant spread of 12 inches or more. This need decreases to 0.75 inch per week during cooler seasons.

Droplet size and irrigation rate are also important when irrigating vegetable crops. Large droplets resulting from low pressure at the sprinkler head can cause damage to young vegetable plants and can contribute to crusting when the soil dries. Irrigation rate is also important in sandy soils that absorb water more readily than clay soils. However, clay soils have a greater percent of available water. Irrigation rate will depend on soil type; but application rates should not exceed 0.40 inch per hour for sandy soils, 0.30 inch per hour for loamy soils, or 0.20 inch per hour for clay soils. High application rates of water will result in irrigation water running off the field, contributing to erosion and fertilizer runoff.

Improving Stands. Most vegetables have small seeds that are planted ¾ inch deep or less. The upper layer of the soil can dry rapidly, leaving shallowly sown seeds susceptible to drying out. Without enough soil moisture, the seed is left partially germinated. When this happens, no stand or, at best, an incomplete stand will result. An irrigation of 0.50 to 0.75 inch immediately after sowing should be applied to settle the soil around the seeds and to begin seed germination. For larger seeded crops, it is desirable that irrigation begins a few days prior to sowing. If seeds are slow in emerging from the soil due to cool temperatures or slow germination, then apply 0.75 to 1 inch of water per acre as needed to encourage emergence. Do this to keep the area around the seed moist until seedlings emerge. Irrigation is a valuable tool in producing a good, uniform stand which will help ensure high yields. Good uniform stands mean uniform harvest dates and greater production efficiency.

Vegetable transplants also require good soil moisture. A light irrigation of 0.50 to 0.75 inch per acre will help in the establishment of young transplants by providing a ready supply of water to young, broken roots.

In addition to hastening seedling emergence, irrigation at planting time can reduce soil crusting. If 0.50 to 0.75 inch of irrigation is slowly applied, either with low rates or by turning the irrigation system off long enough to allow water to soak in, crusting can be reduced and stands will be improved.

Product Development and Fruit Set. Wide fluctuation in soil moisture injures fruit crop vegetables such as tomatoes and peppers (see table). These fruits contain large amounts of water and are dependent on this water for expansion and growth. When soil moisture is allowed to drop below the proper level, fruits do not expand to produce the maximum size before they ripen. Thus their yield is reduced. If moisture is allowed to fluctuate too much, blossom-end rot can occur and fruits are no longer useable.

If moisture fluctuation occurs during the fruit expansion stage, fruit cracking will occur. This typically occurs when the application of inadequate water has been followed by heavy rainfall (see table). The best way to prevent fruit cracking is to apply a steady supply of moisture. In addition, it is soil moisture fluctuation that causes secondary growth, or knobs, in Irish potatoes.

Rooting Depth. It is important that the soil profile be filled with water during each irrigation event. Otherwise, frequent light irrigation events result in the formation of shallow root systems. Shallow root systems result in plants being stressed even in short periods of water deficit. (See table for crop specifics.) In addition, these plants with shallow root systems are more prone to lodging and nutrient deficiencies (shallow root systems neither explore nor exploit all of the available nutrients in an area). On the other hand, excessive irrigation can leach nutrients from the soil and encourage the development of diseases and nutrient deficiencies. The rooting depth of various vegetable crops is listed in the table. It is important that shallow-rooted crops receive more frequent irrigations.

Preferred Minimum Soil Moisture. Soil moisture is measured with a ***tensiometer*** or ***soil block.*** The former is preferred for sandy soils and the latter for clays and loams. Tensiometers report soil moisture in centibars. Suggested soil tensions for various vegetables are reported below. Soil blocks report available soil moisture (ASM), and the table suggests minimum levels for most vegetables. For more information on using tensiometers or soil blocks, consult Extension publication, ANR-467, "Scheduling Irrigation Using Soil Moisture Tension."

Amount and Timing. Irrigation amounts and the time between irrigations are critical to efficient irrigation practices. Some suggestions for amount and timing of irrigations are presented in the table.

Critical Moisture Periods. Critical periods of water needs can best be defined as that time when soil moisture stress can most reduce yield in an otherwise healthy crop (see table). This is not to say that it is the only time in the life of the crop that moisture stress reduces yield. It is, however, the time when moisture stress will exert its greatest effect.

Most 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 in the Southeast. Although all vegetables benefit from irrigation, each class responds differently.

Leaf vegetables. Cabbage, lettuce, and spinach are generally planted at or near field capacity. Field capacity is the maximum amount of water a field can hold without water runoff or loss due to gravity. Being shallow rooted, these crops benefit from frequent irrigation throughout the season. Since leaf expansion relates closely to water availability, these crops, especially cabbage and lettuce, are particularly sensitive to drought stress during the period between head formation and harvest. Overwatering or irregular watering can result in burst heads.

Broccoli and cauliflower, although not grown specifically for their leaves, respond to irrigation much as the leafy vegetables do. Broccoli and cauliflower are sensitive to drought stress at all stages of growth, responding with reduced growth and premature heading.

Root, tuber, and bulb vegetables. In sweetpotatoes, Irish potatoes, carrots, and onions, yield depends 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. Moisture stress causes the formation of small, woody, and poorly flavored roots. Uneven irrigation can lead to misshapen or split roots in carrots, secondary growth in Irish potatoes, and early bulbing in onions.

Fruit and seed 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 during fruit and seed development. Fruit set on these crops can be seriously reduced if water is limiting. An adequate supply of water during the period of fruit enlargement can reduce the incidence of fruit cracking and blossom-end rot in tomatoes. For example, after fruit enlargement, irrigation is often reduced as fruit and seed crops mature.

Vegetable Irrigation Needs, Critical Moisture Periods, Drought Tolerance, Rooting Depth, and Concerns

Crop	Preferred Minimum Soil Moisture: Bars	Preferred Minimum Soil Moisture: ASM[1]	Amount/Inches in "X" Days	Irrigation Critical Moisture Period	Preferred Irrigation Method[2]	Drou Tolera
Asparagus	-.70	40%	1/20	Crown set and transplanting	a,b	H
Beans, dry	-.45	50%	1/7	Flowering	a	M
Beans, lima	-.45	50%	1/7	Flowering	a,b	L-M
Beans, pole	-.34	60%	1/5	Flowering	a	L-M
Beans, snap	-.45	50%	1/7	Flowering	a	L-M
Beans, soy (edible)	-.70	40%	1/14	Flowering	a,b	M
Beet	-2.00	20%	1/14	Root expansion	a,b	M
Broccoli	-.25	70%	1/5	Head development	a,b,c	L
Brussels sprout	-.25	70%	1/5	Sprout formation	a,b,c	M
Cabbage	-.34	60%	1/10	Head development	a,b	M-H
Cantaloupe	-.34	60%	1/10	Flowering and fruit development	a,b	M
Carrot	-.45	50%	1/21	Seed germination and root expansion	a,b	M-H
Cauliflower	-.34	60%	1/5	Head development	a,b,c	L
Celery	-.25	70%	1/5	Continuous	a,b,c,d	L
Chinese cabbage	-.25	70%	1/5	Continuous	a,c	L
Collards	-.45	50%	1/14	Continuous	a,b,c	M
Corn, sweet	-.45	50%	1/14	Silking	a,b	M-H
Cucumber, pickles	-.45	50%	1/7	Flowering and fruiting	a,b,c	L
Cucumber, slicer	-.45	50%	1/7	Flowering and fruiting	a,b,c	L
Eggplant	-.45	50%	1/7	Flowering and fruiting	a,b,c	M
Greens (turnip, mustard, kale)	-.25	70%	1/7	Continuous	a,b	L
Leek	-.25	70%	1/5	Continuous	a,b	L-M
Lettuce (head, Bibb, leaf, cos)	-.34	60%	1/7	Head expansion	a,b	M-H
New Zealand Spinach	-.25	70%	1/5	Continuous	a,b,d	L
Okra	-.70	40%	1/14	Flowering	a,c	M-H
Onion	-.25	70%	1/7	Bulbing and bulb expansion	a,b	L
Parsnip	-.70	40%	1/14	Root expansion	a,b	H
Peas, Garden (English)	-.70	40%	1/7	Flowering	a	L
Peppers	-.45	50%	1/7	Transplanting flower up to ½" fruit	a,b,c	M
Potato, Irish	-.35	70%	1/7	After flowering	a,b	M
Pumpkin	-.70	40%	1/14	Fruiting	a,b	M
Radish	-.25	70%	1/5	Continuous	a	L
Rhubarb	-2.00	20%	1/21	Leaf emergence	a,b	M
Rutabagas	-.45	50%	1/14	Root expansion	a,b	M
Southernpeas	-.70	40%	1/14	Flowering and pod swelling	a,b	M
Squash, summer	-.25	70%	1/5	Fruit sizing	a,c	L
Squash, winter	-.70	40%	1/10	Fruit sizing	a,b	M
Sweetpotato	-2.00	20%	1/21	Fruit and last 40 days	a,b	H
Tomato, staked	-.45	50%	1/5	Fruit expansion	a,c	M
Tomato, ground	-.45	50%	1/7	Fruit expansion	a,b	M
Tomato, processing	-.45	50%	1/7	Fruit expansion	a,b	M
Turnip	-.45	50%	1/10	Root expansion	a,b	M
Watermelon	-2.00	40%	1/21	Fruit expansion	a,b,c	M-H

[1]ASM (Available Soil Moisture). Percentage of soil water between field capacity (-0.1 bar) and permanent wilting point (-15 bars).
[2]Irrigation method: a = Sprinkler, b = Big Gun, c = Trickle (drip), d = Flood
[3]Drought tolerance : L = low, needs frequent irrigation; M = moderate, needs irrigation in most years; H = high, seldom needs irrigation.
[4]Depth of rooting, of most roots: S = shallow, 12 to 18 inches; M = moderate, 18 to 24 inches; D = deep, 24 inches plus.

ght nce[3]	Rooting Depth[4]	Defects Caused by Water Deficit	Comments
	D	Shriveling	Will withstand most drought
	M	Poor pod fill and small beans	No irrigation after pods begin to dry
M	D	Poor pod fill and small beans	Cooling irrigation can increase yield
M	M	Poor pod fill and pithy pods	Steady moisture supply is necessary during flowering
M	M	Poor pod fill and pithy pods	Irrigation prior to flowering has little benefit
	M	Poor pod fill	Irrigation prior to flowering has little benefit
	M	Growth cracks	
	S	Strong flavor	
	S	Poor sprout production	
H	S	Growth cracks	
	S-M		
H	S-M	Growth cracks, misshapen roots	Avoid droughts during root expansion
	S	Ricey curd, buttoning	
	S	Small petioles	Moisture deficit can stop growth irreversibly
	S	Tough leaves	
	S	Tough leaves	
H	S	Poor ear fill	Irrigation prior to silking has little value
	S-M	Pointed and cracked fruit	Moisture deficit can drastically reduce yield and quality
	S-M	Pointed and cracked fruit	Moisture deficit can drastically reduce yield and quality
	M	Blossom-end rot, misshapen fruit	
	M	Tough leaves	Good continuous moisture essential to good yields
M	S	Thin scale formation	
H	D	Tough small leaves	
	S	Tough leaves, poor production	Irrigate to keep growth continuous and rapid
H	D	Tough pods	Irrigation can reduce yield
	S	Poor size	
	D		
	M	Poor pod fill	
	M	Shriveled pods, blossom-end rot	Irrigate for increased pod size and yield
	S	Second growth and misshapen roots	Irrigate only during extreme drought during root development
	D	Blossom-end rot	
	S	Pithy roots	Keep soil moisture levels high to promote rapid growth
	D	Pithy stems	
	M	Tough roots	
	M	Poor pod fill	Plants will recover from drought but yield is reduced
	M	Pointed and misshapen fruit	Fruit sizing. Irrigation can double or triple yields
	D		
	D	Small and misshapen roots	
	D	Blossom and root growth cracks	Continuous water supply helps avoid blossom-end rot and increase fruit size
	D	Blossom and root growth cracks	Continuous water supply helps avoid blossom-end rot and increase fruit size
	D	Blossom and root growth cracks	Continuous water supply helps avoid blossom-end rot and increase fruit size
	M	Woody roots	
H	D	Blossom end rot	This crop can withstand extreme drought, but there will be some yield reduction

The 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.

Irrigation Methods. Vegetable crops differ in which method of irrigation can be used economically in their production (see table). Three types of irrigation are commonly used in Alabama: sprinkler (Figure 1), big gun (Figure 2), and trickle or drip irrigation (Figures 3a and 3b).

Drought Tolerance. Drought tolerance is an indication of a crop's ability to withstand short periods of drought without significantly reducing yield. We have classified vegetables for drought tolerance in the table.

Defects From Stress. Most vegetables respond to water deficit with reduced yield and quality. However, most crops also express this stress with growth abnormalities. Many of the common abnormalities are listed in the table.

Figure 1. Sprinkler irrigation for sweet corn production

Figure 2. Big gun irrigation over several crops

Figure 3a. Close-up of drip tape used for trickle (or drip) irrigation for pumpkin production

Figure 3b. Typical wetting pattern of drip irrigation tape

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