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Vegetable Irrigation: Melon

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Proper irrigation is essential to growing a healthy and productive melon crop. For ideal fruit development, a consistent moisture supply throughout the season is necessary. Too little irrigation will result in weak plants with under-sized fruits and reduced quality. Over irrigation can lead to disease problems and nutrient leaching. There are a number of irrigation systems that can be used to irrigate a melon crop, each with different management considerations. Regardless of the irrigation system used, there are some basic principles to understand that will help ensure proper irrigation. This fact sheet will discuss these basic principles.

Properly managing irrigation is analogous to managing money. In addition to knowing your current bank balance (soil water content), it is important to track both expenses (evapotranspiration) and income (rainfall and irrigation).

Bank Balance (Soil Water Content)

How big is my bank account? – Water holding capacity
First, some terminology:

- Field Capacity is the amount of water that can be held in the soil after excess water has percolated out due to gravity.
- Permanent Wilting Point is the point at which the water remaining in the soil is not available for uptake by plant roots. When the soil water content reaches this point, plants die.
- Available Water is the amount of water held in the soil between field capacity and permanent wilting point. (Figure 1.)
- Allowable Depletion (readily available) is the point where plants begin to experience drought stress. Depending on soil type, the amount of allowable depletion for melons is about 50% of the total available water in the soil. (Figure 2.)

The goal of a well-managed irrigation program is to maintain soil moisture between field capacity and the point of allowable depletion, or in other words, to make sure that there is always readily available water and that plants do not experience water stress.

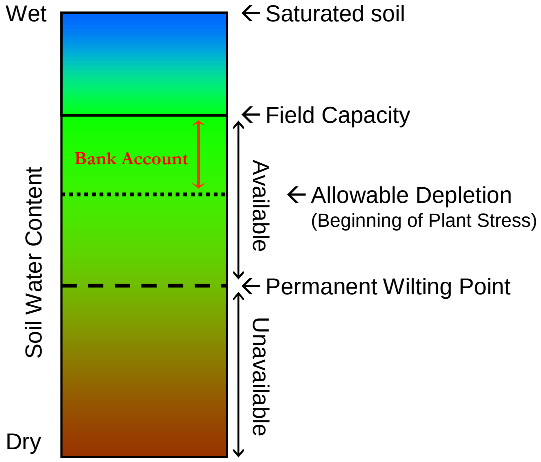

Figure 1. Soil water content from saturated to dry. Optimal soil moisture levels for plant growth are between field capacity and allowable depletion.

The amount of readily available water is related to the effective rooting depth of the plant, and the water holding capacity of the soil. The effective rooting depth depends on soil conditions and variety. About 70% of melon roots are in the top foot of soil, with 30% in the second foot and the tap roots extend down to 3 feet. The water holding capacity within that rooting depth is related to soil texture, with coarser soils (sands) holding less water than fine textured soils such as silts and clays. (See Table 1.) A deep sandy loam soil at field capacity, i.e., would contain 0.6 to 0.75 inch of readily available water in an effective rooting depth of 1 foot.

What's in the bank? -- Measuring Soil Moisture

In order to assess soil water content, one needs to monitor soil moisture at several depths, from just below the soil surface (2 to 3 inches), to the bottom of the effective rooting depth (1.5 feet). One of the more cost effective and reliable methods for measuring soil moisture is by electrical resistance block, such as the Watermark^{TM} sensor (Irrometer Co., Riverside CA). These blocks are permanently installed in the soil, and wires from the sensors are attached to a handheld unit that measures electrical resistance. Resistance measurements are then related to soil water potential, which is an indicator of how hard the plant roots have to "pull" to obtain water from the soil.

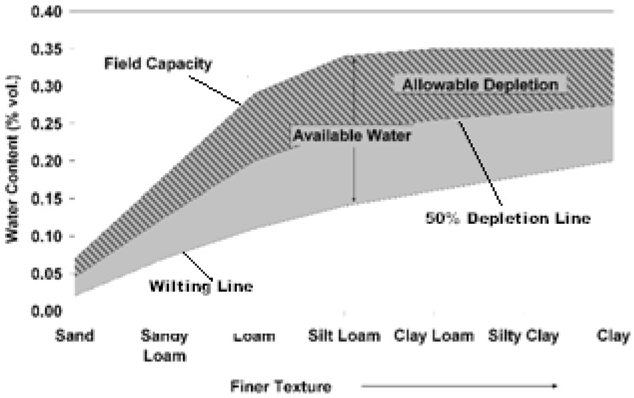

Figure 2. The amount of allowable depletion, or the readily available water, represents about 50 percent of the total available water.

Table 1. Available water holding capacity for different soil textures, in inches of water per foot of soil. Total available water is the amount of water in the soil between field capacity and permanent wilting point. Allowable depletion (readily available water) is the amount of water the plant can use from the total available before experiencing drought stress. Allowable depletion for melons is approximately 50% of total available.

Soil Texture	Total Available Water	Allowable Depletion *inches* (Readily available)	
	inch/foot	In top1'	In top1.5'
Sands and fine sands	0.5 - 0.75	0.25 - 0.38	0.38 - 0.57
Loamy sand	0.8 - 1.0	0.4 - 0.5	0.6 - 0.75
Sandy loam	1.2 - 1.5	0.6 - 0.75	0.9 - 1.13
Loam	1.9 - 2.0	0.95 - 1.0	1.43 - 1.5
Silt loam, silt	2.0 - 2.1	1.0 - 1.05	1.5 - 1.58
Silty clay loam	1.9 - 2.0	0.95 - 1.0	1.43 - 1.5
Sandy clay loam, clay loam	1.7 - 2.0	0.85 - 1.0	1.28 - 1.5

The handheld unit reports soil moisture content in centibars, where values close to zero indicate a wet soil and high values represent dry soil. The relationship between soil water potential and available water differs by soil type. The range of the sensor is calibrated to 0-200 centibars (higher values indicate drier soil), which covers the range of allowable depletion in most soils. The sensors are less effective in coarse sandy soils, and will overestimate soil water potential in saline soils. Remember that allowable depletion is 50% of available water, which roughly corresponds to soil water potentials of 50 centibars for a loamy sand soil, and 70 centibars for a loam (Table 2, 50% depletion values for each soil texture).

Table 2. Recommended Watermark™ sensor values at which to irrigate.

Soil Type	Irrigation Needed
	(*centibars*)
Loamy sand	40 - 50
Sandy loam	50 - 70
Loam	60 - 90
Silt loam, silt	70 - 90
Clay loam or clay	90 - 120

^{TM}Watermark is a registered trademark of Irrometer, Co., Riverside, CA.

Expenses – Evapotranspiration

Water is lost from the field through surface runoff, deep percolation (moving below the root zone), evaporation from the soil surface, and transpiration through the leaves of the plant. Of these, the biggest losses are typically due to evaporation and transpiration, collectively known as "evapotranspiration" or ET. Deep percolation from excess irrigation can be another large loss. Estimates of ET are based on weather data, including air temperature, relative humidity and wind speed. Table 3 lists average daily reference ET values for several cities across Utah. Many more sites are monitored in the state, if your city is not listed, visit climate.usurf.usu.edu to find a location near you.

Some weather stations in Utah are programmed to calculate and report the ET estimates for alfalfa as a reference crop (ET_{ref} or ET_r). The ET of your crop can be determined by multiplying the ET_r by a correction factor or crop coefficient (K_{crop}) that is specific to your crop and its stage of development.

$$ET_{crop} = ET_r \times K_{crop}$$

The K_{crop} for cantaloupe and watermelons are shown in Table 4. The K_{crop} varies depending on current ground cover relative to the row width, which provides an estimate of percent ground cover. Ground cover can be estimated by placing a yard stick under the canopy of the plant and counting the number of inches that are shaded. Measurements should be taken when the sun is directly overhead. When the vine covers 20% of the ground, a field of cantaloupes is using about 30% of the amount of water used by the alfalfa reference crop. Water use increases gradually as the canopy develops until the full canopy is established. For melons, reducing the amount of water applied in the last week before harvest by about 10 to 15% will improve flavor and quality. However, it is important to remember that melon fields may be harvested over several weeks, so sustained water reduction may affect later developing fruit size and yield.

Table 3. Daily total alfalfa reference evapotranspiration (ET_r) for seven Utah cities expressed in (A) inches per day, (B) gallons per acre per day, and (C) drip-irrigated gallons per 100 feet of bed length per day.

Month	Logan	Farmington	Spanish Fork	Salt Lake City	Green River	Moab	St. George
(A) Inches per day							
Mar	0.09	0.12	0.12	0.11	0.15	0.12	0.15
Apr	0.15	0.19	0.16	0.17	0.23	0.19	0.22
May	0.2	0.25	0.21	0.22	0.29	0.24	0.28
Jun	0.24	0.3	0.26	0.28	0.32	0.3	0.32
Jul	0.29	0.27	0.28	0.30	0.32	0.29	0.31
Aug	0.26	0.23	0.25	0.27	0.25	0.26	0.28
Sep	0.18	0.19	0.18	0.19	0.2	0.2	0.21
Oct	0.09	0.12	0.1	0.11	0.12	0.13	0.14
(B) Gallons per acre per day. Irrigation amounts need to be adjusted by Crop Coefficient and Irrigation Efficiency. [1]							
Mar	2444	3259	3259	2987	4073	3259	4073
Apr	4073	5160	4345	4617	6246	5160	5974
May	5431	6789	5703	5974	7875	6517	7604
Jun	6517	8147	7061	7604	8690	8147	8690
Jul	7875	7332	7604	8147	8690	7875	8418
Aug	7061	6246	6789	7332	6789	7061	7604
Sep	4888	5160	4888	5160	5431	5431	5703
Oct	2444	3259	2716	2987	3259	3530	3802
(C) Drip-irrigated gallons per 100 feet of bed length per day based on 6-foot bed spacing. Irrigation amounts need to be adjusted by Crop Coefficient and Irrigation Efficiency.[2]							
Mar	33.7	44.9	44.9	41.1	56.1	44.9	56.1
Apr	56.1	71.1	59.8	63.6	86	71.1	82.3
May	74.8	93.5	78.6	82.3	108.5	89.8	104.7
Jun	89.8	112.2	97.3	104.7	119.7	112.2	119.7
Jul	108.5	101	104.7	112.2	119.7	108.5	116
Aug	97.3	86	93.5	101	93.5	97.3	104.7
Sep	67.3	71.1	67.3	71.1	74.8	74.8	78.6
Oct	33.7	44.9	37.4	41.1	44.9	48.6	52.4

[1] Conversion to gallons per acre per day (B) = (A) x 7.481 * 43560 / 12.

[2] Calculation for drip-irrigation: (C) = (B) x 6 ft. (bed spacing) / 435.6. If different bed spacing is used, adjust calculation accordingly.

Calculated from long-term monthly evapotranspiration values available at climate.usurf.usu.edu.

Table 4. Description of growth (percent of ground covered) and crop coefficient estimates for melons grown in a plasticulture system.

		Ground Cover (%)				
Crop	**Crop coefficient**	**20**	**40**	**60**	**80**	**100**
Cantaloupe[1]	K_{crop}	0.24	0.48	0.60	0.68	0.72
Watermelon[2]	K_{crop}	0.32	0.52	0.64	0.80	0.60

1. Grattan, et al., 1998 (adjusted for alfalfa reference ET).
2. Ministry of Agriculture and Food. October 2001 (adjusted for alfalfa reference ET).
3.

Income – Irrigation and Rainfall

In Utah's high elevation desert climate, rainfall contributes a small fraction of the in-season water requirements of the crop. Therefore, regular irrigation is needed to supply plant water needs. This irrigation water can be supplied by furrow, impact sprinklers, drip lines or microsprinklers.

Whichever irrigation system you utilize, it is important to calibrate your system so that you know precisely how much water is being applied. With sprinklers and microsprinklers, the simplest way to do this is to place catch cans in multiple locations in your planting and collect water for a set period of time. The amount of water collected over time will give you an application rate (inches per hour), and differences in water collected among the catch cans will tell you how uniform the application is within your planting.

When trying to determine application uniformity, it is best to measure output at both ends of your irrigation system. Also, if your planting is on a slope, you should measure output at the highest and lowest points of your field. Elevation differences and the distance the water travels through the irrigation lines both affect water pressure, and consequently the flow rate at the nozzle.

Drip irrigation tape comes with recommended operating pressures, a variety of emitter spacings, and various flow rates. Most drip tapes operates at 10 psi. Emitters may be spaced from 4 to 36 inches apart and come in a variety of flow rates. Flow rates are commonly reported in gallons per100 feet of tape per hour (GPH) or gallons/emitter/hr. For a tape with a 12-inch emitter spacing, 24 gallons/100ft/hr = 24/100 = 0.24 gallons/emitter/hr. Pressure compensating emitters (PC) provide the best uniformity. Flow rate from each emitter and emitter spacing can be used to calculate rate per area (see Table 3). Drip irrigation systems are usually operated every day or every few days to maintain optimal soil moisture.

The efficiency of your system is a measure of how much you have to over-water the wettest spots in the field to get adequate water to the dry spots. Efficiency is related to the uniformity of application and to the amount of evaporation that occurs before the water can move into the soil. A well-designed microsprinkler or drip system can be 70 to 90% efficient. Overhead sprinkler systems are typically 60 to 75% efficient, while flood and furrow irrigation is typically 30 to 50% efficient. If your water supply is limited, a more efficient system can make a large difference in water savings and crop productivity.

Case Study

Following is an example of how to calculate water needs for a cantaloupe crop with a full canopy. The soil is a deep sandy loam with drip irrigated rows every 6 feet.

- Water use (Expenses)
    - ETr values are 0.30 inches per day (weather station data).
    - Crop coefficient is 0.80 (Growth stage = 100, from Table 4).
    - $ET_{crop} = ET_r \times K_{crop}$
    - $ET_{crop} = 0.30$ inches/day * $0.8 = 0.24$ inches/day
- Soil storage capacity (potential bank balance)
    - The total storage capacity for readily available water over the 2-foot effective rooting depth is 1.1 inches (Table 1).
    - 1.1 inches / 0.24 inches per day = 4.6 (4) days between irrigations. In 4 days replace 0.96 inches.
- Restated, the soil moisture in the rootzone will go from field capacity to plant stress levels in 4.6 days.
- To recharge the soil profile, you will need to add a net of 0.96 inches of water every 4 days. Assuming a drip irrigation system with an efficiency of 80%, 1.2 inches of water application will be required for each watering. If you are operating your drip system on a daily basis you would set your system to apply 0.3 inches per day (0.24/0.80). For a two day irrigation interval apply 0.6 inches (2*0.24/0.80).
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Summary

Good irrigation management requires:

1. An understanding of the soil-plant-water relationship
2. A properly designed and maintained irrigation system, and a knowledge of the efficiency of the system
3. Proper timing based on
    a. Soil water holding capacity
    b. Weather and its effects on crop demand
    c. Stage of crop growth.

Each of these components requires a commitment to proper management. Proper management will lead to the maximum yields per applied irrigation water, and will optimize the long term health and productivity of your crop.

Additional Resources

AgriMet Crop Coefficients. Pacific Northwest Regional office of the Bureau of Reclamation.US Dept. of the Interior www.usbr.gov/pn/agrimet/cropcurves/crop_curves.html.

Crop coefficients for use in irrigation scheduling. Water Conservation Factsheet. No. 577.100-5. British Columbia Ministry of Agriculture and Food. October 2001. www.agf.gov.bc.ca/resmgmt/publist/500Series/577100-5.pdf.

Grattan, S.R., W. Bowers, A. Dong, R. Snyder, J. Carroll and W. George. 1998. New crop coefficients estimate water use of vegetables, row crops. California Agriculture 52:1p16-20.

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Hill, R.W. 1994. Consumptive Use of Irrigated Crops in Utah. Utah Ag. Exp. Stn. Res. Rpt. #145. Utah State University, Logan UT. Available on the Web at http://nrwrt1.nr.state.ut.us/techinfo/consumpt/default.asp

Irrigation Application Rates

- Surface Irrigation (flow usually in cubic feet per second)

Inches/hour = cubic feet per second (cfs) / acres
Example: 4 cfs/ 5 acres = 0.8 inches/hour

- Sprinkler Irrigation (flow is usually in gallons per minute)

Inches/hour=96.24 *gallons per minute (gpm)/area (ft^2)
Example: 96.24*7 gpm / (40 feet*60 feet) = 0.28 inches/hour

- Drip Irrigation (flow per emitter is usually in gallons per hour)

Inches/hour=1.6 *gallons per hour (gph)/emitter spacing (feet^2)
Example: 1.6*.5 gph / (1 feet* 2.5 feet) = 0.32 inches/hour

- Irrigation Set Times

Set time (hours) = Gross Irrigation Need (inches) / application rate (inches/hour)
Example: 3 inches / 0.28 inches/hour = 10.7 hours

- Conversions

1 cfs= 448.8 gpm
1 gpm= 60 gph
1 acre = 43,560 feet^2