MARYLAND COOPERATIVE EXTENSION
UNIVERSITY OF MARYLAND
COLLEGE PARK•EASTERN SHORE

Fact Sheet

Fact Sheet 447

Estimating Irrigation Water Requirements

Why Estimate Water Needs?

Predicting water needs for irrigation is necessary for the development of an adequate water supply and the proper size of equipment. The value of irrigation is significantly reduced if the water supply or the irrigation equipment is incapable of delivering the amount of water your crops need during a drought.

Irrigation supplements probable rainfall so that the seasonal water needs of the crop are satisfied. Water should be delivered at a rate sufficient to meet the crop's peak water use rate. Seasonal water need and peak water use rates are directly related to yield goal. High-yield goals have a high water demand. A water supply that restricts either the seasonal amount or rate of application limits the potential yield.

Seasonal Water Requirements

The amount of water needed during a growing season depends on the crop, yield goal, soil, temperature, solar radiation, and other cultural factors. Long-season crops require more water than short-season crops. Some crops such as corn respond to irrigation during the entire growing season and use more water than other crops such as soybeans, which benefit mostly from additional water at specific critical stages of maturity. High-yield goals require more water than lower-yield goals for the same crop. (High yield cannot be obtained with additional water only. All other cultural practices must be intensified.) Table 1 lists some typical Maryland crop yield goals and growing season lengths.

The amount of irrigation required for crop production depends on the particular season's useful rainfall, the soil's water holding capacity and the crop water need. Useful rainfall is that portion of the rain which is stored in the soil root zone (rainfall minus surface

Table 1. Yield goals and season lengths for common crops

Crop	Yield goal		Growing season (days)
	Moderate	High	
Field crops (bushels/acre)			
grain corn	150	200	120
soybeans[a]	40	60	120
Vegetable crops (tons/acre)			
cantaloupes	3	5	90
cucumbers	6	10	60
lima beans	1.5	2.5	80
peas	2.5	4	100
small vegetables	--	--	60
sweet corn	6	8	90
sweet potatoes	8	10	120
tomatoes	20	30	100
watermelons	18	28	110

[a] Although a 120-day crop, soybeans are irrigated primarily from flowering to maturity.

Table 2. Estimated irrigation water requirement (in inches)

Crop	Assurance level		
	50 percent	80 percent	90 percent
Grain corn	8(12)[a]	10(15)	--
Soybeans	5(8)	7(11)	--
Sweet potatoes	5(7)	6(9)	--
Cucumbers	4(6)	--	5(8)
Lima beans	3(4)	--	4(5)
Peas	3(4)	--	4(5)
Small vegetables[b]	2(3)	--	3(4)
Sweet corn	3(4)	--	4(5)
Tomatoes	4(6)	--	5(7)
Watermelon	4(6)	--	6(8)

[a] Moderate yield (high yield).
[b] Assumes a single 60-day planting.

runoff, minus deep percolation). Fine-textured soils (clays, silts, loams) can store more water than coarse-textured soils (sands and gravels). Hence, coarse-textured soils dry faster and require more frequent irrigation than fine-textured soils.

To determine seasonal irrigation water needs, you must predict future rainfall amounts, intensities, and frequencies. You can do this by assuming that future rainfall will follow historical rainfall patterns. The risk of drought is lessened by the irrigation assurance level. For example, a 50-percent assurance level means that the irrigation amount will be sufficient to meet crop yield goal requirements in 5 out of 10 years. As the assurance level increases (lower risk) the required seasonal irrigation water volume increases.

Table 2 gives estimates of the required irrigation capacity with 3 assurance levels for high and moderate yields of common crops. The irrigation amounts for each crop are based on the historic rainfall patterns and the typical soils of the major growing regions where irrigation is normally practiced in Maryland.

Water Use Rates

Water use rates by plants (evapotranspiration or ET) change with environmental conditions and plant maturity. Plants have specific critical periods of increased water needs (Table 3). The combination of hot, dry, and windy conditions will cause rapid water loss from the soil and plant. If excessive soil drying occurs during a critical water-need period, the yield can be significantly reduced. Irrigation must be able to supply water at the expected peak water use rate in order to be totally successful during rainfall-deficient periods.

The peak water use rate for vegetables and most grain crops falls between 0.2 and 0.25 inches per day (5,500 to 7,000 gallons per acre per day). The peak water use rate for high-yielding grain corn can reach 0.33 inches per day (9,000 gallons per acre per day).

Table 3. Critical periods of water needs for crops

Crop	Critical period
Alfalfa	Start of flowering and before cutting
Apples	Bud stage and fruit enlargement
Beans, lima	No particular period
Beans, snap	Pod enlargement
Carrots	Root enlargement
Cabbage	Head development
Corn	Tasseling through ear development
Cucumbers	Flowering through harvest
Lettuce	Head development
Melons	Blossom to harvest
Onions	Bulb enlargement
Peaches	Final fruit enlargement and pit hardening
Peas	Flowering and seed enlargement
Peppers	Planting to fruit set
Potatoes, Irish	Blossom to harvest
Potatoes, sweet	At transplant
Soybeans	Flowering to seed enlargement
Strawberries	Fruit enlargement and bud set, August and September
Tomatoes	Early flowering, fruit set, and enlargement

Pumping Rates

You can translate daily peak water use rates into pumping rates based on the total hours of time available for operating the irrigation system. As pumping time decreases, the flow rate of the pump must increase to provide the required daily volume of water (Table 4).

If you had 20 acres of sweet corn (peak use rate 0.25 inches per day) and irrigated the entire 20 acres for 24 hours every day, the application rate would be 4.8 gallons per minute per acre or 96 gallons per minute for the 20 acres (4.8 x 20 = 96). If you irrigated only 15 hours per day, every day, the application rate would be 7.6 gallons per minute per acre or 152 gallons per minute for the 20 acres.

Water losses occur between the water source and the plant through leaks, runoff, and evaporation. These losses are variable depending on the irrigation equipment. Spray systems may lose 25 percent of the total water pumped, whereas drip systems may lose less than 5 percent. Therefore, to ensure that the plants receive the necessary amount of water, the water supply would have to provide for the peak use plus the expected loss. Table 5 lists typical systems and water loss factors. Multiply the application rate by the water loss factor to determine the required pumping rate.

Table 4. Required application rates for meeting peak irrigation water demand[a]

Daily pumping hours	Water use rate (inches per day)		
	0.2	0.25	0.33
24	3.8	4.8	6.3
20	4.6	5.7	7.6
15	6.1	7.6	10.1
10	9.1	11.4	15.1

[a] Gallons per minute per acre.

Table 5. Typical water loss factors[a]

Drip trickle	1.05
Low pressure spray pivots linear move buried solid set	1.15
High pressure spray pivots traveling guns	1.20
Hand move spray sprinklers big guns	1.25

[a]Add 0.05 to the above factors for long mns of portable aluminum pipe with rubber gaskets.

If you irrigated the 20 acres of sweet corn with a traveling gun for 15 hours per day, the required pumping rate would be 182 gallons per minute (152 x 1.20 [from Table 5] = 182).

If you do not irrigate your crop everyday, then the application rate must be increased. If you irrigate once every 2 days, multiply the values in Table 4 by 2. For once every 3 days, multiply the values by 3 and so forth. Therefore, if you irrigated the 20 acres of sweet corn for 15 hours every third day, the required application rate would be 456 gallons per minute (7.6 x 3 X 20 = 456). The peak pumping rate for the traveling gun would then be 547 gallons per minute (456 x 1.20 = 547).

An irrigated area may be so large that it takes several days to irrigate the entire field. In this case, use the area irrigated each day for calculating the pumping rate. An example is a center pivot that completes a circle every 3 days. One-third of the total field area is irrigated daily. However, the irrigation frequency for any part of the field is once in 3 days.

The application rate of water should not exceed the ability of the water to enter the soil (infiltration rate). Yet, the amount of water in the soil should not be allowed to decline below 50 percent of the maximum amount stored. These conditions, related to soil properties and plant rooting depth, determine the design frequency of water application and are an important part of irrigation system design. However, regardless of irrigation frequency, the cumulative daily peak water use must be satisfied.

Summary

The volume of water used for irrigation is highly variable and depends on the soil, crop, yield goal, and weather. The information in this fact sheet will allow the computation of needed seasonal water volumes and peak pumping rates. Use the attached worksheet for the computation. If you cannot develop water supplies to meet these needs, then establish a different crop or a lower-yield goal.

Irrigation Worksheet

	Example	Yours
1. Crop (from Table 1)	corn	
2. Yield goal (bushels per acre)	200	
3. Compare goal with Table 1. Is it moderate or high?	high	
4. Assurance level (percent)	80	
5. Seasonal water use (from Table 2, in inches)	15	
6. Total acres irrigated	100	
7. Seasonal water use (line 5 x line 6, in acre inches)	1,500	
8. Peak water use (0.2, 0.25, or 0.33 inches per day)	.33	
moderate yields all crops = 0.2		
high-yield vegetables = 0.25		
high-yield corn = 0.33		
9. Hours of irrigation per day	24	
10. Pumping rate (Table 4)	6.3	
11. Application frequency (days)	3	
(1 in every 1, 2, 3, 4, or 5 days)		
12. Area irrigated per day (acres)	33.3	
13. Type of system	low pressure spray	
14. Water loss factor (Table 5)	1.15	
15. Peak pumping rate (gallons per minute)		
(line 10 X line 11 x line 12 x line 14)		
6.3 x 3 x 33.3 x 1.15 = 724		
_____ X _____ X _____ X _____ =		_____
16. Estimated total seasonal water withdrawal	1,725	
(line 14 x line 7, in acre inches)		
17. Estimated peak 30-day water withdrawal	23,481,563	
(line 16 X 0.5 X 27,225[a] gallons)		
18. Estimated annual average daily withdrawal	128,666	
(line 17 x 2 /365, in gallons per day)[b]		
Summary		
Total seasonal water needed (line 16, in acre inches)	1,725	
Peak pumping rate (line 15, in gallons per minute)	724	

[a] There are 27,225 gallons in 1 acre inch.

[b] If this number is greater than 10,000, a Maryland Water Appropriations permit is required.

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