IRRIGATION

Seasonal Water Needs and Opportunities for Limited Irrigation for Colorado Crops

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Quick Facts...

Knowing seasonal crop water requirements is crucial for planning your crop mixture.

Net crop water requirements are estimated using models, based on weather variables.

To irrigate for the greatest return, producers need to understand how crops respond to water, how crop rotation enhances water availability, and how changes in agronomic practices affect water needs.

Crop water use, consumptive use and evapotranspiration (ET), are terms used interchangeably to describe the water consumed by a crop. This water is mainly used for cooling purposes; a negligible amount is retained by the crop for growth. For more information on ET refer to Colorado State University Extension Fact Sheet 4.715, *Crop Water Use and Growth Stages.*

Water requirements for crops depend mainly on environmental conditions. Plants use water for cooling purposes and the driving force of this process is prevailing weather conditions. Different crops have different water use requirements, under the same weather conditions. Crops will transpire water at the maximum rate when the soil water is at field capacity. When soil moisture decreases, crops have to exert greater forces (energy) to extract water from the soil. Usually, the transpiration rate doesn't decrease significantly until the soil moisture falls below 50 percent of available water capacity.

Knowing seasonal crop water requirements is crucial for planning your crop planting mixture, especially during drought years. For example, in the Greeley area, the seasonal water use of sugar beets is 30 inches, while corn uses only 22 inches of water. That means to fully irrigate sugar beets you need to apply 36 percent more water as compared to corn. These water requirements are net crop water use, the amount that the **crop will use** (not counting water losses) in an average year, given soil moisture levels don't fall below critical levels. Under ideal conditions, this net water requirement is reduced by the effective rain, which for the Greeley area is 7 inches for the growing season.

The rest of the crop water requirement must be supplied by irrigation. No irrigation system is 100 percent efficient, so to apply the net water requirement to the entire field, increase the amount of water or multiply by the efficiency (or inefficiency) of the irrigation system. Looking at the above example, the net water requirements, after subtracting effective rain, are 23 inches for sugar beets and 15 inches for corn. If the irrigation system is 85 percent efficient, apply 27 inches (gross irrigation amount) to the sugar beets crop and 17.6 inches to the corn crop to store the net water requirement in the crops' root zone. Now the difference between the seasonal gross water requirements of sugar beets and corn is 52 percent. The difference in the gross irrigation requirement amounts increases as the irrigation system efficiency decreases.

Net Crop Water Requirement

Net crop water requirement is estimated using models that are based on weather variables. Estimate seasonal crop water requirement by using these models and averaging weather conditions over many years. This will create an average weather year. Tables 1 and 2 are a summary of net water requirements of different crops and effective precipitation for different locations in eastern Colorado and western Colorado, respectively. To figure the net irrigation

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2. reduce irrigation amounts to the entire field, or
3. include different crops that require less irrigation.

requirement, subtract the effective rain (Average Effective Precipitation from Tables 1 and 2) from the net crop water requirement. The gross irrigation water requirement is the net irrigation requirement divided by the irrigation system efficiency (fraction of one). For example, corn for grain in Burlington requires 26 inches of water. Effective precipitation is 11.28 inches for the season; therefore the net irrigation requirement is 14.72 inches. The gross irrigation requirement for a center pivot with 80 percent irrigation efficiency is 18.4 inches. For a furrow irrigation system with 55 percent irrigation efficiency, the gross irrigation requirement is 26.7 inches.

In Colorado's semi-arid climate, irrigation is important to increasing ET and grain yields, supplementing rainfall in periods when ET is greater than precipitation. However, not all of the water applied by irrigation is used for ET. Inefficiencies in applications by the system result in losses. As yield is maximized, more losses occur since the soil is closer to field capacity and more prone to losses, such as deep percolation, which cause the deviation from the straight line (Figure 2). By applying less than needed for maximum yield, water can be saved. As seen in Figure 2, a reduction in water applied from point A to point B can save water with little or no yield reduction.

Table 1. Estimated seasonal water requirement (consumptive use) in eastern Colorado (inches/season).

	Burlington	Byers	Cheyenne Wells	Colo. Springs	Holly	Greeley	Lamar	Longmont	Rocky Ford	Springfield	Sterling	Trinidad	Wray
Alfalfa	35.64	32.13	36.14	30.04	39.34	31.58	39.06	30.91	37.75	37.44	35.24	33.29	35.24
Grass hay/pasture	31.06	27.45	31.74	26.04	34.66	26.63	34.16	26.17	32.92	32.61	28.01	28.10	30.92
Dry beans	19.22					18.42		15.83		18.75			18.75
Corn, grain	26.00		25.81	20.49	29.40		26.81	21.66	27.73	26.67		21.31	25.42
Corn, silage	22.82		22.11	18.22	26.12	21.74		19.74	24.28		20.29	19.15	
Corn, sweet						22.75			20.37				
Melons					15.85		15.80		15.13				
Potatoes						28.14							
Small vegetables					18.71	17.70	18.85		22.23				
Sorghum, grain	21.51	20.46		15.99	25.20	19.48	22.64			22.65			16.09
Soybeans													10.41
Spring grains		12.49					11.82	11.36	14.15	10.44	14.29		15.17
Sugar beets	29.98		30.43		34.83	29.31	34.27	25.48	32.70	32.28	29.99		29.99
Wheat, winter	18.99	16.42	18.55	14.06	19.65	16.38	19.30	18.46		18.64	12.53	16.14	
Av. Precipitation	16.35	18.57	16.26	15.73	15.33	12.20	5.33	12.74	12.53	15.36	14.92	12.80	18.51
Av. Effective Precipitation	11.28	10.39	11.68	10.59	10.72	7.32	11.00	6.99	8.89	10.93	6.68	8.28	12.56

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Limited Irrigation

When water supplies are restricted in some way, so that full evapotranspiration demands cannot be met, limited irrigation results. Reasons that producers may be limited on the amount of available water include: 1.)

Table 2. Estimated seasonal water requirement (consumptive use) in western Colorado* (inches/season).

	Canon City	Cortez	Durango	Gunnison	Fruita	Meeker	Monte Vista	Norwood	Salida	Walden
Alfalfa	39.69	29.36	27.49	17.99	36.22	23.55	23.58	23.58	24.83	12.89
Grass hay/pasture	33.49	24.74	23.17	17.12	31.44	21.43	19.85	20.40	20.90	13.61
Dry beans					19.93					
Corn, grain					25.12					
Corn, silage	22.21	17.98	16.06		22.67	17.34				
Corn										
Melons										
Orchards w/o cover crop	27.12									
Orchards w/ cover crop					25.71					
Potatoes							16.49			
Small vegetables					18.06		6.79			
Sorghum, grain										
Soybeans										
Spring grains		13.51	14.79	16.73		19.61	15.46	12.66	11.38	18.04
(barley, wheat)										
Sugarbeets					31.58					
Wheat, winter	18.70	20.13	18.83		18.95					
Av. Precipitation	12.99	12.90	18.59	11.00	8.30	17.06	7.25	15.73	11.37	9.56
Av. Effective Precipitation	9.28	5.09	8.34	3.80	3.98	6.19	3.93	6.05	5.66	3.02

*Colorado Irrigation Guide, 1988. Net irrigation requirement is the difference between crop consumptive use and effective precipitation.

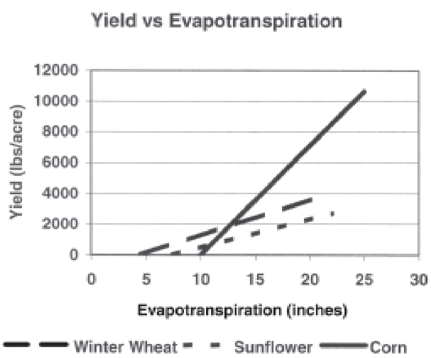

Figure 1: Yield vs. ET relationship for several irrigated crops.

limited capacity of the irrigation well – in regions with limited saturated depth of the aquifer, well yields can be marginal and not sufficient to meet the needs of the crop; 2.) reduced surface water storage – in regions that rely upon surface water, droughts and seasonal fluctuation affect the water allocations available for users.

When producers cannot apply water to meet the crop ET, they must realize that with typical management practices, yields and returns will be reduced as compared to a fully irrigated crop. To properly manage the water for the greatest return, producers must understand how crops respond to water, how crop rotations can enhance water availability, and how changes in agronomic practices influence water needs.

Yield vs. ET and Irrigation

Crop yields increase linearly with the water that is used by the crop (Figure 1). Crops such as corn, respond with more yield for every inch of water that the crop consumes as compared to winter wheat or sunflower. High water use crops, such as corn, require more ET for plant development or maintenance before yields are produced. Corn requires approximately 10 inches of ET as compared to 4.5 and 7.5 inches of ET for wheat and sunflower. These crops also require less ET for maximum production compared to corn.

Irrigation is important to increasing ET and grain yields. Irrigation is used to supplement rainfall in periods when ET is greater than precipitation. However, not all of the water applied by irrigation can be used for ET. Inefficiencies in applications by the system result in losses. As yield is maximized, more losses occur since the soil is nearer to field capacity and more prone to losses such as deep percolation (Figure 2). Water can be saved by applying less water than needed for maximum yield. As seen in Figure 2, a reduction in water applied from point A to point B can save water with little or no yield reduction.

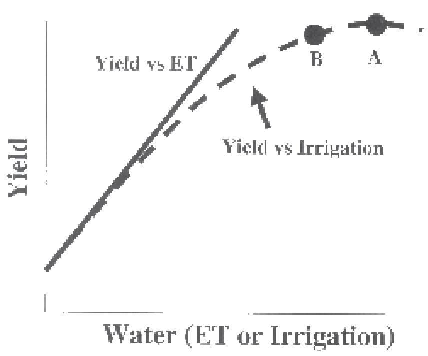

Figure 2: Generalized Yield vs. ET and Yield vs. Irrigation production functions.

Limited Water Management – Reduced Allocations

When producers are faced with reduced surface water storage, they have three management options. They can: 1.) reduce irrigated acreage, 2.) reduce irrigation to the entire field, or 3.) include different crops that require less irrigation. Option 1 will idle potentially productive ground while option 2 will reduce yields for the irrigated acres unless precipitation is above normal. Option 3 incorporates the use of crops that require less irrigation for maximum production to apply the "saved water" for traditionally irrigated crops.

An example in Longmont would be irrigating all corn or irrigating some corn and dry beans. Corn requires 17.3 inches of irrigation (85 percent efficiency) and dry bean requires 10.4 inches. If the allocation from the ditch limits a producer to 14 inches of water, he or she could raise 80 percent of their acres to irrigated corn and the remainder in dryland production or idle. They could also raise 100 percent of available acres to corn and apply only 80 percent of the irrigation required for maximum production. The final option would be to raise 50 percent of available acres to dry bean and 50 percent to corn and maintain maximum production on all acreage.

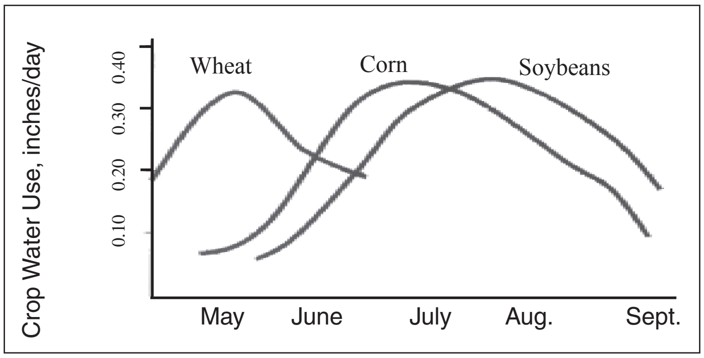

Figure 3: Example of daily ET during the growing season.

Limited Water Management – Low Capacity Systems

When managing for maximum production, irrigation systems must have minimum capacities that meet crop water requirements during peak water use periods. (See Fact Sheet 4.704, *Center-pivot Irrigation Systems*.) If irrigation system capacities are below what is normally required, reduced yields are expected with normal precipitation. Management strategies to compensate for low capacity include pre-irrigation and beginning irrigation at higher soil moisture contents. These strategies may maintain yields in above normal precipitation years but do not help as much in below normal precipitation years. Management strategies to alleviate this problem include splitting systems into two or more crops that have different peak water needs, thus reducing the rate of water requirements during both peak periods.

Crop rotations also spread the irrigation season over a greater time period as compared to a single crop. When planting multiple crops such as corn and winter wheat under irrigation, the irrigation season is extended from May to early October as compared to continuous corn, which is predominantly irrigated from June to early September.

Crops such as corn, soybean and wheat have different timings for peak water use (Figure 3). With low capacity wells, planting multiple crops with smaller acreages allows for water to be applied at amounts and times when the crop needs the water. The net effect of irrigating fewer acres at any one point in time is that ET demand of that crop can be better met. If capacities are increased by splitting acres into crops that have different water timing needs, management can be done to replace stored soil moisture rather than maintaining soil moisture near field capacity in anticipation of crop ET since the system will not meet ET.

Another option is to plant the entire pivot or field to a single crop. Irrigation management with low capacity systems requires that a producer maintain soil moisture at or near field capacity when ET is less than what the system can apply. When the ET for the crop is greater than the capacity of the system, plants will use stored soil moisture to maintain ET. This type of management is necessary to insure that moisture will be available for plants when they reach the reproductive growth stage. However, if precipitation is less than anticipated, soil moisture may be less than 50 percent of available during the reproductive growth stage and yields will be reduced.

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