IRRIGATION

Seasonal Water Needs and Opportunities for Limited Irrigation for Colorado Crops

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by I. Broner and J. Schneekloth[1]

Quick Facts...

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

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

To water 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 effects water needs.

Crop water use, consumptive use and evapotranspiration (ET), are terms used interchangeably to describe the water that is consumed by a crop. This water moves through the plant and cools the plant as it evaporates while carrying the nutrients needed for its growth. For more information on ET and growth stages, refer to fact sheet *4.715, Crop Water Use and Growth Stages.*

Water requirements of 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 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 higher 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 field 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 for silage uses only 22 inches of water. That means sugar beets require 36 percent more water than corn to fully irrigate. These water requirements are net crop water use or the amount a **crop will use** (not counting water losses such as deep percolation and runoff) 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 Greeley is 7 inches for the growing season.

The rest of the crop water requirements 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 by dividing the gross water requirement by the efficiency of the irrigation system (system efficiency is a fraction of one). Therefore, the difference in the gross irrigation water requirements between the two crops is also increased by the irrigation system efficiency. The net water requirements for the above example, after subtracting effective rain, are 23 inches for sugar beets and 15 inches for corn for silage. If the irrigation system is 85 percent efficient, sugar beets will require 27 inches (gross irrigation amount) and the corn crop will require 6 inches of water in order to store the net water requirement in the crops' root zone. The difference between the seasonal gross water requirements of sugar beets and corn is now 53 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 based on weather variables. Seasonal crop water requirement can be estimated using these models by estimating crop water requirements for many years and averaging the

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

numbers to arrive at an average crop water requirements. 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 determine the net irrigation requirement, subtract the effective rain (Av. 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 11.3 inches for the season, therefore the net irrigation requirement is 14.7 inches. The gross irrigation requirement for a center pivot with 80 percent irrigation efficiency is 18.4 inches, while for a furrow irrigation system with a 55 percent irrigation efficiency the gross irrigation requirement is 26.8 inches.

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

	Burlington	Byers	Cheyenne Wells	Colo Springs	Greeley	Lamar	Longmont	Rocky Ford	Springfield	Sterling	Trinidad	Wray
Alfalfa	35.64	32.13	36.14	30.04	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	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		26.81	21.66	27.73	26.67		21.31	25.42
Corn, silage	22.82		22.11	18.22	21.74		19.74	24.28		20.29	19.15	
Corn, sweet					22.75			20.37				
Melons						15.80		15.13				
Potatoes					28.14							
Small vegetables					17.70	18.85		22.23				
Sorghum, grain	21.51	20.46		15.99	19.48	22.64			22.65			21.00
Spring grains		12.49				11.82	11.36	14.15	10.44	14.29		15.17
Sugarbeets	29.98		30.43		29.31	34.27	25.48	32.70	32.28	29.99		29.99
Wheat, winter	18.99	16.42	18.55	14.06	16.38	19.30	18.46		18.64	18.50	16.14	
Av. Precipitation	16.35	18.57	16.26	15.73	12.20	15.33	12.74	12.53	15.36	14.92	12.80	18.51
Av. Effective Precipitation	11.28	10.39	11.68	10.59	7.32	11.00	6.99	8.89	10.93	6.68	8.28	12.56

Limited Irrigation

Limited irrigation occurs when water supplies are restricted and full evapotranspiration demands cannot be met. Reasons that producers may be limited on the amount of available water include: 1) 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); and 2) reduced surface water supplies due to droughts, seasonal water fluctuation and/or junior water rights reducing the water allocations available for users.

When producers cannot apply water to meet crop ET, 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 cropping mixes can be adjusted to better match water availability, and how changes in agronomic practices can 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 also 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 before any yield is produced. These crops also require less ET for maximum production compared to corn.

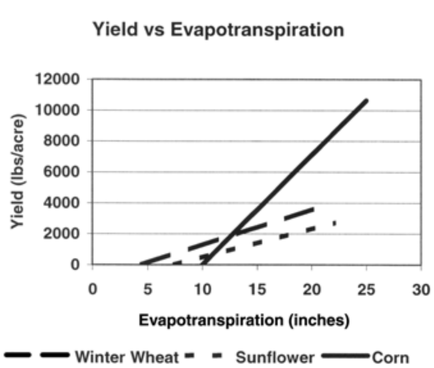

Figure 1: Yield vs. ET relationship for several irrigated crops.

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				
Orchards w/o cover crop	27.12									
Orchards w/ cover crop					25.71					
Potatoes							16.49			
Small vegetables					18.06		6.79			
Spring grains (barley, wheat)	13.51	14.79	16.73		19.61	15.46	12.66	11.38	18.04	
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

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 is 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.

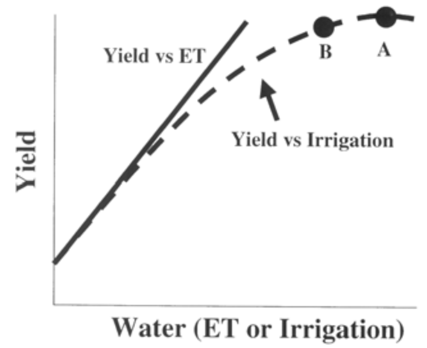

Figure 2: Generalized Yield vs. ET and Yield vs. Irrigation production functions.

Limited Water Management – Reduced Allocations

When producers are faced with reduced surface water supplies, they have three management options. Producers can reduce irrigated acreage, reduce irrigation amounts to the entire field, or include different crops that require less irrigation. The first option idles potentially productive ground while option two reduces yields for the entire irrigated acres unless precipitation is above normal. The third option incorporates the use of crops with lower water requirement for maximum production on some of the acres and the rest of the acres are used for traditionally irrigated crops. Thus, the combined water requirement doesn't exceed the available water.

The following is an example of option three for Longmont, Colorado. A grower can irrigate all corn or irrigate some corn and plant a lower water use crop such as dry beans. Corn requires 17.3 inches of gross irrigation (85 percent efficiency) and dry beans require 10.4 inches. If the allocation from the ditch limits a producer to 14 inches of water, producers can raise 80 percent of their acres to irrigated corn and the remainder in dry-land production or leave idle. They can also plant 100 percent of their acreage to corn and apply only 80 percent of the irrigation required for maximum production. The final option means they can raise 50 percent of their acres to dry bean and 50 percent to corn and apply the maximum water requirement on all of their acres.

Limited Water Management – Low Capacity Systems

When managing for maximum production, irrigation systems must have minimum capacities to meet crop water requirements during peak water use periods (see fact sheet 4.704, *Center-pivot irrigation systems).* If irrigation system capacities are below normal requirements, expect reduced yields. Management strategies to compensate for low capacity include pre-irrigation and begin 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 (fields) 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 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.

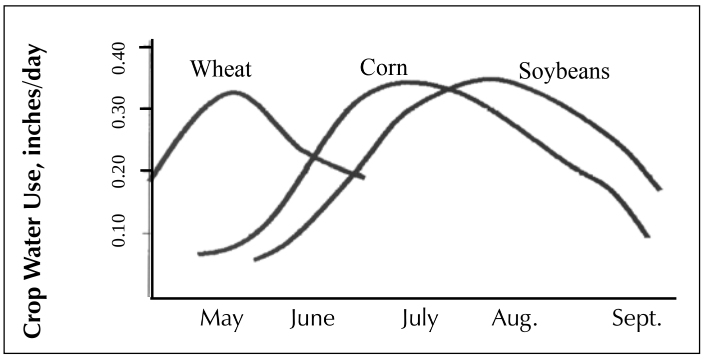

Figure 3: Example of daily ET during the growing season.

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 with different water timing needs, management can be done to replace stored soil moisture rather than maintaining soil moisture near field capacity in anticipation of peak crop ET since the system will not meet ET. This strategy allows the user to take better advantage of effective precipitation.

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 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, which is also the peak water demand. However, if precipitation is less than anticipated, soil moisture, during peak water demand, may fall below critical levels and yields will probably be reduced.

[1]*I. Broner, Colorado State University Cooperative Extension irrigation specialist and associate professor, civil engineering;*
J. Schneekloth, Cooperative Extension water resource specialist, U. S. Central Great Plains Research Station, Akron, Colorado.

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