CONSERVATION TILLAGE
FACTS

Water Use /Yield Relationships for Central Great Plains Crops

Knowing and using these relationships can help you to make wise cropping decisions

The single most important factor determining crop yield grown in rotations in the central Great Plains is available water. When nutrients are not limiting, and pests and weeds are controlled, the relationship between water used and final grain yield is usually a simple linear function. Knowing these relationships for various crops can be a valuable aid for producers making crop choices for rotations in their cropping systems.

The amount of water used by a crop is sometimes referred to as evapotranspiration or ET. It is comprised of evaporation (the water that evaporates from wet soil and plant surfaces following a rain), and transpiration (the water that moves from the soil profile through the roots and stem, and out through the leaves to the air). Good residue management prior to the crop growing season can increase the amount of water available for transpiration by increasing infiltration rates of the soil, and by decreasing evaporation rates from the soil surface.

As water is taken up by roots, the plant combines water with carbon dioxide from the air to synthesize plant parts: leaves, roots, stems, and grain. The more water the plant can take up, the more of these components the plant can make.

An example of the relationship between ET and grain yield for corn and for wheat is shown in Fig. 1. The equations at the top of the figure define the lines that run through the data points. The first number in each equation is the slope of the plotted line. The steeper the slope, the more responsive crop yield is to additional water. The point where the line intersects the Cumulative ET axis of the figure shows how much ET is necessary before any grain can be produced. For corn, the relationship tells us that 582.2 lb/a (10.4 bu/a) of grain are produced for each additional inch of water used after about 9 inches of water use. Winter wheat, on the other hand, is less responsive to water than corn, producing 390.4 lb/a (6.5 bu/a) of grain for each additional inch of water used after about 6.8 inches of water use. The water use/yield equation coefficients for other crops are given in Table 1.

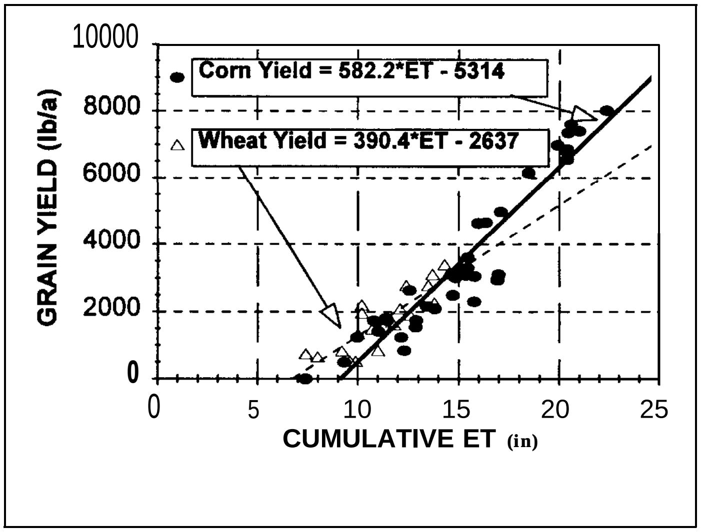

Figure 1. Corn and wheat grain produced (lb/a) as a function of water used (in).

Table 1. Water use/yield prediction equation coefficients and inches of ET that must occur before grain is produced.

Crop	Slope (lb/a per inch ET)	Y-axis intercept	inches of ET before yield
Corn	582.2	-5314	9.1
Winter Wheat	390.4	-2637	6.8
Proso Millet	236.7	-818	3.5
Safflower	185.2	-1698	9.2
Sunflower	160.5	-843	5.3

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From the slopes of the relationships in Table 1, we note that corn is the most responsive to additional increments of water, while sunflower is the least responsive. Proso millet requires the least amount of water to grow the plant before grain production begins (3.5 inches).

An example of how these water use/yield relationships can be used is given in Table 2. In this example we assume that we sampled the soil prior to corn planting and found that there were 4 inches of extractable water in the soil profile. This is water stored in the soil from the time the last crop was harvested to the time the corn crop is planted that will be available to the crop during the growing season. Table 2 gives three possible precipitation scenarios: average precipitation during the growing season, and average precipitation plus or minus 30%. (This range would cover about 80% of the years at Akron, CO.) Precipitation plus extractable water is the total growing season ET that is used with the equation coefflcients given in Table 1 to arrive at the predicted yield. For example, an extractable soil water content of 4 inches and a growing season precipitation of 11.4 inches would give a total water use of 15.4 inches. Using the factors given in Table 2 for corn, we would calculate:

15.4" * 582.2. 5314 = 3652 lb/a or about 66 bu/a.

If the ET were reduced to 12 inches (4”+ 8“), then the grain yield would be 1672 lb/a. Under wetter conditions of 18.8 inches of ET (4” + 14.8”), we would expect to harvest 5631 lb/a. Table 2 shows the results of similar calculations for other crops.

Table 2. Predictions of yield for various crops assuming varying amounts of growing season precipitation and using the water use/yield relationships given in Table1.

		------------------ Precipitation (in) ------------------			Grain Yield at Given Precipitation Level (lb/a)		
Crop	Extractable Soil Water (in)	Avg - 30%	Average	Avg + 30%	Avg - 30%	Average	Avg + 30%
Corn	4	8.0	11.4	14.8	1672	3652	5631
Wheat	4	5.6	8.0	10.4	1111	2048	2985
Millet	4	5.5	7.8	10.1	1430	1975	2519
Safflower	4	8.3	11.9	15.5	580	1247	1913
Sunflower	4	6.2	8.9	11.6	794	1227	1661

Final Comments

One caution that users of these water use/yield relationships should be aware of is that final grain yield of a crop is influenced by the timing of precipitation as well as the amount of water used. This is one reason why the data points shown in Fig. 1 do not all fall exactly on the water use/yield relationship line. In fact, two of the points shown for corn in Fig. 1 at about 17" of cumulative ET are about 1700 lb/a lower than the yield predicted by the water use/yield relationship. This happens because of corn's high sensitivity to water deficits during the tasseling and pollination stages. Low water availability and restriction of ET at this time reduces yield much more than a similar level of water deficit during the early vegetative growth stage. Consequently, the water use/yield relationships given in Table 1 are valuable for approximating potential grain production for an upcoming growing season, but will not exactly predict final grain yield due to variations in yield that will occur due to timing of water stress.

Predicting growing season precipitation is virtually impossible. But a producer can know the amount of extractable water in the soil profile by soil sampling with a hand probe, or with tensiometers or gypsum blocks. Knowledge of the amount of water in the soil in the spring along with an assumed amount of growing season precipitation in the proper water use/yield relationships can help the producer make a wise decision regarding the choice of a crop to use in his production system.