CHARTING SOIL WATER -- A TOOL FOR IRRIGATION SCHEDULING

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The amount of water present in soil is a key indicator for scheduling irrigations. The amount of readily available water remaining in the root zone along with the expected evapotranspiration (ET) indicates the time remaining before the crop experiences stress. The amount of room left in the active root zone to store water indicates when irrigation can be started. Soil water can be measured or estimated by going to the field with a soil probe or other instruments, such as tensiometers or gypsum blocks.

The amount of soil water can also be estimated by calculating a "soil water balance", based on how much water has been used for ET and how much water has been added from rainfall or irrigation. If this soil water balance is calculated on a daily basis, it can be charted as shown in Figure 2. This process is like charting the market or charting the balance in your checkbook. Some have referred to this method as the "checkbook" method for irrigation scheduling. Spreadsheets for personal computers and irrigation scheduling software have made the charting process easier, but it still takes gathering some basic information.

With our bank accounts, we do not go to the bank every day to check the balance of our accounts. However, we do calculate a daily balance and we do receive a monthly statement to verify if our calculations are on track. The same is true for charting soil water. We need to go to the field periodically to verify the amount of soil water.

SOIL WATER DEFINITIONS

Soil water is classified into three categories: (1) excess soil water or gravitational water, (2) available soil water, and (3) unavailable soil water. See Figure 1 for a schematic representation of soil water from the very driest to the very wettest.

Excess soil water or gravitational water drains or percolates readily by gravitational force. This water is very transient in the soil from the time soil is saturated until it reaches "field capacity". Part of the gravitational water may be use by plants as it moves through, but we do not count on it in calculating irrigation schedules.

Field capacity is the water content of a soil at the upper limit of the "available water capacity". It is the amount of water remaining in a soil after it has been saturated and allowed to drain for 24-48 hours. As the soil dries further, there is only slow gravitational drainage.

Available soil water is retained in the soil by capillary forces and can be extracted by the plant. This soil water is most important for crop production. It is the water held by the soil between field capacity and "wilting point". Plants can us approximately 50 percent of the available water without stress. When less than 50 percent of available water remains, stress can occur.

Permanent wilting point is the lower limit of the available water range. When plants have removed all of the available water, they wilt and do not recover.

Available water capacity is all the water that a soil can possibly hold between field capacity and wilting point. The capacity varies with soil texture.

Unavailable water is water held so firmly to soil particles by adsorptive forces that it cannot be extracted by plants. Unavailable water remains when soil is drier than the wilting point.

CHARTING SOIL WATER

On any day during the growing season, the actual amount of soil water can be determined in the field. This measurement would fall somewhere along one of the bars in Figure 1. If we did this every day during the growing season, we would be able to trace a line of soil water like the dashed line in Figure 2. There are two important differences between Figures 1 and 2. Figure 1 indicates soil water in terms of inches of total soil water per foot of soil. Figure 2 represents inches of available water in the active root zone. The horizontal zero axis in Figure 2 is actually the wilting point, which means that the unavailable water has been subtracted off and available water starts from zero. On Figure 2, the space between the zero axis and the "minimum available water" solid line is the water that is available to plants, but they are likely to be under stress. This space increases from May 5 through July 28 because the root zone increases. The space above the "maximum available water" solid line (the same as field capacity) is the excess or gravitational water. That water cannot be held in the root zone and percolates through. The shaded area between maximum and minimum available water is the irrigation "management zone". This represents water that is available for plants that are not under stress and increases as the root zone increases.

The dashed line for available water does not exceed the maximum available water (field capacity) even if more irrigation or rainfall occurs. These events are indicated by the squares and triangles, which cause the available water to increase. Daily evapotranspiration by the crop cause the dashed line, the available water, to go down. If we do not go to the field every day to measure available water, it can be calculated by the following equation:

$$AW_t = AW_y + PPT_t + IRR_t - ET_t + S_t,$$

where: AW_t = the root zone available water today,
AW_y = the root zone available water yesterday,
PPT_t = the precipitation for today,
IRR_t = the net irrigation for today,
ET_t = the crop evapotranspiration for today
S_t = the change in root zone storage for today, resulting from root zone expansion.

Daily precipitation should be measured at each field. The rainfall measurements can be adjusted to account for runoff using the technique of Cahoon et al. (1992). "Net" irrigation, which is the amount of water that infiltrates into the active root zone, should be recorded. Yonts and Klocke (1985) have suggested some average efficiencies for irrigation systems. These efficiencies relate the "gross" water applied to the field to net irrigation. Crop ET can be obtained from region weather stations. Rates of root growth expansion have also been tabulated by Yonts and Klocke (1985). These values for the equation all require measurements, which are all subject to inaccuracies, which illustrates the need to go back to the field periodically to check the actual available water in the soil.

EXAMPLES OF SOIL WATER CHARTING

The examples for charting available soil water in Figures 2, 3, and 4 are from irrigated fields in central Nebraska during the 1993 growing season. Until early August, rainfall and stores soil water were sufficient to meet the ET needs of the crop. Figure 2 is for a center pivot system. The operator did keep available water within the management zone during August with four irrigations totalling 4.5 inches and some rainfall. Figure 3 is for a continuous flow furrow irrigated filed. this operator waited until the soil water was depleted to the point that the crop probably experienced water stress. The soil was able to hold the one irrigation of 4.1 inches and a subsequent rain, but crop yield probably was affected. Figure 4 represents a furrow irrigated field with surge valves. The operator applied two irrigations totalling 6.5 inches; however, the soil could not completely hold either of these irrigations. The excess water probably percolated through the root zone.

Charting of available soil water illustrates the value of this tool for not only scheduling irrigations but also for reviewing the filed history to evaluate management decisions. It also can identify possible inefficiencies in water use. Irrigation scheduling software and crop consultants should be moving to this technique as an aid for irrigation management decisions.

FOR MORE INFORMATION:

Cahoon, J.E., C.D. Yonts, and S. Melvin. 1992. Estimating effective rainfall. NebGuide G92-1099. University of Nebraska-Lincoln, Cooperative Extension.

Klocke, N.L., and G.W. Hergert. 1990. How soil holds water. NebGuide G90-964. University of Nebraska-Lincoln, Cooperative Extension.

Klocke, N.L., and P. Fischbach. 1984. Estimating soil moisture by appearance and feel. NebGuide G84-690. University of Nebraska-Lincoln, Cooperative Extension.

Yonts, C.D. and N.L. Klocke, 1985. Irrigation scheduling using crop water use data. NebGuide G85-753. University of Nebraska-Lincoln, Cooperative Extension.

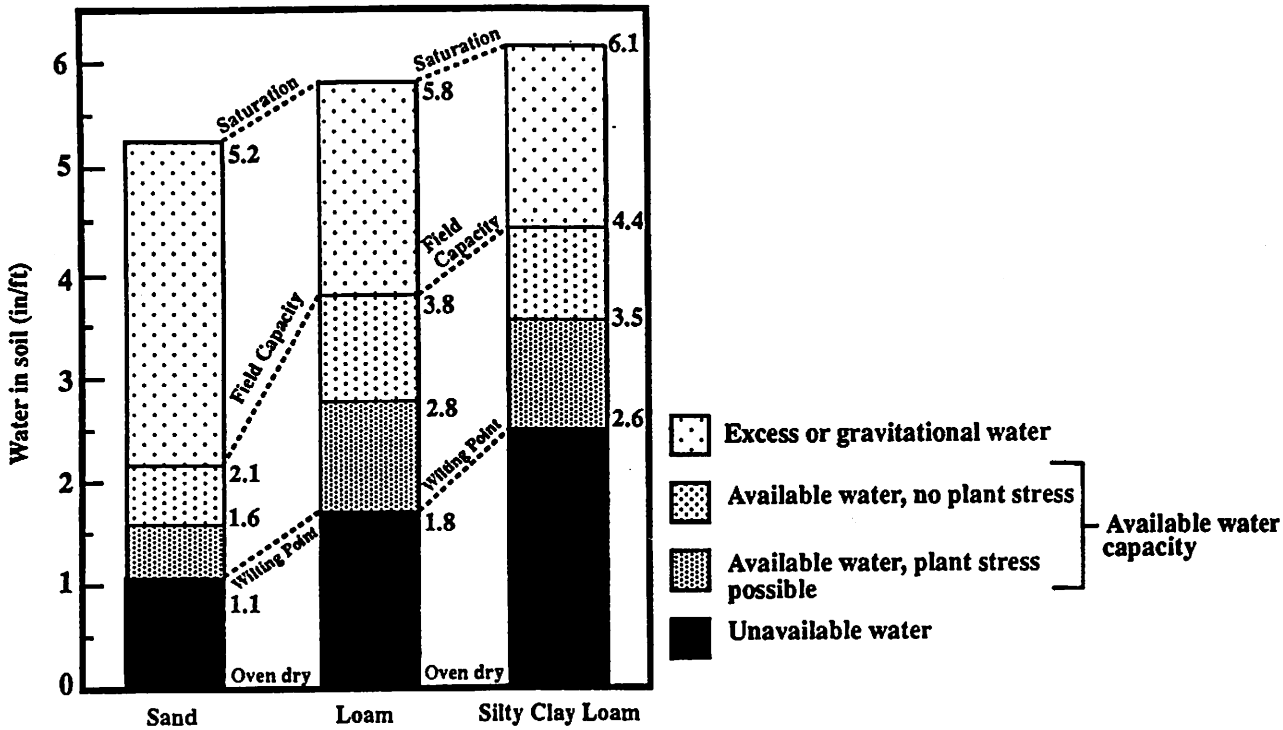

Fig 1. Representation of soil water for three soil textures in terms of inches of water per foot of soil.

Total irrigation:	4.5 inches
Number of irrigations:	Four
Type of irrigation:	Pivot
Total rainfall:	20.9 inches

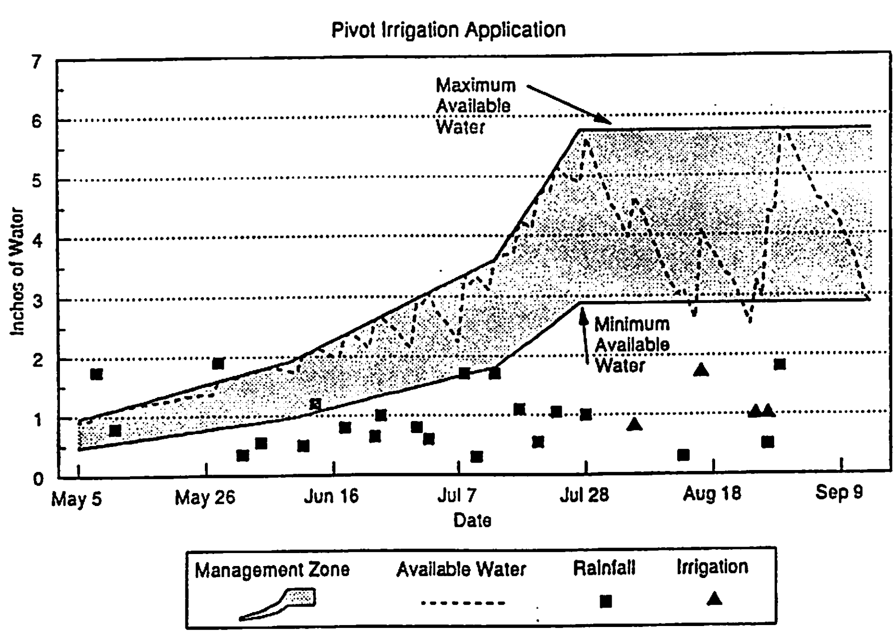

Fig 2. Chart of available soil water for center pivot irrigated field in central Nebraska during 1993.

Total irrigation:	4.1 inches
Number of irrigations:	One
Type of irrigation:	Continuous flow
Total rainfall:	17.6 inches

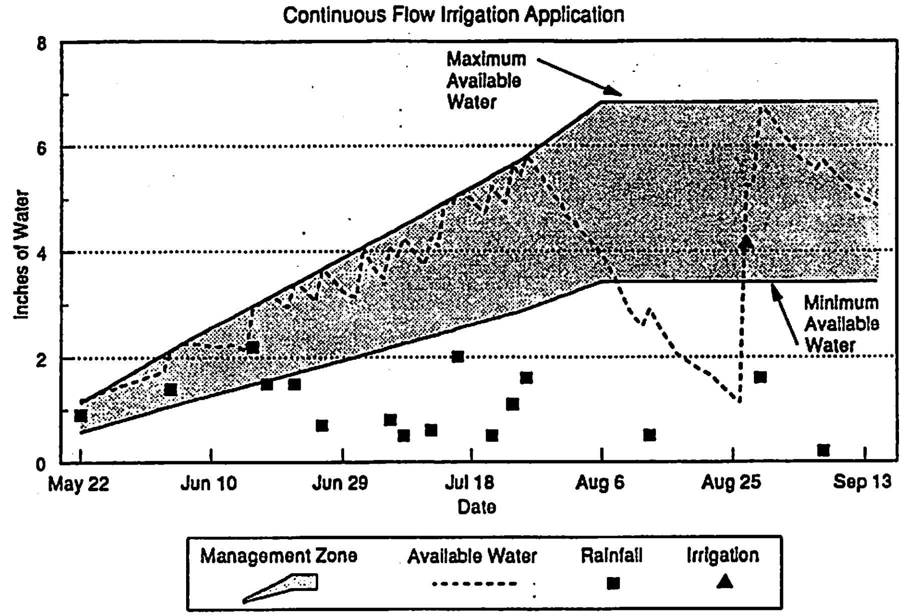

Fig 3. Chart of available soil water for furrow irrigated field with continuous flow in central Nebraska during 1993.

Total irrigation:	6.5 inches
Number of irrigations:	Two
Type of irrigation:	Surged flow
Total rainfall:	28.7 inches

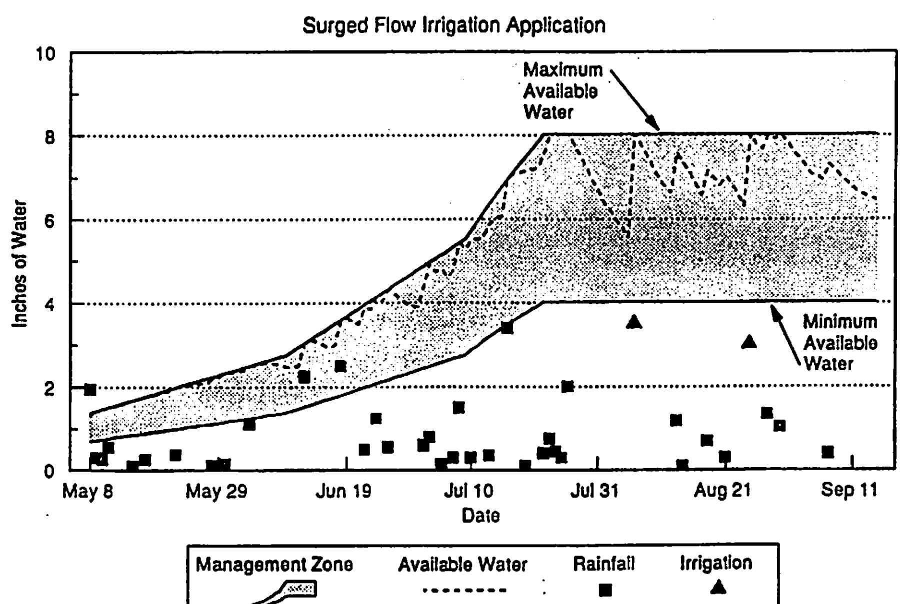

Fig 4. Chart of available soil water for furrow irrigated field with surge flow in central Nebraska during 1993.