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Energy Conservation through Better Irrigation Practices—for Farmers

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IRRIGATION of field crops in Michigan has increased 100 percent in the last 4 to 5 years. Can we expect irrigation to continue to intensify? Will water resources be sufficient to support such intensive use? Even though water appears to be in abundance in Michigan, the fuel required to use the water for irrigation dictates that we use the best water management practices available.

Irrigation of a crop for maximum production is directly associated with the farmer's livelihood and indirectly associated with all who depend on the farmer for food and fiber. Few would argue against the high priority of food production. Yet it is evident from the rising costs experienced by farmers in the past few years that all management practices related to food production—irrigation included—should be reexamined to make sure that resources are used in the best way possible.

Irrigation has been very important for many farmers in Michigan and adjacent states in recent drouth years. For example, a Purdue University study[1] shows that irrigated corn yields, averaged over 16 years, were 73 bushels per acre higher than yields for nonirrigated corn. For many farmers it is not a question of whether irrigation is worthwhile, but what water management techniques could now be used to get maximum yield from minimum consumption of water and energy.

Undoubtedly, the most energy can be saved by applying the minimum amount of water required for maximum crop productivity. Too much or too little will reduce yields. For example, in a water renovation experiment at Michigan State University, 40 and 80 inches of plant-nutrient-enriched wastewater were applied to corn over the growing season. The 40-inch treatment supplied 171 pounds of additional nitrogen and the 80-inch treatment 307 pounds of additional nitrogen. The yields, averaged over 4 years, were each 103 bushels per acre. Forty inches of additional water countered any benefit the additional nitrogen added. Hence, the additional costs of 136 pounds of nitrogen, the fuel required to pump 40 inches of additional water, the additional wear and tear on the irrigation equipment, and the additional labor costs were of no benefit in terms of yield.

Such intense applications generally are not used for crop production in Michigan, but the evidence clearly shows that water management plays an important role. More realistically, Watts[2] cites an irrigation system in Nebraska where the operator applied 29.5 inches to corn, about 11.5 inches in excess of that needed. This extra water resulted in a cost for fuel and fertilizer of about $42 per acre. This additional expenditure produced the same yield as that obtained under good water management. For the entire 130-acre field additional cost amounted to $5,365.

More recent irrigation research in Nebraska[3] shows that limited irrigation can produce corn and sugar beet yields as good as or better than when the crop is irrigated to capacity. Hence, nearly half the water and half the energy can be saved. Tests have shown that under Nebraska conditions only 6 to 10 inches of irrigation are needed most years.

To avoid over-irrigating, farmers must become better acquainted with the water retention capacity of their soil. This, along with the climatic intensity, will determine the frequency of irrigation and the amount of water to apply. Sensors, such as tensiometers and moisture blocks (Figure 1), may be used in evaluating the plant-available water. Such equipment is helpful but not absolutely necessary if the operator is willing to use an auger or spade to obtain information on water penetration depth and variation of texture with depth, and relate these values to the amount of water applied. Too much water during an irrigation or irrigating too frequently will cause the water to move beyond the reach of the plant roots. This water will carry with it plant nutrients such as nitrogen which are lost for crop production.

Still another method that irrigators may use in water management is shown in Figure 2. This chart shows graphically the inputs of rainfall, irrigation and evapotranspiration, all components of the zig-zag line (**zz**). Rainfall is shown by the vertical lines, irrigation by the vertical dashed lines, and evapotranspiration by the hori-

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[1] *Carson, E. E., R. Z. Wheaton, and J. V. Mannering. Irrigation of field crops in Indiana. Cooperative Extension Serv. Bulletin, ID-119. Purdue University, West Lafayette, IN. 1977.*

[2] *Watts, D. G. Irrigation water management: One way to lower production costs. Fertilizer Solutions, Vol. 21:20-30. 1977.*

[3] *Anonymous. Management for efficient use of irrigation water. Doane's Agricultural Report —Crop Section. pp. 127-128. 1977.*

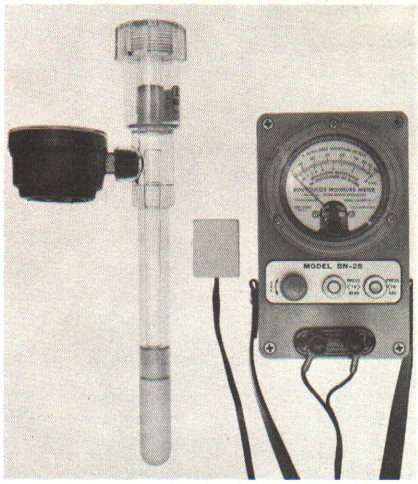

Figure 1—Tensiometer (left) moisture block and meter (right) used in measuring plant-available water in soil.

zontal solid lines, all components of **zz**. Good management requires that the **zz** stay between the two parallel lines. The distance between the two parallel lines represents 50 percent of the water storage capacity of the soil. In the case of sand, the lines would be closer together, resulting in a smaller storage capacity. When **zz** approaches the bottom line, water should be added. When **zz** approaches the upper line because of irrigation or rainfall, the soil is full and no more water can be stored. The slope of the two parallel lines gives the average estimated daily loss by evapotranspiration. (Rather than 1 inch of water for 5 days, we have here $5 \times .174 = 0.87$ inch.) Rain in June and part of July was adequate in 1971. As seen from the chart, three irrigations were applied in July and early August. Two more inches should have been applied in the middle of August for maximum yield.

Fifteen years of rainfall data at Michigan State University show that on the average only 10 inches of rain is received during June, July and August, resulting in a 6- to 8-inch deficit. Hence, for maximum yields with minimum water and energy consumption, no more than 6 to 8 inches of water should be applied for an average year. The goal of good water management is to supply water to a crop without under-irrigating, resulting in plant water stress, or over-irrigating and thereby losing water and plant nutrients.

Other suggestions for conserving water and energy in irrigating large fields are as follows:

1. Keep accurate rainfall and irrigation records. Know how much water is being applied to a particular field. Subtract the estimated runoff and deep percolation estimates, leaving only water stored in the root zone.

2. Know the storage capacity of your soil by checking the depth of a wetted zone after applying a known amount of water.

3. Improve irrigation efficiency by irrigating at night or during the day when wind velocities are low.

4. Reduce the amount of water stored in the soil by less frequent irrigation as the crop matures. **With corn, irrigation should cease when the kernels reach the dough stage.** Reduced water content of the soil at this time will hasten maturity and permit earlier harvest.

5. Irrigation systems should be operated at pressures that will produce a uniform distribution of water. This will vary with various systems and nozzle sizes. Care should be given to drilling properly designed wells and then matching the irrigation system, engine horsepower, and pumping units to the capacity of the wells.

6. Irrigation in the absence of other good management practices is not very profitable and wastes fuel and water. With water not a limiting production factor, all other management factors may need change to maximize crop production. This may include such considerations as plant hybrids, plant population, time of planting, use of herbicides and insecticides, quantity of fertilizer and when applied, and time required for maturity.

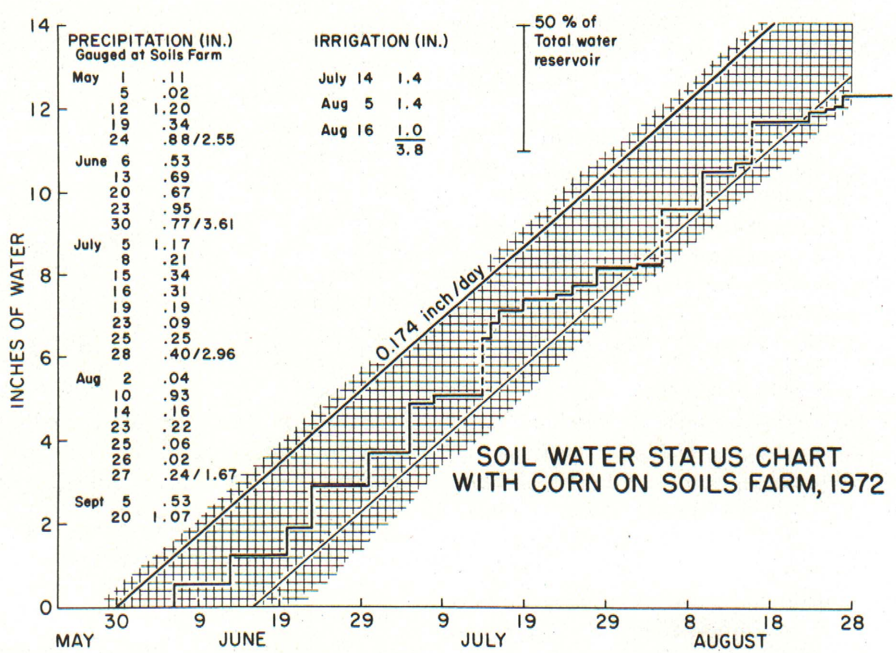

Figure 2—Water balance chart showing water inputs from rainfall and irrigation and water losses from evapotranspiration. (See text.)

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