Using a Programmable Calculator to Schedule Irrigation

Jean Steiner

E. T. Kanemasu

William L. Powers

Recommended Citation

K-STATE
Research and Extension

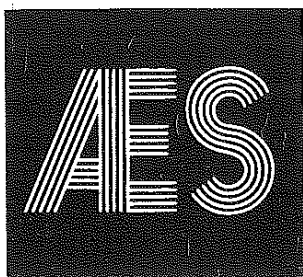# Using a Programmable Calculator to Schedule Irrigation

Keywords

Keeping up with research; 45 (Jan. 1980); Kansas Agricultural Experiment Station contribution; no. 80-213-S; Irrigation management; Programmable calculator; Evapotranspiration; Soil moisture; Schedule

Creative Commons License

Keeping Up With Research

45

JANUARY 1980

Using a Programmable Calculator To Schedule Irrigation[1]

Jean Steiner, E. T. Kanemasu, and W. L. Powers[2]

Water and energy resources are becoming increasingly scarce and valuable. To preserve these resources and to hold the costs of production down, improved irrigation management techniques are being examined.

One of the ways to improve irrigation management is to understand water use by crops throughout the season. Evapotranspiration (ET) is the amount of water lost through evaporation from the soil surface and transpiration from the plants. On a given day, ET from a field depends primarily on the type of crop, the amount of crop cover, surface soil moisture, and climatological conditions. ET can be estimated mathematically, using field and climatic data.

ET estimates have been made at Kansas State University for several years, but the information has been used primarily for research purposes, because most people in the state don't have access to computer facilities. We have simplified the K-State ET model so it can be run on a programmable calculator and so the data necessary to run the model are relatively easy to collect.

AGRICULTURAL EXPERIMENT STATION
Kansas State University, Manhattan
Floyd W. Smith, Director

For a full cover crop, ET depends primarily on the amount of energy available to evaporate water, and therefore depends on solar radiation and air temperature. At less than full cover, ET depends primarily on the crop cover and the surface soil moisture.

To use the ET model for a field, one must know the soil type, the water holding capacity of the soil, and the initial moisture in the soil profile, as well as daily maximum and minimum temperature, solar radiation, leaf-area index, rainfall, and irrigation. The model then estimates evaporation and transpiration and calculates a soil moisture balance for the day.

Solar radiation and temperature measurements are available from the National Weather Service and from several Agricultural Experiment Stations.

Leaf-area index is the ratio of green leaf surface area to soil surface area and is determined by measuring the leaf area of representative plants and multiplying by the number of plants in a given soil area (plant population). The best results are obtained by measuring the leaf-area index in each field, but since a crop follows a specific pattern of growth and development, leaf-area index could be estimated from generalized curves.
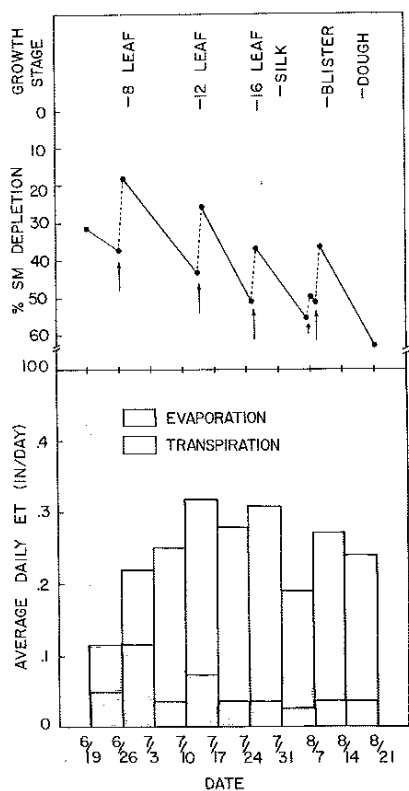

Figure 1. Average daily evapotranspiration, soil moisture depletion (of a Ulysses silt loam with 12.6 inches of maximum available water), and growth stages of corn.

After the daily ET is calculated, the soil moisture balance is updated by adding rainfall or irrigation and subtracting ET, runoff and deep percolation. An irrigator who knows the soil moisture status of his fields and the rate a crop uses water can make better management decisions. An example of ET and soil moisture balance information is presented in Figure 1.

Soil Moisture Balance

The soil moisture balance is calculated daily by the model. A weekly soil moisture balance from July 16 through August 13 is calculated in a similar way for the same field as shown below.

Soil Moisture Information

To maintain a soil-moisture balance, you must first know how much water is in the soil profile and how much of that water is available for uptake by the plants. The best way to determine the initial soil moisture is to take a soil sample with a probe and weigh the samples while they are moist, then after they dry. For example, (moist weight — dry weight)/ dry weight = 22.6% (.226) by weight. Assuming a bulk density of 1.3, the moisture percentage by volume is 22.6 × 1.3 or 29.4%. Total moisture in a 5-foot profile is then .294 × 60 inches = 17.64 inches.

To determine maximum available water (AW_{max}), you must know field capacity (FC) and permanent wilting point (PWP). Both are available from the Soil Conservation Service or from county extension agents. For our sample calculations, we consider FC = 36.8% and PWP = 15.6%. To find the amount of water the soil can hold easily available to plants, you subtract PWP from FC. In this case, AW_{max} = FC − PWP = 36.8 − 15.8 = 21.0%, which is the water than can be managed for crop production. The maximum available water is .210 × 60" = 12.6 inches.

Sample Calculations:

Corn, Grant County, Kansas, 1978
Ulysses Silt Loam — Maximum available water = 12.6"

	Total soil moisture, inches	% depletion	Avail. soil moisture, inches
July 17-July 23			
Initial soil moisture	17.64	35	8.27
Rainfall	+ .68		
Average daily ET .29" × 7 days	− 2.03		
	16.29	45	6.92
July 24-July 30			
Initial soil moisture	16.29		
Irrigation	+ 2.01		
Average daily ET .31" × 7 days	− 2.17		
	16.13	47	6.76

July 31-August 6

Initial soil moisture	16.13		
Rainfall	+ .17		
Average daily ET .20"	— 1.47		
× 7 days	14.83	56	5.46

August 7-August 13

Initial soil moisture	14.83		
Rainfall	+ 1.03		
Runoff	— .01		
Irrigation	+ 2.01		
Average daily ET .27"	— 1.89		
× 7 days	15.97	47	6.60

Scheduling Irrigation

The irrigator in this example scheduled his water applications to allow a gradual depletion of the stored soil moisture throughout the season, without allowing it to drop too low until the season ended. A late July irrigation assured adequate soil moisture during the tassel and silking stages, which is critical. He did not completely refill the soil moisture profile when he irrigated, so rainfall could be beneficially used by the crop, and he gradually allowed the soil moisture reserve to be depleted as the crop matured.

An ET model helps an irrigator who wants to limit the water he applies to his crops. It allows him to monitor the depletion of water from his soil profile so that he knows when additional water must be added. It also gives him an idea of the rate water is used, so he can decide whether he wants to replace all or part of the water that the crop depletes from the soil.