IRRIGATION MANAGEMENT SERIES

PREDICTING THE FINAL IRRIGATION FOR CORN, GRAIN SORGHUM, AND SOYBEANS

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Water–use efficiency is becoming an important concern for irrigators, state water officials, and Kansas citizens. Deciding when to apply the last irrigation is an important crop and water–management decision. Water, as well as expenses associated with its delivery, can be saved by closely monitoring the soil water levels and scheduling the last irrigation. Applying one extra irrigation may mean wasting 1 to 4 inches of water and the fuel needed for pumping. Other reasons for scheduling the final irrigation are to prevent harvest delays and soil compaction due to wet fields late in the season. However, early cutoff of irrigation water may result in unnecessary yield loss. Determining when to apply the final irrigation is an important management decision.

REQUIREMENTS FOR PREDICTING THE FINAL IRRIGATION

When scheduling the final irrigation of a season, there are two goals to keep in mind:

1) Provide enough water to the root zone to carry the crop to maturity and to maintain yields.
2) Reduce the soil water levels as far as possible to provide room for off–season precipitation, to minimize costs associated with irrigation, and to minimize risks of soil compaction during harvest.

These goals seem to conflict, but irrigators can accomplish them by scheduling the final irrigation. To schedule the final irrigation, the following information is needed:

a) Current crop stage of growth.
b) Predicted water use to maturity.
c) Amount of usable water in the root zone.

For the purpose of predicting the final irrigation, it will be assumed that no precipitation occurs. In the event of precipitation, the procedures presented in this bulletin should be repeated.

SCHEDULING THE FINAL IRRIGATION

Scheduling of the final irrigation may be performed in Table 1 to estimate how much additional water will be necessary to finish the season. Table 1 also shows an example. To complete this form, follow these steps.

1. Record the date, field, crop type, soil type, and the stage of growth. Refer to the local NRCS County Soil Survey to determine the soil type and to Tables 2–4 to determine the stage of growth.
2. Determine the Water Required to reach Crop Maturity (WRCM). Table 5 gives approximate values for appropriate stages of growth.
3. Determine the Available Soil Water Holding Capacity (ASWHC) for the soil type listed in Step 1. The ASWHC can be found for general soil descriptions in Table 6.
4. Find the Total Available Water (TAW) in the root zone by multiplying the ASWHC from Step 5 by the root zone depth.
5. Calculate the Allowable Soil Water Depletion by multiplying the TAW found in Step 4 by allowable soil depletion.
6. Measure the Current Soil Water Depletion (CSWD).
7. Calculate the Remaining Usable Water (RUW) in the root zone by subtracting the CSWD found in Step 6 from the ASWD calculated in Step 5.
8. Determine the Irrigation Requirement (IR) by subtracting the RUW found in Step 7 from the WRCM determined in Step 2.

When the value determined for the remaining usable water is greater than the amount of water required to reach crop maturity, no irrigation is required. Additional information on how to fill each part of the table is also included in this bulletin.

STAGES OF CROP DEVELOPMENT (STEP 1)

For best yields, crops should be provided with water up to the time of physiological maturity. Since some of the required water can come from the soil water reserves, the final irrigation can usually be applied several weeks before crop maturity. To help determine the approximate number of days left and subsequently the water use until crop maturity, it is helpful to recognize the stages of growth for the crop of interest. Tables 2–4 describe relevant growth stages for corn, grain sorghum, and soybeans. A more

Table 1. Estimating Remaining Irrigation Requirement

Steps		Example	Your Field
1.	Date		
	Field	North 80	
	Crop	Corn	
	Soil Type	Silty clay loam	
	Stage of Growth (Tables 2–4)	Dent	
2.	Water Required to Crop Maturity (WRCM from Table 5)	2.5in	
3.	Available Soil Water Holding Capacity (ASWHC from Table 6)	2.1 in/ft.	
4.	Total Available Water (TAW = ASWHC x Root Zone)	6.3 in.	
5.	Allowable Soil Water Depletion (ASWD = Deplete x TAW)	3.8 in.	
6.	Current Soil Water Depletion(measured value)	2.0 in.	
7.	Remaining Usable Water (RUW = ASWD – CSWD) (RUW = STEP 5 – STEP 6)	1.8 in.	
8.	Irrigation Requirement (IR = WRCM – RUW) (IR = STEP 2 – STEP 7)	0.7 in.	

NOTE: If RUW is greater than WRCM, no more irrigation is needed.

Table 2. Reproductive Stages of a Corn Plant

Stage	Description
Silking	Silks visible outside the husks; pollen shedding.
Blister	Kernels are white and resemble a blister in shape.
Milk	Kernels are yellow and inner fluid is milky white.
Dough	Inner fluid has a pasty consistency.
Dent	Kernels are dented or denting; cob is dark red.
Physiological maturity	All kernels achieving maximum dry weight.

Source: How a Corn Plant Develops, Special Report No. 48, Iowa State University, 1989

Table 3. Reproductive Stages of a Sorghum Plant

Stage	Description
Boot	Head extended into flag leaf sheath.
Half–bloom	Half of plants at some stage of bloom.
Soft dough	Grain forming rapidly, culm losing weight.
Hard dough	3/4 of grain dry weight accumulated.
Physiological maturity	Maximum dry weight of the plant reached.

Source: How a Sorghum Plant Develops, S–3 Revised, Kansas State University, 1993

detailed discussion on plant development can be found in the source listed with each respective table.

PREDICTING WATER USE TO MATURITY (STEP 2)

Determining the amount of water use to crop maturity involves estimating and summing the amount of daily evapotranspiration (ET) from the time of interest until crop maturity. ET is the amount of water used by a growing crop. Each day water is evaporated from the soil and plant surfaces, and transpired through the plants. ET is this combination of evaporation and transpiration. Transpiration is the last step in a plant's continuous water–use cycle. Water is pulled from the soil into plant roots, then delivered through plant stems and leaves, where it eventually evaporates from leaf and plant surfaces.

ET demand is influenced by such factors as temperature, relative humidity, wind, and solar radiation. This ET value is referred to as reference ET (Etr). To find the crop ET, crop conditions such as the stage of growth must be considered. To obtain the water use for a particular crop during a particular growth stage, the reference ET must be multiplied by a crop coefficient (K_{co}):

$$\text{Crop ET} = ET_r \times K_{co}$$

Table 5 gives approximate crop water use to maturity values for different stages of crop development. The prediction procedure can be repeated to increase reliably as the end of the season approaches.

DETERMINING THE REMAINING USABLE WATER IN THE ROOT ZONE (STEPS 3–7)

To determine the remaining usable water in the root zone, first determine the allowable soil water deficit (ASWD) and the current soil water deficit (CSWD). The remaining usable water in the root zone can then be found by subtracting the CSWD from the ASWD.

Determine Available Soil Water Holding Capacity (Step 3)

Different soil types have different water holding capacities, it is impor-

types along with their ASWHC. The NRCS Soil Survey is probably the easiest way to determine soil types for individual fields.

Determine Total Available Water (Step 4)

The root depth for the crop of interest needs to be determined. All three of the crops being discussed in this bulletin have root depths of 4 to 6 feet deep if no soil restrictions plant growth. The KSU Extension bulletin *Soil, Water and Plant Relationships* L–904 gives more information on plant root depth. However, 70 percent of the water is taken from the top half of the root system. Therefore a general recommendation is to use a rooting depth of 3 feet. Calculate the TAW by multiplying the root zone depth (RZD) or:

TAW = ASWHC x RZD

Determine Allowable Soil Water Depletion (Step 5)

Another general irrigation management guideline is to maintain soil water levels at or above 50 percent depletion, especially during the initiative of grain reproductive stages of growth. There are some research indications that as the crop approaches maturity, a higher percentage depletion (DEPLETE) could be used and not reduce the grain yield. In the example, ASWD was calculated using 60 percent depletion. Be certain to use a decimal fraction for the value of DEPLETE in Table 1.

ASWD = TAW x DEPLETE

Measure Current Soil Water Depletion (Step 6)

There are many methods available to help determine the current soil water depletion. (CSWD) These methods include making electronic measurements with neutron probes or resistance blocks, making a physical measurement with tensiometer, estimating the soil water by appearance and feel, or through the use of irrigation scheduling with ET data. KSU Extension bulletin L–795, *Soil Water Measurement*; L–901, *Scheduling Irrigation by Electrical Resistance Block*; or L–796, *Tensiometer Use in Scheduling Irrigation* may be useful for additional information.

Table 4. Reproductive Stages of a Soybean Plant

Stage	Description
Beginning bloom	One open flower at any node on main stem.
Full bloom	Open flower at two uppermost nodes with leaf.
Beginning pod	3/16–inch pod at one of the four uppermost nodes with leaf.
Full pod	3/4–inch pod at one of the four uppermost nodes with leaf.
Beginning seed	1/8–inch seed in pod at one of the four uppermost nodes.
Full seed	Green seed that fills pod cavity at one of the four uppermost nodes.
Beginning maturity	One normal pod on main stem that has reached mature color.
Full maturity	95 percent of the pods have reached their mature pod color.

Source: How a Soybean Plant Develops, Special Report No. 53, Iowa State University, 1988

Table 5. Normal Water Requirements for Corn, Grain Sorghum, and Soybeans Between Various Stages of Growth and Maturity

Stage of growth	Approximate number of days to maturity	Water use to maturity (inches)
Corn		
Blister	45	10.5
Dough	34	7.5
Beginning dent	24	5.0
Full dent	13	2.5
Physiological maturity	0	0.0
Grain Sorghum		
Half bloom	34	9.0
Soft dough	23	5.0
Hard dough	12	2.0
Physiological maturity	0	0.0
Soybeans		
Full pod	37	9.0
Beginning seed	29	6.5
Full seed	17	3.5
Full maturity	0	0.0

Table 6. Soil Types and Their Available Soil Water Holding Capacities (ASWHC)

General Soil Description	NRCS Intake Family	ASWHC (in/ft)
clay loam	0.1	2.0
silty clay loam	0.3	2.1
silt loam	0.5	2.4
sandy loam	1.0	2.0
fine sandy loam	1.5	1.9
loamy fine sand	2.0	1.1
fine sand	3.0	0.8

Remaining Usable Water (Step 7)

Once the ASWD and the CSWD are known, the remaining usable water (RUW) in the root zone is found by substraction:

RUW = ASWD – CSWD

Irrigation Requirement (Step 8)

The remaining irrigation requirement is found by subtracting the remaining usable water (RUW) (Step 7) from the water required to reach crop maturity. (WRCM) (Step 2)

IR = WRCM – RUW

If IR is negative, that is RUW is greater then WRCM and no irrigation is needed.

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