NebGuide

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Predicting the Last Irrigation of the Season

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This NebGuide presents criteria and "rules of thumb" for predicting the last irrigation of the season for corn, grain sorghum, soybeans and dry beans.

The last few irrigations of the season require some of the most important water management decisions of the year. An extra irrigation may mean wasting 1 to 3 inches of water and 2 to 5 gallons of diesel fuel per acre.

In addition to saving water and lowering expenses, leaving the soil dry in the fall has several important advantages.

First, soil compaction always is a concern with the heavy harvest equipment used today. Dry soils resist compaction much better than wetter soils.

Second, harvest delays from rain are of less concern if the soil is left dryer. After the crop has matured and stopped using water, the only significant way for the soil to dry out is for the water to move down into the profile. Evaporation also can help to dry the soil but oftentimes dry leaves covering the ground can limit the amount of water leaving the soil.

Third, soil cracking from drying is beneficial for breaking up compaction, building soil structure, and increasing water infiltration rates.

Fourth, having the soil dry allows more room for storing off-season precipitation.

Criteria for Estimating the Last Irrigation of the Season

The irrigation management objective near the end of the season for fully watered crops should be to provide enough soil water in the root zone to carry the crop to maturity and produce top yields while leaving the soil fairly dry.

Although this goal sounds challenging, it can be achieved if field information is available or predictable. The following information is necessary to predict the amount of water needed to take the crop through to maturity:

- predicted crop maturity date
- predicted water use by the crop to maturity
- remaining available water in the soil
- predicted rainfall before crop maturity

Obviously, rainfall is difficult to predict. Consequently, one must assume that no rainfall will occur. Few things on the farm benefit from procrastination, but starting the last irrigation is one exception in order to take advantage of any late precipitation. The crop is using less water each day because it is getting more mature and the days are getting shorter and cooler. A crop growing in a silt loam soil that is refilled to field capacity three or four weeks before the crop matures could have enough water to finish. A better strategy with a center pivot or other system that can apply the desired amount of water uniformly is to start drying the soil down four to six weeks before crop maturity with the target of having the soil dried down to 40 percent of available water by maturity.

Crop Maturity

Plants use water up to the time of physiological maturity to increase grain yield. Physiological maturity is defined as the time when kernels or seeds have stopped accumulating dry matter. For corn and grain sorghum, black layer formation at the tip of the kernel is a good indicator of maturity. For soybeans and dry beans, beginning maturity is when one normal pod on the main stem has reached its mature pod color.

The water requirements between a given stage of growth and physiological maturity for corn, sorghum, soybeans and dry beans are given in *Table I*. The amount of water was calculated by using normal crop development rates and water use patterns for Nebraska. See *Tables III-VI* for descriptions of crop growth stages.

Table I. Normal water requirements for corn, grain sorghum, soybeans, and dry beans between various stages of growth and maturity in Nebraska.

	Stage of growth	*Approximate days to maturity*	*Water use to maturity (inches)*
	Corn		
R4	Dough	34	7.5
R4.7	Beginning dent	24	5.0
R5	¼ milk line	19	3.75
	½ milk line — Full dent	13	2.25
	¾ milk line	7	1.0
R6	Physiological maturity	0	0.0
	Grain Sorghum		
Stage 6	Half bloom	34	9.0
Stage 7	Soft dough	23	5.0
Stage 8	Hard dough	12	2.0
Stage 9	Physiological maturity	0	0.0
	Soybeans		
R4	End of pod elongation	37	9.0
R5	Beginning seed enlargement	29	6.5
R6	End of seed enlargement	18	3.5
R6.5	Leaves begin to yellow	10	1.9
R7	Beginning maturity	0	0.0
	Dry beans		
R5	Early seed fill	35	7.0
R6	Mid-seed fill	25	4.2
R7	Beginning maturity	15	2.0
R8	Harvest maturity	0	0

Available Water in the Root Zone

Determining the amount of available water in the root zone is the final point of information needed to predict the last irrigation. The volume of water stored between field capacity and the permanent wilting point is called the plant-available water-holding capacity, or simply, available water. Each soil texture has a maximum deposit or water storage limit which is called field capacity. If the soil is filled beyond field capacity, water may drain below the root zone (deep percolation) and become unavailable for crop use. Permanent wilting point is defined as the lower end of the available water range and refers to the level of soil water content at which plants permanently wilt and die.

Soil water sensors should be used to record soil water content in the crop's active root zone. This means monitoring soil water content in the top 4 feet for corn, grain sorghum, and soybeans and 3 feet for dry beans. Roots will penetrate deeper into the soil, but little water will be used from these depths. Some soils have root-restricting layers from compaction, major change in texture (gravel layer), etc. If the field has one of these conditions, adjust the root zone accordingly, and use the equation in the next section, rather than *Table II* to determine available water.

Calculating the Water Needed

There are two general approaches to expressing soil water status: soil water balance and soil water deficit.

Soil water balance refers to the available water remaining in the soil (the glass is half full).

Soil water deficit refers to the portion of the available water already used (the glass is half empty).

As an example, when 25 percent of the available water has been used (deficit), 75 percent of the available water is remaining (balance) or to say it another way, 75 percent of the available water. In this discussion we will use the soil water balance method (the glass is half full) where field capacity would be 100 percent and permanent wilting point would be 0 percent.

The top soil layer will get wetter (e.g. 125 percent of available water) from rain and irrigation at times throughout the season. However, if deeper layers are this wet, the result would be deep percolation and drainage of excess water below the crop rooting zone, making it unavailable for plant use.

Remaining available water in the root zone is the difference between the current water balance and the minimum water balance at maturity. Research shows that the available water in the top 4 feet can be lowered to 40 percent at crop

Table II. Total available water in top 4 feet if soil is at field capacity and minimum balances at physiological maturity.

Soil textural classification		*Available water in 1 foot of soil at 100% of available water*	*Available water in top 4 feet at 100% of available water*	*Minimum balance in top 4 feet at 40% of available water*[a]
		----------in/ft----------	------------------------in/ 4 ft------------------------	
Fine Sands		1.0	4.0	1.6
Loamy Sand		1.1	4.4	1.8
Sandy Loam		1.4	5.6	2.2
Silty Clay or Clay		1.6	6.4	2.6
Fine Sandy Loam, Silty Clay Loam, or Clay Loam		1.8	7.2	2.9
Sandy Clay Loam		2.0	8.0	3.2
Loam, Very Fine Sandy Loam, or Silt Loam Topsoil	Silty clay loam or silty clay subsoil	2.0	8.0	3.2
Loam, Very Fine Sandy Loam, or Silt Loam Topsoil	Medium textured subsoil	2.5	10.0	4.0

[a] Based on leaving 40% of the available water holding capacity at physiological maturity.

Table III. Reproductive stages of corn plant development.

Stage	*Description*
Dough **R4**	Most kernels contain semi-solid, pasty material
Beginning Dent **R4.7**	Kernels at base of ear are beginning to dent.
Milk line progression **R5** Dent **R5.5**	All or nearly all kernels are dented and the shelled cob is dark red in color (on red-cobbed hybrids). Milk line or starch line appears shortly after denting as a line across the kernel when it is viewed from opposite the embryo side and will advance toward the base of the kernel (toward the cob).
Physiological Maturity **R6**	Mature, black layer formed, kernel moisture 25 to 35%

Table IV. Reproductive stages of a grain sorghum plant development.

Stage	*Description*
Half bloom **Stage 6**	The flowering has progressed halfway down the head.
Soft dough **Stage 7**	When grain is crushed, a white substance emerges in a semi-solid form.
Hard dough **Stage 8**	Grain is firm and nothing emerges when crushed.
Physiological Maturity **Stage 9**	A thin black layer has developed on bottom tip of grain.

maturity without reducing grain yield. Therefore, minimum balance can be calculated using the following equation:

$$MB = 0.4 \times AW \times RZD.$$

MB = **M**inimum **B**alance, shown in *Table II*, column 4.
AW = **A**vailable **W**ater of the soil in inches per foot, from *Table II*, column 1.
RZD = **R**oot **Z**one **D**epth in feet (use 4 feet or less).

Soils are classified by their texture. Fine-textured soils (silt and clay) hold more available water than coarse-textured soils (sand). If the soil texture is unknown, check with the local Natural Resources Conservation Service Office (NRCS), look up the soil in the county soil survey book, or look online at *http://websoilsurvey.nrcs.usda.gov/app/*. Some fields have several different soil textures and require choosing the one that will be used for scheduling. The coarser-textured soil often requires more irrigation than finer-textured soils. Basically the decision comes down to either overwatering the finer-textured areas or underwatering and losing yield on the coarser-textured areas.

Predicting End of Season Irrigation

The following form can be used in conjunction with *Tables I* and *II* as a guide to determine how much additional water, if any, will be needed from rain and/or irrigation to carry the crop to maturity. An example is included for a field of corn that is at beginning dent on Aug. 20. The soil is a silt loam with silty clay subsoil that is at 90 percent of available water.

For best efficiency, the water applied during the last few irrigations of the season should not exceed the calculated irrigation requirement. Also, start using the stored soil water earlier in the season rather than just keeping the soil wet through the last irrigation and then letting it dry down all at once. By starting to delay irrigation toward the end of the season, the probability of receiving enough rainfall to meet crop water requirement increases.

Table V. Reproductive stages of soybean plant development.

Stage	*Description*
End of Pod Elongation **R4**	At least one pod of ¾-inch length is present at one of the four uppermost nodes that have fully developed leaves.
Beginning Seed Enlargement **R5**	At least one pod containing small seeds is present at one of the four uppermost nodes that fully developed leaves. You can hold a pod up to the bright sky to see the small developing seeds in the pod cavities.
End of Seed Enlargement **R6**	At least one pod whose cavities are completely filled with green seeds is present at one of the four uppermost nodes that have fully developed leaves. The pod, when backlit by a bright sky, will have its cavities completely occupied by dark green seeds. Seed growth slows after R6, but does not entirely cease until the seed attains physiological maturity.
Leaves begin to yellow **(R6.5)**	Rapid leaf yellowing begins in the lower canopy and progresses upwards.
Beginning Maturity **R7**	At least one (normal) pod that has attained its final mature color (tan or brown, depending on variety) is present on any main stem node.
Full Maturity **R8**	95% of the pods have reached their mature pod color.

Table VI. Reproductive stages of dry bean plant development.

Stage	*Description*
Early seed fill **R5**	One pod with fully developed seeds.
Mid seed fill **R6**	50% of pods have fully developed seeds.
Beginning maturity **R7**	One pod has changed to mature color.
Harvest maturity **R8**	80% of pods have changed to mature color.

End of Season Irrigation Worksheet

	Example	*Enter your field data here*
Field	*West Pivot*	______________
Today's Date	*8/20*	______________
Crop	*Corn*	______________
Soil Texture	*Silt Loam Top soil* *Silty Clay subsoil*	______________
Current Available Water	90%	______________
Present Stage of Growth.	*Beginning Dent*	______________
Predicted Maturity Date (today's date + 24 days) *Table I*	*9/13*	______________
1. Current % of available water * available water in top 4 ft 90 % * 8.0 in *(Table II)*= 7.2 in _______ % * _______ inches = _____inches	*7.2*	______________
2. Water required to crop maturity. *(Table I)*.	*5.0*	______________
3. Predicted water balance at maturity line 1 minus line 2	*2.2*	______________
4. Minimum balance (*Table II)*.	*3.2*	______________
5. Remaining available water at maturity. (line 3 minus line 4).	*-1.0*	______________
6. Irrigation requirement in inches assuming no rainfall. (If line 5 is positive, no further irrigation is needed. If line 5 is negative, then the amount of rain plus irrigation needs to be equal to line 5)	*Between today and 9/13, rain plus irrigation needs to equal 1.0 inch*	______________

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