Corn and Soybean Irrigation Guidelines

By Jason Krutz and Dan Roach

As we traveled through Tunica county today we noticed a few growers received a shower or two recently. Elsewhere across the Delta, a shower would be a welcomed Memorial Day event. Over the last couple of days we have received numerous questions regarding irrigation initiation for corn and soybeans. A couple of tables below detail general guidelines for corn and soybeans in soils ranging from silt loams to heavy clays. Center pivot irrigation field thresholds are approximately 15-20 centibars less than the values presented in the charts. Information on calculating average soil moisture can be found here, Watermark Sensors, Calculating Soil Moisture. Remember, evaluation of sensor readings at different depths should reveal the active rooting zone. If over a period of a few days a sensor has little or no movement, remaining in the 0 to 20cb range, most likely the roots have not developed to that depth. On the other hand, if the sensors are progressively moving upward 10-15cb per day, most likely roots are developed and utilizing moisture at that depth.

Irrigation Guide for Corn

Growth Stage	Active Rooting Depth Average Sensor Readings in Centibar
Emergence to V-14	90-100
V-15 to Tasseling (wet at tasseling)	80
Dent to Black Layer	90

Irrigation Guide for Soybeans

Growth Stage	Active Rooting Depth Average Sensor Readings in Centibar
V1-R3	80-90
R3-R6	75
R6	Irrigate if needed to supply needs to R6.5
R6.5	Terminate Irrigation

Utilizing Moisture Sensors to Increase Irrigation Efficiency

By Jason Krutz and Dan Roach

Utilizing moisture sensors to trigger an irrigation event is one method to increase irrigation efficiency. Using the "calendar" or the "neighbor" method of determining when to trigger an irrigation event is not the most efficient method. Soil moisture sensors are one tool that we can utilize to better assess soil moisture in the soil profile and schedule an irrigation appropriately.

The Watermark™ sensors are tension based sensors measuring field water holding capacity. The normal range of operation of the Watermark ™ sensors is from 0 to 200 cb, with 0 cb signifying a soil saturated with water, and 200 cb representing dangerously dry soil. We believe an appropriate irrigation trigger for our Mississippi soils should generally be from 80 cb to 100 cb, for our row crops based on field experience and research. Other factors, such as irrigation capacity or type, as well as crop growth stage may affect appropriate moisture level for scheduling irrigation. For example, we would suggest using a trigger point approximately 20 cb lower than the above values for older center pivots with limited capacity, compared to other irrigation systems.

Proper irrigation timing involves evaluation of the sensor values throughout the rooting zone. The rooting zone is defined as depth at which roots are utilizing water. If you have sensors placed 6, 12, and 24 inches deep within the soil profile, the initial readings immediately after installation may read much like this: 5, 3, and 0 cb. After a week of becoming acclimated to the soil conditions with no rainfall or irrigation events, the sensors may read 50, 40, and 0 cb. These fluctuating readings confirm the plants roots are utilizing water present at least 12 inches deep, but are not presently utilizing water beyond that depth. Although this effective rooting zone may change with time, in this example the entire rooting zone is in the top 12 inches of soil. Knowing that the rooting zone consists of the top 12 inches (100%) of the soil profile with a sensor at 6″ (50%) and one at 12″ (50%), calculating the irrigation initiation trigger is quite easy. As the effective rooting zone moves deeper, we must use an appropriate factor depending on the spacing between sensors at different depths.

Following are three different examples for your review.

In the first example, the rooting zone is only 12 inches, so calculations are only based on the 6 and 12" sensors. Each sensor reading is multiplied by 50% and the sum total is an average moisture value of 45 cb.

Rooting Depth	Sensor Depth (in)	Sensor Reading (cb)		Factor		Value
↕	6	50	x	50%	=	25
	12	40	x	50%	=	20
	24	0				
	36	0				
	Average Soil Moisture (cb)					45

In the second example, the rooting zone is 24 inches, so calculations are based on readings at 6, 12 and 24" sensors. The sensor readings at 6 and 12" are multiplied by 25% (since each accounts for 25% of 24") and the 24" reading is multiplied by 50% (since it represents 12" of a total 24" rooting zone). The sum total or average moisture value for this second example is 59 cb.

Rooting Depth	Sensor Depth (in)	Sensor Reading (cb)		Factor		Value
↕	6	80	x	25%	=	20
	12	75	x	25%	=	19
	24	40	x	50%	=	20
	36	0				
	Average Soil Moisture (cb)					59

In the third example, the rooting zone is 36 inches, so calculations are based on all four sensors. The sensor readings at 6 and 12" are multiplied by 16% (since each account for 17% of 36") and the 24 and 36" readings are multiplied by 33% (since each represents 12" of a total 36" rooting zone). The sum total or average moisture value for this third example is 56 cb.

Rooting Depth	Sensor Depth (in)	Sensor Reading (cb)		Factor		Value
↕	6	95	x	17%	=	16
	12	80	x	17%	=	13
	24	50	x	33%	=	17
	36	30	x	33%	=	10
	Average Soil Moisture (cb)					56

Assuming an initiation trigger of 80 cb, none of these three examples justify triggering an irrigation event at this time.

Watermark Sensors, Calculating Soil Moisture for Irrigation Initiation.

By Jason Krutz and Dan Roach

With irrigation season ramping up quickly, Mississippi State University Extension Service has lots of expertise and programs available to assist with your needs. One tool that we are using to better assess soil moisture and schedule appropriate irrigation is Watermark™ sensors.

The Watermark™ sensors are tension based sensors measuring field water holding capacity. The normal range of operation of the Watermark ™ sensors is from 0 to 200 cb, with 0 cb signifying a soil saturated with water, and 200 cb representing dangerously dry soil. We believe an appropriate irrigation trigger for our Mississippi soils should generally be from 80 cb to 100 cb, for our row crops based on ours' and other field experience and research. Other factors, such as irrigation capacity or type, as well as crop growth stage may affect appropriate moisture level for scheduling irrigation. For example, we would suggest using a trigger point approximately 20 cb lower than the above values for older center pivots with limited capacity, compared to other irrigation systems.

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Following are three different examples for your review.

In the first example, the rooting zone is only 12 inches, so calculations are only based on the 6 and 12" sensors. Each sensor reading is multiplied by 50% and the sum total is an average moisture value of 45 cb.

Rooting Depth	Sensor Depth (in)	Sensor Reading (cb)		Factor		Value
↕	6	50	x	50%	=	25
	12	40	x	50%	=	20
	24	0				
	36	0				
	Average Soil Moisture (cb)					45

In the second example, the rooting zone is 24 inches, so calculations are based on readings at 6, 12 and 24" sensors. The sensor readings at 6 and 12" are multiplied by 25% (since each accounts for 25% of 24") and the 24" reading is multiplied by 50% (since it represents 12" of a total 24" rooting zone). The sum total or average moisture value for this second example is 59 cb.

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	24	40	x	50%	=	20
	36	0				
	Average Soil Moisture (cb)					59

In the third example, the rooting zone is 36 inches, so calculations are based on all four sensors. The sensor readings at 6 and 12" are multiplied by 16% (since each account for 17% of 36") and the 24 and 36" readings are multiplied by 33% (since each represents 12" of a total 36" rooting zone). The sum total or average moisture value for this third example is 56 cb.

Rooting Depth	Sensor Depth (in)	Sensor Reading (cb)		Factor		Value
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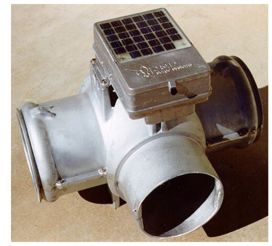
	24	50	x	33%	=	17
↓	36	30	x	33%	=	10
	Average Soil Moisture (cb)					56

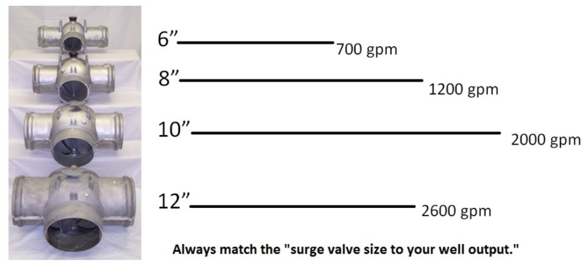
Assuming an initiation trigger of 80 cb, none of these three examples justify triggering an irrigation event at this time.

Surge Valves Increase Application Efficiency

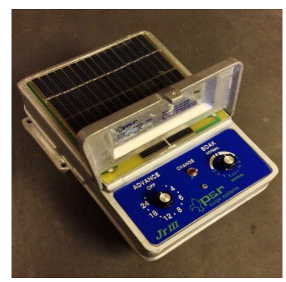
By Jason Krutz and Dan Roach



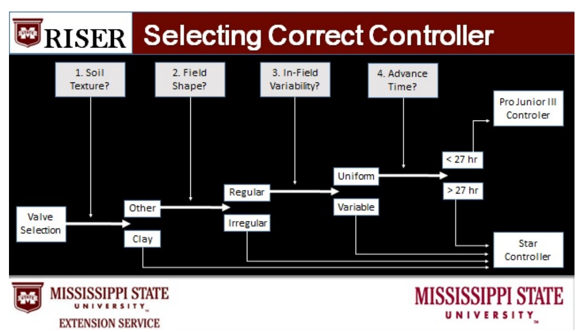
In 2014, the Irrigation Team added surge valves to our list of tools to increase irrigation application efficiency. When using a surge valve, water is applied in a series of on-off cycles alternating between two irrigation sets. By utilizing surge valves Producers can expect reduced surface runoff, reduced deep percolation loss, and application inefficiencies 25% great than conventional irrigation techniques. In sealing silt loam soils improved infiltration rates have been documented. Understanding the correct operation procedure and purchasing the correct surge valve is imperative to the success of deploying a surge valve.



Deciding on the correct surge valve to purchase is the first step in utilizing a surge valve. Before purchasing a surge valve, here are some considerations. Producers need to be aware of the limitations and capacity restraints of surge valves. Producers will need to select the proper valve based on the output of the well or riser. Based on the chart to the right, a 6″ surge valve has a capacity from 0 to approximately 700 GPM while the much larger 12″ will handle well capacities up to 2600 GPM.



Producers also need to be aware of the limitation of the two types of valve controllers prior to purchase. P&R Surge Systems manufacture two surge valve controllers, the Star and the Jr.III. The Star controller is totally digital and much more flexible in programming. The Jr.III, being the more economic controller, lacks many of the features as of the top of the line, Star controller. If you are using a Jr.III you'll need to understand its limitations. We have put together the following guide to assist Producers in the selection process. (the image is clickable for your convenience) You will notice that the only situation that a Jr.III controller is applicable is; a uniform, regular or square shaped field that a set is irrigable in less than 27 hours.



Phases of Furrow Irrigation

1. Advance Cycle – The phase in which the dry furrow is wetted. This cycle creates multiple pluses down the field.
2. Out Time – The time required for water to reach the end of the furrow.
3. Soaking Cycle – The phase in which the required application depth is infiltrated. This is a single pulse, with each pulse reaching the tail ditch.
4. Soaking Time – The time it takes the required application depth to infiltrate.

A video explaining these cycles can be seen here. http://www.youtube.com/watch?v=46sSLFBUrh8

The following are points to consider when setting up a surge valve:

If you have a silt loam or sandy soil that has a tendency to seal causing water infiltration to be an issue:
1. Determine the Out Time from past experience.
2. Set the Advance Cycle to ½ of the Out Time + one hour. For example, if you have a field that has historically

required 24 hours to get the water across and you now have this same field set up with a surge valve, the Advance Cycle would be set to 13 hours.

3. It is critical that the time required for water to actually reach the tail ditch be recorded. Any adjustments to the Advance Cycle of the surge valve need to be made before the Soaking Cycle begins. You made need to add or subtract time from the original settings of the Advance Cycle. If you miss this timing, adjustments can only be made after the completion of the Soaking Cycle.

4. The Soaking Time or completion time can be found on your PHAUCET printout. If PHAUCET requires 20 hours to apply 3 acre inches on each set, then the total system run time is 40 hours before you shut the system and well off. It is equally important to adjust the Soaking Time, if the single pulse is falling short of the tail ditch, time should be added, if the single pulse is putting water in the ditch, time should be subtracted.

If you have a cracking clay soil:

When programing the advance cycle of the Star controller for a clay soil types, producers need to refer to the Phaucet or Pipe Planner printout for the time required to apply 3 acre inches and set the advance cycle accordingly. For example, if the printout says that 22 hours are required to apply 3 acre inches, the advance cycle would be set for 22 hours. After setting the advance cycle time producers need to adjust the total number of cycles per side for the valve to complete. It is recommended to subtract two cycles from the value displayed on the controller, but never less than a total number of 3 cycles. Press the “custom” tab, lets say the controller displays 6 cycles per side, use the down arrow key to subtract 2 cycles from the number of cycles per side (#cycles/side). The display should display 6-2 (or 4 cycles per side) Never use less than 3 cycles per side, so if the controller displays 4 cycles per side, do not subtract the recommended two, use 4-1. (3 cycles per side) Please see example at bottom.

Surge Valve Star Controller Recommendations for Clay Soils

It is recommended that the number of cycles per side equals the default setting minus two.
The total cycles per side should never be less than three.

Advance Setting	Default Cycles/Side Setting	Custom Cycles/Side Reccomedation
Input by user	Under Custom tab	use down arrow to adjust
5	**4**	**4-1 (3)** Total
10	**5**	**5-2 (3)** Total
15	**6**	**6-2 (4)** Total
20	**6**	**6-2 (4)** Total
30	**6**	**6-2 (4)** Total

Irrigation Scheduling with Soil Moisture Sensors

Soybeans *Not for use with portable dielectric type sensors

Recommendations:

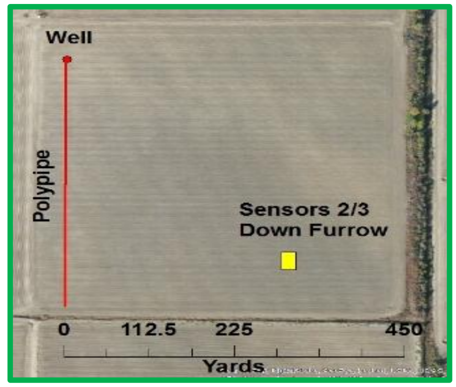
- Computerized Hole Selection Irrigation (PHAUCET, Pipeplanner) is recommended for all furrow-irrigated fields to achieve the best results when utilizing soil moisture sensors to schedule irrigations. SURGE Valves may also be necessary to adequately saturate the rooting zone.

Sensor Placement:

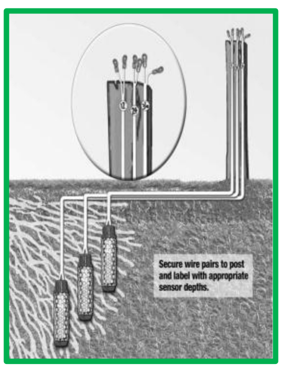
- Use a minimum of one (1) sensor set per 40-80 acres.
- Place sensor approximately 2/3 down row in a representative area of the field.
- Determine representative area based on yield maps, soil maps, etc.
- If putting multiple sensors in an irrigation set, the first and last field in a rotation may be the most optimal for monitoring start time to complete spin while maintaining the threshold of the last field.

Applicable Soils:

- Understand your soil. These general rules apply to heavy clay soils to fine loam soils, variance may apply to sandy soils.



Typical Sensor Depth:



6”

12”

24”

36”

Irrigation Guidelines*: Initiate irrigation within the listed centibar reading

Growth Stage	Centibar Threshold Reading
V1-R3	80-90
R3-R6.5	60-70
R6.5	Terminate Irrigation
R6	Can apply last irrigation to maintain moisture to R6.5

*These recommendations are strictly guidelines based on available data. Plants can tolerate stress up to R3 but are less tolerant from R3-R6.

*Reference growth stages information on back

*Base reading off weighted average within the active rooting zone

*Based on research and methods performed by Jason Krutz (MSU)

Determining Centibar Weighted Average within Active Rooting Zone

Sensor	Sensor Depth	Sensor Reading	%Rooting Zone	Weighted Reading
1	6”	100 cB	X .25	= 25 cB
2	12”	60 cB	X .25	= 15 cB
3	24”	32 cB	X .50	= 16 cB
4	36”	<5 cB		
			Weighted Average = 56 cB	

Example 1:

- Sensors 1-3 show reduction in soil moisture indicating presence of root activity at 0”-24”
- Sensor 4 shows no reduction in moisture indicating no root activity at 36”
- Active Root Zone 0-24”
- 100% of Root Zone = 24”
- 50% of Root Zone = 12”
- 25% of Root Zone = 6”

Sensor	Sensor Depth	Sensor Reading	%Rooting Zone	Weighted Reading
1	6”	100 cB	X .17	= 17.0 cB
2	12”	75 cB	X .17	= 12.8 cB
3	24”	50 cB	X .33	= 16.5 cB
4	36”	35 cB	X .33	= 11.6 cB
			Weighted Average = 57.9 cB	

Example 2:

- Sensors 1-4 show reduction in soil moisture indicating presence of root activity at 0”-36”
- Active Root Zone 0-36”
- 100% of Root Zone = 36”
- 33% of Root Zone = 12”
- 17% of Root Zone = 6”

Internet Information:

Hansen AM400

http://www.mkhansen.com/documents/install.pdf

Watermark 200SS Sensors and Data Logger

http://www.irrometer.com

Effective Dates: May 2014 – September 2014

YMD

Irrigation Scheduling with Soil Moisture Sensors

Soybeans *Not for use with portable dielectric type sensors

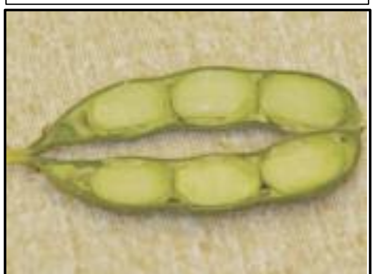
R1: First flower anywhere on the plant.

R2: Flower in the upper (youngest) two nodes.

R3: 3/16-inch-long pod in upper four nodes.

R4: ¾-inch-long pod in upper four nodes

R5: Visible seed in pod of upper four nodes.

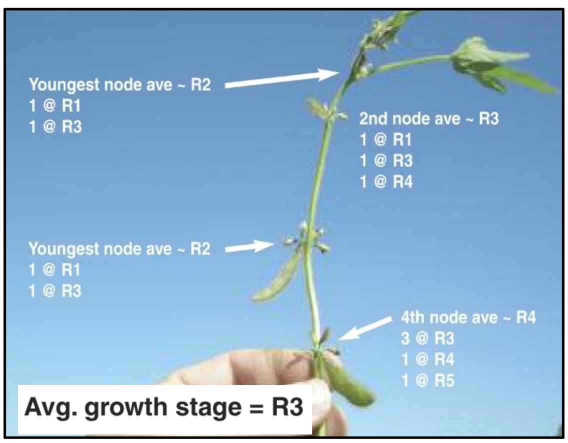


R6: Beans touching inside pods of upper four nodes.

R6.5: Pod and pod wall beginning to turn mature

R7: Pod mature in color anywhere on plant.

*Source: Mississippi Extension Publication 2588 (Guide to Soybean Growth Stages)



How to Determine Soybean Growth Stage: Concentrate on the youngest (upper) four nodes to determine soybean growth stage. Estimate the average growth stage for the reproductive growth (flowers and pods) on the youngest four nodes. Begin with the youngest fully expanded leaf and estimate growth stage down the next three nodes,

*Source: Mississippi Extension Publication 2588 (Guide to Soybean Growth Stages)

Table 2. Estimated range of dates for occurrence of R1, R3, and R6 of MG 4, 5, and 6 soybeans planted in central Mississippi during indicated periods of April, May, and June.

		Date range of stage occurrence		
MG	**Planting period**	**R 1**	**R 3**	**R 6**
4	Early April	May 15-19	June 2-5	July 23-26
	Mid-April	May 20-24	June 11-14	July 29-Aug. 1
	Late April	June 1-5	June 20-23	Aug. 8-11
	Early May	June 10-14	July 2-5	Aug. 13-16
	Mid-May	June 20-24	July 12-15	Aug. 21-24
	Late May	July 1-5	July 20-23	Aug. 30–Sept. 2
	Early June	July 10-14	July 27-30	Sept. 1-4
5	Early April	June 1-5	June 24-27	Aug. 16-19
	Mid-April	June 7-11	July 1-4	Aug. 21-24
	Late April	June 15-19	July 9-12	Aug. 27-30
	Early May	June 26-30	July 18-21	Sept. 1-4
	Mid-May	July 4-8	July 25-28	Sept. 5-8
	Late May	July 12-16	July 30–Aug. 2	Sept. 10-13
	Early June	July 20-24	Aug. 3-6	Sept. 12-15
6	Early May	July 5-9	Aug. 4-7	Sept. 14-17
	Mid-May	July 14-18	Aug. 11-14	Sept. 19-22
	Late May	July 20-24	Aug. 15-18	Sept. 20-23
	Early June	July 30–Aug.	Aug. 20-23	Sept. 23-26

*Source: University of Arkansas Coop Extension Service (Soybean Irrigation Guide for the Southern US)

Irrigation Scheduling with Soil Moisture Sensors

Corn *Not for use with portable dielectric type sensors

Recommendations:

- Computerized Hole Selection Irrigation (PHAUCET, Pipeplanner) is recommended for all furrow-irrigated fields to achieve the best results when utilizing soil moisture sensors to schedule irrigations. SURGE Valves may also be necessary to adequately saturate the rooting zone.

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- Use a minimum of one (1) sensor set per 40-80 acres.
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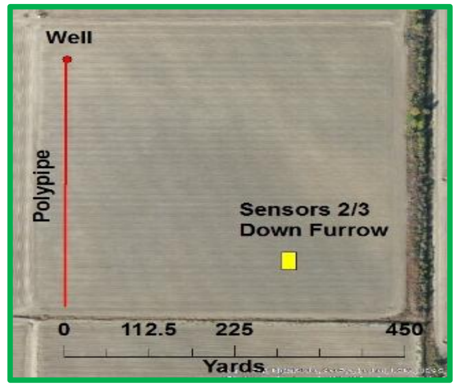
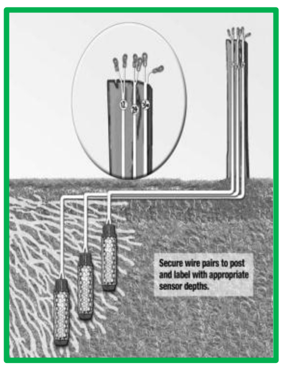


Typical Sensor Depth:



6"
12"
24"
36"

Irrigation Guidelines*: Initiate irrigation within the following centibar readings

Growth Stage	Centibar Threshold Reading
Emergence-Tasseling	80-90
Tasseling-Dent	60-70
Dent-Black Layer	90

*These recommendations are strictly guidelines based on available data. Corn plants are less tolerant to stress from tasseling to dent

*Reference growth stages information on back

*Base reading off weighted average within the active rooting zone

*Based on research and methods performed by Jason Krutz (MSU)

Determining Centibar Weighted Average within Active Rooting Zone

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Weighted Average = 56 cB

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- 25% of Root Zone = 6"

Sensor	Sensor Depth	Sensor Reading	%Rooting Zone	Weighted Reading
1	6"	100 cB	X .17	= 17.0 cB
2	12"	75 cB	X .17	= 12.8 cB
3	24"	50 cB	X .33	= 16.5 cB
4	36"	35 cB	X .33	= 11.6 cB

Weighted Average = 57.9 cB

Example 2:

- Sensors 1-4 show reduction in soil moisture indicating presence of root activity at 0"-36"
- Active Root Zone 0-36"
- 100% of Root Zone = 36"
- 33% of Root Zone = 12"
- 17% of Root Zone = 6"

Internet Information:

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Irrigation Scheduling with Soil Moisture Sensors

Corn *Not for use with portable dielectric type sensors

Stage	Stage Title	Days	Description
V2		5	Two fully developed leaves with collars
V4			Four fully developed leaves with collars
V5-V16			V12-V16, new leaves appear every 2-3 days until VT
VT	Tasseling		Lowest branch of tassel visible. Silks may be visible on husk
R1	Silking	65	Silks have emerged from tip of ear on most plants
R2	Blister		Milk turns thick and pasty. Kernel visible
R3	Milking		20 days after silking, kernel turns yellow. Silks are brown
R4	Dough		26 days after silking, kernel has a dough/paste like substance
R5	Beginning Dent	90	Dent on top of kernels, starch line progressing from top of kernel towards tip
R5	Full Dent		Dent on kernels, starch line fully across
R6	Black Layer/Mature	125	Kernels have reached maximum dry weight

*Source: University of Arkansas Research and Extension

V2

VT

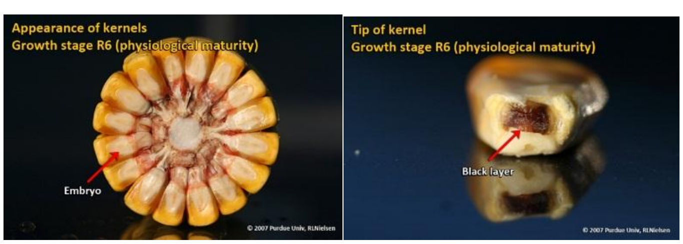
R1

R2

R3

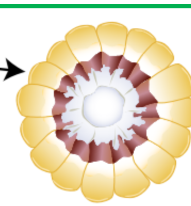
R4

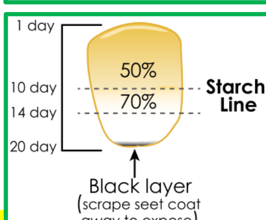
R5



R6

At beginning dent or about 90 days, check starch line. Break an ear of corn in half. Inspect the top half of the ear. Terminate irrigation when starch line reaches 50% for furrow irrigation and 70% for sprinkler systems from top of kernel and good soil moisture.





- Source: University of Arkansas Research and Extension

Effective Dates: May 2014 – September 2014

Irrigation Scheduling Calculation Sheet: **Calculating Weighted Centibar Average** ***Not for use with portable dielectric type sensors**

Farm:	Field:	Crop:

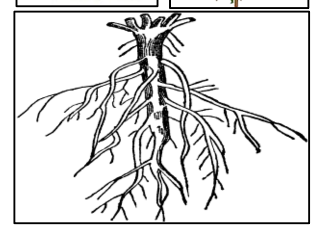
Sensor ID	Sensor Depth	Sensor Zone		Active Rooting Zone* (6", 12", 24", 36")		%Rooting Zone (=Sensor Zone/Active Rooting Zone)				Centibar Reading (From Data Logger)		Weighted Centibar Reading (=Centibar Reading x %Rooting Zone)			
				(Ex.1)	(Ex.2)	(Ex.1)		(Ex.2)		(Ex.1)	(Ex.2)	(Ex.1)		(Ex.2)	
A1	6	0-6" =	**6**	**36**	**24**	6/36 =	**0.17**	6/24 =	**0.25**	**100**	**100**	100x.17 =	**17**	100x.25 =	**25**
A2	12	6-12" =	**6**	**36**	**24**	6/36 =	**0.17**	6/24 =	**0.25**	**70**	**70**	70x.17 =	**12**	70x.25 =	**18**
A3	24	12-24" =	**12**	**36**	**24**	12/36 =	**0.33**	12/24 =	**0.50**	**50**	**50**	50x.33 =	**17**	50x.50 =	**25**
A4	36	24-36" =	**12**	**36**		12/36 =	**0.33**			**30**	<5	30x.33 =	**10**		
												Weighted Centibar Average =	**55**		**68**

<u>*Active Rooting Zone:</u>

- Area where plant roots are actively using water
- If centibar readings are noticeably drying out (increase in centibar readings) roots are actively using water in that zone
- If centibar readings are not noticeably changing (centibar readings remain low, ex.<5) roots are not actively using water in that zone
- Example 1 has a 36" rooting zone. Example 2 has a 24" rooting zone (as shown in Table above)

<u>Weighted Centibar Average Reading:</u>

- Sum of weighted centibar (cB) readings
- Use this number as final centibar reading to determine irrigations
- Example 1 has a weighted centibar reading of 55cB. Example 2 has a weighted centibar reading of 68cB



Soybeans

Growth Stage	Centibar Threshold Reading
V1-R3	80-90
R3-R6.5	60-70
R6.5	Terminate Irrigation
R6	Can apply last irrigation to maintain moisture to R6.5

Corn

Growth Stage	Centibar Threshold Reading
Emergence-Tasseling	80-90
Tasseling-Dent	60-70
Dent-Black Layer	90

*Based on research and methods performed by Jason Krutz (MSU)