Mitigating Irrigation Fatigue and Drought Stress in 2022

Christopher G. Henry, Professor and Water Management Engineer

When the spring 2022 rains shut off this year, it really compressed the workload for managing irrigation. Our minds need to shift from “I can’t keep up” to “where does the water I have, need to go.” The next 30 days will be critical for many irrigators, as fatigues sets in, and many crops are still at or entering high water demand. However, there are things that farmers can do to mitigate the both the human and plant stress being experienced. The following are recommendations for reducing stress and extending the capacity of irrigation systems.

Computerized Hole Selection such as Pipe Planner, Rice Irrigation or PHAUCET help plan water distribution across the field. These programs reduce pump time usually between 10% and 50%.

Plan for it taking longer: Most crops need between 0.25 and 0.35 inches per day to meet peak water demand. What happens is that as wells are drafted and reservoirs are withdrawn, our pumps reduce capacity because they must lift water further as groundwater declines and reservoirs are drawn down. Thus, irrigation sets we designed with computerized hole selection were planned to irrigate in 24 hours take longer. Some alluvial wells can drop off as much as 50% and its not uncommon for relifts to fall off 30% as we get to the bottom. Expect to take longer to irrigate a set or flood up a field, and adjust accordingly. Flowmeters aid in predicting how much longer sets will take. For irrigation sets that are planned for 24 hours, that are taking longer because pump capacity are reduced by 30%, those sets may now require 30 hours. Additionally, if the normal application depth of 2 inches was used, but now require 3 inches because the soil is so dry and the furrow flow rates are reduced, the 24 hour set is now a 47 hour set. In addition to heat and drought stress, water stress is now being introduced since water may be standing on some of the field for more than 40 hours.

Time irrigation for when it will yield the most profit: Deficit irrigation is when irrigation water supply is inadequate to meet full crop demand, and we are using the water to maximize yield. In general, to do this effectively provide just enough water during the vegetative phase of growth and then apply irrigation during the reproductive phase, and if it’s going to be short, do it at the very end. So, for soybeans, provide irrigation sparingly until R3 and use the remaining irrigation supply and capacity until termination. The last irrigation needs to well before maturity. For example, on soybeans we need 2.9 inches to finish at R6.5 so apply any irrigation before then because if any extra may not contribute to yield. In a limited situation, put the last irrigation on by R6 (where 4.7 inches is needed) where the risk of yield penalty is greater than at R6.5. Thus, in water limited situations, refrain from irrigation as much as possible until R3 and apply at R6 to maximize yield if for example only adequate water exists for two irrigations. For corn, once the starch line develops, increase the frequency of irrigation until 50% starch, make last irrigation at this time if water is limited.

Soil moisture sensors save profitability: Irrigators who are using soil moisture sensors, surge irrigation and computerized hole selection should be more efficient and have an assessment of the soil water balance. Its not necessary to have soil moisture sensors in every field, even just a few can help to understand how many days we can wait between irrigations. In generally stress does not accumulate until after 50% allowable depletion, the average of all sensors in the profile where stress would begin to occur is shown in Table 1.

Table 1. Soil Tension where no readily Plant Available Water Remains (50% allowable depletion)

	Sand (1.0 in/ft)	Sandy Loam (1.4 in/ft)	Silt Loam with Pan (1.58 in/ft)	Silt Loam (2.37 in/ft)	Clay (1.6 in/ft)
Stress level (centibars)	25	70	123	134	120

It's not too late to incorporate sensors into irrigation management in 2022 (there are still hundreds in inventory in vendor warehouses). Watermark™ sensors cost $35 each and 3-4 are needed per location. There is a factsheet series (www.uaex.uada.edu/irrigation) on how to use them or contact county Extension agents or NRCS irrigation water management technicians for help with sensors.

Using sensors to determine the last irrigation of the season is the largest payback of monitoring soil moisture, it almost always saves at least one irrigation and allows for planning ahead of dwindling irrigation supplies. The last factsheet in the series, "How to Predict the Last Irrigation of the Season Using Watermark™ Soil Moisture Sensors." outlines how to do this on www.uada.edu/irrigation. However, the easiest way is to use the mobile app, "Arkansas Watermark Tool." Just enter the sensor readings, the effective rooting depth, time it takes to irrigate, soil type and crop growth stage and it calculates the amount of water needed to finish out the crop. The app also shows how much water is needed for each growth stage and how much is needed for the rest of the season, a nice piece of information, if you are dry. The fields with the growth stage at the highest water use need attention first.

Most important, doing this will allow for stopping unnecessary irrigation, its now possible to easily plan out if you have enough water for the crop or if measures need to be taken to preserve profitability.

Even with a handful of sensors, put the sensors in a field, then read two days later, remove and move to the next field. This technique can be used to assess several fields in a week with one set of sensors. Use the sensor readings and the mobile app to predict how much water will be needed to finish out the season. This is a low-cost investment and considerable help is available to aid in doing this through Extension and NRCS irrigation technicians.

Deep Irrigate: Instead of flushing water across fields, put a full 2 to 3 ac-in/ac across the field, try to fill the profile when you do irrigate. This will force the roots to go deeper for water and extract the subsoil moisture later. Focus on doing a good irrigation so it will be a while before you need to come back. In sealed up silt loams, where it is not uncommon to only put on 0.5 inches in an irrigation, try irrigating and then irrigating again the next day to get more into the soil. It can have mixed results, but can allow more time between irrigations.

How to estimate irrigations remaining? The top quartile average total water use efficiencies, (yield / (rain + irrigation) observed in the Most Crop per Drop Contest are 6, 10 and 4 bu/in for rice, corn and soybeans are used in Table 2 to provide an estimate of total water needs for drought planning. To estimate how much additional water or the number of irrigations needed to finish out the season, take the yield goal time the WUE. For example, for a farm with a yield goal (or APH) of 225 bu corn, take 10 bu/in divided by the yield goal of 225 bushels, which yields 22.5 inches of total water. Then subtract effective rainfall since emergence, if rain since emergence was 8 inches, the subtract from 22.5 inches – 8 inches = 14.5 inches. Most apply 2 inches per irrigation so, divide 14.5 inches by 2 inches per irrigation, which equals 7 irrigations. If there have been 5 irrigations so far, then plan 2 additional irrigation between now and 50%-75% starch.

Table 2. Target Water Use Efficiencies of Crops for Drought Planning maintain fully irrigated yields.

Crop	Target Total Water Use Efficiency (bu/in) [yield/(rain + irrigation)]
Corn	10
Rice	6
Soybeans	4

$$Water\ demand\ (inches) = \frac{Yield\ goal\ \left(\frac{bushels}{ac}\right)}{Target\,Total\,WUE\ \left(\frac{bu}{in}\right)}$$

$$22.5\ inches\ = \frac{225\,\frac{bu}{ac}\,corn}{10\ bu/in}$$

$$Irrigation\ Needed\ to\ finish = Water\ demand - rainfall$$
$$14.5\ inches = 22.4\ inches - 8\ inches$$
$$\#\ of\ total\ irrigations = 14.5\ inches / 2\ inches\ per\ irrigation = 7\ irrigations\ total\ needed$$

For those with soil moisture sensors and the Arkansas Watermark tool mobile app, the water needed by the crop is automatically calculated and this estimate can be used to predict the amount of water remaining.

Tables 3, 4 and 5 for corn, soybeans and rice report the amount of water to finish a crop out can be estimated. These tables can be used to estimate how many irrigations are needed to finish out the growing season. Soil moisture sensors can be used to estimate the amount of water remaining in the soil, using the app or the factsheet. Those without sensors will have to estimate how much water is still available in the soil using the feel method. Subtract any rain experienced at the field.

These tables can be used to estimate irrigations, even without sensors and the feel method. For example, if corn is at R5 50% milk, even without sensor data, if the soil is really dry, it will take a full 2 inch irrigation to finish out the crop, at R5 and 25% milk line, 3.7 inches is required, so two irrigations will be needed.

For soybeans at R6.5, if the soil is dry at this stage, 4.7 inches are required, so at least 2.5 irrigations of 2 ac-in/ac, will be needed. If there is still moisture in the soil at this point, then 2 may be adequate.

Table 3. Crop Water Demand for Corn

Crop Growth Stage[1]	Kernel Development	Days to Maturity	Water needed to mature (in*)[1]
R4	Dough	34	7.5
R4.7	Beginning dent	24	5
R5	¼ milk line	19	3.7
R5	½ milk line to full dent	13	2.2
R5	¾ milk line	7	1.0
R6	Maturity	0	0

*[1]Source: Yonts, C.D., S.R. Melvin and D.E. Eisenhauer. Predicting the last irrigation of the season. Nebguide G1871. Lincoln, Nebraska. * acre-inches per acre.*

Table 4. Crop Water Demand for Soybeans

Crop Growth Stage[1]	Pod & Plant Development	Days to Maturity	Water needed to mature (in)[2,3]
R4	End of Pod Elongation	50 – 60	--
R5	Beginning of seed enlargement	40 – 50	10.0
R6 – R 6.5	End of seed enlargement to leaves beginning to yellow	30 – 40	4.71
R6.5 – R7	Leaves begin to yellow	20 – 30	2.9
R7	Beginning Maturity	10 – 15	0.75
R8	Maturity	0	0.27

[1]Source: A visual guide to soybean growth stages (https://coolbean.info/library/documents/2017_Soybean_GrowthDev_Guide_FINAL.pdf)
[2]Results from sap flow experiments conducted in 2017 at Lon Mann Research and Extension Center, Marianna, AR.
[3] acre-inches per acre.

Table 5. Crop Water Demand for Rice

Crop Growth Stage	Plant Development	Days to Maturity	Water to finish
VF-1 to VF-2	Pre-flood	2	14.9
VF-3 to VF-4	Flood	19	14.7
VF-4 to Flag Leaf (VF)	Flag Leaf (VF)	29	11.9
R2	Pre-boot	6	6.7
R3 (boot) – R5	Boot and panicle development	7	6.1
R6 – R7	At least one yellow hull	11	5.0
R8	Prior to drain time for rice	10	3.3
R9	All grains have brown hull, near drain time	24	1.8

Source: M. Reba, USDA ARS Delta Water Management Center, Jonesboro, Arkansas

Reservoir Dilemma: Reservoirs are only designed to supplement 10 ac-in/ac of irrigation water. Thus in years or in time of drought it may be prudent to estimate how much water is needed by crops and how much remains in the reservoir.

To estimate how many irrigations may be available in a reservoir first make an estimate of the area and depth. For a 40 acre reservoir that has 10 feet remaining, 400 acre feet are available or 4,800 acre inches (4800 times 12). For a 750 acre farm, 4,800 divided by 750 acres leaves 6.4 inches of water or about 3 irrigations at 2 ac-in/ac. If the farm is half rice at boot and half soybeans at R1, the soybeans will need 12.7 inches to finish and the rice will need 6.1 inches to finish. So there is enough water in the reservoir for rice, but only half of what will be needed for soybeans. So if a well can provide the extra 1,125 acre inches (3 inches times 375 acres of beans). In this case if a 500 gpm well can provide 26 acre inches in 1 day. Thus 375 acres of beans times 6 acre inches is 2,250 acre inches and it will take 2,250/26 = 86 days to make up. There is only about 30 or 45 days left in the season, so the well could only make up half of the remaining water. In this situation, it would be wise to delay irrigation on the soybeans as much as possible so that there is enough water in the reservoir for the R5 and R6 growth stages where stress will have less yield impact.

Use the feel method: NRCS has a published method on how to estimate soil water using the feel method. Download the publication for Estimating Soil Moisture Content by Feel and Appearance on the USDA NRCS website.

If sensor data is not available, use the feel method and a soil probe to estimate soil water. It will be necessary to probe at least 24 inches down to estimate the moisture in the subsoil.

Managing Rice with Limited Water: For rice, Alternating Wetting and Drying (AWD), drying down to mud is safe AWD, but data from Mississippi indicated one can go as far as 2-4 inches below the surface before we would experience yield penalty. This is using a panni pipe, or perforated PVC pipe installed in the ground. However, a spade can be used instead to see how wet the soil is below the surface, and if one can still see water just below the surface you can go this far between re-floods.

Use DD50 to plan to predict the drain date, the strategy should be to have the field at mud consistency at that DD50 date. Plan to stop irrigating before this date to get to have the soil at this condition on the DD50 drain date so water is not wasted that could be used on other crops.

For row rice, data on silt loams that suggests a 40% allowable depletion will not result in yield penalty. This equates, in general, to about 7 days between irrigation, before a significant yield penalty. However even irrigation every 14 days irrigation only resulted in a yield penalty of 25 bpa. At least for hybrids, even though they may look stressed, the yield penalty may not be as much as it appears.

From our water stress research 30 total inches of water (rain plus irrigation) would be a target for any rice field before water stress would likely impact yield. For comparison the rice verification program normally measures 32 ac-in/ac of irrigation on average, so when water is scarce, acceptable yields are still achievable. There are several apps available to track rainfall in fields.

Don't overlook the obvious: Irrigation pumps in Arkansas operate just under 800 hrs per year, but the drought is going to push way past that normal run time. For diesel power units, oil changes, greasing propeller shafts may seen obvious, but changing the oil in the gear head is often overlooked.

For electric motors, greasing the bearings, often requires grease specific for electric motors, and on vertical hollow shaft motors, there is a dry plug that should be removed then 3-4 pumps max, grease should come out of the dry port. Don’t over lubricate an electric motor, or the grease will fill up the housing and get into the windings. The top bearing in a hollow shaft motor runs in oil, and should be changed annually. Obtain the proper lubricants for electric motors from your well driller or pump dealers. If the oil in the sight window is black or white, there is a high risk of bearing failure.   Drip oil should be set in the morning, 6-8 drips per minute, when it is cool as the oil expands during the day. Setting the dripper in the heat of the day, could stop the drip when the temperature cools in the morning.

For poly pipe, there are zipper repair patches and a press-on patch that are good to keep on hand in addition to repair couplers for pipe repairs.

Heat stress and heat exhaustion awareness are real threats to safely sustaining irrigation, keep ample water to employees and yourself and don’t get in a hurry, it may take more time to do things safely. Take care not to slip near drive shafts.