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Efficient Irrigation Management With Center Pivot Systems

Younsuk Dong, Lyndon Kelley, Steve A. Miller

Introduction

Efficient irrigation management provides benefits such as saving fresh water and energy, reducing nutrient leaching, increasing crop yield and grain quality, and maximizing return on investments. Investments made each year to irrigate a crop include the costs of energy, labor, and maintenance and repair of the system. Investments in growing the crop include tillage, seed, fertilizer, and labor. Properly managed irrigation can significantly increase yield over dryland farming, ensuring return on these investments. Irrigation can be used to incorporate fertilizers and pesticides and allow for applying fertilizer when required by the crop, thus proving to be environmentally sustainable as well as providing economic benefits. Irrigation decision-making tools such as irrigation scheduling programs and soil moisture sensors are available to improve the irrigation water use efficiency. In addition, irrigation system design, maintenance, and operation can improve application efficiency. Producers of agricultural commodities typically operate with a low profit margin. Because irrigation systems are an additional investment cost, the design and expense for equipment maintenance and energy usage should be carefully reviewed to maximize profit. Areas that have the potential to reduce irrigation costs are discussed in this bulletin. The Michigan Generally Accepted Agricultural and Management Practices (GAAMPs) for Irrigation Water Use (*https://www.michigan.gov/documents/mdard/Irrigation_Water_Use_2020_GAAMPS_682474_7.pdf*) lists 23 practices for proper management of agricultural irrigation systems. The implementation of these practices has improved water resource efficiency, protected water resources, and saved money. Some of the practices will be highlighted in this bulletin.

Only Apply Water That Will Increase Return on Investments

Supplying the water necessary to prevent crop water stress is the goal of irrigation scheduling. Irrigation scheduling can help the producer get the highest yield with minimum irrigation. Michigan has an extensive network for weather stations that provide evapotranspiration (ET) data required for scheduling (Figure 1).

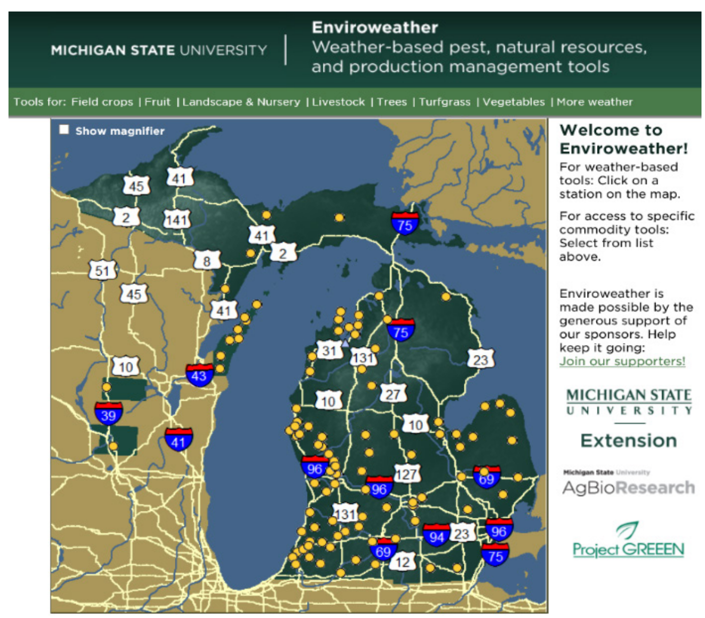

Figure 1. Enviroweather website (*https://enviroweather.msu.edu/*).

Over the years, technology has been developed to assist in irrigation water management. Soil moisture sensors have been used to improve the water and fertilizer use efficiency, which can increase crop production. Sensors provide greater insight into water needs and can inform better management through precise irrigation scheduling. In addition to the water savings, the use of soil moisture sensors can reduce nitrate leaching (loss of nitrogen fertilizer) below the root zone. Figures 2 and 3 show soil moisture monitoring systems.

Figure 2. Soil moisture monitoring system in a seed corn field.

Figure 3. Soil moisture sensor monitoring.

Some of the GAAMPs related to this section include:

- *Avoid applying irrigation water in excess of the quantity of water needed to replace the soil/substrate moisture deficit in the root zone.*
- *Know the depth of rooting for each crop irrigated.*
- *Know the allowable soil moisture depletion at each stage of crop growth.*
- *Measure, estimate, or use published evapotranspiration data and crop co-efficient (when available) to determine crop water use.*
- *Measure rainfall in each field irrigated.*

(Michigan Department of Agriculture and Rural Development, 2020, pp. 5–8)

Apply Ideal Irrigation Volume

A list of irrigation best practices follows.

- Never irrigate below the root zone. Figure 4 shows an example of soybean root system development at different crop stages. Find other crop's root system development on the Michigan State University (MSU) Irrigation website (https://www.egr.msu.edu/bae/water/irrigation/crops-root-system-development).
- Provide water to at least the top half of the root mass.
- Make individual irrigation applications large enough to minimize the number of times wetting the crop and soil surface.

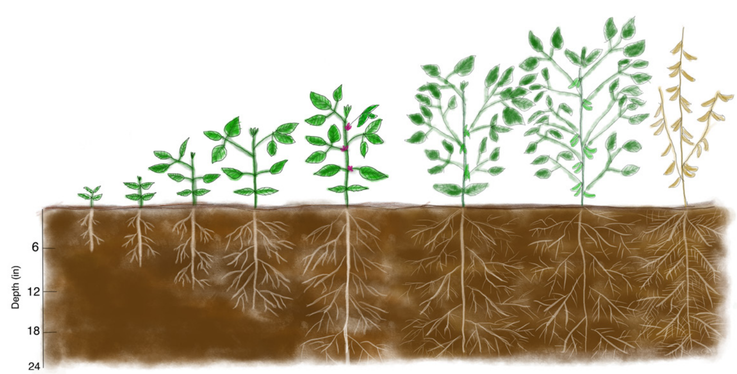

Figure 4. Soybean root development at different crop stages.

Use the Biggest Irrigation Applications Possible While Avoiding Runoff

To make the best use of irrigation water, producers should try to provide 4 or 5 days worth of crop water use per application, typically 1 to 1.25 inches at peak water use periods. These larger irrigation applications increase the amount of effective water available to the crop by reducing the water lost by evaporation in the crop canopy and on the soil surface. Regardless of the amount of irrigation water applied, approximately 0.1 inches is lost per application when the crop is in a mature canopy. Irrigators with center pivots that apply water faster than the water can infiltrate into the soil should use smaller applications (less than 0.5 inches) to avoid runoff. Find infiltration rates for soil types on the MSU Irrigation website (*https://www.egr.msu.edu/bae/water/irrigation/soil-infiltration-rate*).

The GAAMP related to this section follows:

- *Assure that sprinkler application rates are below the soil infiltration rate in order to prevent runoff and accumulation of water in lower areas, which may result in excess infiltration and leaching.*

(Michigan Department of Agriculture and Rural Development, 2020, p. 10)

Factors that increase runoff include sprinklers with small wetted area, larger application volumes, soil compaction, heavy soils, slope, and row hilling (Figure 5).

Figure 5. Runoff caused by larger application on heavy soils.

Optimize Late Season Irrigation

Lack of water in the late season can result in low test-weight corn and undersized soybean in uppermost pods. Applying irrigation until the crop reaches maturity is important to maintain or increase the quantity and quality of the crop. The irrigator should maintain at least 40% of the available soil water holding capacity until:

- Corn reaches black layer.
- Most pods turn yellow for soybeans (Figure 6).

However, late in the season the crop requires less irrigation as the weather is generally cooler and days are shorter. There is also greater chance of precipitation.

Figure 6. Most of soybean pods turn yellow.

Evaluate the Irrigation System

Some practices that can save water, energy, and cost for irrigation systems follow. Evaluation of irrigation system uniformity is critical. The area affected by non-uniform irrigation applications will become much larger with increasing the number of irrigation applications. For example, a 30% deviation during a season that would require 8 inches of supplemental irrigation will have areas receiving as little as 5.6

inches and as great as 10.4 inches. Typically, a 10% or less deviation from the average is ideal, but 15% is acceptable. When designing a center pivot system, additional nozzles–a relatively small investment–can increase the uniformity. Kelley (2014) has described the procedure for testing the uniformity of the center pivot (Figure 7). Kelley and Anderson (2019) demonstrated the use of an Unmanned Aerial Vehicle (UAV) (Figure 8) to inspect the uniformity of irrigation systems.

Figure 7. Catch can test to check uniformity of the center pivot system.

Figure 8. UAV to inspect the uniformity of the center pivot system (Photo Credit: Eric Anderson, MSU Extension Educator).

The irrigation system should be periodically inspected for clogged nozzles and emitters, leaky pipelines, and riser gaskets among other components (Figure 9). Deep percolation from leaking pipes could leach nutrients or chemicals to groundwater. Read the pressure gauge at the center pivot regularly to identify the potential problem with the system.

Figure 9. Pressurize the system and inspect for leaks, holes, and damaged sprinklers. Use a crayon mark, flag, or photo to identify the needed repair. The quicker the repair is made, the lower the crop damage incurred at the site.

Some of the GAAMPs related to this section include:

- *Evaluate the irrigation system uniformity.*
- *Keep records on all system inspections and repairs that influence uniformity and leaks.*
- *Maintain the irrigation system in good working condition.*

(Michigan Department of Agriculture and Rural Development, 2020, pp. 3-4)

Choose the Right Sprinkler Package

When choosing a sprinkler system, water loss by evaporation is only a minor concern in Michigan where the relative humidity is high. However, runoff is a significant issue in irrigated fields with steep slopes.

The considerations for selecting the sprinkler include:

- Greatest wetted area and pressure required
- Most uniform
- Easily updated nozzle package
- Greatest tolerance of pressure change
- Wind drift
- Sprinkler spacing
- Chemigation
- Pressure regulation

Find more details on selecting the sprinkler package for a system in the University of Nebraska–Lincoln Extension bulletin *Converting Center Pivot Sprinkler Packages: System Considerations (G1124)* (http://extensionpubs.unl.edu/publication/9000016364367/converting-center-pivot-sprinkler-packages/).

Consider Variable Rate Irrigation

Variable rate irrigation (VRI) controls the speed of the pivot to apply varying volumes of water to specific sections of the field. A simple and relatively inexpensive option is the speed control, available in most center pivot systems. Speed control VRI benefits production when:

- There are multiple crops and soil textures in the field.
- There is relatively inexpensive cost compared to zone or sprinkler control VRI systems.
- It is allowable to add speed control on the existing center pivot.

The speed control VRI can only control applications in pie slice-shaped parcels.

Zone or sprinkler control VRI systems can adjust the application rates of individual nozzles. A producer can adjust these parameters at multiple points along the path of the pivot circle using GPS. The benefits of the zone or sprinkler control VRI systems are most apparent when:

- There are two or more soil textures in the field since soil texture plays a major role in determining water holding capacity.
- Multiple crop species, crops with different planting dates, or crops with different maturities are grown under a single irrigation system since evapotranspiration rates will be different for these situations.
- There are areas where irrigation is unnecessary such as ditches, farm lanes, and woodlots.

Considerations for zone or sprinkler control VRI include:

- Complex system
- More expensive
- Additional maintenance and management

Find detailed information on VRI in the University of Nebrasks-Lincoln Extension bulletin *Variable Rate Application of Irrigation Water With Center Pivots (EC2000)* (http://extensionpubs.unl.edu/publication/9000016369256/variable-rate-application-of-irrigation-water-with-center-pivots/).

Use Fertigation or Split Nitrogen Application to Maximize Your Return

Irrigated production has the advantage of fertigation as an option in nitrogen (N) management. Fertigation is the process of applying fertilizer through irrigation water. Urea ammonium nitrate is the most common product for fertigation with proper equipment. From a management standpoint, fertigation allows producers the opportunity to evaluate crop stands, N losses due to wet conditions or heavy rains, and current market conditions to adjust their N management plan to meet crop needs, maximize profitability, or do both. The closer the N fertilizer is applied to the time of peak crop need, the lower the potential for N loss, and the greater the return for your N investment.

Even if you never fertigate, irrigation still provides the opportunity to water in surface applied or knifed in N applications. Incorporation by irrigation reduces N loss to vaporization, increasing the usable amount of N for the crop.

Some of the GAAMPs related to this section include:

- *When irrigation is used, split application of nitrogen fertilizer or use controlled release fertilizer.*

- *Incorporate appropriate backflow-prevention safety devices if a chemigation system is used.*

(Michigan Department of Agriculture and Rural Development, 2020, p. 11)

Automation of an irrigation system can be an extra expense at a time when budgets are tight, but interlocking pumps and center pivots or other distribution systems can be done for under $500 and can avoid overwatering when the pivot stops or application cycle ends.

The GAAMP related to this section follows:

- *Irrigation systems used for applying chemigation should have adequate interlock and safety systems to prevent overapplication of pesticide, fertilizer and water when pumps continue to run and the distribution system stops moving.*

(Michigan Department of Agriculture and Rural Development, 2020, p. 11)

Maintain Irrigation Equipment to Minimize Expensive Repairs

Irrigation technicians and service providers agree that preventative maintenance and precautionary startup procedures can help avoid future costly repairs. Recommendations include:

- Remove mice, insects, vermin, and their nests and waste. Close access to electrical control boxes before spring startup (Figure 10).
- Clean and inspect the function of electric disconnect boxes and well starter systems.
- Test center pivot-end stop controls and stop structures before the first run.
- Test traveler-end run-stop control system before the first run.
- Trim or remove trees and brush that are near the pivot-end boom's travel path.
- Inspect tires early in spring, add air to specification, and recheck a couple of weeks later, repairing any tire that lost pressure (Figure 11).
- Observe each center pivot drive motor and drive gearbox while running, drain accumulated water, check oil levels, and refill. Growling and grinding sounds indicate the need for replacement or repair.

Dealing with these issues before planting reduces the need for expensive repairs and minimizes startup delays or downtime during the middle of the growing season. The added benefit of being ready to irrigate to aid in germination and emergence, incorporate fertilizer, or activate herbicide often leads to a better start to a profitable year.

Figure 10. Mice, snakes, and other small vermin squeeze into electric boxes for shelter.

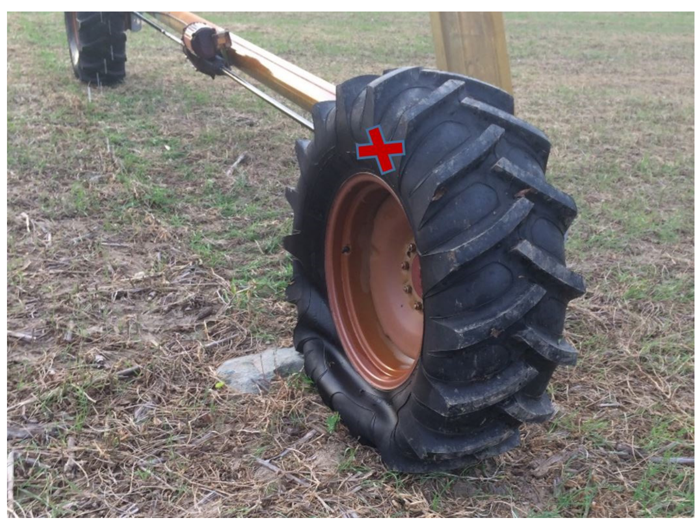

Figure 11. Tires are ruined quickly if run while low or flat. The pivot does not move normally with a flat tire, which may apply more water.

"The Generally Accepted Agricultural and Management Practices (GAAMPs) for Irrigation are based on the core principle of stewardship. Stewardship in irrigation management includes stewardship of water quantity, water quality, soil, plant quality, and crop yield.

- *Stewardship of the water quantity means using water as efficiently as possible while providing for the crop/landscape water needs. Utilizing more water than necessary for production of a quality crop is wasteful of the water resource and can have negative environmental and production impacts resulting from leaching of nitrogen and possibly pesticides. With certain exceptions, over-irrigation is when water applications exceed the quantity needed to replace the soil/substrate moisture deficit. The amount of irrigation water to apply generally is equal to the total evapotranspiration since the last irrigation minus any precipitation that occurred during the period.*
- *Stewardship of the water quality means being careful to apply water at a rate that will infiltrate uniformly into the soil/substrate and be properly stored for crop use while not causing surface runoff or water movement below the root zone.*
- *Stewardship of the soil means following management practices that will sustain and improve soil surface infiltration characteristics and soil moisture holding capacity through increasing organic matter levels and biological activity while reducing compaction.*
- *Stewardship of the crop means managing water to promote plant establishment, sustain plant development, and foster the long-term sustainability of the managed landscape system.*
- *Stewardship of the agricultural sector of the Michigan economy means producing high-quality crops that maintain and enhance Michigan's reputation as a superior supplier in the marketplace."*

(Michigan Department of Agriculture and Rural Development, 2020, p. 1)

References

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Kelley, L. (2014). *Evaluating irrigation system uniformity*. Michigan State University Extension and Purdue University Extension. https://www.canr.msu.edu/uploads/235/67987/resources/EvaluatingIrrigationSystemUniformity05.14.pdf

Michigan Department of Agriculture and Rural Development. (2020, January). *Generally Accepted Agricultural and Management Practices for Irrigation Water Use*. https://www.michigan.gov/documents/mdard/Irrigation_Water_Use_2020_GAAMPS_682474_7.pdf

Resources

Michigan GAAMPs: https://www.michigan.gov/documents/mdard/Irrigation_Water_Use_2020_GAAMPS_682474_7.pdf

Michigan State University Biosystems & Agricultural Engineering Irrigation: https://www.egr.msu.edu/bae/water/irrigation/

Michigan State University Extension Irrigation: https://www.canr.msu.edu/irrigation/

University of Nebraska–Lincoln Extension, *Converting Center Pivot Sprinkler Packages: System Considerations (G1124):* http://extensionpubs.unl.edu/publication/9000016364367/converting-center-pivot-sprinkler-packages/

University of Nebrasks-Lincoln Extension, *Variable Rate Application of Irrigation Water With Center Pivots (EC2000):* http://extensionpubs.unl.edu/publication/9000016369256/variable-rate-application-of-irrigation-water-with-center-pivots/

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