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Programmed Soil Moisture Depletion

G 73-58
(Revised)

Top Yields With Least Water

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The development of automated irrigation has introduced a revised concept to irrigation water management that will mean savings of water and energy. By not completely refilling the root zone each irrigation, soil moisture storage capacity is left within the root zone to take advantage of any rainfall that occurs after an irrigation.

The old recommendation—refilling the root zone each irrigation—is wasteful. If rainfall occurred soon after the field was irrigated, water would percolate below the root zone, carrying soluble nutrients, such as nitrates, with it.

Conservation of water is important because supplies are being depleted in many areas. Water should be applied efficiently and rainfall used effectively in irrigation practices. Irrigation water runoff and deep percolation of water should not be allowed during the growing season.

Research Results

Irrigation research at the University of Nebraska Field Laboratory at Mead, North Platte Station, and the Agricultural Laboratory at Alliance showed that a limited capacity irrigation system gave as good or better yields of corn and sugarbeets than a full-capacity system.

The research was conducted during irrigation seasons in 1969, 1970, 1971 and 1972. The lowest rainfall occurred during the 1971 season, when only 4.57 inches of rain fell on the plots at Mead from June 29 through September 29. However, the highest yield (132 bu per acre) was produced on the plots simulating an irrigation system capacity of 0.15 inch per day design criteria equivalent. This is equal to a system operating 24 hours a day with 2.8 gallons per minute per acre. More or less water reduced the corn yields significantly.

During the 1972 irrigation season rainfall was 9.45 inches from June 14 to September 20 at the same location. On July 26, 1.65 inches of rain fell and on August 1 another 0.31 inch. The corn was in the critical pollination stage of growth. Rainfall or an irrigation during this stage is important to high corn grain yields.

Non-irrigated corn produced 102 bushels per acre *(Table 1)*. However, applying 0.53 inch of water every 3.5 days, for a total of 8.5 inches of irrigation water during the high water use period, produced 165 bushels per acre.

In addition to the 8.5 inches of irrigation water and 9.45 inches of rainfall, 1.99 inches was extracted out of the root system zone from June 14 to September 20. Also, applying 1.05 inches every 7 days for a total of 8.0 inches of irrigation water during the season produced 167 bushels of corn per acre. There was a deficit of 1.47 inches of water in the root zone on September 20. Again, applying more or less water reduced the corn yields significantly *(Table 1)*.

Adjusting System

Adjusting a system to apply the limited amounts of water is not difficult and could cut energy requirements significantly. Reducing the capacity of a system from 900 to 600 gallons per minute could reduce the power requirement by one-third, providing total lifts would remain the

same. Usually total dynamic heads would also decrease, possibly reducing the total power requirements by nearly one-half.

Center-pivot sprinkler systems are capable of applying less than an inch of water each irrigation. Likewise, the automated gated pipe system is capable of applying 2 inches or less per irrigation. The automated solid-set sprinklers are capable of applying even less than one-tenth of an inch per irrigation if the operator so desires.

Automation of irrigation systems has increased initial investments but has reduced labor requirements to the point where labor costs are no longer a major consideration in determining the amount of water applied or the frequency of irrigation.

A system should probably be designed for larger capacity than is actually needed *(Table 2)* to take care of unexpected interruptions. A center-pivot may get out of alignment during the night and the operator may not notice it until morning. Interference with power to the irrigation well may delay the system's starting for several hours.

System Capacity

The system capacity for a 130-acre center pivot could be 600 gallons per minute. The operator then could program the system to be idle 20 to 30 percent of the time. The past procedure had been to design the system with a capacity of 900 to 1,000 gallons per minute for a 130-acre center-pivot sprinkler system.

Another possibility would be to design or operate systems now in the field with capacities of approximately 900 gallons per minute about half the time during the day. Electric motor driven irrigation wells could be programmed by the electric power district to operate when the electric loads are low. This could mean a great savings to some rural electric districts which pay for electricity on the basis of peak electrical loads.

Programmed Soil Moisture Depletion

1. Be sure that soil is at least 5 feet deep with a water holding capacity of 1.5 inches or more per foot of depth.
2. See that the soil moisture in the profile is at field capacity (root zone filled or nearly filled) to a depth of 5 feet or more by June 20.
3. Be ready to start the irrigation system before a soil moisture deficit of 2 inches occurs within the root zone, sooner if necessary when small corn is shallow rooted.
4. Start out applying 1 inch per week. Measure it with a water meter or follow sprinkler manufacturer's charts or tables for application amounts.
5. Monitor soil moisture with electrical resistance blocks or by sampling with a probe, and measure rainfall with a rain gauge.
6. Adjust applications to more or less than an inch per week if stored soil moisture indicates a need for change.

CAUTION: Research on programmed soil moisture depletion has not been done during a growing season when air temperatures exceeded 105° and hot winds occurred for several days.

Table 1. Effect of various sprinkler irrigation treatments on corn yields at the U of N Field Lab at Mead, 1972

Design criteria	*Amt of water per irrigation*	*Frequency of irrig.*	*Total irrig water applied*	*Rainfall[a] plus irrig.*	*Stored moisture change in root zone[b]*	*Corn Yield*
Inch/day	*Inches*	*Days*	*Inches*	*Inches*	*Inches*	*Bulac*
0.30	1.05	3.5	14.3	23.7	0	161
0.24	0.84	3.5	11.5	21.0	- 0.26	163
0.15	0.53	3.5	8.5	17.9	- 1.99	165[c]
0.10	0.35	3.5	6.2	15.6	- 8.66	158
0.30	2.10	7	13.2	22.7	0	158
0.24	1.68	7	10.7	20.2	0	156
0.15	1.05	7	8.0	17.4	- 1.47	167[c]
0.10	0.70	7	6.2	15.7	- 5.38	159
Check[d]	0	0	0	9.45	-12.65	102[e]

[a] Rainfall was 0.45 inches June 14 through September 20

[b] Reduction in stored moisture in the soil because of water requirement of corn was not met by rainfall and irrigation during the growing season. Stored soil moisture is crop insurance.

[c] Significantly higher 95 percent of the time from all other treatments.

[d] The soil moisture was at field capacity to a depth of six feet at planting time.

[e] Significantly lower at the five percent level from all irrigation treatments.

Table 2. Design Criteria for Irrigation Systems[a]

Equivalent amounts of water per acre		*System capacity*		
		100 acres	*130 acres*	*150 acres*
Inch/day	*Gal/min for 24 hrs.*	*Gal/min*	*Gal/min*	*Gal/min*
.30	5.62	562	731	843
.24	4.50	450	585	675
.15	2.80	280	365	420
.10	1.90	190	247	285

[a] Assuming no runoff, no deep percolation, a uniformity coefficient of at least 80, and a system that operates 24 hours a day.

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