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Effect of Irrigation Ending Date on Corn Yield and Irrigation Scheduling for Water Conservation

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Abstract. The results from a two-year field study indicate that the corn growers of western Kansas may not have to irrigate until black layer formation, as is the current practice. With the decline of Ogallala aquifer groundwater level and rising fuel cost any reduction of pumping makes economic sense. The first irrigation ending date was on August 10-15, corresponding to denting and starch layer formation of ¼ to ½ towards the germ layer resulted in yield that averaged 7 bushels per acre less than the second ending date on August 21-22, which corresponds to starch layer at ½ to ¾ towards the germ layer. However, continuing irrigation until September 1, corresponding to the start of black layer formation, improved yield by only 2 bushels per acre. A statistical analysis over the two years of data indicates that the first ending date is different from the last ending date, but the second ending date is not different from either first or last ending dates. Economic sensitivity tests show that irrigating until the formation of starch layer at ½ to ¾ towards germ layer is feasible with a corn price of $2 per bushel and $6 per inch pumping costs. However, irrigating past this stage of grain development is not feasible even with $2.75 / bushel of corn and pumping costs as low as $2 / inch.

Keywords. Ogallala aquifer, corn

Introduction

Crop production in western Kansas is dependent on irrigation. The irrigation water source for the area is groundwater from the Ogallala aquifer. The water level of the Ogallala aquifer is declining causing the depth of pumping to increase. The additional fuel consumption required for greater pumping depths and higher energy costs have resulted in higher pumping costs in recent years. Because of declining water levels and higher pumping costs, it is necessary to conserve water by adopting efficient water management practices. Irrigation scheduling is an important management tool. Farmers are interested in information on optimum timing for ending the irrigation season. There are some misconceptions regarding the optimum irrigation ending dates. Some farmers believe that the corn crop must continue to have water to avoid eardrop. Over application at the end of season based on this thought cause waste of water, increases cost of production, and may even cause degradation of quality of the grain due to high humidity or disease. Most of all, the excess use of water may reduce the useful life of the Ogallala aquifer which is a confined aquifer with little or no recharge. Depletion of the Ogallala aquifer will impact irrigated agriculture and the present economy of the area.

The objective of the study was to determine the affect that irrigation ending date had on corn yield and economic return.

Procedures

A producer's center pivot sprinkler irrigated field was selected for the study. Two sets of six nozzles were shut progressively after the formation of starch layer in the corn grain. The first closure was done when the starch layer was ¼ to ½ to the germ. This corresponded to August 10 in 2001 and August 15 in 2000, depending on growing degree units. The second closure was done when the starch layer was ½ to ¾ to the corn germ. This corresponded to August 21 and 22 in 2001 and 2000 respectively. The third closure occurred when the producer ended irrigation for the year. This happened on September 1 in both the years.

Four random plots of 30 ft. by 30 ft. were identified within the circle over which the selected nozzles would pass during an irrigation event. Ridges were built around the plots to prevent entry of water from the adjacent areas. Gypsum block soil water sensors were buried in the plots at three different depths – 1, 2, and 3 feet below the soil surface. The soil of the test field is Ulysses silt loam series. It is relatively dark with a deep profile and good water holding capacity. The soil surface, however, cracks when dry.

Corn ears were hand harvested. Four contiguous rows measuring ten feet each were harvested at the middle of each plot to remove any border effect. Grain yields were adjusted to 15.5% moisture content.

Results and Discussion

Applied irrigation, yield, and irrigation ending dates in relation to growth stage are presented in Table 1 for 2000 and 2001. Continuation of irrigation from the first ending date on August 15 to the second ending on August 22, 2000, gave an increase of average 7 bushels of grain per acre. The additional irrigation application amounted to 2.1 inches for the six-day period. The yield difference from the August 22 ending date to the September 1, 2000, was only 5 bushels per acre. The additional irrigation for the period amounted to 3 inches.

Table 1: Yield of corn grain as affected by irrigation ending date at different growth stage, Stevens County, Kansas, 2000 -2001

Year	Irrigation ending date	Corn Growth stage	Additional Irrigation, inches*	Yield, bu/ac.
2000	August 15	Dented, starch layer ¼ to ½ to germ	0	238
	August 22	Starch layer ½ to ¾ way to germ layer	2.1	245
	September 1	Starch layer at germ, black layer visible	5.1	250
2001	August 10	Dented, starch layer ¼ to ½ to germ	0	243
	August 21	Starch layer ½ to ¾ way to germ layer	2.6	250
	September 1	Starch layer at germ, black layer visible	5.6	249

*Note: Additional irrigation compared to the first irrigation ending date

In 2001, the yield difference between the first and second irrigation ending date was 7 bushels per acre. However, there was a loss of one bushel per acre from the second to the third ending date.

A statistical analysis was completed to determine if the results were consistent from year to year and if there was interaction between the years. The results indicated that the results were consistent and there was no significant interaction between years. Figure 1 shows the results of the statistical analysis combining both years of data.

The results shown in Figure 1 indicate that the yield difference between the first and the last ending date is significant, however, the yield difference is not significant between the first and second ending dates. The average yield difference of 8 bushels per acre between the first and second ending dates is approximately equal to the LSD value, thus prompting an economic analysis to determine the optimum irrigation ending date with different corn prices and pumping costs. The results of this analysis are shown in Figures 2 and 3.

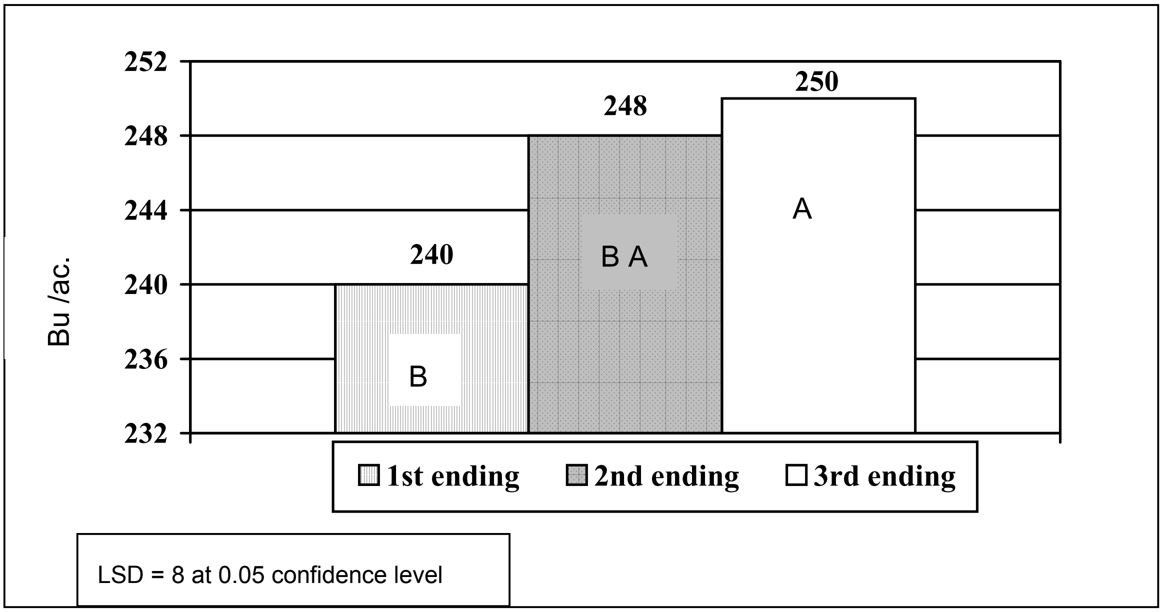

Figure 1: Corn grain yield as affected by irrigation ending dates

The tool used to determine the optimum irrigation ending date was the marginal value vs. marginal cost analysis. In this analysis corn price ranged from $2.00 to $2.75 per bushel, while pumping cost ranged from $2.00 to $7.00 per inch. Positive returns indicate that the marginal benefit of continuing irrigation was greater than the cost of applying water.

Figure 2 shows that under nearly all scenarios, irrigation remains profitable until the second ending date. The one exception is when the price of corn is $2.00 per bushel and pumping costs are $7.00 per inch. However, irrigation past this growth stage may not be profitable (Figure 3).

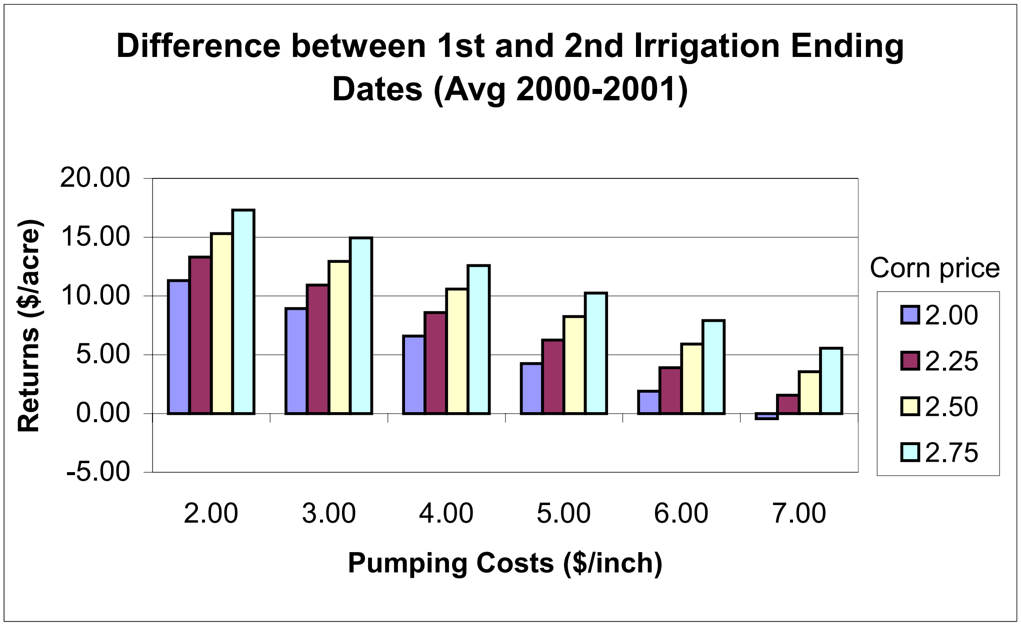

Figure 2: Returns at different levels of input cost and price of corn for difference between 1st and 2nd ending dates

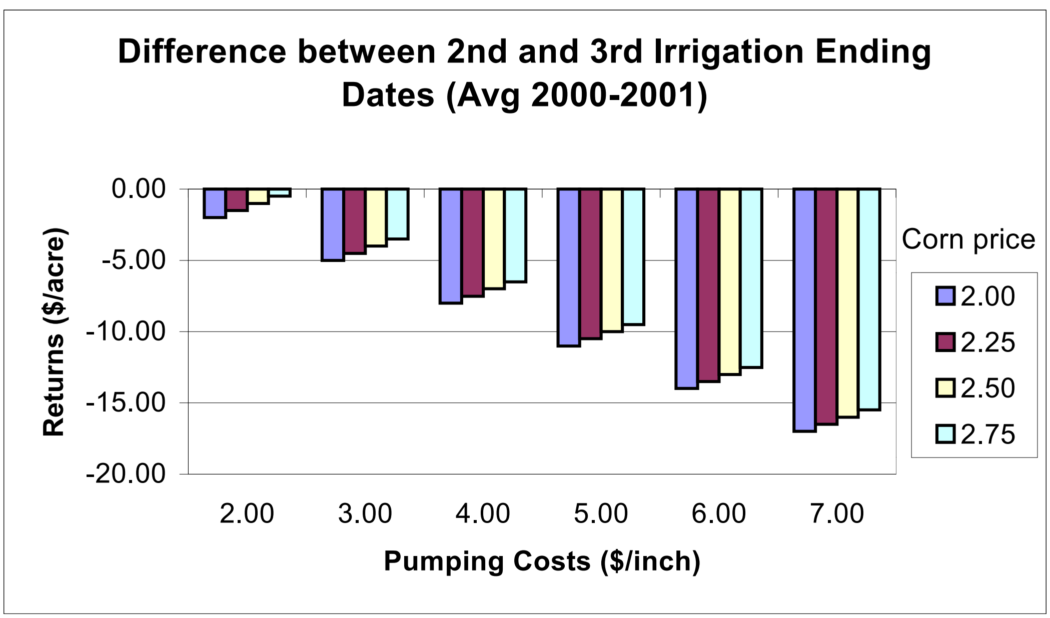

Figure 3: Returns at different levels of input cost and price of corn for difference between 2nd and 3rd ending dates

Kansas State University water management bulletin No. MF-2174 presents a table showing normal water requirements for corn between stages of growth and maturity. Corn grain, at full dent, will use 2.5 inches of water for the remaining 13 days before reaching physiological maturity.

The available water holding capacity of the soil in the study field is estimated to be approximately six inches or more per 3 feet of root zone. It is expected that at a 50 percent management allowable depletion level this soil will provide about 3 inches of water. This may be the reason that there was no appreciable benefit from continuing irrigation past August 21 or after the starch layer has moved past ½ to ¾ towards germ layer. The soil water sensors indicated that the soil water condition was adequate to carry the crop to full maturity. Soil water status monitored by gypsum block sensors are presented in Figure 4-6.

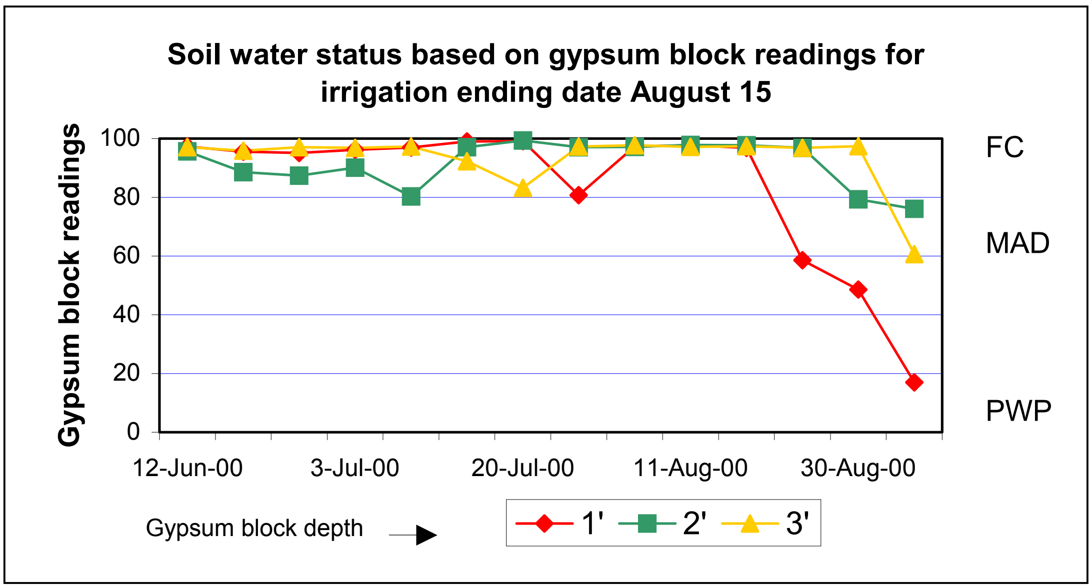

Figure 4: Soil water status for 1st irrigation ending date. FC = Field capacity, MAD = Management Allowable Depletion, and PWP = Permanent Wilting Point.

Figure 4 shows that the soil water at first and third feet depths were falling below Management Allowable Depletion (MAD) level for the first ending date that caused reduction in yield. Figure 5 shows that soil water in first foot started to go down in the plots of second ending date, but there was enough in second and third foot to carry the crop to maturity.

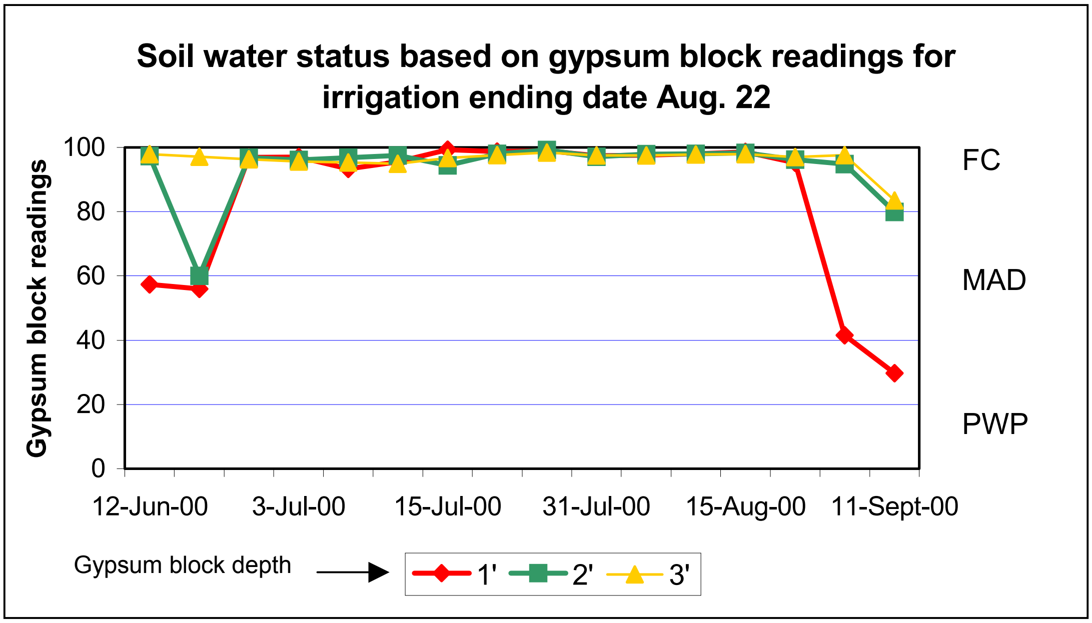

Figure 5: Soil water status for 2nd irrigation ending date. (FC = Field Capacity, MAD = Management Allowable Depletion, and PWP = Permanent Wilting Point)

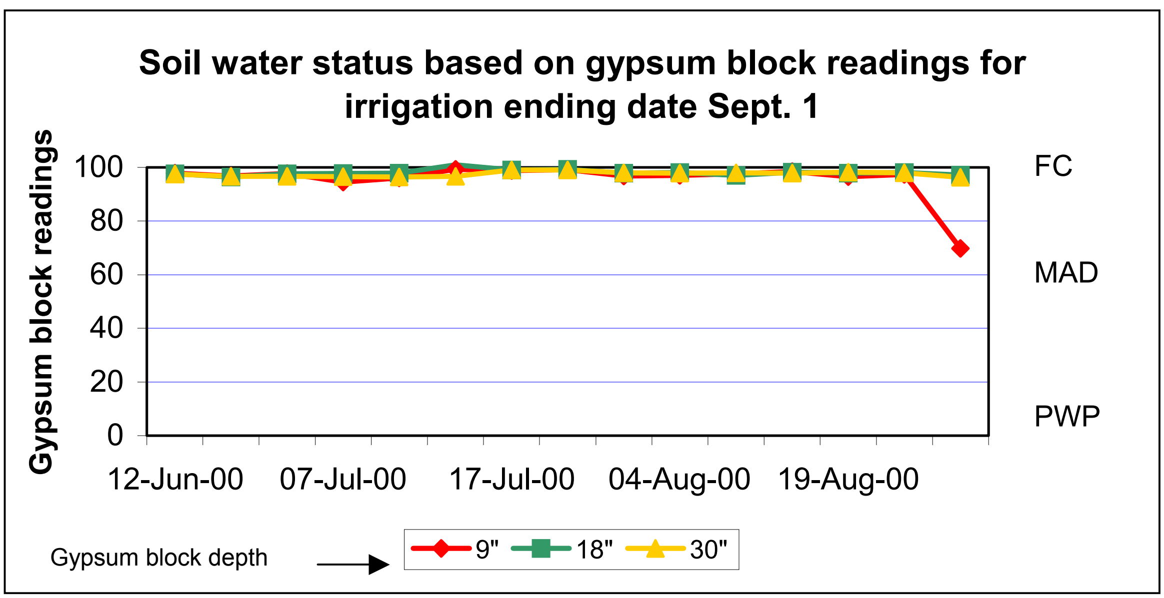

Figure 6: Soil water status on 3rd irrigation ending date. (FC = Field Capacity, MAD = Management Allowable Depletion, and PWP = Permanent Wilting Point)

Soil water readings taken on September 11 in the plot where irrigation continued until September 1, indicate that soil water was almost at Field Capacity, except for the first foot of the profile (Figure 6). The crop was already mature and there was no more water use. The profile was left with high water content over the winter. Most of the cornfields in western Kansas reflect this situation and have little room to store winter and early spring precipitation. This causes double loss from not taking advantage of natural precipitation and leaching of nutrient with the deep percolation of excess water. A three-year study by Rogers and Lamm (1994) also indicated that the irrigation practices of corn producers of western Kansas leave approximately 1.4 inches of available soil water per foot of soil profile.

Irrigated agricultural producers are continuously being educated on irrigation scheduling. Kansas State University Biological and Agricultural Engineering developed computer software called KanSched to provide the producers with an easy to use tool for irrigation scheduling. The irrigation events, rainfall, and crop water use (Evapotranspiration) data were entered to track soil water depletion pattern, which is presented in Figure 7. Tracking of crop water use and irrigation application show that the soil profile was pretty full at the end of the season when irrigation was continued until September 1.

System 12- Summer 2001

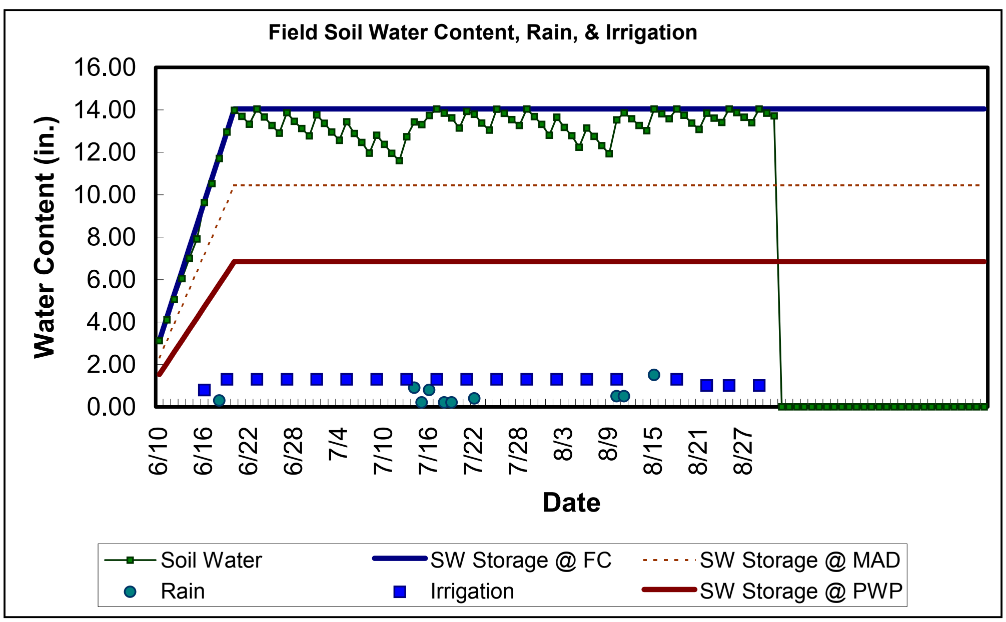

Figure 7: Chart showing water balance between soil water storage at field capacity and permanent wilting point. The dashed line in the middle represents management allowable depletion.

It would be worthwhile to mention that there was no appreciable eardrop observed in the field within the circular area with the earliest irrigation ending. However, the plants were dryer as compared to the rest of the field at the time of harvest.

Conclusion

A two-year field study indicates that the present practice of irrigating until the formation of black layer in corn grain may not be economical. An earlier ending date for irrigation corresponding to the starch layer at ½ to ¾ of the grain may help improve the economic return and best utilize the soil profile water. Soil water monitoring may help in the decision process.

Acknowledgements

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