# Economics of Irrigation Ending Date for Corn[1]

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## Summary

The results from a field study indicate that corn growers of western Kansas may cut back the last one or two irrigation events of the season without appreciable loss in production. This will improve the economic return by reducing input cost from water. Recent increases in energy costs for pumping water necessitated this study to compare the benefits of continuing irrigation until black layer formation. With the decline of Ogallala aquifer groundwater level and rising fuel costs, any reduction of pumping makes economic sense. Ending irrigation around August 10-15, corresponding to denting at 1/4 to 1/2 of starch-layer formation toward the germ layer, resulted in a yield reduction of 17 bushels per acre, compared with ending irrigation around August 21-22, corresponding to 1/2 to 3/4 of starch-layer formation toward the germ layer. Whereas, continuing irrigation until September 1, corresponding to the start of black layer formation improved yield by only 2.5 bushels per acre. Economic sensitivity tests show that irrigating until the formation of starch layer at 1/2 to 3/4 towards germ layer is feasible with a corn price of $2 per bushel and $8 per inch pumping costs. Irrigating past this stage of grain development is not economical, even with $2.75 / bushel of corn and pumping costs as low as $4 / inch.

## Introduction

Crop production in western Kansas is dependent on irrigation. The irrigation water source 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 increased 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 perception, causes waste of water, increases cost of production, and may even cause degradation of the 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

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aquifer will impact irrigated agriculture and the present economy of the area. The objective of the study was to determine the effect that irrigation ending date had on corn yield and economic return.

## Procedures

A producer's field with center-pivot sprinkler irrigation was selected for the study. A Ulysses silty loam soil was selected, and the study was conducted for four years (2000-2003). Two sets of six nozzles were shut progressively after the formation of the starch layer in the corn grain. The first closure was done when the starch layer was 1/4 to 1/2 to the germ. This corresponded to August 10 to 15, depending on growing degree units. The second closure was done when the starch layer was 1/2 to 3/4 to the corn germ. This corresponded to August 21 to 24. The third closure occurred when the producer ended irrigation for the year. This happened during the first week of September.

Four random plots of 30 ft by 30 ft were identified within the center-pivot sprinkler 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 1, 2, and 3 ft below the soil surface. The soil of the test field is relatively dark, with a deep profile and good water-holding capacity, but the soil surface cracks when dry.

Corn ears were hand harvested. Four contiguous rows, measuring 10 ft each, were harvested at the middle of each plot to remove any border effect. Grain yields were adjusted to 15.5% moisture content.

In 2005, the study was moved to a field with loamy fine sand soil (Vona loamy fine sand) to evaluate irrigation ending date for a light textured soil with less water-holding capacity. The hypothesis is that the sandy soil may require continuation of irrigation, and irrigation ending date may be delayed, compared with a silty loam soil having greater water-holding capacity. The procedure followed was similar to the earlier study, in which two sets of six nozzles were closed progressively as the grain formed its starch layer.

## Results and Discussion

Continuation of irrigation from the first ending date in early August (August 10 to 15) to the second ending date in the beginning of the fourth week (August 21 to 22) gave an increase averaging 17 bushels of grain per acre. The additional irrigation application amounted to 2.1 inches. The yield difference from the August 22 ending date to the ending date in the first week of September, as normally practiced, was only 2.5 bushels per acre, on average, over four years. The additional irrigation quantity for the period from the second ending to last irrigation date was about 2.5 inches. The yearly yields are shown in figure 1.

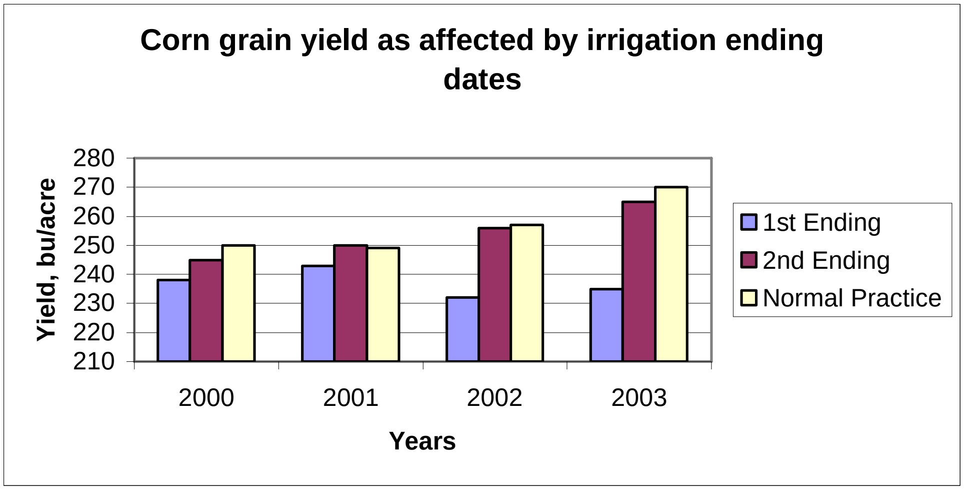


Figure 1: Yield of corn grain as affected by irrigation ending date at different growth stage on a silty loam soil, Stevens County, Kansas, 2000 to 2003.

The tool used to determine the optimum irrigation ending date was the marginal value vs. marginal cost analysis. In this analysis, corn prices ranged from $2.00 to $2.75 per bushel, and pumping costs ranged from $3.00 to $8.00 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. Irrigation past this growth stage may not be profitable (Figure 3). Return becomes negative for corn at a pumping cost of $4.00 per inch, even at a corn price of $2.75 per bushel.

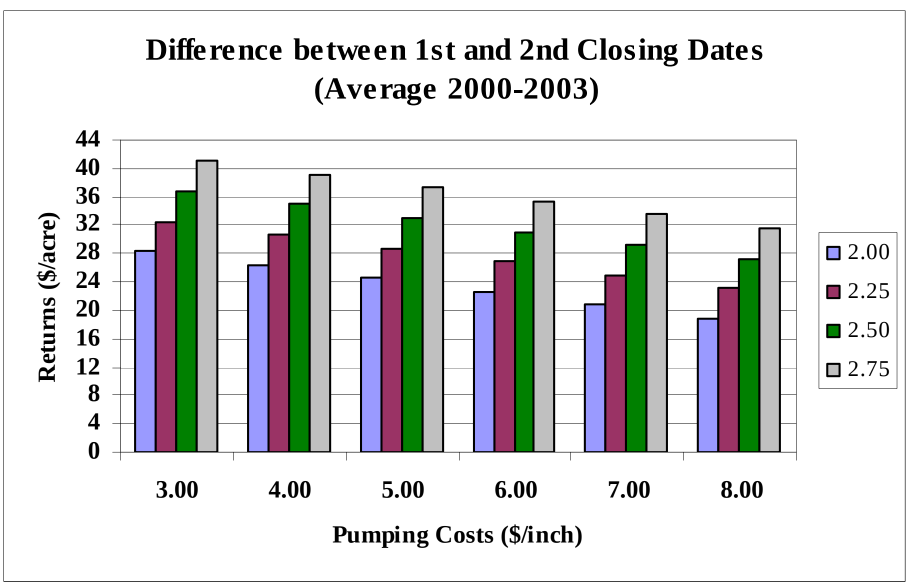


Figure 2: Returns at different levels of input cost and price of corn for difference between first and second ending dates

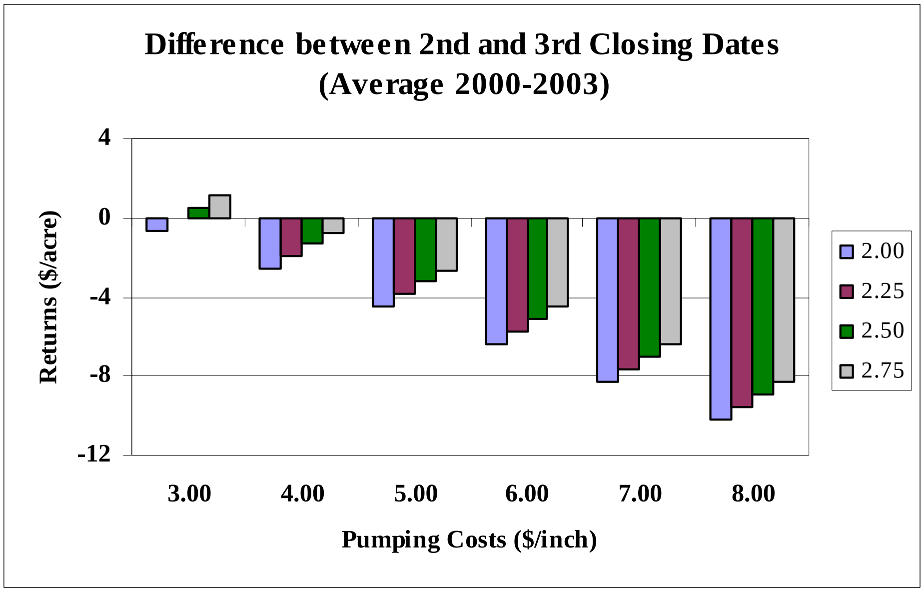


Figure 3: Returns at different levels of input cost and price of corn for difference between second and third ending dates

Kansas State University irrigation management bulletin number MF-2174: Predicting the Final Irrigation for Corn etc. presents a table showing normal water requirements for corn between stages of growth and maturity. The bulletin may be accessed at the website www.oznet.ksu.edu/mil under MIL Tool Kit & Resources. 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% management allowable depletion level, this soil will provide about 3 inches of water. This may be why there was no appreciable benefit from continuing irrigation past August 21 or after the starch layer has moved past 1/2 to 3/4 toward the germ layer. The soil water sensors indicated that the soil water condition was adequate to carry the crop to full maturity.

Figure 4 shows that the soil water at 1 and 3-ft depths were falling below Management Allowable Depletion (MAD) level for the first ending date, which caused a reduction in yield. Figure 5 shows that soil water in the top 1 ft started to decrease in the plots of the second ending date, but there was enough water at the 2- and 3-ft depths to carry the crop to maturity. At this site for some reason, the moisture level at 1 to 2 ft was at MAD levels at the beginning of the season. This changed as irrigation started.

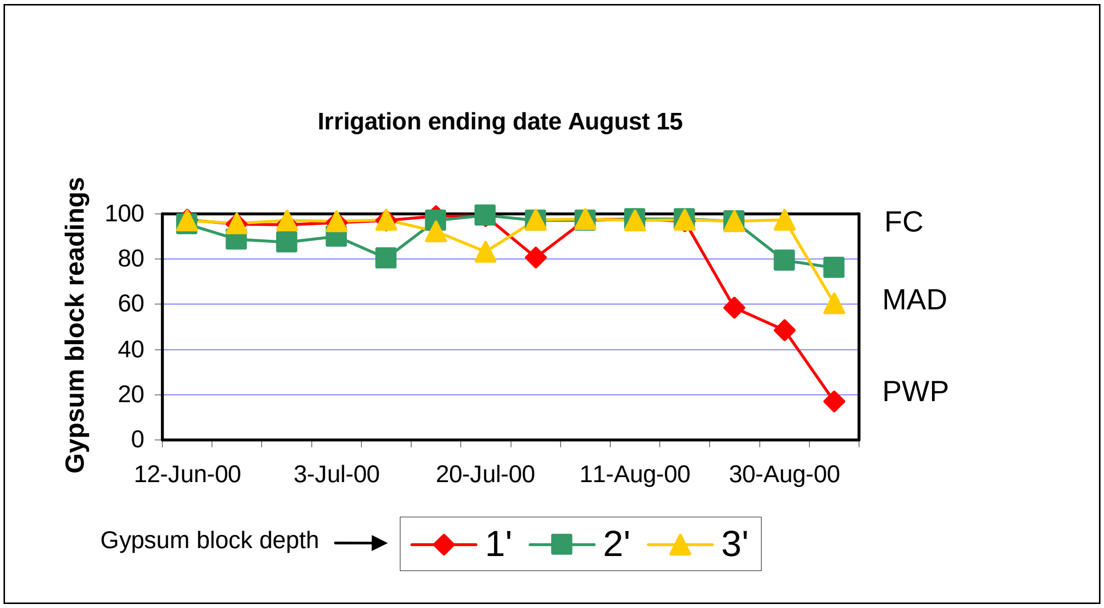


Figure 4: Soil water readings using gypsum blocks for first irrigation ending date (FC = Field capacity, MAD = Management Allowable Depletion, PWP = Permanent Wilting Point; these are to illustrate relative soil water status)

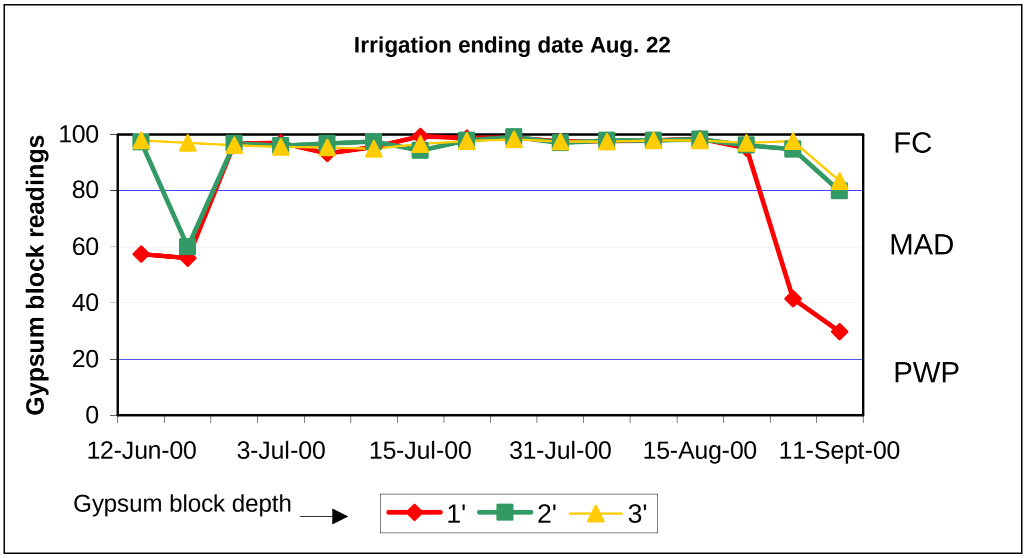


Figure 5: Soil water readings using gypsum blocks for second ending date.

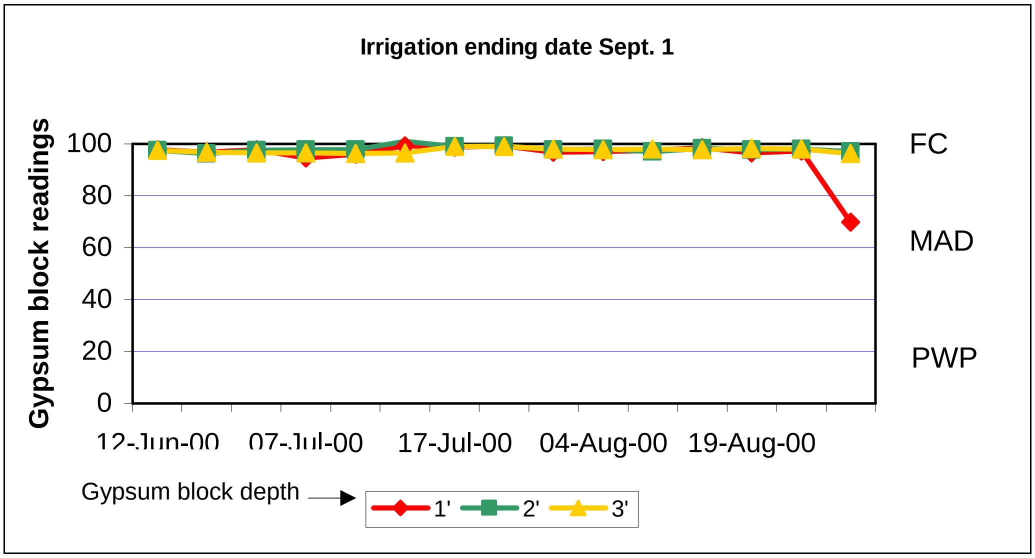


Figure 6: Soil water readings using gypsum blocks for last irrigation ending date

Figure 6 shows soil water readings taken until September 11 at the area where irrigation continued until September 1 under producers' practices; the readings indicate that soil water was almost at Field Capacity, except for the first foot of the profile. 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 irrigated 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 from leaching of nutrients 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 at harvest.

Producers using irrigated agriculture 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 the soil water depletion pattern, which is presented in Figure 7. Tracking of crop water use and irrigation applications show that the soil profile was pretty full at the end of the season when irrigation was continued until September 1.

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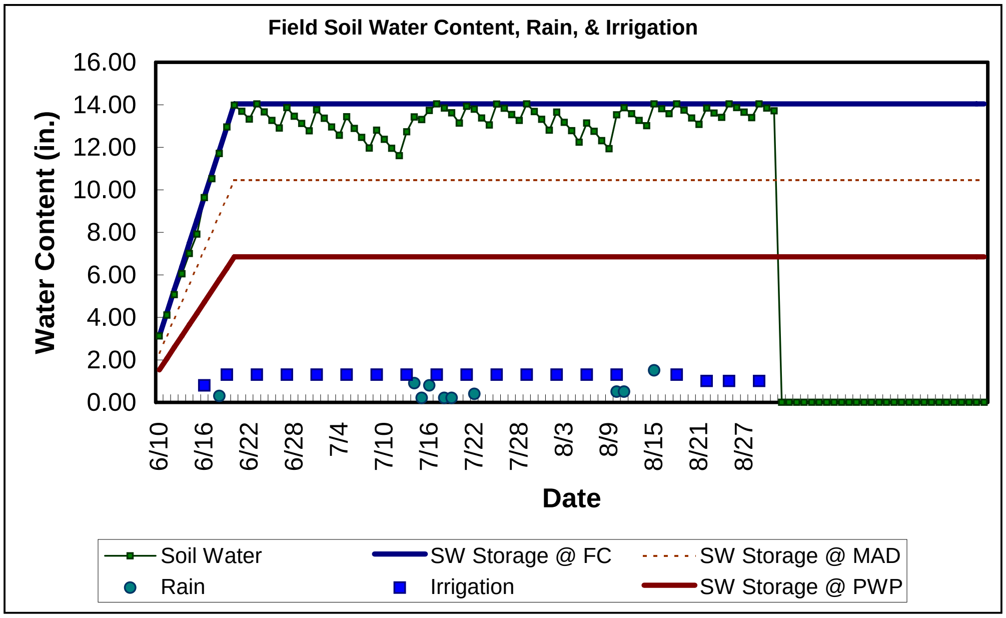


Figure 7: Chart showing water balance between soil water storage at field capacity and permanent wilting point. The dashed line in the middle represents management allowable depletion.

It would be worthwhile to mention that there was no appreciable eardrop observed in the field within the circular area having the first irrigation ending date, but the plants were dryer than plants in the rest of the field at the time of harvest.

The 2005 trial on Vona loamy fine sand needs to be continued to establish a trend, but the first-year results do indicate that the return remains positive at a pumping cost of $5.00 per inch, although the rate of return has been greatly reduced, Figures 8 and 9.

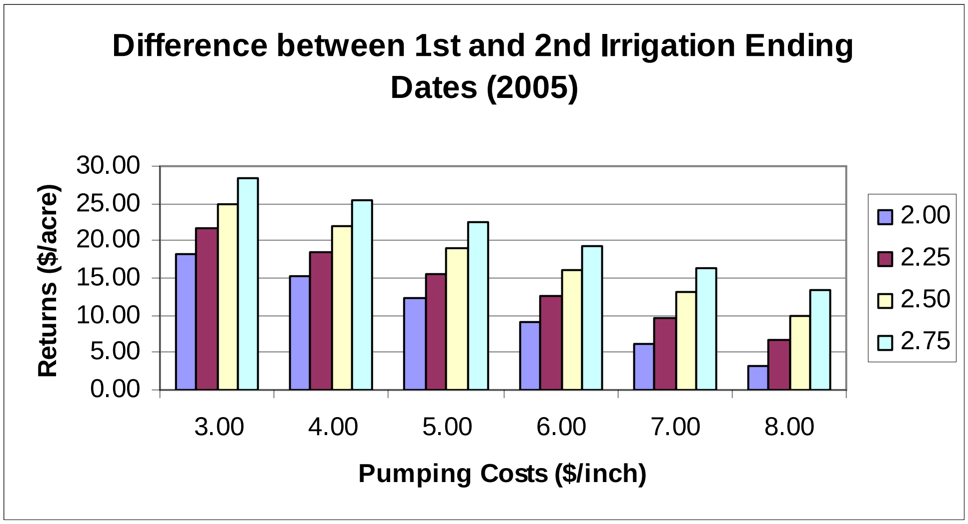


Figure 8: Returns at different levels of input cost and price of corn for difference between first and second ending dates.

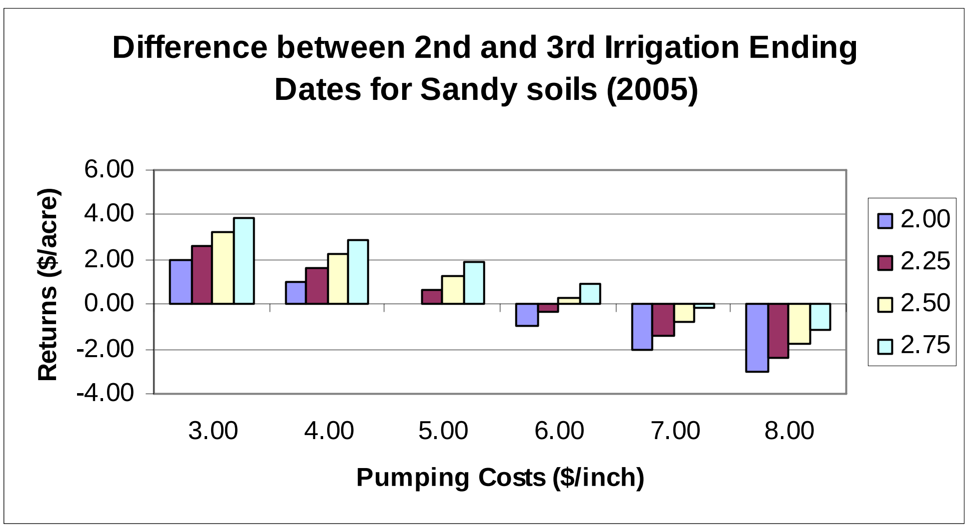


Figure 9: Returns at different levels of input cost and price of corn for difference between second and third ending dates

## Concluding Remark

The four-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 1/2 to 3/4 of the grain may help improve the economic return and best utilize the soil profile water in a silt loam soil. Using KanSched or Soil water monitoring by other means may help in the decision process. Earlier ending dates may require more cautious evaluation for a sandy soil because of its poor water-holding capacity.

## *Acknowledgements*

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