ON-FARM ACTIVITIES TO PROMOTE IRRIGATION SCHEDULING THE SOUTH CENTRAL KANSAS IRRIGATION MANAGEMENT PROJECT

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ABSTRACT

Irrigation scheduling has been promoted as management tool to minimize irrigation water application, however, few irrigators regularly followed any rigorous scheduling methodology. Kansas State University Research and Extension in conjunction with an irrigation association, Water PACK, began a long-term project to promote ET based irrigation scheduling and other management technology. Area irrigators serve as the focal point of the project and over time have been asked to assume responsibility of scheduling the project fields. A long-term commitment and on-farm activities such as variable water application tests and center pivot uniformity tests seems to have generated confidence and acceptance of ET-based irrigation scheduling.

INTRODUCTION

The South Central Kansas Irrigation Management Project (SCKIMP) is a cooperative effort between K-State Research and Extension (KSRE) and irrigation farmers of South Central Kansas to refine, promote, and transfer the use of

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irrigation scheduling and water management technology. The primary partnership between KSRE and Water PACK (Water Protection Association of Central Kansas; members primarily consist of irrigation farmers in the area), has an overall goal of improving irrigation water application and water use efficiency to the fullest extent possible to maintain a sustainable irrigated crop production base. The thirteen county service area of Water PACK has an irrigated acreage base of over one-half million acres and adds millions of additional dollars to the area's economy. Although localized areas have groundwater decline problems, in general, the south central Kansas aquifer system is being managed at a safe yield as compared to the more well known Ogallala aquifer in western Kansas. However, this region has a great diversity of water use types. Muncipal and industrial water use from the Equus Beds near Wichita, is approximately equal in volume to agricultural uses, whereas state-wide agricultural water accounts for over 80% of the total water use. Other areas, especially along several stream corridors, have substantial and critical surface water needs for wildlife and recreational areas. Any reduction in irrigation demand through either improved system efficiency or management procedures without crop yield impact could have a positive water resource impact without irrigation economic consequences. This was one of the motivations that lead south central Kansas area irrigators, through their irrigation association (Water PACK) to request establishment of an area based irrigation scheduling and water management project.

The primary focus group of SCKIMP involves thirteen irrigator field partner sites whose operators have made a commitment to allow access to their fields for monitoring of production activities, to serve as educational sites for tours, to enhance project publicity, and to learn and adopt, as appropriate, improved irrigation scheduling and water management procedures.

Partner field information is then used to educate other area irrigators through in-field tours, and winter irrigation seminars. Information and experiences are also published in written educational materials. Each field site displays a large project sign to provide year round publicity. During the irrigation season, the signs are updated with approximately weekly and seasonal information on in-field values of evapotranspiration (ET or crop water use), rainfall and irrigation. Project newsletters featuring project activities and results are also used to transfer information. The newsletters are targeted to KSRE agents and other local water-related agency personnel for their programming use.

Co-sponsoring agencies for this extensive project include the Kansas Water Office, through State Water Plan Funds, and the Kansas Corn Commission. Senninger and Nelson Irrigation Corporations have also provided irrigation supplies used in field research and demonstration activities. Automated weather stations in south central Kansas established and maintained by the Equus Beds and Big Bend Groundwater Management Districts (GMD's) are also essential components for the project's success.

IRRIGATION SCHEDULING USING ET

ET, short for evapotranspiration, is a measure of crop water use. Reference ET is based on the measured climatic conditions from a weather station for a "standardized" crop. The reference ET value is a reflection of the atmospheric demand placed on the reference crop. This value is then modified by coefficients specific to each type of crop. The GMD's in that area of Kansas use a grass-based Penman-Monteith reference ET (ET_r). The ET_r estimate is modified by crop coeffients to estimate crop ET (ET_c) and then used to develop a water budget or irrigation schedule specific to a given field or crop. Irrigation scheduling is a process used to determine when and how much water needs to be provided to prevent yield limiting water stress or to apply limited water resources at the most beneficial times. Unlike most crop production management decisions, irrigation scheduling requires daily data, making it a somewhat tedious management procedure to implement at the farm level. Climatic based reference ET estimations and computer software (available through both public and commercial sources) allow the daily collection and processing of data in a more viable management manner. Field partners have been asked to assume more of the irrigation scheduling responsibility for their project field during the course of the project. Over half of the partners are now scheduling.

Figure 1 shows the daily evapotranspiration (ET) for irrigated corn grown in Pratt county in 1998 which was planted May 10 and reached physiological maturity on September 1. In June, which was abnormally hot and dry, daily crop water use rates were approaching and exceeding 0.40 inches per day. However, this high ET period was followed by July and August with relatively low to moderate corn ET values. Cumulative daily ET, rainfall and irrigation amounts are shown in Figure 2 for the period. The cumulative rainfall line shows the long periods without rainfall. Rainfall at that site was below normal for in-season rainfall amounts.

A field soil water balance is shown in Figure 3 and illustrates the essence of irrigation scheduling. This chart is part of a spreadsheet package provided to the partners by the SCKIMP project managers. The partners enter information to characterize the field, crop and irrigation system. Daily inputs of reference ET, rain, irrigation or a measured field soil water content value are used to update the balance sheet and output charts. The upper and lower horizontal lines on Figure 3 represent the soil field capacity (FC) and permanent wilting point (PWP) levels, respectively. The middle dotted line is the management allowed deficit (MAD) soil water value. The goal of the irrigation scheduling procedure is to maintain the field soil water content between the field capacity and the management allowed deficit values. Rain amounts (dots) and irrigation applications (squares) are also displayed. During June, the modeled field soil water content was depleted below the MAD, in spite of the applied irrigation. This means that the crop ET rate was greater than the irrigation capacity to replenish water use by the crop. Fortunately the early crop stress was primarily during the vegetative growth stages and severe yield losses did not occur. However, earlier irrigation would not have been beneficial since the field soil water content was near the field capacity level at that time. Thus, the soil profile for that site could not hold additional water. Most fields in south central Kansas are very sandy and have very low water holding capacity values.

FIELD VERIFICATION OF THE ET WATER BALANCE

Part of the process of getting ET based irrigation scheduling implemented involves building irrigator confidence in the information. One way to accomplish this is to apply varying amounts of water to parts of a field and measuring the effects on yield. Four partner center pivot sprinkler systems were modified in 1997 by adjusting sprinkler nozzle sizes to apply 25% less, 25% more, and "normal" irrigation amounts to test zones on narrow strips (approximately 50 ft. wide). These test zones or rings were placed near to the pivot point to minimize the number of acres affected by the test. The test zone sprinklers were pressure regulated and metered to assure the desired application, however uniformity tests on two of the sites showed that there was more variability in the application depths than expected. As a consequence of the uniformity test, the size of the test zones were increased in 1998 to minimize the effect of adjacent un-modified sprinklers on the test zone area.

Rainfall was higher than normal in 1997, minimizing the potential yield impacts of the variable water application amounts. Rainfall and irrigation amounts for the four sites are shown in Figure 4. All sites had similar crop water use and relatively good corn yields, although sites 4 and 8 with 236 bu/ac and 247 bu/ac (hand harvest) were the highest (data not shown). Field water use efficiency (FWUE) defined as the bushels of grain produced divided by a water depth, which was either irrigation plus seasonal rainfall or irrigation only, is shown in Figure 5.

The 1998 variable water rate study was modified so that the three zones applied approximately 50, 75, or 100% of the amount applied by the partner. Three of the sites were in corn and the application amounts and yields resulted in a confusing mixture of yield versus applied water results. The fourth field was cropped with soybean. Yield, applied irrigation, and field water use efficiency (FWUE) for that site are shown in Figure 6. The yield trend shows the response of increasing irrigation with the highest yield at the 100% water application level. However, FWUE decreased slightly for the 100% level as compared to the 75% zone.

IN-FIELD PIVOT UNIFORMITY EVALUATION

Irrigation efficiency and water distribution uniformity for full sized systems are also being examined as part of the scheduling project. Adoption of irrigation scheduling techniques, especially ET based scheduling, increases the importance of good uniformity since an underlying assumption of scheduling is that each plant has an equal opportunity for access to applied water. Figure 7 shows the plot of water application catch depth from the outer three spans of a field partner center pivot system. The outer half of the center pivot represents over two-thirds of the irrigated field area and allows for efficient collection of representative water application data. The uniformity coefficient for this system was 91%, which meets the accepted industry guideline. However, reduced application depths were measured in the 1100 feet to 1250 feet distance range. The applied depth in that zone was 15 to 20% less than the system average, so in the course of an irrigation season, when eight to twelve application events might occur, that portion of the system would apply a 1 ½ to 3 inches less total water than the field average. Irrigation WUE efficiency for corn can be 10 to 20 bushels per inch of applied water. Therefore, the "underirrigated" portion of the field could have yield losses as much as 50 bushels of corn per acre due to the irrigation system water application non-uniformity. The area under this center pivot represents about 25 acres which could translate into substantial financial losses. Sprinkler package nonuniformities have been identified in almost every tested system and have increased interest of other farmers in uniformity evaluations for their systems.

1998 FIELD SUMMARY

Table 1 is a summary of yield, irrigation, and irrigation water use efficiency from 1998 and shows there is considerable variance between partners. However, examination of individual field records is required to determine if the irrigation schedule followed was appropriate to the field conditions. Rainfall amounts and distribution, and soil type also have a large influence on the amount of irrigation

water needed. Furthermore, yield is also dependent on other production factors that are not discussed here.

CONCLUDING REMARKS

The South Central Kansas Irrigation Scheduling Project began its third full year in the summer of 1999 and will continue through the summer of 2001.

SCKIMP has provided an excellent opportunity to develop and maintain a long-term relationship with irrigation farmers in south central Kansas, resulting in positive progress in establishing acceptance of ET-based irrigation scheduling as a water management tool. The in-field information measurements and observations largely been complimentary to experimental field plot and laboratory based research which increases acceptance of irrigation information from those sources.

Table 1: FIELD PARTNER WATER USE AND YIELD SUMMARY FOR 1998

Partner	Crop	Irrigation inches	Production bu/ac	Area acres	June-August Rainfall inches
1	Corn	14.1	162	133	5.3
2	Corn	15.5	180	126	6.34
4	Corn	10.8	180	138	9.2
5	Corn	7.3	142	125	10.01
6	Corn	8.4	177	136	8.33
9	Corn	16.1	175	163	6.52
13	Corn	15.6	143	112	5.93
8	Soybeans	14.4	54	123	7.57
10	Soybeans	19.9	55	122	4.71
11	Soybeans	17.7	62	130	4.72
7	Alfalfa	21.7	8.1*	130	4.87
3	Wheat/ Alfalfa	11.8	62	169	4.84
12	Wheat/ Milo/Oats	17.2	57	125	4.88

* tons per acre

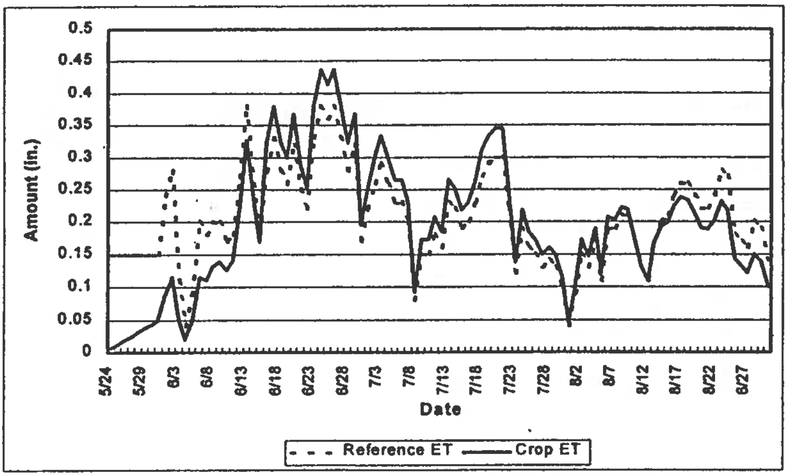


Figure 1. Daily Crop Evapotranspiration

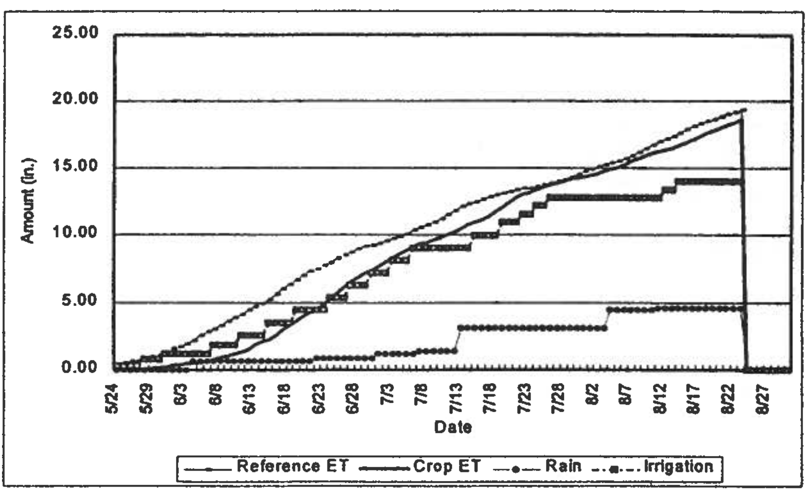


Figure 2. Cumulative Field Water Budget

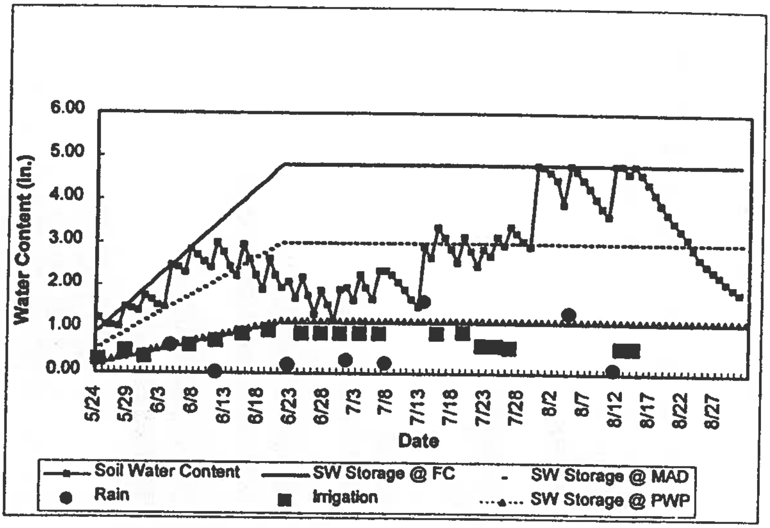
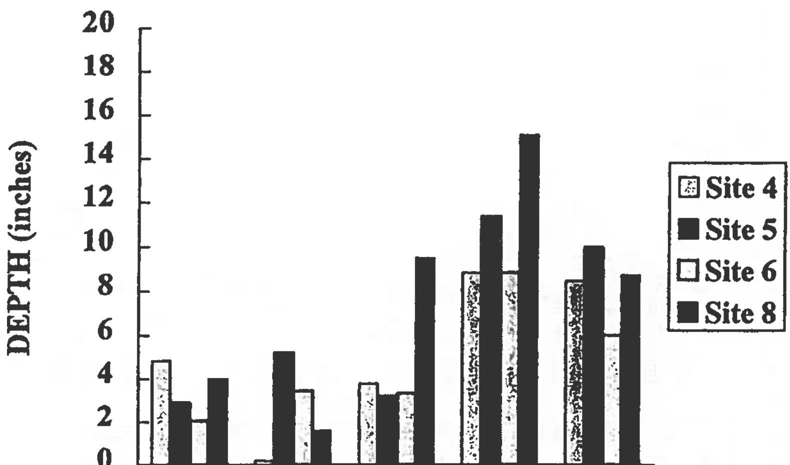
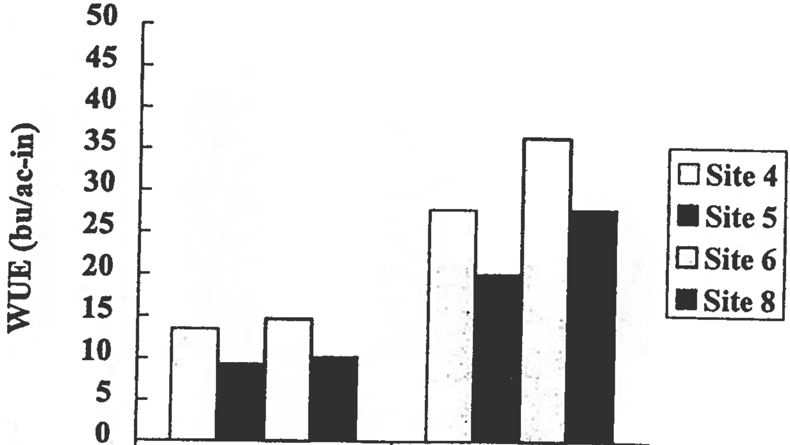


Figure 3. Field Soil Water Content, Rain, & Irrigation



	June	July	August	Total Rain	Irrigation
□ Site 4	4.85	0.18	3.78	8.81	8.46
■ Site 5	2.96	5.2	3.24	11.4	10
□ Site 6	2.05	3.42	3.35	8.82	6
■ Site 8	4.01	1.6	9.5	15.11	8.75

Figure 4. Site Rainfall and Irrigation - 1997



	Irr+Rain	Irrig
Site 4	13.6	27.8
Site 5	9.4	20.1
Site 6	14.7	36.4
Site 8	10.3	28

Figure 5. Field Water Use Efficiency - 1997

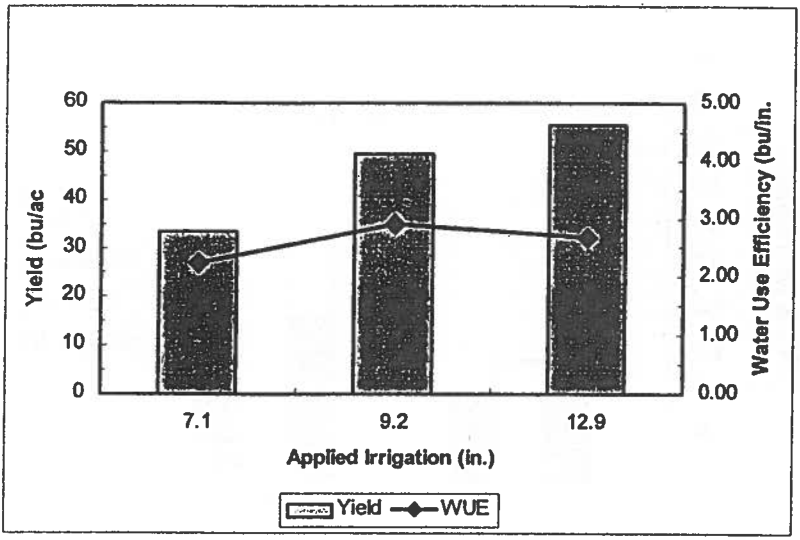


Figure 6. Yield and Water Use Efficiency - Site 8
Soybean (1998)

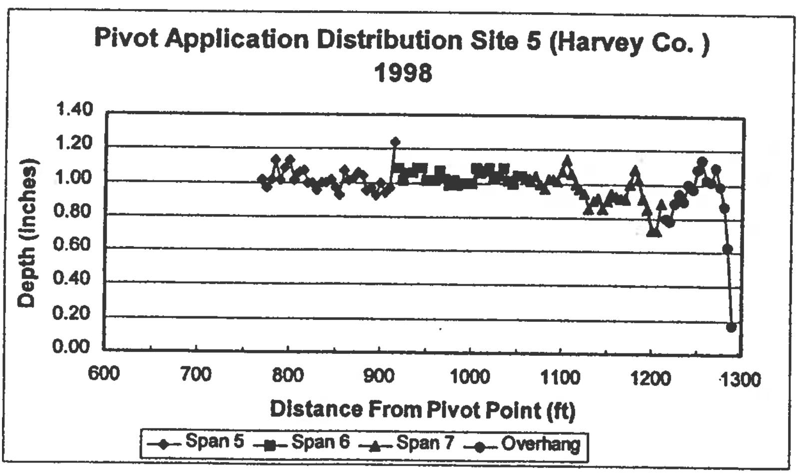


Figure 7. Pivot Application Distribution Site 5
(Harvey Co.) 1998