A Mobile Irrigation Lab For Water Conservation: I. Physical and Electronic Tools[1]

Gary Clark, Danny Rogers, Mahbub Alam, Dale Fjell and Steven Briggeman[2]

Abstract

A Mobile Irrigation Lab (MIL) has been developed to promote water conservation in agricultural irrigation production systems through education and technical assistance. This paper discusses and provides details on physical and electronic tools developed to help irrigation managers know more about their systems. A non-evaporating, low cost, in-field irrigation depth measurement gauge, called the IrriGage, has been developed and field tested. IrriGages are easily deployed and allow a field technician to perform performance evaluations of center pivot systems. IrriGages are also provided to educational program participants as a tool to enhance their knowledge of the irrigation depth component of their field water budget. Electronic tools currently include an irrigation energy/cost evaluation program (FuelCost) and a water budget based irrigation scheduling program (KanSched). Both of these have been widely accepted by farmers and government agency personnel. These electronic tools and other information are available on CD's and the MIL website (http://www.oznet.ksu.edu/mil/).

Overview

The Mobile Irrigation Lab (MIL) project is an educational and technical assistance program that is focused on enhancing irrigation and water management practices by Kansas agricultural producers, system managers, and crop consultants. The Mobile Irrigation Lab field unit is a 16 foot long, 8 foot wide trailer that has been subdivided into two 8 ft by 8 ft partitions. The front half has a classroom equipped with computers and decision management software that allows on-site, hands-on educational activities with a specific emphasis on irrigation and water management. The rear half of the MIL field unit houses field equipment that is used to conduct evaluations of irrigation systems, and to provide on-site technical assistance and other educational activities related to irrigation and cropping systems. Details on the MIL field unit and field data are discussed by Rogers et al. (2002) and in a companion paper by Rogers et al. in this proceedings.

IrriGages

The IrriGage is an in-field, non-evaporating rainfall and sprinkler irrigation measurement device. Several processes were involved in the construction of IrriGages (Fig. 1). Most of the gage materials were PVC pipe and could easily be attached by solvent welding with PVC cement. IrriGages were constructed using an 8-inch long piece of SDR 35 PVC sewer pipe for the body tube [4-inch nominal size], and a PVC sewer and drain cap for the barrel bottom cap [4-inch nominal]. The top lip of the body tube was beveled using a router to create a "sharp edge". A 4-inch long piece of ¾-inch nominal PVC pipe was capped on one end and solvent welded to the side of the IrriGage barrel tube for use as a mounting tube. Prior to solvent welding onto the IrriGage, one

[2] Professor (gac@ksu.edu), Professor, and Associate Professor of Biological and Agricultural Engineering, respectively; Professor of Agronomy, and Student Research Assistant, Department of Biological and Agricultural Engineering; Kansas State University, Manhattan, KS.

edge of the side mounting tube was sanded flat to eliminate the protruding edge of the end cap and to increase the surface area of contact for the solvent welding procedure.
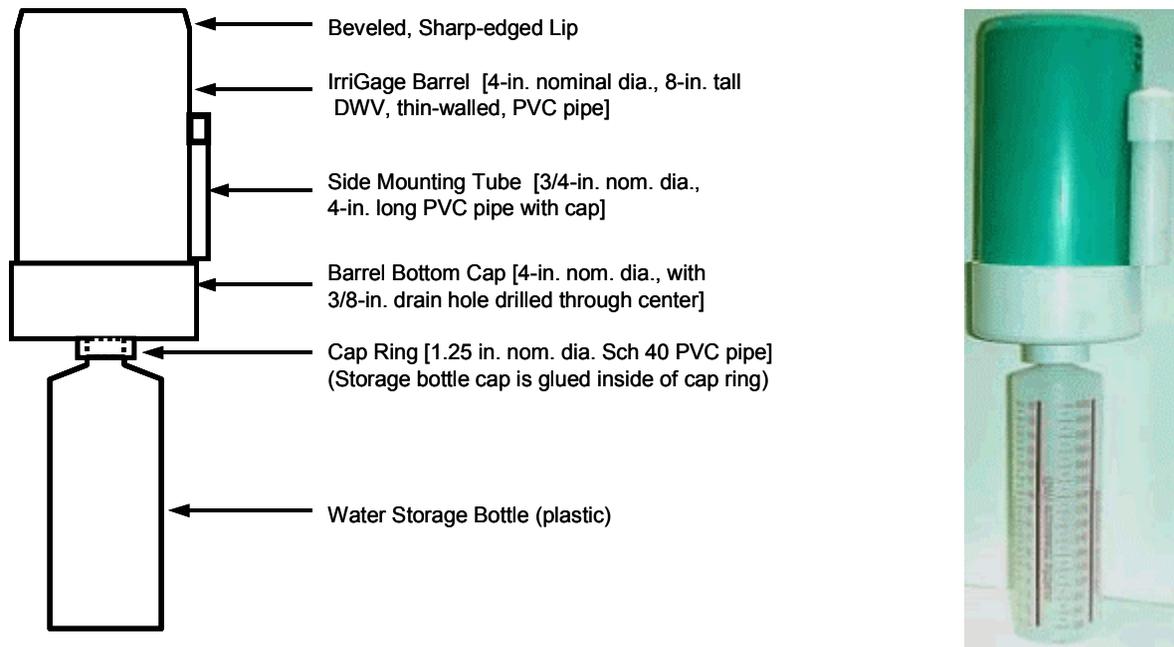

Figure 1. Construction and material details of the IrriGage with a completed device.

Several bottle types were used for storage bottles and because of different plastic types it was challenging to find a glue or adhesive material to attach the bottle cap to the barrel bottom cap. Some of the initial bottles had large diameter caps, which were attached to the barrel bottom cap with a silicone sealer and screws. The current storage bottle is a graduated and marked 500 ml plastic bottle with a 1.25-inch diameter hard plastic cap. In order to secure the bottle cap to the barrel bottom cap, a ½-inch long ring of 1.65-in. outside diameter (1.25-inch nominal) schedule 40 PVC pipe was solvent welded onto the center of the outside of the barrel bottom cap for use as a cap ring support. The storage bottle cap fit inside of the cap ring and was attached to the barrel bottom cap using Plumbers Goop[3] adhesive and sealant, which also acted as a supportive filler between the storage bottle cap and the cap ring.

The 500 ml capacity of the storage bottle was sufficient to hold 2.5-inches of precipitation, and was considered adequate for most irrigation events and many rainfall events. Because the Irrigage could be used as an in-field device for multiple irrigation and rainfall events that may exceed the 2.5-inch depth capacity, excess water would be stored in the body tube and an air hole was not drilled into the top of the storage bottle. Rather a 3/8-inch diameter hole was drilled through the center of the storage bottle cap and the barrel bottom cap to allow collected water to flow into the storage bottle. Extensive field-testing has shown that the IrriGage is an effective tool to measure sprinkler irrigation application or rainfall without any evaporative loss for an extended period (Clark et al. 2002).

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[3] Mention of specific products, trade-names, or companies does not imply endorsement by the authors or Kansas State University.

KanSched

KanSched is a computer program that can be used for irrigation scheduling or general field water management purposes. The KanSched program has been field tested in south central and southwest Kansas by farmers, crop consultants, and researchers. The program started out as a coded Excel file that could only handle one field at a time, but is now coded in an executable Visual Basic format that is very easy to use and can handle multiple fields. The program was designed for irrigation management and scheduling of summer annual crops. A "field" is an irrigated field that is managed as a single zone. The opening window (Fig. 2) allows the user to create a new field, edit an existing field, to update the ET (evapotranspiration) data set, or to view the different ET groups. An ET group is simply the name of a weather station or unit to which several fields may be associated.
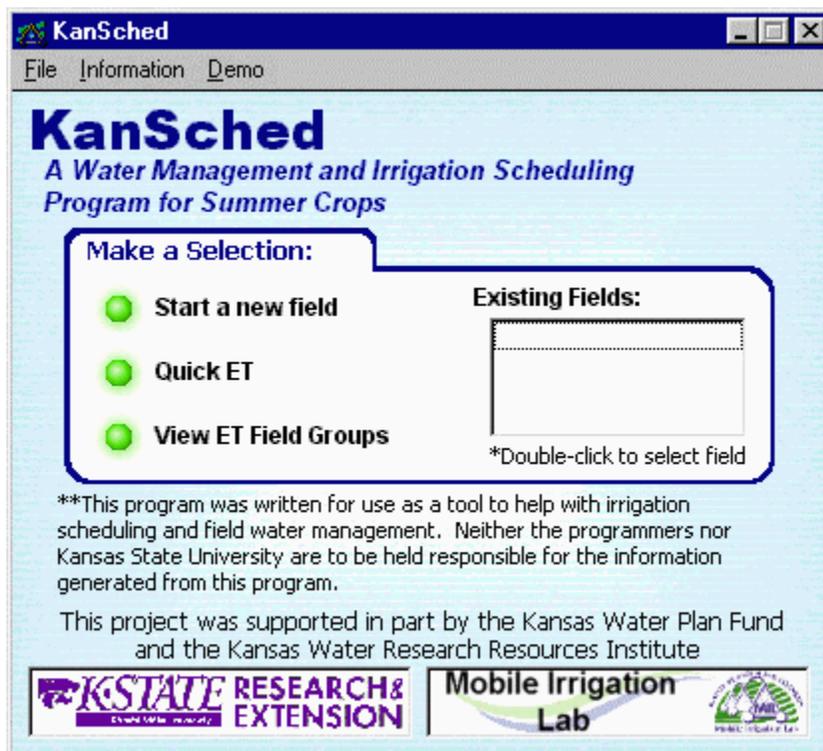

Figure 2. KanSched opening window.

Field specific characteristic data are entered onto the "Input" data page (Fig. 3, upper). These data include soil and crop characteristics that are used to create the capacity of the water budget reservoir, and to internally generate a crop coefficient data curve that is used to modify the inputted reference evapotranspiration (ETo: grassed-based; or ETr: alfalfa-based) to a crop evapotranspiration (ETc) value. The user may enter soil and crop characteristics value, or default soil data based upon different textures and crop data based on crop type, emergence date, and season length may be used.
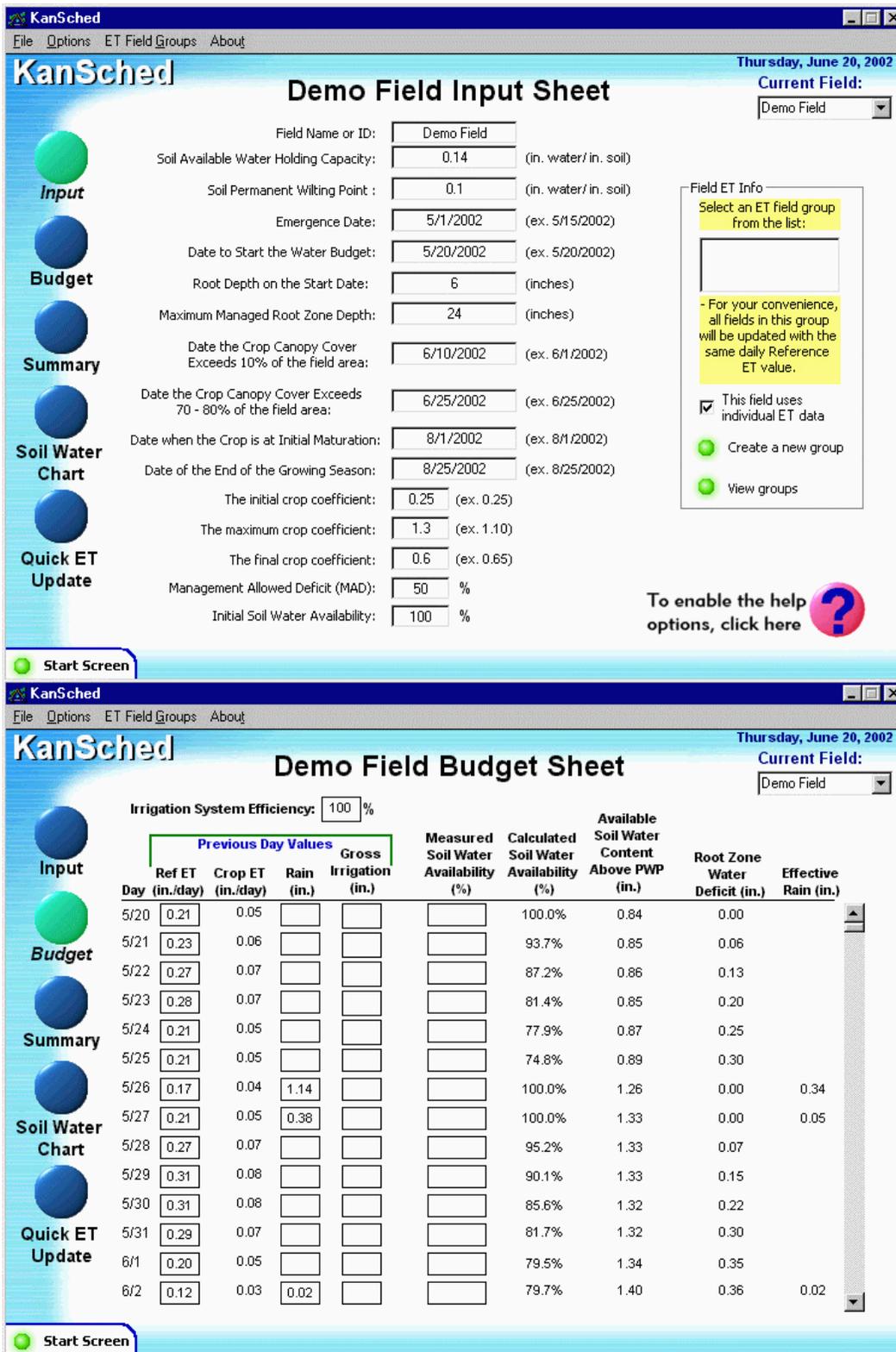
KanSched
File Options ET Field Groups About

KanSched

Thursday, June 20, 2002

Demo Field Input Sheet

Current Field:
Demo Field

Input

Budget

Summary

Soil Water Chart

Quick ET Update

Field Name or ID:	Demo Field	
Soil Available Water Holding Capacity:	0.14	(in. water/ in. soil)
Soil Permanent Wilting Point :	0.1	(in. water/ in. soil)
Emergence Date:	5/1/2002	(ex. 5/15/2002)
Date to Start the Water Budget:	5/20/2002	(ex. 5/20/2002)
Root Depth on the Start Date:	6	(inches)
Maximum Managed Root Zone Depth:	24	(inches)
Date the Crop Canopy Cover Exceeds 10% of the field area:	6/10/2002	(ex. 6/1/2002)
Date the Crop Canopy Cover Exceeds 70 - 80% of the field area:	6/25/2002	(ex. 6/25/2002)
Date when the Crop is at Initial Maturation:	8/1/2002	(ex. 8/1/2002)
Date of the End of the Growing Season:	8/25/2002	(ex. 8/25/2002)
The initial crop coefficient:	0.25	(ex. 0.25)
The maximum crop coefficient:	1.3	(ex. 1.10)
The final crop coefficient:	0.6	(ex. 0.65)
Management Allowed Deficit (MAD):	50 %	
Initial Soil Water Availability:	100 %	

Field ET Info

Select an ET field group from the list:

- For your convenience, all fields in this group will be updated with the same daily Reference ET value.

☑ This field uses individual ET data

⬤ Create a new group

⬤ View groups

To enable the help options, click here ❓

⬤ Start Screen

KanSched
File Options ET Field Groups About

KanSched

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Demo Field Budget Sheet

Current Field:
Demo Field

Input

Budget

Summary

Soil Water Chart

Quick ET Update

Irrigation System Efficiency: 100 %

Day	Previous Day Values Ref ET (in./day)	Crop ET (in./day)	Rain (in.)	Gross Irrigation (in.)	Measured Soil Water Availability (%)	Calculated Soil Water Availability (%)	Available Soil Water Content Above PWP (in.)	Root Zone Water Deficit (in.)	Effective Rain (in.)
5/20	0.21	0.05				100.0%	0.84	0.00	
5/21	0.23	0.06				93.7%	0.85	0.06	
5/22	0.27	0.07				87.2%	0.86	0.13	
5/23	0.28	0.07				81.4%	0.85	0.20	
5/24	0.21	0.05				77.9%	0.87	0.25	
5/25	0.21	0.05				74.8%	0.89	0.30	
5/26	0.17	0.04	1.14			100.0%	1.26	0.00	0.34
5/27	0.21	0.05	0.38			100.0%	1.33	0.00	0.05
5/28	0.27	0.07				95.2%	1.33	0.07	
5/29	0.31	0.08				90.1%	1.33	0.15	
5/30	0.31	0.08				85.6%	1.32	0.22	
5/31	0.29	0.07				81.7%	1.32	0.30	
6/1	0.20	0.05				79.5%	1.34	0.35	
6/2	0.12	0.03	0.02			79.7%	1.40	0.36	0.02

⬤ Start Screen

Figure 3. "Input" page (upper) for general field characteristic data, and "Budget" page (lower) for entering and monitoring field water budget data.

The input data page (Fig. 3, upper) and other pages include a sidebar of "page buttons" to let the user access other pages. The "Budget" page (Fig. 3, lower) is the page that calculates and shows the field water budget information. ET data can be entered on this page or on the "Quick ET" page (not shown). Calculated crop ET data are then displayed in the third column. Site-specific rainfall and "Gross Irrigation" are entered into columns four and five on this page for the field that is identified in the upper right-hand corner. Irrigation system (application) efficiency is entered in the upper left window of this page and is used to adjust the gross entered irrigation depths to net depths.

Column seven displays the calculated soil water availability. Zero represents permanent wilting point and 100% represents the field capacity value for the profile. If the user has measured field data of soil water content (as a percent of "full") they can enter that value into column 6 ("Measured Soil Water Availability") to adjust "calculated" values into field calibrated values. Column eight shows the available soil water content for the profile that is above the permanent wilting point and column nine shows the root zone water deficit value that is below field capacity. Thus, the user can estimate how much water remains in the profile and how much water the profile can hold until it is full.
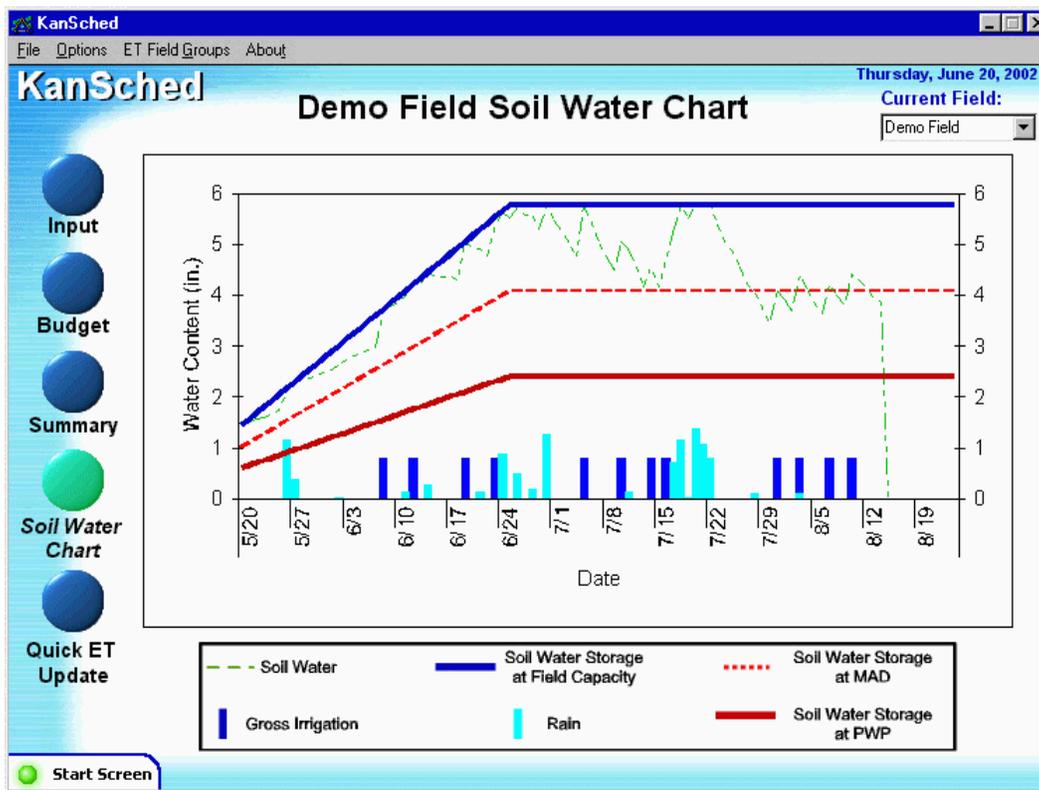
Figure 4. "Soil Water Chart" page showing the field soil water content with field capacity, management allowed deficit (MAD) and permanent wilting point limits along with rainfall and irrigation events.

The rightmost (tenth) column displays "Effective Rain" which is defined as the amount of rain that the profile could hold at the time of a rainfall event. For example, on May 26 (Fig. 3, lower) a 1.14-inch rainfall event was recorded for May 25. The root zone water deficit on May 25 was 0.30 inches and the crop ET was 0.04 inches (as shown on May 26 for the previous day value). Therefore any rain in excess of (0.30 + 0.04 inches) 0.34

inches was considered "not effective" since the profile did not have the storage capacity to hold it. These data are also shown graphically on the "Soil Water Chart" (Fig. 4). This chart helps the user to visually monitor their soil water profile along with upper and lower storage limits, and rainfall and irrigation events.

Finally a "Summary" page (not shown) provides the users with seasonal cumulative summary information on net and gross irrigation amounts, total and effective rainfall, and crop evapotranspiration.

Irrigation Fuel Cost Evaluator

The Irrigation Fuel Cost Evaluator program (FuelCost) is a simple, executable program that can be used to assess the cost of irrigation and to initiate pumping plant system performance evaluations. The user needs to input irrigated field size (acres), irrigation system capacity (gpm), operating pressure (psi) at the wellhead, an estimate of lift and friction head (feet), and their individual event or seasonal irrigation depth (inches). Help windows open to provide assistance with determining these values. The user then selects the type of power unit (Natural Gas, Electric, Diesel, or Propane) and enters the cost per unit of fuel. If they know their cost for the irrigation event or season, they can enter that value. The program then calculates what the energy cost "should" be with the Nebraska performance criteria and compares that to what the user entered.
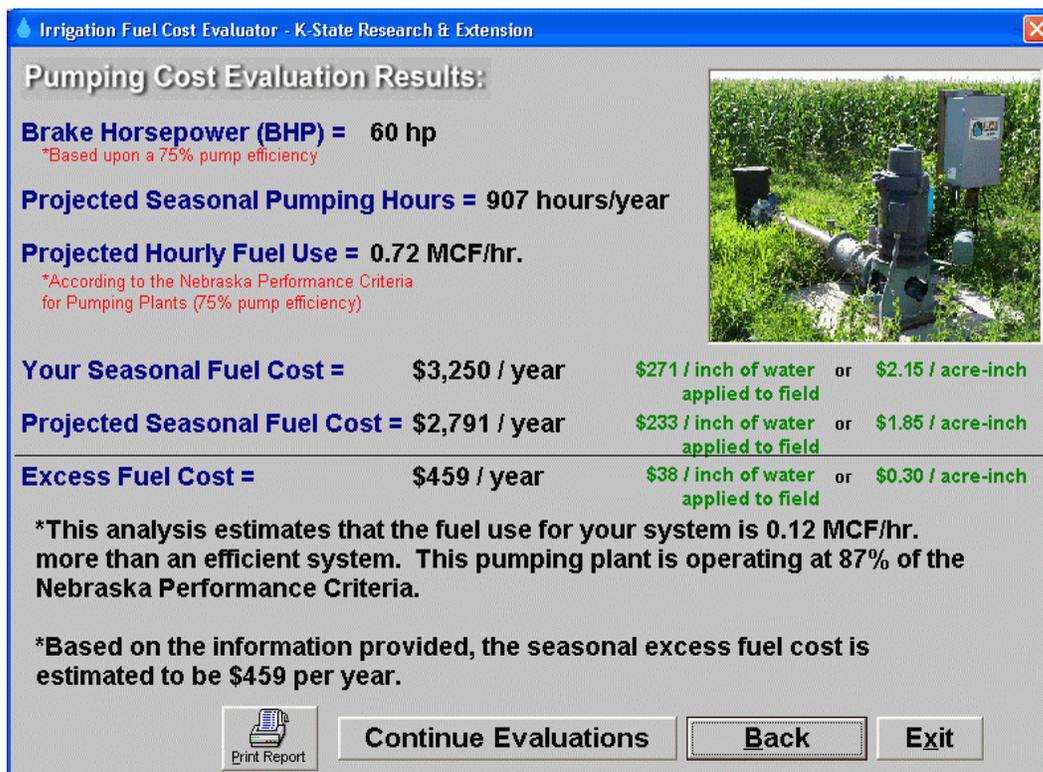
Figure 5. Irrigation Fuel Cost Evaluator program output for the example data set.

For example, consider the following inputs: Field size:126-acres; System capacity: 750 gpm; Operating pressure at the well head: 35 psi; Pump lift anf friction head: 155 ft; Annual irrigation application depth: 12 inches; Price for natural gas: $4.25/MCF; Current seasonal irrigation fuel cost $3250/yr. These data were entered into the Irrigation Fuel Cost Evaluator program. The output screen in Fig. 5 (above) shows that the

while the actual seasonal irrigation fuel cost was $3,250 the projected cost based on the Nebraska performance criteria for pumping plants would be $2,791. Thus, the system perhaps has an "excess" fuel cost of $459. This information is used to help the owner/operator to decide if a physical pumping station performance evaluation should be conducted. In addition, the output shows that the current application costs average $271 per inch for the entire field. This other piece if information is useful when discussing the economic savings associated with irrigation scheduling.

Center Pivot Depth Calibrator

The Center Pivot Depth Calibrator program (http://www.oznet.ksu.edu./mil/) is an online tool that can be used to provide a timer setting / application depth chart for a center pivot system using on-site, in-field data. The user enters from one to three sets of data points (Fig.6) that would have in-field measured water depths and the associated center pivot system panel setting (%) value. The program then calculates a scaled output chart of irrigation system application amounts for different panel setting values (Fig. 6). The program also includes a print option to print a copy of the application table.

Figure 6. Screen shot of the online center pivot system application depth calibration program.

Mobile Irrigation Lab (MIL) Website

The previously discussed programs are available as downloadable electronic tools on the Mobile Irrigation Lab (MIL) website (http://www.oznet.ksu.edu./mil/). Users manuals with supporting audio files are also available on the MIL website. Additional resources on the MIL website includes other printed and electronic media with information related to irrigation systems and water management, a photo gallery of relevant pictures, and links to related websites.

Summary

This paper presented information on both physical and electronic tools that can be used for irrigation system performance evaluations and system management. Tools included the IrriGage: a non-evaporating, in-field precipitation measurement device; KanSched: an easy to use, computer program that uses reference crop evapotranspiration (ETo or ETr) in a water budget based irrigation scheduling and water management program; FuelCost : a simple program that can be used to assess current irrigation fuel costs and to compare with standard performance criteria; and Center Pivot Depth Calibrator: an online electronic tool that creates a center pivot timer setting / application depth calibration chart based on measured field data.

Acknowledgements

References

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