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SCHEDULING IRRIGATION ON COTTON USING INTERNET-BASED WOODRUFF IRRIGATION CHARTS

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Abstract

Irrigation scheduling is important to insure yield loss is minimized and profit maximized. Some methods of scheduling can be time consuming or require expensive sensor systems. A simple scheduling approach developed for Missouri based on historic weather records is referred to as the "Woodruff Chart". Originally this was a paper-based chart, and now this method is available to producers over the Internet. Initial results indicate users of the Woodruff method are not obtaining yields as high as those using another irrigation scheduling program, the Arkansas Scheduler; however, these results are based on a very limited number of producers (two over a four year period) using the Woodruff method.

Introduction

Missouri has a temperate climate with an annual rainfall amount of 40 to 50 inches. This precipitation amount is nearly twice the annual consumptive use requirement for one of its major agronomic crops, cotton. Unfortunately, not enough of this rainfall comes during the summer months, which leads to yield decline from water stress. Currently, irrigated yields surpass dryland yields by 177 lbs of lint per acre on cotton. These increases relative to dryland yields have been slowly edging up over the least several years. Farm surveys showed that 17% of the irrigators were using irrigation scheduling (Henggeler, 2004), but the use is mostly by corn growers with cotton growers one of the least likely groups to use scheduling.

In semi-humid areas where intermittent rainfall occurs and there is probability for rain on the horizon, it can be difficult to make the decision to irrigate. The two prime scheduling methods in Missouri are the computer program ***Arkansas Scheduler*** developed by the University of Arkansas (Ferguson et al., 2000) and an irrigation graphical method called a Woodruff chart. The latter has now been put on the Internet and is the topic of this paper.

What a Woodruff Chart Is

The Woodruff irrigation scheduling method uses historic weather data and modern crop coefficients to develop a chart that is used as a graphical means to schedule irrigation. The chart consists of a graph containing two parallel, curvilinear lines. The top one represents the accumulative crop water of the crop for the emergence date and the locale in question. The bottom line indicates when drought would occur and is offset a vertical distance equal to the water holding capacity of the soil. The X- axis (horizontal axis) of the graph represents time, while the Y-axis (vertical axis) represents inches of water.

To schedule irrigations, the user merely pencils in the rainfall amounts in an up-and-down fashion on the day they occur, using the same vertical units that the crop water use curve is plotted with. The second and subsequent rainfall events are penciled in on the graph on their appropriate date. These subsequent lines start at a level equal in elevation to the top of the last penciled-in rainfall event, creating a stair-step pattern. Irrigation occurs before the stair-step crosses the bottom (drought) line. Irrigation amounts are penciled in the same manner as rainfall events. If a rainfall or irrigation amount takes the stair-step across the top line, any portion above the accumulative curve is considered deep-percolation, and is discounted. In this case, the irrigator begins the stair-step, not at the top of the rainfall line, but at a level equal to where the rainfall line and the accumulative water use line crossed.

The Internet Woodruff Chart

The opening query screen (Figure 1) asks the user to choose a crop (corn, cotton, or soybeans), soil type, irrigation method (pivot or flood), and county in Missouri. The Blaney-Criddle evapotranspiration (ET_{BC}) equation is employed in the Internet version. Daily values of evapotranspiration are calculated using a splining function upon published monthly mean values of daily maximum and minimum temperatures. Latitudinal values are used to calculate daylight hours, part of the Blaney-Criddle equation. A database was established that contains, for each Missouri county, latitude, daily maximum temperature, daily minimum temperature, and daily ET_{BC}. These data were based on 30-year weather records.

The next screen that a viewer sees (Figure 2) asks for additional information including emergence date, field name, acreage and Relative Maturity or Maturity Group, depending on whether corn or soybeans had been chosen. It was found that "field name" was important as some growers had a number of various fields that Woodruff charts were printed up for. Acreage data was asked for so that developers could measure total impact.

The final screen (Figure 3) before the graph is created, presents computer-suggested data including date crop will cease up-taking water, estimated water holding capacity of the soil, the ideal soil moisture status at the end of the season, and the deficit at which to trigger irrigations. These values are derived from data already supplied by the user, and can be adjusted if needed to be.

Irrigation Trigger Points

The soil type, crop, and method of irrigation determine the irrigation trigger (a.k.a., deficit) to default to (Table 1). This value represents the off-set between the bands in the chart. These suggested values are based on empirical research done by the University of Arkansas and are employed in their computer program, ***Arkansas Scheduler*** (Ferguson, 2000).

Results

Table 2 shows the results from four years of surveys (Henggeler, 2004) that show the yields made by irrigators who do not schedule, those who use the Arkansas Scheduler, and those that use the Woodruff scheduler. For cotton, the Arkansas Scheduler did the best and made 100 lbs of lint per acre more then non-users. The Woodruff users (only 2 in four year's of survey) did not do near as well. This may be do to the small sample size, as it is known that one of Missouri's most successful cotton irrigator makes use of the charts. The table includes data for other crops. The Woodruff users do very well on corn.

References

Ferguson, J., D. Edwards, J. Cahoon, E. Vories, and P. Tacker. 2000. UACES Irrigation: Microcomputer Based Irrigation Scheduler, Ver. 1.1w. University of Arkansas.

Henggeler, J. 2004. 2000-03 Bootheel Irrigation Surveys. Unpublished data, University of Missouri.

Table 1. Recommended irrigation deficits used by the Internet Woodruff chart program

	Pivot	Flood
Soil Type	Default Irrigation Deficit (inches per application)	
Coarse Sand	1.00	1.50
Fine Sand	1.50	2.00
Loamy Sand	1.05	2.00
Sandy Loam	1.75	2.25
Fine Sandy Loam	1.75	2.25
Very Fine Sandy Loam	1.75	2.25
Clay	1.50	2.00
Clay Loam	1.50	2.00
Silty Clay	2.00	2.50
Silty Clay Loam	2.00	2.50
Silt Loam	2.00	2.50

Table 2. Yields and number of Missouri irrigators who do not use scheduling tools, use the Arkansas Scheduler and use Woodruff charts, 2000-2003.

Crop	No scheduling method	Arkansas Scheduler	Woodruff irrigation charts
Cotton	871.1 lbs/ac n = 82	978.2 lbs/ac n = 12	813.0 lbs/ac n = 2
Corn	168.7 bu/ac n = 153	177.0 bu/ac n = 20	181.2 bu/ac n = 29
Soybean	44.0 bu/ac n = 118	46.7 bu/ac n = 10	46.7 bu/ac n = 6
D.C. Soybean	39.7 bu/ac n = 75	44.3 bu/ac n = 4	39.5 bu/ac n = 2

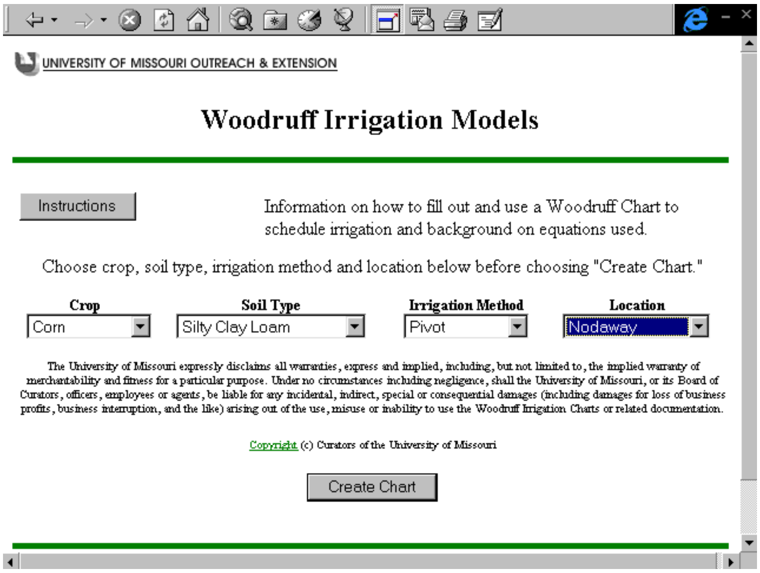

Figure 1. Opening query screen of the Woodruff Irrigation Chart Internet site.

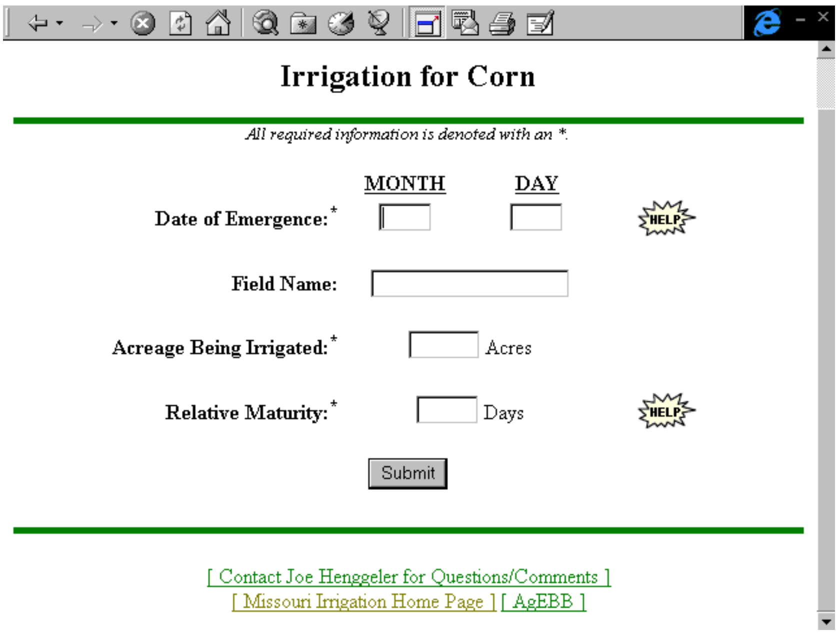

Figure 2. The second query screen that collects data for developing the Woodruff chart.

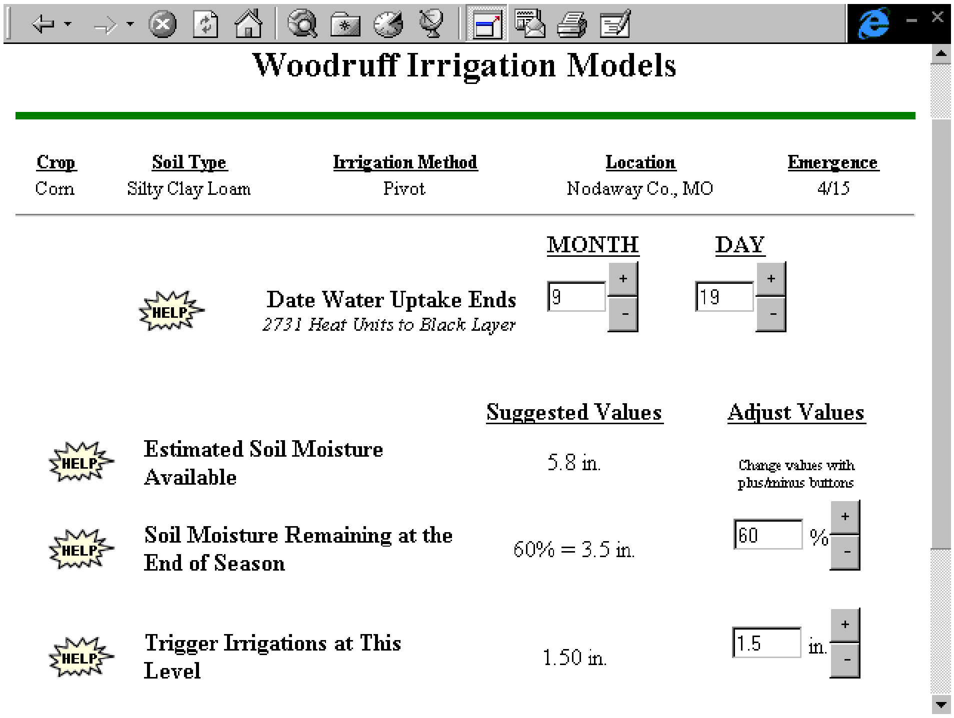

Figure 3. Final query screen. Values include estimated date of final water use, estimated soil moisture available, dry-down level for end-of-season, and ideal irrigation trigger level. These values can be changed based on grower's preference.