Software Programs Currently Available for Irrigation Scheduling

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I. Irrigation Scheduling Programs (Real-Time Weather)

1.-- The ***Michiana Irrigation Scheduler*** program is available free from the Internet. It schedules irrigation for a variety of crops. Some of the notable features are as follows. Based on the Stress Day Index concept, one is able to view estimated final yield throughout the season (yields are reduced from an inputted maximum yield value) as the soil becomes too dry. The associated soil moisture status (status can go saturated) is presented both numerically and graphically, through quantities of "+" or "-". Historical weather sets for various latitudes of Michigan and Indiana are included. Real weather (only maximum and minimum temperature) is compared to averages to show deviation from norm. Software is compact (562 K), but does a good job and is easy to use. One toggles between the two main input screens "Field, Crop & Soil Data" and "Weather & Irrigation Data" (Fig. 1.1) to input the data. Hitting the "CALC" button allows the program to calculate and present data. One problem is that summary data (total deficit, days until 1-in of deficit occurs, current ET_c) is only visible for a single date (which was chosen back on the input screens).

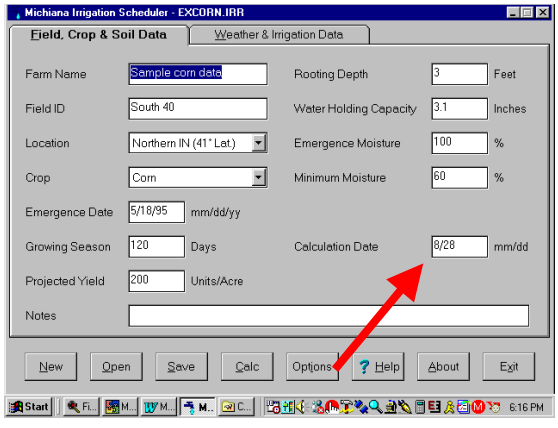


Fig. 1.1 - The main menu page for the *Michiana Scheduler*, tabbed over to show "Field, Crop & Soil Data" side. The date shown on this page (red arrow) will have its summary data shown; the program will forecast 7 days beyond this point.

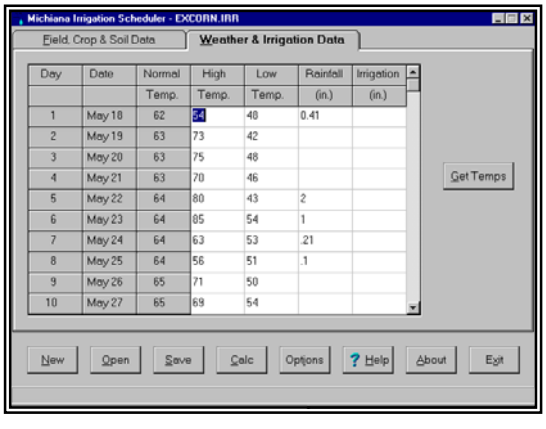


Fig. 1.2 - The "Weather & Irrigation Data" side of the main menu page for the *Michiana Scheduler*. High & low temps are shown; historic is used until actual data is supplied. "Options" selection will give user the choice of using average, rather then max/min temperature. One can get weather data from another file by using "Get Temps."

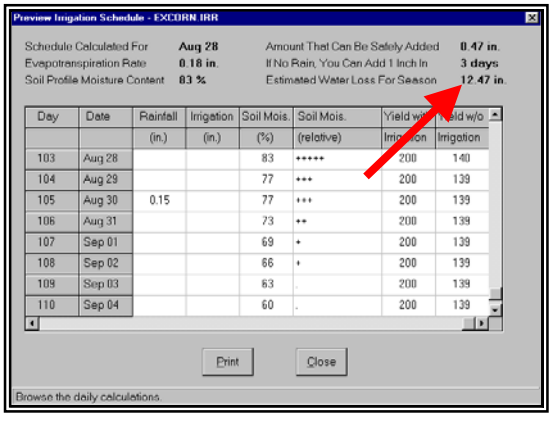


Fig. 1.3 - The page showing resulting data (after choosing "Calc" from main menu page). All the data at the top of the mast is just for the single date previously chosen on the main menu. The *Michiana Scheduler* is predicting final yield to be 139 bu/acre based on the seasonal stress endured by the crop. Note it also provides estimates of water loss to deep percolation (red arrow); this might be a useable tool to make fertigation decisions with . Not shown in the figure is the deviation from historic daily temperatures.

2.-- The ***Arkansas Scheduler*** is a computer program that has been around since 1980. It is developed and strongly supported by the University of Arkansas. The University's innovated ***Verification Program*** is partially responsible for its widespread use in Arkansas and other states in the mid-South. The Verification Program is a pseudo-consulting effort by the University, in which only a couple of producers per commodity (corn, soybeans, rice, and wheat) in a county are chosen to be worked with. These producers provide a field to follow University BMPs and a check field. The yield results are outstanding. Participants point to weed control and irrigation as the two areas they alter the most. One of the BMPs for irrigation is using the ***Arkansas Scheduler***. Thus the impact of irrigation scheduling over a significant number of years and a large number of locations can be seen. One of the most controversial aspects of using the ***Arkansas Scheduler*** regards whether to irrigate on the date it calls for if a rain is forecast. The university-endorsed protocol is to irrigate anyway, as many showers never materialize. The advice appears to be beneficial, as growers in the program continue to experience good yields. The program is free from the Internet. The day to day use of it is fairly easy, but many growers have a hard time getting the files initially set up, which is done by choosing option 4 "Alter or Initialize Irrigation File" in the main menu, which is shown in Figure 2.1.

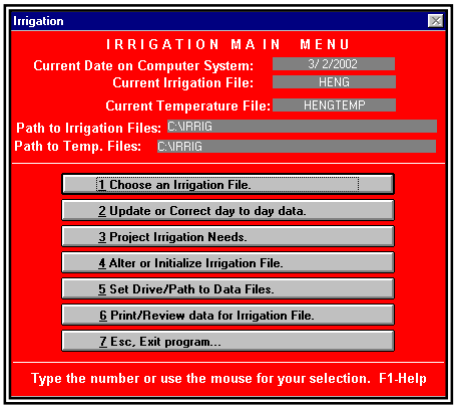


Fig 2.1 - The main menu for the *Arkansas Scheduler*.

The set up takes place in the menu shown in Figure 2.2. One of the greatest innovations in the ***Arkansas Scheduler*** is that it suggests the irrigation deficit based on crop and soil, and to a degree, irrigation method. The suggested deficit values will appear in a pop-up text box when the user is in the "Start Irrig. Deficit" column (Fig. 2.2). Thus, users does not have to toy with crop rooting depths, soil water holding capacities, and MADs. The suggested deficits have been empirically derived. Growers, however, can alter these deficits if they desire to. Once the original set-up data is saved and stored, one does not need to deal with this screen again. From the main menu, choose option 2 "Update or Correct day to day data" to input weather data (only max temperature is needed) and irrigation and rainfall amounts. Choice 3, "Project Irrigation Needs", will go through several screens that show current moisture status (Fig. 2.3) and project when to irrigate.

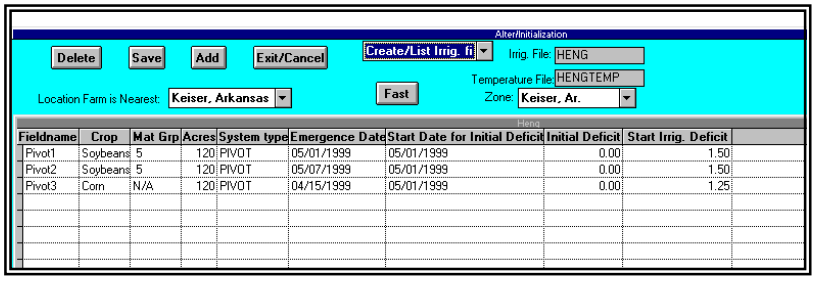


Fig. 2.2 - The set up page for *Arkansas Scheduler*. Up to 16 separate fields can be set up. The irrigation deficit values at which to trigger watering are suggested as BMPs. The starting moisture condition can occur before, on, or after actual emergence date of the crop. The program suggests using an ample rainfall event sometime around emergence as a starting point, in which case the deficit is known to be 0.0 inches.

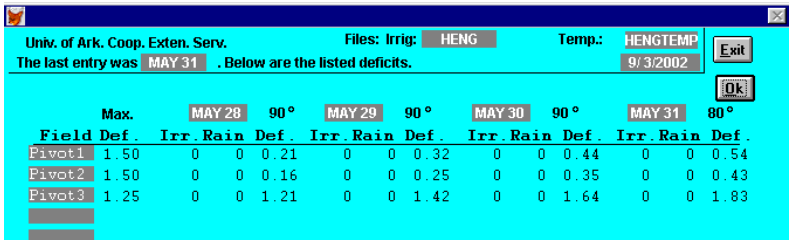


Fig. 2.3 - Recent moisture status conditions is shown.

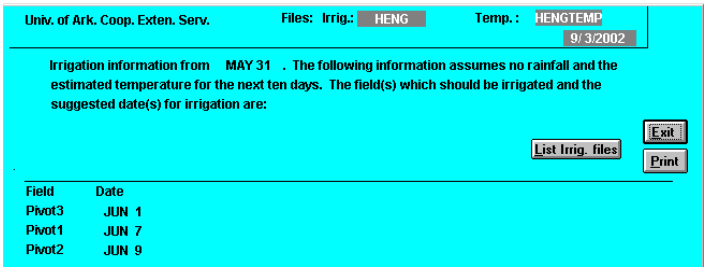


Fig. 2.4 - Final viewed page lists the fields that need to be irrigated and the dates on which to apply the irrigation. Clearly delineating the date irrigation will occur ahead of time is an important aspect of any good irrigation scheduling program.

3.-- The ***KanSched*** program began life as ***Kiscorn,*** a spreadsheet scheduling program. Kansas State University developed the program. It is very nice looking, which, it is felt, has aided in grower adoption. The program does not use raw weather data, but instead needs ET_o or ET_r data. Kansas has a network of weather stations and ET is available on the Internet. Unfortunately, these data must be hand input at this time. The program's main operations work out of a single page (Fig 3.1) that makes things handy. It displays soil moisture deficit when clicking on "Soil Water Chart". However, the required 16 data input fields are too cumbersome, and seek information that most farmers would not have readily available (e.g., four separate dates regarding maturity stage of the crop [including the date when canopy covers 70-80% of the field]). Fortunately, a help screen is available in which you merely choose season length (and with the already-inputted emergence date) which then provides best estimates for the four required dates. A help screen is also available that will allow one to choose one of the eleven major soil textural groups, rather then having to input what the Permanent Wilting Point and soil available water holding capacity values are.

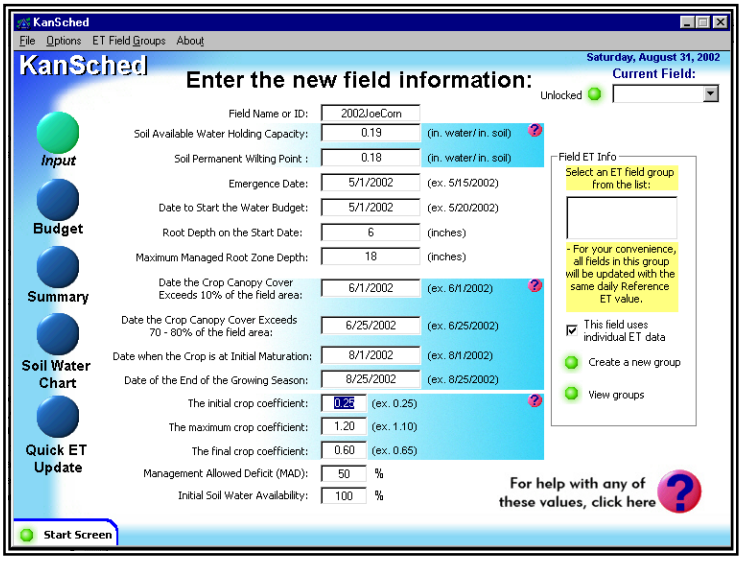


Fig. 3.1 - Main page for *KanSched*. Data can be input from here and options moved on to from here. This centralization makes the program easy to use.

4.-- NDSU's ***Computerized Irrigation Scheduling by the Checkbook Method.*** North Dakota State University has been a leader in developing Internet irrigation scheduling tools. Water use of various crops (with various emergence dates) is graphical displayed in beautiful JPG images showing the statewide 1-, 3-, 7-, and 14-day consumptive use. A companion tool is the ***Computerized Irrigation Scheduling by the Checkbook Method*** developed by them (and the University of Minnesota) based on an earlier bulletin on checkbook irrigation scheduling. The program is a compiled spreadsheet that tracks soil moisture depletion. While the program has little visual impact, it performs what needs to be done. As a spreadsheet, it allows for cut-and-paste insertion of weather data or crop water use, a feature that many of the database irrigation scheduling programs lack (Fig. 4.1). This functionality may explain why NDSU's server has more hits on its tabular ET data then its handsome graphically presented data. Some other special features include soil moisture depletion functions, easy-to-use root zone soil moisture calculators, and minimal weather data requirements (only maximum temperature). Each field can have two portions and is saved in a separate compiled spreadsheet at 2 1/2 meg each, so multiple locations could add up to large storage needs.

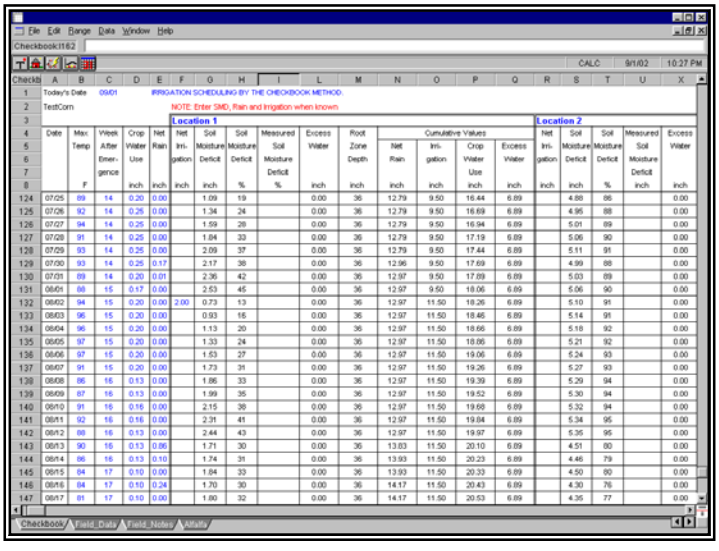


Fig. 4.1 - The program creates a spreadsheet screen for each field being scheduled. Data is input and results are viewed on the "Checkbook" tab, being displayed here. The initialization for each field is done under the "Field Data" tab.

5.--The ***AZSched*** program of the University of Arizona had an earlier life as a DOS-based program. It has some outstanding features, one of which is the large number of irrigated crops it supports. The crop coefficients are Heat Unit-driven, which is nice. However, they use a day-long integrated heat unit that is not exactly like the normal base heat unit that most places do. Therefore, some care should be taken in transporting these data to other locales, especially those that normally experience cloud cover. The program is built upon the excellent UA-run weather network, and current weather can be downloaded from about two dozen stations. Data from previous years is also available. The soil moisture content query pages can painlessly extract lots of detailed information on soil parameters (Fig. 5.1). One of the nice features of the program is that it clearly displays the moisture status of the fields being audited, so that dangerous depletion levels should not creep up on the user. A single page report with dates to irrigate can be ordered, also.

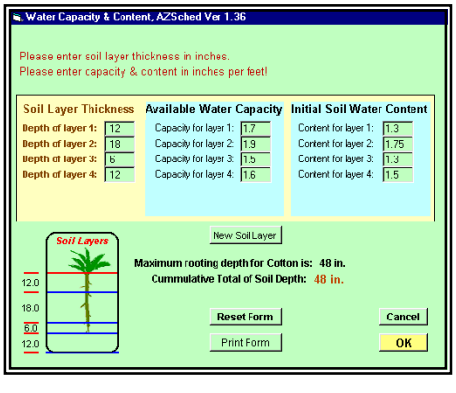


Fig. 5.1 - *AZSched* has nice input screen for inputting information about soil moisture holding data.

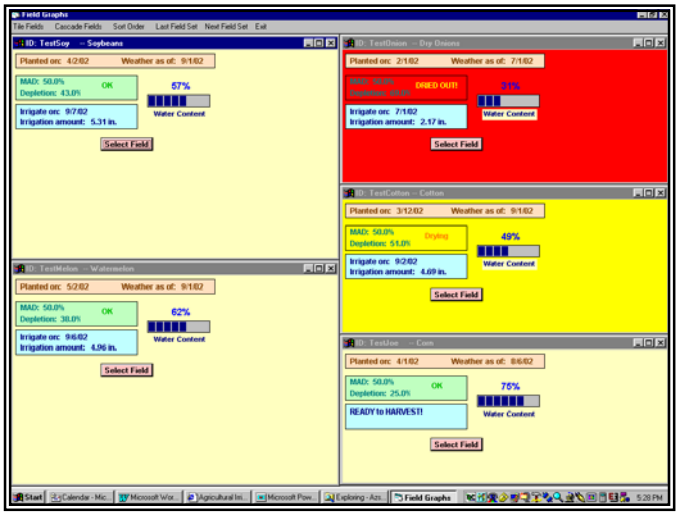
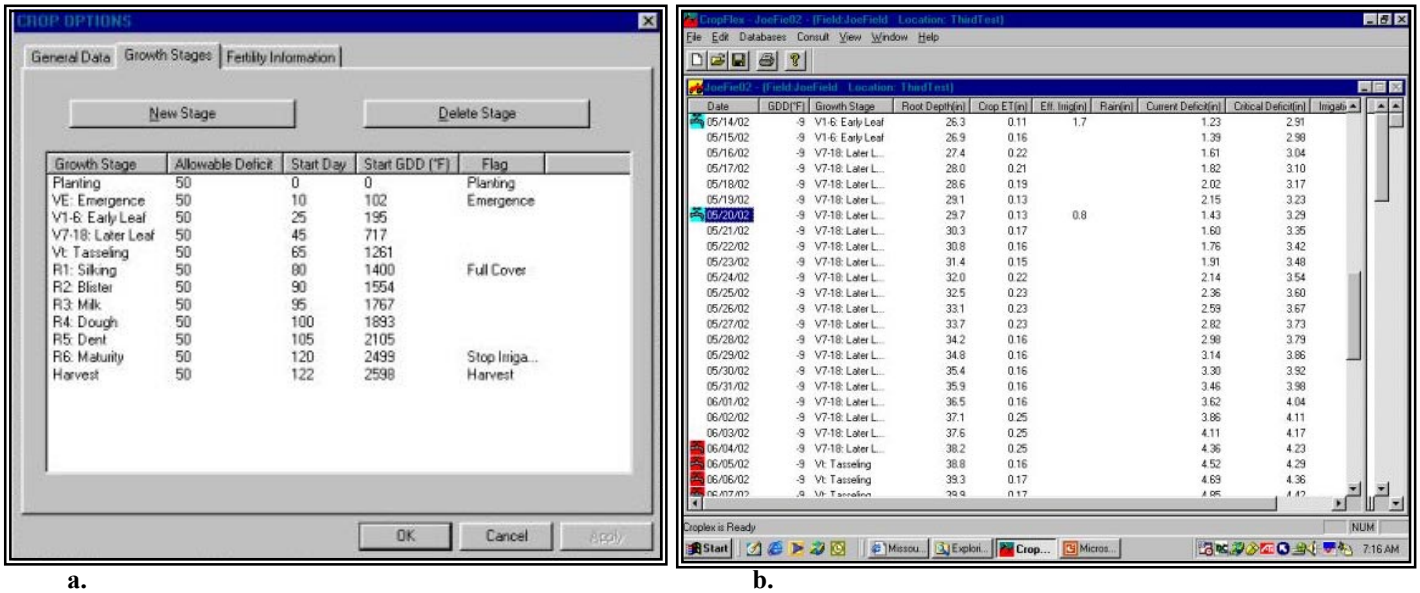


Fig. 5.2 - *AZSched* has a special page where the current status of all fields being monitored is displayed together. Backgrounds are color-coded based on how dry they are. Dates and amounts for next irrigation are shown.

6.--The ***Cropflex 2000*** program is Colorado State University's effort at managing both fertility and irrigation. The fertility management is impressive and very detailed (e.g., it not only asks for things like soil test data, but queries whether you trust the results!) The irrigation details get partially lost in the shuffle. The program imports weather text files in the CSU, KSU or USDA format; it is fortunate to be able to do this, as the manual inputting goes very slow. Generic crop data could be used (the file would still have to be made for it), but hybrid-specific files are possible. Multiple stages could be created that would have stage name, MAD, days to reach, heat units to reach, and message to display (Fig. 6.1a). These crops would also need values for the polynomial of Kc (before and after full cover). The multi-stage MAD is a worthwhile characteristic. The irrigation status is shown in a tabular form by date after planting and lists information on root depth, ETc, irrigations, rainfall, and deficits. Green-background icons on the line indicate an irrigation occurred that day. Red of the same indicates irrigation is needed (Fig. 6.1b).



a. **b.**

Fig. 6.1(a) - *Cropflex 2000*'s growth stage screen where the physiology of a crop can be entered; tab to the "General Data" to enter the values of the polynomial describing Kc. (b) Information on the daily status of soil moisture, rooting depth, etc. can be seen. Icons allow one to easily see important dates.

II. Irrigation Scheduling Programs (Historic Weather)

7.-- ***The Woodruff Chart maker.*** One very unique tool for scheduling is the Woodruff chart. The web-based program from the University of Missouri uses historical weather data to develop an accumulative water use curve for the crop, emergence date, and weather file in question.. This curve serves as a graphical tool for timing irrigations. Figure 7.1a queries the user for the initial needed information; choosing the county selects the 30-year weather average for that county. The next screen (Fig. 7.1b) queries for additional information. The Relative Maturity (RM) value of the corn hybrid or the Maturity Group (MG) of the soybean variety is input. RM information tied to emergence date and the county-associated weather file will predict black layer for the corn. MG information along with emergence date and county-based latitude allows the date of full maturity of soybeans to be predicted. Thus, this program does a very good job in predicting how long in the season to irrigate.

The concept of the Woodruff site was to keep it very simple. Growers do not have to enter root depth, water holding capacity or MAD to develop an irrigation depth per application. The program chooses this based on the crop and soil chosen. The Internet site constructs the appropriate graph and the user prints it off. From then on scheduling is done with a pencil. Figure 7.2 shows a Woodruff graph.

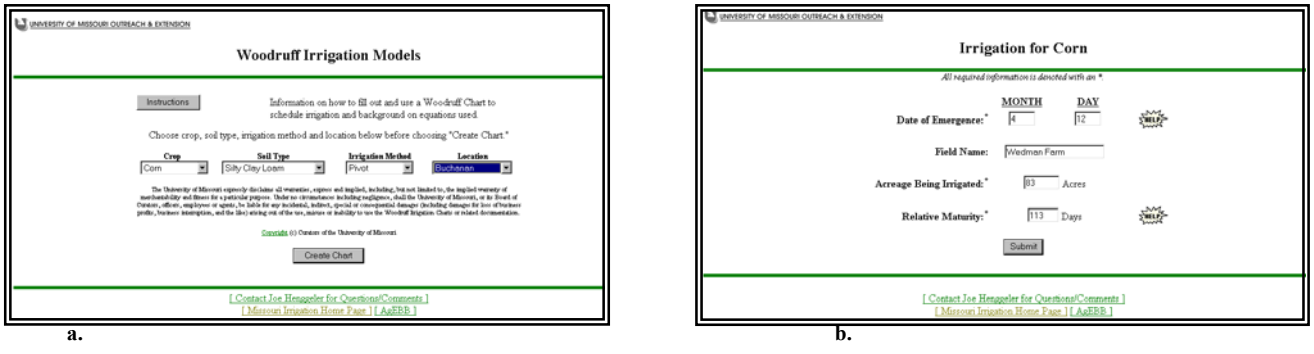


Fig. 7.1 (a) - The opening query menu for the University of Missouri's Woodruff Chart maker (which resides on the Internet). (b) Fig. 7.1 (b) - The next WWW level query screen interrogates for additional information.

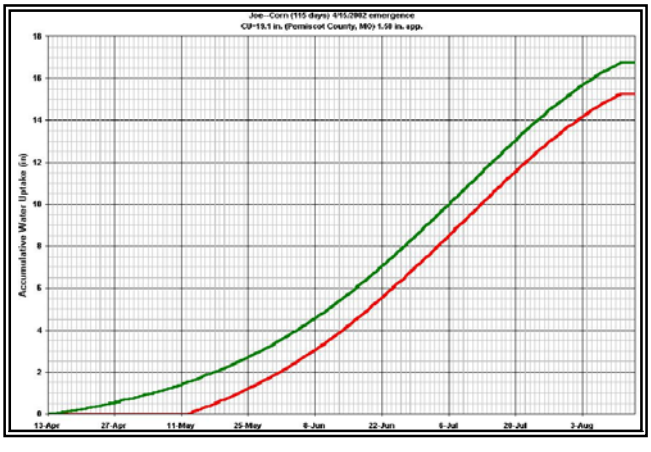


Fig. 7.2 – A customized Woodruff irrigation as it is delivered off the Internet. The green line is accumulative water use; the red line is drought region. A farmer pencils in the rains and irrigations, so as to stay between the two lines.

8. – **Wateright** is basically an irrigation scheduling tutorial developed by the Center for Irrigation Technology. It is built around the CIMIS weather network, plus the weather stations in WA, OR, ID and MN. It gathers current weather data and uses archived data for future periods. This (and the arid climate it is associated with) allows a reasonable estimate of when to apply irrigation. However, the program does not allow for any input (such as actual rainfall and irrigation), so it remains hampered as a real scheduling tool. The fields that you create are kept as "cookies", and when you log back on the Wateright Internet site, they are still there.

Two tables follow with more detail on these eight irrigation scheduling programs.

Name	Crops	ET referenced	Type of K_c	Init. [A]	Method that weather data is input	Wet [B]	Pre [C]	Graph [D]	Root [E]	Projects crop ending point	Irrigation amount dictated by	Predicts irrigation data?	How is rainfall handled?	How is irrigation system efficiencies handled?	How are soil parameters handled?
Arkansas Scheduler [1] Ver. 1.0 (1999)	corn cotton soybeans milo	potential ET or potential ET estimated from Max Temp	time-based	e	hand input within program; historic data supplied; some sites have real-time WWW files	yes	yes	no	no	soft prediction	desired deficit	yes (10-day forecast)	hand input; if it exceeds 1.0 inches, user is queried re: effective rain	automatically subtracts out 10% of what is applied by sprinkler; nothing for flood	uses soil type & crop to suggest deficit to use; no calculations
Michiana Irrigation Scheduler [2] Ver. 1.0 (1997	corn soybeans alfalfa dry bean potato	accepts hi/low temps; possibly Hargreaves-Samani	unknown	e	hand input within program; historic data supplied	no	no	pseudo	no	user indicates	desired soil moisture %	yes (7-day forecast)	hand input	no	user inputs root zone storage amount and MAD value
KanSched [3] Ver. 1.1 (2002)	corn soybeans milo cotton	ET_r or ET_o	derived from value inputted at various % of canopy closure & other items	e	hand input either ET_r or ET_o	no	no	yes	yes	user indicates	choosing what ever % depletion desired (50% is default)	if future ET_o was input, one could use graph to eyeball when	hand input; tally of deep percolation occurs	choose value	place available to input water % at Permanent Wilting & available storage %. AS times input rooting depth gives total water; this times MAD is irrigation trigger point
NDSU's Computerized Irrigation Scheduling by the Checkbook Method [4] Ver. 2.01 (2001)	corn wheat barley soybeans sunflower potato pintobeans sugar beet alfalfa	potential ET estimated from Max Temp	weeks post emergence	e	hand input or cut-and-paste (only max T needed)	no	no	yes	yes	program picks end date	choosing whatever % depletion desired	yes	hand input or cut-and-paste	user is suppose to put in net	choosing soil type by 6-inch layers gives holding capacity; 36-inch max or less for some crops
AZSched [5] Ver. 1.36 (2002)	alfalfa barley 2 melons corn cotton grn. chiles potato safflower soybeans wheat 9 veggies 3 grapes	ET_r	heat-unit based	p	can download text files for about 25 AZ weather stations (current & past); can also hand input	no	no	no	yes	program chooses	based on % of depletion Also tells amount needed to fill deficit	as a report and as a screen flag	hand input	hand input	very nicely; rooting depth chosen by computer; user inputs soil layer info in terms of in/ft based on layers chosen
Woodruff Irrigation Chart Maker [6]	corn cotton soybeans	historic Blaney-Criddle	HU-based (% of seasonal HUs)	e	internal; all MO counties included	no	no	no	no	model prediction	desired deficit	yes (rainfall must be used to adjust)	users pencil it in on the chart	Assumes net amount applied	uses soil type & crop to suggest deficit to use; no calculations
Cropflex 2000 [7]	many possible	ET_r uses Kimberly Penman, Jensen-Haise or Hargreaves	Heat Unit or Days	p	can load text files from three formats (CSU, KSU, and USDA)	no	no	no	yes	user supplies	critical deficit in inches (or can be converted to %)	yes	from inputted file or manually	efficiencies vary with method; not readily changeable	current rooting depth times soil's AWHC times a MAD that can change over crop stage
WATERIGHT [8] Evaluated on-line 2/2002	many	ET_r	5-point time method; can be adjusted	p	internal; all cooperating weather station real-time data from CA (also, WA, OR, ID, MT)	yes	no	no	yes	user indicates	desired deficit; set interval	average date of irrigations (deviations in rainfall amounts & ETmust be used to adjust)	Within the pulled-down data file (other data can't be entered)	user inputc	Selecting soil type chooses holding cap.; user inputs rooting depth & MAD

[A] Init. = "Initial Readings from" where "e" is emergence and "p" is planting
[B] Wet = "Wet surface evaporation feature available?"
[C] Pre = "Pre-season moisture balance equations made?"
[D] Graph = "Graphical representation of soil moisture deficit available?"
[E] Root = "Changing root depth?"

[1] University of Arkansas; available for downloading from: http://www.aragriculture.org/computer/schedule/default.asp
[2] Purdue Research Foundation; available for downloading from: http://www.agry.purdue.edu/hua/inhua.htm
[3] Kansas State University; available for download from: http://www.oznet.ksu.edu/mil (choose "downloads" then "MIL Toolkit download")
[4] North Dakota State University or University of Minnesota ; available for purchase at $35.00.
[5] University of Arizona
[6] University of Missouri; available from interactive web site at: http://agebb.missouri.edu/irrigate/woodruff/
[7] Colorado State University; available for download from: http://ulysses.atmos.colostate.edu/~crop/
[8] Center for Irrigation Technology at California State University, Fresno; available from interactive web site at: http://www.wateright.org/

Name	Computer Space Required	Cost	Designed For	Contains Soil Stress Function	Other notes
Arkansas Scheduler	3.1 megs	free	AR, TN, MS, LA, MO	no	New version will be out for 2003 that will work off the Internet; pioneer in using empirical research to determine ideal deficit, so as to avoid the root depth X holding capacity X MAD
Michiana Irrigation Scheduler	0.5 megs	free	MI, IN, KY	yes	Gives temp deviation; indicates soil moisture (can go to saturated conditions); graphically shows good or bad soil moisture condition by how many "+" or "-" are printed out; shows daily and accumulative yield loss coming from soil moisture stress (user inputs expected maximum); summary data (total deficit, days until 1-in of deficit occurs, current ET_c) is shown only for the single date selected to be viewed
KanSched	1.7 megs	free	KS (but could be universal)	no	Nice presentation; compact—works off a central page; fields can be grouped, so as not to have to re-apply ET info; weather data not needed, only ET data; ET data can not be put in automatically; having both ET_r or ET_o and separate K_c values could lead to confusion
NDSU's Computerized Irrigation Scheduling by the Checkbook Method	2.6 megs, plus 2.3 megs for each field	$ 35	ND, MN	yes	A compiled spreadsheet; one can adjust predicted values of soil moisture deficit by putting in data from hand sampling; alfalfa handled differently then the other crops; lots of weather files from locations in ND & MN are built-in; each field can have 2 locations; every field will be a separate spreadsheet (@ 2 megs)
AZSched	8.5 meg	free	AZ	yes	Nice display; large selection of crops; easy to learn; lots of weather data resources are available
Woodruff Chart Maker	0 megs	free	MO	no	Chart is printed at beginning of the season and penciled in; good user support
Cropflex 2000	0.8 megs	free	CO, KS	no	An excellent fertility management program; new crop data would need an expert to initialize; might be an excellent scheduling tool for a seed company; can use SI units
WATERIGHT	0 megs	free	CA (also, WA, OR, ID, MT)	no	A lot there, but not really a checkbook method as actual irrigation amounts/dates and rainfall can't be entered; keeps "cookies" of your files, so you don't have to re-enter