



KanSched2

An ET-Based Irrigation Scheduling Tool

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KanSched 2.0 is a program that is designed to help monitor the root zone soil profile water balance and schedule irrigation events on a field using evapotranspiration (ET) data. The program can also be used to monitor the soil profile water content of non-irrigated fields. ET-based irrigation scheduling is a tool that can help you determine when and how much irrigation water to apply. The basic process involves using data on crop water use (crop evapotranspiration or ETc), rainfall, and soil water storage to assess when an irrigation event is needed and how much water could be applied.

The original version of KanSched program was developed as part of the Mobile Irrigation Lab, which is supported by a partnership between K-State Research and Extension, the Kansas Water Office with State Water Plan Funds, Kansas Water Resources Research Institute, the Kansas Corn Commission, and the Ogallala Initiative Project. This new release, KanSched 2.0, offers some new features, in response to requests by irrigators. These include additional crop options, including a built-in feature to account for cutting cycles on alfalfa, an irrigation forecast, irrigation fuel cost accounting, and a water record page for individual fields. However, users of KanSched 1.0 version series should find KanSched 2.0 very familiar and have little or no difficulty in adapting.

Disclaimer: Use of trade names does not imply endorsement of named product or criticism of others.

General Overview

Irrigation scheduling that uses evapotranspiration (ET) information is much like checkbook accounting procedures where the valued commodities are tracked. In this case, soil water, rather than money, is the valued commodity and the debit is crop water use while credits are rainfall and irrigation. One notable difference is that the water balance can be in excess as well as deficient. ETc, short for crop evapotranspiration, is the amount of water that a crop withdraws from the soil water reserve in the crop root zone. Deposits to the soil water reserve are rainfall and applied irrigation. The major goal of the accounting procedure is to help the irrigation manager keep the amount of water in reserve above a minimum acceptable soil water balance level to prevent water stress to the growing crop. The upper limit to the account is the amount of water that can be physically stored in the root zone area of the soil profile. Deposits of water, once the upper limit is exceeded, result in the water being lost as either deep percolation or surface runoff.

Irrigation scheduling can help minimize deep percolation losses, although even the most rigorously followed schedule cannot prevent all losses since large rainfall events can exceed soil water storage capacity by themselves. The benefits of irrigation scheduling generally translate into increased net returns through several possible avenues. Irrigation scheduling may also reduce irrigation labor and equipment operation pumping cost, and may also result in improved yields due to less water stress or less loss of fertilizer due to leaching.

One of the major obstacles to adoption of on-farm irrigation scheduling has been the time

management problem of gathering, processing, and implementing scheduling on a daily irrigation cycle period. Computer technology presents the opportunity for information gathering, transferring, and processing to be done much more easily, efficiently, and sometimes automatically. Scheduling software, communication, and control technology exists that can provide management recommendations which could then be remotely implemented. This manual describes the input and output windows of KanSched 2.0.

The Start Screen

Each time start KanSched 2.0 is started, the opening screen pictured in Figure 1 will appear. From this point, the options are to open a field collection, create a new field collection, import older KanSched data or load demo field collection. The following sections will describe each of these options in detail and they can be used in KanSched 2.0. However, several functions appear across the top of the screen in the Menu bar. These functions will be described first.




Figure 1: The start screen of KanSched 2.0.

The Menu Bar

At the top of each window in KanSched 2.0 is the menu bar. The start screen's menu bar has five main menus: File, Field Collection, Field Options, Tools, and About.

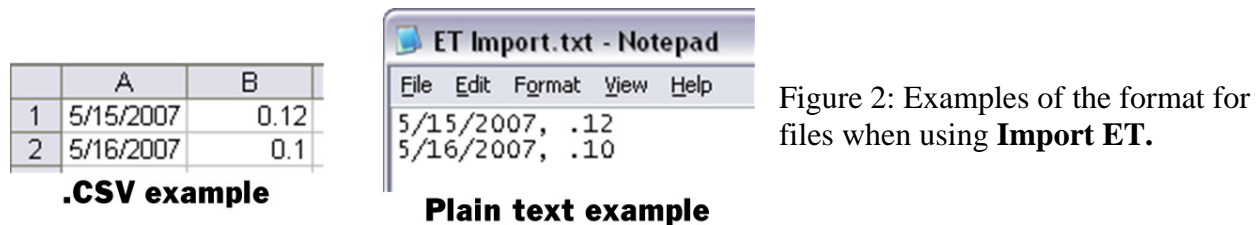
The File menu contains commands of 1) **New field collection**, 2) **Open field collection**, 3) **Save**, 4) **Save As**, 5) **Print**, 6) **Print setup**, 7) **Import older KanSched** and 8) **Exit KanSched**. Items 1, 2, and 7 can also be managed from the opening KanSched2 screen and are discussed below. The **Save** function records all updates made to KanSched2 while **Save As** saves the updates with new names or locations. The updates can also be made by clicking on the save bar on top of the pages that follow the start screen. This bar appears whenever changes have been made. KanSched2 has a built in printable report accessed by the **Print** button.

KanSched2 can be exited using the **Exit KanSched** on the File menu but it is more easily accomplished by clicking the  button at the top right corner of the KanSched window. The button to the left expands KanSched2 screen to the maximum screen size of the computer, while the small bar will minimize KanSched2 to the toolbar to allow you use of other programs without exiting KanSched. The Field Collection

menu has the function to rename a field collection. The tool to change to a different field collection, once the user is past the initial start screen of KanSched2 is located under the *File* menu as described above.

The *Field Options* menu allows **Start a new season**, **Season options** of **Change season year**, or **Deleting a season**, and **Delete this field**. **Start a new season** advances all the dates in the fields of the field collection forward by one year and retains the previous season's information intact under that year. The filed data for previous seasons is accessed by using the Season drop down menu just about the Field Setup control bar on the left hand side of the screen. In the first year of use, there will only be one season available for view unless data from previous years is imported. The functions in the **Season options** would most likely be used in event of entry errors.

The *Tools* menu has data management functions to move data into or out of KanSched2, using either **Import ET** or **Export Budget Page**. ET data can be imported from any comma delimited text file, easily created with Microsoft Excel (.csv) or any other spreadsheet or text editor (.txt). The ET data file must have the date listed first, followed by the ET reading, separated by a comma. Each pair of *date* and *ET value* should be on a separate line. The date can be listed in several formats (e.g. mm/dd/yyyy, mm-dd-yyyy, m-d-yy), ET values should be listed as a decimal point followed by at least one digit. See the formatting example in Figure 2. **Export Budget Page** creates the types data files described for **Import ET**.



The *About* menu provides the version information for KanSched2 and the contact information for K-State Research and Extension Engineers responsible for administering the KanSched2 program.

Start: For the first time or for a new field collection

When entering KanSched2 for the first time, the most likely course of action will be to create a field collection. To start a new field collection, click the button labeled "Create new field collection". A new window will appear asking you to enter a name for the field collection. After typing a name and either returning the enter button or clicking OK, a similar window will appear to ask for a field name. This will be the first field in that collection. Once this name is entered, KanSched2 will advance to the Field Setup page, where the information on the field and crop will be entered, as shown in Figure 3. The first page of the Field Setup section is the general information section. On this page, the name of the field, the crop type, the ET group and the Rain group for the field can be entered. The ET and Rain group options will be explained later. The field collection name should appear on the screens just below **Field Options** on the toolbar. The field name will appear in a blue bar just below the field collection name and the date. Once a field collection has been established, the collection can be opened on from the start screen using the "Open Field Collection" button.

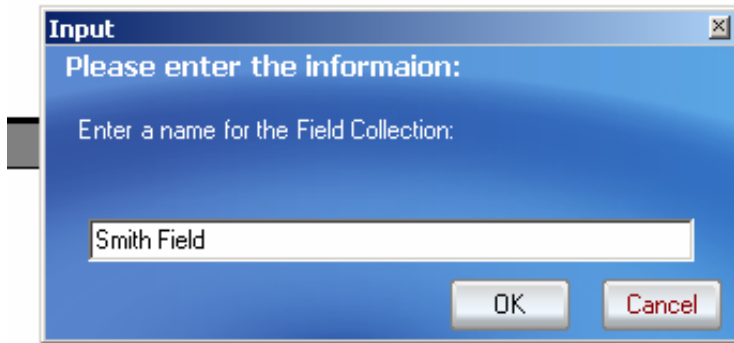


Figure 2: Window for naming a field collection.

Other Start Screen Functions

KanSched2 does come with an initial field collection, which can be activated by using the “Load Demo Field Collection” button on the Start page. The historical field collection contains the actual grass reference ET (ETo) information and rainfall data for three years from the Northwest Kansas Research and Extension Center of Kansas State University at Colby, Ks. The years of record are 1996, 1998, and 2002. These years represent low ETo and high rainfall, average ETo and rainfall, and low rainfall and high ETo conditions respectively for the site. This data is provided so producers or water managers have access to some actual data to use when familiarizing themselves with the KanSched program.

Entering Information into KanSched

Before KanSched2 can begin tracking the field’s soil water content and crop water usage, it needs information about the crop, growing season, and soil type for each field. This is accomplished using a series of pages under the Field Setup toolbar, beginning with the general information page. Once the field name is entered, the crop type is entered. Click on the down arrow in the crop type box and the crops that have been preloaded into KanSched2 appear. Click on the appropriate crop and the enter key. After selecting the crop, click on the Next button. This advances KanSched2 to the Season Dates information screen (See Figure 4). KanSched2 has a new feature to allow additional crops to be entered into the crop type list by clicking on the blue line of “Add/Edit custom crops”. The use of this section requires specialized information. Contact the authors of KanSched2 if this option is needed. Their contact information can be found by clicking on the *About* button on the menu bar.

KanSched2 also has alfalfa as a crop option. To accommodate the in-season cutting cycles of alfalfa, KanSched2 has a budget sheet column appear that allows the noting of the cutting date. This will re-start the crop growth cycle within KanSched. The season dates and crop coefficient entry pages for alfalfa will request slightly different information than for summer planted crops. However the information entry will follow the same format as described below.

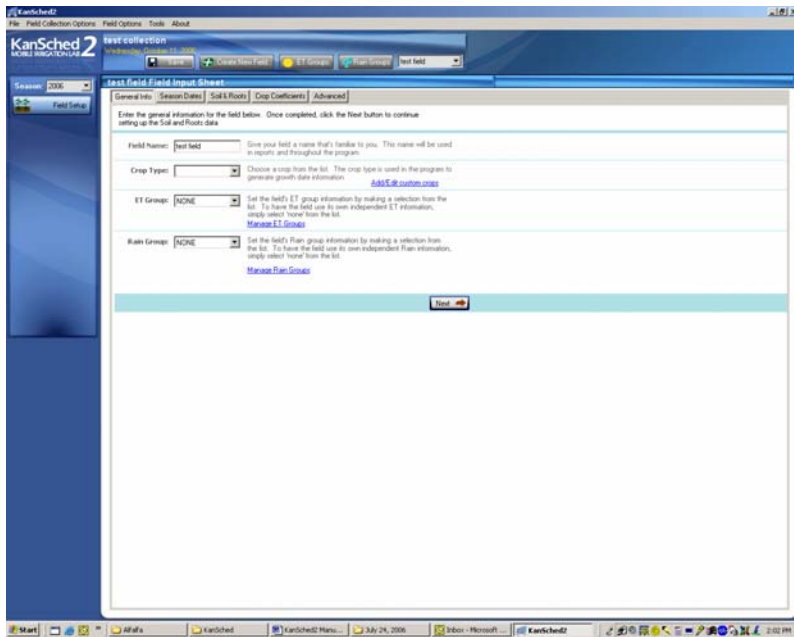


Figure 3: Field Setup section of KanSched2, showing the General Information page.

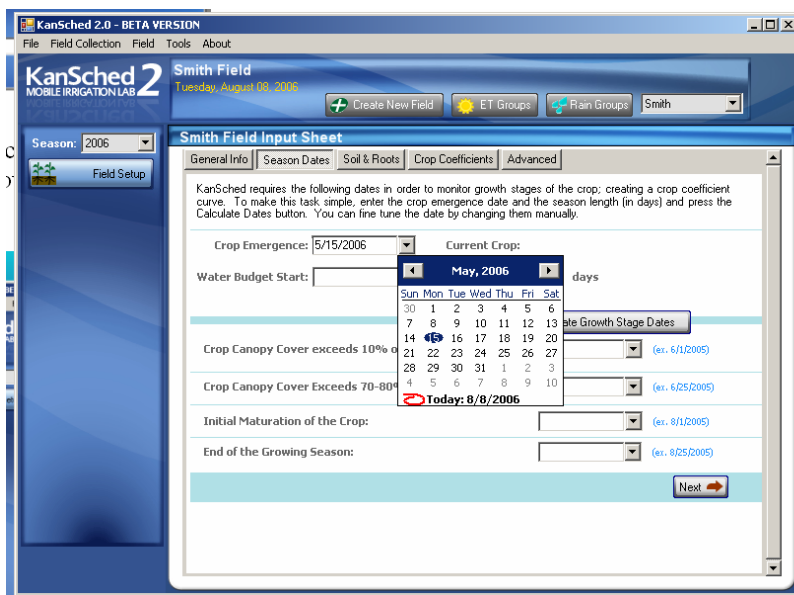


Figure 4: Field Setup section of KanSched2, showing the Season Dates page.

The Season Dates page asks for information needed to describe the growing season for the selected crop. Click on the down arrow at the Crop Emergence date window and a calendar will pop up. The arrows on the top of the calendar allow movement to the proper month and then click on the emergence date and repeat the process for the water budget start date. KanSched2 allows the option of starting the water budget before the emergence date. This option might be used if a deficit soil water profile exists and irrigation prior to planting is desired. In this case, the beginning crop root zone and the managed root zone must be equal. KanSched2 will indicate this automatically. Soil root zones will be completely discussed in the next section. The season length of the crop is the next entry. Once an emergence date and a season length is entered, click on the “Calculate Growth Stage Dates” and KanSched2 will calculate important stage of growth dates needed to determine the modifications to the weather based reference ET information that will be used later to determine the crop water use of the crop. Remember the end of the growing season refers to when the crop has reached physiological maturity (no additional yield potential) and not when has

reached harvest conditions. Then click on the Next button to go to the Soils and Roots input information screen.

The first entry box on the Soils and Roots page is Soil Texture. This box has a drop down menu that allow the selection of the appropriate soil type for the field. Once the soil type is selected the values for the available soil water holding capacity and the permanent wilting point are shown. The initial Soil Water Availability at the start of the water budget date can now be entered. In most cases, the initial condition is 100 percent, or at least very high, since spring conditions in Kansas generally have rainfall in excess of crop needs and soil water evaporation. The initial root depth at the start of the water budget is entered in the next box. Six inches is usually considered as the minimum depth for entry. The maximum managed root zone manages is entered next and is limited to 48 inches. While it is true that many field crops have roots at much greater depths then 48 inches, the extraction rate is very slow and generally good irrigation management would not want to purposely put irrigation water that deep into the soil profile. The managed root zone can be much less due to either shallow rooted crops or soils that limit root penetration due to texture or restrictive layers.

The two options for handling the crop root zone are 1) grow the roots as would occur in the field or 2) establish the mature root zone at the start of the water budget and manage the soil water level for the entire zone throughout the irrigation season. The first option is the general practice when full irrigation of the crops and normal early rainfall has occurred; meaning the lower portions of the soil profile is at or near field capacity (full water storage). KanSched2 will grow the roots from the initial depth entered to maximum depth. The maximum root depth will be at the stage of growth date of "Crop canopy cover exceeds 70 to 80 % of the field area". As the crop (and roots) grows, the root zone will be increasing and the new root added will be at 100% soil water availability. Remember the initial soil water availability entered previously only effect the initial root zone.

A second way to enter the root zone information is to set the initial root zone to the maximum managed root zone. Now when the initial soil water availability is entered, it reflects the soil water content of the managed root zone. When soil water deficits exist in the profile prior to the growing season, some producers may want to increase the soil water levels with pre-irrigation, especially those with limited irrigation capacity during the active growing season. KanSched2 will allow the water budget to begin prior to crop emergence, so that these irrigation events can be recorded in the water budget. Click on the next button to advance to the Crop Coefficients screen.

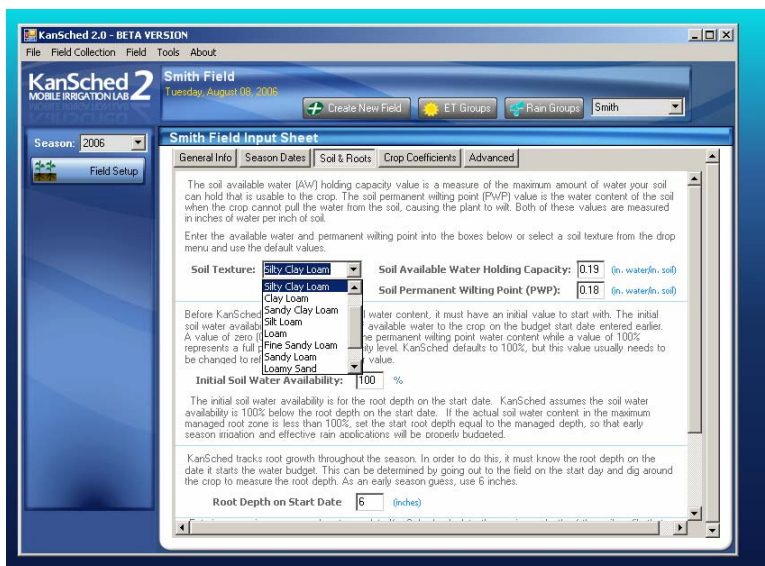


Figure 5: Field Setup section of KanSched2, showing the Soils and Roots page.

There are two common reference crop bases used for determining the reference ET. These are either alfalfa or grass reference. Reference ET might be thought of as the atmospheric demand that a crop experiences due to temperature, humidity, wind and solar radiation. The actual water used by the crop of interest is determined by multiplying the reference ET by a crop coefficient. To determine the Crop Coefficients, select the type of reference ET crop used by the weather station system being accessed (Figure 6). Select either alfalfa reference ET (ET_r) or grass based reference ET (ET_o). Next, click on the Calculate Crop Coefficients button. KanSched will then calculate the crop coefficient for each day of the crop's growing season. After the crop coefficients are calculated for the field, the other control buttons appear along the left hand side of the screen. However, one other Field Setup option is still available. Click on the Next button to go to the Advanced screen information.

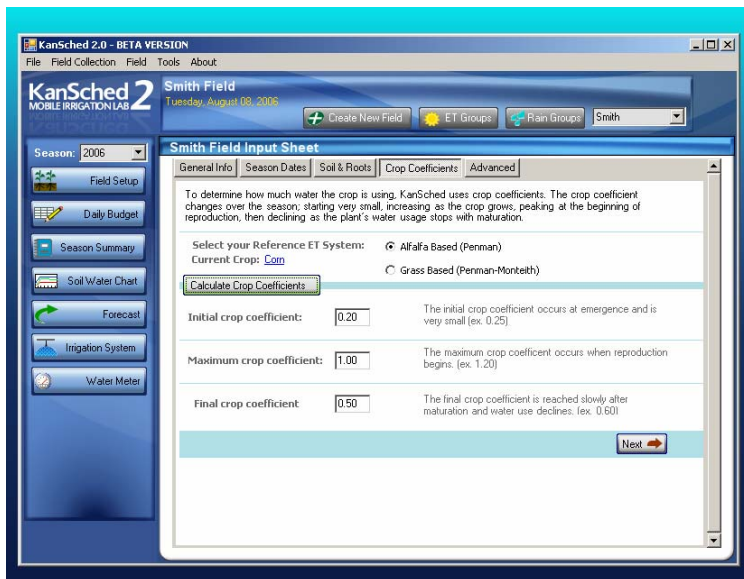


Figure 6: Field Setup section of KanSched2, showing the Crop Coefficient page.

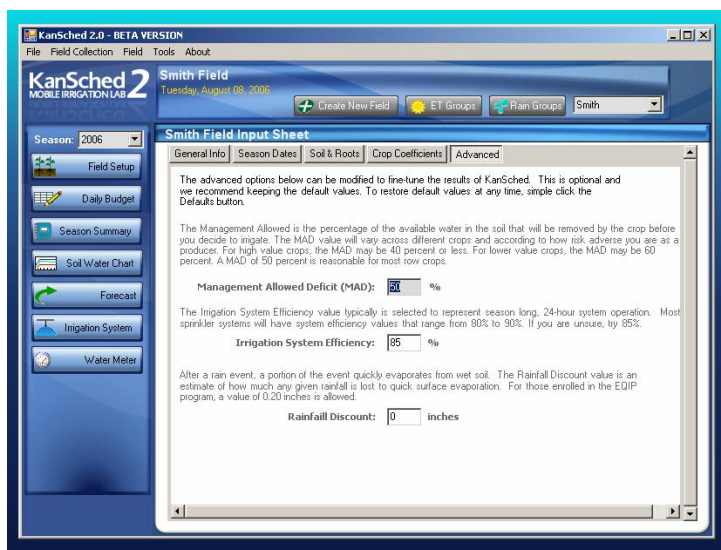


Figure 7: Field Setup section of KanSched2, showing the Advanced page.

Options available on the *Advanced* page are Management Allowed Deficit (MAD), the Irrigation Efficiency and the Rainfall Discount. These options contain default values which can be modified if

desired. If no other information is available, the default values are recommended. The new tools that have appeared along the left hand side of the screen available for use include Daily Budget, Season Summary, Soil Water Chart, Forecast, Irrigation System and Water Meter.

Daily Budget

The Daily Budget (Figure 8) consists of rows of input for each day. These inputs include reference ET, rainfall, and gross irrigation. As these inputs are entered into KanSched, it calculates the soil water that is available to a crop. The following sections describe the individual budget page inputs requirements and the program's output.

When alfalfa is the indicated crop, the Daily Budget page will have an additional column appear to the left of the date column. This column is used to indicate when the alfalfa is cut by using the mouse cursor to click on the appropriate date. The date entry is indicated by a check mark. Whenever a cutting date is marked, KanSched2 will re-initialize the crop coefficient cycle of the alfalfa.

Daily Budget Inputs

Reference ET

The reference ET values can be obtained from on-site measurements or from an automated weather station in your county or region. This value needs to be entered for each day of the season as KanSched tracks the soil water content. Daily ET values are required, but the ET values from several days can be entered at one time. The reference ET can also be updated using the ET Groups option that is described later.

Crop ET

After the daily reference ET value is entered, KanSched will calculate and display the crop ET. This value is the amount of water (in inches) the crop used during each of the listed days. KanSched uses the crop coefficient values and the reference ET values to calculate the crop ET value.

Rain

Whenever the crop receives rainfall, enter the value for the appropriate day in KanSched. This value will then be used to calculate your soil's current water content. Enter the on-site measured value of rainfall. If desired, a rainfall discount can be automatically subtracted from this measured value using the rainfall discount option available in the Field Setup tool under the Advanced option tool.

Gross Irrigation

Input irrigation amounts into KanSched every time the field is irrigated. This is a *gross* irrigation amount. The gross irrigation amount will be multiplied by the irrigation efficiency value entered in the Advanced option of the Field Setup tool.

Measured Soil Water Availability

KanSched gives the option of updating the Soil Water Availability value. If an in-field measurement is observed, the value can be entered into KanSched. Remember, KanSched only tracks one location in the field, usually the start point of an irrigation cycle. Soil water observations must be from the same area as represented by KanSched. Any values entered into this column will over-ride the value within KanSched and will be the basis for the next set of water budget calculations.

Daily Budget Outputs

Calculated Soil Water Availability

KanSched's calculation of the available water in the soil is displayed in the *Calculated Soil Water Availability* column. This value can be defined as the percent of water that is available for the crop to use from the available water profile. When this value drops below your MAD value, the *Calculating Soil Water Availability* numbers turn red. A value of zero (0%) represents permanent wilting point (PWP), while 100% represents field capacity.

Available Soil Water Content above PWP

Another way that KanSched interprets the soil's current water content is in the *Available Soil Water Content above PWP* column. This value is an estimate of approximately how much water is in the soil that the crop can use before it reaches the permanent wilting point (e.g. if the *Available Soil Water Content Above PWP* value is 1.5 inches, this means that 1.5 inches of water is available in the soil for the crop to use). However, keep in mind that when the water content reaches the MAD value, the crop has withdrawn the readily available soil water and the crop may begin to experience some stress. However, most field crops do not suffer major stress until the soil profile is much less than 50% depleted.

Root Zone Water Deficit

How much water will it take to fill the soil profile to full capacity? The *Root Zone Water Deficit* value answers that question by displaying how much water (in inches) the managed root zone soil profile needs before the water would be lost either to runoff or deep percolation.

Effective Rain

How does KanSched handle rainfall events on a soil that is already at field capacity? Basically, when the soil profile is at field capacity, any water that is applied to the field will either run off or be lost in the soil through deep percolation. KanSched keeps track of the soil's current profile status and will ignore any rainfall or irrigation events that occur on the soil when it has reached field capacity. This ensures that the program will not credit the soil with more water than it can hold when it receives many rainfall events (or one large rainfall event) in a short period of time.

Total Cost

The fuel costs associated with can also be tracked in KanSched2. This option is discussed in the later section on the Irrigation System tool bar.

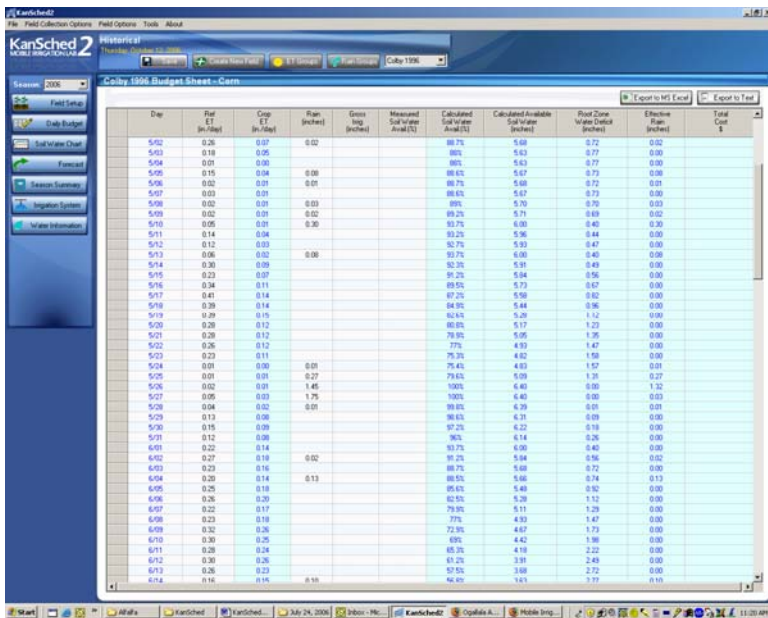


Figure 8: The Daily Budget section of KanSched2.

Soil Water Chart

Daily Budget information is charted on the Soil Water Chart, shown in Figure 9. This chart shows a visual representation of the field soil water content as it changes throughout the season. The rainfall and irrigation events are displayed at the bottom of the chart. The horizontal axis of the chart is labeled with the dates of the crop season, while the vertical axis is in units of inches of water contained within the defined soil profile. The following section describes each component of the Soil Water Chart.

The Soil Water Chart has the ability to get detailed information about any point on the chart. Using the computer mouse, position the cursor arrow and click on any line or column in the chart to get information about that point. This is an easy way to see how much rain or irrigation was received on a particular day, without having to scroll through the budget page to find the information.

Soil Water Storage at Field Capacity-

The dark blue line that forms the upper boundary of the chart is called the *Soil Water Storage at Field Capacity* line. This line represents the total amount of water that the soil can hold before runoff or deep percolation occurs. This line also represents a water availability value of 100%. This value is determined using the soil characteristics from the input screen and the depth of the root zone, as are the PWP and MAD values described next.

Soil Water Storage at PWP-

The dark red line that forms the lower boundary of the chart is called the *Soil Water Storage at PWP* line. This line represents the water content of the soil where plants are unable to extract water from the soil, causing them to wilt and die. This line also represents a water availability value of 0%.

Soil Water Storage at MAD-

The dotted red line represents the MAD level selected during the initial input process for the field. This line will help provide an easy visual reference to the soil water status. As the soil water content goes further and further below the MAD value, plants have increasing difficulty in extracting soil water with the increasing stress. As the water content drops below MAD, KanSched has a function to reduce crop coefficient value to reflect the reduction in water use by plants when under water stress.

Soil Water-

The dotted green line represents the calculated soil water content of the soil. As the days in the season progress, the status of the soil's water content is determined by monitoring this dotted green line. As the line increases, approaching the upper dark blue line, the soil's water content is increasing. Likewise, as the dotted green line falls, approaching the lower dark red line, the soil's water content is decreasing. A quick glance at the trend in the dotted green line shows the status of the soil water content and how much water might be available to the crop. One of the general management goals is to maintain the field water content above the MAD value until the end of the season.

Gross Irrigation-

Each irrigation event is represented by a dark blue column on the date the irrigation was received. The height of the column reflects the amount of the irrigation event.

Rain-

Much like the irrigation events, a light blue column represents the rainfall events on the date the rainfall was received. The height of the column reflects the amount of rain received.

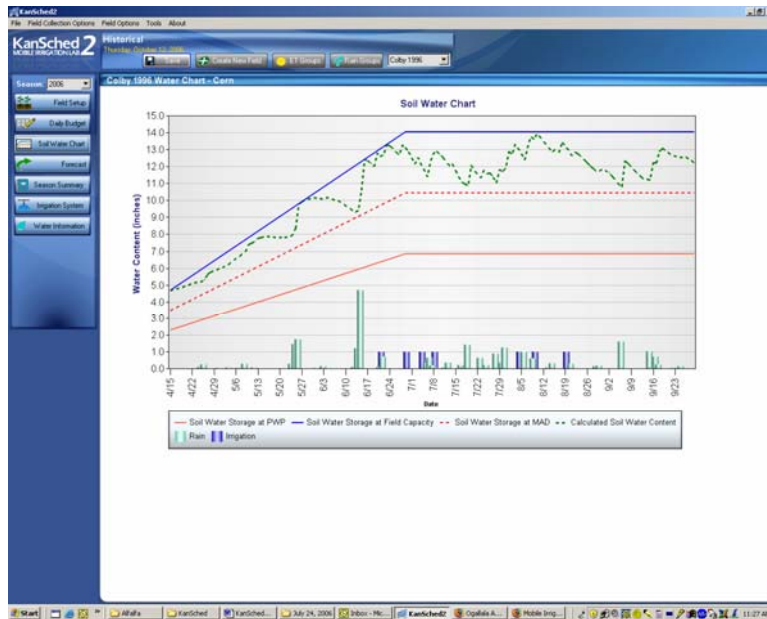


Figure 9: The Soil Water Chart section of KanSched2.

Season Summary

The summary screen (Figure 10) keeps a running total of the various water budget factors for the irrigation season. The values shown are total reference ET, crop ET, rainfall, effective rainfall, gross irrigation amounts, and net irrigation amounts.

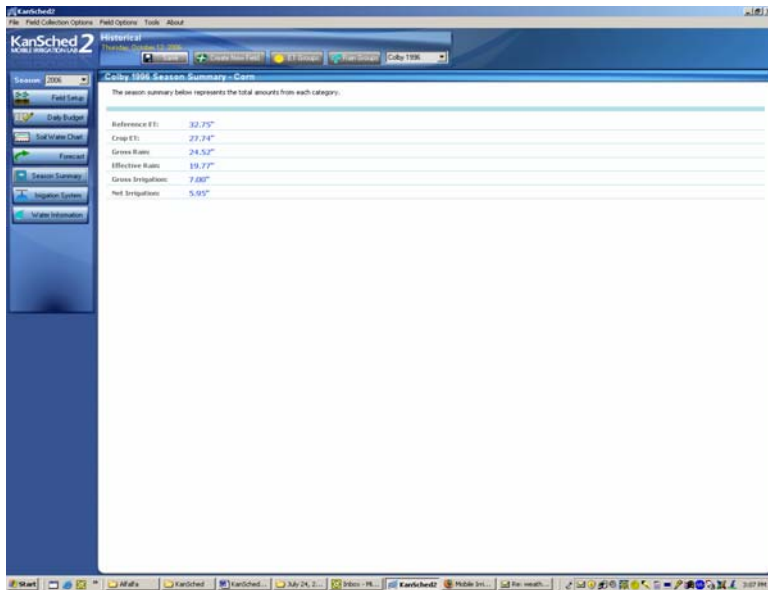


Figure 10: The Season Summary section of KanSched2.

KanSched2 Field Report

A field report can be easily printed using the print function found under the File heading of the KanSched tool bar. The report (Figure 11) shows pertinent field and crop information, the totals from the season summary, and the soil water chart.

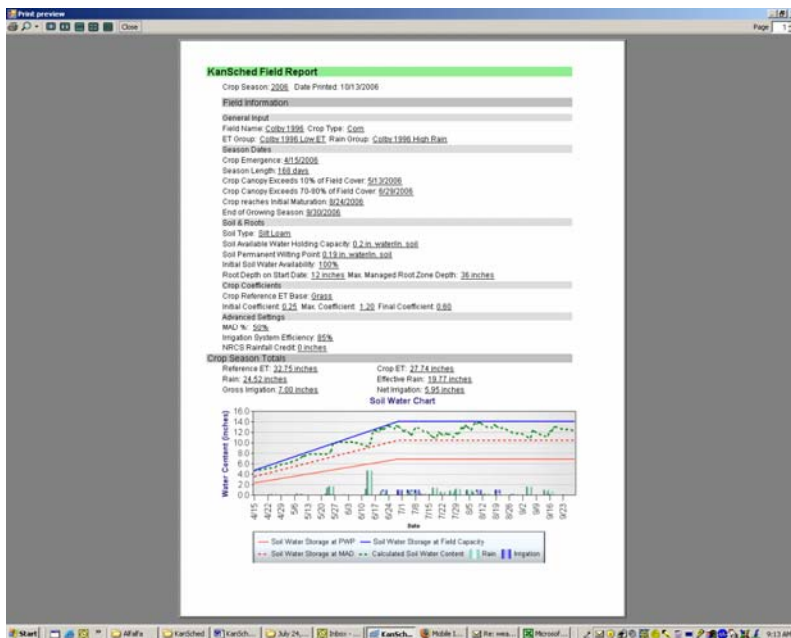


Figure 11: The KanSched2 Field Report

New Tools Available in KanSched2

Forecast

The Forecast toolbar, shown in Figure 12, estimates the soil water status of a field 5 days into the future. The project is based on the average of the previous 5 days of reference ET and the future crop coefficient values of the existing crop. The estimated crop ET and the projected soil water availability are shown. A sliding ET demand bar can adjust the ET demand up or down by 20 percent.

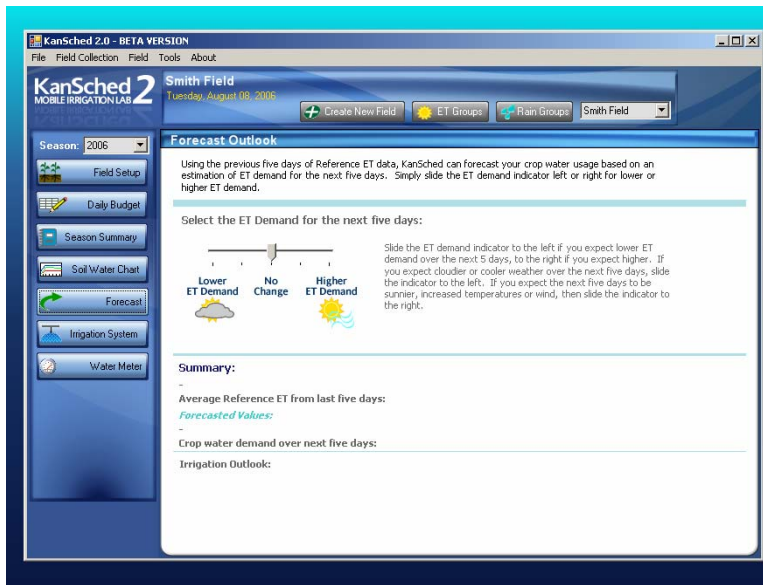


Figure 12: The Forecast section of KanSched2

Irrigation System

Irrigation pumping costs can be estimated and tracked using the Irrigation System tool (Figure 13) of KanSched2. Cost estimates, using the pumping rate, lift and pressure of the system and the fuel type and price, are based on accepted pumping plant performance criteria and shown as on a \$ per inch or \$ per field basis. Actual pumping costs can also be entered. These costs will be tracked and entered on the budget sheet, if this option is activated.

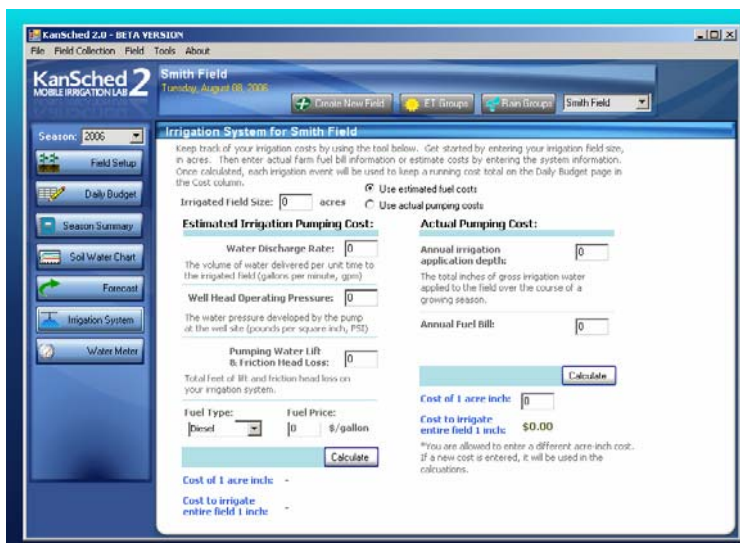


Figure 13: The Irrigation System section of KanSched2

Water Information

The Water Information section (Figure 14) of KanSched2 allows information on the well and water right to be recorded, if desired. This information is not required for KanSched2 to function but could aid in maintaining business records or filling out annual water reports.

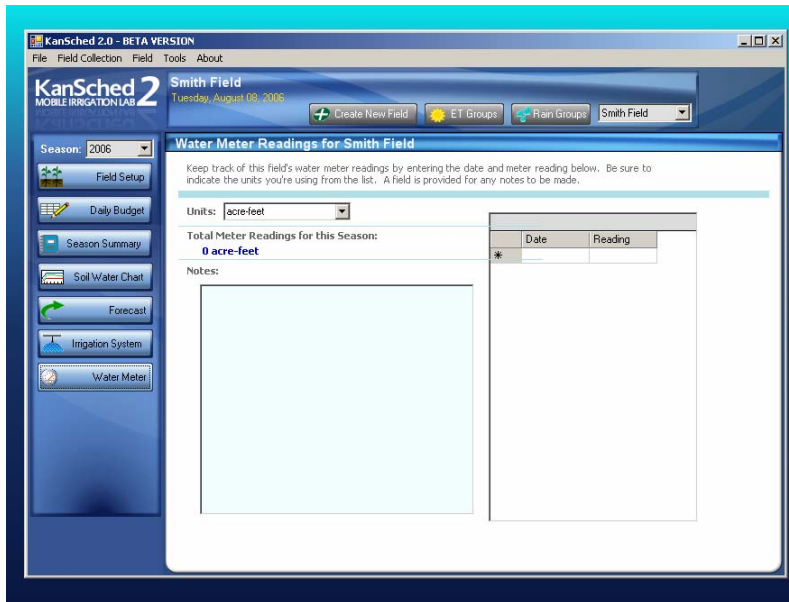


Figure 14: The Water Information section of KanSched2

ET Groups

The ET Groups section, shown in Figure 15, is a carry over function of the original KanSched which was called Quick ET. It allows the ET values to be entered into a group of fields that are using the same weather station as the reference ET information source. ET groups can be accessed from general information page of the Field Setup tool or by clicking on the ET Groups bar on the top of every KanSched2 screen. Once at the ET group page, an ET group can be established by clicking on the new group control bar and typing an identifying name. Fields in the field collection that is active will appear in the box below the ET groups name box. These fields can be associated with an ET Group by simply clicking the small box next the field name. Once fields are ET grouped, these fields will be updated with reference ET data with every entry of ET data, either in the ET Group section or when an entry is made into an individual field. Many producers may have a large number of fields but will use a county based weather station as the ET information source. ET Groups simplifies the updates of individual fields and since only one reference ET entry per day for an ET Group is required. Fields do not have to be entered into an ET Group. They would function as individual fields with the reference ET entered directly into the budget page of that field. Multiple ET Groups can also be established within a field collection.

A field that has had individual ET data entries and is then associated with an ET group will have the reference ET data entries overwritten by the ET Group data.

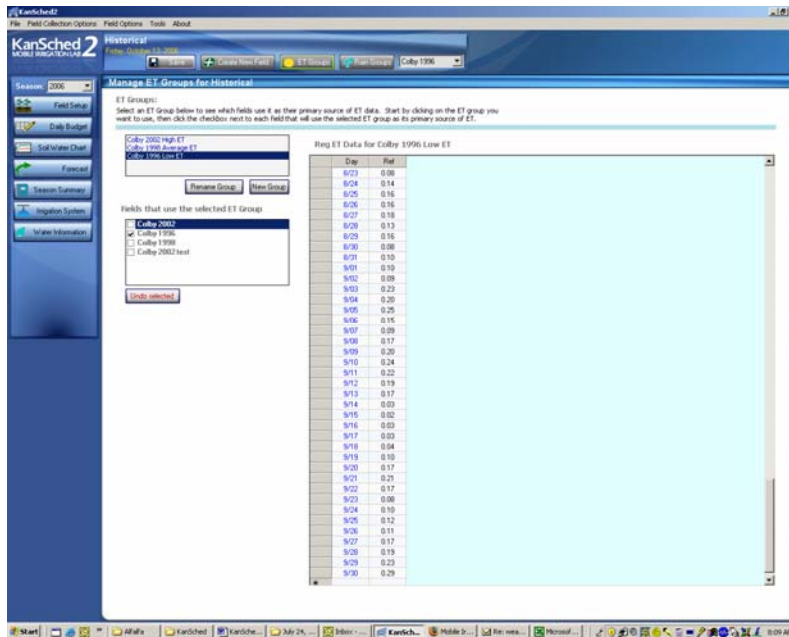


Figure 15: The ET Groups section of KanSched2

Rain Groups

Rain Groups (Figure 16) function in the same manner as ET Groups; however Rain Groups will generally be much smaller,

possibly only two fields. Rain measurements should be made for each individual field but in practice, a single rain gauge might provide the rainfall measurement for two adjunct fields. For example, a single rain gauge in the middle of a section might be adequate for the four fields in that section.

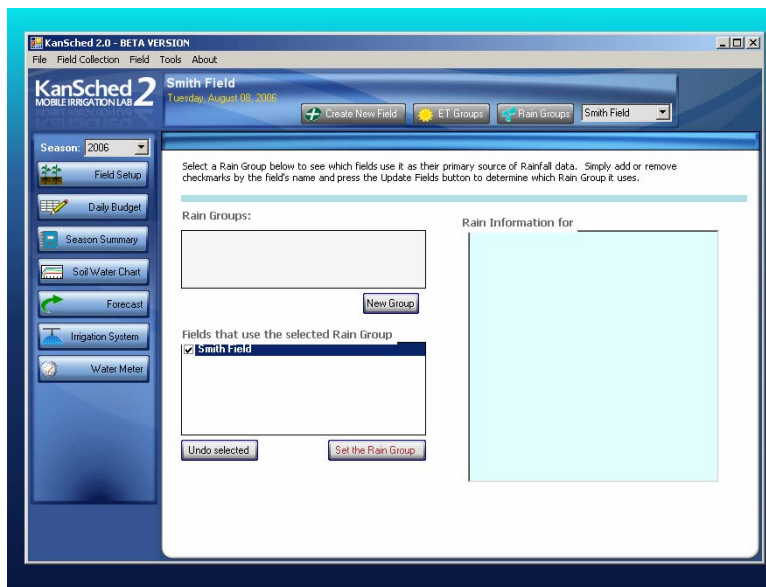


Figure 16: The Rain Groups section of KanSched2

Additional Features in KanSched

KanSched has several built in utilities to increase the functionality of the program. The following section will describe each of these utilities.

Archiving a Field

Once a season is completed or a new season is ready for new data entry, the previous season data can be saved and a new season for the same field can begin without having to create a new field or delete the old data. Archiving of field data is made easy with the use of the **Start a new season** function. The **Start a new season function** advances all the dates in the fields of the field collection forward by one year and retains the previous season's information intact under that year. The filed data for previous seasons is accessed by using the Season drop down menu just about the Field Setup control bar on the left hand side of the screen. In the first year of use, there will only be one season available for view unless data from previous years is imported.

Once the season begins, the field information for the new field will need to be reviewed and updated as necessary as it is unlikely the dates for the new crop season will be the same as the previous year.

Export Season Data to MS Excel or Text File

KanSched2 does allow the option of exporting data to either an excel spreadsheet or a text file. These functions are available as tool bars in the upper right hand corner of the budget page. When this option is selected, the user will be given the option of where to save the text file. After designating the save location and the name of the text file, KanSched will automatically generate the file with all of the daily season values (Date, Reference ET, Crop ET, Rain, Gross Irrigation, Measured Soil Water Content, Calculate Soil Water Content, Root Zone Water Deficit, and Effective Rain) of water budget and soil water contents from the budget page. A text file can be imported into any spreadsheet program desired by the user.

Still Have Questions?

Operating problems and questions on KanSched or other Mobile Irrigation Lab programs can be directed to MIL team members as listed below. However, many county extension agents are familiar with KanSched and may be able to provide assist or can refer any questions on to the MIL Team members.

MIL Team members:

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