Irrigation Scheduling with Personal Computers

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INTRODUCTION

For a number of years, the University of Nebraska has recommended using the "checkbook" method for scheduling irrigation. The checkbook approach is straight forward and simple in concept. Soil moisture is treated as a "bank" and the balance is updated with deposits of rainfalls plus irrigations and withdrawals of crop water use. Crop water stress can occur if the balance drops below a minimum allowable balance. Deposits must be made in the form of irrigation or rainfall before daily crop water use withdrawals push the account into the red. As with a financial based checking account, the depositor should occasionally check with the "bank" to see if the calculated balance corresponds to the actual balance. The soil moisture "bank" can be verified using soil moisture blocks, tensiometers, or by estimating moisture by the appearance and feel of the soil.

The checkbook method of scheduling is inherently math intensive requiring a sharp pencil with a large eraser and a fully charged calculator. The checkbook process, therefore, seems to be a task suited for computer technology. Computers have already been used as irrigation scheduling tools. The computer network AGNET featured an irrigation scheduling program that was widely used by extension agents and some ag consultants beginning in the 1970's. The AGNET program was based on the checkbook method and included direct access to an extensive library of weather and crop water use information. In additon, AGNET had the capacity to execute the mathematics and logic involved in making irrigation scheduling recommendations.

The increase in personal microcomputer use spurred a movement toward decentralized computing -- large numbers of small computers instead of a small number of very large computers. The gains in personal computer acceptance have come at the expense of mainframe based, centralized computer systems such as AGNET. Although the AGNET irrigation scheduling program had advantages over microcomputer software, the access to a database of weather data, the actual and perceived expense of using AGNET for irrigation scheduling and other tasks lead to a decision to discontinue the service.

With the demise of AGNET, producers and consultants were left with two options; purchase a microcomputer base irrigation scheduling software program or develop their own solution. Some individuals have successfully adapted spreadsheet software such as *Lotus 1-2-3* to calculate water balance and project irrigation needs for crops. One disadvantage of these home grown applications is that they are often only useable by the person who designed the worksheet. Additionally, developing accurate projections of water use for different crops may be difficult and is certainly time consuming. Software available from universities, agencies and the private sector is often very regional and specialized. Currently, the selection of "off the shelf" irrigation scheduling software for the northern and central high plains seems to be limited.

In the spring of 1989, we decided to build a stand alone irrigation scheduling software package for microcomputers. A computerized version of the checkbook method of irrigation scheduling could closely paralleled checking

account ledger software. An adaptation of a database or record keeping system where each transaction is a record had potential. We decided to adapt a commercially available database program to create an irrigation scheduling software program.

We chose *Paradox 3* a the database engine for our program for the following reasons:

1. We were familiar with *Paradox* and knew how to use it. IANR is already successfully distributing one software application developed in *Paradox*.

2. *Paradox* is a relational database which allows us to link related files and use look up features in the final product.

3. *Paradox* has flexible reporting and graphing capabilities.

4. The *Paradox* programing language is rich and flexible allowing for a high degree of customization of the final product.

Much of the logic involved with adapting a database to irrigation scheduling had been worked through by Terry Bockstadter from the University of Nebraska South Central Research and Extension Center during his assignment with the Agricultural Energy Conservation Project in the Buffalo County. University of Nebraska extension publications also served as guidelines for developing the software. Throughout the summer of 1989 we tried various designs and worked through some of the problems we encountered trying to adapt a pencil and paper operation to a computer application.

INPUTS FOR PC IRRIGATE

The current version of the program requires the following input and steps of operation:

1. Enter information about the soil and crop into a field record. The following information is required and many of the options are available from pop up menus.

   A. Soil type
   B. Crop
   C. Crop Maturity
   D. emergence Date
   E. Irrigation System
   F. Well Capacity
   G. Moisture monitoring method

2. Enter a beginning water balance for the field. You may enter an actual value or assume a full soil moisture profile. In either case you will need to provide the following information to start estimating future irrigation needs.

A. Date to begin moisture balance calculations -- what is the first date weather data will be entered.

B. The amount of soil moisture available to the crop on the day weather data will first be entered.

3. Use the program as a scheduling tool.

A. Enter or import weather and crop water use information as it becomes available.
B. Enter irrigation dates and the net amount of each irrigation (the software will help calculate the net irrigation).
C. Enter date and amount of each rainfall event.
D. Have the software calculate a "Must begin irrigation before.." date.
E. Repeat process A through D as needed throughout the irrigation season.

OPERATING PC IRRIGATE

The program, which is tentatively called *Irrigate*, treats each day as an entry into the checkbook log. Unlike a checkbook entry which is either a credit or a debit, an *Irrigate* entry always contains a debit (daily water use) and may also include some credit (rainfall and/or irrigation). By using the previous day's balance along with debit and credit information for the current date, the new daily water balance is calculated. When updating the water balance, actual weather data is used to calculate growing degree days (GDD) for corn and beans. The accumulated GDD value is used to estimate the approximate rooting depth of the crop as well as the crop water use capacity.

Irrigate includes a file containing average, normal GDD values from March 15th through November 30th for four different regions of Nebraska. When weather data for a date is absent, an estimated GDD value can be obtained from this file so that crop water use can be estimated.

Weather information in the form of actual temperature and ET should be entered into the software when it becomes available. Once weather information is updated the user can select a recalculation option within *Irrigate* to predict the date when the next irrigation should be applied. The software will then update the current soil water balance for each day containing new weather data using calculated water use, irrigation and rainfall amounts. When the last date of available weather data is reached, *Irrigate* continues to update subsequent daily moisture balances using projected water use until an irrigation date is found. The irrigation date can be found using a view command or by printing a report.

Weather and ET data may be entered by hand from sources such as newspaper articles or radio reports. Additionally, weather and ET data may be imported directly from the *IANR Weather Bulletin Board*. *Irrigate* contains a routine that automatically transfers weather data in downloaded text file from the bulletin board into weather files in the *Irrigate* program.

Special features of the program include the ability to update soil water balance by using the appearance and feel method of soil moisture estimation. We are

currently working an option that would accept readings from tensiometer and soil moisture blocks to update soil moisture status. The program also has the capability to print a predicted irrigation report which will list the number and timing of irrigations needed until the end of the season in the absence of future rainfall.

THE FUTURE OF PC IRRIGATE

During the summer of 1990 we will be testing *Irrigate* with extension agents, crop consultants and producers. The testing phase will hopefully allow us to develop a useful and usable computer tool for irrigation scheduling. We are currently aware of the following limitations and needs:

1. Need to have regression equations that describe corn growth for all regions of Nebraska.

2. Need to add soybeans to the list of available crops.

3. Should add dry beans and sugar beets to the list of available crops.

4. Need one season of full fledged testing and calibration to insure the accuracy of the program.

5. Other states would need to develop mathematical crop growth descriptions for each of their irrigation regions. They would also need to provide projected or average growing degree day values for each of their irrigation regions.

6. Software should be of significant value to extension staff, consultants and producers.

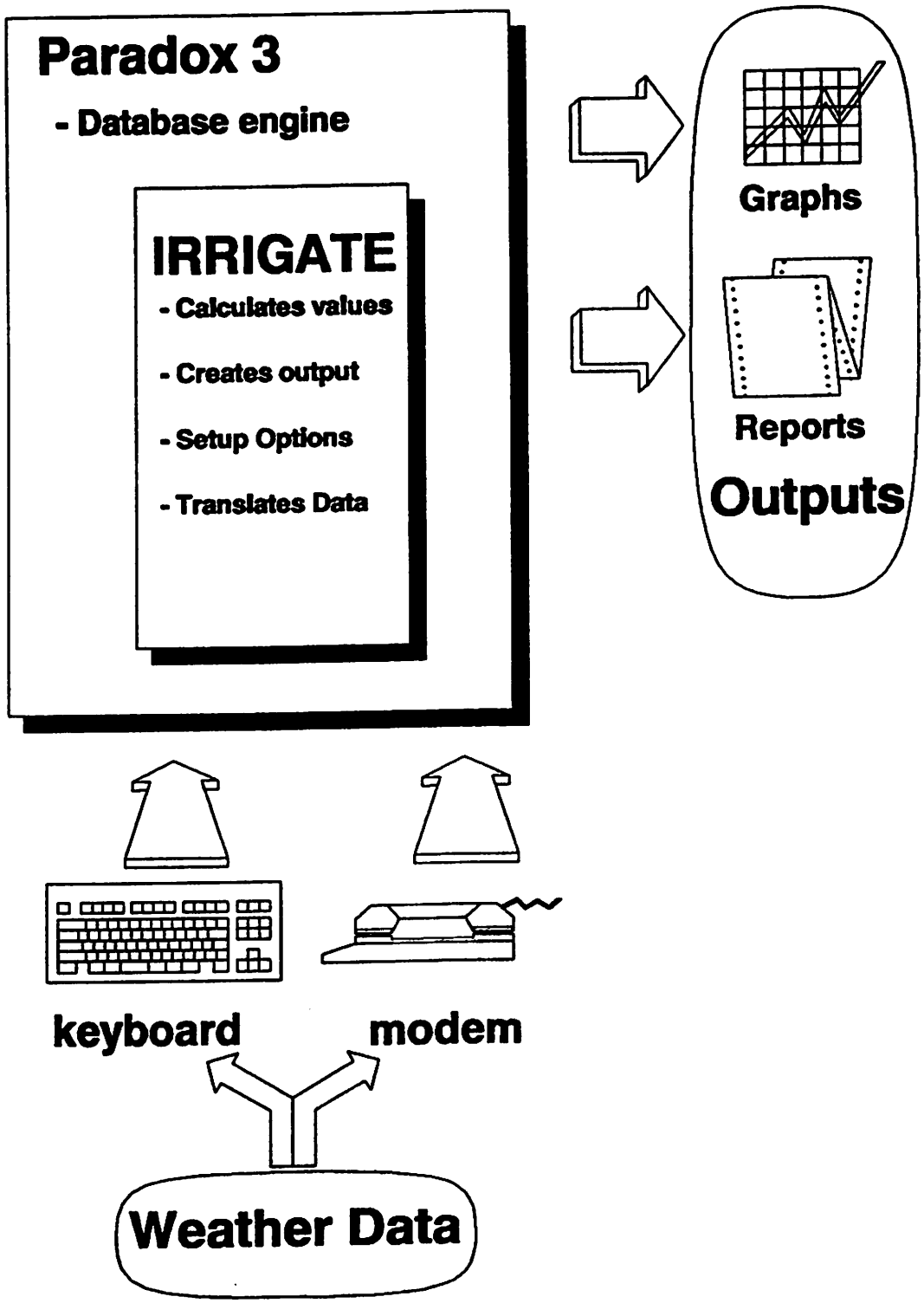
Our goal is to have a microcomputer based irrigation scheduling program for sale through the University of Nebraska by the first quarter of 1991.

Projected system requirements for *Irrigate*:

IBM PC, XT or compatible
640 K of RAM
Hard Disk Drive
DOS 2.10 or higher
Graphics capable monitor suggested but not required

Supporting publications from University of Nebraska Cooperative Extension Service:

NebGuide G85-753*Irrigation Scheduling Using Crop water Use Data*
NebGuide G84-690*Estimating Soil Moisture by Appearance and Feel*
NebGuide G78-393 *Water Measurement Calculations*
EC 84-724*Irrigation Scheduling Using Tensiometers in Sandy Soil*


Paradox 3
- Database engine
IRRIGATE
- Calculates values
- Creates output
- Setup Options
- Translates Data
Graphs
Reports
Outputs
keyboard
modem
Weather Data

Water Balance Report - Oldtest

Field North of the house

Corn, Crow's 111, Mid Season Emergence Date: May 30, 1989

Center Pivot 120 Acres Loam topsoil - heavy subsoil

System Capacity..: 1000 GPM Gross irrigation possible..: 1.11
2.5 Days to complete one irrigation Net irrigation possible....: .89

Date		Potential ET	Kc	Crop ET	Rain	Irrigation	Soil Water Balance	Minimum Allowable Balance	Root Depth (feet)	Accumulated Growing Degree Days	
6/21/89	Wed		.42	.12 *			3.09	1.88	1.5	466	May begin irrigation.
6/22/89	Thu		.44	.12 *	2.30		3.75	1.88	1.5	490	1.52 " of excess water applied.
6/23/89	Fri		.46	.13 *			3.62	1.88	1.5	514	Adequate soil moisture.
6/24/89	Sat		.49	.14 *			3.48	1.88	1.5	538	Adequate soil moisture.
6/25/89	Sun		.51	.14 *			3.34	1.88	1.5	562	Do not start irrigation before 6/25/
6/26/89	Mon		.54	.15 *			3.19	1.88	1.5	586	May begin irrigation.
6/27/89	Tue		.56	.16 *			3.03	1.88	1.5	610	May begin irrigation.
6/28/89	Wed		.58	.16 *			2.87	1.88	1.5	634	May begin irrigation.
6/29/89	Thu		.61	.17 *			2.70	1.88	1.5	658	May begin irrigation.
6/30/89	Fri		.63	.18 *			2.52	1.88	1.5	683	May begin irrigation.
7/01/89	Sat		.65	.19 *			2.33	1.88	1.5	707	MUST BEGIN IRRIGATION BY 7/01/89!
7/02/89	Sun		.68	.20 *			2.13	1.88	1.5	732	Should be irrigating...
7/03/89	Mon		.70	.20 *			1.93	1.88	1.5	756	Should be irrigating...
7/04/89	Tue		.72	.21 *			1.72	1.88	1.5	781	MUST FINISH IRRIGATION BY 7/04/89!

* denotes estimated actual ET

Total water applied from June 21, 1989 through July 4, 1989.

Rainfall = 2.30 inches
Irrigation = 0.00 inches Actual and Estimated ET = 2.27 inches

Oldtest