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Volume 1

DSSAT version 3

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IBSNAT, The International Benchmark Sites Network for Agrotechnology Transfer, is a network consisting of the contractor (University of Hawaii), its subcontractors and many global collaborators. Together they have created a network of national, regional and international agricultural research for the transfer of agrotechnology among global partners in both developed and lesser developed countries.

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DSSAT v3

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VOLUME 1-1

INTRODUCTION

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CHAPTER ONE.
THE IBSNAT PROJECT & DSSAT V3

IBSNAT

The Decision Support System for Agrotechnology Transfer (DSSAT) software and reference documents are products of the International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT) Project. The DSSAT products represent the collective outputs of a number of scientists involved in IBSNAT's global network of collaborators. Support was provided, in part, by each collaborator's participating institution and agency and through a cooperative agreement (No. DAN-4054-A-00-7081-00) between the U.S. Agency for International Development and the University of Hawaii at Manoa.

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XTREE is a registered trademark of Executive Systems, Inc.

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DSSAT v3 Development Team

Many individuals representing a number of institutions and organizations world-wide collaborated in different phases of the development of DSSAT v3. They are listed below in alphabetical order. The IBSNAT Project gratefully appreciates their contributions.

Brian Baer, Michigan State University; William D. Batchelor, University of Florida; Kenneth J. Boote, University of Florida; Walter T. Bowen, International Fertilizer Development Center (IFDC); Horatio V. K. Chan, University of Hawaii; J. Barry Dent, University of Edinburgh; Douglas C. Godwin, Dubbo, Australia; DeeDee Gresham, University of Georgia; James W. Hansen, University of Florida; Gerrit Hoogenboom, University of Georgia; L. Anthony Hunt, University of Guelph; Daniel T. Imamura, University of Hawaii; James W. Jones, University of Florida; Robin Matthews, University of Guelph; Richard M. Ogoshi, University of Hawaii; Hans O. Pinnschmidt, University of Hawaii and International Rice Research Institute; Nigel B. Pickering, University of Florida; Joe T. Ritchie, Michigan State University; Upendra Singh, IFDC; Glenda Smallwood, IFDC; Agatha Y. C. Tang, University of Hawaii; Philip K. Thornton, IFDC; Paul Wilkens, IFDC; and Jeff White, CIAT

CHAPTER TWO. INTRODUCTION TO DSSAT V3

IBSNAT assembled and distributed a decision support software entitled DSSAT (Decision Support System for Agrotechnology Transfer) which enables its users to match the biological requirements of crops to the physical characteristics of land so that objectives specified by the user may be obtained. The decision support software consists of 1) a Data Base Management System (DBMS) to enter, store, and retrieve the "minimum data set" needed to validate, list and use the crop models for solving problems; 2) a set of validated crop models for simulating processes and outcomes of genotype by environment interactions; and 3) an applications program for analyzing and displaying outcomes of long-term simulated agronomic experiments. This decision support system is designed to answer "what if" questions frequently asked by policy makers and farmers concerned with sustaining an economically sound and environmentally safe agriculture. Sustainable agriculture requires tools that enable decision makers to explore the future. A decision support system must help users make choices today that result in desired outcomes, not only next year, but 10, 25, and 50 or more years into the future.

But what confidence can we place in such predictions? A decision support system which purports to predict outcomes in the future should be able to do the same for events in the past. Predicting outcomes of historical events is necessary to validate the system. In agriculture production outcomes are governed by weather, soil conditions, genetic make up of the crop, pests, and crop management. Predicting genotype by environment by management interactions clearly requires interdisciplinary research.

DSSAT v3 is a collection of computer programs integrated into a single software package in order to facilitate the application of crop simulation models in research and decision making. The overall goal of this system is similar to its predecessor, DSSAT v2.1 (IBSNAT, 1989); however, the DSSAT v3 data bases, models, application programs, and their linkages have undergone major revisions. The resulting system is much more flexible and has more functionality for data base manipulation and model applications.

The integration of the various components into an overall functional system was accomplished with two major components. First, a set of data requirements was defined along with standard files, data formats and conventions to facilitate uniform access by all programs and communications between them. These formats are fully described in Volume 2-1 (Jones et al. 1994) of this book. Secondly, the Shell program was developed to allow

users to interactively select any of the functions in DSSAT v3 without their having to know where the programs are or how they are communicating.

System Requirements

Hardware

Processor:	IBM 286 or better, or compatible micro computer Math co-processor required, 287 or better
RAM:	640K (minimum 590K free DOS RAM required)
Display:	VGA color
Hard Disk:	Required, approx. 12 MB for complete DSSAT v3

Software

Operating System: DOS 3.3 or higher, or compatible

CHAPTER THREE. DSSAT V3 OVERVIEW

SHELL

The DSSAT v3 Shell is a menu-driven program which enables users to easily select and use any of the DSSAT components. The Shell has five main menu items, each with various options: DATA, MODELS, ANALYSES, TOOLS and SETUP/QUIT.

The DATA main menu item provides users access to weather, soil and experiment data, similar to that of DSSAT v2.1. One major change is that the new data are all stored in ASCII files so that users can access and manipulate them more easily than in the v2.1 system. Some temporary dBase files are created to allow users to search for data or information contained in the data, also a new capability. There is also a program, Convert, in DSSAT v3 to convert ASCII model input files from DSSAT v2.1 into the new v3 file formats for crop management inputs, soil and weather data. This will allow users to more easily adapt to v3. Although there is no program to convert genetic coefficient data from the old system to the new formats, genetic coefficients for all crop models have been converted and are available in DSSAT v3 for simulation with the new model versions.

New data sections have also been added under the DATA main menu item. Now there is a CLIMATE section which deals with monthly data, which can be used to simulate daily weather data if daily data are not available for a site. This new feature allows users to input monthly data from published sources, such as FAO, and simulate crop performance. There is also a GENOTYPE section, which contains a new genetic coefficient calculation program to assist users when they have cultivars that are not in the genetic coefficient data file. There is a BACKGROUND section which allows users to obtain general information on the data contained in their system, and sections on PEST and ECONOMIC to store and handle pest and economic data. The new data definitions and crop model inputs and outputs are fully described in Volume 2-1 (Jones et al. 1994) of this book.

Under the MODELS section, users can access models for calibration, validation and sensitivity analysis purposes as before. Currently, models are available for various cereal crops (maize, wheat, sorghum, millet, rice and barley), three grain legume crops (soybean, peanut, and dry bean), and cassava. Generally, the three grain legume models operate using one program and the cereal crops operate with another set of code, except for the

rice model. The crop models now have a more modular structure with a separate input module that processes the new files to reduce program size and complexity.

A new crop model graphics program is also available. It is mouse-driven and creates plots of simulated and observed variables similar to the graphics package in DSSAT v2.1. This package, called Graphing of Simulated and Experiment Data, is much more flexible and can output graphs to printers or to files for inserting into other software. Also under each crop model section is a selection for REVIEWing the results from simulation runs. This feature allows users to view results on the screen, or print them out to save them for other purposes. It accesses an ASCII editor which is supplied with DSSAT v3, or one which is specified by the user during setup. This allows users to "install" their own editor into DSSAT or use a default one that is supplied.

Under the ANALYSES section, two choices appear: Season and Sequence. The Season option allows users to setup simulation experiments, simulate them and analyze the results, similar to the strategy evaluation mode in DSSAT v2.1. It provides access to the interactive model input creation program, XCreate, which sets up one or more strategies to compare, for one or more crops. As was the case in DSSAT v2.1, the initial conditions are reset in this mode for each run, so that results represent the variability expected if the practices were implemented with fixed starting conditions. In addition to having the new XCreate program to setup runs and new crop model versions, DSSAT v3 also has a new seasonal evaluation program which will be described in more detail below. The second option under ANALYSES is to simulate sequences of crops, such as in crop rotations, for studying the long term effects of practices on crop and soil performance, with emphasis on time trends and uncertainty.

Under the TOOLS section, users can access their disk manager (such as XTREE), their editor and spreadsheet, or go to the DOS prompt temporarily without leaving DSSAT. These tool options were not available in DSSAT v2.1, and users found it inconvenient to exit and restart DSSAT when some other task had to be performed.

The SETUP/QUIT section is similar to the SETUP menu option in DSSAT v2.1, but more items can be setup or installed in DSSAT v3, such as the tools described above and managers of the different types of data, in addition to the models and analyses programs.

For a comprehension description of the DSSAT v3 Shell and its operation, see Part 3 of this Volume (Volume 1-3, Hunt et al 1994) .

Crop Models

The crop models in DSSAT v3 are new versions created by modifying models from DSSAT v2.1. The cereal crop models were basically integrated into one program referred to as the generic CERES model, and includes maize, wheat, sorghum, millet and barley. The rice model is a stand-alone model based on a CERES-Rice v2.1 conversion to v3 data files and formats. The grain legume models (SOYGRO, PNUTGRO, and BEANGRO) all operate using a generic grain legume model structure, called CROPGRO. The aroid and potato crop models have not yet been converted to the DSSAT v3 file and format structures. The cassava model uses the CROPSIM model structure, which is similar to the CERES models.

CERES

The five cereal models were combined to run with a single set of code by incorporating the development and growth sections from each individual model into a single module with a single soil component. This new module, called CERES, uses the DSSAT v3 input/output file structures and formats, and it is fully compatible with the graphics program, genetic coefficient calculator, and season analysis programs in v3. The input file for genetic coefficients, formerly referred to as GENETICS.MZ9 for maize, has been modified to adapt it to the genetic coefficient calculator program. The new genetic coefficient data file for maize is called MZCER940.CUL, to note that this file is for maize using the generic CERES model version 94-0. The genetic coefficients themselves have not been modified for the cereal crops, but their formats have been. Genetic coefficients for all cultivars in v2.1 have been converted and are available for simulation with the new crop model versions.

CROPGRO

The three grain legume models were also combined to operate under a single module, CROPGRO. In this new module, nitrogen components for the soil and plant system were added, including simulation of nitrogen uptake, fixation and mobilization. The crop carbon and nitrogen balance sections were restructured, and an option was added to simulate photosynthesis at the leaf level, using hourly time steps. Simulation of vegetative and reproductive development were modified, allowing more flexibility for defining the effects of temperature, photoperiod, drought and nitrogen stresses on development during the various soybean growth phases. Other new features include options to simulate the effect of a potential climate change on soybean growth and the effect of pest interactions on soybean productivity.

Evapotranspiration Calculations

In the CERES, CROPGRO and the other DSSAT v3 models, options exist for the Priestly-Taylor method for computing potential evapotranspiration, and for the Penman method using the FAO definitions of the wind term. The Priestly-Taylor method is the same as used by Ritchie (1985). The use of the Penman method requires daily humidity and wind speed data. The new weather file format includes columns for these data when they are available. When they are not available, users should select the Priestly-Taylor method.

Carbon Dioxide Effects

The new models have the capability to simulate the effects of CO_2 on photosynthesis and water use. Daily potential transpiration is modified by CO_2 concentration based on the effects of CO_2 on stomata conductivity (Peart et al., 1989). A multiplicative modification is made to daily canopy photosynthesis as described by Curry et al. (1988).

Climate Change Studies

The DSSAT v3 models have the capability to modify daily weather data that are read in from the weather file, as well as day length. Each weather variable can be modified, by multiplying a constant times the input value and/or adding a constant to it. This gives one the flexibility to change one or all weather variables and includes the capability to make them constant, as in constant environment experiments. Users can specify the date that a given modification is to begin, and can have more that one entry if the experiment included environment switching of any type. These options are available in FILEX for any experiment and are also available interactively during any model run.

Weather Generators

The new models have built-in capabilities for simulating weather using either one of two generators. Coefficients for generating weather are in *.CLI files, such as UFGA.CLI, where UFGA is the site of the weather station. One generator is SIMMETEO (Geng 1986) which requires only monthly averages of solar radiation, maximum and minimum temperatures, precipitation, and days with precipitation. This model then computes coefficients and uses the WGEN to simulate daily data. The second generator is WGEN (Richardson 1985), which requires more statistics which are computed from daily data from a number of years. This ability to simulate weather internally, using only monthly averages of variables will greatly expand the application of the models to areas where the monthly data are all that are available.

Crop Rotations

An option in the models allows users to select whether to reinitialize soil variables after each run or to use ending conditions from one run as inputs to the next run. This allows for crop rotations to be studied in the new models, with carry over effects in the soil currently limited to crop residue, soil N, carbon and water with depth. A sequence model "driver" is available to run the different crops in sequence, including a fallow period between crops. Any number of years of a crop rotation can be simulated in multiple replications, as specified by the user. A sequence analysis program analyzes time trends and variability in crop performance of the sequences.

For a comprehension description of the DSSAT v3 crop models, see Volume 2-2 (Hoogenboom et al. 1994) of this book.

VOLUME 1-2

INSTALLATION

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CHAPTER ONE.
GETTING STARTED

Before you begin the installation of DSSAT v3, turn on your computer and make sure your system has everything you need. See Part 1 of this Volume (Volume 1-1, Tsuji et al. 1994) for a description of system requirements.

Make backup copies of the distributed disks by using the DOS "DISKCOPY" command. Store the original disks in a safe place. The copies are your working disks. If they should become damaged or destroyed, use the original disks to restore DSSAT v3.

Take a moment now to read the file named "README" which will be found on the DSSAT Installation Disk #1. This file contains any changes or instructions incorporated into DSSAT v3 after this book was published.

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CHAPTER TWO.
DSSAT INSTALLATION

DSSAT v3 consists of many different components, including data programs, various crop simulation models and analysis programs for agrotechnology transfer. Its size necessitates the distribution of the system in a compressed format. All DSSAT v3 programs stored on the distributed disks are compressed using an archive utility. The Installation program found on the DSSAT Installation Disk #1 enables users to de-compress and transfer DSSAT v3 to a computer's hard drive.

BEGIN INSTALLATION

To start the DSSAT installation, place the DSSAT Installation System Disk #1 in drive A, or drive B. Change the DOS System C > prompt to the A >, or B> prompt. At the A >, or B> prompt, type "INSTALL," as shown:

A>INSTALL

A title screen (Screen 1 on the following page) with a description of the purpose of the installation program will be presented.

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```
DSSAT Installation                                        Version 3.0

The DSSAT consists of many different applications.  There are
data programs, simulations models for various crops, and analysis
programs for agrotechnology transfer.  Because of the size of the
system, DSSAT has been distributed in a compressed format.  This
installation program will enable you to de-compress and transfer
the DSSAT system to your computer's hard disk.


Please identify the drive to be used as the source drive.  This drive
will be used to read the compressed DSSAT programs.

  A - Drive A:
  B - Drive B:
```

SCREEN 1.

In Screen 1, identify the drive used as the source drive. The source drive is used to read the archived files from the DSSAT installation disks. Select a drive from the menu by highlighting "Drive A" or "Drive B," using the arrow keys, and then pressing the <ENTER> key, or press the <A> or <B> key.

```
DSSAT Installation                                        Version 3.0


                    DSSAT HARD DISK INSTALLATION

Select the portion of the DSSAT you wish to install from the Main Menu.

                          MAIN MENU

                    S Install DSSAT v3.0 Shell
                    D Install Data Programs
                    C Install Crop Models
                    A Install Analysis Programs
                    Q Quit
```

SCREEN 2.

After selecting the source drive, Screen 2 (above) displaying the DSSAT Installation main menu will be presented. The installation program allows you to selectively install any program in DSSAT. However, it is suggested that you install the DSSAT Shell before any other application.

When an option is selected from the menu, you will be prompted to insert the appropriate disks. You will be then asked for the location (drive and path name) of the programs. A default location for each program will be given at the prompt after an option from this menu has been selected. You can either keep the default information, by pressing the <ENTER> key, or enter another drive and path name.

To select one of the options listed in Screen 2, highlight one of the items by using the arrow keys and then press the <ENTER> key, or press the <S>, <D>, <C> or <A> key to install the Shell, Data Programs, Crop Models or Analysis Programs, respectively.

After the desired programs are installed, select "Q Quit" from the main menu to exit.

Configure Your System & Start DSSAT v3

Be sure you have a CONFIG.SYS file with the following statements in the root directory of your hard disk.

```
FILES=30
BUFFERS=30
DEVICE=ANSI.SYS
```

In your AUTOEXE.BAT file, add the drive and path name of the DSSAT v3 main directory (i.e. C:\DSSAT3) to the path statement, and the statement:

```
SET DSSAT3 = C:\DSSAT3
```

For example:

```
PATH C:\DOS; C:\DSSAT3; C:\UTIL
SET DSSAT3 = C:\DSSAT3.
```

After adding these statements to the CONFIG.SYS and AUTOEXE.BAT files, you need to re-boot your computer before running DSSAT v3.

To start DSSAT v3, type "DSSAT3" at the DOS System C> prompt.

VOLUME 1-3

ACCESSING DATA, MODELS & APPLICATION PROGRAMS

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CHAPTER ONE. INTRODUCTION

The DSSAT v3 Shell (Screen 1, shown below) is the interface between the user and the crop models, application programs and data files found in DSSAT v3. The Shell is menu-driven and thus enables users to easily select and use any of the DSSAT components. These components are displayed as menu items under the DSSAT title. Screen 1 shows the main menu items of the Shell and their corresponding menus.

```
DECISION SUPPORT SYSTEM FOR AGROTECHNOLOGY TRANSFER

DATA        MODELS      ANALYSES    TOOLS       SETUP/QUIT

B Background  C Cereals   S Seasonal  O Op.System  S Setup
X Experiment  L Legumes   Q Sequence  D Disk.mngr  Q QUIT
G Genotype    R Rootcrops             E Editor
W Weather     O Others                S Sp.sheet
S Soil
P Pest
E Economic

↑ ↓ → ←  moves through menu choices
ESC      moves to higher menu level                Version: 3.0
```

SCREEN 1.

DSSAT MAIN MENU

When DSSAT v3 is opened, the Shell, shown in Screen 1, will be presented. The DSSAT v3 Shell has 5 main menu options: DATA, MODELS, ANALYSES, TOOLS, SETUP/QUIT. Although Screen 1 shows all the menu options available under the Shell's main menu items, this will not be the case when actually using DSSAT v3; instead DSSAT v3 will open with the DATA main menu options listed. At the bottom of this screen is a display box which will present a description of any highlighted menu choice. For example,

Previous Page Blank

when the "B Background" menu option under DATA is highlighted, the description will read:

"Institutes, sites, and researchers; fields; and codes for data"

This means that by selecting this menu choice you will be able to access the described items.

GUIDELINES

The Shell interface is made up of menus, windows and dialog boxes. The user interacts with DSSAT v3 through the Shell using the menus and windows and the DSSAT program displays information for the user via windows. The mouse is not active in the Shell menu. However, in some of the programs called from the Shell, and described herein, the mouse can be used. If a screen displays a scroll bar, mouse use is available for that screen. To move through data fields presented on screen or to highlight items without a mouse, use the arrow keys or the <SHIFT> and <SHIFT><TAB> keys. To determine which of these key methods to use, look on the screens presented. A message will be displayed if the <SHIFT> and <SHIFT><TAB> keys are to be used. Also, the method to use is described herein for each screen illustrated.

KEYBOARD COMMANDS

Following is a list of keyboard commands that can be used in most, but not all, screens presented in DSSAT v3.

<ESC>	Cancel/Exit the current dialog box or menu.
<F1>	Context sensitive help.
<TAB>	Move to the next data entry field or dialog item.
<SHIFT>-<TAB>	Move to the previous data entry field dialog item.
Up Arrow	Move up a list of items.
Down Arrow	Move down a list of items.

CHAPTER TWO.
DATA MENU OPTIONS: INTRODUCTION

Under the DATA menu item of the DSSAT v3 Shell are options which provide users with access to various types of data on experiments, crops, weather, soils, climate, economics, and pests. Most data in DSSAT are in ASCII files which can be manipulated with text editors and various other software, such as spread sheets. These data are found under the option headings: BACKGROUND, EXPERIMENT, WEATHER, SOIL, PEST and ECONOMIC. Each of these options have various submenus which are accessed when one of the options is selected. For example, the Utilities for entering, searching, graphing, printing, and maintaining data for easy access and use with crop simulation models are also found under the DATA menu.

For ease of reading and operational use, each of the options found under the DATA menu item is described in a separate chapter herein.

CHAPTER THREE.
DATA MENU OPTION: BACKGROUND

To access the "Background" menu option under the DATA main menu item, highlight DATA and then press the <B> key or move the highlight bar with the arrow keys to "Background" and press the <ENTER> key. A menu of options available (shown in Screen 2, below) will be presented.

```
DECISION SUPPORT SYSTEM FOR AGROTECHNOLOGY TRANSFER

DATA        MODELS      ANALYSES      TOOLS      SETUP/QUIT

B Background
X   G General
G   F Fields
W   C Codes
S
P Pest
E Economic

List/edit infromation on institutes, sites and researchers.

↑ ↓ → ←  moves through menu choices
ESC      moves to higher menu level                Version: 3.0
```

SCREEN 2.

GENERAL

The purpose of the "General" menu option is to provide access to information on Institutes, Sites, and People, such as addresses and experiments performed. It also allows users to view and print out the information and to make additions, deletions or changes in the data.

To open this menu option, press the <G> key or highlight "General" and press the <ENTER> key. A submenu will be presented from which you can select "I Institutes," "S Sites" or "P People." Select one of these items by highlighting and pressing the

Previous Page Blank

<ENTER> key or by pressing the <I>, <S> or <P> key, respectively. Since the screens and the information accessed for each of these subjects are similar, only the screen for Institutes will be shown (Screen 3 below) to demonstrate the operation of these menu items.

```
Background Data Manager (BDM)                                  Version 3.0

        Institutes                    Current Choice

     AA  ALBERTA                 Institute.>  Alberta Agriculture
     AC  ACSAD
     AD  DRS                     Address...>
     AE  AES
     AI  INDONESIA               City......>
     AL  ALBANIA                 Province..>  ALBERTA
     AM  NEBRASKA                Country...>  CANADA
     AO  ORS                     Telephone.>
     AP  APAU
     AT  AVRDC
     AU  AU                        <F1>     Help            <F5>  Sort
     BA  BARC                      <F2>     Delete          <F6>  Print
     BB  BB                        <F3>     Add
     BI  BARI                      <F4>     Search          <F8>  Edit/View
     BU  BAU                       <RETURN> Repeat Search
                                   <ESC>    Previous Menu
   PgUp/PgDn   Scrolls
   Home/End    First/Last
```

SCREEN 3.

When "I" for "Institutes" is selected, the screen presented displays a left window listing all the Institute ID codes and their corresponding institutes found in DSSAT v3. Use the arrow keys to highlight one of the listings. The box labeled "Current Choice" in the right window will display information about the institute highlighted. Use the <F> keys listed below this window to get access to help, printing, editing, and other functions. When the <F6> key is selected, the contents of the institute data base will be printed to a printer or to an ASCII file. The file will be named INSTITUTE.PRN and it will be located in the C:\DSSAT3\BACKGRND path. When the <F2>, <F3> or <F8> keys are used, a dialog box is presented in which you can, respectively, delete an institute ID code and its corresponding information from the list, add a new one to the list or edit one. Pressing the <F1> "Help" key displays the following screen (Screen 4).

```
Background Data Manager (BDM)                                  Version 3.0

                              HELP SCREEN

 Use the <↑> key and <↓> key to select a record from the list of items.
 Use the <PgUp> key and <PgDn> key to scroll the list of items up and down.
 Use the <HOME> key and <END> key to select the first and last record in the
      list of items.

 Use the <F2> key to delete the record highlighted in the list of items.
 Use the <F3> key to add a new record to the database.
 Use the <F4> key to select a record from the list of items by entering its
      key field as shown in the list of items.
 Use the <F5> key to sort the list of items displayed.
 Use the <F6> key to print the contents of the data base
 Use the <F8> key to view or edit the record hightlighted in the list of
 items.

 Use the <Esc> key to return to the previous menu.

                          Press any key to continue
```

Screen 4.

Fields

The purpose of the "Fields" menu option is to help users review and edit description data on fields and soil analysis data from the field. The formats of data in the ASCII files that stores this information are the same as those used in the FILEX, or experiment details file, for the *FIELD and *SOIL ANALYSIS sections for individual experiments (see Volume 2-1, Jones et al. 1994, of this book for a description of these formats). The files accessed through the "Fields" menu option are used to store information on many fields and any historical data on soil analyses.

To open this menu option, press the <F> key or highlight "Fields" and press the <ENTER> key. A submenu will be presented from which you can select "D Descriptive Data" or "S Soil Analysis Information." Select one of these items by highlighting it and pressing the <ENTER> key or by pressing the <D> or <S> key, respectively.

FIELD INFORMATION - DESCRIPTIONS DSSAT : 3.0

FIELD	WEATHER	SLOPE	OBSTR	..DRAINAGE..			STONES	TEXTURE	DEPTH	SOIL
UCEA0001	IBHK	10N	5	1	50	50	-99*	SI	100	IBHK920001
UCEA0012	UCEA	5E	0	2	100	15	5S	SICY	125	UCEA880001
UCEA0013	UCEA	5E	0	2	100	15	5S	SICY	125	UCEA880001
UCEA0014	UCEA	5E	0	2	100	15	5S	SICY	125	UCEA880001
UCEA0020	UCEA	5E	0	2	100	15	5S	SICY	125	UCEA880001
UCEA0021	UCEA	5E	0	2	100	15	5S	SICY	125	UCEA880001
UCEA0022	UCEA	5E	0	2	100	15	5S	SICY	125	UCEA880001
UCEA0023	UCEA	5E	0	2	100	15	5S	SICY	125	UCEA880001
UCEA0024	UCEA	5E	0	2	100	15	5S	SICY	125	UCEA880001
UCEA0025	UCEA	5E	0	2	100	15	5S	SICY	125	UCEA880001
UCEA0026	UCEA	5E	0	2	100	15	5S	SICY	125	UCEA880001
UCEA0027	UCEA	5E	0	2	100	15	5S	SICY	125	UCEA880001

Press : Arrows to move ; E to edit ; A to add ; ESC or Q to return.

SCREEN 5.

DESCRIPTIVE DATA

When "D Descriptive Data" is selected from the "Fields" submenu, Screen 5 (above) will be presented. You can scroll through the list of actual fields with the arrow keys, edit the data, or add a new field location and data. If you highlight a field in the list and then press the <E> key to edit it, the file (FIELD.LST) containing the highlighted field's information is accessed either by the editor supplied with DSSAT v3 or one that you have installed. The format of any data you enter must adhere to the specifications for the *FIELDS section given in Volume 2-1 (Jones et al. 1994) of this book.

Press the <A> key to add a new field. A series of screens will be presented in which you will be asked to enter specific data for each column listed in Screen 5. Follow the instructions on each screen. When all entries have been completed, the data you have entered for the field and its name will be added to the list shown in Screen 5.

```
UC.SAN
*SOIL ANALYSES : UNIVERSITY OF GUELPH, CANADA

*UCEA0100 UPPER FIELD
@ADAT  SMHB  SMPX  SMKE
88116     5     6     7
@ SLB  SADM  SAOC  SANI  SAHW  SAHB  SAPX  SAKE
    5  1.55  40.0   5.0   7.5   7.3  10.0  0.33
   15  1.55  40.0   5.0   7.5   7.3  10.0  0.33
   30  1.63   20. 1 2.0   7.4   7.3   9.0  0.29

*UCEA0012 Lower field
@ADAT  SMHB  SMPX  SMKE
88003     1     1     1
@ SLB  SADM  SAOC  SANI  SAHW  SAHB  SAPX  SAKE
    5     1     1     1     1     1     1     1
```

Screen 6.

Soil Analysis Information

When "S Soil Analysis Information" is selected from the "Fields" submenu, a screen displaying a list of experiment fields with soil analyses data available in DSSAT v3 will be presented. To edit the data in any of the fields presented, highlight one of the fields using the arrow keys and press the <E> key. A screen similar to Screen 6 (above) will be presented. Scroll through this screen using the scroll bars on the right, or the arrow keys, and edit the data using either the editor supplied with DSSAT v3 or one that you have installed. The format of any data you enter must adhere to the specifications given in Volume 2-1 (Jones et al. 1994) of this book. Additional data may also be added to a selected field using an editor. Enter new fields and data with an editor, following the example formats shown below the * in the screen above and by naming the field ??.SAN, where ?? is the Institute ID code.

Codes

The purpose of this menu option is to give users access to information on codes used for specifying fertilizers, chemicals, growth stages, and other management inputs as well as abbreviations for data that are observed or simulated. Access to these files is with a user-installed text editor. The path to a user's editor and the name of the executable file must be installed from the SETUP main menu item of the DSSAT v3 Shell (see Chapter 13, "SETUP/QUIT Menu Options").

```
CODES MENU                                                    DSSAT : 3.0

   PRESS:

      D  for DATA            Codes for measured or simulated data.
      P  for PHENOLOGY       Codes for phenological (growth) stages.
      S  for SOIL            Codes for soil information.
      W  for WEATHER         Codes for weather data.
      X  for EXP.DETAILS     Codes for inputs, methods, etc...
      C  for COEFFICIENTS    Codes for genotype (cultivar) coeffs..
      J  for JULIAN DATES    Day of year - day of month conversions.

      ESC  to QUIT

   Access files with codes used when documenting experimental
   conditions, experimental data, weather or cultivar coeffs..
```

SCREEN 7.

To open this menu option, press the <C> key or highlight "Codes" and press the <ENTER> key. A submenu will be presented from which you can select any of the options shown in Screen 7 (above).

Select one of these menu options by pressing the <D>, <P>, <S>, <W>, <X>, <C> or <J> key, respectively. Codes pertaining to each of these items will be presented, as illustrated for "P for Phenology" in Screen 8 below; but the actual screen presented will depend on a user's editor.

```
                                GRSTAGE.CDE
*GROWTH STAGE CODES

*Growth and Development Codes - Maize
VE    50% of plants with some part visible at soil surface
V1    50% of plants with collar of 1st leaf visible
V2    50% of plants with collar of 2nd leaf visible
V3    50% of plants with collar of 3rd leaf visible
V4    50% of plants with collar of 4th leaf visible
V5    50% of plants with collar of 5th leaf visible
V6    50% of plants with collar of 6th leaf visible
Vn    50% of plants with collar of nth leaf visible
VT    50% of plants with last branch of tassel visible, but silks not yet vis
R1    50% of plants with some silks visible outside husks
R2    50% of plants in blister stage
R3    50% of plants in milk stage
R4    50% of plants in dough stage
R5    50% of plants in dent stage
R6    50% of plants in physiological maturity
R7    50% of plants harvest maturity

*Growth and Development Codes - Soybean, Dry Bean
```

SCREEN 8.

CHAPTER FOUR.
DATA MENU OPTION: EXPERIMENT

To access the "Experiment" menu option under the DATA main menu item, highlight DATA and then press the <X> key or move the highlight bar with the arrow keys to "Experiment" and press the <ENTER> key. The purpose of the "Experiment" menu option is to provide access to experimental data management functions, including inputting, editing, graphing, listing, linking them to models, and printing. When it is accessed, a menu of three options will be presented: "L List/Edit," "C Create" and "U Utilities."

LIST/EDIT

The purposes of the "List/Edit" menu option are as follows.

1. Lists all experiments in a particular directory, giving, for each experiment, the file name, the crop code, standard and local experiment names and a brief description of the experiment. It also lists soil texture and depth, latitude, longitude and elevation of the experiment site and the climate or agroecological zone to which the site belongs. Keeps this list of files in a file named EXPLST.DBF, which is updated after new experiments are added using the <F9> key.
2. Provides access to any of the experiment files (FILEXs), with the <F8> key, using a file editor. Users can choose experiment data files (FILEXs) and crop performance averages (in FILETs and FILEAs). Access is with either a user-installed text editor or the editor supplied with DSSAT v3.
3. Allows for sorting of files to locate experiments for specified crops, standard or universal names, or local names. Sorting is performed by placing the cursor in a column to search on and then pressing the <F5> key to initiate the sort operation.
4. Updates the experiment list (EXP.LST) read by the crop models to include new experiments or to reduce the number of experiments that are listed for model simulation. Allows users to toggle any experiment in the path to be included or excluded form EXP.LST, using the <L> key.
5. Allows users to search and locate experiments in the current path based on the types of treatments included in the experiment, on types of soils, on people who conducted the experiment and on experiments performed at specific institutes. Use the <F4> key.
6. Allows users access to a global list (EXPLSTG.DBF) of experiments for all crops in all DSSAT v3 directories, using the <F10> key. Allows users to select experiments in

other paths, and presents experiments in the paths selected in order to maintain the EXP.LST for each crop.

```
Experiment File Manager (EFM)                                    Version 3.0
                    - Files In All Installed Directories -

  FILE NAME      CG   UNV NAME   LCL NAME   EXPERIMENT FACTOR (S)/NAME
  CCPA7802.CSX   CS   CCPA7802   VELTKAM1   CULTIVARS 4C
  CCPA7901.CSX   CS   CCPA7901   VELTKAM2   CULTIVARS 4C
  CCPA8001.CSX   CS   CCPA8001   VELTKAM3   CULTIVARS 4C
  CCPA8629.BNX   BN   CCPA8629              3 CULTIVARS, 2 ROW WIDTHS, 2 DENS
  CCSA7901.CSX   CS   CCSA7901   CONNOR     DROUGHT 2C*2DR
  DTSP8502.RIX   RI   DTSP8502              EFFECTS OF APPL. N & ENVIR. ON RI
  FLSC8101.MZX   MZ   FLSC8101   CERES MA   N X IRRIG., S.C.
  IBSI8001.MZX   MZ   IBSI8001              MULTI-YEAR TEST, SITIUNG
  IBWA8301.MZX   MZ   IBWA8301              N X VAR WAPIO, IBSNAT EXP.1983-4
  ICTH8001.WHX   WH   ICTH8001              TEL HADYA SYRIA MULTIPLE YEAR RUN
  IFRO7401.WHX   WH   IFRO7401              ROTHAMSTED ENGLAND 1975
  IFSW7501.WHX   WH   IFSW7501              SWIFT CURRENT CANADA 1975

F1  - Help                 F4  - Search          F7  - Colour OFF
F2  - Institute Listing    F5  - Sort            F8  - EDIT
F3  - Site Listing         F6  - Print           F9  - Remake List
Esc - Quit                                       F10 - Working List
```

SCREEN 9.

To open the "List/Edit" menu option, press the <L> key or highlight "List/Edit" and press the <ENTER> key. Screen 9 (above) will be presented, displaying the global list of experiments with crop code, experiment name and a summary of experimental factors. The UNV NAME is the name according to the naming convention described in Volume 2-1 (Jones et al 1994) of this book, whereas the LCL name could be any identifier that the user wishes to have. The general <F> key functions for searching, sending, printing and editing are similar to those described under Screen 3 in Chapter 3. There are two keys that need additional explanations.

The Database List shown in Screen 9 includes files in all directories identified with an EXD code in the file DSSATLST.FLE; in other words, a global listing of all directories in you computer with experiments in them. This file is similar to DSSATPRO.FLE, but it also contains pointers to any path in your computer that has experimental data. DSSATLST.FLE is found in the C:\DSSAT3 directory and can be edited by any text editor to add new paths. If the DSSATLST.FLE file is edited, you must press the <F9> key to re-build the global experiment list. The Working List (key <F10>) displays a list of experiments in the working directory. The working directory can be changed by moving

```
Experiment File Manager (EFM)                                    Version 3.0
                    - Files In Directory: C:\DSSAT3\SOYBEAN -

L   FILE NAME      CG  UNV NAME  LCL NAME  EXPERIMENT FACTOR (S) /NAME
√   IUCA7901.SBX    SB  IUCA7901            WAYNE, IRRIGATED & NON-IRRIGAT
√   UFGA7801.SBX    SB  UFGA7801            BRAGG, IRRIGATED & NON-IRRIGAT
√   UFGA7802.SBX    SB  UFGA7802            BRAGG IRR*INSECT DAMAGE
√   UFGA7901.SBX    SB  UFGA7901            IRRIGATION II
√   UFGA8101.SBX    SB  UFGA8101            COBB, IRRIGATED, VEG. & REPROD
√   UFQU7901.SBX    SB  UFQU7901            BRAGG, WELL IRRIGATED
√   UFQU7902.SBX    SB  UFQU7902            BRAGG, DEFOLIATION STUDY

F1  - Help                  F4  - Search              F7  - Colour OFF
F2  - Institute Listing     F5  - Sort                F8  - EDIT
F3  - Site Listing          F6  - Print               F9  - Remake List
Esc - Quit            L - Include/Exclude In Sublist  F10 - Edit Config File
```

SCREEN 10.

the highlight bar over a particular experiment and pressing the <F10> key. The program will then transfer to the directory containing that experiment and list all experiments in that directory. You can go back to the global list by pressing the <F10> key again.

The screen for the Working List is shown in Screen 10 (above). While viewing this screen, you have access to various function keys. They are the same as those for the Database (or Global) List, except for the addition of the <L> key. By highlighting a particular experiment and pressing the <L> key, that experiment is marked so it can be accessed by the crop models. Note the first column on Screen 10 is headed by an "L" with check marks in this column for particular rows. The experiments checked will be written to the EXP.LST file in the working directory so that models can access those experiments. This will allow many experiments to be stored on a disk. In Screen 10, the EXP.LST will be written to the path C:\DSSAT\SOYBEAN with all experiments listed (checked) for model access.

CREATE

The purpose of the "Create" menu option is to enable the user to create an experiment description file (FILEX), which is used as an input file to the crop models, using the program entitled XCreate. Users can define treatments for a new experiment as well as the crop management inputs used to manage the experiment. These includes field informa-

tion, initial conditions, irrigation, fertilizer management, residue management, cultivar, and other data needed to specify experimental conditions. Users can select an existing experiment from those in the current path (listed in EXP.LST) and modify it to create a new experiment, or they may start with an empty file and enter all data for a particular experiment. XCreate can be used to enter real experiments as well as hypothetical ones for sensitivity analysis, risk analysis, etc. It also allows users to specify Simulation Control options.

To open the "Create" menu option, press the <C> key or highlight "Create" and press the <ENTER> key. A complete description of the XCreate program and its use are described in detail in Part 4 of this Volume (Volume 1-4, Imamura 1994).

UTILITIES

The purpose of the "Utilities" menu option is to allow the user to review crop performance data, compute averages from replicate data, and display graphs of measurements made within the growing season (time series graphs) and summary responses. From within this menu option, users may also convert DSSAT v2.1 model input and experimental data files into the file formats of DSSAT v3.

To open this menu option, press the <U> key or highlight "Utilities"and press the <ENTER> key. When it is accessed, a menu of three options will be presented: "L List/Edit," "G Graphs" and "C Convert."

LIST/EDIT

The "List/Edit" utility allows the user to list and edit crop performance data stored in FILEA, FILET, or FILEP files. These files are described in Volume 2-1 (Jones et al. 1994) of this book.

To open the "List/Edit" option, press the <L> key or highlight "List/Edit" and press the <ENTER> key. A submenu listing the crops in DSSAT v3 will be presented. After a crop is selected, a screen will be presented which displays all of the time series, seasonal average and crop performance (replicate) data files (T, A, and P, respectively) found in the directory specified in the DSSATPRO.FLE for that crop. Screen 11 (shown on the following page) is an example screen showing these files for Soybean.

The list that is made from this collection of data files is not used by the crop models. The <F10> button in Screen 11 allows you to specify an alternate name for this list and you can configure wild card inclusions and exclusions from the list.

```
General File Manager - Experiment data                          Version 3.0
                        - Files In Directory: C:\DSSAT3\SOYBEAN -
 L   FILE NAME       FILE HEADING
     FILEX.RPT       EXP.DETAILS: UFGA7801SB BRAGG, IRRIGATED & NON-IRRIGATED
     IUCA7901.SBA    PERFORMANCE DATA - AVERAGE VALUES
     IUCA7901.SBT    PERFORMANCE DATA - TIME COURSE OF AVERAGE VALUES
     UFGA7801.SBA    PERFORMANCE DATA - AVERAGE VALUES
     UFGA7801.SBT    PERFORMANCE DATA - TIME COURSE OF AVERAGE VALUES
     UFGA7901.SBA    PERFORMANCE DATA - AVERAGE VALUES
     UFGA7901.SBT    PERFORMANCE DATA - TIME COURSE OF AVERAGE VALUES
     UFGA8101.SBA    PERFORMANCE DATA - AVERAGE VALUES
     UFGA8101.SBT    PERFORMANCE DATA - TIME COURSE OF AVERAGE VALUES
     UFQU7901.SBA    PERFORMANCE DATA - AVERAGE VALUES
     UFQU7901.SBT    PERFORMANCE DATA - TIME COURSE OF AVERAGE VALUES

F1  - Help                    F4  - Search                F7  - Colour OFF
F2  - Institute Listing       F5  - Sort                  F8  - EDIT
F3  - Site Listing            F6  - Print                 F9  - Remake List
Esc - Quit              L - Include/Exclude In Sublist    F10 - Edit Config File
```

SCREEN 11.

GRAPHS

The purposes of the "Graphs" utility are to enable the user to graph time series measurements from FILETs and to graph any crop response vs. other crop variables or management inputs that are in FILEAs. Users can select from any of the experiments found in a particular path and then select the type of graph (time series or summary responses) to display. When the type of graph is selected, a list of variables for graphing will be displayed; 1 to 6 variables can be plotted on the same graph. The graph can be saved in a file or printed on a printer, with options available to users for selecting the type of file and type of printer. This graphics program, entitled Graphing Simulated and Experiment Data, can also plot simulated and experimental data under the MODELS menu of DSSAT v3, and is described in detail in Volume 2-3 (Chan et al. 1994) of this book.

CONVERT

The purpose of the "Convert" utility is to enable users to convert DSSAT v2.1 crop model input files and crop performance files into DSSAT v3 experiment (FILEX) and crop performance (FILEA and FILET) files, using the program, Convert. The program enables users to convert weather data, experiment data, and soil data from the old model inputs and outputs described in IBSNAT Technical Report 5 (IBSNAT 1990) into the DSSAT v3 files and formats described in detail in Volume 2-1 (Jones et al. 1994) of this book. The program searches the disk for existing files for all of the crops in DSSAT v2.1 and lists them. Users can then select one or more crops and any one or all of the experiments for

each crop to convert. Once the files are converted, the data can be used as inputs to the different model, graphics, and analyses programs available in DSSAT v3. The Convert program and its operation are described in detail in Part 5 of this Volume (Volume 1-5, Imamura & Tang, 1994).

CHAPTER FIVE.
DATA MENU OPTION: GENOTYPE

To access the "Genotype" menu option under the DATA main menu item, highlight DATA and then press the <G> key or move the highlight bar with the arrow keys to "Genotype" and press the <ENTER> key. The purpose of the "Genotype" menu is to provide access to information on crop cultivars, and on cultivar coefficients for crop models. It also allows users to calculate cultivar coefficients for crop models using their own experiment data, and allows users to access ecotype and species coefficients for crop models, if they are available. In DSSAT v3, these files exist for the grain legume models only. When "Genotype" is accessed, a menu of three options will be presented: "L List/Edit," "A Append" and "C Calculate."

LIST/EDIT

The purpose of the "List/Edit" menu option is to enable users access to data files in order to search for information on genotypes, based on crop and cultivar names, as well as those based on experiments, institutes, sites and people providing the information.

To open this menu option, press the <L> key or highlight "List/Edit" and press the <ENTER> key. The "List/Edit "program used for genotype data is the same as that used for "Experiment" data (see the section entitled "Experiment" in this chapter). However, it is set up to work only in the C:\DSSAT3\GENOTYPE directory. In addition, it is configured by using the <F10> key to produce a listing of checked files with CUL, SPE and ECO extensions in the file named GENOTYPE.FLE.

APPEND

The purpose of the "Append" menu option is to enable the user to add a new cultivar entry into a cultivar coefficient file so that the genetic coefficient calculator program will have starting values when it estimates coefficients from experimental data.

To open this menu option, press the <A> key or highlight "Append" and press the <ENTER> key. A screen will be presented in which you are asked to select a crop. Enter the one-letter code for the crop you are working with.

Enter the cultivar name when the next screen asks for it. Next, enter the institute ID code (e.g., UF).

The program will then search for other cultivars with this same institute ID code and check for the first vacant number before assigning the new cultivar a number. It will also determine whether a cultivar with the same name is already in the file. For example, if the cultivar file SBGRO940.CUL has cultivar UF0019 in it and UF was entered as an institute ID code, then the new entry will be labeled UH0020.

```
CULTIVAR ADDITION                                          DSSAT : 3.0

    To what 'type' does the cultivar belong ?

    Number -->

    1  M GROUP   1          9  M GROUP   0
    2  M GROUP   2         10  M GROUP  10
    3  M GROUP   3         11  M GROUP 000
    4  M GROUP   4         12  M GROUP  00
    5  M GROUP   5         13  M GROUP   0
    6  M GROUP   6
    7  M GROUP   7
    8  M GROUP   8

       Add a new cultivar to coefficient file : SBGRO930.CUL
```

SCREEN 13.

The next screen presented (Screen 13 above) will display several general cultivars, if they were designated as such in the cultivar file by '99' in the institute slots (e.g., 990001 would be general soybean maturity group 1 coefficients.) Enter a number to choose a cultivar "type." The group types listed in Screen 13 are soybean maturity (M) groups which are photoperiod sensitive and which are stratified by latitude. Thus, the maturity group type number increases as you move away from the equator. You can then type in notes in response to a screen question, and edit the file to confirm that the new cultivar was added with initial values for coefficients. For a more detailed explanation, see Volume 2-2 (Hoogenboom et al. 1994) of this book.

CALCULATE

The purpose of the "Calculate" menu option is to enable the user to calculate cultivar coefficients for different crops. To open this menu option, press the <C> key or highlight "Calculate" and press the <ENTER> key.

When "Calculate" is selected, three options are presented: "I for INDIVIDUAL determinations," "A for AVERAGES calculations" and "Q to QUIT." If "I" is selected, the program adjusts one coefficient at a time, runs the crop model, compares simulated with observed traits, and repeats this process until the differences drop to a low, acceptable level. This process may take some time because the model may be run many times as the program adjusts the different coefficients. Allowable ranges for each coefficient are included in control files for the calculator, and the program stops searching on a particular coefficient if it tries to exceed this range. Note, however, that the actual coefficients vary from crop to crop, and this is taken into account in crop-specific control files that are contained in the system. For a complete description of this program and its operation, see Volume 3-4 (Hunt et al. 1994) of this book.

Select "A" only after determining coefficients for several experiments.

CAUTION: *Before using the "Calculate" program to compute cultivar coefficients, users should create a backup copy of all of their cultivar coefficient files. These files, with CUL extensions, will be found in the GENOTYPE directory (i.e., C:\DSSAT3\GENOTYPE) and should be copied into files of the same prefix name but with a SAV extension. Newly computed cultivar coefficients are written into this file as an option, and contents of the original file could be destroyed.*

CHAPTER SIX.
DATA MENU OPTION: WEATHER

To access the "Weather" menu option under the DATA main menu item, highlight DATA and then press the <W> key or move the highlight bar with the arrow keys to "Weather" and press the <ENTER> key. The purpose of the "Weather" menu is to provide users access to a wide range of weather data management capabilities including searching and sorting for weather stations; editing, printing, re-formatting weather data files; generating daily data; inputting monthly data; analyzing real and simulated weather data; cleaning and filling-in missing observations; and graphing daily weather data and summary statistics. When "Weather" is accessed, a menu of two options will be presented: "L List/Edit" and "U Utilities."

LIST/EDIT

The purposes of the "List/Edit" menu option are as follows:

1. Lists all daily weather files in a path with the filename, site name, zone, years (station in place), latitude, longitude, elevation and annual temperature average and amplitude and sequences for each data file. Keeps this list of files in a file named WTHLST.DBF, which is updated, using the <F9> key, after new weather files are added.
2. Provides access to any of the daily weather data files (*.WTH files) using a file editor. Access is with either a user-installed text editor or the editor supplied with DSSAT v3.
3. Allows sorting of the files in order to locate weather for specified filename, site name, zone, years, latitude, longitude, elevation and annual temperature average and amplitudes and sequences. Sorting is performed by placing the cursor in a column to search on and then pressing the <F5> key to initiate the sort operation.
4. Updates the experiment list (WTH.LST) read by the crop models to include new weather data or to reduce the number of weather files that are listed for model simulation. Allows users to toggle any weather file in the list on the screen to be included or excluded form WTH.LST, using the <L> key.
5. Allows users to search in order to locate weather data in the current path based on the filename, site name, zone, years, latitude, longitude, elevation and annual temperature average and amplitude. Use the <F4> key.
6. Allows users access to a global list (WTHLSTG.DBF) of weather data in various paths, using the <F10> key. Allows users to select weather files in other paths and presents

Previous Page Blank

weather files in the path selected in order to maintain the WTH.LST for each path where weather data are contained.

7.) Provides capabilities for users to determine what daily generated weather data files are available.

8. Climate files (.CLI files) contain general site information as well as long-term monthly means of daily weather variables. These data are used to generate daily weather data when actual daily data are not available for a site. A climate data list manager provides capabilities for users to determine what climate data files are available, to view and edit them, to search for climates with certain characteristics, and to maintain a list of available sites for use by the crop models and weather generator.

To open the "List/Edit" menu option, press the <L> key or highlight "List/Edit" and press the <ENTER> key. Screen 14 (below) will be presented, displaying the global list of weather files with filename, site name, zone, years, latitude, longitude, elevation and annual temperature average and amplitude and sequences. Since all the columns do not fit on one screen, use the arrow keys to scroll left and right through the columns.

Weather File Manager (WFM) Version 3.0

- Files In All Installed Directories -

FILENAME	SITE NAME	ZONE	YR	LAT	LONG	ELEV
CCPA8601.WTH	CIAT,PALMIRA,COLOMBI	XXX	-9	3.5	-76.4	-99
CCPA8601.WTH	CIAT,PALMIRA,COLOMBI	XXX	-9	3.5	-76.4	-99
DTSP8501.WTH	SUPHEN_BURI,THAILAND	XXX	-9	14.5	100.1	-99
EBGO8701.WTH	CNPAF,GOIANIA,BRAZIL	XXX	0	-16.3	-49.1	-99
FLSC8101.WTH	FLORENCE,SOUTH_CAROL	XXX	-9	34.0	0.0	0
GABL.CLI	ESTIMATED_FROM_DAILY	XXX	0	33.2	-84.4	0
GABL.WTD			0	4.5	9.4	2
GABL8701.WTH	BLEDSOEFARM,WILLIAMS	XXX	-9	33.2	-84.4	0
GABL8801.WTH	BLEDSOEFARM,WILLIAMS	XXX	-9	33.2	-84.4	0
GABL8901.WTH	BLEDSOEFARM,WILLIAMS	XXX	-9	33.2	-84.4	0
GABL9001.WTH	BLEDSOEFARM,WILLIAMS	XXX	0	33.2	-84.4	0
GABL9101.WTH	BLEDSOEFARM,WILLIAMS	XXX	-9	33.2	-84.4	0

F1 - Help F4 - Search F7 - Colour OFF
F2 - Institute Listing F5 - Sort F8 - Edit
F3 - Site Listing F6 - Print F9 - Remake List
Esc - Quit L - Include/Exclude In Sublist F10 - Database List

SCREEN 14.

The FILENAME is the name of the weather file, using the DSSAT v3 file naming convention. The SITE NAME is the name of the weather station site. ZONE can be any

weather classification system the user wishes to use. YR is the number of years of weather data for that site. LAT and LONG and ELEV are latitude, longitude and elevation, respectively, and describe the location of the weather station. TAV is the annual average temperature. TAMP is the annual average amplitude. SEQUENCES is listed so the user can enter weather sequence numbers for that site if desired; for example, 84001-87365. ZONE, YR and SEQUENCES are not required data. The general functions for searching, sorting, printing and editing are similar to the other data operations described under Screen 3 in Chapter 3, as are the <F9>, <F10> and <L> keys, which are described under "List/Edit" in Chapter 4.

The Database List shown in Screen 14 includes files in all directories identified with a WTH or CLI extension in the file DSSATLST.FLE; in other words, it is a global listing. The DSSATLST.FLE is found in the C:\DSSAT3 directory and can be edited by any text editor to add new paths. If the file is edited, you must press the <F9> key to re-build the global experiment list. The Working List displays a list of weather files in the working directory. The working directory can be changed by moving the highlight bar over a particular weather file and pressing <F10>. The program will then transfer to the directory containing that file and list all weather files in that directory. You can go back to the global list by pressing <F10> again.

UTILITIES

The purpose of the "Utilities" menu option is to enable users to reformat ASCII weather data files, fill missing data, generate weather data, compute statistics on daily weather data, and graph data. The weather manager program is called WeatherMan (WM.EXE) and a detailed description of its capabilities and its operation can be found in Volume 3-3 Hansen et al. 1994) of this book. The program functions both with a mouse or the keyboard; however, the use of a mouse is recommended. WeatherMan was designed to run under DSSAT v3 or to run stand-alone.

To open the "Utilities" menu option, press the <U> key or highlight "Utilities" and press the <ENTER> key. The WeatherMan program will open, displaying the WeatherMan main menu options, described below.

FILE

Provide access to an editor from within WeatherMan, change working directory (e.g., go to DOS shell), access general information about WeatherMan, and exit the program.

STATION

Select a station name, enter/edit station information and monthly mean weather data manually, or compute monthly means from previously archived daily data files for the station. The station name is used to locate all daily, climate, generated and archived data files. Selection of a station is required for most operations, but it is not required for a quick Convert Format.

IMPORT/EXPORT

Convert. The "Convert" menu option allows users to quickly convert weather data files by naming the file to be converted, specifying its format, naming the new file and specifying the final format. Format specification can be made by selecting the name of a previously defined format, such as IBSNAT2 or IBSNAT3 or a previously user-defined name or by building a new format interactively. Data are assumed to be in column format for this version. A file viewer is provided to assist in building the format.

Import. The "Import" menu item is similar to "Convert," but it allows users to save data into an ASCII archive file, named ssss.WTD, where "ssss" is the weather station code. Imported data will be added to data already in the archive file. On "Import," data can be checked and flagged for erroneous characters, missing data, missing dates, out of range data, and data that change too rapidly from one day to the next. The flags are defined in WeatherMan (Volume 3-4, Hansen et al. 1994, of this book) and in Appendix D of Volume 2-1 (Jones et al. 1994).

Export. The "Export" menu option enables users to export data from the station archive file by specifying a format and naming an export file. The default format and file naming convention are those defined in Volume 2-1 (Jones et al. 1994) of this book. Options under this section allow users to determine whether data errors and missing data will be filled, and if so, whether running averages, monthly averages or generated daily values will be used.

GENERATE

With the "Generate" menu option, weather coefficients can be calculated from daily weather data stored in the archive (WTD) files and daily weather data generated. Daily weather can be generated using the WGEN (Richardson and Wright, 1984) model which requires coefficients computed from daily data, or the SIMMETEO model (Geng et al., 1988; Geng and Auburn, 1987) which operates using long-term monthly averages. Generated data are stored in temporary archive files, named ssss_GEN.WTD, for further

analysis. Generated data can then be exported to yearly files, such as those defined for DSSAT v3, or to a single file.

ANALYZE

With the "Analyze" menu item, users can select from several types of statistics that can be computed for the data contained in any existing archive file. Statistics can be printed or viewed under the "Report" menu item. A graphics program (WMGRAF.EXE) is included to display daily data or statistics, and the graphs can be printed or written to a file. Comparisons between original data and generated data and between sites are also possible. Note that only time series graphs are available for DSSAT v3.

OPTIONS

With the "Options" menu item, users can change the directories used by the WeatherMan program, change the display mode and colors, specify the format for graphs, and select graph output options. Any changes made can be saved to a configuration file. Users can also enable or disable access to DSSAT v3 directory information for stand-alone operation. See Volume 3-3 (Hansen et al. 1994) of this book for a detailed description of WeatherMan.

CHAPTER SEVEN.
DATA MENU OPTION: SOIL

To access the "Soil" menu option under the DATA main menu item, highlight DATA and then press the <S> key or move the highlight bar with the arrow keys to "Soil" and press the <ENTER> key. The purpose of the "Soil" menu is to provide users access to all soil profile data in DSSAT v3. In DSSAT v3, soil data for models can be stored in a file named SOIL.SOL, or they may be stored in other files, such as UF.SOL, which designates the institute code for organizing a set of soils. Users can search on soils by name, description, texture, and depth as well as site, country, and latitude and longitude of the soil sample. Functions to sort, print, and select files for editing are made available. Graphs of selected soil attributes vs. depth can be viewed.

Another major function of this menu option is to allow users to create new soil profiles for running the crop models in three ways: 1) by entering soil data interactively with a program which will compute the soil parameters for the *.SOL files; 2) by accessing a large data base of soil characteristic data and selecting a soil similar to the one at a site; and 3) by using a text editor to enter the soil parameters directly, based on the file formats given in Volume 2-1 (Jones et al. 1994) of this book.

When "Soil" is accessed, a menu of three options will be presented: "L List/Edit," "C Create" and "U Utilities."

LIST/EDIT

The purposes of the "List/Edit" menu option are as follows.

1. Lists all soils from all *.SOL files in a path. The columns on the screen display the soil code, texture, depth, description, site, country, latitude, longitude, data source, and taxonomy. Horizontal scrolling allows one to view all columns while keeping the code on the screen. This list of files is kept in a file named SOLLST.DBF, which can be updated after new soil profile characteristics are added using the <F9> key.
2. Provides access to any of the soils in any of the soil files using a file editor. Access is with either a user-installed text editor or the editor supplied with DSSAT v3.
3. Allows sorting in order to locate soils based on any of the information in the columns. To sort, place the cursor in a column and then press the <F5> to initiate the sort.

Previous Page Blank

4. Creates a list of selected soils (SOL.LST) for use by the crop models by allowing the user to include new soils or to reduce the number of soils that are listed for model simulation. Use the <L> key to toggle-check any soil in the list for inclusion in or exclusion from the SOL.LST file.
5. Allows users to search and locate soils in the current path based on soil code, texture, depth, description, site, country, latitude, longitude, data source, and classification. Use the <F4> key.
6. Allows users access to a global list (SOLLSTG.DBF) of soils for various paths on the computer, using the <F10> key. Allows users to select soil files in other paths and presents files in the paths selected in order to maintain the SOL.LST.

To open the "List/Edit" menu option, press the <L> key or highlight "List/Edit" and press the <ENTER> key. Screen 16 (below) will be presented, displaying the global list of soils with soil code, texture, depth, description, site, country, latitude, longitude, data source and taxonomy.

```
Soil File Manager (SFM)                                          Version 3.0
                    - Files In Directory: C:\DSSAT3\SOIL -

 L   SOIL CODE    TEXTUR   DEP   DESCRIPTION
 √   99WH000001   SICY     210   DEFAULT - DEEP SILTY CLAY
 √   99WH000002   SICY     150   DEFAULT - MEDIUM SITLY CLAY
 √   99WH000003   SICY     60    DEFAULT - SHALLOW SILTY CLAY
 √   99WH000004   SILO     210   DEFAULT - DEEPT SILTY LOAM
 √   99WH000005   SILO     150   DEFAULT - MEDIUM SILTY LOAM
 √   99WH000006   SILO     60    DEFAULT - SHALLOW SILTY LOAM
 √   99WH000007   SALO     210   DEFAULT - DEEP SANDY LOAM
     99WH000008   SALO     150   DEFAULT - MEDIUM SANDY LOAM
     99WH000009   SALO     60    DEFAULT - SHALLOW SANDY LOAM
     99WH000010   SA       210   DEFAULT - DEEP SAND
     99WH000011   SA       150   DEFAULT - MEDIUM SAND
     99WH000012   SA       60    DEFAULT - SHALLOW SAND

F1  - Help                  F4  - Search              F7  - Colour OFF
F2  - Institute Listing     F5  - Sort                F8  - Edit
F3  - Site Listing          F6  - Print               F9  - Remake List
Esc - Quit            L  - Include/Exclude In Sublist F10 - Database List
```

SCREEN 16.

The SOIL CODE is a 10-character identifier for the particular soil. The first two letters of this code should be the institute ID code. The next 8 characters could be whatever the user chooses, but it is recommended that the next two characters be the site ID code; characters 5 and 6, the year; characters 7 and 8, an institute ID code if the assigning institute

differs from that denoted with characters 1 and 2; and the last two characters, a number for identification. A '99' as the first two characters of the soil code indicates that the institute ID code for that soil is not known or has not been entered. TEXTUR is for texture codes, which are found in Appendix B in Volume 2-1 (Jones et al. 1994) of this book. DEP is soil depth in cm. The DESCRIPTION is the full description of the soil texture. SITE is the name of the soil site. COUNTRY, LATITUDE, LONGITUDE and DATA SOURCE are self-explanatory. TAXONOMY is the soil's taxonomy classification. The general functions for searching, sorting, printing and editing are similar to the other data operations already described in Chapter 3, as are the <F9>, <F10> and <L> keys, described in Chapter 4.

The Database List includes soil files in all directories identified with a SOL extension in the file DSSATLST.FLE; in other word, it is a global listing. This file is similar to the file DSSATPRO.FLE, but it contains pointers to any path on your computer that has experiment data. DSSATLST.FLE is in the C:\DSSAT3 directory and can be edited by any text editor to add new paths. After editing this file, you must press <F9> to re-build the global experiment list. The Working List displays a list of soils in the working directory. The working directory can be changed by moving the highlight bar over a particular soil and pressing <F10>. The program will then transfer to the directory containing that soil file and list all soil files in that directory. You can go back to the global list by pressing <F10> again.

CREATE

The purpose of the "Create" menu option is to enable users to create new soil profile data for the crop models, with a Soil Retrieval program. With this program, users can either manually input soil data to create a new soil profile or retrieve data from soil data files distributed with DSSAT v3.

To open this menu option, press the <C> key or highlight "Create" and press the <ENTER> key. Screen 17 (on the following page) will be presented.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0


                    SOIL RETRIEVAL MENU

          1 - Manually Input Soil Data for SOIL.SOL
          2 - Retrieve Data from DSSAT Soil Data Files

                  Select option:

   <F1> for help
   <ESC> to quit
```

Screen 17.

The Soil Retrieval menu presents two options. Select Option 1 to manually input soil data and create a SOIL.SOL file. Follow the instructions in the section entitled, "Manually-Entered Soil Data," in this Chapter..

Select Option 2 to retrieve soil data from the international data base of soils from USDA-SCS that was also included in DSSAT v2.1. Follow the instructions in the following section entitled, "Retrieve Soil Information."

RETRIEVE SOIL INFORMATION

When Option 2 of the Soil Data Retrieval menu is selected, Screen 18 (below) will be presented.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0



        1 - Search for closest matching soil classification
        2 - Search for a particular country
        3 - Select a particular Pedon Number

        Select option:  [ ]



<ESC to quit   (F1) for help
```

SCREEN 18.

To search for the closest matching soil classification. Choose Option 1 in Screen 18. Turn to the section entitled, "Option 1: Search by Soil Classification," in this Chapter.

To search for soils from a particular country. Choose Option 2 in Screen 18. Turn to the section entitled, "Option 2: Search by Country," in this chapter.

To select a soil by pedon number. Choose Option 3 in Screen 18. Turn to the section entitled, "Option 3: Select by Pedon Number," in this Chapter.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0

Enter Soil Classification:

Parsing classification...

Search DSSAT Data Files using this classification?  (Y/N) Y

                          Messages

<ESC to quit   (F1) for help
```

SCREEN 19.

OPTION 1: SEARCH BY SOIL CLASSIFICATION

Screen19 (above) is displayed if Option 1, "Search for closest matching soil classification," in Screen 18 is selected. The soil classification entered here is used as the initial description of search classification. Make any changes by typing your description over the classification displayed on the screen. Press the <ENTER> key when you have finished making changes to the search classification.

NOTE: The soil classification search uses terminology associated with Soil Taxonomy (Soil Survey Staff 1975).

Type 'Y' to search the soil data files by the displayed soil classification.; type 'N' to enter a different soil classification.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0

Enter Soil Classification:

Parsing classification...

Search DSSAT Data Files using this classification?  (Y/N) Y

                    Messages

Searching DSSAT Soil Data Files...
Number of soils of the Alfisol order=74

Do you want to see theses profiles?   (Y/N)
```

SCREEN 20.

Searching the Data Files. The program searches by soil classification using a process of elimination. This process begins by matching the soil Order (e.g., Alfisols) found in the soil classification box in Screen 20 (above) with those pedons in the DSSAT soil data files having the same soil Order.

To see a listing of the remaining soil profiles, type 'Y' at the prompt in the bottom-most window of this screen; otherwise, type 'N' and the search will continue.

The program continues matching profiles using the following criteria in the order given: Suborder, Great group, Subgroup modifiers and soil Family modifiers, texture, mineralogy, reaction and temperature regime. At each step of the elimination process, type "Y" to view the remaining profiles. When 32 or less profiles remain, you may stop the elimination process at any time. At the prompt, type 'Y' to continue the elimination process with the next search criteria; type 'N' if you do not want to continue the elimination process.

NOTE: The program will terminate its search if the next step of the process eliminates all of the remaining profiles.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0

Desired classification:
FINE, MIXED, ISOHYPERTHERMIC OXIC PALEUSTALF

Options:                                        7800169
     <ESC> to QUIT                              7800171
     <ENTER> to SELECT highlighted YEAR         7800231
     <PgUp> to go to PREVIOUS year              7800233
     <PgDn> to go on to the NEXT pedons         7800240
     <↑> to move highlight UP                   7800241
     <↓> to move highlight DOWN                 7800244
                                                7800246
                                                7800325
                                              ↓ 8100220

     KENYA: fine-loamy, kaolinitic, isothermic Ultic Paleustalf
```

SCREEN 21.

Selecting a Pedon Number. When all matching profiles have been found, their pedon numbers are displayed as shown on Screen 21 (above). The boxed window at the bottom of the screen will display the country and classification of the soil associated with the selected (highlighted) pedon number.

Use the arrow keys to move the highlight bar over a pedon number. Press the <ENTER> key once the pedon number of the profile you wish to retrieve is highlighted.

NOTE: If the country name is missing or the classification is unknown, this is probably because the profile record has a blank country-code field or is missing data in all of the classification code fields.

Go to the section entitled, "Complete the Retrieval" in this chapter.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0

Enter Name of Country to search for:
KENYA

<ESC to quit   (F1) for help
```

SCREEN 22.

OPTION 2: SEARCH BY COUNTRY

If you choose Option 2 in Screen 18, "Search for a particular country," Screen 22 (above) will be displayed. Enter the name of the country for which you want soil data retrieved.

NOTE: You may enter a partial country name if you do not know the complete country name.

Validating Country Name. After the country name is entered, the program searches its country-code file to determine if the name is valid. If the country name that you entered is a close match to a country listed in the country-code file, the program will display the message shown in the following dialog box. For exact matches, the program will not display this dialog box.

```
Country:      Kenya
Code:         505

Is this the correct country        (Y/N) N
```

If the located country is correct, type 'Y'. If it is not correct, type 'N', and the program will search for the next possible match and prompt you again.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0

Enter Name of Country to search for:
KENYA

Options:                                   7800167
     <ESC> to QUIT                         7800168
     <ENTER> to SELECT highlighted YEAR    7800169
     <PgUp> to go to PREVIOUS year         7800170
     <PgDn> to go on to the NEXT pedons    7800171
     <↑> to move highlight UP              7800172
     <↓> to move highlight DOWN            7800173
                                           7800233
                                           7800224
                                          ↓8100225

        KENYA: Very fine, mixed, isothermic Oxic Rhodustalf
```

SCREEN 23.

Selecting a Pedon Number. When the search is completed, the first soil profile from the specified country is displayed as well as all pedon number for that country, as shown on Screen 23 (above). The boxed window at the bottom of the screen will display the country and classification of the soil associated with the selected (highlighted) pedon number.

Use the arrow keys to move the highlight bar over a pedon number. Press the <ENTER> key once the pedon number of the profile you wish to retrieve is highlighted.

NOTE: *If the classification is unknown, this is probably because the profile record is missing data in all of the classification code fields.*

Go to the section entitled, "Complete Retrieval" in this chapter.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0


Select Soil Sampling YEAR ......................

    Options:                                          1969
         <ESC> to QUIT                                1970
         <ENTER> to SELECT highlighted YEAR           1976
.....<HOME> for beginning of YEAR list                1978
         <END> for end of YEAR LIST                   1979
         <PgUp> to go to PREVIOUS year                1981
         <↑> to move highlight UP                     1982
         <↓> to move highlight DOWN                   1983
                                                      1984
                                                      1985
```

SCREEN 24.

OPTION 3: SELECT BY PEDON NUMBER

If you choose Option 3 in Screen 18, " Select a particular Pedon Number," Screen 24 (above) will be presented. You must now manually select the soil information you wish to retrieve from the data files to run the crop models.

1. Press the <ESC> key if you wish to return to Screen 18.

2. To select a soil profile, use the arrow keys to select the year that the soil was sampled or select UNKNOWN if you do not know the sampling year. "UNKNOWN" will be found at the bottom of the year listing.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0

Select Soil Sampling YEAR ....................... UNKNOWN

  Options:                                        6900137
      <ESC> to select ANOTHER YEAR                  7000412
      <ENTER> to SELECT highlighted PEDON           7600193
      <PgUp> to go to PREVIOUS pedons               7600323
      <PgDn> to go on to the NEXT pedons            7800167
      <↑> to move highlight UP                      7800168
      <↓> to move highlight DOWN                    7800169
                                                    7800170
                                                    7800171
                                                    7800172

Thailand : fine-loamy, siliceous, isohyperthermic Oxic Paleustult
```

SCREEN 25.

Selecting a Pedon Number. After selecting the year of sampling, the pedon numbers of all profiles sampled during that year are displayed in the right-hand boxed window of Screen 25 (above). The boxed window at the bottom of the screen will display the country and classification of the soil associated with the selected (highlighted) pedon number.

Use the arrow keys to move the highlight bar over a pedon number. Press the <ENTER> key once the pedon number of the profile you wish to retrieve is highlighted.

NOTE: If the country name is missing or the classification is unknown, this is probably because the profile record has a blank country-code field or is missing data in all of the classification code fields.

Go to the section entitled, "Complete the Retrieval," in this Chapter.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0

Retrieving...

Country    :    KENYA
Latitude   :    Missing
Longitude  :    Missing
Pedon No.  :    7800167
Name       :    very fine, mixed, isothermic Oxic Rhodustalf

Exiting Retrieval...

=================================== Messages ===================================

*** WARNING - Top layer soil color is blank

Process Successfully Completed...
```

SCREEN 26.

COMPLETE THE RETRIEVAL

During profile retrieval, warning and/or error messages are generated and displayed at the bottom of the screen in the message area, as shown in Screen 26 (above).

Although warning and error messages may occur during retrieval processing, the program will still produce a soil output file. The resulting output file will contain whatever valid information was contained in the selected soil profile from the DSSAT soil data files, and this file may be used to create a SOIL.SOL.

Go to the section entitled, "Create a Soil Profile," in this Chapter for an explanation of how to use the retrieved data to create the model input file SOIL.SOL.

MANUALLY-ENTERED SOIL DATA

This section explains how to create a soil profile by manually entering data. If you selected Option 1, "Manually Input Soil Data for SOIL.SOL" from the Soil Data Retrieval menu in Screen 17, you must have soil profile information in hard-copy format at hand and want to manually enter the data from the keyboard.

Type 'Y' when the first screen appears if you have this data at hand; otherwise, type 'N' to end the program.

SOIL DATA INPUT GUIDELINES

The following guidelines may be helpful during manual soil information data entry.

1. In each of the input screens that follow, you may press the <ESC> key before entering data to abort the manual input process. If you quit before completing the manual input process, any data already entered will not be saved, and you will be given the option of starting over and creating a new soil profile.

2. The program allows you to correct data input errors after data entry for a section that is completed, but **not** during data entry.

   For example, if you enter an incorrect value (e.g., '3.2') for the pH value of layer 3 in Screen 38, you should complete data entry for the pH values of the rest of the layers and when the program prompts with:

   "Are these values OK? (Y/N)"

   type 'N' and press the <ENTER> key. The program will prompt with:

   "Enter layer number of value you wish to change (0 for ALL)"

   Type in the layer number ('3' in our example for pH) or '0' if you wish to change all the values entered, enter the correct value(s), and press the <ENTER> key.

3. After error checking the input data, the program will display current input data that will be used in the calculations. The program will then prompt you with:

   "Do you want to make changes to input data?" (Y/N)

If you discover that there are some errors and you wish to change any or all of the input data, type 'Y' and press the <ENTER> key. Otherwise, type 'N' and press the <ENTER> key to begin calculations.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                          Version 3.0

Input Data used to create SOIL.SOL:

INPUT                                          VARIABLE(S) CALCULATED
Lower/Upper depths for each layer (cm)                       SWCON2, WR
% Sand                                        LL, DUL, SAT, SALB, U
% Clay                                        LL, DUL, SAT, SALB, U
% Silt                                        LL, DUL, SAT, SALB, U
Bulk dens. 1/3 bar (g/cm3)                   LL, DUL, SAT, SWCON, WR
Organic carbon                                   LL, DUL, SAT, SALB
Coarse fraction>2mm, % of whole soil                 LL, DUL, SAT
pH-H2O) of soil                                                  WR
Al saturation (cm3/cm3)                                          WR
Soil Classification                                             CN2
Soil horizons                                                   CN2
Root abundance information                                       WR
Slope                                                           CN2
Soil color                                                     SALB
Permeability code                                               CN2
Drainage code                                                 SWCON

Press any key to continue
```

Screen 27.

Input/Calculated Variables

Screen 27 (above) specifies the input data (left-hand column) the program requires to correctly calculate the variables (listed in the right-hand column) used by the crop models. You may enter default values for any missing input data values. If you enter default values, however, the resulting calculated output values may not be correct.

Select Crop Code

After checking the required data in Screen 27 and making sure you have these data, the next screen presented after pressing any key to continue will ask you to enter a crop code from those listed on the screen. Enter a code to continue or press the <ESC> key to return to Screen 18. If you continue, Screen 28 (on the following page) will be presented.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0

MANUAL DATA INPUT

Enter Country          :                Enter Latitude          :
Enter Institute Code   :                Enter Longitude         :
Enter Site Name        :                Sampling Year
                                        (last 2 digits)         :
Enter Soil Classification    :

Soil Tex.  : CLOSA   CSALO   FLO   FSALO   LOSA   SACLL   SILO   VFSA
     Codes : CSA     CL      FLOSA SICLL   SA     SI      SALO   VFSAL
           : CSI     CLLO    FSA   LO      SACL   SICL    VFLOS
Enter Soil Texture Code  :

Enter number of layers in profile  :
<ESC> to quit
```

Screen 28.

Soil Profile Input Data

After you enter the crop code, Screen 28 (above) will be presented. Enter name of country, institute code, site name, latitude and longitude of site and the sampling year (the last two digits).

Enter the soil name or classification, texture, and the number of layers in the profile.

NOTE: For a explanation of soil texture codes, see Appendix B in Volume 2-1 (Jones et al. 1994) of this book.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0

MANUAL DATA INPUT

Enter % Slope (##)    :  1

Color codes    : BN - brown     Red - red      BK - black
                 G  - gray      Y   - yellow   YR - yellow-red

Enter color of top soil layer (def.=BN)    :  BN


Are these values OK?    (Y/N)    Y
```

SCREEN 29.

SLOPE AND COLOR

In Screen 29 (above), enter slope and soil color. For slope, enter a percentage between 0 and 99. For color information, enter the code letters corresponding to the color of the top layer of the soil.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0

MANUAL DATA INPUT

Perm.    1 - very slow    2 - slow         3 - mod.slow
codes:   4 - moderate     5 - mod.rapid    6 - rapid
         7 - very rapid   0 - not permeable/unknown

Enter Permeability Code of soil :  4

Are these values OK?   (Y/N)   Y
```

SCREEN 30.

PERMEABILITY

In Screen 30 (above) enter the code number corresponding to the permeability class of the soil (e.g., enter '4' for "moderate").

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0

MANUAL DATA INPUT

Drain.   1 - very poorly   2 - poorly    3 - somewhat poorly
codes:   4 - mod.well      5 - well      6 - somewhat excessively
         7 - excessively   0 - unknown/missing

Enter Drainage Code of soil:   5

Are these values OK?   (Y/N)   Y
```

SCREEN 31.

DRAINAGE

In Screen 31 (above), enter the code number corresponding to the drainage class of the soil (e.g., enter '5' for "well").

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0

MANUAL DATA INPUT

Enter Thickness (cm) of layer # 1 (###) :  13
Enter Thickness (cm) of layer # 2 (###) :  17
Enter Thickness (cm) of layer # 3 (###) :  32
Enter Thickness (cm) of layer # 4 (###) :  22
Enter Thickness (cm) of layer # 5 (###) :  16
Enter Thickness (cm) of layer # 6 (###) :  40
Enter Thickness (cm) of layer # 7 (###) :  40

<ESC> to quit
```

SCREEN 32.

SOIL LAYER DEPTHS

In Screen 32 (above), enter the thickness, in cm, of each layer. With this information, the program calculates the upper and lower depths associated with each soil layer. Sample values are displayed in the above screen. Using these sample values, the program would display a screen listing the layer thickness as follows:

Layer	#1:	0	-	13	cm
Layer	2:	13	-	30	cm
Layer	3:	30	-	62	cm
Layer	4:	62	-	84	cm
Layer	5:	84	-	100	cm
Layer	6:	100	-	140	cm
Layer	7:	140	-	180	cm

NOTE: *For the layer thickness, you must re-enter all of the values if you wish to change any one of them.*

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0


MANUAL DATA INPUT

Enter Horizon Designation for layer # 1 (XX):  ap
Enter Horizon Designation for layer # 2 (XX):  ap
Enter Horizon Designation for layer # 3 (XX):  ba
Enter Horizon Designation for layer # 4 (XX):  ba
Enter Horizon Designation for layer # 5 (XX):  bt
Enter Horizon Designation for layer # 6 (XX):  bt
Enter Horizon Designation for layer # 7 (XX):  bt



<ESC> to quit
```

SCREEN 33.

SOIL HORIZONS

In Screen 33 (above), enter the soil horizons associated with each layer. Enter only the first two characters of the horizon designation.

CLAY CONTENT

The clay content screen is similar to that of Screen 33 for Soil Horizons. Enter the percentage clay content, from 0 to 100, for each soil layer.

SILT CONTENT

The silt content screen is similar to that of Screen 33 for Soil Horizons. Enter the percentage silt content, from 0 to 100, for each soil layer.

SOIL DATA RETRIEVAL FOR CROP MODELS Version 3.0

MANUAL DATA INPUT

	% Clay	% Silt	% Sand
Layer 1	3.2	18.9	77.9
Layer 2	8.5	14.1	77.4
Layer 3	10.5	16.1	73.4
Layer 4	8.9	17.5	73.6
Layer 5	12.5	17.0	70.5
Layer 6	12.6	18.5	68.9
Layer 7	14.5	16.2	69.3

Press any key to continue

<ESC> to quit

SCREEN 34.

SAND CONTENT

In Screen 34 (above), the program will compute the percentage sand content for each soil layer from the clay and silt values entered. (It assumes that all three components sum to 100 percent.)

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0


MANUAL DATA INPUT

Note:  Enter '-99' for unknown/blank/missing values

Enter Coarse Fractions > 2 mm for layer # 1 (###) :  0
Enter Coarse Fractions > 2 mm for layer # 2 (###) :  0
Enter Coarse Fractions > 2 mm for layer # 3 (###) :  0
Enter Coarse Fractions > 2 mm for layer # 4 (###) :  0
Enter Coarse Fractions > 2 mm for layer # 5 (###) :  0
Enter Coarse Fractions > 2 mm for layer # 6 (###) :  0
Enter Coarse Fractions > 2 mm for layer # 7 (###) :  0
```

Screen 35.

Coarse Fractions

In Screen 35 (above), enter the volume fraction percentage, from 0 to 100 of gravel, cobbles and stones for each layer.

Organic Carbon

The organic carbon screen is similar to that of Screen 35 for Coarse Fractions. Enter the organic carbon content percentage, from 0 to 100, for each soil layer.

Bulk Density

The bulk density screen is similar to that of Screen 35 for Coarse Fractions. Enter the bulk density, as g/cm^3, for each soil layer.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0


MANUAL DATA INPUT
Note:  Enter '-99' for unknown/blank/missing values

Enter Sat. Hydraulic Cond. (cm/h) for layer # 1 (###.#) : -99
Enter Sat. Hydraulic Cond. (cm/h) for layer # 2 (###.#) : -99
Enter Sat. Hydraulic Cond. (cm/h) for layer # 3 (###.#) : -99
Enter Sat. Hydraulic Cond. (cm/h) for layer # 4 (###.#) : -99
Enter Sat. Hydraulic Cond. (cm/h) for layer # 5 (###.#) : -99
Enter Sat. Hydraulic Cond. (cm/h) for layer # 6 (###.#) : -99
Enter Sat. Hydraulic Cond. (cm/h) for layer # 7 (###.#) : -99


<ESC> to quit
```

Screen 36.

Saturated Hydraulic Conductivity

In Screen 36 (above), enter the saturated hydraulic conductivity, as cm/h, for each soil layer.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0


MANUAL DATA INPUT
Note:  Enter '-99' for unknown/blank/missing values

Enter TOTAL NITROGEN (%) for layer # 1 (##.##) : -99
Enter TOTAL NITROGEN (%) for layer # 2 (##.##) : -99
Enter TOTAL NITROGEN (%) for layer # 3 (##.##) : -99
Enter TOTAL NITROGEN (%) for layer # 4 (##.##) : -99
Enter TOTAL NITROGEN (%) for layer # 5 (##.##) : -99
Enter TOTAL NITROGEN (%) for layer # 6 (##.##) : -99
Enter TOTAL NITROGEN (%) for layer # 7 (##.##) : -99



<ESC> to quit
```

SCREEN 37.

TOTAL NITROGEN

In Screen 37 (above), enter total nitrogen, as percentage (%), for each soil layer.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0


MANUAL DATA INPUT

Note:  Enter '-99' for unknown/blank/missing values

Enter pH  1:1  in  water  for layer  #  1  (##.##) : 5.6
Enter pH  1:1  in  water  for layer  #  2  (##.##) : 5.1
Enter pH  1:1  in  water  for layer  #  3  (##.##) : 4.7
Enter pH  1:1  in  water  for layer  #  4  (##.##) : 5.4
Enter pH  1:1  in  water  for layer  #  5  (##.##) : 6.7
Enter pH  1:1  in  water  for layer  #  6  (##.##) : 9
Enter pH  1:1  in  water  for layer  #  7  (##.##) : 8.7


<ESC> to quit
```

SCREEN 38.

pH IN H_2O

In Screen 38 (above), enter the pH of the soil in water for each soil layer.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0


MANUAL DATA INPUT
Note:  Enter '-99' for unknown/blank/missing values

Enter pH 1:1 in buffer for layer # 1 (##.##) : -99
Enter pH 1:1 in buffer for layer # 2 (##.##) : -99
Enter pH 1:1 in buffer for layer # 3 (##.##) : -99
Enter pH 1:1 in buffer for layer # 4 (##.##) : -99
Enter pH 1:1 in buffer for layer # 5 (##.##) : -99
Enter pH 1:1 in buffer for layer # 6 (##.##) : -99
Enter pH 1:1 in buffer for layer # 7 (##.##) : -99

<ESC> to quit
```

Screen 39.

pH in Buffer

In Screen 39 (above), enter the pH of the soil in a buffer for each soil layer.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0

MANUAL DATA INPUT

Note:  If pH > 5.5, then Al=0
       Enter '-99' for unknown/blank/missing values

Enter % Al  Saturation  for  layer  #  1  (###)  : 0
Enter % Al  Saturation  for  layer  #  2  (###)  : 0
Enter % Al  Saturation  for  layer  #  3  (###)  : 0
Enter % Al  Saturation  for  layer  #  4  (###)  : 0
Enter % Al  Saturation  for  layer  #  5  (###)  : 0
Enter % Al  Saturation  for  layer  #  6  (###)  : 0
Enter % Al  Saturation  for  layer  #  7  (###)  : 0

<ESC> to quit
```

SCREEN 40.

ALUMINUM SATURATION

In Screen 40 (above), enter the aluminum saturation of each soil layer.

NOTE: If the pH of a particular layer is greater than 5.5, then the program will not prompt for the aluminum saturation value for that layer and will set the percentage of aluminum saturation to 0 (zero).

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0

MANUAL DATA INPUT
Note:  Enter '-99' for unknown/blank/missing values

Enter CEC cmol/kg for layer # 1 (##.##) : 2.6
Enter CEC cmol/kg for layer # 2 (##.##) : 2.6
Enter CEC cmol/kg for layer # 3 (##.##) : 3.3
Enter CEC cmol/kg for layer # 4 (##.##) : 2.4
Enter CEC cmol/kg for layer # 5 (##.##) : 5.8
Enter CEC cmol/kg for layer # 6 (##.##) : 6.4
Enter CEC cmol/kg for layer # 7 (##.##) : 7.3

<ESC> to quit
```

SCREEN 41.

CEC

In Screen 41 (above), enter CEC, as cmol/kg, for each soil layer.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0

MANUAL DATA INPUT

Note:  For this section of data input, you need soil profile
descriptive information.

VF  -  very few       FF -very few to few    F  -  Few
FC  -  few to common  C  -   common          CM -  common to many
M   -  many           MT -   matted          N  -  no roots
##  -  blank/missing

Enter Root Quantity code for layer 1 (0-13 cm) (XX)  :  C
```

SCREEN 42.

ROOT QUANTITY INFORMATION

In Screen 42 (above), enter the quantity of roots in each soil layer. For each layer, enter the appropriate code from those listed at the top of the screen (e.g., enter 'C' for "common").

Go to the next section, entitled "Create a Soil Profile," in this Chapter.

CREATE A SOIL PROFILE

This section explains how to create a Soil Profile using data retrieved from the DSSAT soil data files or from data input by the user. The Soil Profile created is saved to a model input file called SOIL.SOL.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0



        AR - Aroid                PT - Potato
        CS - Cassava              RI - Rice
        BN - Dry Bean             SB - Soybean
        MZ - Maize                SG - Sorghum
        ML - Millet               WH - Wheat
        PN - Peanut               BA - Barley

        Enter Crop code (XX)

<ESC> to quit
```

SCREEN 43.

SELECT A CROP CODE

If you have retrieved data using Option 2, "Retrieve Data from DSSAT Soil Data Files" (from Screen 17), Screen 43 (above) will now be displayed and you will be prompted for the crop code of the crop model for which the soil profile is being created. When the crop code is entered, Screen 44 (on the following page) will be presented. Press the <ESC> key if you wish to exit the program at this point.

If you entered soil data manually using Option 1, "Manually Input Soil Data for SOIL.SOL" (from Screen 17), Screen 44 (on the following page) will appear when you have completed data entry.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0


*** OTHER INFORMATION ***

NOTE:   The following information is required for the NITROGEN component
        of the models.  Press <ENTER> to accept DEFAULT values.

Enter Zero-to -unity factor for mineralization (def. = 1)    :  1
```

SCREEN 44.

NITROGEN DATA

Enter the requested values in Screen 44; these data are required by the nitrogen component of the models. Change the default value by entering a new value.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0

*** INPUT DATA ***

Insc.  ID = IB        Country = THAILAND
Site = UNKNOWN
Lat =  -99.000         Long =  -99.000      Sample Yr = 82

Taxon = COARSE-LOAMY, SILICEOUS, ISOHYPERTHERMIC TYPIC NATRUSTALF

Slope = 1 %
Color = BN
Permeability code   = 4
Drainage code       = 5

Dmod = 1.000000

Press any key to continue
```

SCREEN 45.

ERROR-CHECKED DATA

Before variables are calculated from the retrieved or input data, four screens displaying these data are presented. Screen 45 (above) is the first screen of data.

Dmod - Zero-to-unity factor for mineralization

SOIL DATA RETRIEVAL FOR CROP MODELS Version 3.0

*** INPUT DATA ***

Layer	Upper	Lower	Horizon	Clay	Silt	Sand
1	0	13	AP	3.2	18.9	77.9
2	13	30	AP	8.5	14.1	77.4
3	30	62	BA	10.5	16.1	73.4
4	62	84	BA	8.9	17.5	73.6
5	84	100	BT	12.5	17.0	70.5
6	100	140	BT	12.5	18.5	68.9
7	140	180	BT	14.5	16.2	69.3

Press any key to continue

SCREEN 46.

Screen 46 is the second screen of data.

SOIL DATA RETRIEVAL FOR CROP MODELS Version 3.0

*** INPUT DATA ***

Layer	% Stone	OC	BD 1/3 bar	Al SAT	pH in H20
1	0.0	0.42	1.66	0.0	5.6
2	0.0	0.32	1.68	0.0	5.1
3	0.0	0.17	1.58	0.0	4.7
4	0.0	0.13	1.55	0.0	5.4
5	0.0	0.17	1.76	0.0	6.7
6	0.0	0.15	1.63	0.0	9.0
7	0.0	0.13	1.57	0.0	8.7

Press any key to continue

SCREEN 47.

Screen 47 is the third screen of data.

OC - Organic Carbon (%)
BD - 1/3 bar Bulk Density (g/cm^3)
Al SAT - Aluminum Saturation (%)

SOIL DATA RETRIEVAL FOR CROP MODELS Version 3.0

Layer	pH in Buffer	CEC	Root Quantity Code
1	-3.0	2.6	C
2	-3.0	2.6	F
3	-3.0	3.3	F
4	-3.0	2.4	F
5	-3.0	5.8	F
6	-3.0	6.4	F
7	-3.0	7.3	FF

Do you want to make changes to the input data ? (Y/N)

SCREEN 48.

Screen 48 is the fourth screen of data. At this point, you may change any or all of the data. At the prompt to make changes in Screen 48, if you choose 'Y', Screen 49 (on the following page) will appear. If you choose 'N' at the prompt, go to the section entitled "Calculated Data."

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0

MANUAL DATA EDIT

 1. - Slope / Color      2. - Permeability      3. - Drainage
 4. - Layer Depths       5. - Horizon Design    6. - Sand,Silt,Clay
 7. - Coarse Frac.       8. - Organic Carbon    9. - Bulk Density
10. - pH in water       11. - pH in Buffer     12. - Aluminum Sat.
13. - Sat. Hy. Cond.    14. - Total N          15. - CEC
16. - Root Quan.

Select variable to edit by number (0 - quit) :
```

SCREEN 49.

FINAL DATA EDITING

From the Manual Data Edit menu shown in Screen 49 (above), choose the input variable value(s) you wish to change by selecting and entering the corresponding number. The screens presented after entering a number will be those previously presented for that variable.

Enter zero (0) when all values are correct. The program will then begin variable data calculations (see Screen 50).

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0


*** Beginning CALCULATIONS ***

Calculating Soil Water Content Values...
Layer  #  1 :  LL  =  0.052737  DUL  =  0.169387  SAT  =  0.296600
Layer  #  2 :  LL  =  0.053312  DUL  =  0.171228  SAT  =  0.309597
Layer  #  3 :  LL  =  0.076278  DUL  =  0.183114  SAT  =  0.316859
Layer  #  4 :  LL  =  0.069708  DUL  =  0.177139  SAT  =  0.313949
Layer  #  5 :  LL  =  0.084528  DUL  =  0.191868  SAT  =  0.322452
Layer  #  6 :  LL  =  0.084962  DUL  =  0.193020  SAT  =  0.324211
Layer  #  7 :  LL  =  0.092766  DUL  =  0.199787  SAT  =  0.325858


Press any key to continue
```

SCREEN 50.

CALCULATED DATA

Soil Water Contents. The soil water contents values are printed on the screen (Screen 50 above) as they are calculated.

LL	-	Lower Limit (%, volume basis)
DUL	-	Drain Upper Limit (%, volume basis)
SAT	-	Saturation (%, volume basis)

Root Growth Weighting Factor. Next, the program calculates WR, the weighting factor used to determine new root growth, using two methods (see Screen 51 on following page). One method uses root abundance information, if any, and a table to determine WR values for each layer. The other method uses a formula based on the depth of each soil layer and is further modified depending on the values given for soil pH and Al saturation for each layer.

If the root abundance information is not in the retrieved data or has not been inputted for a certain layer, the second method to estimate WR for that layer will be used.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0


Calculating WR...
*** WARNING - no root quantity information for layer 7, estimating WR
     Layer #  1 :  WR  =  0.50
     Layer #  2 :  WR  =  0.20
     Layer #  3 :  WR  =  0.20
     Layer #  4 :  WR  =  0.20
     Layer #  5 :  WR  =  0.20
     Layer #  6 :  WR  =  0.15
     Layer #  7 :  WR  =  0.04


Press any key to continue
```

SCREEN 51.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0


     Calculating SALB...
          Color     :    BN
          SALB      =    0.150000
     Calculating SWCON...
          Drainage cod    :   5
          SWCON           =   0.428708
     Calculating SWCON2
          SWCON2          =   102.156525
     Calculating U...
          U        =      9.000000


     Press any key to continue
```

SCREEN 52.

SALB, U, SWCON, SWCON2, CN2. As shown in Screen 52 (above) and Screen 53 (on the following page), the program next calculates values for Bare Soil Albedo (SALB), Upper Limit of Stage 1 Soil Evaporation (U), Soil Water Drainage Constant (SWCON), SWCON2 and Runoff Curve Number (CN2).

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0


Calculating CN2...
    Soil group : B
    CN2 = 76.000000

*** CALCULATIONS Completed ***
```

SCREEN 53.

QUIT

After processing for the current soil profile has been completed, a message will be displayed on the screen (see Screen 54 below) and you will be asked if you wish to create another soil profile.

```
SOIL DATA RETRIEVAL FOR CROP MODELS                    Version 3.0

*** Output completed, File closed***









Do you wish to add another soil to SOIL.SOL ?    (Y/N)  Y
```

SCREEN 54.

Type 'Y' to begin the program again.

Type 'N' to return to the DSSAT Shell main menu.

UTILITIES

The purpose of the "Utilities" menu option is enable users to graph selected soil properties vs. depth. This program, called GUMGRAF, was written by R. Matthews for crop models. The graph program works with the standardized DSSAT v3 data files which have data in columns with variables defined by abbreviations. For a complete description of these files, their formats and structure, see Volume 2-1, Jones et al. 1994, of this book.

To open this menu option, press the<U> key or highlight "Utilities" and press the <ENTER> key. Screen 55 (below) will be presented, listing soil files which can be graphed.

```
GENERAL GRAPHICS (GGRAF)                                  VERSION 1.0

                    FILES:  C:\DSSAT3\SOIL\*.SOL
99.SOL          SOIL.SOL        UC.SOL

                         DATASETS

⇓: Select   F1:Help   C:Clear   G:Graphs   P:Plot   S:Setup   V:View   W:sWitch
```

SCREEN 55.

While viewing Screen 55, you have access to a set of function keys, shown at the bottom of the screen. You may clear the screen, graph, plot, setup the graphs, view the data files and switch between the top and bottom windows by using the <C>, <G>, <P>, <S>, <V> and <W> keys, respectively. To select a file displayed on the screen, highlight it and press the <ENTER> key.

Before graphing, one or more graphs should first be defined from the setup menu. To access this menu, press the <S> key. The SETUP menu shown in Screen 56 (on the following page) will be displayed.

```
GENERAL GRAPHICS (GGRAF)                                  VERSION 1.0

 SETUP MENU      FILES:  C:\DSSAT3\SOIL\*.SOL
 Defaults        SOIL.SOL        UC.SOL
 Graphs
 Save Config
 Load Config
 Directory

                        DATASETS

ESC:quit        ⟨®:Cursor        ⇓: Select
```

SCREEN 56.

SET UP GRAPH

To set up a graph(s), highlight the "Graphs" option, shown in Screen 56, under the Setup menu, using the arrow keys, and press the <ENTER> key. A dialog box, shown in Screen 57 (below) will be presented.

```
 1/5            SETUP GRAPH CONFIGURATION
                                                    VERSION 1.0
 X-axis variable abbreviation:  SLB
 Y-axis variable abbreviation:  SLLL
 X-axis label: Layer base cm
 Y-axis label: Lower limit cm3 cm-3
 Graph title: Lower limit vs depth
 X-axis: Mode Auto    Min 0      Max 0
 Y-axis: Mode Auto    Min 0      Max 0

 Dataset      Color       LineType      Marker

    1       Green         Solid       None
    2       Cyan          Dotted      None
    3       Red           Center      None
    4       Magenta       Dash        None
    5       Brown         Solid       None
    6       LightGray     Dotted      None
    7       DarkGray      Center      None

ESC:Quit   ^D:DelGraf    ^N:iNsGraf    PgUp/PgDn:Prev/Next    ^A:Accept
```

SCREEN 57.

Define the X and Y variables by entering variable names in Screen 57 as defined in Volume 2-1 (Jones et al. 1994) of this book for the soil file (FILES). The default values found in the dialog box in Screen 57 may be used. Use the <PgUp> and <PgDn> keys to move through the various pages in this dialog box, each presenting different X/Y axes for graphing. You may also enter a Graph Title and Min and Max increments for plotting, as well as the color, linetype and marker for each line plot on each graph.

When you have completed your selection, press <Ctrl><A>, or press <ESC> if you do not wish to use the data you have entered. If you do press <Ctrl><A>, the graph data entered will be used to plot the graph(s), but will be lost when you exit the Utilities program. To save your configurations, highlight, using the arrow keys, the "Save Config" option under the SETUP menu, and press the <ENTER> key. Enter in the dialog box presented, the drive and path and file name where you want the data stored, or use the default given.

You may also load previously saved graph data from the SETUP menu by using the "Load Config" option.

Select Data Sets For Graphing

When you have defined your graph(s), return to Screen 55 by pressing the <ESC> key. Select one or more files from the upper window. To do this, highlight a file and press the <ENTER> key. A listing of data sets in this file will be presented in the bottom window (see Screen 58 on following page).

Move the selection bar to the bottom window of Screen 58 by using the <W> key. From the list in the bottom window, select data sets for graphing by highlighting an item and pressing the <ENTER> key. A data set selected has a ♦ mark to its left. Toggle selections ON/OFF with the <ENTER> key.

Plot Graph(s)

When you have made your data set selections, press the <P> key. The first graph of your variable and data set selections will be presented (see Screen 59 on following page). Use the <PgUp> and <PgDn> keys to view graphs presenting other X/Y variable selections and data sets.

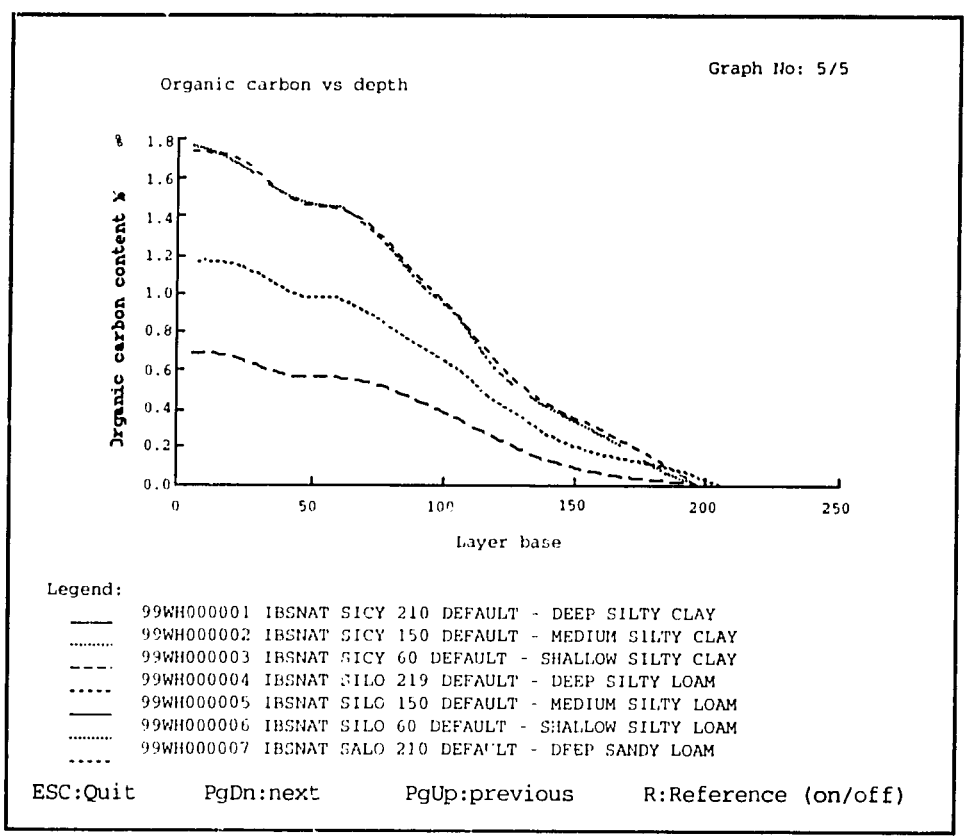
```
GENERAL GRAPHICS (GGRAF)                                  VERSION 1.0

                    FILES:  C:\DSSAT3\SOIL\*.SOL
99.SOL          SOIL.SOL        UC.SOL

                          DATASETS
 ♦   4. 99WH000004 IBSNAT SILO 210 DEFAULT - DEEP SILTY LOAM
 ♦   5. 99WH000005 IBSNAT SILO 150 DEFAULT - MEDIUM SILTY LOAM
 ♦   6. 99WH000006 IBSNAT SILO 60 DEFAULT - SHALLOW SILTY LOAM
 ♦   7. 99WH000007 IBSNAT SALO 210 DEFAULT - DEEP SANDY LOAM
     8. 99WH000008 IBSNAT SALO 150 DEFAULT - MEDIUM SANDY LOAM
     9. 99WH000009 IBSNAT SALO 60 DEFAULT - SHALLOW SANDY LOAM
    10. 99WH000010 IBSNAT SA 210 DEFAULT - DEEP SAND
    11. 99WH000011 IBSNAT SA 150 DEFAULT - MEDIUM SAND
    12. 99WH000012 IBSNAT SA 60  DEFAULT - SHALLOW SAND

⇓: Select  F1:Help  C:Clear  G:Graphs  P:Plot  S:Setup  V:View  W:sWitch
```

SCREEN 58.



SCREEN 59.

CHAPTER EIGHT.
DATA MENU OPTION: PEST

To access the "Pest" menu option under the DATA main menu item, highlight DATA and then press the <P> key or move the highlight bar with the arrow keys to "Pest" and press the <ENTER> key. The purpose of the "Pest" menu is to provide users access to information on pests of different crops for listing, editing, printing, and viewing. Data files that contain pest coefficients for integrating pest damage to crop models are available for viewing and modifying using a text editor found under this section. The pest coefficients quantify the amount of damage by different pests to different crop tissues or reductions in rate variables (such as photosynthesis) per unit of pest population or damage that is observed. In DSSAT v3, pest files are available for only three crops: soybean, drybean and peanut. Pests have also been coupled to rice using this same approach (Pinnschmidt et al., 1990), but this model is not yet available in DSSAT v3. When "Pest" is accessed, Screen 60 (below) is presented. displaying the global list of pest files with file name and description.

```
General File Manager - PEST INFORMATION                          Version 3.0
                        - Files In Directory: C:\DSSAT3\PEST -

 L   FILE NAME        FILE HEADING

     BNGRO930.PST     PEST PARAMETER INPUT FILE (DRY BEAN)
 √   PNGRO930.PST     PEST PARAMETER INPUT FILE (PEANUT)
 √   SBGRO930.PST     PEST PARAMETER INPUT FILE (SOYBEAN)

F1  - Help                    F4  - Search                F7  - Colour OFl
F2  - Inst.tute Listing       F5  - Sort                  F8  - Edit
F3  - Site Listing            F6  - Print                 F9  - Remake List
Esc - Quit              L - Include/Exc.ude In Sublist    F10 - Edit Config File
```

SCREEN 60.

The pest FILE NAME is the name of the pest. The FILE HEADING describes the file. The general functions for searching, sorting, printing and editing are similar to the other data operations already described in Chapter 4 herein, as are the <F9> and <L> keys.

All of the PST files contained in the directory specified in the file DSSATPRO.FLE for pests will be listed in Screen 60. The <F10> button in this screen allows you to specify an alternate name for the Pest list, and you can configure wild card inclusions and exclusions from the list. If additional PST files are added to that directory, the <F9> key will add them to the list and remake the list.

To edit any of the pest files listed, highlight a file using the arrow keys and press the <F8> key. The file containing the highlighted pest information is accessed either by the editor supplied with DSSAT v3 or one that you have installed. Depending on the editor used, the information will be presented in a screen similar to Screen 61 (below). The format of any data you enter must adhere to the specifications given in Volume 2-2 (Hoogenboom et al. 1994) of this book.

```
*PEST PARAMETER INPUT FILE (PEANUT)
01 CEW6 Corn Earworm                1 LAD   0.00505000   0.0000   m2/larva/d   Szm
02 VBC5 5 Instar Velvetbean         1 LAD   0.00081000   0.0000   m2/larva/d   Rie
03 VBC6 6 Instar Velvetbean         1 LAD   0.00144000   0.0000   m2/larva/d   Rei
04 SL4  Soybean Looper              1 LAD   0.00044000   0.0000   m2/larva/d   Rei
05 SL5  Soybean Looper              1 LAD   0.00071000   0.0000   m2/larva/d   Rei
06 SL6  Soybean Looper              1 LAD   0.00124000   0.0000   m2/larva/d   Rei
07 FAW  Fall Armyworm               1 LMD   2.00000000   0.0000   g/larva/d    est
08 RTWM rootworm                    1 RLV   1.00000000   0.0000   cm/cm2/lar/d est
09 PCLA Obs.% defoliation           2 LAD   1.00000000   0.0000   %
10 PSTM Obs.% Stem damage           2 SMD   1.00000000   0.0000   %
11 PDLA % Diseased Leaf Area        3 PDLA  1.00000000   0.0000   %/day
12 PRP  % Reduction in Photo        3 ASM   1.00000000   0.0000   %/day
13 PLAI % daily LAI dest.           3 LAD   1.00000000   0.0000   %/day
14 PLM  % daily Leaf Mass           3 LMD   1.00000000   0.0000   %/day
15 PWP  % Whole Plants              3 WPD   1.00000000   0.0000   %/day
16 PSDN % All Seed Dest.            3 SDNL  1.00000000   0.0000   %/day
                                    3 SDNS  1.00000000   0.0000   %/day
                                    3 SDNM  1.00000000   0.0000   %/day
17 PSHN % All Shell Dest.           3 SHNL  1.00000000   0.0000   %/day
                                    3 SHNS  1.00000000   0.0000   %/day
                                    3 SHNM  1.00000000   0.0000   %/day
18 PPDN % All Pod Dest.             3 PPDN  1.00000000   0.0000   %/day
```

SCREEN 61.

CHAPTER NINE.
DATA MENU OPTION: ECONOMIC

To access the "Economic" menu option under the DATA main menu item, highlight DATA and then press the <E> key or move the highlight bar with the arrow keys to "Economic" and press the <ENTER> key. The purpose of the "Economic" menu is to provide users access to economic data on crops and inputs for production for viewing, printing, listing and editing. These data can be stored by year to document the time changes in economic factors by region. Data are stored in files named by institute and site. These files will be used for the price data for strategy analyses. When "Economic" is accessed, Screen 62 (below) will be presented, displaying the global list of economic files with file name and description.

```
General File Manager - ECONOMIC INFORMATION                    Version 3.0
                        - Files In Directory: C:\DSSAT3\ECONOMIC -
 L   FILE NAME        FILE HEADING
 √   DEFAULT.PRI      PRICE-COST_FILE : DEFAULT FOR SEASONAL ANALYSIS
 √   DEFAULT.FEQ      PRICE-COST_FILE : DEFAULT FOR SEQUENCE ANALYSIS

F1  - Help                  F4  - Search              F7  - Colour OFF
F2  - Institute Listing     F5  - Sort                F8  - Edit
F3  - Site Listing          F6  - Print               F9  - Remake List
Esc - Quit            L - Include/Exclude In Sublist  F10 - Edit Config File
```

SCREEN 62.

The economic FILE NAME is the name of the economics file. The FILE HEADING describes the file. The general functions for searching, sending, printing and editing are similar to the other data operations already described in Chapter 4 herein, as are the <F9> and <L> keys.

All of the PRI files contained in the directory specified in the file DSSATPRO.FLE for prices will be listed. The <F10> button in Screen 62 allows you to specify an alternate name for the Price list, and you can configure wild card inclusions and exclusions from this list. If additional PRI files are added to that directory, the <F9> key will remake and add them to the list.

To edit any of the economic files listed, highlight a file using the arrow keys and press the <F8> key. The file containing the highlighted economic information is accessed either by the editor supplied with DSSAT v3 or one that you have installed. Depending on the editor used, the information will be presented in a screen similar to Screen 63 (below). The format of any data you enter must adhere to the specifications given in Volume 3-1 (Thornton et al. 1994) of this book.

```
*PRICE-COST_FILE : DEFAULT FOR SEASONAL ANALYSIS

! if IDIS=-1, cost/price component is ignored in analysis
! if IDIS= 0, fixed value in Par1
! if IDIS= 1, uniform variate (PAR1=lower, PAR2=upper bound)
! if IDIS= 2, triangular variate (PAR1=lower, PAR2=mode, PAR3=upper bound)
! if IDIS= 3, normal variate (PAR1=mean, PAR2=st. dev.)

! File sectioned by crop.  A crop's treatment sections must be contiguous.

* MZ
* TREATMENT 1
@PRAM     GRAN     BYPR     BASE     NFER     NCOS     IRRI     IRCO
IDIS       3        0        0        0        0        0        0
PAR1    160.00    10.00   240.00     0.45    12.00      .50    12.50
PAR2     16.00      .00      .00      .00      .00      .00      .00
PAR3       .00      .00      .00      .00      .00      .00      .00

* SB
* TREATMENT 1
@PRAM     GRAN     BYPR     BASE     NFER     NCOS     IRRI     IRCO
IDIS       3        0        0        0        0        0        0
PAR1    320.00     0.00   390.00     0.45    12.00      .50    12.50
PAR2     32.00      .00      .00      .00      .00      .00      .00
```

SCREEN 63.

CHAPTER TEN.
MODELS MENU OPTIONS

Under the MODELS main menu item are listed "C Cereals," "L Legumes," "R Root Crops" and "O Other." These items provide users with access to crop simulation models for simulating the performance of real experiments and for comparing model results with observed results. Capabilities for interactive sensitivity analyses on model parameters and for simulating hypothetical management practices are also accessed under the MODELS main menu item. Graphs of simulated and observed data can be viewed and printed, numerical results of simulations can be viewed, and new FILEXs or hypothetical experiments can be input. A detailed description and use of the crop models can be found in Volume 2-2 (Hoogenboom et al. 1994) of this book, and details of seasonal and sequence strategy analysis and their operation can be found in Volumes 3-1 (Thornton et al. 1994 a and 3-2 (Thornton et al. 1994 b) of this book, respectively, as well as in Chapter 11 herein.

CEREALS

To access the "Cereals" menu option under the MODELS main menu item, highlight MODELS and then press the <C> key or move the highlight bar with the arrow keys to "Cereals" and press the <ENTER> key. A list of cereal or CERES crop models (shown below) converted to conform to DSSAT v3 file and format structures will be presented. All of these crops except rice have been implemented in a single executable code to minimize duplication of programming for input and output file features. The rice model is in a separate executable module. The following cereal crops can be simulated:

B Barley
M Maize
P Millet
R Rice
S Sorghum
W Wheat

LEGUMES

To access the "Legumes" menu option under the MODELS main menu item, highlight MODELS and then press the <L> key or move the highlight bar with the arrow keys to "Legumes" and press the <ENTER> key. A list of legume or CROPGRO crop models (shown below) converted to conform to DSSAT v3 file and format structures will be pre-

sented. Like the CERES models, the CROPGRO models have been implemented with a modular code code to minimize duplication of programming for input and output file features. The following legume crops can be simulated:

S Soybean
P Peanut
D Drybean

Root Crops

To access the "Root Crops" menu option under the MODELS main menu item, highlight MODELS and then press the <R> key or move the highlight bar with the arrow keys to "Root Crops" and press the <ENTER> key. A list of root crop models (shown below) will be presented. The aroid and potato models have not been converted to conform to DSSAT v3 file and format structures. Of the following Root Crops, only cassava can be simulated:

A Aroid
C Cassava
P Potato

Other

To access the "Other" menu option under the MODELS main menu item, highlight MODELS and then press the <O> key or move the highlight bar with the arrow keys to "Other" and press the <ENTER> key. This option allows other models to be incorporated into DSSAT in order to use the data contained within the system and to take advantage of the various graphics and strategy analysis capabilities, provided those models adhere to the DSSAT v3 files and data formats.

```
DECISION SUPPORT SYSTEM FOR AGROTECHNOLOGY TRANSFER

DATA        MODELS      ANALYSES      TOOLS      SETUP/QUIT

                 C Cereal
                 L Legumes
                 R
                 O   D Dry Bean
                     S Soybean
                     P
                       C Create
                       I Inputs
                       S Simulate
                       O Outputs
                       G Graph

Create new experiment details files for simulation.

↑ ↓ → ←   moves through menu choices
ESC       moves to higher menu level                Version: 3.0
```

SCREEN 64.

When any of the specific crop models listed under the MODELS main menu item is opened, the menu options shown in Screen 64 (above) will be presented. For example, as shown in Screen 64, after "Legumes" and then "Soybean" are highlighted, the third tier of menu options is available for access. These options are described below.

CREATE

The purpose of the "Create" menu option is to allow users to create a new set of inputs for a real or hypothetical experiment. Opening this option calls the program, XCreate, which enables a user to load an existing experiment and modify the crop management and other inputs to those described in Volume 2-1 (Jones et al. 1994) of this book. XCreate is also used to input experimental practices for an actual experiment and is the same program used to enter multiple season or sequence input conditions under the ANALYSES main menu option described in Chapter 11 herein.

To open the "Create" menu option, press the <C> key or highlight "Create" and press the <ENTER> key. For a detailed description of the operation of XCreate, see Part 4 of this Volume (Volume 1-4, Imamura et al. 1994).

INPUTS

The purposes of the "Inputs" menu option are as follows:

1. Lists all experiments in a path, giving its file name, the crop code, standard and local experiment names, and a brief description of the experiment. Keeps this list of files in a file named EXPLST.DBF, which is updated after new experiments are added using the <F9> key.
2. Provides access to any of the experiment files (FILEXs) using an file editor. Users can choose experimental data files (FILEXs), crop performance averages (in FILETs and FILEAs). Access is either with a user-installed text editor or an internal editor distributed with DSSAT v3.
3. Allows for sorting of the files to locate experiments for specified crops, standard or universal names, or local names. Sorting is performed by placing the cursor in a column to search on and pressing the <F5> key to initiate the sort operation.
4. Updates the experiment list (EXPLST) read by the crop models to include new experiments or to reduce the number of experiments that are listed for model simulation. Allows users to toggle any experiment in the path to be included or excluded form EXPLST, using the <L> key.
5. Allows users to search to locate experiments in the current path based on the types of treatments included in the experiment, on types of soils, on people who conducted the experiments, and on experiments performed at specific institutes. Use the <F4> key.
6. Establish a global list (EXPLSTG.DBF) of experiments for all crops on the computer in various paths, using the F10 key. Allows users to select experiments in other paths and go to that path for maintaining EXPLST for each crop.

To open the "Inputs" menu option, press the <I> key or highlight "Inputs" and press the <ENTER> key. Screen 65 (see next page) will be presented, displaying experiment file names for the particular crop under which you have opened the "Inputs" option.

Screen 65 is similar to the one found under the "List/Edit" option in Chapter 4 herein. It gives users access to list, view, edit, print and search inputs to the crop models. The only difference is that when accessed under a particular crop model menu, it lists FILEX experiment details (real and hypothetical) that are stored in the directory allocated to that particular crop. The experiments that are checked (left-hand column) are listed in the EXPLST file for access by the crop model, and you may check more or uncheck some to manage the size of your EXPLST when you have many experiments. You can also toggle (using the <F10>key) to the global database list from here.

```
Experiment File Manager (EFM)                                    Version 3.0
                    Files In Directory: C:\DSSAT3\SOYBEAN -

| L | FILE NAME      | CG | UNV NAME | LCL NAME | EXPERIMENT FACTOR (S) /NAME |
|---|----------------|----|----------|----------|---|
| √ | IUCA7901.SBX   | SB | IUCA7901 |          | WAYNE, IRRIGATED & NON-IRRIGAT |
| √ | UFGA7801.SBX   | SB | UFGA7801 |          | BRAGG, IRRIGATED & NON-IRRIGAT |
| √ | UFGA7901.SBX   | SB | UFGA7901 |          | IRRIGATION 3I |
| √ | UFGA8101.SBX   | SB | UFGA8101 |          | COBB, IRRIGATED, VEG. & REPROD |
| √ | UFQU7901.SBX   | SB | UFQU7901 |          | BRAGG, WELL IRRIGATED |

F1  - Help                    F4  - Search                F7  - Colour OFF
F2  - Institute Listing       F5  - Sort                  F8  - Edit
F3  - Site Listing            F6  - Print                 F9  - Remake List
Esc - Quit                L   Include/Exclude In Sublist  F10 - Database List
```

SCREEN 65.

For a complete description of the operation of Screen 65, column definitions and key functions, see under "List/Edit" in Chapter 4 herein.

SIMULATE

The purpose of the "Simulate" menu option is to enable users to run a simulation model for a specific crop. When this option is selected, the directory path is changed to the path for the specific crop (e.g., C:\DSSAT3\MAIZE), the appropriate crop model is called, and a list of available experiments for the selected crop is presented. After an experiment from this list is selected by entering the number of the experiment, a screen is presented from which the user selects a treatment from a list of treatments. Following a treatment selection, a screen is presented which allows the user to choose between continuing with the simulation defined by the experiment file selected, or modifying a range of management variables, soil characteristics, weather data and cultivar coefficients for a sensitivity analysis. Then the model is run, displaying summary experiment, soil, weather and simulated results on the screen. Additional runs may be made if desired, before returning to the DSSAT v3 Shell.

To open the "Simulate" menu option, press the <S> key or highlight "Simulate" and press the <ENTER> key. For a full description of the operation of DSSAT v3 crop models, see Volume 2-2 (Hoogenboom et al. 1994) of this book.

```
General File Manager - Model outputs                          Version 3.0
                        - Files In Directory: C:\DSSAT3\SOYBEAN

L   FILE NAME        FILE HEADING
√   GROWTH.OUT       GROWTH ASPECTS OUTPUT FILE
√   NBAL.OUT         NITROGEN BALANCE SUMMARY FILE
√   NITROGEN.OUT     NITROGEN BALANCE OUTPUT FILE
√   OVERVIEW.OUT     SIMULATION OVERVIEW FILE
    SUMMARY.OUT      SUMMARY : UFQU7901SB BRAGG, WELL IRRIGATED
    WATER.OUT        WATER BALANCE OUTPUT FILE

F1  - Help                    F4  - Search                F7  - Colour OFF
F2  - Institute Listing       F5  - Sort                  F8  - Edit
F3  - Site Listing            F6  - Print                 F9  - Remake List
Esc - Quit              L - Include/Exclude In Sublist    F10 - Edit Config File
```

SCREEN 66.

OUTPUTS

The purpose of the "Outputs" menu option is to give users easy access to crop model output files so that they can be listed, printed and viewed from within the DSSAT v3 Shell. This option allows users to access model output files for the selected crop with the standard naming conventions detailed in Volume 2-1 (Jones et al. 1994) of this book.

To open the "Outputs" menu option, press the <O> key or highlight "Outputs" and press the <ENTER> key. Screen 66 (above) will be presented, displaying the outputs files (OUT) for a particular crop. In example Screen 66, output files for Soybean are listed. For a complete description of the operation of this screen and its key functions, see under "List/Edit" in Chapter 4 herein.

GRAPH

The purpose of the "Graph" menu option is to provide users with graphical analysis of simulated and observed results. A program called Graphing Simulated and Experiment Data is initiated from DSSAT v3 when this option is selected, and the data used for plotting is for the crop which was selected before "Graph" was opened. Users will have typically simulated one or more experiments and treatments before opening this menu option.

To open the "Graph" menu option, press the <G> key or highlight "Graph" and press the <ENTER> key. For a complete description of Graphing Simulated and Experiment Data program and its operation, see Volume 2-3 (Chan et al. 1994) of this book.

CHAPTER ELEVEN.
ANALYSES MENU OPTIONS

Under the ANALYSES main menu item are options that give users access to two programs, Seasonal Analysis and Sequence Analysis, that provide analysis capabilities for uncertainty and risk as well as for long-term sustainability of agricultural practices at a field scale. Seasonal Analysis allows you to run large experiments with many treatments replicated across many years of simulated or historical weather data. The results can be analyzed by comparing the treatments or "strategies" with respect to a wide variety of model outputs, such as yield. Economic comparison of the treatments can also be made, allowing the user to draw tentative conclusions concerning the economic risk associated with each treatment. In Sequence Analysis mode, crop rotations or sequences can be simulated, along with the attendant carry-over effects of soil water and nitrogen processes from one crop to another, including some fallow periods. These rotations can also be replicated with respect to different weather sequences.

To access the "Seasonal" menu option under the ANALYSES main menu item, highlight ANALYSES and then press the <S> key or move the highlight bar with the arrow keys to "Seasonal" and then press the <ENTER> key. A menu of options available (shown in Screen 67 below) will be presented.

```
DECISION SUPPORT SYSTEM FOR AGROTECHNOLOGY TRANSFER

DATA        MODELS      ANALYSES      TOOLS      SETUP/QUIT

                        S Seasonal
                        Q
                          C Create
                          I Inputs
                          S Simulate
                          O Outputs
                          A Analyze

Create new seasonal/sequential analysis files.

↑ ↓ → ←  moves through menu choices
ESC      move to higher menu level                Version: 3.0
```

SCREEN 67.

SEASONAL

The purpose of the "Seasonal" menu option is to enable users to run multiple year simulations with one or more crop models, using actual or generated weather data. With this program, soil initial conditions are re-initialized before each season's crop simulation run to simulate the uncertainty in crop performance due to uncertainty in weather under specified starting soil conditions. As many as 20 different combinations of crops and management practices may be specified. The program allows users to create the combination of crops and practices to be run, and to analyze the biophysical variability and economic risks of each practice, indicating the one or ones that are most risk efficient. For a complete description of the operation of the Seasonal program, see Volume 3-1 (Thornton et al. 1994 a) of this book.

CREATE AND OUTPUTS

The purpose and operation of the menu options "Create" and "Outputs" is similar to those described under the same headings in Chapter 10 herein. The screen presented under "Outputs" will be similar to that found in Screen 68, except that the files listed will be Seasonal files with an SNS suffix. For a description of these options and how to use them, see Chapter 10, "Models Menu Options."

INPUTS

The purpose of the "Inputs" menu option is to provide users access to data management functions for maintaining a list of previously defined multi-year experiments for seasonal analysis. This facility allows users to display a list of all available seasonal files, locate those for specific purposes and update a list that is accessed by the "driver" program for running the crop models. When "Inputs" is selected, a screen similar to Screen 65 presented in Chapter 10 under the same option heading will appear, displaying the global list of seasonal files, crop code, experiment name and a summary of experimental factors. The only difference is that the files listed in the screen will be Seasonal (SNX) files.

SIMULATE

The purpose of the "Simulate" menu option is to enable users to simulate a set of crop management treatments that were previously created and saved in an experiment list (EXP.LST). A "driver" program displays all available experiments that have been created previously, and users select the one that is to be run. The "driver," called SEADRV.EXE, calls the appropriate crop models to simulate all combinations of crops and treatment combinations, for the number of years specified. Results are saved in a summary output file, called SUMMARY.OUT, or optionally, ssssssss.SNS, where the "ssssssss" stands for the

name of the input FILEX used, the "SN" for seasonal analysis, and the final "S" for summary output file. An entry is made to the SEASON.LST file to indicate that another run has been made for variability analysis.

To open the "Simulate" menu option,press the <S> key or highlight "Simulate" and press the <ENTER> key. For a more detailed description of the "Simulate" option and its operation, see Volume 3-1 (Thornton et al. 1994 a) of this book.

ANALYZE

The purpose of the "Analyze" menu option is to enable users to perform analyses on the variability of simulated crop performance results and on economic variables to provide an assessment of risk of different practices. It accesses previously simulated results. If several seasonal simulations have been run, you will be presented with a list of these to choose from. This program provides graphical outputs of cumulative probabilities and box plots, and it gives the most risk efficient practice(s) from the set that were simulated.

To open the "Analyze" menu option, press the <A> key or highlight "Analyze" and press the <ENTER> key. For a more detailed description of the "Analyze" option and its operation, see Volume 3-1 (Thornton et al. 1994 a) of this book.

SEQUENCE

To access the "Sequence" menu option under the ANALYSES main menu item, highlight ANALYSES and the press the <Q> key or move the highlight bar with the arrow keys to "Sequence" and then press the <ENTER> key. A menu of options available (shown in Screen 67 under "Seasonal") will be presented.

The purpose of the "Sequence" menu option is to give users the capability of running multiple year simulations with one or more crop models, using actual or generated weather data. Here, soil initial conditions are carried over from one crop to the next to simulate the time-changes in soil conditions as practices are simulated. This program allows users to create the combination of crops and practices to be run in rotation, including fallow periods, and to analyze the biophysical variability in results and the economic risks of each practice.

CREATE

The purpose of the "Create" menu option is to enable users to create a new set of crop management inputs for a multi-year simulation experiment. From this menu item, the

XCreate program is called to allow users to load an existing experiment and modify the crop management and other inputs described in Volume 2-1 (Jones et al. 1994) of this book. XCreate is the same program that is used to create FILEXs (input experiment files) for an actual experiment, and it and its operation are described in Part 4 of this Volume (Volume 1-4, Imamura et al. 1994).

INPUTS

The purpose of the "Inputs" menu option is to provide users access to data management functions for maintaining a list of previously defined multi-year experiments for sequence analysis. This facility allows users to display a list of all available sequence files, locate those for specific purposes and update a list that is accessed by the "driver" program for running the crop models. When "Inputs" is selected, a screen similar to Screen 65 presented in Chapter 10 under the same option heading will appear, displaying the global list of sequence files, crop code, experiment name and a summary of experimental factors. The only difference is that the files listed in the screen will be Sequence (SQX) files.

OUTPUTS

The purpose of the "Outputs" menu option is to give users easy access to crop model output files so that they can be listed, printed and viewed from within the DSSAT v3 Shell. The files accessed are model output files for the selected crop with the standard naming conventions detailed in Volume 2-1 (Jones et al. 1994) of this book. The screen presented when "Outputs" is selected is similar to that of Screen 68 (on the following page); note that the sequence output files have a SQS suffix. The general <F> key functions for searching, sending, printing and editing are similar to the data operations already described under "List/Edit" in Chapter 4 herein, as are the <F9>, <F10> and <L> keys.

```
General File Manager - SEQUENCE ANALYSIS                          Version 3.0
                        - Files In Directory: C:\DSSAT3\SEQUENCE -

 L   FILE NAME        FILE HEADING
 √   UFGA1001.SQS     MAIZE-FALLOW, 10:5
 √   UFGA7801.SQS     BRAGG, SEQUENCE ANALYSIS, SB-FA, 25:5
 √   UFGA7802.SQS     SEQUENCE EXAMPLE, SOYBEAN-FALLOW-BEAN-FALLOW, 10:3
 √   UFGA7803.SQS     SEQUENCE ANALYSIS, SIMPLE MULTI-TREAT FILE, 5:5
 √   UFGA7804.SQS     BN-BN YR 1, SB YR 2 EXAMPLE, 10:5
 √   UFGA7807.SQS     MAIZE-FALLOW, 12:20
 √   UFGA7809.SQS     BN-BN YR 1, SB YR 2, MZ YR 3 EXAMPLE, 18:5

F1  - Help                    F4  - Search                F7  - Colour OFF
F2  - Institute Listing       F5  - Sort                  F8  - Edit
F3  - Site Listing            F6  - Print                 F9  - Remake List
Esc - Quit              L - Include/Exclude In Sublist    F10 - Edit Config File
```

SCREEN 68.

Users may edit the files listed by pressing the <F8> key. A screen displaying the contents of the file will be presented, with key functions for editing found at the bottom of the screen.

ANALYZE

The purpose of the "Analyze" menu option is to allow users to simulate a sequence of crops or a crop rotation that was previously created and saved in an experiment list (EXP.LST). A "driver" program displays all available sequence experiments that have been created previously; users select the one that is to be run. Then, the "driver," called SEQ-DRV.EXE, calls the appropriate crop models to simulate the rotation or sequence for the number of years specified. Results are saved in a summary output file, called SUMMA-RY.OUT or optionally ssssssss.SQS where the "ssssssss" stands for the name of the input FILEX used, the "SQ" for sequence analysis, and the final "S" for summary output file. An entry is made to the SEQUENCE.LST file to indicate that another run has been made for crop sequence analysis.

To open the "Analyze" menu option, press the <A> key or highlight "Analyze" and press the <ENTER> key. For a detailed description of the "Analyze" option and its operation, see Volume 3-2 (Thornton et al. 1994 b) of this book.

CHAPTER TWELVE.
TOOLS MENU OPTIONS

Under the TOOLS main menu item are options that give users access to the DOS shell and to user-supplied disk manager, text editor, and spread sheet programs. Paths to these programs are specified under the SETUP/QUIT main menu item of the Shell (see Chapter 13 in this section.)

OPERATING SYSTEM

To access the "Operating System" menu option under the TOOLS main menu item, highlight TOOLS and then press the <O> key or move the highlight bar with the arrow keys to "Operating System" and press the <ENTER> key.

The purpose of the "Operating System" menu option is to allow users to go to the DOS operating system prompt while DSSAT v3 remains in memory. Note that DSSAT v3 requires about 100K of memory, and DOS operations that require large amounts of memory may be affected when this operation is done. Users must type "EXIT" and then press the <ENTER> when they wish to return to DSSAT.

DISK MANAGER

To access the "Disk Manager" menu option under the TOOLS main menu item, highlight TOOLS and then press the <D> key or move the highlight bar with the arrow keys to "Disk Manager" and press the <ENTER> key.

The purpose of the "Disk Manager" menu option is to enable access to a user's disk manager program. If one is not installed, an error message will be displayed. To install a disk manager, use the option "Tools" under the SETUP/QUIT Shell option.

EDITOR

To access the "Editor" menu option under the TOOLS main menu item, highlight TOOLS and then press the <E> key or move the highlight bar with the arrow keys to "Editor" and press the <ENTER> key.

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The purpose of the "Editor" menu option is to allow access to a user's text editor program. If you have not installed an editor under the SETUP/QUIT Shell menu option, "Tool," the editor supplied with DSSAT v3 will be accessed.

SPREADSHEET

To access the "Spread Sheet" menu option under the TOOLS main menu item, highlight TOOLS and then press the <S> key or move the highlight bar with the arrow keys to "Spread Sheet" and press the <ENTER> key.

The purpose of the "Spread Sheet" menu option is to allow access to a user's spread sheet program. If one is not installed, an error message will be displayed. To install a spread sheet, use the option "Tools" under the SETUP/QUIT Shell option.

CHAPTER THIRTEEN. SETUP/QUIT MENU OPTIONS

Under the SETUP/QUIT main menu item are options that enable users to modify program paths, program names, and data file paths used in the different sections of DSSAT v3. These menu options allow users to tailor the DSSAT v3 package to their own disk configurations and to have more than one path on the computer with data or models that may be "linked" to DSSAT v3 at any desired time. For example, users may have weather data in two paths for two different regions. Then, the path definition under the SETUP/QUIT section can be set to the path required for a specific set of runs. It is also possible for users to have more than one model of the same crop and select the model they want run run by specifying its path and name under the SETUP/QUIT menu item.

Use the options under this main menu item to set up the paths of the major sections of DSSAT v3; that is, DATA, MODELS, ANALYSES, TOOLS, to save the modified configuration, and to quit DSSAT v3.

SETUP

To access the "Setup" menu option under the SETUP/QUIT main menu item, highlight SETUP/QUIT and then press the <S> key or move the highlight bar with the arrow keys to "Setup" and press the <ENTER> key.

DATA, MODELS, ANALYSES, TOOLS AND SAVE

The purpose of the "Data," "Models," "Analyses" and "Tools" menu options is to allow users to change the drive and path, or location, of a particular program under each one of these main menu options and/or to change the drive and path of specific data locations. The "Save" menu option, saves any drive and path changes made.

Select one of these items by highlighting and pressing the <ENTER> key or by pressing the <D>, <M>, <A>, <T> or <S> key, respectively. The "Save" option would generally be used after location changes have been made to a program or data file using the first four menu options.

It should be noted that a file containing the setup configuration, named DSSATPRO.FLE, is rewritten each time the SAVE option is selected. This file MUST be in the path C:\DSSAT3. This is the ONLY path that must be on disk C:; all other files may be on other disks. Users

should make a backup of this file after selecting the total configuration on a system. The contents of the DSSATPRO.FLE file can be found in the Appendix to this Volume.

Since the screens accessed for "Data," "Models," "Analysis" and "Tools" are similar, only the screens for "Models" will be shown to demonstrate the operation of these menu options.

```
DECISION SUPPORT SYSTEM FOR AGROTECHNOLOGY TRANSFER

DATA        MODELS        ANALYSES        TOOLS        SETUP/QUIT

  Rice                    Use the cursor key to select a menu
  Sorghum                 item and press <RETURN> to edit its
  Wheat                   drive, path, and program name.
  Dry Bean                Items indented are used in menus
  Soybean                 spawned by DSSAT.
  Peanut
  Aroids                  Press <ESC> when done with the menu.

                 Location of Program

  DRIVE & PATH  c : \dssat 3
  DRIVER  MOD:  MDRIV930.EXE    INPUT MOD:  MINPT930.EXE
  RUNTIME MOD:  CRGRO930.EXE    FILE TYPE:  I

                 Location of Data

  DRIVE & PATH  c: \dssat3\soybean
```

SCREEN 69.

When "Models" is selected, Screen 69 (above) will be presented. In the top lift-hand window will be listed the crop models in DSSAT v3. Directions for selecting one of the items listed in this window are written on the screen to the right of this window. When an item is selected, the middle window of this screen, containing the drive and path name and other items for the particular program selected, as well as the bottom window for the drive and path name for data location, will be highlighted. To change any of the highlighted items, type in the highlighted areas. Any changes you make under the SETUP menu option will be saved only until you exit DSSAT v3.

To save your changes so they are available when you next open DSSAT v3, you must use the "Save" option under the SETUP menu item after you have made the changes.

QUIT

To "Quit" DSSAT v3, highlight SETUP/QUIT and then press the <Q> key or move the highlight bar with the arrow keys to "Quit" and press the <ENTER> key.

VOLUME 1-4

CREATING MANAGEMENT FILES TO RUN MODELS & DOCUMENT EXPERIMENTS

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CHAPTER ONE. INTRODUCTION

Researchers in the IBSNAT network have developed a system of data files, formats, and conventions for storing information on crop production. The purposes of this system are to 1) provide a uniform structure for documenting crop experiments conducted at any site and 2) provide uniform data structures for crop model inputs and applications. This system includes files for daily weather, soil, crop and management data for documenting the environment, crop and cultivar characteristics and field management. These data files are also used as input to crop models. Other files are used to store measurements of crop, weather and soil responses during a season and at harvest, which are useful for evaluating the ability of the crop models to simulate real world responses.

The program which creates management files to run models and document experiments is called XCreate and was developed to help users create a file that describes an experiment. This file, referred to as FILEX, can be used to store details for an actual or hypothetical experiment in a standard ASCII file. For a detailed description of FILEX, see Volume 2-1 (Jones et al. 1994) of this book.

XCreate guides users through the complexities of entering various types of management information, and it stores the information in a FILEX that conforms exactly to the DSSAT v3 standard input/output specifications. It does not, however, provide capabilities for creating the other input files, such as soil, weather and crop performance data, which are needed to run the DSSAT v3 crop models.

XCreate can be used to enter data from actual experiments or from hypothetical ones that are to be simulated on a computer. A user can create a FILEX for running the DSSAT v3 crop models in three modes. These are:

1. Interactive or Experiment mode.
2. Seasonal analysis mode.
3. Sequence analysis mode.

There are slight differences between the contents (but not the structure) of the FILEXs for these three modes of running the crop models. These differences are explained below. For a detailed description of the Seasonal and Sequence programs and their operation, see Volumes 3-1 and 3-2 (Thornton et al. 1994, a and b), respectively, of this book.

Interactive Mode

The Interactive (or Experiment) mode for running the crop models will usually be used for calibration, validation and sensitivity analysis; in other words, when you want to run single-season crop simulations, compare simulated with observed outputs, and investigate simple "what if" questions, such as what would happen if in 1993 you had grown variety A rather than variety B in this particular field trial. These model runs are made under the MODELS menu item of the DSSAT Shell, and the experiment FILEXs may involve many treatments that are replicated or not replicated across different weather seasons. Though, however many treatments there are, they would usually relate to one crop and hence to one crop model. Interactive changes to the model input data (as defined in FILEX) may be made, and many different options may be changed for each model run in this mode. Much output from the crop model can be written to the screen as well as to the output files, allowing the user to investigate simulation runs in great detail.

Seasonal Analysis Mode

Running the crop models in Seasonal Analysis mode is done under the ANALYSES menu item of the DSSAT v3 Shell. In contrast to Interactive mode, there is no provision for performing sensitivity analysis: to change the variety, for example, the FILEX has to be edited using the XCreate program or an ASCII text editor. Seasonal Analysis, however, allows you to run large experiments with many treatments replicated across many years of simulated or historical weather data. Furthermore, the results can be analyzed by comparing the treatments or "strategies" with respect to a wide variety of model outputs, such as yield. Economic comparison of the treatments can also be made, allowing the user to draw tentative conclusions concerning the economic risk associated with each treatment. The only differences between a FILEX created for interactive mode and one created for seasonal analysis mode will generally relate to the number of replicates and the possibility of using different crops (comparing the performance of soybean and maize, say, under the same environmental conditions). Any FILEX created for interactive mode can also be used in seasonal analysis mode. A user can modify an experiment FILEX to create a seasonal analysis FILEX by changing the number of years from '1' to 'n', where 'n' is the number of replications. For a complete description of the Seasonal program, see Volume 3-1 (Thornton et al. 1994 a) of this book.

Sequence Analysis Mode

Sequence Analysis mode, like Seasonal Analysis, involves running the crop models under the ANALYSES menu of the DSSAT v3 Shell. In this mode, crop rotations or sequences can be simulated, along with the attendant carry-over effects of soil water and nitrogen processes from one crop to another, including some fallow periods. These rotations can also be replicated with respect to different weather sequences. The method of setting up a FILEX for a sequence experiment (like the other modes, it may be a recorded or hypothetical experiment) is a little different. Instead of defining a complete set of treatments, the rotation "germ" or repeating unit is specified in FILEX, and the appropriate crop models will be run such that the germ is repeated over and over again until a specified number of years of simulated time has elapsed. The results of the sequence simulation can be analyzed with respect to model outputs and the economics of particular rotations or sequence "strategies." Sequence analysis FILEXs can not be used in any other mode because of the different way in which treatments are specified in the file. For a complete description of the Sequence program, see Volume 3-2 (Thornton et al. 1994 b) of this book.

CHAPTER TWO. PROGRAM OVERVIEW

XCreate is, in essence, an experiment data entry program for DSSAT v3 and as such allows the user to enter management information for the various treatments and sections of an experiment. The information includes cultivar, field, soil analysis, initial conditions, planting, irrigation, fertilizer, residue, chemical applications, tillage and rotation, environmental modifications, harvest and simulation control conditions.

The basic procedure involved in creating a FILEX is as follows:

1. Select an existing experiment as a "template."
2. Add or Remove treatments.
3. Edit sections as required until complete.
4. Save the new FILEX.

A user can also start with a blank "template" and enter all treatment data and information needed to describe the details of an experiment.

GUIDELINES

GENERAL

XCreate was developed using Borland C++[1] and TurboVision[1] for the user interface routines. In general, the user interface is made up of menus, windows and dialog boxes. The user interacts with the program via menus and dialog boxes. The program displays information for the user via windows. Both mouse and keyboard commands can be used in this program.

SCREEN "BUTTONS"

In all XCreate screens, where multiple buttons are available (e.g., the SELECT, VIEW, NEW EXPT, CANCEL buttons in Screen 3 in Chapter 3), you may "press" these by one of two methods:

1) If using a mouse, click on the button.
2) If using the keyboard, highlight the button using the <TAB> and <SHIFT> <TAB> keys and then press the <ENTER> key.

[1]Borland C++ and TurboVision are registered trademarks of Borland International, Inc.

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CODES

Abbreviations or codes are used in various places in the experiment files (FILEXs). For example, codes are used for fertilizer types, pesticide types, crops, residue types, methods for applying fertilizers, irrigation methods, soil texture, tillage implements and environment modification flags. These codes are contained in a file named CODES.FLE which is described in Appendix B of Volume 2-1 (Jones et al. 1994) of this book. XCreate opens this file and presents the codes and their descriptions to users at appropriate places, to facilitate the ease with which correct data can be entered for an experiment.

To obtain code lists in XCreate, the user must press the <F2> key when the blinking cursor is on a data field that requires a code.

Users could add new codes to the CODES.FLE file, as needed, to document an experiment. However, current crop models may not recognize new codes.

KEYBOARD COMMANDS

Following is a list of keyboard commands that can be used in most screens presented in the XCreate program.

<ESC>	Cancel/Exit the current dialog box or menu.
<F1>	Context sensitive help.
<F2>	Code selection list, if any.
<F4>	Set initial soil, water and mineral N conditions.
<F7>	Save edited file.
<TAB>	Move to the next data entry field or dialog item.
<SHIFT>-<TAB>	Move to the previous data entry field dialog item.
Up Arrow	Move up a list of items.
Down Arrow	Move down a list of items.
Alt-_	Shortcut keyboard command where "_" is the **BOLD** letter of a

menu item or button. (For example, Alt-F accesses the FILE menu item in the menu bar.)

Alt-X — Exit/Quit XCREATE. (To save a created file, users must press the <F7> key before exiting.)

SCREEN DISPLAY

```
 File  Experiment  Management  Controls  Options                    Crt =  1 1 0 0
                                   FILEX.RPT
*EXP.    Identifiers          VAR WAPIO, IBSNAT EXP.1983-4
         General
*TREA    Plot Information            ------------FACTOR LEVELS------------
@N R     Notes                ..... CU FL SA IC MP MI MF MR MC MT ME MH SM
 1 1                                  1  1  0  1  1  1  1  1  0  0  0  0  1
 2 1 0 0 X304C 50 kg N/ha             1  1  0  2  1  1  2  1  0  0  0  0  1
 3 1 0 0 X304C 200 kg N/ha            1  1  0  3  1  1  3  1  0  0  0  0  1
 4 1 0 0 H610 0 kg N/ha               2  1  0  4  1  1  1  1  0  0  0  0  1
 5 1 0 0 H610 50 kg N/ha              2  1  0  5  1  1  2  1  0  0  0  0  1
 6 1 0 0 H610 200 kg N/ha             2  1  0  6  1  1  3  1  0  0  0  0  1

*CULTIVARS
@C CR INGENO CNAME
 1 MZ IB0063 PIO X 304C
 2 MZ IB0060 H610(UH)

*FIELDS
@L ID_FIELD WSTA....  FLSA  FLOB  FLDT  FLDO  FLDS  FLST SLTX SLDP  ID_SOIL
 1 IBWA0001 IBWA8302 -99       0 IB000     0     0 00000  -99  110  IBMZ91001

*INITIAL CONDITIONS

F1 Help  F2 Lookup  F4 Mineral N  F7 Save  Alt-X Exit
```

SCREEN 1.

Screen 1 is a typical XCreate screen. The top line, with FILE, EXPERIMENT, MANAGEMENT, CONTROLS and OPTIONS is the menu bar. Each item in this menu bar has a related pull-down menu. To access a pull-down menu click on the menu item with the mouse or press "Alt-_" where "_" is the first letter of the menu bar item. (i.e., Alt-F for the "File" menu bar item).

The bottom line of the screen, with "F1 Help," "F2 Look up," "F4 Mineral N," "F7 Save" and "Alt-X Exit," is called a status line. The status line contains short-cut key commands to certain functions available in the menu bar. For example, to save your experiment, you can either press <F7>, referring to "F7 Save" in the status line, or select the "File" menu in the menu bar and then select the "Save current work" menu item.

Immediately below the menu bar is a scrollable text window with the heading "FILEX.RPT." This window displays the current state of the experiment description file (FILEX) being created or modified. To scroll within this window, close all pull-down menus by pressing the <ESC> key. Use the arrow keys to scroll. You may also turn off this window by opening the "Options" menu bar item and selecting "Toggle report window." Select "Toggle report window" to turn the report window on again.

In the upper right-hand corner of every XCreate screen, there is a colored area with "Trt = A B C D" in it, for example, in Screen 1, Trt = 1 1 0 0. This Selected Treatment Indicator is used to denote which treatment is being modified in an experiment. The "A" indicates the current Treatment Number, "B" and "C" indicate the Rotation Component and Rotation Option, respectively, and "D" indicates the Crop Component. See Chapter 6 for a more detailed description of the Selected Treatment Indicator.

CHAPTER THREE. EXECUTE PROGRAM

To access the XCreate program under the DATA main menu item, highlight DATA and then select the "X Experiment" option by pressing the <X> key or by moving the highlight bar with the arrow keys to the "X Experiment" option and pressing the <ENTER> key. From the "X Experiment" menu, select the "C Create" option. The following screen will appear.

```
File  Experiment  Management  Controls  Options                Trt =  0 0 0 0

                 [•]
                  Select FILEX type
                   (•) Experiment          [OK]
                   ( ) Seasonal
                   ( ) Sequence

F1 Help  F2 Lookup  F4 Mineral N  F7 Save  Alt-X Exit
```

SCREEN 2.

In Screen 2, you may select to create an "Experiment," "Seasonal" or "Sequence" FILEX.

1. Select "Experiment" to document a single-season recorded experiment.
2. Select "Seasonal" to create an experiment that is repeated for a number of years. Usually this FILEX is created to analyze the effect of a particular management strategy over multiple seasons. See Volume 3-1 (Thornton et al. 1994 a) of this book for a description of the Seasonal program.
3. Select "Sequence" to create a sequence analysis experiment This FILEX is used to analyze the effect of crop rotations or crop sequencing. See Volume 3-2 (Thornton et al. 1994 b) of this book for a description of the Sequence program.

To create an Experiment FILEX: Select "Experiment" by moving the (•) selector to "Experiment" using the arrow keys. Either press the <ENTER> key or use the mouse to click on the OK button.

To create a Seasonal FILEX: Select "Seasonal" by moving the (•) selector to "Seasonal" using the arrow keys. Either press the <ENTER> key or use the mouse to click on the OK button.

To create a Sequence FILEX: Select "Sequence" by moving the (•) selector to "Sequence" using the arrow keys. Either press the <ENTER> key or use the mouse to click on the OK button.

To exit XCreate: Press <ESC> and then ALT-X.

After you have made a selection to create a FILEX (either Experiment, Seasonal, or Sequence) Screen 3 (below) will appear.

```
File  Experiment  Management  Controls  Options                    Trt =  0 0 0 0

[•]──────────── Select Template Experiment ────────────
  1 FLSC8101 MZX N X IFFIG., S.C.                      [Select]
  2 IBSI8001 MZX MULTI-YEAR TEST,  SITIUNG        ▲    [View]
  3 IBWA8301 MZX N X VAR WAIPIO, IBSNAT EXP.19
  4 UFGA8201 MZX N X IRRIGATION, GAINESVILLE           [New Expt]
                                                       [Cancel]
                                                  ▼

F1 Help  F2 Lookup  F4 Mineral N  F7 Save  Alt-X Exit
```

SCREEN 3.

In Screen 3, you can choose to create a new experiment using an existing experiment as a template or to enter a new experiment without a template.

To select an existing experiment as a template: Scroll through the list of experiments with the scroll bar. Move the highlight bar over the experiment you wish to use as a template and press the SELECT button. Using this option to enter an experiment may be the quickest and easiest way if one of the experiments shown in this dialog box is similar to your experiment. XCreate allows you to load the existing experiment, make any modifications necessary to various sections and then save it as a new experiment.

NOTE: *If you are already in the process of editing an experiment and have not saved it, loading a new one from this dialog box will completely ERASE your current work.*

To view an existing experiment: Move the highlight bar over the experiment, using the arrow keys or mouse, and press the VIEW button. A scrollable text window will pop up with the contents of the VIEWed experiment within it. Press the <ESC> key to close the VIEWing window.

To create a new experiment: Press the NEW EXPT button. Use this button if there are no templates you would like to select or if you want to define a completely new experiment.

To cancel: Press the CANCEL button. Use this button if you do not want to create a new experiment and want to keep the current experiment, if any, that you were editing.

Tips For Creating A New Experiment (Real Or Hypothetical) & For Editing Existing Experiment Files

Adding a New Experiment

1. Under the EXPERIMENT main menu item, select the "Identifiers" menu option. Enter the Experiment ID and crop group, which will create the unique name for this experiment (e.g., UFGA7801 for the ID and SB for the crop group creates the file UFGA7801.SBX).
2. Go to the MANAGEMENT main menu item and select the "Treatments" menu option. Press the ADD TRT button to create the first treatment of the experiment. Enter the name of the treatment.
3. Enter all information for Treatment 1, including all information about fields, planting, cultivars, irrigation, etc. Also, under the CONTROLS main menu item, select the "General" menu option and enter the "Simulation Start Date."
   NOTE: *Press the ADD LVL button each time information is added in the CONTROLS section.*

4. Then, select the "Treatments" option again under the EXPERIMENT main menu item, and press the ADD TRT button to add the second treatment. Name this treatment. This treatment will automatically be given the values of the first treatment as starting values.
5. Select only each management item (e.g., cultivar, planting, fields, etc.) for the second treatment that is different from the first. Enter correct information for the second treatment for each of the management items which are different and press the ADD LVL button to save this new management information for the second treatment. Note that the number "2" will appear in the first position in the Selected Treatment Indicator found in the upper right-hand corner of the screen
6. Continue to add treatments in this way, making sure that all information for a particular treatment is correct before proceeding to the next one. You can use the arrow keys or mouse to highlight any of the previous treatments before pressing the ADD TRT button. This will select the values from that treatment for the new one to be added, so that only one factor will usually have to be added (using the ADD LVL button) for each treatment in a factorial experiment.

Editing an Existing Experiment

1. If the edited file is to replace the existing file, there is no need to change the Experiment ID. However, if you wish to keep the existing file and enter new data for another file, change the ID using a name under which you wish the information to be stored. (See item #1 under the above section "Adding a New Experiment.")
2. Start with Treatment 1, and make all of the modifications to this treatment that you wish to make. Press the OK button to replace existing information with the information that is entered for the first treatment.
3. Proceed to the second treatment, changing everything that needs to be changed. It is best to use the ADD LVL button for each change to make sure that the change that is made is only for the treatment being edited. If duplicate information is found by the software, it will be recognized and corrected.
4. Continue to successive treatments, and check the information behind the menus to be sure that treatments are being correctly created.

CHAPTER FOUR. FILE MENU

Under the FILE menu item (Screen 4 below) are options which enable users to create a new experiment using an existing experiment as a template or to enter a new experiment without a template, to change the working directory and to save a newly created FILEX.

```
 File  Experiment  Management  Controls  Options                    Trt =  1 1 0 0
                                   FILEX.RPT
*EXP.   Identifiers      VAR WAPIO, IBSNAT EXP.1983-4
        People
*TREA   Plot Information        ------------FACTOR LEVELS------------
@N R    Notes            ..... CU FL SA IC MP MI MF MR MC MT ME MH SM
 1 1                            1  1  0  1  1  1  1  1  0  0  0  0  1
 2 1 0 0 X304C 50 kg N/ha       1  1  0  2  1  1  2  1  0  0  0  0  1
 3 1 0 0 X304C 200 kg N/ha      1  1  0  3  1  1  3  1  0  0  0  0  1
 4 1 0 0 H610 0 kg N/ha         2  1  0  4  1  1  1  1  0  0  0  0  1
 5 1 0 0 H610 50 kg N/ha        2  1  0  5  1  1  2  1  0  0  0  0  1
 6 1 0 0 H610 200 kg N/ha       2  1  0  6  1  1  3  1  0  0  0  0  1

*CULTIVARS
@C CR INGENO CNAME
 1 MZ IB0063 PIO X 304C
 2 MZ IB0060 H610(UH)

*FIELDS
@L ID_FIELD WSTA....  FLSA  FLOB  FLDT  FLDO  FLDS  FLST SLTX SLDP  ID_SOIL
 1 IBWA0001 IBWA8302 -99       0 IB000     0     0 00000  -99  110  IBMZ91001

*INITIAL CONDITIONS

F1 Help  F2 Lookup  F4 Mineral N  F7 Save  Alt-X Exit
```

SCREEN 4.

OPEN USING TEMPLATE OPTION

This option allows the user to create a new experiment by selecting an existing experiment as a template or a completely new experiment without a template. See Chapter 3 for more information about this option.

CHANGE WORKING DIRECTORY & SAVE CURRENT WORK OPTIONS

To change the current working directory: In Screen 4, select the "Change working directory" menu item. This will enable you to change the directory in which XCreate looks for and saves X files.

To save your experiment: Select the "Save current work" menu item. This allows you to save your FILEX to the current working directory. If you try to save the file and its name does not contain the institute ID, site ID and experiment number information (i.e., INSIEXNO), a message will appear on the screen. You must enter this information under the EXPERIMENT menu (see Chapter 5). The DSSAT v3 file naming convention is described in Volume 2-1 (Jones et al. 1994) of this book.

CHAPTER FIVE. EXPERIMENT MENU

Under the EXPERIMENT menu item (Screen 5 below) are several options that allow you to enter or modify data that will be stored in the EXPERIMENT section of a FILEX.

```
File  Experiment  Management  Controls  Options                    Trt =  1 1 0 0
                                      FILEX.RPT
*EXP.   Identifiers
        General
*TREA   Plot Information
@N R    Notes
                                VAR WAPIO, IBSNAT EXP.1983-4
                                      -------------FACTOR LEVELS------------
                                ..... CU FL SA IC MP MI MF MR MC MT ME MH SM
 1 1                                   1  1  0  1  1  1  1  1  0  0  0  0  1
 2 1 0 0 X304C 50 kg N/ha              1  1  0  2  1  1  2  1  0  0  0  0  1
 3 1 0 0 X304C 200 kg N/ha             1  1  0  3  1  1  3  1  0  0  0  0  1
 4 1 0 0 H610 0 kg N/ha                2  1  0  4  1  1  1  1  0  0  0  0  1
 5 1 0 0 H610 50 kg N/ha               2  1  0  5  1  1  2  1  0  0  0  0  1
 6 1 0 0 H610 200 kg N/ha              2  1  0  6  1  1  3  1  0  0  0  0  1

*CULTIVARS
@C CR INGENO CNAME
 1 MZ IB0063 PIO X 304C
 2 MZ IB0060 H610(UH)

*FIELDS
@L ID_FIELD WSTA....  FLSA  FLOB  FLDT  FLDO  FLDS  FLST SLTX SLDP  ID_SOIL
 1 IBWA0001 IBWA8302 -99       0 IB000     0     0 00000  -99  110  IBMZ91001

*INITIAL CONDITIONS

F1 Help  F2 Lookup  F4 Mineral N  F7 Save  Alt-X Exit
```

SCREEN 5.

These four menu options are briefly described below.

The "Identifiers" menu option allows you to name the experiment, assign an eight character experiment identifier, define the crop group and provide an experiment name It is suggested that the experiment name be composed of a short name (with no blanks); followed by a blank space; a brief summary of treatment factors; a blank space; and a local abbreviation (if any) for the experiment, enclosed by parenthesis.

The "General" menu option allows you to enter information that identifies the people that were involved with this experiment, their addresses and general sit information. This information is written to three lines in the file: Name of People; Addresses; and Site. The line containing site information should consist of a short site name (with no blanks); fol-

lowed by a blank space; then latitude; longitude; altitude of site; and climate zone; the latter four items separated by semi-colons. For example:

GAINESVILLE, FL 29.63N;82.37W;40M;FLORIDA

The "Plot Information" menu item allow you to enter information that defines the plot on which this experiment was carried out.

The "Notes" menu option allows you to enter up to five lines of notes and any other information that may be helpful in describing this experiment.

CHAPTER SIX. MANAGEMENT MENU

Under the MANAGEMENT menu item (Screen 6 below) are several management options to enable a user to define management-related information for the FILEX. See Volume 2-1 (Jones et al 1994) of this book for a complete description of these options.

```
 File  Experiment  Management  Controls  Options                    Trt =  1 1 0 0
*EXP.DETAILS: IBW   Treatments                  NAT EXP.1983-4                    [ ]
                    Cultivars
*TREA               Fields                      ----FACTOR LEVELS-----------
@N R O C TNAME...   Soil Analysis               IC MP MI MF MR MC MT ME MH SM
 1 1 0 0 X304C 0    Initial Conditions           1  1  1  1  1  0  0  0  0  1
 2 1 0 0 X304C 50   Planting                     2  1  1  2  1  0  0  0  0  1
 3 1 0 0 X304C 20   Irrigation                   3  1  1  3  1  0  0  0  0  1
 4 1 0 0 H610 0 K   Fertilizer                   4  1  1  1  1  0  0  0  0  1
 5 1 0 0 H610 50    Residue                      5  1  1  2  1  0  0  0  0  1
 6 1 0 0 H610 200   Tillage/Rotation             6  1  1  3  1  0  0  0  0  1
*CULTIVARS          Chemicals
@C CR INGENO CNAM   Environment
 1 MZ IB0063 PIO    Harvest
 2 MZ IB0060 H610
*FIELDS
@L ID_FIELD WSTA....  FLSA  FLOB  FLDT  FLDO  FLDS  FLST SLTX SLDP  ID_SOIL
 1 IBWA0001 IBWA8302  99     0 IB000     0     0 00000  -99  110  IBMZ91001
*INITIAL CONDITIONS
F1 Help  F2 Lookup  F4 Mineral N  F7 Save  Alt-X Exit
```

SCREEN 6.

TREATMENTS OPTION

The "Treatment" option is most important. From it, you may select an existing treatment, define a new treatment, edit or remove an existing treatment.

SELECTED TREATMENT INDICATOR

In the upper right-hand corner of every XCreate screen, there is a colored area with "Trt = A B C D" in it. This Selected Treatment Indicator is used to denote which treatment is being modified in an experiment. The "A" indicates the current Treatment Number, "B" and "C" indicate the Rotation Component and Rotation Option, respectively, and "D" indicates the Crop Component. In Screen 6, "A" = 1, "B" = 1, "C" = 0 and "D" = 0.

XCreate will display Treatment 1 of a selected experiment, as the default treatment, whenever a new experiment is loaded, as indicated in the top right hand corner of this screen by the Selected Treatment Indicator (i.e., Trt = 1 1 0 0 in Screen 6). This treatment could then be deleted or edited.

The Selected Treatment Indicator is vital when editing any management section of an experiment (e.g., "Cultivars," "Fields," etc.). The edit operation allows you to change management used for the particular treatment and any other treatment that uses this level of management. (Please note that the term "level" used throughout is identical to treatment levels used in experiments.) Consider the example shown in Screen 7 (below), in which Treatments 3 and 6 have 200 kg N/ha applied fertilizer. To change the fertilizer application in Treatment 3 to 50 kg N/ha, select Treatment 3 under the "Treatments" menu option (see "Treatment Dialog Box" below). When you do this, the Selected Treatment Indicator will change from "Trt = 1 1 0 0," as seen in Screen 7, to "Trt = 3 1 0 0." Next, when you open the "Fertilizer" menu option, you will be asked whether or not you want to create a new, unique fertilizer management level. Since Treatments 3 and 6 both share the same management level, type 'Y' if you want the fertilizer management level in Treatment 3 to differ from that of Treatment 6. Otherwise, type 'N' to modify the fertilizer management level used by both treatments.

```
File  Experiment  Management  Controls  Options                    Trt =  1 1 0 0
FILEX.RPT                                                                    [ ]
*EXP.DETAILS: IBWA8301MZ N X VAR WAPIO, IBSNAT EXP.1983-4
 [•]          Current Treatments                          EVELS-----------
                                                          MR MC MT ME MH SM
   1 1 0 0 X304C 0 kg N/ha          Add Trt                1  0  0  0  0  1
   2 1 0 0 X304C 50 kg N/ha                                1  0  0  0  0  1
   3 1 0 0 X304C 200 kg N/ha        Edit                   1  0  0  0  0  1
   4 1 0 0 H610 0 kg N/ha                                  1  0  0  0  0  1
   5 1 0 0 H610 50 kg N/ha          Remove                 1  0  0  0  0  1
   6 1 0 0 H610 200 kg N/ha                                1  0  0  0  0  1

                                    Select
                                    Review

                                    Done
                                                          T SLTX SLDP  ID_SOIL
 1 IBWA0001 IBWA8302 -99        0 IB000      0      0 00000  -99  110  IBMZ91001

*INITIAL CONDITIONS
F1 Help  F2 Lookup  F4 Mineral N  F7 Save  Alt-X Exit
```

Screen 7.

Treatment Dialog Box

When "Treatments" is selected from the MANAGEMENT menu (see Screen 6), the dia-

log box shown in Screen 7 (on preceding page) is presented. Use the scroll bar to move through this list, using a mouse or the arrow keys.

To change the selected treatment: Move the highlight bar over the treatment you want to select by using the arrow keys or mouse. Press the SELECT button.

To add a new treatment: Move the highlighted bar over the treatment you want to use as a template by using the arrow keys or mouse. Press the ADD Trt button. This allows you to create a new treatment by entering new data and add it to the experiment. The new treatment will initially have the same management as the highlighted treatment when you press the ADD Trt button.

To review an existing treatment: Move the highlight bar over the treatment you want to review by using the arrow keys or mouse. Press the REVIEW button.

To edit an existing treatment: Move the highlight bar over the treatment you want to edit by using the arrow keys or mouse. Press the EDIT button.

To remove an existing treatment: Move the highlight bar over the treatment you want to delete by using the arrow keys or mouse. Press the REMOVE button. Please note that when you delete a treatment, you will also delete all management and control information related to that treatment which is not referenced by some other treatment.

NOTE 1: *In running crop models in Experiment mode, or single season non-sequencing experiment mode, you need only increment Treatment Numbers (N) in the treatment sections of FILEX (e.g., TREATMENTS), leaving the Rotation Component Number (R) at the fixed value of 1.*

NOTE 2: *In running crop models in Seasonal Analysis mode, or replicating treatments across years mode, each season is numbered only by Treatment Number (N). The Rotation Component (R), Rotation Option (O), and Crop Component (C) are all set to fixed values.*

NOTE 3: *In running crop models in Sequence Analysis mode, or crop rotation or sequence mode, each sequence would have a single Treatment Number (N). Each crop in the sequence would then be numbered by the Rotation Component Number (R). The Rotation Option Number (O) is used to indicate if there is an alternative crop in the sequence. For example, a three-stage rotation of maize, dry bean (with wheat as an alternative) and rice, with each crop followed by a fallow period, would be set up like this:*

N	R	O	C	
1	1	1	0	Maize
1	2	1	0	Fallow
1	3	1	0	Dry Bean
1	3	2	0	Alternate Wheat Crop
1	4	1	0	Fallow
1	5	1	0	Rice
1	6	1	0	Fallow

NOTE: *All stages in the same sequence are numbered as Treatment 1, but the Rotation Component Numbers (R) are incremented. Also NOTE the Rotation Option Numbers (O) for the dry bean and alternate wheat crops. Crop Component (C) values are fixed at 0 (zero) by XCreate because this concept is not yet implemented by the DSSAT v3 crop models.*

Cultivars, Fields, Planting, Residue, Tillage/ Rotation, Chemicals and Harvest Options

The data input dialog boxes for "Cultivars," "Fields," "Planting," "Residue," "Tillage/Rotation," "Chemicals" or"Harvest" options are similar. Thus, only the screen dialog box presented for "Fields" (Screen 8) will be illustrated. The data required appear on a single screen as shown in Screen 8 (on the following page).

Move forward through data fields by pressing the <TAB> key and move backward by pressing the <SHIFT> <TAB> keys. Any default or current values for a particular field are shown in brackets to the left of the data input field.

These seven menu options are briefly described as follows.

The "Cultivars" menu option allows you to specify crop and cultivar information for the default treatment.

The "Fields" menu option allows you to enter weather, soil and field description details.

The "Planting" menu option allows you to specify planting date, population, seeding depth and row spacing data.

The "Residue" menu option allows you to specify additions of straw, green manure and animal manure.

The "Chemicals" menu option allows you to specify herbicide and pesticide application data.

The "Tillage/Rotation" menu option allows you to specify tillage date, implement and depth data.

The "Harvest" menu option allows you to specify information on harvest dates, plant components harvested and percentage of products harvested.

```
 File  Experiment  Management  Controls  Options                    Trt =  1 1 0 0
 ──────────────────────────────── FILEX.RPT ──────────────────────────────────[ ]
*EXP.DETAILS: IBWA8301MZ N X VAR WAPIO, IBSNAT EXP.1983-4
 ┌[•]──────────────────────── Field Information ──────────────────────────┐
  Use TAB key to skip to next data field     Trt No  :  1
      SHIFT-TAB for previous data field      Level No:  1

  Field Identifier                  [IBWA0001]              New Lvl
  Weather Station Identifier        [IBWA8302]
  Slope and Aspect (degrees)           [-99  ]              OK
  Obstruction to Sun (degrees)         [    0]
  Drain Type (ceod)                    [IB000]              Cancel
  Drain Depth (cm)                     [    0]
  Drain Spacing (m)                    [    0]
  Surface Stones (Abundance+Size)      [00000]
  Soil Texture                         [-99  ]
  Soil Depth (cm)                      [  110]
  Soil Identifier                 [IBMZ910013]                                IL
                                                                              1001
*INITIAL CONDITIONS
F1 Help  F2 Lookup  F4 Mineral N  F7 Save  Alt-X Exit
```

SCREEN 8.

FIELDS DIALOG BOX

Screen 8 (above) for the "Fields" menu option represents the dialog box that will be presented when you select one of these seven MANAGEMENT menu options. After making changes to the items on the screen, you can do the following.

To save your data: Press the OK button once you have completed entering data or press the NEW LVL button to create a new section with the current data.

To cancel any changes: Press the CANCEL button. This will cancel any changes you have made to data in this dialog box.

NOTE: *You may not remove CULTIVAR, FIELD or PLANTING information once it has been added to a treatment because these sections are required data for every treatment.*

Soil Analysis, Initial Conditions & Irrigation Options

The data input dialog boxes for "Soil Analysis," "Initial Conditions" or "Irrigation" options are similar. Thus, only the screen dialog boxes presented for "Initial Conditions" will be illustrated (see Screens 9 and 10) for these Management menu options. Data for each of these options are made of two parts and are entered using two dialog boxes. In the first dialog box, enter data related to the option in general. In the second dialog box, enter data for one or more layers or the dates of application depending upon the option selected Move forward through data fields by pressing the <TAB> key and move backward by pressing the <SHIFT><TAB> keys. Any default or current values for a particular field are shown in brackets to the left of the data input field.

These three menu options are briefly described as follows:

The "Soil Analysis" option allows you to enter the set of soil properties (bulk density, organic carbon, pH) used for the simulation of nutrient dynamics, based on field nutrient sampling, if any. These properties are also contained in the soil profile data which may have been derived from a more general set of soil information.

The "Initial Conditions" option allows you to specify starting conditions for water and nitrogen in the profile. It is also used for carry over of root residue from the previous crop and N symbiosis initialization details when needed.

The "Irrigation" option allows you to enter irrigation dates, amounts, thresholds and rice flood water depths.

```
 File  Experiment  Management  Controls  Options                Trt =  1 1 0 0
                                  FILEX.RPT                                  [ ]
*EXP.DETAILS: IBWA8301MZ N X VAR WAPIO, IBSNAT EXP.1983-4
*TREA                          ------------FACTOR LEVELS------------
@N F [•]                 Initial Condition Information
 1 1
 2 1   Use TAB key to skip to next data field     Trt No  :  1
 3 1       SHIFT TAB for previous data field      Level No:  1
 4 1
 5 1   Measurement Date (yr+days)          [83326]                 OK
 6 1   Previous Crop Code                  [   MZ]
       Previous Crop Root Wt (kg/ha)       [  200]                 Remove
*CUI   Previous Crop Nodule Wt (kg/ha)     [  -99]
@C     Rhizobia Number (0 - 1 scale)       [ 1.00]                 Cancel
 1 N   Rhizobia Effectiveness              [ 1.00]
 2 N
*FI
@L ID_FIELD WSTA....  FLSA  FLOB  FLDT  FLDO  FLDS  FLST SLTX SLDP  ID_SOIL
 1 IBWA0001 IBWA8302 -99       0 IB000     0     0 00000  -99  110  IBMZ91001
*INITIAL CONDITIONS
F1 Help  F2 Lookup  F4 Mineral N  F7 Save  Alt-X Exit
```

SCREEN 9.

INITIAL CONDITIONS DIALOG BOX 1

Screen 9 (above) for the "Initial Conditions" menu option represents the first dialog box that will be presented when you select one of these three MANAGEMENT menu options. After making changes to the items on the screen, you can do the following.

To save your data and continue: Press the OK button. Once you have completed the first part, the next dialog box will appear and you may begin entering data for the rest of the section.

To remove a data section: Press the REMOVE button. This will erase the initial conditions section from the currently selected treatment in the experiment.

To cancel any changes: Press the CANCEL button. This will cancel any changes you have made to data in this dialog box.

```
 File  Experiment  Management  Controls  Options                    Trt =  1 1 0 0
                                   FILEX.RPT                                        [ ]
*EXP.DETAILS: IBWA8301MZ N X VAR WAPIO, IBSNAT EXP.1983-4
*T  [•]- Initial Condition Layers ---------FACTOR LEVELS-----------
@N                                 FL SA IC MP MI MF MR MC MT ME MH SM
 1    Trt No  :   1                 1  0  1  1  1  1  1  0  0  0  0  1
 2    Level No:   6                 1  0  2  1  1  2  1  0  0  0  0  1
 3                                  1  0  3  1  1  3  1  0  0  0  0  1
 4     #    Depth                   1  0  4  1  1  1  1  0  0  0  0  1
 5     1      5        Add          1  0  5  1  1  2  1  0  0  0  0  1
 6     2     15                     1  0  6  1  1  3  1  0  0  0  0  1
       3     30        Edit
*C     4     50
@C     5     70        Delete
 1     6     90
 2     7    110        Exit
*R
@L                                 DT  FLDO  FLDS  FLST SLTX SLDP  ID_SOIL
 1 IBWA0001 IBWA8302 -99        0 IB000     0     0 00000  -99  110  IBMZ91001
*INITIAL CONDITIONS
F1 Help  F2 Lookup  F4 Mineral N  F7 Save  Alt-X Exit
```

SCREEN 10.

Initial Conditions Dialog Box 2

Screen 10 (above) shows an example of the second dialog box for data entry into the "Soil Analysis," "Initial Conditions" and "Irrigation" options. It displays data for any existing layer or for dates of application in the left-hand scrolling list. After making changes to the items on the screen, you can do the following.

To add a new layer or date: Press the ADD button. A new dialog box will appear into which you may enter your data. The date must include a 2-digit year number, followed by the Julian day of year (e.g., "78" for the year; "170" for Julian day of year). Press the OK button in this box to save the data you have entered.

To edit an existing layer or date: Move the highlight bar over a layer or a date by using the arrow keys and press the EDIT button. A dialog box will appear in which you may edit your data. Press the OK button in this box to save your data. Press the CANCEL button to abort any changes you have made.

To delete an existing layer or date: Move the highlight bar over a layer or a date by using the arrow keys. Press the DELETE button.

To exit this dialog: Press the EXIT button. The information for this treatment will be modified based on the changes that you have made.

FERTILIZER & ENVIRONMENT OPTIONS

The data input dialog boxes presented after the "Fertilizer" or "Environment" option is selected are similar. Thus, only a screen dialog box presented for "Fertilizer" will be illustrated (see Screen 11 below). The data input for these two sections are similar. All data required are entered using one dialog box. The data are made up of one or more dates of application or modification.

These two menu options are briefly described as follows:

The "Fertilizer" menu option allows you to enter fertilizer application level, date, type and depth data.

The "Environment" menu option allows you to specify any adjustment factors for weather parameters as used in climate change, controlled environment or growth chamber studies.

```
File  Experiment  Management  Controls  Options                Trt =  1 1 0 0
                          FILEX.RPT                                        [ ]
*EXP.DETAILS: IBWA8301MZ N X VAR WAPIO, IBSNAT EXP.1983-4
*T [•]------- Fertilization Dates -------------FACTOR LEVELS------------
@N                                            P MI MF MR MC MT ME MH SM
 1   Trt No  :   1                            1  1  1  1  0  0  0  0  1
 2   Level No:   1            Remove Level    1  1  2  1  0  0  0  0  1
 3                                            1  1  3  1  0  0  0  0  1
 4   Date   Material   N-Amt                  1  1  1  1  0  0  0  0  1
 5   83333  IB000          0   ▲   Add        1  1  2  1  0  0  0  0  1
 6                                            1  1  3  1  0  0  0  0  1
*C                                   Edit
@C                                   Delete
 1
 2                                   Exit
*F
@I                                           LDS  FLST SLTX SLDP  ID_SOIL
 1 IBWA0001 IBWA8302 -99        0 IB000     0   0 00000  -99  110  IBMZ9!001
*INITIAL CONDITIONS
F1 Help  F2 Lookup  F4 Mineral N  F7 Save  Alt-X Exit
```

SCREEN 11.

FERTILIZER DIALOG BOX

Screen 11 (above) for the "Fertilizer" menu option represents the dialog box that will be presented when you select one of these MANAGEMENT menu options. After making changes to the items on the screen, you can do the following.

To add a new application: Press the ADD button. A new dialog box will appear into which you may enter your data. When data entry is complete, press the OK button in that box to save your data. The date must include a 2-digit year number followed by Julian day of year (e.g., '78' for the year; '170' for Julian day of year). Press the CANCEL button to abort any changes you have made.

To edit an existing application: Move the highlight bar over the date by using the arrow keys and press the EDIT button. A dialog box will appear with which you may edit your data. Press the OK button in the box to save your data.

To delete an existing application: Move the highlight bar over the date by using the arrow keys. Press the DELETE button.

To exit this dialog: Press the EXIT button.

CHAPTER SEVEN. CONTROLS MENU

The CONTROLS menu (Screen 12 below) allows you to set various Simulation Control options, including starting dates and ON/OFF options for model components such as soil water or nitrogen balances for FILEX. This information is not necessary for documenting experiments, but it is needed to control the computer simulation of the experiment using crop models. For a description of these Simulation Controls and their use in FILEX, as well as a display of their structure and some examples, see Volume 2-1 (Jones et al. 1994) of this book.

```
 File  Experiment  Management  Controls  Options                    Trt =  1 1 0 0
                                                                                [ ]
*EXP.DETAILS: IBWA8301MZ N X      General      T EXP.1983-4
                                  Options
*TREA                             Methods     --FACTOR LEVELS------------
@N R O C TNAME...                 Management   MP MI MF MR MC MT ME MH SM
 1 1 0 0 X304C 0                  Output        1  1  1  1  0  0  0  0  1
 2 1 0 0 X304C 50 kg N/ha                       1  1  2  1  0  0  0  0  1
 3 1 0 0 X304C 200 kg N/ha          1  1  0  3  1  1  3  1  0  0  0  0  1
 4 1 0 0 H610 0 kg N/ha             2  1  0  4  1  1  1  1  0  0  0  0  1
 5 1 0 0 H610 50 kg N/ha            2  1  0  5  1  1  2  1  0  0  0  0  1
 6 1 0 0 H610 200 kg N/ha           2  1  0  6  1  1  3  1  0  0  0  0  1

*CULTIVARS
@C CR INGENO CNAME
 1 MZ IB0063 PIO X 304C
 2 MZ IB0060 H610(UH)

*FIELDS
@L ID_FIELD WSTA....  FLSA  FLOB  FLDT  FLDD  FLDS  FLST SLTX SLDP  ID_SOIL
 1 IBWA0001 IBWA8302  -99      0 IB000     0     0 00000  -99  110  IBMZ91001

*INITIAL CONDITIONS

F1 Help  F2 Lookup  F4 Mineral N  F7 Save  Alt-X Exit
```

SCREEN 12.

The data input dialog boxes presented after the "General," "Options," "Methods," "Management" or "Output" is selected are similar. Thus, only the screen dialog box for "General" will be illustrated (see Screen 13, following). The data required appear on a single screen, under each option as shown in Screen 13.

Move forward through data fields by pressing <TAB> and move backward by pressing <SHIFT> and <TAB>. Any default or current values for a particular field are shown in brackets to the left of the data input field.

These five menu options are briefly described as follows:

The "General" menu option allows you to specify control information that apply to the treatment in general. For example, number of simulation years, number of replications, start date and name for the simulation.

The "Options" menu option allows you to specify which crop model routines you want to turn ON or OFF for your simulation.

The "Methods" menu option allows you to indicate to the crop model the methods that should be used for computing processes such as evapotranspiration and photosynthesis in the crop model.

The "Management" menu option allows you to specify to the crop model whether different management operations, such as planting and irrigation, are to be based on reported data as input or are to be simulated internally based on automatic management options.

The "Output" menu option allows you to specify the frequency and the types of model outputs to create (such as summary, growth, water, nitrogen and pest).

```
File  Experiment  Management  Controls  Options                    Trt =  1 1 0 0
                                  FILEX.RPT                                    [ ]
*EXP.DETAILS: IBWA8301MZ N X VAR WAPIO, IBSNAT EXP.1983-4
*TREATMENTS                        -------------FACTOR LEVELS------------
@N R [•]                 Simulation Control: General
 1 1
 2 1   Use TAB key to skip to next data field     Trt No  :  2
 3 1       SHIFT-TAB for previous data field      Level No:  1
 4 1
 5 1   Sim. Name        [N X VAR WAPIO, IBSNAT EXP]
 6 1
       Number of Simulation Years              [ 1]          New Lvl
*CUI   Number of Replications                  [ 1]
@C C                                                          OK
 1 N   Start of Simulation Code (E,I,P,S)        [S]
 2 N   Simulation Start Date (yr+days)        [83326]         Cancel
       Random number seed value               [ 2150]
*FIE                                                                  )IL
@L I
 1 IBWA0001 IBWA8302 -99        0 IB000      0      0 00000  -99  IIO  IBMZ91001
*INITIAL CONDITIONS
F1 Help  F2 Lookup  F4 Mineral N  F7 Save  Alt-X Exit
```

SCREEN 13.

GENERAL SIMULATION CONTROLS DIALOG BOX

Screen 13 (above) for the "General" menu option represents the dialog box that will be presented when you select one of these five CONTROLS menu options. After making changes to the items on the screen, you can do the following.

To save your data: Press the OK button once you have completed entering data or press the NEW LVL button to create a new section with the current data.

To cancel any changes: Press the CANCEL button. This will cancel any changes you have made to data in this dialog box.

CHAPTER EIGHT.
<F4> KEY: MINERAL NITROGEN & SOIL WATER INITIAL CONDITIONS

In documenting an experiment or setting up a hypothetical experiment for crop model use, it is important to specify initial soil water and N conditions. If these data were not measured in the experiment, using the <F4> key allows you to estimate layer by layer values of water and nitrogen content by specifying overall mineral N in the field and relative soil water availability.

When the <F4> key is pressed, the dialog box shown in Screen 14 (below) is presented. In this screen you can create and modify soil water and soil nitrogen initial condition values by entering a mineral nitrogen value and/or a soil water index value.

```
File  Experiment  Management  Controls  Options                Trt =  1 1 0 0
                                FILEX.RPT                                  [ ]
 [•]                    MINERAL N AND SW Index
 Layer No.  Depth    SW     NH4     NO3
            -cm-            --mg/kg---      Mineral N (kg/ha) [    105]
    1          5   0.260   3.1     5.2
    2         15   0.260   2.5     4.2
    3         30   0.260   1.0     1.2     SW Index (0 - 1)  [  1.00]
    4         50   0.260   0.9     0.2
    5         70   0.260   0.6     0.1                  [ Calc ]
    6         90   0.260   0.2     0.1
    7        110   0.260   0.1     0.1                  [ Done ]
                                                                   IL
                                                                   1001
F1 Help  F2 Lookup  F4 Mineral N  F7 Save  Alt-X Exit
```

SCREEN 14.

<F4> DIALOG BOX

To change the NH_4 and NO_3 values: Enter a value for total Mineral N. Press the CALC button. The current mineral N value is shown in the brackets just above the data field.

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XCreate will take the mineral N value and distribute the amount among all the layers and between NH_4 and NO_3 values.

To change the SW values: Enter a SW value, from 0 - 1, which represents your estimate of the fraction of water in the soil relative to its water-holding capacity. Press the CALC button. The current SW Index value is shown in the brackets just above the data field. XCreate will use the entered SW Index value to recalculate the SW for each layer of the initial condition by multiplying the index by the available water in each layer.

To exit this dialog: When you have completed setting the initial conditions to your desired specifications, select the DONE button, and the changes will be saved.

VOLUME 1-5

CONVERTING FROM DSSAT V2.1 TO DSSAT V3 DATA FILES AND FORMATS

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CHAPTER ONE. INTRODUCTION

The DSSAT program for converting from DSSAT v2.1 to DSSAT v3 data files and formats is called Convert and allows the user to convert DSSAT v2.1 crop model input files (see Tech. Report 5, Documentation for IBSNAT Crop Model Input & Output Files, Version 1.1, IBSNAT 1986, for more information) for experiments, weather, and soil data to the new DSSAT v3 crop model input file formats.

EXPERIMENT CROP MODEL INPUT FILES

This program will convert crop model input FILEs 4, 5, 6, 7, 8, A, B, C, and D of DSSAT v2.1 to the new FILE X, A and T formats of DSSAT v3. It will also automatically convert the soil data required to run the experiment being converted to v3.

SOIL CROP MODEL INPUT FILE

This program will convert soil profile data in the SPROFILE.XX2, where XX is the crop code, of DSSAT v2.1 to the new soil file SOIL.SOL of DSSAT v3. You have the option to convert any or all of the soil profiles contained in the SPROFILE.XX2.

WEATHER CROP MODEL INPUT FILE

This program can be used to convert ASCII weather data that is in DSSAT v2.1 IBSNAT format to the new DSSAT v3 ASCII weather data format. You have the option to convert any or all weather data stored in a particular directory.

MISSING DATA AND DEFAULTS

During the conversion of DSSAT v2.1 files to DSSAT v3 files, any missing values or new variables not defined in v2.1 will be replaced by a "-99" value. In general, a data set that worked in v2.1 will be sufficient to run in v3 with the default simulation control settings.

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EXECUTE CONVERT PROGRAM

To access the Convert program under the DATA main menu item, highlight DATA and then select the "X Experiment" option by pressing the <X> key or by moving the highlight bar with the arrow keys to the "X Experiment" option and pressing the <ENTER> key. From the "X Experiment" menu, select the "U Utilities" option and then press the <C> key to open the Convert program. Screen 1 (below) will be presented.

```
Data Files Conversion from Version 2.1 to 3.0


                    SELECT DATA TO CONVERT

                    Weather Data
                    Experiment & Soil Data
                    Soil Data




Convert selected weather data set(s) in file WTH.DIR
```

SCREEN 1.

To convert weather data: Select "Weather Data" by moving the highlight bar using the arrow keys and press the <ENTER> key.

To convert experiment data: Select "Experiment & Soil Data" by moving the highlight bar using the arrow keys and press the <ENTER> key.

To convert soil data: Select "Soil Data" by moving the highlight bar using the arrow keys and press the <ENTER> key.

To exit Convert: Press the <ESC> key.

CHAPTER TWO. WEATHER DATA CONVERSION

The Convert "Weather Data" menu option allows you to convert DSSAT v2.1 weather data sets to DSSAT v3 data formats. When this option is selected, Screen 2 (below) will be presented. A crop list is displayed because weather data were usually stored in each crop's data directory. Move through the list using the arrow keys. When a crop is highlighted, the default drive and path of that crop are shown in the right hand window. Selecting a crop, also selects the drive and path displayed; the user, however, may change these. Weather data converted for any crop will work with other crop models in DSSAT v3.

```
        Data Files Conversion from Version 2.1 to 3.0 - ASCII to ASCII

            Crop List
        ┌──────────────┬──────────────────────────────────────────────
        │   Barley     │ Driv. & Path > C : \DSSAT\MODEL\SOYBEAN\DATA
        │   Dry Bean   │
        │   Maize      │
        │   Millet     │
        │   Peanut     │
        │   Rice       │
        │   Sorghum    │
        │ √ Soybean    │
        │   Wheat      │
        │              │
        │              │ ──────────────── Messages ────────────────
        │              │ F1 - Help                  F4    - Select all
        │              │ F2 - Change drive & path   ENTER - Select/Unselect
        │              │
        │              │ ESC - Quit                 F10   - Continue
        └──────────────┘
```

Screen 2.

To select a crop for conversion: Use the arrow keys to move the highlight bar over the crop(s) you wish to select. Press the <ENTER> key. Once selected, a "check" mark will appear to the left of the selected item. This "check" mark behaves like a toggle switch and can be turned on and off by repeatedly pressing the <ENTER> key while the item is highlighted.

To obtain help: Press the <F1> key.

To select all crops: Press <F4> to "check" mark all of them.

To change a crop's drive and path: Press <F2> and enter the correct drive and path.

To continue with conversion: Press <F10> once you have completed selecting crops.

To return to Screen 1: Press the <ESC> key.

```
Data Files Conversion from Version 2.1 to 3.0 - ASCII to ASCII

  Crop List
 ┌──────────┐  ──────────────────────────────────────────
 │ Barley   │  Driv. & Path > C : \DSSAT\MODEL\SOYBEAN\DATA
 │ Dry Bean │
 │ Maize    │  Output Ver. 3.0 Weather data file(s) to?
 │ Millet   │  Drv. & Path > C:\DSSAT3\WEATHER
 │ Peanut   │
 │ Rice     │
 │ Sorghum  │
 │√ Soybean │
 │ Wheat    │
 │          │
 │          │
 │          │  ──────────────────Messages──────────────────
 │          │
 │          │
 └──────────┘
```

SCREEN 3.

When you have made a selection for conversion, the dialog box shown in Screen 3 (above) will appear. You must enter in this screen the drive and path where you want the new DSSAT v3 format file to be stored.

For example, these files could be stored in C:\DSSAT3\WEATHER.

Once a path is entered, a screen similar to Screen 4 (on the following page) will be presented. In this screen are listed all weather data sets in the path or paths selected that may be converted from DSSAT v2.1 to v3 format.

```
Data Files Conversion from Version 2.1 to 3.0 - ASCII to ASCII

Wea.ID        Weather Data Entries from File WTH.DIR
√ UFGA
√ UFGA        Driv. & Path > C : \DSSAT1\MODEL\SOYBEAN\DATA
√ UFGA        GAINESVILLE (29.6N,82.4W), FLORIDA 1981 01-01-81 12-31-81
√ UFGA        UFGA0112.W81
  UFQU
  IUCA
  IBKU

                          Messages
F1    - Help                    F4    - Select all
                                ENTER - Select/Unselect
ESC   - Quit                    F10   - CONVERT
```

SCREEN 4.

To select a weather data set for conversion: Use the arrow keys to move the highlighted bar over the weather data set(s) you wish to select. Press the <ENTER> key. Once selected, a "check" mark will appear to the left of the selected item. This "check" mark behaves like a toggle switch and can be turned on and off by repeatedly pressing the <ENTER> key while the item is highlighted.

The operations of the <F1>, <F4>, <F10> and <ESC> keys are the same as described under Screen 2 in this Chapter.

CHAPTER THREE.
EXPERIMENT & SOIL DATA CONVERSION

The "Experiment & Soil Data" menu option allow you to convert DSSAT v2.1 experiment data sets to DSSAT v3 data sets. When this option is selected, Screen 5 (below) will be presented. As is the case with the "Weather Data" menu option, a crop list is displayed because experiment data were usually stored in each crop's data directory. Move through the list using the arrow keys. When a crop is highlighted, the default drive and path of that crop are shown in the right hand window. Selecting a crop, also selects the drive and path displayed; the user, however, may change these. The Convert program will convert crop model input FILEs 4,5,6,7,8,A,B,C and D, as well as the companion soil profile data used by the selected experiments.

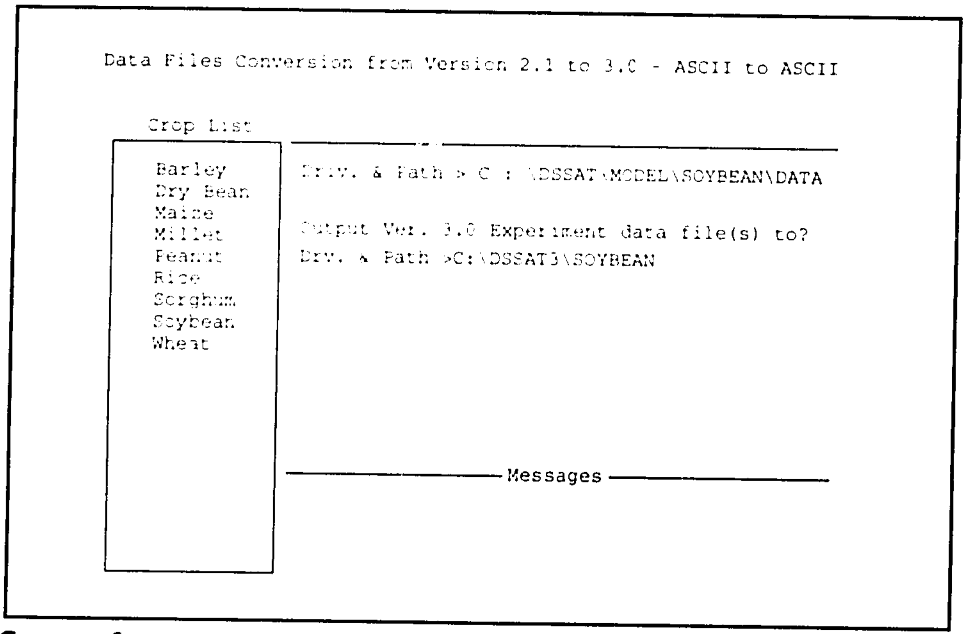
```
Data Files Conversion from Version 2.1 to 3.0 - ASCII to ASCII

   Crop List
 ______________  ________________________________________________
|  Barley      | Driv. & Path > C : \DSSAT1\MODEL\SOYBEAN\DATA
|  Dry Bean    |
|  Maize       |
|  Millet      |
|  Peanut      |
|  Rice        |
|  Sorghum     |
|  Soybean     |
|  Wheat       |
|              |
|              |
|              | ------------------ Messages ------------------
|              | F1  - Help                   F4    - Select all
|              | F2  - Change drive & path    ENTER - Select/Unselect
|              |
|              | ESC - Quit                   F10   - Continue
|______________|
```

SCREEN 5.

To select a crop for conversion: Use the arrow keys to move the highlight bar over the crop(s) you wish to select. Press the <ENTER> key. Once selected, a "check" mark will appear to the left of the selected item. This "check" mark will appear to the left of the selected item. This "check" mark behaves like a toggle switch and can be turned on and off by repeatedly pressing the <ENTER> key while the item is highlighted.

Previous Page Blank

The operations of the <F1>, <F4>, <F10> and <ESC> keys are the same as described under Screen 2 in Chapter 2.



SCREEN 6.

When you have made a selection for conversion, the dialog box shown in Screen 6 (above) will appear. You must enter in this screen the drive and path where you want the new DSSAT v3 format file to be stored.

For example, these files could be stored in C:\DSSAT3\SOYBEAN.

Once a path is entered, a screen similar to Screen 7 (on the following page) will be presented. In this screen are listed all the experiments for the selected crop(s) that may be converted from DSSAT v2.1 to v3 format.

```
Data Files Conversion from Version 2.1 to 3.0 - ASCII to ASCII

  Wea.ID          Exper. Entries from SBEXP.DIR
 ------------------------------------------------------------------------
 √ UFGA7801   Driv. & Path > C : \DSSAT1\MODEL\SOYBEAN\DATA
 √ UFGA7901   UFQU7901 BRAGG, WELL IRRIGATED                UFQU0112.W79 SP
 √ UFQU7901   UFQU7901.SB4 UFQU7901.SB5 UFQU7901.SB6 UFQU7901.SB7 UFQU7901.SB8
   UFGA8101   UFQU7901.SBA UFQU7901.SBB OUT1.SB OUT2.SB OUT3.SB OUT4.SB OUT5.SB
   UFGA8501
   IUCA7901
   NIO19101

                                  Messages
                 F1     - Help                    F4     - Select all
                                                  ENTER  - Select/Unselect
                 ESC    - Quit                    F10    - CONVERT
```

Screen 7.

To select an experiment data set for conversion: Use the arrow keys to move the highlight bar over the experiment(s) you wish to select. Press the <ENTER> key. Once selected, a "check" mark will appear to the left of the selected item. This "check" mark behaves like a toggle switch and can be turned on and off by repeatedly pressing the <ENTER> key while the item is highlighted.

The operations of the <F1>, <F4>, <F10> and <ESC> keys are the same as described under Screen 2 in Chapter 2.

CHAPTER FOUR.
SOIL DATA CONVERSION

The "Soil Data" menu option allows you to convert soil profiles stored in DSSAT v2.1 SPROFILE format into DSSAT v3 file format. When this option is selected, Screen 8 (below) will be presented. As is the case with the "Weather Data" menu option, a crop list is displayed. Move through the list using the arrow keys. When a crop is highlighted, the default drive and path of that crop are shown in the right hand window. Selecting a crop, also selects the drive and path displayed; the user, however, may change these. In v2.1, soil profile data files exists for each crop. Thus, you must select all crops for which v2.1 soil files are available to be sure that all of your soil data are converted.

```
        Data Files Conversion from Version 2.1 to 3.0 - ASCII to ASCII

            Crop List
          ____________  ___________________________________________
         |  Barley    | Driv. & Path > C : \DSSAT1\MODEL\SOYBEAN\DATA
         |  Dry Bean  |
         |  Maize     |
         |  Millet    |
         |  Peanut    |
         |  Rice      |
         |  Sorghum   |
         |  Soybean   |
         |  Wheat     |
         |            |
         |            |
         |            | ______________ Messages ______________
         |            | F1 - Help                 F4    - Select all
         |            | F2 - Change drive & path  ENTER - Select/Unselect
         |            |
         |____________| ESC - Quit                F10   - Continue
```

SCREEN 8.

To select a crop for conversion: Use the arrow keys to move the highlight bar over the experiment(s) you wish to select. Press the <ENTER> key. Once selected, a "check" mark will appear to the left of the selected item. This "check" mark behaves like a toggle switch and can be turned on and off by repeatedly pressing the <ENTER> key while the item is highlighted.

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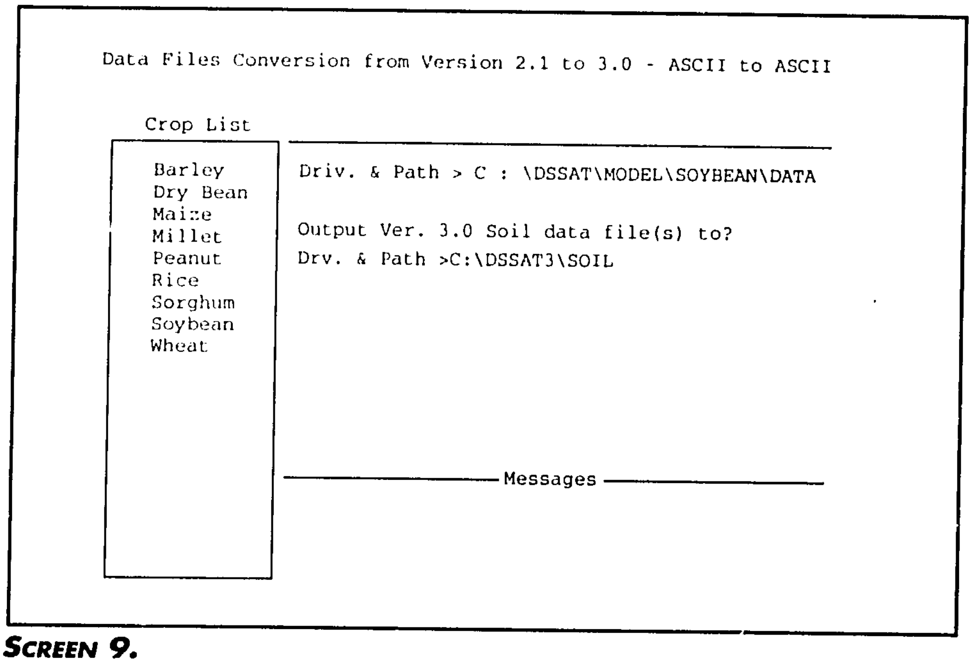
The operations of the <F1>, <F4>, <F10> and <ESC> keys are the same as described under Screen 2 in Chapter 2.



SCREEN 9.

When you have made a selection for conversion, the dialog box shown in Screen 9 (above) will appear. You must enter in this screen the drive and path where you want the new DSSAT v3 format file to be stored.

For example, these files could be stored in C:\DSSAT3\SOIL.

Once a path is entered, a screen similar to Screen 10 (on the following page) will be presented. In this screen are listed all the soil profiles that may be converted from DSSAT v2.1 to v3 format.

```
Data Files Conversion from Version 2.1 to 3.0 - ASCII to ASCII

  Soil #        Soil Profile File SPROFILE.SB2
 ------------------------------------------------------------------------
    01
    02   Drv. & Path: C : \DSSAT1\MODEL\SOYBEAN\DATA
    03    09                SHALLOW SANDY LOAM
    04       .13  6.00    .40  74.00   6.9  13.9 1.0  1.32E-03    98.4   6.67
    05       10.   .086   .220   .320   .220 1.000   1.61    .70  2.5   3.3
    06       10.   .086   .220   .320   .220  .819   1.61    .66  2.4   3.2
√   07       10.   .086   .220   .320   .220  .607   1.61    .58  2.2   3.0
√   08       10.   .087   .219   .319   .219  .449   1.61    .46  2.1   2.7
√   09       15.   .087   .219   .319   .219  .449   1.61    .46  2.1   2.7
    10
    11
    12
    13
    14
    15
    16
    17                                  Messages
    18   F1    - Help                     F4    - Select all
    19                                    ENTER - Select/Unselect
         ESC   - Quit                     F10   - CONVERT
```

SCREEN 10.

To select a soil profile for conversion: Use the arrow keys to move the highlight bar over the soil number you wish to select. Press the <ENTER> key. Once selected, a "check" mark will appear to the left of the selected item. This "check" mark behaves like a toggle switch and can be turned on and off by repeatedly pressing the <ENTER> key while the item is highlighted.

The operations of the <F1>, <F4>, <F10> and <ESC> keys are the same as described under Screen 2 in Chapter 2.

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APPENDIX.
DSSATPRO.FLE FILE

```
*** * DSSATPRO FILE * ***
DDB C: \DSSAT3 BDM.EXE
DTB C: \DSSAT3 CODEMENU.EXE
DTE C: \DSSAT3 EFM.EXE
DTO C: \DSSAT3 GFM.EXE
DTX C: \DSSAT3 EMENU.EXE
DPT C: \DSSAT3 GETSOIL.BAT
DIM C: \DSSAT3 CONVERT.EXE
DTP C: \DSSAT3 GFM.EXE
DPF C: \DSSAT3 FLFM.EXE
DFO C: \DSSAT3 GCFA.EXE
DIS C: \DSSAT3 WINGRAF.BAT
DDW C: \DSSAT3 WFM.EXE
DWG C: \DSSAT3 WMGRAF.EXE
DWC C: \DSSAT3 WM.EXE
DDS C: \DSSAT3 SFM.EXE
DTS C: \DSSAT3 GUMGRAF.BAT
DDG C: \DSSAT3 GFM.EXE
DCG C: \DSSAT3 GENCALC.EXE
DPM C: \DSSAT3 GFM.EXE
DDE C: \DSSAT3 GFM.EXE
MBA C: \DSSAT3 0 0 0 I
MMZ C: \DSSAT3 MDRIV940.EXE MINPT940.EXE GECER940.EXE I
MML C: \ 0 0 0 I
MRI C: \DSSAT3 MDRIV940.EXE MINPT940.EXE RICER940.EXE I
MSG C: \DSSAT3 0 0 0 I
MWH C: \DSSAT3 MDRIV940.EXE MINPT940.EXE GECER940.EXE I
MBN C: \DSSAT3 MDRIV940.EXE MINPT940.EXE CRGRO940.EXE I
MSB C: \DSSAT3 MDRIV940.EXE MINPT940.EXE CRGRO940.EXE I
MPN C: \DSSAT3 MDRIV940.EXE MINPT940.EXE CRGRO940.EXE I
MAR C: \DSSAT3 0 0 0 I
MCS C: \DSSAT3 MDRIV940.EXE MINPT940.EXE CSCAS940.EXE I
MPT C: \DSSAT3 0 0 0 I
MOT C: \ 0 0 0
MFA C: \DSSAT3 MDRIV940.EXE MINPT940.EXE LEGRO940.EXE I
MIO C: \DSSAT3 EFM.EXE 0 0
MLO C: \DSSAT3 GFM.EXE 0 0
MGR C: \DSSAT3 WINGRAF.EXE
ASP C: \DSSAT3 XCREATE.EXE 0 0
ASS C: \DSSAT3 SEADRV.EXE
ASA C: \DSSAT3 VARAN2.EXE
AGR C: \DSSAT3 WMGRAF.EXE
```

```
AQS C: \DSSAT3 SEQDRV.EXE
AQA C: \DSSAT3 SUSTAIN2.EXE
TOE C: \DSSAT3 TED.COM
TOS C: \
TOM C: \
BGD C: \DSSAT3\BACKGRND
CDD C: \DSSAT3
WED C: \DSSAT3\WEATHER
WGD C: \DSSAT3\WEATHER\GEN
CLD C: \DSSAT3\WEATHER\CLIMATE
SLD C: \DSSAT3\SOIL
CRD C: \DSSAT3\GENOTYPE
EXD C: \DSSAT3\EXPER
FID C: \DSSAT3\BACKGRND
BAD C: \DSSAT3
MZD C: \DSSAT3\MAIZE
MLD C: \DSSAT3
RID C: \DSSAT3\RICE
SGD C: \DSSAT3
WHD C: \DSSAT3\WHEAT
BND C: \DSSAT3\DRYBEAN
SBD C: \DSSAT3\SOYBEAN
PND C: \DSSAT3\PEANUT
ARD C: \DSSAT3
CSD C: \DSSAT3\CASSAVA
PTD C: \DSSAT3
OTD C: \
ASD C: \DSSAT3\SEASONAL
AQD C: \DSSAT3\SEQUENCE
PSD C: \DSSAT3\PEST
ECD C: \DSSAT3\ECONOMIC
TOD C: \
```

Volume 2

DSSAT version 3

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IBSNAT, The International Benchmark Sites Network for Agrotechnology Transfer, is a network consisting of the contractor (University of Hawaii), its subcontractors and many global collaborators. Together they have created a network of national, regional and international agricultural research for the transfer of agrotechnology among global partners in both developed and lesser developed countries.

From 1982 to 1987, IBSNAT was a program of the U.S. Agency for International Development under a cost-reimbursement Contract, No. DAN-4054-C-00-2071-00, with the University of Hawaii. From 1987 to 1993, the contract was replaced with a Cooperative Agreement, No. DAN-4054-A-00-7081-00, between the University of Hawaii and USAID.

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DSSAT v3

VOLUME 2

VOLUME 2-1
INPUT & OUTPUT FILES

VOLUME 2-2
CROP MODELS

VOLUME 2-3
GRAPHING SIMULATED AND EXPERIMENT DATA

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INPUT AND OUTPUT FILES

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CHAPTER ONE. INTRODUCTION

For over twenty years scientists and engineers have been developing process-oriented simulation models of various crops. Models have been published for most of the world's major food crops as well as for cotton, tobacco, grasses and ornamental crops. These models generally describe the development, growth and yield of a crop on a homogeneous area of soil exposed to certain weather conditions.

The objectives of crop modelers have varied, from understanding mechanisms of plant growth processes, to assisting in management and decision making. Although there are considerable differences in the mathematical structures, the processes included, and the levels of detail and mechanism in each model, there are also some major similarities. Most models are deterministic, operate on daily time steps and require similar input data for soil, weather and management conditions. Models developed for application to conditions other than those in an experiment usually only require weather and soil data that are widely available, and produce outputs that are of general interest to people studying crop management or to those interested in decision making and planning.

Many scientists routinely collect experimental data that can be used to validate and improve existing crop models. These data represent a valuable resource for testing future models. However, to provide easy-to-use data sets for future model testing, and minimize unnecessary manipulation of data, a set of standards is needed for organizing the data files. Crop models which predict crop performance in differing environments are appealing to users from diverse disciplines. Many of these model users need application programs which perform analyses on model outputs. Other users working with spatial data bases may utilize programs which interpolate model inputs between points. Operation of these application programs requires inputs and outputs in a standard form.

In recent years, the International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT) has published documentation for a set of crop model inputs and outputs (IBSNAT, 1986, 1990). This system of files and data formats was used for the models integrated into the Decision Support System for Agrotechnology Transfer (DSSAT v2.1) (IBSNAT, 1989), in which corn, wheat, soybean, and peanut crop models all used the same database software and strategy evaluation program. This system was useful for running and validating the models, for conducting sensitivity analysis, and for evaluating the variability and risks of different management strategies for a range of locations specified

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by soil and weather data. The attempt to develop and use general files and formats provided a good start and demonstrated the utility of the endeavor. However, the introduction of other crops (such as rice), the introduction of other models of the same crops, and the introduction of other processes into the existing models revealed several deficiencies. Further, the large number of files presented difficulties to many users. Work was initiated, therefore, to develop a more universal set of files.

The work reported by IBSNAT (1986, 1990) provided a basis for many of the files and file structures presented here. In that original work, the inputs and outputs were limited to those that described weather, soil water and nutrient conditions, row and planting geometries and crop management. In the current document, not only have those inputs and outputs been expanded but they are now more flexible, have more variables and contain additional environmental conditions. The inputs and outputs refer to a point in space and do not include watershed or other spatially varying conditions. The present structure, however, is sufficiently flexible to easily allow additions of these and other factors in the future.

A utility program called Convert (see Volume 1-5, Imamura and Tang 1994, of this book) is available in DSSAT v3 to convert DSSAT v2.1 files to the new file structure. Moreover, if a user wishes to create a new experiment data set for DSSAT v3, there is a utility program called XCreate (see Volume 1-4, Imamura 1994, of this book) which creates the new crop management or experiment input file which is referred to as FILEX.

The files and file structures described here are designed to accommodate a diversity of crop models and applications. Their specifications are the basis of the data structures used in DSSAT v3. They have been constructed to facilitate the exchange of data among modelers and other users and can be used as direct input to crop models. They also may function as a medium to generate model-specific input files and keep intact the facility for data set interchange. Considerable thought has been given to designing a system to maximize the flexibility of input configurations. This flexibility has often meant specification of a considerable number of "slots" for inputs. Within this document, examples of minimum configurations of input files for particular applications are highlighted (see the section entitled, "Examples of FILEX for Various Experiments").

CHAPTER TWO.
FILE STRUCTURE

The files are organized into input, output and experiment performance data files (Table 1). A typical organization of these is depicted in Figure 1. The experiment performance files are needed only when simulated results are to be compared with data recorded in a particular experiment. In some cases, however, they could be used as input files to 'reset' some variables during the course of a simulation run. They could also be used to record time series of pests or pest damage to the crop, which could be used as input to crop models. The model output files are organized to allow users to select the information needed for a particular application. Similarly, model inputs are organized to allow some flexibility in their use with specific models. For example, there is a soil nutrient management section that users could eliminate when their crop model does not include a soil fertility component or when fertilizer was applied to eliminate nutrient stresses.

FILE ANNOTATION

Each file should contain file headings, and, if the file is partitioned into sections, section headings. In addition, it is often desirable to add remarks to data contained within a file. These remarks may be header lines indicating the nature of following data items or may be comments on some aspects of the quality or source of the data. Headers may be used by the input components of a model to undertake particular operations, while comment lines would generally be ignored. The following symbols, placed in column 1, indicate the nature of the annotation:

- * file or section heading
- @ header line specifying variables occurring below
- ! comment line.

FILE NAMING CONVENTIONS

A set of file-naming conventions have been adopted to facilitate recognition of different categories of data. The convention has two parts: 1) the file extension which is used to specify the type of file; and 2) the prefix which is used to identify the contents of the file. Following is a list of extensions and prefixes.

EXTENSIONS

.WTH	Weather data file
.SOL	Soil profile data file

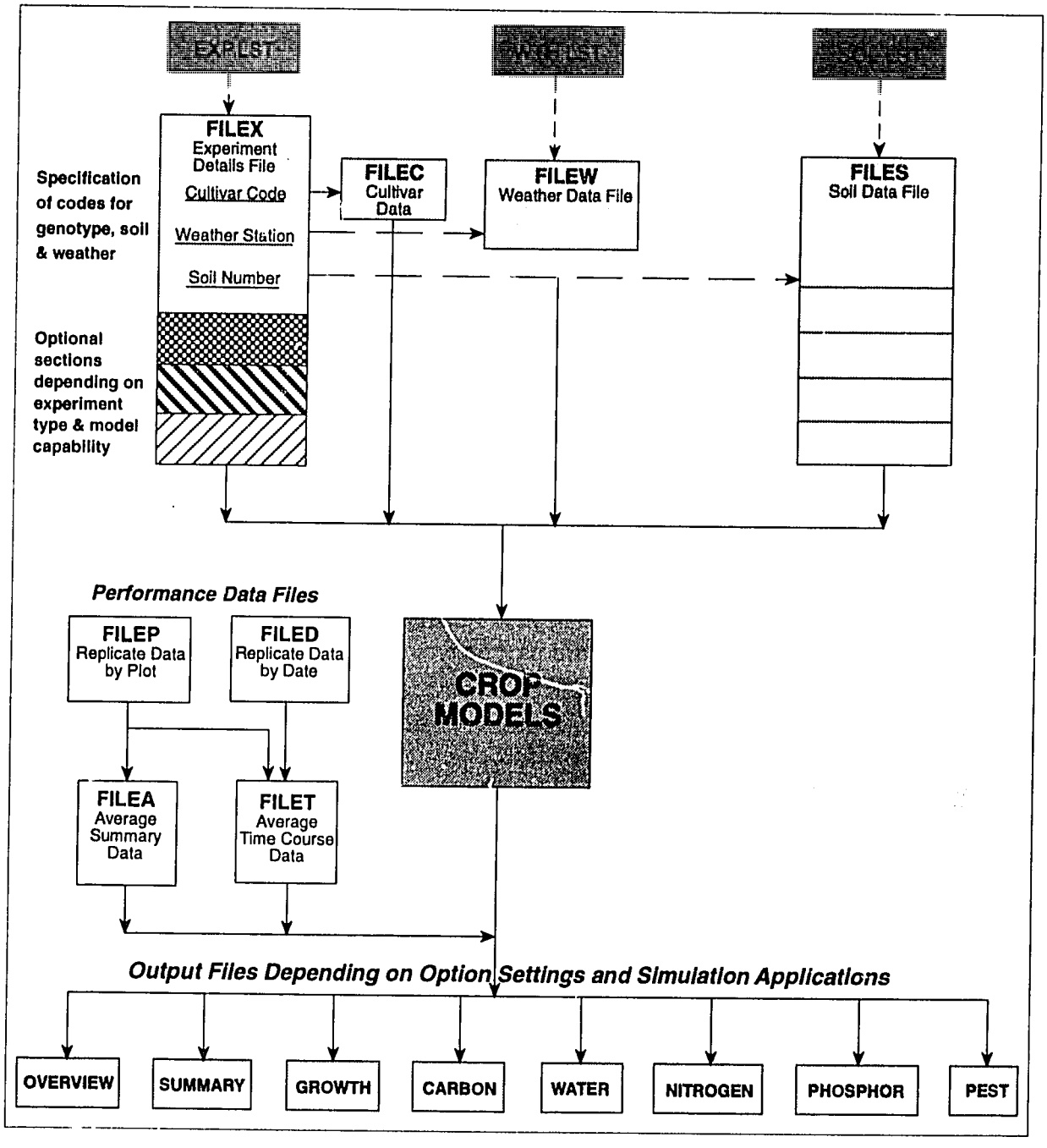

FIGURE 1. OVERVIEW OF INPUT AND OUTPUT FILES USED BY CROP MODELS.

.CUL	Cultivar/variety specific coefficient file
.ECO	Ecotype specific coefficient file
.SPE	Crop (species) specific coefficient file
.OUT	Output file generated by the crop model
.LST	A list file - provides a list of either experiments, weather data sets or soil data sets
.ccX	Experiment details file (i.e., FILEX)
.ccP	Observation data (replicate values)
.ccD	Performance data (replicate values)
.ccA	Average values of observation data
.ccT	Time course data (averages)

The 'cc' in the above extensions indicates a crop code (e.g., WH). The current crop codes used are listed below:

Code	Crop
AL	Alfalfa/Lucerna
AR	Aroid
BA	Barley
BN	Dry bean (Phaseolus bean)
BW	Broad leaf weeds
CO	Cotton
CS	Cassava
FA	Fallow
GW	Grass-weeds
ML	Pearl millet
MZ	Maize/Corn
PN	Peanut
PT	Potato
RI	Rice
SB	Soybean
SC	Sugar cane
SG	Sorghum
ST	Shrubs/Trees
WH	Wheat

Prefixes

For most model input files and experiment observation files, the prefix is constructed from an institute code (2 characters), a site code (2 characters), the year of the experiment (2 characters) and an experiment number (2 characters). For example, an experiment con-

ducted by the University of Florida (UF) at Gainesville (GA) in 1988 (88) would yield a file prefix of UFGA8801. The file prefix conventions used for output files and genotype coefficient files are shown in Table 1.

Missing Data

For all input files, the value '-99' is entered when required numeric data are missing or unavailable.

CHAPTER THREE.
INPUTS

Input files are further divided into those dealing with the experiment, weather and soil, and the characteristics of different genotypes (crop and cultivar) (Table 1).

EXPERIMENT LIST FILE

The EXP.LST file (or FILEL) contains a listing of available simulation experiments (Table 2). This file contains no information on individual experiments, but lists all of the experiment files available in the working directory, having one line of information for each experiment. First on this line is the optional experiment list number. There is a blank space and then there is the experiment identifier which specifies the institute code, site code, year of experiment, and experiment number (see the "Prefixes" section above). There is a blank space and then three characters. The first two characters are used for the crop species code (which can specify a group of species as well as one individual species, e.g., WH for Wheat), and the third character defines the file type; the default file type for the IBSNAT models is "X" (see example in Table 2). There is a blank space and then the next field of 60 characters briefly describes the experiment, usually by giving the experiment name. If there are any peculiarities of the experimental conditions at the specific site, these should be added after the experiment name, using a semicolon to separate the two items. Finally, factors included in the experiment, and the number of levels for each factor, should be documented in abbreviated form (e.g., cultivars as CV; irrigation as IR, etc.) and added after the experiment name, each one separated by a semicolon. For each experiment file available for simulation, one line of information, equivalent in content to the one just described, must be placed in the EXP.LST file. Typically, during model execution, this experiment list would appear as a menu from which the user could select an experiment for simulation.

The IBSNAT models are organized to allow users to perform sensitivity analysis, and in such cases, weather data files, soil profiles and other data files (as necessary) are needed and a listing of these, in a form the models can read, must be generated by the user through a utility found in DSSAT v3, so users can select alternate files during a simulation. Examples of a weather list file (WTH.LST) and a soil list file (SOL.LST) used by crop models in DSSAT v3 are given in Appendix A. These list files may be model-specific and are not essential for documenting basic model inputs and outputs.

TABLE 1. CROP MODEL INPUT AND OUTPUT FILES.

Internal File Name	Example File Name(s)	External Description
INPUT FILES		
Experiment		
FILEL	EXP.LST	Listing of all available experiment details files (FILEXs)
FILEX	UFGA8801.SBX	Experiment details file for a specific experiment (e.g., soybean at UFGA): treatments, field conditions, crop management and simulation controls
Weather and Soil		
FILEW	UFGA8801.WTH	Weather data, daily, for a specific (e.g.,UFGA) station and time period (e.g., for one year)
FILES	SOIL.SOL	Soil profile data for a group of experimental sites in general (e.g.,SOIL.SOL) or for a specific institute (e.g., UF.SOL)
Crop and Cultivar		
FILEC	SBGRO940.CUL[1,2]	Cultivar/variety coefficients for a particular crop species and model; e.g., soybean for the 'GRO' model,version 940 (i.e., released in 1994)
FILEE	SBGRO940.ECO[3]	Ecotype specific coefficients for a particular crop species and model; e.g., soybean for the 'GRO' model,version 940(i.e., released in 1994)
FILEG	SBGRO940.SPE[3]	Crop (species) specific coefficients for a particular model; e.g., soybean for the 'GRO' model, version 940 (i.e., release in 1994)
OUTPUT FILES[4]		
OUTO	OVERVIEW.OUT	Overview of inputs and major crop and soil variables.
OUTS	SUMMARY.OUT	Summary information: crop and soil input and output variables; one line for each crop cycle or model run.

		Detailed time-sequence information on:
OUTG	GROWTH.OUT	Growth
OUTC	CARBON.OUT	Carbon balance
OUTW	WATER.OUT	Water balance
OUTN	NITROGEN.OUT	Nitrogen balance
OUTP	PHOSPHOR.OUT	Phosphorus balance
OUTD	PEST.OUT	Pests, diseases, weed damage/levels

Experiment Data Files

FILEP	UFGA8801.SBP	Performance data (replicate values, arranged by plots) for a soybean experiment. (Used for basic experimental data from which averages and time course data are calculated.)
FILED	UFGA8801.SBD	Performance data (replicate values, arranged by date) for a soybean experiment. (Used for basic experimental data from which averages and time course data are calculated.)
FILEA	UFGA8801.SBA	Average values of performance data for a soybean experiment. (Used for comparison with summary model results.)
FILET	UFGA8801.SBT	Time course data (averages) for a soybean experiment. (Used for graphical comparison of measured and simulated time course re sults.)

[1] *These names reflect a standard naming convention in which the first two spaces are for the crop code, the next five characters are for the model name, beginning at position 3, and the final one is a file identifier that in general is set to zero.*

[2] *General names (e.g., SOYBEAN.CUL) have been reserved for those cases where the data requirements are truly model independent.*

[3] *These files are used by the 'GRO' models, but other crop models may not need them; thus FILEC is the only required Cultivar file for running all crop models.*

[4] *The example names for the output files (e.g., GROWTH.OUT) are for temporary files that are rewritten during each simulation run. Output files can be saved, however, and in this case the file names are made up of the usual institute, site, experiment and crop identifiers, with a final letter, G, W, etc., to designate growth, water or other data types. (An example of a saved OVERVIEW output file would be UFGA8801.SBO, where the "O" designates Overview; other examples would be UFGA8801.SBS,G,C,W,N,P,D where the letters designate Summary, Growth, Carbon, Water, Nitrogen, Phosphorus and Pest output files, respectively.)*

TABLE 2. EXPERIMENT LIST FILE. (FILEL = "EXP.LST")

STRUCTURE

Variable	Variable Name[1]	Header[2]	Format[3]
Experiment list number[4]	EXLTN	#	0 I 2
Experiment identifier, generally made up of:			
Institute code (2 characters)			
Site code (2 characters)			
Experiment code (4 characters)	EXPER	FILENAME	1 C 8
File extension (where the 1st two characters are the crop group code(e.g., "WH")[5]	EXT	EXT	1 C 3
Experiment name	ENAME	ENAME	1 C 60

[1] *Abbreviations used as variable names in the IBSNAT models.*

[2] *Abbreviations suggested for use in header lines (those designated with '@') within the file.*

[3] *Formats are presented as follows: number of leading spaces, variable type (Character = C, Integer = I), variable width.*

[4] *"Experiment list number" is an optional entry for this line. If it is not used, two blank spaces must be left at the beginning of each line.*

[5] *The IBSNAT models use "X" for tne third character of the extension.*

EXAMPLE

```
*EXPERIMENT LIST
@# FILENAME EXT
ENAME.................................................
 1 UFGA7801 SBX BRAGG,IRRIGATED&NON-IRRIGATED;2IR
 2 UFGA8101 SBX COBB,IRRIGATED+VEG+REPROD.STRESS;3IR
 3 UFGA9101 SBX POTENTIAL YIELD EXAMPLE;2CV;2SI
 4 UFGA9102 SBX CLIMATE CHANGE STUDY EXAMPLE;2CV;ESI
```

Experiment Details File

One main file, referred to as FILEX (Table 3), documents the inputs to the models for each "experiment" to be simulated. Each experiment could be a real one for which there would be corresponding observed field data, or a hypothetical one defined for simulation. Thus, inputs for many real and hypothetical experiments can be stored for documentation and for use at different times. The file heading contains the experiment code and name, the treatment combinations, and details of the experimental conditions (field characteristics, soil analysis data, initial soil water and inorganic nitrogen conditions, seedbed preparation and planting geometries, irrigation and water management, fertilizer management, organic residue applications, chemical applications, tillage operations, environmental modifications, harvest management), and simulation controls. The experiment code uses the same convention as the file naming system to provide information on institute, site, planting year, experiment number, and crop. For example: UFGA8201MZ, is the code for maize experiment 01, planted in 1982 by the institute designated by UF (University of Florida) at site GA (Gainesville). The file can also contain the names of the people supplying the data set and information on the plot sizes, etc., used in the experiment. It may also contain any incidents that occurred during the course of the experiment that may affect the interpretation of the data. These latter items are not normally used by simulations models but are provided for reference and assistance in interpreting simulation results. Documentation of these sections is included in Table 3, for use when required.

The structure of FILEX has been designed with the goal of maximizing the flexibility of input configurations while preserving the concept of entering only a minimum of inputs to run a simulation. The file can be easily configured to accommodate very different types of simulation runs. To enable this flexibility, the file description provides slots for inputs and descriptive information which may be needed for some types of simulation runs but not for others. FILEX has been configured in such a way that only those data required for individual simulations need be entered.

In order for FILEX to accommodate a wide variety of experimental layouts, a broad definition of what comprises a treatment is necessary. For the purposes of data organization in FILEX, a treatment can be any factor of the experiment which varies. In addition to such things as combinations of fertilizer rates, varieties and irrigation levels, treatments can be different fields or different soils or different soil analyses or different weather. Thus if an experiment compared varieties across locations without water, nutrient and pest limitations, the locations of fields become treatments. This enables one experiment to utilize multiple weather data sets which was not possible when using the IBSNAT v2.1 model inputs and outputs (IBSNAT, 1990).

Most experiments will have more than one treatment. Many experiments will be conducted on only one site with treatments confined to such factors as fertilizer rates, varieties or irrigation treatments. Alternatively, an experiment such as a plant breeding experiment may span several sites where the sites and varieties are treatments. To accommodate these differing possibilities, FILEX has been designed with specific sections dedicated to particular categories of inputs. Only those sections required for the particular simulation need be present in FILEX.

Thus, data for the first treatment of an experiment are entered in the appropriate sections in FILEX. If, however, the experiment has more than one treatment, which is usually the case, then the data which are common to all treatments need not be repeated. This contrasts with the organization of inputs described for previous generations of IBSNAT models (IBSNAT, 1986 and 1990). In this newest version, only those data which are "new" for the treatment need be coded. For example, if an experiment examined the effect of five nitrogen rates, FILEX would contain sections for planting details and initial conditions and a section for fertilizer rate information for the first treatment. For the second treatment, the planting details and initial conditions would not be repeated but a second rate would appear in the fertilizer details section.

The various sections of FILEX are summarized below.

FILE SECTION	***TYPICAL CONTENTS***
Experiment details	Experiment name and codes
General	Names of people, addresses; name and location of experiment site(s); plot information
Treatments	Treatment number, name and specification of level codes of the treatment factors
Cultivar	Cultivar level, crop code, cultivar ID and name
Fields	Specification of field level, ID, weather station name, soil, and field description details
Soil Analysis	Set of soil properties used for the simulation of nutrient dynamics, based on field nutrient sampling, if any

Initial Conditions	Starting conditions for water and nitrogen in the profile. Also used for carryover of root residue from the previous crop, and N symbiosis initialization details when needed
Planting Details	Planting date, population, seeding depth and row spacing data
Irrigation and Water Management	Irrigation dates, amounts, thresholds and rice flood water depths
Fertilizers	Fertilizer rate, date and type information
Residues	Additions of straw, green manure, animal manure
Chemical Applications	Herbicide and pesticide application data
Environment Modifications	Adjustment factors for weather parameters as used in climate change and constant environment studies (e.g., constant daylength, shading, constant tempera ture, etc.)
Tillage Information	Details of dates, types of tillage operations
Harvest Details	Information on harvest dates, plant components harvested, etc.
Simulation Controls	Specification of simulation options (e.g., starting dates), on/off options for model components (e.g., water, and nitrogen balances), and output options

It should be noted that for any particular simulation, only a few of these sections would be needed. However, the minimum required information for a simulation (that is, when there are no water, nutrient or pest stresses, and when soil water and nitrogen balances are not used) are the Experiment, Cultivar, Treatment, Field, Planting Details and Simulation Controls sections.

TABLE 3. EXPERIMENT DETAILS FILE. (FILEX)

STRUCTURE

Variable	Variable Name[1]	Header[2]	Format[3]
Line 1			
*EXP.DETAILS:			0 C 13
Experiment identifier, made up of:			
Institute code	INSTE		1 C 2
Site code	SITEE		0 C 2
Experiment number/abbreviation	EXPTNO		0 C 4
Crop group code	CG		0 C 2
Experiment name[4]	ENAME[4]		1 C 60
*GENERAL[5]			
Line 1 (People)			
Names of scientists	PEOPLE	PEOPLE	1 C 75
Line 2 (Address)			
Contact address of principal scientist	ADDRESS	ADDRESS	1 C 75
Line 3 (Sites)			
Name and location of experimental site(s)	SITE(S)[6]	SITE(S)	1 C 75
Line 4 (Plot information)			
Gross plot area per rep, m^{-2}	PAREA	PAREA	3 R 6 1
Rows per plot	PRNO	PRNO	1 I 5
Plot length, m	PLEN	PLEN	1 R 5 1
Plots relative to drains, degrees	PLDR	PLDR	1 I 5
Plot spacing, cm	PLSP	PLSP	1 I 5
Plot layout	PLAY	PLAY	1 C 5
Harvest area, m^{-2}	HAREA	HAREA	1 R 5 1
Harvest row number	HRNO	HRNO	1 I 5
Harvest row length, m	HLEN	HLEN	1 R 5 1
Harvest method	HARM	HARM	1 C 15
All other lines (Incidents)			
Notes	NOTES	NOTES	1 C 75
*TREATMENTS			
Treatment number	TRTNO	TN	0 I 2
Rotation component: number (default=1);	ROTNO	R	1 I 1
option (default=1)	ROTOPT	O	1 I 1
Crop component number (default = 0)	CRPNO	C	1 I 1

Treatment name	TITLET	TNAME	1	C	25
Cultivar level	LNCU	CU	1	I	2
Field level	LNFLD	FL	1	I	2
Soil analysis level	LNSA	SA	1	I	2
Initial conditions level	LNIC	IC	1	I	2
Planting level	LNPLT	MP	1	I	2
Irrigation level	LNIR	MI	1	I	2
Fertilizer level	LNFER	MF	1	I	2
Residue level	LNRES	MR	1	I	2
Chemical applications level	LNCHE	MC	1	I	2
Tillage and rotations level	LNTIL	MT	1	I	2
Environmental modifications level	LNENV	ME	1	I	2
Harvest level	LNHAR	MH	1	I	2
Simulation control level	LNSIM	SM	1	I	2
*CULTIVARS					
Cultivar level	LNCU	CU	0	I	2
Crop code	CG	CR	1	C	2
Cultivar identifier (Institute code + Number)	VARNO	INGENO	1	C	6
Cultivar name	CNAME	CNAME	1	C	16
*FIELDS					
Field level	LNFLD	FL	0	I	2
Field ID (Institute + Site + Field)	FLDNAM	ID_FIELD	1	C	8
Weather station code (Institute+Site)	WSTA	WSTA	1	C	8
Slope and aspect, degrees from horizontal plus direction (W, NW, etc.)	SLOPE	FLSA	1	C	5
Obstruction to sun, degrees	FLOB	FLOB	1	R	5 0
Drainage type, code[7]	DFDRN	FLDT	1	C	5
Drain depth, cm	FLDD	FLDD	1	R	5 0
Drain spacing, m	SFDRN	FLDS	1	R	5 0
Surface stones(Abundance,%+Size,S,M,L)	FLST	FLST	1	C	5
Soil texture[7]	SLTX	SLTX	1	C	5
Soil depth, cm	SLDP	SLDP	1	R	5 0
Soil ID (Institute+Site+Year+Soil)	SLNO	ID_SOIL	1	C	10
*SOIL ANALYSIS					
Line 1					
Soil analysis level	LNSA	SA	0	I	2
Analysis date, year + days from Jan. 1	SADAT	SADAT	1	I	5
pH in buffer determination method, code[7]	SMHB	SMHB	1	C	5
Phosphorus determination method, code[7]	SMPX	SMPX	1	C	5
Potassium determination method, code[7]	SMKE	SMKE	1	C	5

All other lines (L = Layer number)						
Soil analysis level	LNSA	SA	0	I	2	
Depth, base of layer, cm	SABL(L)	SABL	1	R	5	0
Bulk density, moist, g cm^{-3}	SADM(L)	SADM	1	R	5	1
Organic carbon, g kg^{-1}	SAOC(L)	SAOC	1	R	5	2
Total nitrogen, g kg^{-1}	SANI(L)	SANI	1	R	5	2
pH in water	SAPHW(L)	SAHW	1	R	5	1
pH in buffer	SAPHB(L)	SAHB	1	R	5	1
Phosphorus, extractable, mg kg^{-1}	SAPX(L)	SAEX	1	R	5	1
Potassium, exchangeable, cmol kg^{-1}	SAKE(L)	SAKE	1	R	5	1
*INITIAL CONDITIONS						
Line 1						
Initial conditions level	LNIC	IC	0	I	2	
Previous crop code	PRCROP	PCR	1	C	5	
Initial conditions measurement date, year + days	IDAYIC	ICDAT	1	I	5	
Root weight from previous crop, kg ha^{-1}	WRESR	ICRT	1	R	5	0
Nodule weight from previous crop, kg ha^{-1}	WRESND	ICND	1	R	5	0
Rhizobia number, 0 to 1 scale (default = 1)	EFINOC	ICRN	1	R	5	2
Rhizobia effectiveness, 0 to 1 scale (default = 1)	EFNFIX	ICRE	1	R	5	2
All other lines (L = Layer number)						
Initial conditions level	LNIC	IC	0	I	2	
Depth, base of layer, cm	DLAYR(L)	ICBL	1	R	5	0
Water, cm^3 cm^{-3} x 100 volume percent	SWINIT(L)	SH20	1	R	5	3
Ammonium, KCl, g elemental N Mg^{-1} soil	INH4(L)	SNH4	1	R	5	
Nitrate, KCl, g elemental N Mg^{-1} soil	INO3(L)	SNO3	1	R	5	1
*PLANTING DETAILS						
Planting level number	LNPLT	MP	0	I	2	
Planting date, year + days from Jan. 1	YRPLT	PDATE	1	I	5	
Emergence date, earliest treatment	IEMRG	EDATE	1	I	5	
Plant population at seeding, plants m^{-2}	PLANTS	PPOP	1	R	5	1
Plant population at emergence, plants m^{-2}	PLTPOP	PPOE	1	R	5	1
Planting method, transplant (T), seed (S), pregerminated seed (P) or nursery (N)	PLME	PLME	5	C	1	
Planting distribution, row (R), broadcast (B) or hill (H)	PLDS	PLDS	5	C	1	
Row spacing, cm	ROWSPC	PLRS	[illegible]	R	5	0
Row direction, degrees from N	AZIR	PLRD	1	R	5	0
Planting depth, cm	SDEPTH	PLDP	1	R	5	1

Planting material dry weight, kg ha^{-1}	SDWTPL	PLWT	1 R 5 0
Transplant age, days	SDAGE	PAGE	1 R 5 0
Temp. of transplant environment, °C	ATEMP	PENV	1 R 5 1
Plants per hill (if appropriate)	PLPH	PLPH	1 R 5 1
*IRRIGATION AND WATER MANAGEMENT			
Line 1			
Irrigation level	LNIR	MI	0 I 2
Irrigation application efficiency, fraction	EFFIRX	EFIR	1 R 5 2
Management depth for automatic application, cm	DSOILX	IDEP	1 R 5 0
Threshold for automatic appl., % of max. available	THETCX	ITHR	1 R 5 0
End point for automatic appl., % of max. available	IEPTX	IEPT	1 R 5 0
End of applications, growth stage	IOFFX	IOFF	1 C 5
Method for automatic applications, code[5]	IAMEX	IAME	1 C 5
Amount per irrigation if fixed, mm	AIRAMX	IAMT	1 R 5 0
All other lines (J = Irrigation application number)			
Irrigation level	LNIR	MI	0 I 2
Irrigation date, year + day or days from planting	IDLAPL(J)	IDATE	1 I 5
Irrigation operation, code[7]	IRRCOD(J)	IROP	1 C 5
Irrigation amount, depth of water/water table, bund height, or percolation rate, mm or mm day^{-1}	AMT(J)	IRVAL	1 R 5 0
*FERTILIZERS (INORGANIC) (J = Fertilizer application number)			
Fertilizer application level	LNFERT	MF	0 I 2
Fertilization date, year + day or days from planting	FDAY(J)	FDATE	1 I 5
Fertilizer material, code[7]	IFTYPE(J)	FMCD	1 C 5
Fertilizer application/placement, code[7]	FERCOD(J)	FACD	1 C 5
Fertilizer incorporation/application depth, cm	DFERT(J)	FDEP	1 R 5 0
N in applied fertilizer, kg ha^{-1}	ANFER(J)	FAMN	1 R 5 0
P in applied fertilizer, kg ha^{-1}	APFER(J)	FAMP	1 R 5 0
K in applied fertilizer, kg ha^{-1}	AKFER(J)	FAMK	1 R 5 0
Ca in applied fertilizer, kg ha^{-1}	ACFER(J)	FAMC	1 R 5 0
Other elements in applied fertilizer, kg ha^{-1}	AOFER(J)	FAMO	1 R 5 0
Other element code, e.g.,. MG	FOCOD(J)	FOCD	1 C 5

*RESIDUES AND OTHER ORGANIC MATERIALS (J = Residue application number)						
Residue management level	LNRES	MR	0	I	2	
Incorporation date, year + days	RESDAY(J)	RDATE	1	I	5	
Residue material, code[7]	RESCOD(J)	RCOD	1	C	5	
Residue amount, kg ha^{-1}	RESIDUE(J)	RAMT	1	R	5	0
Residue nitrogen concentration, %	RESN(J)	RESN	1	R	5	2
Residue phosphorus concentration, %	RESP(J)	RESP	1	R	5	2
Residue potassium concentration, %	RESK(J)	RESK	1	R	5	2
Residue incorporation percentage, %	RINP(J)	RINP	1	R	5	0
Residue incorporation depth, cm	DEPRES(J)	RDEP	1	R	5	0
*CHEMICAL APPLICATIONS (J = Chemical application number)						
Chemical applications level	LNCHE	MC	0	I	2	
Application date, year + day or days from planting	CDATE(J)	CDATE	1	I	5	
Chemical material, code[7]	CHCOD(J)	CHCOD	1	C	5	
Chemical application amount, kg ha^{-1}	CHAMT(J)	CHAMT	1	R	5	2
Chemical application method, code	CHMET(J)	CHME	1	C	5	
Chemical application depth, cm	CHDEP(J)	CHDEP	1	C	5	
Chemical targets	CHT	CHT	1	C	5	
*TILLAGE (J = Tillage application number)						
Tillage level	TL	TL	0	I	2	
Tillage date, year + day	TDATE(J)	TDATE	1	I	5	
Tillage implement, code[7]	TIMPL(J)	TIMPL	1	C	5	
Tillage depth, cm	TDEP(J)	TDEP	1	R	5	0
*ENVIRONMENT MODIFICATIONS (J = Environment modification number)						
Environment modifications level	LNENV	ME	0	I	2	
Modification date, year + day or days from planting	WMDATE(J)	ODATE	1	I	5	
Daylength adjustment factor (A,S,M,R)	DAYFAC(J)	E	1	C	1	
Daylength adjustment, h	DAYADJ(J)	DAY	0	R	4	1
Radiation adjustment factor (A,S,M,R)	RADFAC(J)	E	1	C	1	
Radiation adjustment, MJ m^{-2} d^{-1}	RADADJ(J)	RAD	0	R	4	1
Temperature (maximum) adjustment factor (A,S,M,R)	TXFAC(J)	E	1	C	1	
Temperature (maximum) adjustment, °C	TXADJ(J)	MAX	0	R	4	1
Temperature (minimum) adjustment factor (A,S,M,R)	TMFAC(J)	E	1	C	1	
Temperature (minimum) adjustment, °C	TMADJ(J)	MIN	0	R	4	1
Precipitation adjustment factor (A,S,M,R)	PRCFAC(J)	E	1	C	1	
Precipitation adjustment, mm	PRCADJ(J)	RAIN	0	R	4	1
CO_2 adjustment code (A,S,M,R)	CO2FAC(J)	E	1	C	1	
CO_2 adjustment, vpm	CO2ADJ(J)	CO2	0	R	4	0
Humidity adjustment factor (A,S,M,R)	DPTFAC(J)	E	1	C	1	
Humidity (dew pt) adjustment, °C	DPTADJ(J)	DEW	0	R	4	1

Wind adjustment factor (A,S,M,R)	WNDFAC(J)	E	1	C	1	
Wind adjustment, km day^{-1}	WNDADJ(J)	WIND	0	R	4	1
N.B. A = add, S = subtract, M = multiply, R = replace						
*HARVEST DETAILS (J = Harvest number)						
Harvest level	LNHAR	HL	0	I	2	
Harvest date, year + day or days from planting	HDATE(J)	HDATE	1	I	5	
Harvest stage	HSTG(J)	HSTG	1	C	5	
Harvest component, code[7]	HCOM(J)	HCOM	1	C	5	
Harvest size group, code[7]	HSIZ(J)	HSIZ	1	C	5	
Harvest percentage, %	HPC(J)	HPC	1	R	5	0

1 *Abbreviations used as variable names in the IBSNAT models.*

2 *Abbreviations suggested for use in header lines (those designated with '@') within the file.*

3 *Formats are presented as follows: number of leading spaces, variable type (Character = C, Real = R, Integer = I), variable width, and (if real) number of decimals.*

4 *It is suggested that Experiment Name be composed of a short name, followed by a blank space, summary of treatment factors, followed by a blank space, and end with a local abbreviation for the experiment in parenthesis. This information will then be available for searching and organizing experiments, using the list managers described in Volume 1-3 (Hunt et al. 1994) of this book.*

5 *Each section in the actual file needs a heading of this type.*

6 *It is suggested that the SITE information on data line 3 be composed of a short site name, followed by a blank space, then latitude, longitude, elevation (in meters above sea level, and climate zone, each separated by a semi-colon. For example:*

GAINESVILLE,FL 29.63N;82.37W;40M;SEUSA

7 *For a complete listing of these codes, see Appendix B.*

TREATMENT LEVEL INDICATORS

A system of pointers or treatment level indicators reduces the amount of data contained in FILEX. These level indicators are used to specify the combinations of inputs for each treatment. They flag the models as to which sections of FILEX are needed for the simulation. Within each flagged section, the indicators point to the data relevant to the chosen treatment.

The level indicators in the order in which they appear in FILEX, together with their abbreviations are shown below:

Cultivar Level	CU
Field Level	FL
Soil Analysis Level	SA
Initial Conditions Level	IC
Planting Level	MP
Irrigation Level	MI
Fertilizer Level	MF
Residue Level	MR
Chemical applications Level	MC
Tillage And Rotations Level	MT
Environmental Modification Level	ME
Harvest Level	MH
Simulation Control Level	SM

As an example, consider an experiment with 3 N rates and 2 irrigation management levels. In this experiment, the cultivar, field details, initial conditions and residue management remain the same for all treatments. Assuming planting details and required simulation options are also the same for both treatments and there is no consideration given to chemical, tillage and environmental modification, then the treatment section of FILEX and the corresponding level indicators would appear as below. Note how the level indicators for water and fertilizer vary with treatments.

```
*TREATMENTS
@N  R  O  C TNAME           CU FL SA IC MP MI MF MR MC MT ME MH SM
01  1  1  0 0  N LOW WATER   1  1  0  1  1  1  1  1  0  0  0  0  1
02  1  1  0 30 N LOW WATER   1  1  0  1  1  1  2  1  0  0  0  0  1
03  1  1  0 90 N LOW WATER   1  1  0  1  1  1  3  1  0  0  0  0  1
04  1  1  0 0  N HI WATER    1  1  0  1  1  2  1  1  0  0  0  0  1
05  1  1  0 30 N HI WATER    1  1  0  1  1  2  2  1  0  0  0  0  1
06  1  1  0 90 N HI WATER    1  1  0  1  1  2  3  1  0  0  0  0  1
```

From the data depicted here, the model will discern that it must locate data in the cultivar (CU), field (FL), initial conditions (IC), planting (MP), irrigation (MI), fertilizers (MF), residue (MR) and simulation control (SM) sections of FILEX. The zeros for soil analysis (SA), chemical (MC), tillage (MT), environment (ME), and harvest (MH) indicate that no data are required for these sections. In treatment one, the irrigation data to be used would be those appearing first in the irrigation section. The fertilizer data for treatment one would be those appearing first in the fertilizer section. For the second treatment the same irrigation data are used but the second set of fertilizer data from the fertilizer section is used. For the fourth treatment, the second irrigation data set and the first fertilizer data set are used.

Details of all sections of FILEX are provided in Table 3. It should also be noted that not all entries within a particular section are required for all simulations. To facilitate construction of a typical FILEX, various examples are provided in the "Examples" section below.

Simulation Control Information

The Simulation Controls section (see Table 4) in FILEX has two basic functions. First, it specifies the options to be used in a particular simulation run and controls the types and frequencies of outputs to be obtained. An OPTIONS line specifies whether the water and nitrogen balances will be used and whether pest damage will be considered in the run. The METHODS line specifies the methods for computing processes such as evapotranspiration and photosynthesis. The MANAGEMENT line specifies whether different management operations, such as planting and irrigation, are to be based on recorded data as input in the FILEX or are to be simulated internally based on automatic management options specified in this section. The OUTPUTS line specifies the frequency of daily outputs and the types of outputs to write (such as summary, growth, water, nitrogen and pest). Since there are no default selections for the variables contained under Methods, Management and Outputs, selections for these variables *must* be made.

The second function of the Simulation Control section is to specify the parameters for controlling automatic management in the simulation (if any are used) for planting, irrigating, applying nitrogen and residues, and harvesting. For example, information on the "sowing" and 'harvesting" windows for use with hypothetical experiments, as well as the soil water threshold that triggers automatic application and the depth of water management, are contained in this section.

One Simulation Control section is required for each FILEX, and more than one could be used to control simulation for different treatments if needed.

TABLE 4. SIMULATION CONTROLS.

STRUCTURE

Variable	Variable Name[1]	Header[2]	Format[3]		
Line 1: General					
Level number	LNSIM	N	0	I	2
Identifier	TITCOM	GENERAL	1	C	11
Runs:					
Years	NYRS	NYERS	4	I	2
Replications	NREPSQ	NREPS	4	I	2
Start of Simulation, code:	ISIMI	START	5	C	1
Suggested codes:					
E = On reported emergence date					
I = When initial conditions measured					
P = On reported planting date					
S = On specified date					
Date, year + day (if needed)	YRSIM	SDATE	1	I	5
Random number seed	RSEED	RSEED	1	I	5
Title	TITSIM	SNAME	1	C	25
Line 2: Options					
Level number	LNSIM	N	0	I	2
Identifier	TITOPT	OPTIONS	1	C	11
Water (Y = yes; N = no)	ISWWAT	WATER	5	C	1
Nitrogen (Y = yes; N = no)	ISWNIT	NITRO	5	C	1
Symbiosis (Y= yes, N= no, U= unlimited N)	ISWSYM	SYMBI	5	C	1
Phosphorus (Y = yes; N = no)	ISWPHO	PHOSP	5	C	1
Potassium (Y = yes; N = no)	ISWPOT	POTAS	5	C	1
Diseases and other pests (Y = yes; N = no)	ISWDIS	DISES	5	C	1
(Y = simulate process; N = do not simulate process)					
Line 3: Methods					
Level number	LNSIM	N	0	I	2
Identifier	TITMET	METHODS	1	C	11
Weather	MEWTH	WTHER	5	C	1
M = Measured data, as recorded					
G = Simulated data, stored as *.WTG files					
S = Simulated data (Internal weather generator using monthly inputs)					
W = Simulated data (Internal WGEN weather generator)					
Initial Soil Conditions	MESIC	INCON	5	C	1
M = As reported					
S = Simulated outputs from previous model run					

Light interception	MELI	LIGHT	5	C	1
E = Exponential with LAI					
H = 'Hedgerow' calculations					
Evaporation	MEEVP	EVAPO	5	C	1
P = FAO - Penman					
R = Ritchie modification of Priestley-Taylor					
Infiltration	MEINF	INFIL	5	C	1
R = Ritchie method					
S = Soil Conservation Service routines					
Photosynthesis	MEPHO	PHOTO	5	C	1
C = Canopy photosynthesis response curve					
R = Radiation use efficiency					
L = Leaf photosynthesis response curve					

Line 4: Management

Level number	LNSIM	N	0	I	2
Identifier	TITMAT	MANAGEMENT	1	C	11
Planting/Transplanting	IPLTI	PLANT	5	C	1
A = Automatic when conditions satisfactory					
R = On reported date					
Irrigation and Water Management	IIRRI	IRRIG	5	C	1
A = Automatic when required					
N = Not irrigated					
F = Automatic with fixed amounts at each irrigation date					
R = On reported dates					
D = As reported, in days after planting					
Fertilization	IFERI	FERTI	5	C	1
A = Automatic when required					
N = Not fertilized					
F = Automatic with fixed amounts at each fertilization date					
R = On reported dates					
D = As reported, in days after planting					
Residue applications	IRESI	RESID	5	C	1
A = Automatic for multiple years/crop sequences					
N = No applications					
F = Automatic with fixed amounts at each residue application date					
R = On reported dates					
D = As reported, in days after planting					
Harvest	IHARI	HARVS	5	C	1
A = Automatic when conditions satisfactory					
G = At reported growth stage(s)					
M = At maturity					
R = On reported date(s)					
D = On reported days after planting					

Line 5: Outputs

Level number	LNSIM	N	0	I	2
Identifier	TITOUT	OUTPUTS	1	C	11
Experiment (Y = yes, files named with the experiment code; N = no)	IOX	FNAME	5	C	1
General (Y = yes, new; A = append; N = no)					
Overview	IDETO	OVVEW	5	C	1
Summary	IDETS	SUMRY	5	C	1
Details - individual aspects					
Frequency of output (days)	FROP	FROPT	4	I	2
Growth (Y = yes; N = no)	IDETG	GROUT	5	C	1
Carbon (Y = yes; N = no)	IDETC	CAOUT	5	C	1
Water (Y = yes; N = no)	IDETW	WAOUT	5	C	1
Nitrogen (Y = yes; N = no)	IDETN	NIOUT	5	C	1
Phosphorous (Y = yes; N = no)	IDETP	MIOUT	5	C	1
Diseases and other pests (Y = yes; N = no)	IDETD	DIOUT	5	C	1
Wide (Y) or 80-column (N) daily outputs	IDETL	LONG	5	C	1

Other lines

These deal separately with different aspects of automatic management. They are only necessary if automatic management is called for.

Planting:						
Level number	LNSIM	N	0	I	2	
Identifier	TITPLA	PLANTING	1	C	11	
Earliest, year and day of year (YRDOY)	PWDINF	PFRST	1	I	5	
Latest, year and day of year (YRDOY)	PWDINL	PLAST	1	I	5	
Lowermost soil water, %	SWPLTL	PH20L	1	R	5	0
Uppermost soil water, %	SWPLTH	PH2OU	1	R	5	0
Management depth for water, cm	SWPLTD	PH20D	1	R	5	0
Max. soil temp. (10 cm av.), °C	PTX	PSTMX	1	R	5	0
Min. soil temp. (10 cm av.), °C	PTTN	PSTMN	1	R	5	0
Irrigation and Water Management:						
Level number	LNSIM	N	0	I	2	
Identifier	TITIRR	IRRIGATION	1	C	11	
Management depth, cm	DSOIL	IMDEP	1	R	5	0
Threshold, % of maximum available	THETAC	ITHRL	1	R	5	0
End point, % of maximum available	IEPT	ITHRU	1	R	5	0
End of applications, growth stage	IOFF	IROFF	1	C	5	
Method, code	IAME	IMETH	1	C	5	
Amount per irrigation, if fixed, mm	AIRAMT	IRAMT	1	R	5	0
Irrigation application efficiency, fraction	EFFIRR	IREFF	1	R	5	2

Nitrogen Fertilization:						
Level number	LNSIM	N	0	I	2	
Identifier	TITNIT	NITROGEN	1	C	11	
Application depth, cm	DSOILN	NMDEP	1	R	5	0
Threshold, N stress factor, %	SOILNC	NMTHR	1	R	5	0
Amount per application, kg N ha^{-1}	SOILNX	NAMNT	1	R	5	0
Material, code	NCODE	NCODE	1	C	5	
End of applications, growth stage	NEND	NAOFF	1	C	5	
Residues:						
Level number	LNSIM	N	0	I	2	
Identifier	TITRES	RESIDUES	1	C	11	
Incorporation percentage, % of remaining	RIP	RIPCN	1	R	5	0
Incorporation time, days after harvest	NRESDL	RTIME	1	I	5	
Incorporation depth, cm	DRESMG	RIDEP	1	R	5	0
Harvests:						
Level number	LNSIM	N	0	I	2	
Identifier	TITHAR	HARVESTS	1	C	11	
Earliest, days after maturity	HDLAY	HFRST	1	I	5	
Latest, year and day of year (YRDOY)	HLATE	HLAST	1	I	5	
Percentage of product harvested, %	HPP	HPCNP	1	R	5	0
Percentage of residue harvested, %	HRP	HRCNR	1	R	5	0

[1] *Abbreviations used as variable names in the IBSNAT models.*

[2] *Abbreviations suggested for use in header lines (those designated with '@') within the file.*

[3] *Formats are presented as follows: number of leading spaces, variable type (Character = C, Real = R, Integer - I), variable width, and (if real) number of decimals.*

Examples of FILEX for Various Experiments

The examples chosen below commence with the most simple experiment where only a minimum set of data are required and end with a soil fertility simulation experiment where the simulation models require considerably more data.

Experiment 1 (Potential Yield)

Users may wish to examine the impact of weather on crop duration and yield potential of two varieties of soybean at two sites with no water, nutrient or pest constraints. For this experiment the only data required in FILEX are the experiment and treatment titles and codes for the variety, soil, a weather data set, planting data and simulation controls. The codes for variety and soil must also be contained in the cultivar and soil files, respectively, so that crop models can obtain the genetic coefficients for the planted variety and the soil inputs for the soil in which the crop was grown. The file name for weather data is required, e.g., UFGA8801.WTH. Alternately, the code for weather data can be specified to construct a file name which contains daily weather data in the DSSAT v3 crop models, e.g., the code UFGA for the weather station would result in the file name of UFGA8801.WTH if the experiment were planted in 1988. An example FILEX for this experiment is given in Table 5 and the required data are highlighted. Note the default settings used in the Simulation Controls section.

Table 5. Example FILEX for a Potential Yield Experiment in Which There Are Two Varieties of Soybean Grown in Two Locations. The File Name for Storing this Experiment Information Would Be UFGA9101.SBX.

```
*EXP.DETAILS: UFGA9101SB SOYBEAN POTENTIAL YIELD, 2 VARIETIES, 2 SITES (EXAMPLE)

*GENERAL
@PEOPLE
 A. B. HOWART AND K. T. BARTH
@ADDRESS
 DEPARTMENT OF AGRONOMY, THE UNIVERSITY OF FLORIDA
@SITE
 GAINESVILLE,FLORIDA,ANDHONOLULU,HAWAII
@ PAREA  PRNO  PLEN  PLDR  PLSP  PLAY HAREA  HRNO  HLEN HARM..........
   30.0     4  15.0     0    50 N-S    10.0    10   2.0 Hand Harvest
@NOTES
 Example experiment with 2 varieties at 2 locations.  BRAGG and COBB
 soybeans are planted at Gainesville, Florida in field UFGA0001, weather
 station UFGA and soil UFGA9101, and planted at Honolulu, Hawaii, in field
 IBUH0001, weather station IBUH in soil IBUH8801

*TREATMENTS                        -------------FACTOR LEVELS------------
@N R O C TNAME.................... CU FL SA IC MP MI MF MR MC MT ME MH SM
 1 1 0 0 BRAGG AT GAINESVILLE       1  1  0  0  1  0  0  0  0  0  0  0  1
 2 1 0 0 BRAGG AT HAWAII            1  2  0  0  1  0  0  0  0  0  0  0  1
 3 1 0 0 COBB AT GAINESVILLE        2  1  0  0  1  0  0  0  0  0  0  0  1
 4 1 0 0 COBB AT HAWAII             2  2  0  0  1  0  0  0  0  0  0  0  1

*CULTIVARS
@C CR INGENO CNAME
 1 SB UF0001 BRAGG
 2 SB UF0002 COBB

*FIELDS
@L ID_FIELD WSTA....  FLSA  FLOB  FLDT  FLDD  FLDS  FLST  SLTX  SLDP  ID_SOIL
 1 UFGA0001 UFGA     90-N     0 DR001     0     0     0  SA     180 UFGA9101
 2 IBUH0001 IBUH     30-N     0 DR001     0     0     0  SALO   200 IBUH8801

*PLANTING DETAILS
@P PDATE EDATE  PPOP  PPOE  PLME  PLDS  PLRS  PLRD  PLDP  PLWT  PAGE  PENV  PLPH
 1 91177        30.0  30.0     S     R    75     0   4.0   -99   -99 -99.0 -99.0
```

```
*SIMULATION CONTROLS
@N GENERAL      NYERS NREPS START SDATE RSEED SNAME....................
 1                  1     1     S 91177  2150 POTENTIAL YIELD
@N OPTIONS      WATER NITRO SYMBI PHOSP POTAS DISES
 1                  N     N     N     N     N     N
@N METHODS      WTHER INCON LIGHT EVAPO INFIL PHOTO
 1                  M     M     E     R     S     C
@N MANAGEMENT   PLANT IRRIG FERTI RESID HARVS
 1                  R     N     N     N     M
@N OUTPUTS      XCODE OVVEW SUMRY FROPT GROTH CARBN WATER NITRO MINER DISES  LONG
 1                  N     Y     Y     3     Y     N     N     N     N     N     N

@  AUTOMATIC MANAGEMENT
@N PLANTING     PFRST PLAST PH2OL PH2OU PH2OD PSTMX PSTMN
 1                155   200    40   100    30    40    10
@N IRRIGATION   IMDEP ITHRL ITHRU IROFF IMETH IRAMT IREFF
 1                 30    50   100 GS000 IR001    10  1.00
@N NITROGEN     NMDEP NMTHR NAMNT NCODE NAOFF
 1                 30    50    25 FE001 GS000
@N RESIDUES     RIPCN RTIME RIDEP
 1                100     1    20
@N HARVEST      HFRST HLAST HPCNP HPCNR
 1                  0   365   100     0
```

EXPERIMENT 2 (CLIMATE CHANGE STUDY)

If users wish to determine the effects of a 4°C temperature increase on yield of the crops in Experiment 1 described above, a section on Environmental Modification would be added to FILEX. As shown in Table 6, which illustrates an example FILEX for this experiment, the same 4 treatments from Experiment 1 are included, then 4 additional treatments are specified with the Environmental Modification level set to 1 under the Factor Levels in the Treatments section. In the Environmental Modification section, an entry is made to specify that 4°C is added to both daily minimum and maximum temperatures starting on the day of planting. In this hypothetical experiment, which is to be simulated, there are still no water, nutrient or pest stresses, and the soil water and nitrogen balances are still not used. The settings for the Simulation Controls section remain the same as those given in the example FILEX for "Experiment 1" (Table 5).

Table 6. Example FILEX for a Climate Change Experiment in Which Maximum and Minimum Daily Temperature Are Raised 4 °C, And There Are 2 Varieties of Soybean Grown in Two Locations. The File Name for Storing this Experiment Information Would Be UFGA9102.SBX.

```
*EXP.DETAILS: UFGA9102SB SOYBEAN CLIMATE CHANGE : 2 VARIETIES, 2 SITES (EXAMPLE2)

*GENERAL
@PEOPLE
 A. B. HOWART AND K. T. BARTH
@ADDRESS
 DEPARTMENT OF AGRONOMY, THE UNIVERSITY OF FLORIDA
@SITE
 GAINESVILLE,FLORIDA,ANDHONOLULU,HAWAII
@ PAREA  PRNO  PLEN  PLDR  PLSP  PLAY HAREA  HRNO  HLEN HARM..........
   30.0     4  15.0     0    50 N-S    10.0    10   2.0 Hand Harvest
@NOTES
 This is a climate change experiment with 2 varieties at 2 locations
 Varieties BRAGG and COBB are planted at Gainesville, Florida in field
 UFGA0001, weather station site UFGA and soil UFGA9101, and at Honolulu,
 Hawaii, in field IBUH0001, weather station site IBUH in soil IBUH8801.
 Max. and Min. temperature are increased at 4C.

*TREATMENTS                        -------------FACTOR LEVELS------------
@N R O C TNAME.................... CU FL SA IC MP MI MF MR MC MT ME MH SM
 1 1 0 0 BRAGG AT GAINESVILLE       1  1  0  0  1  0  0  0  0  0  0  0  1
 2 1 0 0 BRAGG AT HAWAII            1  2  0  0  1  0  0  0  0  0  0  0  1
 3 1 0 0 COBB AT GAINESVILLE        2  1  0  0  1  0  0  0  0  0  0  0  1
 4 1 0 0 COBB AT HAWAII             2  2  0  0  1  0  0  0  0  0  0  0  1
 5 1 0 0 +4 C, BRAGG AT GAINESVILL  1  1  0  0  1  0  0  0  0  0  1  0  1
 6 1 0 0 +4 C, BRAGG AT HAWAII      1  2  0  0  1  0  0  0  0  0  1  0  1
 7 1 0 0 +4 C, COBB AT GAINESVILLE  2  1  0  0  1  0  0  0  0  0  1  0  1
 8 1 0 0 +4 C, COBB AT HAWAII       2  2  0  0  1  0  0  0  0  0  1  0  1

*CULTIVARS
@C CR INGENO CNAME
 1 SB UF0001 BRAGG
 2 SB UF0002 COBB

*FIELDS
@L ID_FIELD WSTA....  FLSA  FLOB  FLDT  FLDD  FLDS  FLST  SLTX  SLDP  ID_SOIL
 1 UFGA0001 UFGA      90-N     0 DR001     0     0     0  SA     180 UFGA9101
 2 IBUH0001 IBUH      30-N     0 DR001     0     0     0  SALO   200 IBUH8801
```

```
*PLANTING DETAILS
@P PDATE EDATE  PPOP  PPOE  PLME  PLDS  PLRS  PLRD  PLDP  PLWT  PAGE  PENV  PLPH
 1 91177        30.0  30.0 S     R       75     0   4.0   -99   -99 -99.0 -99.0

*ENVIRONMENTAL MODIFICATIONS
@E ODATE EDAY  ERAD  EMAX  EMIN  ERAIN  ECO2  EDEW EWIND
 1 91177 A 0.0 A 0.0 A 4.0 A 4.0 A 0.0 A   0 A 0.0 A 0.0

*SIMULATION CONTROLS
@N GENERAL     NYERS NREPS START SDATE RSEED SNAME....................
 1                 1     1     S 91177  2150 CLIMATE CHANGE SIMULATION
@N OPTIONS     WATER NITRO SYMBI PHOSP POTAS DISES
 1                 N     N     N     N     N     N
@N METHODS     WTHER INCON LIGHT EVAPO INFIL PHOTO
 1                 M     M     E     R     S     C
@N MANAGEMENT  PLANT IRRIG FERTI RESID HARVS
 1                 R     N     N     N     M
@N OUTPUTS     FNAME OVVEW SUMRY FROPT GROUT CAOUT WAOUT NIOUT MIOUT DIOUT  LONG
 1                 N     Y     Y     3     Y     N     N     N     N     N     N

@  AUTOMATIC MANAGEMENT
@N PLANTING    PFRST PLAST PH2OL PH2OU PH2OD PSTMX PSTMN
 1               155   200    40   100    30    40    10
@N IRRIGATION  IMDEP ITHRL ITHRU IROFF IMETH IRAMT IREFF
 1                30    50   100 GS000 IR001    10  1.00
@N NITROGEN    NMDEP NMTHR NAMNT NCODE NAOFF
 1                30    50    25 FE001 GS000
@N RESIDUES    RIPCN RTIMF RIDEP
 1               100     1    20
@N HARVEST     HFRST HLAST HPCNP HPCNR
 1                 0   365   100     0
```

Experiment 3 (Irrigation Studies)

In this example, one variety of maize is planted on 2 different dates, with and without irrigation in a factorial arrangement. Table 7 shows the corresponding example FILEX with the 4 treatments. Note that there are 2 entries in the Planting section and 2 entries in the Irrigation section since the date for the second planting is different from that of the first planting. Also in this example, there is an Initial Conditions section with initial values of soil water. The "-99" values in the initial NO_3 and NH_4 columns indicate that initial values of soil nitrogen were not taken. Because the soil nitrogen balance is switched off in the Simulation Controls section, this will not affect results. Also note that the water balance is switched on in the Simulation Controls section as indicted by the "Y" under WATER in Options, and that the switch for irrigation management in the Simulation Controls section is "R" under IRRIG in Management, which means that reported field data are to be used in the simulation. Output controls specify that the overview, summary, daily growth, and daily water outputs are to be produced with 3 day intervals.

TABLE 7. EXAMPLE FILEX FOR A MAIZE IRRIGATION EXPERIMENT. THE FILE NAME FOR STORING FHIS EXPERIMENT INFORMATION WOULD BE UFGA8101.MZX.

```
*EXP.DETAILS: UFGA8101MZ MAIZE EXPERIMENT, IRR. AND NON-IRR. (EXAMPLE3)

*GENERAL
@PEOPLE
 DR. J. BENNETT
@ADDRESS
 GAINESVILLE, FLORIDA
@SITE
  GAINESVILLE,FL 29.63N;82.37W;40M;SE-USA
@ PAREA  PRNO  PLEN  PLDR  PLSP  PLAY HAREA  HRNO  HLEN HARM..........
   30.0     4  15.0     0    50 N-S   10.0    10   2.0 Hand harvest
@NOTES
 This is a maize irrigation experiment, conducted at Gainesville, Florida,
 using the variety Pioneer 304C with 4 treatments :
 2 irrigation levels and 2 planting dates

*TREATMENTS                        -------------FACTOR LEVELS------------
@N R O C TNAME.................... CU FL SA IC MP MI MF MR MC MT ME MH SM
 1 1 0 0 IRRIG, PL-DAY 177 PI304C   1  1  0  1  1  1  0  0  0  0  0  0  1
 2 1 0 0 NON-IRR,PL-DAY 177,PIO304  1  1  0  1  1  0  0  0  0  0  0  0  1
 3 1 0 0 IRRIG, PL-DAY 195 PI304C   1  1  0  2  2  2  0  0  0  0  0  0  1
 4 1 0 0 NON-IRR,PL-DAY 195, PIO30  1  1  0  2  2  0  0  0  0  0  0  0  1

*CULTIVARS
@C CR INGENO CNAME
 1 MZ UF0001 PI304C

*FIELDS
@L ID_FIELD WSTA....  FLSA  FLOB  FLDT  FLDD  FLDS  FLST  SLTX  SLDP  ID_SOIL
 1 UFGA0001 UFGA     90-N     0 DR001     0     0     0  LOSA   180 UFGA7701

*INITIAL CONDITIONS
@C   PCR ICDAT  ICRT  ICND  ICRN  ICRE
 1    SB 81177   100     0  1.00  1.00
@C  ICBL  SH2O  SNH4  SNO3
 1     5 0.086 -99.0 -99.0
 1    15 0.086 -99.0 -99.0
 1    30 0.086 -99.0 -99.0
 1    45 0.086 -99.0 -99.0
 1    60 0.086 -99.0 -99.0
 1    90 0.076 -99.0 -99.0
 1   120 0.076 -99.0 -99.0
 1   150 0.130 -99.0 -99.0
 1   180 0.258 -99.0 -99.0
```

```
@C   PCR ICDAT  ICRT  ICND  ICRN  ICRE
 2    SB 81195   100     0  1.00  1.00
@C  ICBL  SH2O  SNH4  SNO3
 2     5 0.070 -99.0 -99.0
 2    15 0.080 -99.0 -99.0
 2    30 0.077 -99.0 -99.0
 2    45 0.080 -99.0 -99.0
 2    60 0.080 -99.0 -99.0
 2    90 0.076 -99.0 -99.0
 2   120 0.055 -99.0 -99.0
 2   150 0.110 -99.0 -99.0
 2   180 0.198 -99.0 -99.0

*PLANTING DETAILS
@P PDATE EDATE  PPOP  PPOE  PLME  PLDS  PLRS  PLRD  PLDP  PLWT  PAGE  PENV  PLPH
 1 81177         9.5   9.5 S     R      100     0   4.0   -99   -99 -99.0 -99.0
 2 8 195         9.5   9.5 S     R      100     0   4.0   -99   -99 -99.0 -99.0

*IRRIGATION AND WATER MANAGEMENT
@I  IEFF  IDEP  ITHR  IEPT  IOFF  IAME  IAMT
 1  1.00    30    50   100 GS000 IR001    15
@I IDATE  IROP  IRVAL
 1 81204 IR001    19
 1 81211 IR001    20
 1 81227 IR001    20
 1 81239 IR001    20
 1 81249 IR001    20
@I  EFIR  IDEP  ITHR  IEPT  IOFF  IAME  IAMT
 2  1.00    30    50   100 IB001 IB001    15
@I IDATE  IROP  IRVAL
 2 81211 IR001    20
 2 81227 IR001    20
 2 81239 IR001    20
 2 81249 IR001    20
 2 81258 IR001    30

*SIMULATION CONTROLS
@N GENERAL     NYERS NREPS START SDATE RSEED SNAME....................
 1                 1     1     S 81177  2150 MAIZE - IRRIGATION
@N OPTIONS     WATER NITRO SYMBI PHOSP POTAS DISES
 1                 Y     N     N     N     N     N
@N METHODS     WTHER INCON LIGHT EVAPO INFIL PHOTO
 1                 M     M     E     R     S     C
@N MANAGEMENT  PLANT IRRIG FERTI RESID HARVS
 1                 R     R     N     N     M
@N OUTPUTS     FNAME OVVEW SUMRY FROPT GROUT CAOUT WAOUT NIOUT MIOUT DIOUT  LONG
 1                 N     Y     Y     3     Y     N     Y     N     N     N     N
```

```
@  AUTOMATIC MANAGEMENT
@N PLANTING     PFRST PLAST PH2OL PH2OU PH2OD PSTMX PSTMN
 1                155   200    40   100    30    40    10
@N IRRIGATION   IMDEP ITHRL ITHRU IROFF IMETH IRAMT IREFF
 1                 30    50   100 GS000 IR001    10  1.00
@N NITROGEN     NMDEP NMTHR NAMNT NCODE NAOFF
 1                 30    50    25 FE001 GS000
@N RESIDUES     RIPCN RTIME RIDEP
 1                100     1    20
@N HARVEST      HFRST HLAST HPCNP HPCNR
 1                  0   365   100     0
```

Experiment 4 (Fertilizer and Irrigation Studies)

In this final example, a maize crop is to be grown with and without irrigation, and with 3 N fertilizer amounts (0, 50, and 100 kg N/ha). In Table 8, the example FILEX shows that Fertilizer and Residue sections have been added. The Residue section has only one entry, which means that all treatments had the same residue management history. In the Fertilizer section, there are 2 entries to specify the 50 and 100 kg N/ha application levels. An entry was not required for the 0 kg N/ha. Treatments 2, 4, and 6 were not irrigated, as indicated by the 0's in the MI column, and treatments 1, 3, and 5 all had the same irrigation schedule. For example, Treatment 5 had 50 kg N/ha applied and was irrigated 5 times. In the Simulation Controls section, the water and nitrogen balances were both turned on as indicated by the "Y" under WATER and NITRO in Options. This example does not show a Soil Analysis section, since soil samples were collected from the field for organic carbon, phosphorus, etc., and used to replace the values in the soil file which may have been collected from another site. In this example, recorded data were selected in the Simulation Controls section in Management as shown by the irrigation section switched to "R" under IRRIG. If no irrigation data are available, then the user can select the simulated irrigation management option ("A" or "R") which are both automatic. If the automatic ("A") option for fertilizer or irrigation is specified in Management in the Simulation Controls section, then the model determines when management applications for these are made. In that case, the user should specify the set points on when and how much irrigation and/or fertilizer are applied and the method used to apply them.

TABLE 8. EXAMPLE FILEX FOR A MAIZE IRRIGATION AND NITROGEN LEVEL EXPERIMENT. THE FILE NAME FOR STORING THIS EXPERIMENT INFORMATION WOULD BE UFGA8102.MZX.

```
*EXP.DETAILS: UFGA8102MZ MAIZE EXPERIMENT, IRR. AND NITROGEN (EXAMPLE4)

*GENERAL
@PEOPLE
 DR. K. J. BOOTE
@ADDRESS
 DEPARTMENT OF AGRONOMY, UNIV. OF FLORIDA, GAINESVILLE
@SITE
 IRRIGATION PARK,GAINESVILLE,FLORIDA 29.63N;82.37W;40M;SE-USA
@ PAREA  PRNO  PLEN  PLDR  PLSP  PLAY HAREA  HRNO  HLEN HARM..........
   60.0     6  10.0     0   100 N-S    20.0    10   2.0 Hand harvest
@NOTES
 This is a maize irrigation experiment, conducted at Gainesville, Florida,
 using the variety Pioneer 304C with 4 treatments :
 2 irrigation levels and 2 planting dates

*TREATMENTS                        -------------FACTOR LEVELS------------
@N R O C TNAME.................... CU FL SA IC MP MI MF MR MC MT ME MH SM
 1 1 0 0 IRRIG,  0 N                1  1  0  1  1  1  0  1  0  0  0  0  1
 2 1 0 0 NON-IRRIG, 0 N             1  1  0  1  1  0  0  1  0  0  0  0  1
 3 1 0 0 IRRIG, 50 KG/HA N          1  1  0  1  1  1  1  1  0  0  0  0  1
 4 1 0 0 NON-IRRIG, 50 KG/HA        1  1  0  1  1  0  1  1  0  0  0  0  1
 5 1 0 0 IRRIG, 100 KG/HA           1  1  0  1  1  1  2  1  0  0  0  0  1
 6 1 0 0 NON-IRRIG, 100 KG/HA       1  1  0  1  1  0  2  1  0  0  0  0  1

*CULTIVARS
@C CR INGENO CNAME
 1 MZ UF0001 PI304C

*FIELDS
@L ID_FIELD WSTA....  FLSA  FLOB  FLDT  FLDD  FLDS  FLST  SLTX  SLDP  ID_SOIL
 1 UFGA0001 UFGA     90-N     0 DR001     0     0     0  LOSA   180 UFGA7701

*INITIAL CONDITIONS
@C   PCR ICDAT  ICRT  ICND  ICRN  ICRE
 1    SB 81177   100     0 1.00  1.00
@C  ICBL  SH2O  SNH4  SNO3
 1     5 0.086   0.6   1.5
 1    15 0.086   0.6   1.5
 1    30 0.086   0.6   1.5
 1    45 0.086   0.6   1.5
 1    60 0.086   0.6   1.5
 1    90 0.076   0.6   0.6
 1   120 0.076   0.6   0.5
```

```
 1   150 0.130    0.6    0.5
 1   180 0.258    0.6    0.5

*PLANTING DETAILS
@P PDATE EDATE  PPOP  PPOE  PLME  PLDS  PLRS  PLRD  PLDP  PLWT  PAGE  PENV  PLPH
 1 81177         9.5   9.5 S     R      100     0   4.0   -99   -99 -99.0 -99.0

*IRRIGATION AND WATER MANAGEMENT
@I  IEFF  IDEP  ITHR  IEPT  IOFF  IAME  IAMT
 1  1.00    30    50   100 IB001 IB001    15
@I IDATE  IROP  IRVAL
 1 81204 IR001    19
 1 81211 IR001    20
 1 81227 IR001    20
 1 81239 IR001    20
 1 81249 IR001    20

*FERTILIZERS (INORGANIC)
@F FDATE  FMCD  FACD  FDEP  FAMN  FAMP  FAMK  FAMC  FAMO  FOCD
 1 81177 FE005 AP001    10    50     0     0     0     0     0
 2 81177 FE005 AP001    10   100     0     0     0     0     0

*RESIDUES AND OTHER ORGANIC MATERIALS
@R RDATE  RCOD  RAMT  RESN  RESP  RESK  RINP  RDEP
 1 81177 RE001  1000  0.80  0.00  0.00   100    15

*SIMULATION CONTROLS
@N GENERAL     NYERS NREPS START SDATE RSEED SNAME....................
 1                 1     1     S 81177  2150 MAIZE-IRRIG & NITROGEN
@N OPTIONS     WATER NITRO SYMBI PHOSP POTAS DISES
 1                 Y     Y     N     N     N     N
@N METHODS     WTHER INCON LIGHT EVAPO INFIL PHOTO
 1                 M     M     E     R     S     C
@N MANAGEMENT  PLANT IRRIG FERTI RESID HARVS
 1                 R     R     R     R     M
@N OUTPUTS     FNAME OVVEW SUMRY FROPT GROUT CAOUT WAOUT NIOUT MIOUT DIOUT  LONG
 1                 N     Y     Y     3     Y     Y     Y     Y     N     N     N

@  AUTOMATIC MANAGEMENT
@N PLANTING    PFRST PLAST PH2OL PH2OU PH2OD PSTMX PSTMN
 1               155   200    40   100    30    40    10
@N IRRIGATION  IMDEP ITHRL ITHRU IROFF IMETH IRAMT IREFF
 1                30    50   100 GS000 IR001    10  1.00
@N NITROGEN    NMDEP NMTHR NAMNT NCODE NAOFF
 1                30    50    25 FE001 GS000
@N RESIDUES    RIPCN RTIME RIDEP
 1               100     1    20
@N HARVEST     HFRST HLAST HPCNP HPCNR
 1                 0   365   100     0
```

Weather Data File

Daily weather data are required and must be available for the duration of the growing season, beginning with the day of planting and ending at crop maturity. Ideally, the weather file (FILEW) should contain data collected from before planting to after maturity. This would allow a simulation to be started before planting, thus providing an estimate of soil conditions at planting time. Additional weather data would also allow users to select alternate planting dates, simulate planting decisions based on weather and soil conditions, and simulate longer duration crop cultivars for model sensitivity analysis.

These files should be named according to the file naming convention described previously in the section entitled "File Naming Conventions." The first lines in each weather data file, regardless of file length, contain some details of the site (name, country, annual average temperature and amplitude of its monthly averages, latitude and longitude, elevation). On all subsequent lines, there could be 8 variables, 7 of which are different weather aspects. It is not necessary to have data for all variables, but the minimum data required for DSSAT v3 crop models are solar radiation, minimum and maximum air temperature and rainfall. The standard format for variables should be followed. The structure of the file and an abbreviated example is shown in Table 9. The file as presented is similar to the standard weather data file used by IBSNAT models in DSSAT v2.1 (IBSNAT, 1989), but scope for more variables has been added. The DSSAT v2.1 files only included total solar radiation, maximum and minimum air temperature, and precipitation.

TABLE 9. WEATHER DATA FILE. (FILEW)

STRUCTURE

Variable	Variable Name[1]	Header[2]	Format[3]
Line 1			
*WEATHER :		0	C 10
Site + country name		1	C 60
Line 2			
Institute code	INSTE	IN	2 C 2
Site code	SITEE	SI	0 C 2
Latitude, degrees (decimals)	XLAT	LAT	1 R 8 3
Longitude, degrees (decimals)	XLONG	LONG	1 R 8 3
Elevation, m	ELEV	ELEV	1 R 5 0
Air temperature average, °C	TAV	TAV	1 R 5 1
Air temperature amplitude, monthly averages, °C	TAMP	AMP	1 R 5 1
Height of temperature measurements, m	REFHT	TMHT	1 R 5 1
Height of wind measurements, m	WNDHT	WMHT	1 R 5 1
All other lines			
Year + days from Jan. 1	YRDOYW	DATE	0 I 5
Solar radiation, MJ m^{-2} day^{-1}	SRAD	SRAD	1 R 5 1
Air temperature maximum, °C	TMAX	TMAX	1 R 5 1
Air temperature minimum, °C	TMIN	TMIN	1 R 5 1
Precipitation, mm	RAIN	RAIN	1 R 5 1
Dewpoint temperature[5], °C	TDEW	DEWP	1 R 5 1
Wind run[5], km day^{-1}	WINDSP	WIND	1 R 5 1
Photosynthetic active radiation (PAR)[5], moles m^{-2} day^{-1}	PAR	PAR	1 R 5 1

1 *Abbreviations used as variable names in the IBSNAT models.*

2 *Abbreviations suggested for use in header lines (those designated with '@') within the file.*

3 *Formats are presented as follows: number of leading spaces, variable type (Character = C, Real = R, Integer = I), variable width, and (if real) number of decimals.*

4 *The blank space following a weather variable can be used to place a "flag," which would indicate an estimated value had replaced missing or suspect data. (e.g., UFGAE 29.6 32.6...), where 'E' is the "flag" indicating the data item following it (i.e,'29.6') is an error value. In this example, since no "flag" preceeds the 32.6', this number is a reported value. (See Appendix D for a full listing of Weather Flags.)*

5 *Optional data, which are used by crop models for some options but are not necessary.*

EXAMPLE WEATHER DATA FILE. (FILEW = "UFGA7801.WTH")

```
*WEATHER : GAINESVILLE,FLORIDA,U.S.A
@ INSI      LAT     LONG  ELEV   TAV   AMP REFHT WNDHT
  UFGA   29.630  -82.370    40  20.9   7.4   1.5   2.0
@DATE  SRAD  TMAX  TMIN  RAIN
78001   5.3  18.3  13.3   4.8
78002  11.1  18.3   8.3   0.0
78003  14.7  13.9   3.3   0.0
78004  14.4  19.4   0.0   0.0
78005  10.9  23.9   6.7   0.0
78006  10.8  25.6  11.1   0.0
78007   9.5  25.0   9.4   0.0
78008   3.1  23.9  15.6  10.4
78009  16.3  18.3   1.1  25.1
78010  15.7   8.9  -3.9   0.0
78011  15.4  11.7  -2.8   0.0
78012   7.2  19.4   1.7   0.0
78013  10.9  20.0  13.3  27.9
78014  11.4  14.4   3.3   0.0
78015  14.2   7.8  -3.3   0.0
78016  13.2  16.1  -3.9   0.0
78017  10.4  21.7   9.4   4.8
78018  15.0  21.7   6.7   0.0
78019   0.6  19.4   8.9  71.9
78020   4.3  16.7   7.2   6.9
78021  10.4  10.0   1.1   0.0
78022  13.4  16.7   1.1   0.0
78023   6.6  16.7   7.8   0.0
78024  10.7  23.3   5.6   0.0
78025   7.4  26.1  16.7   0.0
78026  17.1  25.6   6.1   5.6
78027   7.4  12.2   0.0   0.0
78028  15.9  11.1  -1.1   0.0
78029  17.4  10.6  -4.4   0.0
78030  16.2  12.2  -3.3   0.0
78031   3.8  12.2   4.4   0.0
```

Soil Data File

The soil file (FILES) contains data on the soil profile properties. These data are used in the soil water, nitrogen, phosphorus and root growth sections of the crop models. The file generally contains information that is available for the soil at a particular experimental site, and supplementary information extracted from a soil survey database for a soil of the same taxonomic classification as the soil at the experimental site. Occasionally, when a detailed soil analysis has been performed at the experimental site, the file will contain no information from a survey database.

In FILES, the first line of data contains the soil identifiers, information on soil texture and depth, a description that could equate to the soil classification according to a specified, locally used system (such as the Canadian soil classification system), and the country. The second line contains geographic data together with taxonomic information presented according to Soil Taxonomy (Soil Survey Staff, 1975). The third line contains information on soil properties that do not vary with depth, such as surface albedo, and on measurement techniques. The fourth line contains data on the first layer; the fifth line on the second layer, and so on for each succeeding layer in the soil profile. The second tier of information for the soil layers is optional and contains variables related to the soil phosphorus balance, and other nutrients. Soil organic carbon is included in this file because it is frequently used to compute other soil properties. The percentage of sand is assumed to be 100 minus the percentages of clay and silt, and thus is not included as an input. The number of layers, and the thickness of each layer should be the same as those in the soil analysis and initial conditions sections of the experiment file whenever possible. The file may contain properties for several soils of the same classification, providing each soil has its own code number. The data for each soil are simply appended to the file. The structure of the file and a truncated example are shown in Table 10.

The data in the soils file are arranged so that entries need be made only for the aspects simulated. For example, if only water aspects are to be simulated, only those variables described as physical characteristics need be supplied. If only water and nitrogen aspects are to be simulated, then the physical, N and pH variables need to be entered. If phosphorus is to be considered, then all these latter variables plus all P variables must be entered.

TABLE 10. SOIL DATA FILE. (FILES)

STRUCTURE

Variable	Variable Name[1]	Header[2]	Format[3]
Line 1			
*SOILS:			0 C 10
Institute + country name			1 C 70
Subsequent lines relate to sections, as follows:			
Line 1			
Identifier (Institute + Site + Year + Soil)	PEDON	ID_SOIL	1 C 10
Source	SLSOUR	SLSOURCE	2 C 11
Texture, code[4]	SLTX	SLTX	1 C 5
Depth, cm	SLDP	SLDP	1 R 5 0
Description or local classification	SLDESC	SLDESCRIP	1 C 50
Line 2			
Site name	SSITE	SITE	1 C 11
Country name	SCOUNT	COUNTRY	1 C 11
Latitude	SLAT	LAT	1 R 8 3
Longitude	SLONG	LONG	1 R 8 3
Family, SCS system	TACON	SCSFAMILY	1 C 50
Line 3			
Color, moist, Munsell hue	SCOM	SCOM	1 C 5
Albedo, fraction	SALB	SALB	1 R 5 2
Evaporation limit, cm	U	SLU1	1 R 5 0
Drainage rate, fraction day^{-1}	SWCON	SLDR	1 R 5 2
Runoff curve number (Soil Conservation Service)	CN2	SLRO	1 R 5 0
Mineralization factor, 0 to 1 scale	SLNF	SLNF	1 R 5 2
Photosynthesis factor, 0 to 1 scale	SLPF	SLPF	1 R 5 2
pH in buffer determination method, code[4]	SMHB	SMHB	1 C 5
Phosphorus, extractable, determination code[4]	SMPX	SMPX	1 C 5
Potassium determination method, code[4]	SMKE	SMKE	1 C 5
Line 4 + (NL-1), where NL = number of layers. (L = Layer number)			
Depth, base of layer, cm	ZLYR(L)	SLB	1 R 5 0
Master horizon	MH(L)	SLMH	1 C 5
Lower limit, $cm^3\ cm^{-3}$	LL(L)	SLLL	1 R 5 3
Upper limit, drained, $cm^3\ cm^{-3}$	DUL(L)	SDUL	1 R 5 3

Upper limit, saturated, $cm^3\ cm^{-3}$	SAT(L)	SSAT	1 R 5 3
Root growth factor, 0.0 to 1.0	SHF(L)	SRGF	1 R 5 2
Sat. hydraulic conductivity, macropore, $cm\ h^{-1}$	SWCN(L)	SSKS	1 R 5 1
Bulk density, moist, $g\ cm^{-3}$	BD(L)	SBDM	1 R 5 2
Organic carbon, %	OC(L)	SLOC	1 R 5 2
Clay (<0.002 mm), %	CLAY(L)	SLCL	1 R 5 1
Silt (0.05 to 0.002 mm), %	SILT(L)	SLSI	1 R 5 1
Coarse fraction (>2 mm), %	STONES(L)	SLCF	1 R 5 1
Total nitrogen, %	TOTN(L)	SLNI	1 R 5 2
pH in water	PH(L)	SLHW	1 R 5 1
pH in buffer	PHKCL(L)	SLHB	1 R 5 1
Cation exchange capacity, $cmol\ kg^{-1}$	CEC(L)	SCEC	1 R 5 1

Line 4 + NL to (4 + NL + (NL - 1)), where NL = number of layers.
(L = Layer number)

Depth, base of layer, cm	ZZLYR(L)	SLB	1 R 5 0
Phosphorus, extractable, $mg\ kg^{-1}$	EXTP(L)	SLPX	1 R 5 1
Phosphorus, total, $mg\ kg^{-1}$	TOTP(L)	SLPT	1 R 5 1
Phosphorus, organic, $mg\ kg^{-1}$	ORGP(L)	SLPO	1 R 5 1
$CaCO_3$ content, $g\ kg^{-1}$	CACO(L)	SLCA	1 R 5 1
Aluminum	EXTAL(L)	SLAL	1 R 5 1
Iron	EXTFE(L)	SLFE	1 R 5 1
Manganese	EXTMN(L)	SLMN	1 R 5 1
Base saturation, $cmol\ kg^{-1}$	TOTBAS(L)	SLBS	1 R 5 1
Phosphorus isotherm A, $mmol\ kg^{-1}$	PTERMA(L)	SLPA	1 R 5 1
Phosphorus iostherm B, $mmol\ kg^{-1}$	PTERMB(L)	SLPB	1 R 5 1
Potassium, exchangeable, $cmol\ kg^{-1}$	EXK(L)	SLKE	1 R 5 1
Magnesium, $cmol\ kg^{-1}$	EXMG(L)	SLMG	1 R 5 1
Sodium, $cmol\ kg^{-1}$	EXNA(L)	SLNA	1 R 5 1
Sulfur	EXTS(L)	SLSU	1 R 5 1
Electric conductivity, seimen	SLEC(L)	SLEC	1 R 5 1

[1] *Abbreviations used as variable names in the IBSNAT models.*

[2] *Abbreviations suggested for use in header lines (those designated with '@') within the file.*

[3] *Formats are presented as follows: number of leading spaces, variable type (Character = C, Real = R, Integer = I), variable width, and (if real) number of decimals.*

[4] *For a complete listing of these codes, see Appendix B.*

EXAMPLE SOIL DATA FILE. (FILES = "SOIL.SOL")

```
*SOIL INPUT FILE

*IBMZ910014  SCS          FSA     180 Millhopper Fine Sand
@SITE        COUNTRY          LAT     LONG SCS FAMILY
 Gainesville USA            29.63   -82.37 Loamy,silic,hyperth Arenic Paleudult ( 14)
@ SCOM  SALB  SLU1  SLDR  SLRO  SLNF  SLPF  SMHB  SMPX  SMKE
    99  0.18   2.0  0.65  60.0  1.00  0.80 SA001 SA001 SA001
@  SLB  SLMH  SLLL  SDUL  SSAT  SRGF  SSKS  SBDM  SLOC  SLCL  SLSI  SLCF  SLNI  SLHW  SLHB  SCEC
     5   -99 0.026 0.096 0.230 1.000   -99  1.30  2.00   -99   -99   -99   -99   -99   -99   -99
    15   -99 0.025 0.086 0.230 1.000   -99  1.30  1.00   -99   -99   -99   -99   -99   -99   -99
    30   -99 0.025 0.086 0.230 0.800   -99  1.40  1.00   -99   -99   -99   -99   -99   -99   -99
    60   -99 0.025 0.086 0.230 0.200   -99  1.40  0.50   -99   -99   -99   -99   -99   -99   -99
    90   -99 0.028 0.090 0.230 0.100   -99  1.45  0.10   -99   -99   -99   -99   -99   -99   -99
   120   -99 0.028 0.090 0.230 0.050   -99  1.45  0.10   -99   -99   -99   -99   -99   -99   -99
   150   -99 0.029 0.130 0.230 0.002   -99  1.45  0.04   -99   -99   -99   -99   -99   -99   -99
   180   -99 0.070 0.258 0.360 0.000   -99  1.20  0.24   -99   -99   -99   -99   -99   -99   -99
```

GENOTYPE

Three files are suggested for dealing with the morphological and physiological characteristics of a particular genotype: one for the specific species (crop) characteristics (FILEG), one for the "ecotype" characteristics within a species (FILEE), and one for the specific cultivar characteristics within an ecotype grouping (FILEC).

These files would contain all genotype specific inputs required for simulation. Their content and organization, and indeed their usage, currently vary greatly among crop models and crops. No attempt has been made, therefore, to document contents. The use of at least one genotype file, specifically FILEC, is highly recommended. For such a file, a standard format is recommended with each line beginning with 6 spaces for a cultivar identification code (the first two items should be the code for the Institute that assigned the number), a blank, 16 spaces for the cultivar name, a blank, 6 spaces for a type identifier (e.g., an identifier for highland or lowland bean ecotypes), and then data in a (1X, F5.?) format (i.e., 1 blank, followed by 5 spaces for a real variable with the required number of decimals).

CHAPTER FOUR. OUTPUTS

A number of output files for each simulation run, which may encompass several experiments, are described in Table 1. The first output file, OVERVIEW.OUT (Table 11), provides an overview of input conditions and crop performance, and a comparison with actual data if available. The first section in this file presents information that uniquely describes the simulated data set, as described below.

Line 1:	Run number and description; default to experiment code and name plus treatment number and name
Line 2:	Model name and version
Line 3:	Experiment name, Institute code, Site code, Experiment no., Crop (group) code
Line 4:	Treatment number and specifications
Line 5:	Crop, cultivar, ecotype
Line 6:	Simulation starting date
Line 7:	Planting date, population, and row spacing
Line 8:	Weather location, site and year
Line 9:	Soil number, texture and family
Line 10:	Soil initial conditions
Line 11:	Water balance
Line 12:	Irrigation
Line 13:	Nitrogen balance
Line 14:	Fertilizer N applications
Line 15:	Residue applications
Line 16:	Environmental options
Line 17:	Simulation options
Line 18:	Management options

The second section contains a summary of soil characteristics and cultivar coefficients. The next section deals with the crop and soil status at the main developmental stages, followed by a comparison of simulated and measured data for major variables. This in turn is followed by information on simulated stress factors and weather data summary during the different developmental phases (as appropriate to the crop). An example of the file is shown in Table 11.

The second output file, SUMMARY.OUT (Table 12), provides a summary of outputs for use in applications programs with one line of data for each crop season. The third to last files contain detailed simulation results, including simulated seasonal (at daily or less frequent intervals) growth and development (Table 13), carbon balance (Table 14), water balance (Table 15), nitrogen balance (Table 16), phosphorus balance and pest (Table 17) aspects. These files are included for detailed graphic and numerical comparisons of simulated results with data collected periodically during a growing season. They can be saved in files named according to the code of the first experiment in the simulation session, but with a final letter to indicate the aspect dealt with in the file.

All of the above output files are set up so that successive simulated results in one session are appended to the respective files. The output files are temporary information transfer files, created during simulation, and they are overwritten when a new simulation session is started. The output files can include additional information such as may relate to parameter changes for sensitivity analysis. However, the symbol "!" should be put in column 1 when such additional information is included in the output files. The "!" symbol designates a comment and graphics and other analysis programs must be designed to ignore these lines.

TABLE 11. EXAMPLE OF THE SIMULATION OVERVIEW FILE. (OUTO)

```
*SIMULATION OVERVIEW FILE

*RUN   1          : IRRIGATED, COBB
 MODEL            : CRGRO940 - SOYBEAN
 EXPERIMENT       : UFGA8101 SB    COBB, IRRIGATED, VEG. & REPROD. STRESS
 TREATMENT  1     : IRRIGATED, COBB

 CROP             : SOYBEAN        CULTIVAR : COBB             -  MATURITY GROUP 8
 STARTING DATE    : JUN 26 1981
 PLANTING DATE    : JUN 26 1981    PLANTS/m2 : 35.9     ROW SPACING :  76.cm
 WEATHER          : UFGA   1981
 SOIL             : IBSB910015     TEXTURE :        - Millhopper Fine Sand
 SOIL INITIAL C   : DEPTH:180cm EXTR. H2O:158.4mm  NO3:   .0kg/ha  NH4:   .0kg/ha
 WATER BALANCE    : IRRIGATE ACCORDING TO FIELD SCHEDULE
 IRRIGATION       :      315 mm IN    19 APPLICATIONS
 NITROGEN BAL.    : SOIL-N, N-UPTAKE & DYNAMIC N-FIXATION SIMULATION
 N FERTILIZER     :        0 kg/ha IN     0 APPLICATIONS
 RESIDUE/MANURE   :        0 kg/ha IN     0 APPLICATIONS
 ENVIRONM. OPT.   : DAYL=      .0  SRAD=      .0  TMAX=      .0  TMIN=      .0
                    RAIN=      .0  CO2 = R 330.0  DEW =      .0  WIND=      .0
 SIMULATION OPT   : WATER   :Y  NITROGEN:Y  N-FIX:Y  PESTS  :N  PHOTO  :C  ET :R
 MANAGEMENT OPT   : PLANTING:R  IRRIG   :R  FERT :R  RESIDUE:R  HARVEST:M  WTH:M

*SUMMARY OF SOIL AND GENETIC INPUT PARAMETERS

   SOIL LOWER UPPER   SAT  EXTR  INIT   ROOT   BULK     pH    NO3    NH4    ORG
  DEPTH LIMIT LIMIT    SW    SW    SW   DIST   DENS                         C
   cm   cm3/cm3     cm3/cm3     cm3/cm3         g/cm3          ugN/g  ugN/g    %
-----------------------------------------------------------------------------------
   0-  5  .023  .086  .230  .063  .086   1.00   1.36   5.30    .00    .00    .90
   5- 15  .023  .086  .230  .063  .086   1.00   1.40   5.40    .00    .00    .69
  15- 30  .023  .086  .230  .063  .086    .50   1.46   5.70    .00    .00    .28
  30- 45  .023  .086  .230  .063  .086    .29   1.47   5.80    .00    .00    .20
  45- 60  .023  .086  .230  .063  .086    .29   1.47   5.80    .00    .00    .20
  60- 90  .021  .076  .230  .055  .076    .38   1.43   5.90    .00    .00    .09
  90-120  .020  .076  .230  .056  .076    .13   1.48   5.90    .00    .00    .03
 120-150  .027  .130  .230  .103  .130    .06   1.57   5.90    .00    .00    .03
 150-180  .070  .258  .360  .188  .258    .03   1.79   5.90    .00    .00    .03

TOT-180    5.5  21.4  45.3  15.8  21.4  <--cm   -  kg/ha-->     .0     .0  38949
SOIL ALBEDO     :  .18        EVAPORATION LIMIT : 5.00        MIN. FACTOR  : 1.00
RUNOFF CURVE # :66.00         DRAINAGE RATE     :  .50        FERT. FACTOR :  .84
```

SOYBEAN CULTIVAR :IB0002-COBB ECOTYPE :SB0801-MATURITY GROUP 8
CSDVAR :12.25 PPSEN : .33 EMG-FLW:21.00 FLW-FSD:16.00 FSD-PHM :37.00
WTPSD : .180 SDPDVR : 2.05 SDFDUR :23.00 PODDUR :15.00 XFRUIT : 1.00

*SIMULATED CROP AND SOIL STATUS AT MAIN DEVELOPMENT STAGES

RUN NO. 1 IRRIGATED, COBB

DATE	CROP AGE	GROWTH STAGE	BIOMASS kg/ha	LAI	LEAF NUM.	ET mm	RAIN mm	IRRIG mm	SWATER mm	CROP kg/ha	N %	STRESS H2O	STRESS N
26 JUN	0	START SIM	0	.00	.0	4	18	0	172	0	.0	.00	.00
26 JUN	0	SOWING	0	.00	.0	4	18	0	172	0	.0	.00	.00
29 JUN	3	EMERGENCE	25	.04	.0	5	19	0	162	1	5.1	.00	.00
29 JUN	3	END JUVEN.	25	.04	.0	5	19	0	162	1	5.1	.00	.00
7 JUL	11	UNIFOLIATE	81	.13	1.3	13	19	8	158	3	3.4	.00	.00
11 JUL	15	FLOWER IND	143	.25	2.3	25	41	8	161	4	3.0	.07	.00
11 AUG	46	FIRST FLWR	2630	4.45	11.1	165	141	85	157	96	3.7	.02	.00
27 AUG	62	FIRST POD	4320	5.41	15.5	230	165	142	157	153	3.6	.00	.00
27 AUG	62	FIRST POD	4320	5.41	15.5	230	165	142	157	153	3.6	.00	.00
29 AUG	64	END MSNODE	4337	5.20	16.1	235	192	142	180	155	3.6	.00	.00
5 SEP	71	END LEAF	5163	5.06	16.1	265	219	142	147	175	3.4	.00	.00
7 SEP	73	FIRST SEED	5355	4.96	16.1	272	221	157	153	179	3.3	.00	.00
8 OCT	104	END POD	7978	3.30	16.1	397	248	272	142	269	3.4	.00	.00
18 OCT	114	PHYS. MAT	8658	3.03	16.1	429	250	287	124	302	3.5	.00	.04
30 OCT	126	HARV. MAT	7340	.20	16.1	456	268	315	134	264	3.6	.00	.16
30 OCT	126	HARVEST	7340	.20	16.1	456	268	315	134	264	3.6	.00	.16

*MAIN GROWTH AND DEVELOPMENT VARIABLES

@ VARIABLE	PREDICTED	MEASURED
ANTHESIS DATE (DAP)	46	47
FIRST PEG / POD (DAP)	62	66
FIRST SEED (DAP)	73	66
PHYSIOLOGICAL MATURITY (DAP)	114	118
POD YIELD (kg/ha)	4545	4526.
SEED YIELD (kg/ha)	3575	3502.
SHELLING PERCENTAGE (%)	78.65	-99
WEIGHT PER SEED (g)	.165	.1476
SEED NUMBER (SEED/m2)	2166	2374.
SEEDS/POD	2.05	1.88
MAXIMUM LAI (m2/m2)	5.41	6.25
BIOMASS (kg/ha) AT ANTHESIS	2630	-99
BIOMASS N (kg N/ha) AT ANTHESIS	96	-99

BIOMASS (kg/ha) AT HARVEST MAT.	7340	6851.
STALK (kg/ha) AT HARVEST MAT.	2712	2137.
HARVEST INDEX (kg/kg)	.487	-99
FINAL LEAF NUMBER (MAIN STEM)	16.10	-99
SEED N (kg N/ha	228	-99
BIOMASS N (kg N/ha)	264	-99
STALK N (kg N/ha)	21	-99
SEED N (%)	6.37	-99

*ENVIRONMENTAL AND STRESS FACTORS

ENVIRONMENT						STRESS		
DEVELOPMENT PHASE	TIME	WEATHER				WATER	NITROGEN	
	DURATION days	TEMP MAX oC	TEMP MIN oC	SOLAR RAD MJ/m2	PHOTOP [day] hr	PHOTO SYNTH	GROWTH	PHOTO SYNTH	GROWTH
Emergence -First Flower	43	34.07	22.26	20.01	13.60	.000	.019	.000	.000
First Flower-First Seed	27	32.41	21.98	16.30	12.80	.000	.000	.000	.000
First Seed - Phys. Mat.	41	30.87	17.54	16.38	11.78	.000	.000	.049	.009
Emergence - Phys. Mat.	111	32.48	20.45	17.77	12.73	.000	.007	.018	.003

(0.0 = Minimum Stress
1.0 = Maximum Stress)

SOYBEAN YIELD : 3575 kg/ha [DRY WEIGHT]

TABLE 12. DETAILED SIMULATION SUMMARY OUTPUT FILE. (OUTS)

STRUCTURE

Variable	Variable Name[1]	Header[2]	Format[3]
Line 1			
*SUMMARY :			0 C 10
Institute code	INSTE		1 C 2
Site code	SITEE		0 C 2
Experiment code	EXPTNO		0 C 4
Crop group code	CROP		1 C 2
Experiment name	ENAME		1 C 60
Line 2 to number runs made. Details of each simulation run, as follows:			
Run number	RUNO	RP	0 I 2
Treatment number	TRTNO	TN	1 I 2
Rotation component	ROTNO	R	1 I 1
Rotation option	ROTOPT	O	0 I 1
Crop component	CRPNO	C	0 I 1
Crop code	CROP	CR	1 C 2
Title	TITLET	TNAM	1 C 19
Field identifier	FLDNAM	FNAM	1 C 8
Simulation start date, year + day of year	YRSIM	SDAT	1 I 5
Planting date, year + day of year	YRPLT	PDAT	1 I 5
Anthesis date, start, year + day of year	YRNR1	ADAT	1 I 5
Maturity (physiological) date, year+day of year	YRNR7	MDAT	1 I 5
Harvest date, year + day of year	YRDOY	HDAT	1 I 5
Planting material dry weight, kg ha^{-1}	SDRATE	DWAP	1 I 5
Canopy dry weight at maturity, kg ha^{-1}	TOPWT	CWAM	1 I 5
Yield at maturity, kg ha^{-1}	SDWT	HWAM	1 I 5
Yield at harvest, kg ha^{-1}	SDWTAM	HWAH	1 I 5
Harvested byproduct dry weight, kg ha^{-1}	BWAH	BWAH	1 I 5
Harvest product individual dry wt., mg or g	HWUM	HWUM	1 I 5
Harvest product number per m^2 at maturity	SEEDNO	H#AM	1 I 5
Harvest product number per unit at maturity	PSPP	H#UM	1 R 5 2
Irrigation applications, number	NAP	IR#M	1 I 5
Irrigation applied, cumulative, mm	TOTIR	IRCM	1 I 5
Precipitation cumulative, mm	CRAIN	PRCM	1 I 5
Evapotranspiration in season, cumulative, mm	CET	ETCM	1 I 5
Runoff, cumulative, mm	TRUNOF	ROCM	1 I 5
Cumulative drainage from profile, mm	TDRAIN	DRCM	1 I 5
Water remaining in soil, available, mm	PESW	SWXM	1 I 5
Nitrogen applications, number	NAPNIT	NI#M	1 I 5
Nitrogen applied, cumulative, kg ha^{-1}	AMTNIT	NICM	1 I 5

Nitrogen fixed, cumulative, kg ha^{-1}	WTNFX	NFXM	1 I 5
Total N uptake during season, kg/ha	WTNUP	NUCM	1 I 5
Nitrogen leached, cumulative, kg ha^{-1}	TLCH	NLCM	1 I 5
Inorganic N in soil at maturity, kg/ha	TSIN	NIAM	1 I 5
Tops N at maturity, kg ha^{-1}	WTNCAN	CNAM	1 I 5
Nitrogen in harvest product (seed), kg ha^{-1}	WTNSD	GNAM	1 I 5
Residue, etc. applied, cumulative, kg ha^{-1}	CRESAP	RECM	1 I 5
Soil organic N at end of season, kg ha^{-1}	TSON	ONAM	1 I 5
Soil C at end of season, t ha^{-1}	TSOC	OCAM	1 I 5
Number of phosphorus applications	NNAPHO	PO#M	1 I 5
Total P applied during season, kg/ha	TOTPH	POCM	1 I 5
Cumulative plant P uptake, kg/ha	TOTPUP	CPAM	1 I 5
Soil P at end of season, kg/ha	TPLEFT	SPAM	1 I 5

[1] *Abbreviations used as variable names in the IBSNAT models.*

[2] *Abbreviations suggested for use in header lines (those designated with '@') within the file.*

[3] *Formats are presented as follows: number of leading spaces, variable type (Character = C, Real = R, Integer = I), variable width, and (if real) number of decimals.*

Example Summary Output File

```
*SUMMARY : UFGA8101 SB COBB, IRRIGATED, VEG. & REPROD. STRESS

!IDENTIFIERS............................ DATES.......................
@RP TN ROC CR TNAM                  FNAM      SDAT  PDAT  ADAT  MDAT  HDAT
  1  1 110 SB IRRIGATED, COBB       UFGA0001 81177 81177 81223 81291 81303
  2  2 110 SB IRRIGATED, WITH VEG   UFGA0001 81177 81177 81224 81293 81305
  3  3 110 SB IRRIGATED, WITH REP   UFGA0001 81177 81177 81223 81291 81303
  1  1 110 SB IRRIGATED             UFGA0001 78166 78166 78211 78282 78294
  2  2 110 SB NON - IRRIGATED       UFGA0001 78166 78166 78211 78278 78290


DRY WEIGHTS.................................
DWAP  CWAM  HWAM  HWAH  BWAH  HWUM  H#AM  H#UM
  81  7340  3575  3575  3765   165  2166  2.05
  81  6178  3174  3174  3004   157  2021  2.05
  81  7038  3389  3389  3649   159  2126  2.05
  75  6116  2962  2962  3153   134  2208  2.05
  75  3056  1139  1139  1917   145   784  2.05


WATER.................................
IR#M  IRCM  PRCM  ETCM  ROCM  DRCM  SWXM
  19   315   268   456     0    72   134
  13   206   269   424     0    36   121
  15   264   268   448     0    72   104
  19   190   534   440    31   290    74
   0     0   534   319    31   284    59


NITROGEN.................................
NI#M  NICM  NFXM  NUCM  NLCM  NIAM  CNAM  GNAM
   0     0   352     2     0    32   264   228
   0     0   322     1     0    29   234   202
   0     0   342     1     0    31   252   216
   0     0   314     4    20    39   222   189
   0     0   204     2    20    37    96    73
```

ORGANIC MATTER...			PHOSPHORUS.....			
RECM	ONAM	OCAM	PO#M	POCM	CPAM	SPAM
0	3870	39	0	0	0	0
0	3873	39	0	0	0	0
0	3873	39	0	0	0	0
1000	3838	39	0	0	0	0
1000	3842	39	0	0	0	0

TABLE 13. DETAILED SIMULATION GROWTH OUTPUT FILE. (OUTG)

STRUCTURE

Variable	Variable Name[1]	Header[2]	Format[3]
Line 1			
Run number[4]	NREP		5 I 3
Run identifier	TITLER		1 0 C 25
Line 2			
Model name	MODEL		18 C 8
Crop name	CROPD		3 C 10
Line 3			
Experiment identifier, made up of:			
Institute code	INSTE		18 C 2
Site code	SITEE		0 C 2
Experiment number/abbreviation	EXPTNO		0 C 4
Crop group code	CROP		1 C 2
Experiment name (Treatment set and experimental condition names, separated by a semi-colon)	ENAME		18 C 60
Line 4			
Treatment number	TRTNO		11 I 2
Treatment name	TITLET		5 C 25
Line 5[5]			
Variable abbreviations			1 C 77+
Line 6 on			
Date (Year + days from Jan. 1)	YRDOY	DATE	1 I 5
Crop age (days from planting)	DAP	CDAY	1 I 5
Leaf number	VSTAGE	L#SD	1 R 5 1
Growth stage	RSTAGE	GSTD	1 I 5
Leaf area index	XLAI	LAID	1 R 5 2
Leaf dry weight, kg ha^{-1}	WTLF	LWAD	1 I 5
Stem dry weight, kg ha^{-1}	STMWT	SWAD	1 I 5
Grain dry weight, kg ha^{-1}	SDWT	GWAD	1 I 5
Root dry weight in layer L, kg ha^{-1}	RTWT	RWAD	1 I 5
Crop dry weight, kg $ha-^{1}$	TOPWT	CWAD	1 I 5
Grain number, #/m^2	SEEDNO	G#AD	1 I 5
Grain dry weight, mg/grain	SDSIZE	GWGD	1 R 5 1
Harvest index	HI	HIAD	1 R 5 3

---

1 Abbreviations used as variable names in the IBSNAT models.

2 Abbreviations suggested for use in header lines (those designated with '@') within the file. They correspond to the variable names used in the associated database.

3 Formats are presented as follows: number of leading spaces, variable type (Character = C, Real = R, Integer = I), variable width, and (if real) number of decimals.

4 Each new run should be demarcated with '*RUN' at the beginning of this line in each file.

5 Additional information can be placed between lines 4 and 5, as required by a user, as illustrated in the example, and as documented for the Overview file in the text.

Example Growth Output File

```
*GROWTH ASPECTS OUTPUT FILE

*RUN   1          : IRRIGATED, COBB
 MODEL            : CRGRO940 - SOYBEAN
 EXPERIMENT       : UFGA8101 SB    COBB, IRRIGATED, VEG. & REPROD. STRESS
 TREATMENT  1     : IRRIGATED, COBB

 CROP             : SOYBEAN        CULTIVAR : COBB              -  MATURITY GROUP 8
 STARTING DATE    : JUN 26 1981
 PLANTING DATE    : JUN 26 1981    PLANTS/m2 : 35.9     ROW SPACING :  76.cm
 WEATHER          : UFGA   1981
 SOIL             : IBSB910015     TEXTURE :        - Millhopper Fine Sand
 SOIL INITIAL C   : DEPTH:180cm EXTR. H2O:158.4mm  NO3:    .0kg/ha  NH4:    .0kg/ha
 WATER BALANCE    : IRRIGATE ACCORDING TO FIELD SCHEDULE
 IRRIGATION       :      315 mm IN    19 APPLICATIONS
 NITROGEN BAL.    : SOIL-N, N-UPTAKE & DYNAMIC N-FIXATION SIMULATION
 N FERTILIZER     :        0 kg/ha IN     0 APPLICATIONS
 RESIDUE/MANURE   :        0 kg/ha IN     0 APPLICATIONS
 ENVIRONM. OPT.   : DAYL=       .0  SRAD=       .0  TMAX=       .0  TMIN=       .0
                    RAIN=       .0  CO2 = R 330.0  DEW =       .0  WIND=       .0
 SIMULATION OPT   : WATER    :Y  NITROGEN:Y  N-FIX:Y  PESTS  :N  PHOTO  :C  ET :R
 MANAGEMENT OPT   : PLANTING:R  IRRIG    :R  FERT :R  RESIDUE:R  HARVEST:M  WTH:M
```

@DATE	CDAY	L#SD	GSTD	LAID	LWAD	SWAD	GWAD	RWAD	CWAD	G#AD	GWGD	HIAD
81177	0	.0	0	.00	0	0	0	0	0	0	.0	.000
81183	6	.4	0	.07	35	6	0	23	41	0	.0	.000
81189	12	1.6	0	.16	77	15	0	44	92	0	.0	.000
81195	18	3.1	0	.40	173	46	0	98	219	0	.0	.000
81201	24	4.9	0	.95	313	134	0	192	447	0	.0	.000
81207	30	6.5	0	1.75	533	324	0	381	658	0	.0	.000
81213	36	8.2	0	2.82	801	613	0	567	1414	0	.0	.000
81219	42	9.9	0	3.84	1080	1047	0	753	2127	0	.0	.000
81225	48	11.7	1	4.73	1325	1560	0	905	2885	0	.0	.000
81231	54	13.4	1	5.32	1540	2078	0	1051	3619	0	.0	.000
81237	60	15.0	1	5.39	1618	2473	0	1161	4091	0	.0	.000
81243	66	16.1	3	5.15	1658	2859	0	1264	4533	0	.0	.000
81249	72	16.1	3	4.99	1760	3303	0	1366	5232	0	.0	.000
81255	78	16.1	5	4.71	1799	3625	34	1437	5897	403	8.4	.006
81261	84	16.1	5	4.31	1699	3648	298	1429	6425	950	31.4	.046
81267	90	16.1	5	3.97	1578	3523	777	1402	6901	1453	53.5	.113
81273	96	16.1	5	3.63	1425	3315	1544	1333	7364	2106	73.3	.210
81279	102	16.1	5	3.37	1318	3182	2331	1280	7868	2166	107.6	.296

TABLE 14. DETAILED SIMULATION CARBON BALANCE OUTPUT FILE. (OUTC)

STRUCTURE

Variable	Variable Name[1]	Header[2]	Format[3]			
Line 1						
Run number[4]	NREP		5	I	3	
Run identifier	TITLER		10	C	25	
Line 2						
Model name	MODEL		18	C	8	
Crop name	CROPD		3	C	10	
Line 3						
Experiment identifier, made up of:						
Institute code	INSTE		18	C	2	
Site code	SITEE		0	C	2	
Experiment number/abbreviation	EXPTNO		0	C	4	
Crop group code	CROP		1	C	2	
Experiment name (Treatment set and experimental condition names, separated by a semi-colon)	ENAME		18	C	60	
Line 4						
Treatment number	TRTNO		11	I	2	
Treatment name	TITLET		5	C	25	
Line 5[5]						
Variable abbreviations			1	C	77+	
Line 6 on						
Date (Year + days from Jan. 1)	YRDOY	DATE	1	I	5	
Days from planting	DAP	CDAY	1	I	5	
Soil organic carbon, kg ha^{-1}	TSOC	SOCD	1	I	5	
Total plant weight, kg ha^{-1}	TOTWT	TWAD	1	I	5	
Canopy interception of PAR, %	PCINP	LI%D	1	R	5	2
Canopy gross photosynthesis, g $CH_2O/m^2/d$	PG	PHAD	1	R	5	2
Carbon mobilized for growth, g $CH_2O/m^2/d$	CMINEA	CMAD	1	R	5	2
Canopy growth rate, g tissue/m^2/d	GROWTH	CGRD	1	R	5	2
Canopy growth resp, g $CH_2O/m^2/d$	GRWRES	GRAD	1	R	5	2
Canopy maint resp, g $CH_2O/m^2/d$	MAINR	MRAD	1	R	5	2
C stored in a day, g $CH_2O/m^2/d$	CAD	CHAD	1	R	5	2
Percent C in leaf, %	RHOL	CL%D	1	R	5	2
Percent C in stem, %	RHOS	CS%D	1	R	5	2

---

1 Abbreviations used as variable names in the IBSNAT models.

2 Abbreviations suggested for use in header lines (those designated with '@') within the file. They correspond to the variable names used in the associated database.

3 Formats are presented as follows: number of leading spaces, variable type (Character = C, Real = R, Integer = I), variable width, and (if real) number of decimals.

4 Each new run should be demarcated with '*RUN' at the beginning of this line in each file.

5 Additional information can be placed between lines 4 and 5, as required by a user, as illustrated in the example, and as documented for the Overview file in the text.

Example Carbon Output File

```
*CARBON BALANCE OUTPUT FILE

*RUN   1          : IRRIGATED, COBB
 MODEL            : CRGRO930 - SOYBEAN
 EXPERIMENT       : UFGA8101 SB    COBB, IRRIGATED, VEG. & REPROD. STRESS
 TREATMENT  1     : IRRIGATED, COBB

 CROP             : SOYBEAN        CULTIVAR : COBB             -  MATURITY GROUP 8
 STARTING DATE    : JUN 26 1981
 PLANTING DATE    : JUN 26 1981    PLANTS/m2 : 35.9     ROW SPACING :  76.cm
 WEATHER          : FGA   1981
 SOIL             : IBSB910015     TEXTURE :       - Millhopper Fine Sand
 SOIL INITIAL C   : DEPTH:180cm EXTR. H2O:158.4mm  NO3:   .0kg/ha  NH4:   .0kg/ha
 WATER BALANCE    : IRRIGATE ACCORDING TO FIELD SCHEDULE
 IRRIGATION       :      315 mm IN    19 APPLICATIONS
 NITROGEN BAL.    : SOIL-N, N-UPTAKE & DYNAMIC N-FIXATION SIMULATION
 N FERTILIZER     :        0 kg/ha IN     0 APPLICATIONS
 RESIDUE/MANURE   :        0 kg/ha IN     0 APPLICATIONS
 ENVIRONM. OPT.   : DAYL=      .0  SRAD=      .0  TMAX=      .0  TMIN=      .0
                    RAIN=      .0  CO2 = R 330.0  DEW =      .0  WIND=      .0
 SIMULATION OPT   : WATER   :Y  NITROGEN:Y  N-FIX:Y  PESTS  :N  PHOTO  :C  ET :R
 MANAGEMENT OPT   : PLANTING:R  IRRIG   :R  FERT :R  RESIDUE:R  HARVEST:M  WTH:M
```

@DATE	CDAY	SOCD	TWAD	LI%D	PHAD	CMAD	CGRD	GRAD	MRAD	CHAD	CL%D	CS%D
81177	0	39	0	.00	.00	.00	.00	.00	.00	.00	.00	.00
81183	6	39	64	.00	1.25	.00	.57	.34	.13	.21	20.39	21.35
81189	12	39	136	.00	2.81	.00	1.34	.79	.32	.35	29.76	27.58
81195	18	39	317	.00	6.96	.00	3.29	1.96	.80	.91	34.23	26.99
81201	24	39	638	.00	12.21	.28	7.40	3.75	1.34	.00	21.66	15.14
81207	30	39	1238	.00	21.69	.32	12.36	6.77	2.88	.00	12.12	9.59
81213	36	39	1981	.00	24.45	.37	14.46	6.91	3.44	.00	7.96	7.74
81219	42	39	2880	.00	29.19	.45	17.39	7.99	4.26	.00	5.88	6.86
81225	48	39	3789	.00	28.61	.55	16.32	7.60	4.77	.47	4.84	6.75
81231	54	39	4670	.00	28.54	.76	15.15	7.17	5.58	1.40	4.78	8.30
81237	60	39	5252	.00	31.56	1.00	16.14	8.17	5.44	2.81	5.16	10.40
81243	66	39	5797	.00	28.12	1.38	13.45	6.64	5.90	3.52	5.87	12.99
81249	72	39	6598	.00	24.16	1.99	11.82	4.98	6.27	3.08	6.79	16.00
81255	78	39	7334	.00	32.67	2.70	17.69	6.55	7.48	3.66	7.26	17.61
81261	84	39	7854	.00	31.39	3.11	19.23	8.03	5.14	2.10	7.11	17.31
81267	90	39	8304	.00	28.86	2.99	16.24	8.33	7.29	.00	6.10	14.90
81273	96	39	8697	.00	29.56	2.18	14.43	9.89	7.26	.15	5.02	12.28
81279	102	39	9148	.00	27.81	1.84	13.59	10.00	5.58	.49	4.12	10.21
81285	108	39	9393	.00	23.47	1.34	11.40	8.67	4.41	.34	3.04	7.65
81291	114	39	9860	.00	20.92	.00	2.93	2.05	5.48	10.46	3.56	9.62
81297	120	39	8922	.00	5.92	1.97	2.33	1.05	3.88	.63	1.12	18.71

TABLE 15. DETAILED SIMULATION WATER BALANCE OUTPUTFILE. (OUTW)

STRUCTURE

Variable	Variable Name[1]	Header[2]	Format[3]		
Line 1					
Run number[4]	NREP		5	I	3
Run identifier	TITLER		10	C	25
Line 2					
Model name	MODEL		18	C	8
Crop name	CROPD		3	C	10
Line 3					
Experiment identifier, made up of:					
Institute code	INSTE		18	C	2
Site code	SITEE		0	C	2
Experiment number/abbreviation	EXPTNO		0	C	4
Crop group code	CROP		1	C	2
Experiment name (Treatment set and experimental condition names, separated by a semi-colon)	ENAME		18	C	60
Line 4					
Treatment number	TRTNO		11	I	2
Treatment name	TITLET		5	C	25
Line 5[5]					
Variable abbreviations			1	C	77+
Line 6 on					
Date (Year + days from Jan. 1)	YRDOY	DATE	1	I	5
Days from planting	DAP	CDAY	1	I	5
Plant Transpiration, mm d^{-1}	AVEP	EPAA	1	R	5 2
Evapotranspiration, mm day^{-1}	AVET	ETAA	1	R	5 2
Potential evaporation, mm day^{-1}	AVEO	EOAA	1	R	5 2
Potentially extractable water, cm	PESW	SWXD	1	R	5 1
Cumulative runoff	TRUNOF	ROFC	1	R	5 1
Cumulative drainage	TDRAIN	DRNC	1	I	5
Cumulative precipitation, mm	CRAIN	PREC	1	I	5
Cummulative irrigation, mm	TOTIR	IRRC	1	I	5
Average solar radiation, MJ m^{-2}	AVSRAD	SRAA	1	R	5 1
Average maximum temperature, °C	AVTMX	TMXA	1	R	5 1
Average minimum temperature, °C	AVTMN	TMNA	1	R	5 1

---

1 *Abbreviations used as variable names in the IBSNAT models.*

2 *Abbreviations suggested for use in header lines (thoses designated with '@') within the file. They correspond to the variable names used in the associated database.*

3 *Formats are presented as follows: number of leading spaces, variable type (Character = C, Real = R, Integer = I), variable width, and (if real) number of decimals.*

4 *Each new run should be demarcated with '*RUN' at the beginning of this line in each file.*

5 *Additional information can be placed between lines 4 and 5, as required by a user, as illustrated in the example, and as documented for the Overview file in the text.*

EXAMPLE WATER OUTPUT FILE

```
*WATER BALANCE OUTPUT FILE

*RUN   1          : IRRIGATED, COBB
 MODEL            : CRGRO940 - SOYBEAN
 EXPERIMENT       : UFGA8101 SB    COBB, IRRIGATED, VEG. & REPROD. STRESS
 TREATMENT  1     : IRRIGATED, COBB

 CROP             : SOYBEAN        CULTIVAR : COBB             -  MATURITY GROUP 8
 STARTING DATE    : JUN 26 1981
 PLANTING DATE    : JUN 26 1981    PLANTS/m2 : 35.9     ROW SPACING :  76.cm
 WEATHER          : UFGA   1981
 SOIL             : IBSB910015     TEXTURE :       - Millhopper Fine Sand
 SOIL INITIAL C   : DEPTH:180cm EXTR. H2O:158.4mm  NO3:   .0kg/ha  NH4:   .0kg/ha
 WATER BALANCE    : IRRIGATE ACCORDING TO FIELD SCHEDULE
 IRRIGATION       :      315 mm IN    19 APPLICATIONS
 NITROGEN BAL.    : SOIL-N, N-UPTAKE & DYNAMIC N-FIXATION SIMULATION
 N FERTILIZER     :        0 kg/ha IN     0 APPLICATIONS
 RESIDUE/MANURE   :        0 kg/ha IN     0 APPLICATIONS
 ENVIRONM. OPT.   : DAYL=      .0  SRAD=      .0  TMAX=      .0  TMIN=      .0
                    RAIN=      .0  CO2 = R 330.0  DEW =      .0  WIND=      .0
 SIMULATION OPT   : WATER   :Y  NITROGEN:Y  N-FIX:Y  PESTS  :N  PHOTO  :C  ET :R
 MANAGEMENT OPT   : PLANTING:R  IRRIG   :R  FERT :R  RESIDUE:R  HARVEST:M  WTH:M
```

@DATE	CDAY	EPAA	ETAA	EOAA	SWXD	ROFC	DRNC	PREC	IRRC	SRAA	TMXA	TMNA
81177	0	.00	3.92	7.37	172.3	.0	.0	18	0	25.2	36.1	21.7
81183	6	.27	1.44	5.61	161.1	.0	12.5	19	8	22.2	32.8	19.2
81189	12	.53	2.05	5.35	166.7	.0	13.2	33	8	19.6	34.8	21.7
81195	18	1.47	3.88	5.83	169.7	.0	20.5	63	8	21.5	34.8	22.2
81201	24	1.97	2.62	3.73	156.2	.0	29.6	73	8	14.5	33.7	21.9
81207	30	5.20	5.55	6.62	143.9	.0	29.6	74	27	23.6	35.9	22.2
81213	36	2.60	3.93	3.93	161.6	.0	29.6	94	66	15.6	33.9	21.9
81219	42	4.05	5.20	5.20	163.5	.0	40.1	137	66	21.0	33.3	22.0
81225	48	4.45	5.26	5.26	151.2	.0	41.6	145	85	21.1	33.3	22.2
81231	54	3.93	4.25	4.25	139.8	.0	41.6	146	104	17.1	33.3	23.1
81237	60	4.00	4.44	4.44	151.6	.0	42.1	165	123	18.2	32.6	21.9
81243	66	3.18	3.59	3.59	197.7	.1	44.2	219	142	14.8	31.7	21.9
81249	72	3.44	3.76	3.76	156.2	.1	71.5	220	157	15.4	32.6	21.9
81255	78	4.00	4.56	4.56	148.9	.1	71.5	230	170	18.6	33.1	21.7
81261	84	2.52	2.99	2.99	152.2	.1	71.5	247	183	12.9	30.0	20.2
81267	90	3.69	4.25	4.25	143.1	.1	71.5	247	202	17.8	32.0	19.4
81273	96	3.78	4.51	4.51	139.5	.1	71.5	247	230	18.9	32.2	18.3
81279	102	3.45	3.76	3.76	129.6	.1	71.5	247	249	16.3	30.9	15.9
81285	108	2.46	2.78	2.78	133.5	.1	71.5	250	272	12.0	29.8	18.9
81291	114	3.22	3.76	3.76	123.6	.1	71.5	250	287	16.9	30.7	11.9
81297	120	1.63	2.77	2.89	129.2	.1	71.5	254	315	12.3	30.6	17.1

TABLE 16. DETAILED SIMULATION NITROGEN OUTPUT FILE. (OUTN)

STRUCTURE

Variable	Variable Name[1]	Header[2]	Format[3]			
Line 1						
Run number[4]	NREP		5	I	3	
Run identifier	TITLER		10	C	25	
Line 2						
Model name	MODEL		18	C	8	
Crop name	CROPD		3	C	10	
Line 3						
Experiment identifier, made up of:						
Institute code	INSTE		18	C	2	
Site code	SITEE		0	C	2	
Experiment number/abbreviation	EXPTNO		0	C	4	
Crop group code	CROP		1	C	2	
Experiment name (Treatment set and experimental condition names, separated by a semi-colon)	ENAME		18	C	60	
Line 4						
Treatment number	TRTNO		11	I	2	
Treatment name	TITLET		5	C	25	
Line 5[5]						
Variable abbreviations			1	C	77+	
Line 6 on						
Date (Year + days from Jan. 1)	YRDOY	DATE	1	I	5	
Days from planting	DAP	CDAY	1	I	5	
Crop nitrogen	WTNCAN	CNAD	1	R	5	1
Grain nitrogen, kg ha^{-1}	WTNSD	GNAD	1	R	5	1
Veg. (stem + leaf) nitrogen, kg ha^{-1}	WTNVEG	VNAD	1	R	5	1
Percent nitrogen in grain, %	PCNGRN	HN%D	1	R	5	2
Percent veg(stem+leaf) nitrogen, %	PCNVEG	VN%D	1	R	5	2
Cumulative inorganic N applied, kg ha^{-1}	TANFGR	NAPC	1	R	5	I
Cumulative N fixation, kg ha^{-1}	WTNFX	NFXC	1	R	5	1
Cumulative N uptake, kg ha^{-1}	WTNUP	NUPC	1	R	5	1
Cumulative N leached, kg ha^{-1}	TLCH	NLCC	1	R	5	1
Inorganic N in soil, kg ha^{-1}	TSIN	NIAD	1	R	5	1
Organic N in soil, kg ha^{-1}	TSON	NOAD	1	I	5	

---

1 Abbreviations used as variable names in the IBSNAT models.

2 Abbreviations suggested for use in header lines (those designated with '@') within the file. They correspond to the variable names used in the associated database.

3 Formats are presented as follows: number of leading spaces, variable type (Character = C, Real = R, Integer = I), variable width, and (if real) number of decimals.

4 Each new run should be demarcated with '*RUN' at the beginning of this line in each file.

5 Additional information can be placed between lines 4 and 5, as required by a user, as illustrated in the example, and as documented for the Overview file in the text.

EXAMPLE NITROGEN OUTPUT FILE

```
*NITROGEN BALANCE OUTPUT FILE

*RUN   1          : IRRIGATED, COBB
 MODEL            : CRGRO940 - SOYBEAN
 EXPERIMENT       : UFGA8101 SB    COBB, IRRIGATED, VEG. & REPROD. STRESS
 TREATMENT  1     : IRRIGATED, COBB

 CROP             : SOYBEAN        CULTIVAR : COBB              -  MATURITY GROUP 8
 STARTING DATE    : JUN 26 1981
 PLANTING DATE    : JUN 26 1981    PLANTS/m2 : 35.9     ROW SPACING :  76.cm
 WEATHER          : UFGA   1981
 SOIL             : IBSB910015     TEXTURE :        - Millhopper Fine Sand
 SOIL INITIAL C   : DEPTH:180cm EXTR. H2O:158.4mm  NO3:   .0kg/ha  NH4:   .0kg/ha
 WATER BALANCE    : IRRIGATE ACCORDING TO FIELD SCHEDULE
 IRRIGATION       :      315 mm IN    19 APPLICATIONS
 NITROGEN BAL.    : SOIL-N, N-UPTAKE & DYNAMIC N-FIXATION SIMULATION
 N FERTILIZER     :        0 kg/ha IN     0 APPLICATIONS
 RESIDUE/MANURE   :        0 kg/ha IN     0 APPLICATIONS
 ENVIRONM. OPT.   : DAYL=      .0  SRAD=      .0  TMAX=      .0  TMIN=      .0
                    RAIN=      .0  CO2 = R 330.0  DEW =      .0  WIND=      .0
 SIMULATION OPT   : WATER   :Y  NITROGEN:Y  N-FIX:Y  PESTS  :N  PHOTO  :C  ET :R
 MANAGEMENT OPT   : PLANTING:R  IRRIG   :R  FERT :R  RESIDUE:R  HARVEST:M  WTH:M
```

@DATE	CDAY	CNAD	GNAD	VNAD	GN%D	VN%D	NAPC	NFXC	NUPC	NLCC	NIAD	NOAD
81177	0	.0	.0	.0	.00	.00	0	.0	.0	.0	.2	3895
81183	6	1.6	.0	1.6	.00	4.03	0	.6	.0	-.7	2.3	3893
81189	12	3.0	.0	3.0	.00	3.28	0	2.5	.0	-.7	3.6	3892
81195	18	6.3	.0	6.3	.00	2.89	0	7.2	.0	-1.2	5.4	3891
81201	24	14.3	.0	14.3	.00	3.21	0	17.9	.0	-1.8	7.3	3889
81207	30	30.4	.0	30.4	.00	3.54	0	38.9	.0	-1.8	8.4	3888
81213	36	52.5	.0	52.5	.00	3.72	0	64.7	.0	-1.8	9.6	3887
81219	42	78.8	.0	78.8	.00	3.70	0	94.8	.0	-2.5	11.6	3886
81225	48	105.3	.0	105.3	.00	3.65	0	124.4	.0	-2.6	13.0	3885
81231	54	130.2	.0	130.2	.00	3.60	0	152.9	.0	-2.6	14.2	3883
81237	60	146.3	.0	146.3	.00	3.58	0	174.1	.0	-2.7	15.5	3882
81243	66	160.2	.0	159.7	.00	3.53	0	193.4	.0	-2.8	16.8	3881
81249	72	176.7	.0	171.5	.00	3.39	0	213.6	.0	-4.7	19.9	3880
81255	78	186.2	2.1	170.9	6.37	3.15	0	227.5	.0	-4.7	21.1	3879
81261	84	193.2	19.0	152.1	6.37	2.84	0	237.6	.0	-4.7	22.3	3877
81267	90	210.3	49.5	133.5	6.37	2.62	0	257.4	.0	-4.7	23.3	3876
81273	96	233.4	98.4	109.4	6.37	2.31	0	282.1	.0	-4.7	24.4	3875
81279	102	262.4	148.5	92.4	6.37	2.05	0	312.1	.0	-4.7	25.5	3874
81285	108	281.1	184.6	78.2	6.37	1.83	0	330.7	.5	-4.7	31.0	3873
81291	114	301.8	213.7	71.7	6.37	1.66	0	352.2	.6	-4.7	31.8	3872
81297	120	270.5	222.2	33.7	6.37	1.02	0	352.2	1.3	-4.7	32.0	3871

TABLE 17. DETAILED SIMULATION PEST OUTPUT FILE. (OUTD)

STRUCTURE

Variable	Variable Name[1]	Header[2]	Format[3]
Line 1			
Run number[4]	NREP		5 I 3
Run identifier	TITLER		10 C 25
Line 2			
Model name	MODEL		18 C 8
Crop name	CROPD		3 C 10
Line 3			
Experiment identifier, made up of:			
Institute code	INSTE		18 C 2
Site code	SITEE		0 C 2
Experiment number/abbreviation	EXPTNO		0 C 4
Crop group code	CROP		1 C 2
Experiment name (Treatment set and experimental condition names, separated by a semi-colon)	ENAME		18 C 60
Line 4			
Treatment number	TRTNO		11 I 2
Treatment name	TITLET		5 C 25
Line 5[5]			
Variable abbreviations			1 C 77+
Line 6 on			
Date (Year and days from Jan. 1)	YRDOY	DATE	1 I 5
Crop age (days from planting)	DAP	CDAY	1 I 5
Daily diseased leaf area increase, $cm^2/m^2/d$	DISLA	DL	1 I 5
Daily % diseased leaf area increase, $g/m^2/d$	DISLAP	%DL%	1 R 5 1
Daily leaf area consumed, $m^2/m^2/d$	LAIDT	DLAI	1 R 5 2
Daily leaf mass consumed, $g/m^2/d$	WLIDOT	DLFM	1 R 5 2
Daily stem mass consumed, $g/m^2/d$	WSIDOT	DSTM	1 R 5 2
Daily seed mass consumed, $g/m^2/d$	SWIDOT	DSDM	1 R 5 2
Daily seed number consumed, $\#/m^2/d$	SDIDOT	DSD#	1 R 5 2
Daily shell mass consumed, $g/m^2/d$	WSHIDT	DSHM	1 R 5 2
Daily shell number consumed, $\#/m^2/d$	SHIDOT	DSH#	1 R 5 2
Daily root mass consumed, $g/m^2/d$	WRIDOT	DRTM	1 R 5 2
Daily root length density consumed, $cm/cm^3/d$	RLVDOT	DRLV	1 R 5 2

---

1 *Abbreviations used as variable names in the IBSNAT models.*

2 *Abbreviations suggested for use in header lines (those designated with '@') within the file. They correspond to the variable names used in the associated database.*

3 *Formats are presented as follows: number of leading spaces, variable type (Character = C, Real = R, Integer = I), variable width, and (if real) number of decimals.*

4 *Each new run should be demarcated with '*RUN' at the beginning of this line in each file.*

5 *Additional information can be placed between lines 4 and 5, as required by a user, as illustrated in the example, and as documented for the Overview file in the text.*

Example Pest Output File

```
*PEST ASPECTS OUTPUT FILE

*RUN   1          : Pest and Diseases
 MODEL            : CRGRO940 - PEANUT
 EXPERIMENT       : UFGA7602 PN    PEANUT PEST TEST 1
 TREATMENT  8     : LEAF,STEM,SEED,SHELL MASS

 CROP             : PEANUT         CULTIVAR : FLORUNNER        -  FLORUNNER VARS
 STARTING DATE    : MAY  5 1976
 PLANTING DATE    : MAY  5 1976    PLANTS/m2 : 12.9     ROW SPACING :  31.cm
 WEATHER          : UFGA   1976
 SOIL             : IBPN910015     TEXTURE :       - Millhopper Fine Sand
 SOIL INITIAL C   : DEPTH:180cm EXTR. H2O:158.4mm  NO3:   .0kg/ha  NH4:   0kg/ha
 WATER BALANCE    : IRRIGATE ACCORDING TO FIELD SCHEDULE
 IRRIGATION       :       75 mm IN     4 APPLICATIONS
 NITROGEN BAL.    : NOT SIMULATED ; NO N-STRESS
 N FERTILIZER     :
 RESIDUE/MANURE   :
 ENVIRONM. OPT.   : DAYL=      .0  SRAD=      .0  TMAX=      .0  TMIN=      .0
                    RAIN=      .0  CO2 = R 330.0  DEW =      .0  WIND=      .0
 SIMULATION OPT   : WATER   :Y  NITROGEN:N  N-FIX:Y  PESTS  :Y  PHOTO  :C  ET :R
 MANAGEMENT OPT   : PLANTING:R  IRRIG   :R  FERT :R  RESIDUE:R  HARVEST:R  WTH:M
```

@DATE	CDAY	DLA	%DL%	DLAI	DLFM	DSTM	DSDM	DSD#	DSHM	DSH#	DRTM	DRLV
76126	0	0	.0	.00	.00	.00	.00	.00	.00	.00	.00	.00
76129	3	0	.0	.00	.00	.00	.00	.00	.00	.00	.00	.00
76132	6	0	.0	.00	.00	.00	.00	.00	.00	.00	.00	.00
76135	9	0	.0	.00	.00	.00	.00	.00	.00	.00	.00	.00
76138	12	0	.0	.00	.00	.00	.00	.00	.00	.00	.00	.00
76141	15	0	.0	.00	.00	.00	.00	.00	.00	.00	.00	.00
76144	18	0	.0	.00	.00	.00	.00	.00	.00	.00	.00	.00
76147	21	0	.0	.00	.00	.00	.00	.00	.00	.00	.00	.00
76150	24	0	.0	.00	.00	.00	.00	.00	.00	.00	.00	.00
76153	27	39	1.3	.00	.00	.08	.00	.00	.00	.00	.18	.01
76156	30	100	2.5	.00	.00	.12	.00	.00	.00	.00	.42	.03
76159	33	235	3.8	.00	.00	.23	.00	.00	.00	.00	.68	.05
76162	36	459	5.0	.00	.00	.32	.00	.00	.00	.00	1.02	.08
76165	39	648	6.2	.00	.00	.35	.00	.00	.00	.00	1.87	.13
76168	42	794	7.5	.00	.00	.45	.00	.00	.00	.00	2.75	.17
76171	45	1031	8.7	.00	.00	.69	.00	.00	.00	.00	3.46	.22
76174	48	1543	10.0	.00	.00	.81	.00	.00	.00	.00	3.32	.21
76177	51	2313	11.3	.01	.60	1.33	.00	.00	.00	.00	3.31	.20
76180	54	3200	12.5	.02	.75	1.54	.00	.76	.06	.39	3.36	.20
76183	57	4118	13.8	.02	.93	1.79	.07	2.89	.26	1.47	3.16	.19
76186	60	4953	15.0	.02	.87	1.93	.17	5.21	.51	2.61	3.28	.19
76189	63	5869	16.3	.02	.97	2.22	.23	6.53	.67	3.22	3.54	.20
76192	66	6722	17.5	.03	1.13	2.41	.29	8.00	.83	3.88	3.33	.18
76195	69	7412	18.8	.02	.96	2.48	.34	9.66	.99	4.62	4.05	.21
76198	72	7761	20.0	.01	.58	1.81	.35	12.32	1.19	5.80	5.29	.26

CHAPTER FIVE.
EXPERIMENT PERFORMANCE DATA FILES

Experiment performance data are contained in FILEP, FILED, FILEA and FILET, which the user generates using the formats shown in Tables 18 and 19. The correct formatting of FILEA and FILET is critical because these files link directly to the model(s). The purpose of these files is to present measured performance data for direct comparison with simulated results. FILEP is the basic performance data file, with information detailed at the replicate level for each treatment, arranged by plots. FILED would contain replicate performance data arranged by date of observations. In other words, FILEP and FILED are the basic performance data files, with information detailed at the replicate level for each treatment, arranged by plots in FILEP and by date of measurement in FILED. FILEA and FILET contain average values derived from the data in FILEP or FILED. FILEA uses one line of information per treatment and this one line is a summary of information of the entire treatment. The dates included on each line are of the main phenological events and the yield and yield components at final harvest, as well as other related variables. FILET contains one line of data for each observation date for each treatment. Averages are arranged in columns in order of treatment in FILEA, in order of date in the time-course file, FILET. The files will have a variable number of columns, depending on the data available. Each could have as few as one measured variable, or as many variables as measured. Each experimental data file, however, will always have an initial section with the institute and site codes and experiment number, the crop group code, and the experiment name. All columns have one leading blank and five spaces for data, and are headed by standard variable abbreviations (see Appendix C for a listing of abbreviations). Each data column, if appropriate, could also have header lines containing information on the date measurements were made, and on the factor by which data need to be multiplied to convert them to standard units. Examples are shown in Tables 18 and 19.

Table 18. Example of an Experiment Performance Data Averages File (FILEA), Stored in the Data File, UFGA8101.SBA.

*EXP.DATA (A): UFGA8101SB COBB, IRRIGATED, VEG. & REPROD. STRESS

@ TRNO	HWAM	HWUM	H#AM	H#UM	LAIX	CWAM	BWAH	ADAT	MDAT	PD1T	PDFT	PWAM
1	3502.	.1476	2374.	1.88	6.25	6851.	2137.	224	295	243	243	4526.
2	3355.	.1529	2195.	1.84	4.48	6109.	1587.	225	295	245	245	4403.
3	2738.	.1292	2119.	1.77	6.25	5881.	2064.	224	295	243	243	3690.

Table 19. Example of an Experiment Time-Course Data File (FILET), Showing Time Series for Treatment 1, Stored in the Data File, UFGA8101.SBT.

*EXP.DATA (T): UFGA8101SB COBB, IRRIGATED, VEG. & REPROD. STRESS

@TRNO	DATE	L#SD	LAID	P#AD	SWAD	GWAD	LWAD	CWAD	PWAD	SHAD	G#AD	SH%D	SLAD
1	81188	.8	.11	0.	18	0.	40	58	0.	0.	0.	00.00	27.
1	81190	1.4	.15	0.	20	0.	53	74	0.	0.	0.	00.00	277
1	81196	2.5	.37	0.	70	0.	144	214	0.	0.	0.	00.00	254
1	81204	6.3	1.27	0.	254	0.	350	604	0.	0.	0.	00.00	360
1	81208	6.8	1.75	0.	404	0.	497	901	0.	0.	0.	00.00	351
1	81210	7.1	1.75	0.	437	0.	499	936	0.	0.	0.	00.00	350
1	81212	7.4	1.74	0.	462	0.	525	987	0.	0.	0.	00.00	332
1	81215	7.9	2.48	0.	678	0.	722	1400	0.	0.	0.	00.00	344
1	81219	8.6	3.11	0.	1005	0.	864	1869	0.	0.	0.	00.00	359
1	81223	10.3	3.47	0.	1260	0.	980	2240	0.	0.	0.	00.00	354
1	81225	10.4	4.20	0.	1384	0.	1102	2486	0.	0.	0.	00.00	380
1	81229	10.6	4.57	0.	1758	0.	1317	3075	0.	0.	0.	00.00	348
1	81233	-99	4.33	0.	1896	0.	1206	3102	0.	0.	0.	00.00	357
1	81237	14.1	5.00	50.	2163	0.	1469	3636	4	4	0.	00.00	341
1	81245	14.4	5.87	757.	2704	0.	1717	4510	89	89	0.	00.00	342
1	81246	-99	6.25	-99	2897	0.	1750	4849	202	202	0.	00.00	359
1	81251	11.8	5.34	992.	2639	0.	1657	4657	361	361	0.	00.00	322
1	81252	-99	4.85	-99	2727	0.	1472	4621	421	421	0.	00.00	330
1	81257	15.3	4.49	1467	2940	0.	1704	5504	860	860	0.	00.00	264
1	81259	-99	5.06	-99	3674	0.	1651	6624	1299	1299	0.	00.00	306
1	81261	15.3	4.74	1505	2928	557	1694	5992	1370	813	2918	40.66	280
1	81266	-99	4.50	-99	3270	919	1612	6794	1912	993	3470	48.06	281
1	81267	15.0	4.10	1442	2566	1037	1409	5957	1983	946	2439	52.29	291
1	81271	16.5	3.85	1184	2419	1294	1549	6154	2185	891	2142	59.22	249
1	81273	-99	4.10	-99	2876	1643	1572	6998	2550	907	2511	64.43	261
1	81274	17.3	4.33	1552	3287	2437	1730	8578	3561	1124	3063	68.44	250
1	81278	16.0	3.17	1193	2603	1804	1398	6732	2732	928	2109	66.03	227
1	81280	-99	3.96	-99	2962	2387	1532	7913	3419	1032	2434	69.82	259
1	81287	-99	3.83	-99	3024	3278	1525	8858	4310	1032	2690	76.06	251
1	81294	-99	2.18	-99	2483	3548	810	7869	4576	1028	2469	77.53	268
1	81301	-99	.61	-99	1966	3208	215	6323	4142	934	2223	77.45	287
1	81308	-99	.44	-99	2307	3796	163	7378	4909	1113	2524	77.33	276

CHAPTER SIX. DISCUSSION

These proposed file structures resulted from the interest in an earlier set of crop model inputs and outputs published by IBSNAT (1986, 1990). The earlier standards have been used for a number of crop models in the integrated software package called DSSAT (Decision Support System for Agrotechnology Transfer). This earlier attempt demonstrated the value of such standards in facilitating the organization and exchange of crop weather, soil, and plot data among modeling and model user groups at various institutions. The inputs and outputs described in this document represent a wider range of crop, weather, and soil conditions, and should be nonspecific to a crop model. By expanding the list of inputs, however, it is more likely that some of the inputs will not be available for all experiments or for all intended applications. This creates a dilemma for modelers, who must decide which of the defined variables are to be a minimum set required to run their models, or must include capabilities in their models to recognize and estimate missing variables. The same is true for outputs. However, this does not create the same difficulty as the lack of inputs; it means that only parts of the models can be validated in any one experiment. Nonetheless, a basic minimum data set is needed for effective interpretation of all experiments, regardless of model validation applications. Such a minimum data set has been defined (IBSNAT, 1988), and vigorous efforts should be made to obtain such information in all experiments. The files described here reflect this minimum data set, and thus form part of an overall system that encompasses forms for data collection in the field, files for data storage, and files for use by various analysis programs. Further changes in the model input component of this system will inevitably have an impact on the other components. The design of the system as an entity makes it easier to accommodate such changes than would be the case if each part was considered separately. It is hoped that such an advantage can be maintained and strengthened in the future.

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APPENDIX A.
WEATHER LIST AND SOIL PROFILE LIST FILES

WEATHER LIST FILE

This file contains a list of weather data files which are available for use by the simulation models. It has one line of information (see Table 20, below) for each weather data set which gives the file name, site name, latitude, longitude, and elevation. The actual weather file used for a particular experiment is specified in the experiment file (FILEX). The weather list file typically would be used in sensitivity analysis where a user may wish to examine crop performance under alternate weather conditions.

TABLE 20. EXAMPLE WEATHER LIST FILE. (WTH.LST)

```
*WEATHER LIST

@# FILENAME EXT SITE NAME................ LAT..... LONG.... ELEV. TAV.. TAMP.
 1 CCPA8601 WTH CIAT,PALMIRA,COLOMBIA        3.5    -76.4   -99 -99.0 -99.0
 2 CCPA8701 WTH CIAT,PALMIRA,COLOMBIA        3.5    -76.4   -99 -99.0 -99.0
 3 DTSP8501 WTH SUPHAN_BURI,THAILAND        14.5    100.1   -99 -99.0 -99.0
 4 EBGO8701 WTH CNPAF,GOIANIA,BRAZIL       -16.3    -49.1   -99 -99.0 -99.0
 5 IGQU8901 WTH ICTA,QUEZADA,GUATEMALA      14.3    -90.0   -99 -99.0 -99.0
 6 IRMZ8501 WTH IRRI,MUNOZ,PHILIPPINES      15.7    120.9   -99 -99.0 -99.0
 7 IRMZ8601 WTH IRRI,MUNOZ,PHILIPPINES      15.7    120.9   -99 -99.0 -99.0
 8 IRPI8001 WTH IRRI,PILA,PHILIPPINES       14.2    121.3    50  27.0   3.8
 9 IRPI8501 WTH IRRI,PILA,PHILIPPINES       14.2    121.3    50  27.0   3.8
10 IRPI8601 WTH IRRI,PILA,PHILIPPINES       14.2    121.3    50  27.0   3.8
11 IUCA7901 WTH CASTANA,IOWA,USA            42.2    -93.7   -99 -99.0 -99.0
12 KSAS8101 WTH ASHLAND,KANSAS,USA          39.0    -97.0   -99 -99.0 -99.0
13 UBKA8601 WTH KAJONDI_FARM,BURUNDI        -3.3     30.0   -99 -99.0 -99.0
14 UFGA7601 WTH GAINESVILLE,FLORIDA,USA     29.6    -82.4    10  20.9   7.4
15 UFGA7801 WTH GAINESVILLE,FLORIDA,USA     29.6    -82.4    10  20.9   7.4
16 UFGA7901 WTH GAINESVILLE,FLORIDA,USA     29.6    -82.4    10  20.9   7.4
17 UFGA8001 WTH GAINESVILLE,FLORIDA,USA     29.6    -82.4    10  20.9   7.4
18 UFGA8101 WTH GAINESVILLE,FLORIDA,USA     29.6    -82.4    10  20.9   7.4
19 UFGA8201 WTH GAINESVILLE,FLORIDA,USA     29.6    -82.4    10  20.9   7.4
20 UFGA8401 WTH GAINESVILLE,FLORIDA,USA     29.6    -82.4    10  20.9   7.4
21 UFGA8501 WTH GAINESVILLE,FLORIDA,USA     29.6    -82.4    10  20.9   7.4
22 UFGA8601 WTH GAINESVILLE,FLORIDA,USA     29.6    -82.4    10  20.9   7.4
23 UFQU7901 WTH QUINCY,FLORIDA,USA          30.6    -86.4   -99 -99.0 -99.0
```


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Soil Profile List File

This file contains a list of soil profiles which are available for use by the simulation models. It has one line of information (see Table 21, below) for each soil profile which gives the file name, soil code, texture, depth and description. The actual soil profile used for a particular experiment is specified in the experiment file (FILEX).

Table 21. Example Soil Profile List File. (SOL.LST)

```
*SOIL LIST

@# FILENAME EXT SOIL CODE  TEXTURE DEPTH  DESCRIPTION
 1 SOIL     SOL GAPN930001 SALO    178    FACEVILLE
 2 SOIL     SOL IBBN910015 FSA     180    MILLHOPPER FINE SAND
 3 SOIL     SOL IBBN910030 -99     209    M3
 4 SOIL     SOL IBBN910038 -99     150    SAN_FERNANDO,QUEZADA
 5 SOIL     SOL IBMZ910014 FSA     180    MILLHOPPER FINE SAND
 6 SOIL     SOL IBPN910015 FSA     180    MILLHOPPER FINE SAND
 7 SOIL     SOL IBRI910001 -99     50     ANDAQUEPTIC HAPLAQUOLL
 8 SOIL     SOL IBRI910002 -99     50     VERTIC TROPAQUEPT
 9 SOIL     SOL IBRI910063 -99     135    UPLAND
10 SOIL     SOL IBRI910071 -99     51     SUPHAN LOWLAND
11 SOIL     SOL IBSB910015 FSA     180    MILLHOPPER FINE SAND
12 SOIL     SOL IBSB910017 SALO    203    ORANGEBURG SANDY LOAM
13 SOIL     SOL IBSB910026 SILO    180    IDA SILT LOAM
14 SOIL     SOL IBWH910018 CSI     180    HAYNIE
```

APPENDIX B.

EXPERIMENT DETAILS CODES

Headers used in the @ line to identify variables are listed first, codes to identify methods, chemicals, etc. are listed next in sections that relate to specific aspects (Chemicals;Crop and weed species;Diseases and pests;Drainage; Environment modification factors; Fertilizers, inoculants and amendments; Harvest components;Harvest size categories;Methods-fertilizer and chemical applications; Methods-irrigation and water management;Methods-soil analysis; Planting materials; Plant distribution; Residues and organic fertilizers; Rotations;Soil texture;and Tillage implements).

The fields in the file are as follows:

CDE The 'universal' code used to facilitate data interchange.

DESCRIPTION A description of the code, with units.

SO The source of the codes (IB=IBSNAT). Codes added by a user should be referenced in this field and the name and address of the person adding the code should be entered as a comment (ie.with a '!' in column 1) below this note. This is important to ensure that information from different workers can be easily integrated. Users adding codes should also ensure that those constructed by adding a number to section code (eg.FE001,CH001) are clearly identified with a letter in the this position (eg.FEK01 for a fertilizer code added by someone with a family name beginning with K).

*Headers

@CDE	DESCRIPTION	SO
ADDRESS	Contact address of principal scientist	IB
C	Crop component number (default = 1)	IB
CDATE	Application date, year + day or days from planting	IB
CHAMT	Chemical application amount, kg ha-1	IB
CHCOD	Chemical material, code	IB
CHDEP	Chemical application depth, cm	IB
CHME	Chemical application method, code	IB
CHNOTES	Chemical notes (Targets, chemical name, etc.)	IB
CNAME	Cultivar name	IB
CNOTES	Cultivar details (Type, pedigree, etc.)	IB
CR	Crop code	IB
CU	Cultivar level	IB
ECO2	CO2 adjustment, A,S,M,R + vpm	IB
EDATE	Emergence date, earliest treatment	IB
EDAY	Daylength adjustment, A,S,M,R + h	IB
EDEW	Humidity adjustment, A,S,M,R + oC	IB
EMAX	Temperature (maximum) adjustment, A,S,M,R + oC	IB
EMIN	Temperature (minimum) adjustment, A,S,M,R + oC	IB
ERAD	Radiation adjustment, A,S,M,R + MJ m-2day-1	IB
ERAIN	Precipitation adjustment, A,S,M,R + mm	IB
EWIND	Wind adjustment, A,S,M,R + km day-1	IB
FACD	Fertilizer application/placement, code	IB
FAMC	Ca in applied fertilizer, kg ha-1	IB
FAMK	K in applied fertilizer, kg ha-1	IB
FAMN	N in applied fertilizer, kg ha-1	IB
FAMO	Other elements in applied fertilizer, kg ha-1	IB
FAMP	P in applied fertilizer, kg ha-1	IB
FDATE	Fertilization date, year + day or days from planting	IB
FDEP	Fertilizer incorporation/application depth, cm	IB
FL	Field level	IB
FLDD	Drain depth, cm	IB
FLDS	Drain spacing, m	IB
FLDT	Drainage type, code	IB
FLOB	Obstruction to sun, degrees	IB
FLSA	Slope and aspect, degrees from horizontal plus direction (W, NW, etc.	IB
FLST	Surface stones (Abundance, % + Size, S,M,L)	IB
FMCD	Fertilizer material, code	IB
FOCD	Other element code, e.g.,. MG	IB
HAREA	Harvest area, m-2	IB
HARM	Harvest method	IB
HCOM	Harvest component, code	IB
HDATE	Harvest date, year + day or days from planting	IB
HL	Harvest level	IB

HLEN	Harvest row length, m	IB
HPC	Harvest percentage, %	IB
HRNO	Harvest row number	IB
HSIZ	Harvest size group, code	IB
HSTG	Harvest stage	IB
IAME	Method for automatic applications, code	IB
IAMT	Amount per automatic irrigation if fixed, mm	IB
IC	Initial conditions level	IB
ICBL	Depth, base of layer, cm	IB
ICDAT	Initial conditions measurement date, year + days	IB
ICND	Nodule weight from previous crop, kg ha-1	IB
ICRE	Rhizobia effectiveness, 0 to 1 scale	IB
ICRN	Rhizobia number, 0 to 1 scale	IB
ICRT	Root weight from previous crop, kg ha-1	IB
IDATE	Irrigation date, year + day or days from planting	IB
IDEP	Management depth for automatic application, cm	IB
ID_FIELD	Field ID (Institute + Site + Field)	IB
ID_SOIL	Soil ID (Institute + Site + Year + Soil)	IB
IEFF	Irrigation application efficiency, fraction	IB
IEPT	End point for automatic appl., % of max. available	IB
INGENO	Cultivar identifier	IB
IOFF	End of automatic applications, growth stage	IB
IROP	Irrigation operation, code	IB
IRVAL	Irrigation amount, depth of water/watertable, etc., mm	IB
ITHR	Threshold for automatic appl., % of max. available	IB
MC	Chemical applications level	IB
ME	Environment modifications level	IB
MF	Fertilizer applications level	IB
MH	Harvest level	IB
MI	Irrigation level	IB
MP	Planting level	IB
MR	Residue level	IB
MT	Tillage level	IB
NOTES	Notes	IB
O	Rotation component - option (default = 1)	IB
ODATE	Environmental modification date, year + day or days from planting	IB
PAGE	Transplant age, days	IB
PAREA	Gross plot area per rep, m-2	IB
PCR	Previous crop code	IB
PDATE	Planting date, year + days from Jan. 1	IB
PENV	Transplant environment, ~C	IB
PEOPLE	Names of scientists	IB
PLAY	Plot layout	IB
PLDP	Planting depth, cm	IB
PLDR	Plots relative to drains, degrees	IB
PLDS	Planting distribution, row R, broadcast B, hill H	IB
PLEN	Plot length, m	IB
PLME	Planting method, code	IB
PLOR	Plot orientation, degrees from N	IB
PLPH	Plants per hill (if appropriate)	IB
PLRD	Row direction, degrees from N	IB
PLRS	Row spacing, cm	IB
PLSP	Plot spacing, cm	IB
PLWT	Planting material dry weight, kg ha-1	IB
PPOE	Plant population at emergence, m-2	IB
PPOP	Plant population at seedling, m-2	IB
PRNO	Rows per plot	IB
R	Rotation component - number (default = 1)	IB
RACD	Residue application/placement, code	IB
RAMT	Residue amount, kg ha-1	IB
RCOD	Residue material, code	IB
RDATE	Incorporation date, year + days	IB
RDEP	Residue incorporation depth, cm	IB
RDMC	Residue dry matter content, %	IB
RESK	Residue potassium concentration, %	IB
RESN	Residue nitrogen concentration, %	IB
RESP	Residue phosphorus concentration, %	IB
RINP	Residue incorporation percentage, %	IB
SA	Soil analysis level	IB
SABD	Bulk density, moist, g cm-3	IB
SABL	Depth, base of layer, cm	IB

SADAT	Analysis date, year + days from Jan. 1	IB
SAHB	pH in buffer	IB
SAHW	pH in water	IB
SAKE	Potassium, exchangeable, cmol kg-1	IB
SANI	Total nitrogen, g kg-1	IB
SAOC	Organic carbon, g kg-1	IB
SAPX	Phosphorus, extractable, mg kg-1	IB
SH20	Water, cm3 cm-3	IB
SITE(S)	Name and location of experimental site(s)	IB
SLDP	Soil depth, cm	IB
SLTX	Soil texture	IB
SM	Simulation control level	IB
SMHB	pH in buffer determination method, code	IB
SMKE	Potassium determination method, code	IB
SMPX	Phosphorus determination method, code	IB
SNH4	Ammonium, KCl, g elemental N Mg-1 soil	IB
SNO3	Nitrate, KCl, g elemental N Mg-1 soil	IB
TDATE	Tillage date, year + day	IB
TDEP	Tillage depth, cm	IB
TIMPL	Tillage implement, code	IB
TL	Tillage level	IB
TN	Treatment number	IB
TNAME	Treatment name	IB
WSTA	Weather station code (Institute + Site)	IB

*Chemicals (Herbicides, Insecticides, Fungicides, etc.)

@CDE	DESCRIPTION	SO
CH001	Alachlor (Lasso), Metolachlor (Dual) [Herbicide]	IB
CH002	Propanil [Herbicide]	IB
CH003	Trifluralin [Herbicide]	IB
CH004	Dalapon [Herbicide]	IB
CH005	MCPA [Herbicide]	IB
CH006	2,4-D [Herbicide]	IB
CH007	2,4,5-T [Herbicide]	IB
CH008	Pendimethalin [Herbicide]	IB
CH009	Atrazine [Herbicide]	IB
CH010	Diquat [Herbicide]	IB
CH011	Paraquat [Herbicide]	IB
CH021	Carbaryl, Sevin, Septene [Insecticide]	IB
CH022	Malathion, Mercaptothion [Insecticide]	IB
CH023	Naled [Insecticide]	IB
CH024	Dimethoate [Insecticide]	IB
CH025	Fention [Insecticide]	IB
CH026	Diazinon, Basudin [Insecticide]	IB
CH027	Ethion, Diethion [Insecticide]	IB
CH028	Oxydemeton-Methyl [Insecticide]	IB
CH029	Azinphos-Methyl [Insecticide]	IB
CH030	Phosphamidon [Insecticide]	IB
CH031	Mevinphosl [Insecticide]	IB
CH032	Methyl Parathion [Insecticide]	IB
CH033	Parathion [Insecticide]	IB
CH034	DDT [Insecticide]	IB
CH035	BHC, HCH [Insecticide]	IB
CH036	Chlordane [Insecticide]	IB
CH037	Heptachlor [Insecticide]	IB
CH038	Toxaphene [Insecticide]	IB
CH039	Aldrin [Insecticide]	IB
CH040	Dieldrin [Insecticide]	IB
CH041	Endrin, Nendrin [Insecticide]	IB
CH042	Methomyl, Lannat [Insecticide]	IB
CH043	Thiotex [Insecticide]	IB
CH044	Furadan [Insecticide]	IB
CH045	Endosulfan [Insecticide]	IB
CH051	Captan [Fungicide]	IB
CH052	Benomyl [Fungicide]	IB
CH053	Zineb [Fungicide]	IB
CH054	Maneb [Fungicide]	IB
CH055	Mancozeb [Fungicide]	IB
CH056	Tilt [Fungicide]	IB
CH057	Rhizobium (for legume crops)	IB

*Crop and Weed Species

```
@CDE   DESCRIPTION                                                    SO
AR     Aroid                                                          IB
AL     Alfalfa/Lucerne                                                IB
BA     Barley                                                         IB
BN     Dry bean                                                       IB
BS     Beet sugar                                                     IB
BW     Broad leaf weeds                                               IB
CO     Cotton                                                         IB
CS     Cassava                                                        IB
FA     Fallow                                                         IB
GW     Grass weeds                                                    IB
ML     Pearl Millet                                                   IB
MZ     Maize                                                          IB
OA     Oats                                                           IB
PN     Peanut                                                         IB
PT     Potato                                                         IB
RI     Rice                                                           IB
SB     Soybean                                                        IB
SC     Sugar Cane                                                     IB
SG     Grain sorghum                                                  IB
ST     Shrubs/trees                                                   IB
WH     Wheat                                                          IB

*Disease and Pest Organisms
@CDE   DESCRIPTION                                                    SO
!Examples of codes that have been used are given below.               IB
CEW    Corn earworm (Heliothis zea), no. m-2                          IB
VBC    Velvetbean caterpillar (Anticarsia gemmatalis), no. m-2        IB
SBL    Soybean looper (Pseudoplusia includens), no. m-2               IB
SKB    Southern green stinkbug (Mezara viridula), no. m-2             IB
RKN    Root-knot nematode (Meloidogyne spp.), no. cm-3 soil           IB
CUT    Cutworm, no. m-2                                               IB

*Drainage
@CDE   DESCRIPTION                                                    SO
DR000  No drainage                                                    IB
DR001  Ditches                                                        IB
DR002  Sub-surface tiles                                              IB
DR003  Surface furrows                                                IB

*Environment Modification Factors
@CDE   DESCRIPTION                                                    SO
A      Add                                                            IB
S      Subtract                                                       IB
M      Multiply                                                       IB
R      Replace                                                        IB

*Fertilizers, Inoculants and Amendments
@CDE   DESCRIPTION                                                    SO
FE001  Ammonium nitrate                                               IB
FE002  Ammonium sulfate                                               IB
FE003  Ammonium-nitrate-sulfate                                       IB
FE004  Anhydrous ammonia                                              IB
FE005  Urea                                                           IB
FE006  Diammnoium phosphate                                           IB
FE007  Monoammonium phosphate                                         IB
FE008  Calcium nitrate                                                IB
FE009  Aqua ammonia                                                   IB
FE010  Urea ammonium nitrate solution                                 IB
FE011  Calcium ammonium nitrate solution                              IB
FE012  Ammonium polyphosphate                                         IB
FE013  Single superphosphate                                          IB
FE014  Triple superphosphate                                          IB
FE015  Liquid phosphoric acid                                         IB
FE016  Potassium chloride                                             IB
FE017  Potassium nitrate                                              IB
FE018  Potassium sulfate                                              IB
FE019  Urea super granules                                            IB
FE020  Dolomitic limestone                                            IB
FE021  Rock phosphate                                                 IB
FE022  Calcitic limestone                                             IB
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FE024	Rhizobium	IB
FE026	Calcium hydroxide	IB

*Harvest components

@CDE	DESCRIPTION	SO
C	Canopy	IB
L	Leaves	IB
H	Harvest product	IB

*Harvest size categories

@CDE	DESCRIPTION	SO
A	All	IB
S	Small - less than 1/3 full size	IB
M	Medium - from 1/3 to 2/3 full size	IB
L	Large - greater than 2/3 full size	IB

*Methods - Fertilizer and Chemical Applications

@CDE	DESCRIPTION	SO
AP000	Applied when required - no shortage	IB
AP001	Broadcast, not incorporated	IB
AP002	Broadcast, incorporated	IB
AP003	Banded on surface	IB
AP004	Banded beneath surface	IB
AP005	Applied in irrigation water	IB
AP006	Foliar spray	IB
AP007	Bottom of hole	IB
AP008	On the seed	IB
AP009	Injected	IB
AP011	Brodcast on flooded/saturated soil, none in soil	IB
AP012	Brodcast on flooded/saturated soil, 15% in soil	IB
AP013	Brodcast on flooded/saturated soil, 30% in soil	IB
AP014	Brodcast on flooded/saturated soil, 45% in soil	IB
AP015	Brodcast on flooded/saturated soil, 60% in soil	IB
AP016	Brodcast on flooded/saturated soil, 75% in soil	IB
AP017	Brodcast on flooded/saturated soil, 90% in soil	IB
AP018	Band on saturated soil,2cm flood, 92% in soil	IB
AP019	Deeply placed urea super granules/pellets, 95% in soil	IB
AP020	Deeply placed urea super granules/pellets, 100% in soil	IB

*Methods - Irrigation and Water Management (Units for associated data)

@CDE	DESCRIPTION	SO
IR001	Furrow, mm	IB
IR002	Alternating furrows, mm	IB
IR003	Flood, mm	IB
IR004	Sprinkler, mm	IB
IR005	Drip or trickle, mm	IB
IR006	Flood depth, mm	IB
IR007	Water table depth, mm	IB
IR008	Percolation rate, mm day-1	IB
IR009	Bund height, mm	IB

*Methods - Soil Analysis

@CDE	DESCRIPTION	SO
SA001	Olsen	IB
SA002	Bray No. 1	IB
SA003	Bray No. 2	IB
SA004	Mehlich	IB
SA005	Anion exchange resin	IB
SA006	Truog	IB
SA007	Double acid	IB
SA008	Colwell	IB
SA009	Water	IB
SA010	IFDC Pi strip	IB

*Planting Material/Method

@CDE	DESCRIPTION	SO
PM001	Dry seed	IB
PM002	Transplants	IB
PM003	Vegetative cuttings	IB
PM004	Pregerminated seed	IB

```
*Plant Distribution
@CDE    DESCRIPTION                                          SO
R       Rows                                                 IB
H       Hills                                                IB
U       Uniform                                              IB

*Residues and Organic Fertilizer
@CDE    DESCRIPTION                                          SO
RE001   Crop residue                                         IB
RE002   Green Manure                                         IB
RE003   Barnyard Manure                                      IB
RE004   Liquid Manure                                        IB

*Rotation
@CDE    DESCRIPTION                                          SO
RO001   Continuous arable crops                              IB
RO002   Rotation with forages                                IB

*Soil Texture
@CDE    DESCRIPTION                                          SO
CLOSA   Coarse loamy sand                                    IB
CSA     Coarse sand                                          IB
CSI     Coarse silt                                          IB
CSALO   Coarse sandy loam                                    IB
CL      Clay                                                 IB
CLLO    Clay loam                                            IB
FLO     Fine loam                                            IB
FLOSA   Fine loamy sand                                      IB
FSA     Fine sand                                            IB
FSALO   Fine sandy loam                                      IB
SICLL   Silty clay loam                                      IB
LO      Loam                                                 IB
LOSA    Loamy sand                                           IB
SA      Sand                                                 IB
SACL    Sandy clay                                           IB
SACLL   Sandy clay loam                                      IB
SI      Silt                                                 IB
SICL    Silty clay                                           IB
SILO    Silty loam                                           IB
SALO    Sandy loam                                           IB
VFLOS   Very fine loamy sand                                 IB
VFSA    Very fine sand                                       IB
VFSAL   Very fine sandy loam                                 IB

*Tillage Implements
@CDE    DESCRIPTION                                          SO
TI002   Tandem disk                                          IB
TI003   Offset disk                                          IB
TI004   Oneway disk                                          IB
TI005   Moldboard plow                                       IB
TI006   Chisel plow                                          IB
TI007   Disk plow                                            IB
TI008   Subsoiler                                            IB
TI009   Beeder/lister                                        IB
TI010   Field cultivator                                     IB
TI011   Row crop cultivator                                  IB
TI012   Harrow-springtooth                                   IB
TI013   Harrow-spike                                         IB
TI014   Rotary hoe                                           IB
TI015   Poto-tiller                                          IB
TI016   Row crop planter                                     IB
TI017   Drill                                                IB
TI018   Shredder                                             IB
TI019   Hoe                                                  IB
TI020   Planting stick                                       IB
TI021   Animal-drawn implement                               IB
TI022   Hand                                                 IB
TI023   Manual hoeing                                        IB
```

APPENDIX C.
SIMULATED AND FIELD DATA CODES

Codes currently used for both simulated and field data are listed in sections relating to specific model output files. Codes currently only used for field data are listed in a section headed Expdata. Codes are assigned as far as possible in accord with the following convention:

1st letter: Plant component (eg. C for canopy; H for harvest product)
2nd letter: Measurement aspect (eg. W for dry weight; N for nitrogen weight)
3rd letter: Basis of measurement (eg. A for unit area; P for plant)
4th letter: Time or stage of measurement (eg. D for specific day)

For complex aspects (eg. ear plus grain) this convention has been modified by dropping the usual 4th letter and using the first 2 letter for component(s). Codes for dates have letters for the stage first and then a D or DAT.

The fields in the file are as follows:

CDE The 'universal' code used to facilitate data interchange.
LABEL A short description used when labelling graphs.
DESCRIPTION A 35 character description of the aspect.
OTHER CODE(S) Additional codes that may be used locally (eg. YILD for HWAM)
SO The source of the codes (IB=IBSNAT). Codes added by a user should be referenced in this field and the name and address of the person adding the code should be entered as a comment (ie.with a '!' in column 1) below this note. This is important to ensure that information from different workers can be easily integrated.
[SE The section to which the code belongs. Used for sorting.]

*SUMMARY

@CDE	LABEL	DESCRIPTION	OTHER CODE(S)	SO	SE
ADAT	ANTHESIS day	Anthesis date (YrDoy)	ANTH	IB	SU
BWAH	BYPRODUCT kg/ha	By-product harvest (kg dm/ha)		IB	SU
CNAA	TOPS N,ANTHESIS	Tops N at anthesis (kg/ha)		IB	SU
CNAM	TOPS N kg/ha	Tops N at maturity (kg/ha)		IB	SU
CPAM	TOPS P kg/ha	Tops P at maturity (kg/ha)		IB	SU
CWAA	TOPS WT,ANTHSIS	Tops weight at anthesis (kg dm/ha)		IB	SU
CWAM	TOPS WT kg/ha	Tops weight at maturity (kg dm/ha)		IB	SU
DRCM	DRAINAGE mm	Season water drainage (mm)		IB	SU
DWAP	SOWING WT kg/ha	Planting material weight (kg dm/ha)		IB	SU
ETCM	ET TOTAL mm	Season evapotranspiration (mm)		IB	SU
FNAM	FIELD NAME	Field name		IB	SU
GN%M	GRAIN N%,MATURE	Grain N at maturity (%)		IB	SU
GNAM	GRAIN N kg/ha	Grain N at maturity (kg/ha)		IB	SU
H#AM	NUMBER #/m2	Number at maturity (no/m2)		IB	SU
H#UM	NUMBER #/unit	Number at maturity (no/unit)		IB	SU
HDAT	HARVEST day	Harvest date (YRDOY)		IB	SU
HIAM	HARVEST INDEX	Harvest index at maturity		IB	SU
HWAH	HAR YIELD kg/ha	Yield at harvest (kg dm/ha)		IB	SU
HWAM	MAT YIELD kg/ha	Yield at maturity (kg dm/ha)		IB	SU
HWUM	WEIGHT mg/unit	Unit wt at maturity (mg dm/unit)		IB	SU
IR#M	IRRIG APPS #	Irrigation applications (no)		IB	SU
IRCM	IRRIG mm	Season irrigation (mm)		IB	SU
L#SM	LEAF NUMBER #	Leaf number per stem,maturity		IB	SU
L#SX	LEAF NUMBER #	Leaf number per stem,maximum		IB	SU
LAIX	LAI MAXIMUM	Leaf area index, maximum		IB	SU
MDAT	MATURITY day	Physiological maturity date (YrDoy)		IB	SU
NFXM	N FIXED kg/h	N fixed during season (kg/ha)		IB	SU
NI#M	N APPLICATION #	N applications (no)		IB	SU
NIAM	SOIL N kg/ha	Inorganic N at maturity (kg N/ha)		IB	SU
NICM	TOT N APP kg/ha	Inorganic N applied (kg N/ha)		IB	SU
NLCM	N LEACHED kg/ha	N leached during season (kg N/ha)		IB	SU
NUCM	N UPTAKE kg/ha	N uptake during season (kg N/ha)		IB	SU
OCAM	ORGANIC C t/ha	Organic soil C at maturity (t/ha)		IB	SU
ONAM	ORGANIC N kg/ha	Organic soil N at maturity (kg/ha)		IB	SU
PD1T	POD 1 DATE yd	Pod 1 date (YrDoy)		IB	SU
PDAT	PLANTING DATE	Planting date (YrDoy)		IB	SU
PDFT	FULL POD DATE	Full pod date (YrDoy)		IB	SU
PO#M	P APPLICATION #	Number of P applications (no)		IB	SU
POCM	P APPLIED kg/ha	P applied (kg/ha)		IB	SU
PRCM	PRECIP mm	Season precipitation (mm)		IB	SU

PWAM	POD WT kg/ha	Pod weight at maturity (kg dm/ha)		IB SU
RECM	RESIDUE kg/ha	Residue applied (kg/ha)		IB SU
ROCM	RUNOFF mm	Season surface runoff (mm)		IB SU
R1AT	FIRST BLOOM	Beginning Bloom Stage		IB SU
R2AT	FIRST PEG	Beginning Peg Stage		IB SU
R3AT	FIRST POD	Beginning Pod Stage		IB SU
R4AT	FULL POD	Full Pod Stage		IB SU
R5AT	FIRST SEED	Beginning Seed Stage		IB SU
R6AT	FULL SEED	Full Seed Stage		IB SU
R7AT	FIRST MATURITY	Beginning Maturity Stage		IB SU
R8AT	HARV MATURITY	Harvest Maturity Stage		IB SU
R9AT	OVER-MATURE	Over-Mature Pod Stage		IB SU
SDAT	SIMULATION DATE	Simulation start date (YrDoy)		IB SU
SNAM	STEM N,MATURITY	Stem N at maturity (kg/ha)		IB SU
SPAM	SOIL P kg/ha	Soil P at maturity (kg/ha)		IB SU
SWXM	EXTR WATER cm	Extractable water at maturity (cm)		IB SU
THAM	THRESHING %	Threshing % at maturity		IB SU
TNAM	TREATMENT NAME	Treatment title		IB SU

*GROWTH

@CDE	LABEL	DESCRIPTION	LOCAL CODE	SO SE
CDAY	CROP AGE days	Crop age (days from planting)		IB GR
CHTD	CANOPY HEIGHT m	Canopy height (m)		IB GR
CWAD	TOPS WT kg/ha	Tops weight (kg dm/ha)		IB GR
CWID	CANOPY WIDTH m	Canopy width (m;for 1 row)		IB GR
E#AD	EAR NO./m2	Ear number (no/m2)		IB GR
EWAD	EAR WT. kg/ha	Ear (no grain) weight (kg dm/ha)		IB GR
G#AD	GRAIN NO #/m2	Grain number (no/m2)		IB GR
GSTD	GROWTH STAGE	Growth stage		IB GR
GWAD	GRAIN WT kg/ha	Grain weight (kg dm/ha)		IB GR
GWGD	GRAIN WT mg	Unit grain weight (mg dm/grain)		IB GR
HIAD	HARVEST INDEX	Harvest index (grain/top)		IB GR
HIPD	POD INDEX	Pod harvest index (pod/top)		IB GR
L#SD	LEAF NUMBER	Leaf number per stem		IB GR
LAID	LAI	Leaf area index		IB GR
LAWD	SLA cm2/g	Specific leaf area (cm2/g)		IB GR
LN%D	LEAF N %	Leaf nitrogen concentration (%)		IB GR
LWAD	LEAF WT kg/ha	Leaf weight (kg dm/ha)		IB GR
NSTD	N STRESS FACTOR	Nitrogen stress factor (0-1)		IB GR
NWAD	NODULE WT kg/ha	Nodule weight (kg dm/ha)		IB GR
P#AD	POD NO #/m2	Pod number (no/m2)		IB GR
PRSD	SHOOT FRACTION	Partitioning of wt to shoot (ratio)		IB GR
PWAD	POD WT kg/ha	Pod weight (kg dm/ha)		IB GR
PWDD	DETACHED POD WT	Detached pod weight (kg dm/ha)		IB GR
PWTD	POD WT kg/ha	Total pod weight (kg dm/ha)		IB GR
RDPD	ROOT DEPTH m	Root depth (m)		IB GR
RL10	RLD 180-210cm	Root density,180-210cm (cm/cm3)		IB GR
RL1D	RLD 0-5 cm	Root density, 0-5 cm (cm/cm3)		IB GR
RL2D	RLD 5-15 cm	Root density, 5-15 cm (cm/cm3)		IB GR
RL3D	RLD 15-30 cm	Root density, 15-30 cm (cm/cm3)		IB GR
RL4D	RLD 30-45 cm	Root density, 30-45 cm (cm/cm3)		IB GR
RL5D	RLD 45-60 cm	Root density, 45-60 cm (cm/cm3)		IB GR
RL6D	RLD 60-90 cm	Root density, 60-90 cm (cm/cm3)		IB GR
RL7D	RLD 90-120cm	Root density, 90-120cm (cm/cm3)		IB GR
RL8D	RLD 120-150cm	Root density,120-150cm (cm/cm3)		IB GR
RL9D	RLD 150-180cm	Root density,150-180cm (cm/cm3)		IB GR
RN%D	ROOT N %	Root N concentration (%)		IB GR
RWAD	ROOT WT kg/ha	Root weight (kg dm/ha)		IB GR
SH%D	SHELLING %	Shelling % (seed wt/pod wt*100)		IB GR
SHAD	SHELL WT kg/ha	Shell weight (kg dm/ha)		IB GR
SHND	SHELL N %	Shell N concentration (%)		IB GR
SLAD	SLA cm2/g	Specific leaf area (cm2/g)		IB GR
SN%D	STEM N %	Stem (stover) N concentration %)		IB GR
SWAD	STEM WT kg/ha	Stem weight (kg dm/ha)		IB GR
T#AD	TILLER NO #/m2	Tiller number (no/m2)		IB GR
WSGD	H20 STRESS,GR	Water stress - growth (0-1)		IB GR
WSPD	H20 STRESS,PHS	Water stress - photosynthesis (0-1)		IB GR

*NITROGEN

@CDE	LABEL	DESCRIPTION	LOCAL CODE	SO	SU
AMLS	NH3VOL kgN/ha/d	Ammonia Vol. (kg N/ha/day)		IB	NI
CNAD	CROP N kg/ha	Tops N (kg/ha)		IB	NI
FALG	ALGAL ACTIVITY	Floodwater Phot.Act.Index (0 to 1)		IB	NI
FALI	FLOOD LT INDX	Floodwater Light Index (0 to 1)		IB	NI
FDEN	DNITRF kgN/ha/d	Floodwater Denitrif Rt (kg N/ha/d)		IB	NI
FL3C	FLD NH3 mg N/l	Floodwater Aqueous NH3 (mg N/l)		IB	NI
FL3N	FLD NO3 mg N/l	Floodwater NO3-N (mg N/l)		IB	NI
FL4C	FLD NH4 mg N/l	Floodwater NH4-N Conc. (mg N/l)		IB	NI
FL4N	FLD NH4 kgN/ha	Floodwater Ammoniacal N (kg N/ha)		IB	NI
FLBD	Puddle BD g/cc	Puddled Soil Surface L BD (g/cc)		IB	NI
FLEF	Flood Evap mm	Floodwater Evaporation Rate (mm/d)		IB	NI
FLNI	FLOOD NIT INDX	Floodwater Nitrogen Index (0 to 1)		IB	NI
FLPH	FLOOD pH	Maximum Daytime Floodwater pH		IB	NI
FLTI	FLOOD TMP INDX	Floodwater Temp. Index (0 to 1)		IB	NI
FLUR	FLD UREA kgN/ha	Floodwater Urea N (kg N/ha)		IB	NI
FUHY	UREA HYD kgN/ha	Urea Hydrol Floodwater (kg N/ha/d)		IB	NI
GN%D	GRAIN N %	Grain N concentration (%)		IB	NI
GNAD	GRAIN N kg/ha	Grain N (kg/ha)		IB	NI
LN%D	LEAF N %	Leaf N concentration (%)		IB	NI
LNAD	LEAF N kg/ha	Leaf N (kg/ha)		IB	NI
NAPC	N APPLIED kg/ha	Inorganic N applied (kg/ha)		IB	NI
NFXC	N FIXED kg/ha	N fixed (kg/ha)		IB	NI
NFXD	N FIXED kg/ha.d	N fixation rate (kg/ha.day)		IB	NI
NH10	NH4 ug/g180-210	NH4 in 180-210cm (ug N/g soil)		IB	NI
NH1D	NH4 ug/g 0-5cm	NH4 in 0-5 cm (ug N/g soil)		IB	NI
NH2D	NH4 ug/g 5-15cm	NH4 in 5-15 cm (ug N/g soil)		IB	NI
NH3D	NH4 ug/g15-30cm	NH4 in 15-30 cm (ug N/g soil)		IB	NI
NH4D	NH4 ug/g30-45cm	NH4 in 30-45 cm (ug N/g soil)		IB	NI
NH5D	NH4 ug/g45-60cm	NH4 in 45-60 cm (ug N/g soil)		IB	NI
NH6D	NH4 ug/g60-90cm	NH4 in 60-90 cm (ug N/g soil)		IB	NI
NH7D	NH4 ug/g 90-120	NH4 in 90-120cm (ug N/g soil)		IB	NI
NH8D	NH4 ug/g120-150	NH4 in 120-150cm (ug N/g soil)		IB	NI
NH9D	NH4 ug/g150-180	NH4 in 150-180cm (ug N/g soil)		IB	NI
NHTD	TOTAL NH4 kg/ha	Total soil NH4 (kg N/ha)		IB	NI
NI10	NO3 ug/g180-210	NO3 in 180-210cm (ug N/g soil)		IB	NI
NI1D	NO3 ug/g 0-5cm	NO3 in 0-5 cm (ug N/g soil)		IB	NI
NI2D	NO3 ug/g 5-15cm	NO3 in 5-15 cm (ug N/g soil)		IB	NI
NI3D	NO3 ug/g15-30cm	NO3 in 15-30 cm (ug N/g soil)		IB	NI
NI4D	NO3 ug/g30-45cm	NO3 in 30-45 cm (ug N/g soil)		IB	NI
NI5D	NO3 ug/g45-60cm	NO3 in 45-60 cm (ug N/g soil)		IB	NI
NI6D	NO3 ug/g60-90cm	NO3 in 60-90 cm (ug N/g soil)		IB	NI
NI7D	NO3 ug/g 90-120	NO3 in 90-120cm (ug N/g soil)		IB	NI
NI8D	NO3 ug/g120-150	NO3 in 120-150cm (ug N/g soil)		IB	NI
NI9D	NO3 ug/g150-180	NO3 in 150-180cm (ug N/g soil)		IB	NI
NIAD	TOTAL N kg/ha	Total soil NO3+NH4 (kg N/ha)		IB	NI
NITD	TOTAL NO3 kg/ha	Total soil NO3 (kg N/ha)		IB	NI
NLCC	N LEACHED kg/ha	N leached (kg N/ha)		IB	NI
NOAD	ORGANIC N kg/ha	Organic N in soil (kg N/ha)		IB	NI
NUPC	N UPTAKE kg/ha	N uptake (kg N/ha)		IB	NI
OXRN	OXNITR kgN/ha/d	Ox Layer Nitrif Rt (kg N/ha/d)		IB	NI
RN%D	ROOT N %	Root N concentration (%)		IB	NI
SHND	SHELL N %	Shell N concentration (%)		IB	NI
SN%D	STEM N %	Stem (stover) N concentration (%)		IB	NI
SNAD	STEM N kg/ha	Stem N (kg/ha)		IB	NI
VN%D	VEG N %	Veg (stem+leaf) N concentration (%)		IB	NI
VNAD	VEGE N kg/ha	Veg (stem+leaf) N (kg/ha)		IB	NI

*WATER

@CDE	LABEL	DESCRIPTION	LOCAL CODE	SO	SE
DA3D	DAYLENGTH h	Daylength (h;3 deg basis)		IB	WA
DAYD	DAYLENGTH h	Daylength (h;sunrise to sunset)		IB	WA
DRNC	DRAINGE mm	Cumulative drainage (mm)		IB	WA
EOAA	POT EVAP mm/d	Av pot.evapotranspiration (mm/d)		IB	WA
EOAD	POT EVAP mm/d	Potential evapotranspiration (mm/d)		IB	WA
EPAA	PLANT EVAP mm/d	Av plant transpiration (mm/d)		IB	WA
EPAC	TRANSPIRATION	Cumulative transpiration (mm)		IB	WA
EPAD	PLANT EVAP mm/d	Plant transpiration (mm/d)		IB	WA
ESAA	SOIL EVAP mm/d	Av soil evaporation (mm/d)		IB	WA
ESAC	SOIL EVAP mm	Cumulative soil evaporation (mm)		IB	WA

ESAD	SOIL EVAP mm/d	Soil evaporation (mm/d)	IB WA
ETAA	EVAPOTRANS mm/d	Av evapotranspiration (mm/d)	IB WA
ETAC	EVAPOTRANS mm	Cumulative evapotranspiration (mm)	IB WA
ETAD	EVAPOTRANS mm/d	Evapotranspiration (mm/d)	IB WA
IR#C	IRRIGATION #	Irrigation applications (no)	IB WA
IRRC	IRRIGATION mm	Cumulative irrigation (mm)	IB WA
PREC	PRECIPITATION	Cumulative precipitation (mm)	IB WA
ROFC	RUNOFF mm	Cumulative runoff (mm)	IB WA
SRAA	SRAD MJ/m2.day	Av solar radiation (MJ/m2.day)	IB WA
SW10	SWC 180-210cm	Soil water 180-210cm(cm3/cm3)	IB WA
SW1D	SWC 0-5 cm	Soil water 0-5 cm(cm3/cm3)	IB WA
SW2D	SWC 5-15 cm	Soil water 5-15 cm(cm3/cm3)	IB WA
SW3D	SWC 15-30 cm	Soil water 15-30 cm(cm3/cm3)	IB WA
SW4D	SWC 30-45 cm	Soil water 30-45 cm(cm3/cm3)	IB WA
SW5D	SWC 45-60 cm	Soil water 45-60 cm(cm3/cm3)	IB WA
SW6D	SWC 60-90 cm	Soil water 60-90 cm(cm3/cm3)	IB WA
SW7D	SWC 90-120cm	Soil water 90-120cm(cm3/cm3)	IB WA
SW8D	SWC 120-150cm	Soil water 120-150cm(cm3/cm3)	IB WA
SW9D	SWC 150-180cm	Soil water 150-180cm(cm3/cm3)	IB WA
SWXD	EXTR WATER cm	Extractable water (cm)	IB WA
TMNA	MINIMUM TEMP C	Av minimum temperature (C)	IB WA
TMXA	MAXIMUM TEMP C	Av maximum temperature (C)	IB WA
TS10	S-TMP 80-210cm	Soil temperature 180-210cm (C)	IB WA
TS1D	S-TMP 0-5 cm	Soil temperature 0-5 cm (C)	IB WA
TS2D	S-TMP 5-15 cm	Soil temperature 5-15 cm (C)	IB WA
TS3D	S-TMP 15-30 cm	Soil temperature 15-30 cm (C)	IB WA
TS4D	S-TMP 30-45 cm	Soil temperature 30-45 cm (C)	IB WA
TS5D	S-TMP 45-60 cm	Soil temperature 45-60 cm (C)	IB WA
TS6D	S-TMP 60-90 cm	Soil temperature 60-90 cm (C)	IB WA
TS7D	S-TMP 90-120cm	Soil temperature 90-120cm (C)	IB WA
TS8D	S-TMP 20-150cm	Soil temperature 120-150cm (C)	IB WA
TS9D	S-TMP 50-180cm	Soil temperature 150-180cm (C)	IB WA

*CARBON

@CDE	LABEL	DESCRIPTION	LOCAL CODE	SO SE
CGRD	CGR g/m2.d	Crop growth rate (g top+store/m2.d)		IB CA
CHAD	CH2O g/m2.d	CH2O accumulation (g CH2O/m2.d)		IB CA
CL%D	LEAF C %	C in leaf (%)		IB CA
CMAD	CH MOB g/m2.d	C mobilization (g CH2O/m2.d)		IB CA
CS%D	STEM C %	C in stem (%)		IB CA
GRAD	GR RESP g/m2.d	Growth respiration (g CH2O/m2.d)		IB CA
LI%D	LIGHT INTER %	Light (PAR) interception (%)		IB CA
LI%N	NOON LIGHT IN %	Noon light (PAR) interception (%)		IB CA
LMHN	NOON PMAX,SHADE	Noon Pmax shaded leaves (mg/m2.s)		IB CA
LMLN	NOON PMAX,LIGHT	Noon Pmax sunlit leaves (mg/m2.s)		IB CA
MRAD	M RESP g/m2.d	Maintenance resp (g CH2O/m2.d)		IB CA
N%HN	NOON N,SHADE %	Noon N shaded leaves (%)		IB CA
N%LN	NOON N,LIGHT %	Noon N sunlit leaves (%)		IB CA
OMAC	OM APPL kg/ha	Cumulative OM applied (kg dm/ha)		IB CA
PHAD	P GROSS g/m2.d	Gross photosynthesis (g CH2O/m2.d)		IB CA
PHAN	PG,NOON mg/m2.s	Gross photosyn.,noon (mg CO2/m2.s)		IB CA
SLHN	NOON SLW,SHADE	SLW in shaded lves,noon (mg dm/cm2)		IB CA
SLLN	NOON SLW,Light	SLW in sunlit lves,noon (mg dm/cm2)		IB CA
SOCD	SOIL OC t/ha	Soil organic carbon (t/ha)		IB CA
TGAV	AVG CAN TMP, C	Daily average canopy temp (C)		IB CA
TGNN	NOON CAN TMP, C	Noon canopy temperature (C)		IB CA
TWAD	TOTAL WT kg/ha	Tops+roots+storage wt (kg dm/ha)		IB CA

*PESTS

@CDE	LABEL	DESCRIPTION	LOCAL CODE	SO SE
CASM	ASSIM g CH2O	Cumulative assimilate reduction		IB PE
CEW	CEW #/row-m	Corn Earworm		IB PE
CLAI	LAI m2/m2	Cumulative leaf area consumed		IB PE
CLFM	LEAF g/m2	Cumulative leaf mass consumed		IB PE
CPO%	PLTPOP %	Cumulative pl population reduction		IB PE
CRLF	ROOT cm/cm2	Cumulative root length consumed		IB PE
CRLV	ROOT cm/cm2	Cumulative root ln density consumed		IB PE
CRTM	ROOT g/m2	Cumulative root mass consumed		IB PE
CSD#	SEED #/m2	Cumulative seed number consumed		IB PE
CSDM	SEED g/m2	Cumulative seed mass consumed		IB PE
CSH#	SHELL #/m2	Cumulative shell number consumed		IB PE

CSHM	SHELL g/m2	Cumulative shell mass consumed		IB PE
CSTM	STEM g/m2	Cumulative stem mass consumed		IB PE
DASM	ASSIM g CH2O/d	Daily carbohydrate pool reduction		IB PE
DLA	DIS. LAI cm2/m2	Daily diseased leaf area increase		IB PE
DLA%	DIS. LAI %/d	Daily % diseased leaf area increase		IB PE
DLAI	LAI m2/m2.d	Daily leaf area consumed		IB PE
DLFM	LEAF g/m2.d	Daily leaf mass consumed		IB PE
DPO%	PLTPOP %/day	Daily plant population reduction		IB PE
DRLF	ROOT cm/cm2.d	Daily total root length consumed		IB PE
DRLV	ROOT cm/cm3.d	Daily root length density consumed		IB PE
DRTM	ROOT g/m2.d	Daily root mass consumed		IB PE
DSD#	SEED #/m2.d	Daily seed number consumed		IB PE
DSDM	SEED g/m2.d	Daily seed mass consumed		IB PE
DSH#	SHELL #/m2.d	Daily shell number consumed		IB PE
DSHM	SHELL g/m2.d	Daily shell mass consumed		IB PE
DSTM	STEM g/m2.d	Daily stem mass consumed		IB PE
FAW	FAW #/m	Fall armyworm		IB PE
RTWM	RTWM #/m	Root worm		IB PE
SGSB	SGSB #/m	Southern green stinkbug		IB PE
SL	SB LOOPER #/m	Soybean looper		IB PE
VBC5	VBC5 #/m	5 instar velvetbean caterpillar		IB PE
VBC6	VBC6 #/m	6 instar velvetbean caterpillar		IB PE

*EXPERIMENTAL DATA

@CDE	LABEL	DESCRIPTION	LOCAL CODE	SO SE
APID	APEX 1cm day	Apex 1cm date (YrDoy)		IB EX
CHN%	CHAFF N %	Chaff N (%)		IB EX
CHWA	CHAFF WT kg/ha	Chaff weight (kg dm/ha)		IB EX
DRID	DOUBLE RIDGES d	Double ridges date (YrDoy)		IB EX
DWAD	DEAD WT kg/ha	Dead material weight (kg dm/ha)		IB EX
EDAT	EMERGENCE day	Emergence date (YrDoy)		IB EX
EEMD	EAR EMERGENCE d	Ear emergence date (YrDoy)		IB EX
EGWA	EAR+GRAIN kg/ha	Ear plus grain weight (kg dm/ha)		IB EX
EGWS	EAR+GRAIN g/s	Ear+grain weight (g dm/shoot)		IB EX
G#PD	GRAIN NO #/pl	Grain number (no/plant)		IB EX
G#SD	GRAIN NO #shoot	Grain number (no/shoot)		IB EX
GW%M	GRAIN H2O %	Grain moisture at maturity (%)		IB EX
GWAM	GRAIN WT kg/ha	Grain wt at maturity (kg dm/ha)		IB EX
GWGM	GRAIN WT mg	Unit wt at maturity (mg dm/grain)		IB EX
GWPM	GRAIN WT g/pl	Grain wt at maturity (g dm/plant)		IB EX
GYAM	GRAIN YLD kg/ha	Grain yield at maturity (kg fm/ha)		IB EX
GYPM	GRAIN YLD g/pl	Grain yld at maturity (g fm/plant)		IB EX
GYVM	TEST WT kg/hl	Test weight at maturity (kg fm/hl)		IB EX
HWAC	COR YIELD kg/ha	Corrected yield (kg dm/ha)		IB EX
HYAM	HARVEST kg/ha	Harvest yld at maturity (kg fm/ha)		IB EX
LAFD	FLAG AREA cm2	Flag leaf area (cm2/leaf)		IB EX
LALD	LEAF AREA cm2	Leaf area (cm2/leaf)		IB EX
LAPD	LEAF AREA cm2/p	Leaf area (cm2/plant)		IB EX
LARD	LEAF APPEARANCE	Leaf appearance rate (#/day)		IB EX
L#IR	LEAF # INCREASE	Leaf number increase rate (#/day)		IB EX
LDAD	DEAD LEAF kg/ha	Dead leaf weight (kg dm/ha)		IB EX
LF3D	LEAF 3 FULL day	Full expansion, leaf 3 (Yrdoy)		IB EX
LF5D	LEAF 5 FULL day	Full expansion, leaf 5 (Yrdoy)		IB EX
LLFD	LAST LEAF day	Last leaf date (YrDoy)		IB EX
LWAM	LEAF WT kg/ha	Leaf weight (kg/ha)		IB EX
LWPD	LEAF WT g/plant	Leaf weight (g/plant)		IB EX
PARI	PAR INTERCEPT %	PAR interception (%)		IB EX
RLAD	ROOT LN cm/cm2	Root length (cm/cm2)		IB EX
RLWD	ROOT L/W cm/g	Root length/weight (cm/g)		IB EX
RWLD	ROOT W/L g/cm	Root weight/length (g/cm)		IB EX
S#PD	SHOOT NO #/pl	Shoot (apex) number (no/plant)		IB EX
S#AD	SHOOT NO #/m2	Shoot (apex) number (no/m2)		IB EX
SCWA	STM+CHAFF kg/ha	Stem plus chaff (kg/ha)		IB EX
SP#P	SPIKELETS #/pl	Spikelet number (no/plant)		IB EX
SWPD	STEM WT g/plant	Stem weight (g dm/plant)		IB EX
T#PD	TILLER NO.#/pl	Tiller number (no/plant)		IB EX
T#AD	TILLER NO.#/m2	Tiller number (no/m2)		IB EX
TNAM	TOTAL N kg/ha	Total N at maturity (kg N/ha)		IB EX
TSPD	TERMINAL SPKL d	Terminal spikelet date (YrDoy)		IB EX
TWAM	TOTAL WT kg/ha	Total wt, maturity (kg dm/ha)		IB EX
VWAM	VEG WT kg/ha	Veg (lf+st) wt,maturity (kg dm/ha)		IB EX

Z21D	ZADOKS 21 day	Zadoks 21 date (YrDoy)	IB EX
Z30D	ZADOKS 30 day	Zadoks 30 date (YrDoy)	IB EX
Z31D	ZADOKS 31 day	Zadoks 31 date (YrDoy)	IB EX
Z37D	ZADOKS 37 day	Zadoks 37 date (YrDoy)	IB EX
Z39D	ZADOKS 39 day	Zadoks 39 date (YrDoy)	IB EX
TDWA	TOTAL+D kg/ha	Tops+roots+storage+dead (kg dm/ha)	IB EX
CDWA	CANOPY+D kg/ha	Tops+dead wt (kg dm/ha)	IB EX
LALN	LEAF AREA,NEW	Leaf area,new leaves (cm2 lf-1)	IB EX
BR1D	BRANCH 1 YrDoy	Branch 1 date (YrDoy)	IB EX
BR2D	BRANCH 2 YrDoy	Branch 1 date (YrDoy)	IB EX
BR3D	BRANCH 3 YrDoy	Branch 1 date (YrDoy)	IB EX
BR4D	BRANCH 4 YrDoy	Branch 1 date (YrDoy)	IB EX
SDWT	SEED WT g/pl	Seed weight (g pl-1)	IB EX
HWAD	YIELD kg/ha	Yield on specified day (kg dm/ha)	IB EX

APPENDIX D.
WEATHER DATA CODES

Headers used in the @ line to identify variables are listed first; codes ('flags') used to designate data types are listed next.

The fields in the file are as follows:
CDE The 'universal' code used to facilitate data interchange.
DESCRIPTION A description of the code, with units.
SO The source of the codes (IB=IBSNAT). Codes added by a user should be referenced in this field and the name and address of the person adding the code should be entered as a comment (ie.with a '!' in column 1) below this note. This is important to ensure that information from different workers can be easily integrated.

*Headers

@CDE	DESCRIPTION	SO
ALPHA	WGEN parameter	IB
ANGA	Angstrom 'a' coefficient	IB
ANGB	Angstrom 'b' coefficient	IB
DATE	Date, year + days from Jan. 1	IB
DEWP	Dewpoint temperature, ~C	IB
DURN	Duration of summarization period for climate files, Yr	IB
ELEV	Elevation, m	IB
GSDU	Growing season duration, Day	IB
GSST	Growing season start day, Doy	IB
IN	Institute code	IB
LAT	Latitude, degrees (decimals)	IB
LONG	Longitude, degrees (decimals)	IB
MONTH	Month, #	IB
NAMN	Temperature minimum,monthly average, C	IB
NASD	WGEN parameter	IB
PAR	Photosynthetic radiation, moles m-2 day-1	IB
PDW	WGEN parameter	IB
RAIN	Rainfall (incl.snow), mm day-1	IB
RAIY	Rainfall,yearly total, mm	IB
REFHT	Reference height for weather measurements, m	IB
RHUMM	Relative humidity average over whole day for month, %	IB
RNUM	Rainy days, # month-1	IB
RTOT	Rainfall total, mm month-1	IB
SAMN	Solar radiation,monthly average, MJ m-2 d-1	IB
SDMN	WGEN parameter	IB
SDSD	WGEN parameter	IB
SI	Site code	IB
SRAD	Solar radiation, MJ m-2 day-1	IB
SRAY	Solar radiation,yearly average, MJ m-2 day-1	IB
START	Start of summary period for climate (CLI) files, Year	IB
SWMN	WGEN parameter	IB
SWSD	WGEN parameter	IB
TAMP	Temperature amplitude, monthly averages, ~C	IB
TAV	Temperature average for whole year, ~C	IB
TMAX	Temperature maximum, ~C	IB
TMIN	Temperature minimum, ~C	IB
WIND	Wind speed average, m sec-1	IB
WINDM	Windspeed average over whole day for month, m s-1	IB
WNDHT	Reference height for windspeed measurements, m	IB
WRUN	Wind run, km day-1	IB
XAMN	Temperature maximum,monthly average, C	IB
XDMN	WGEN parameter	IB
XDSD	WGEN parameter	IB
XWMN	WGEN parameter	IB
XWSD	WGEN parameter	IB

*Flags

Flags attached to data to indicate the nature of the original data. Upper case flags = original data replaced; lower-case flags = original data.

@CDE	DESCRIPTION	
A	Above maximum - data replaced	SC
a	Above maximum - but original data left	IB
B	Below minimum - data replaced	IB
b	Below minimum - - but original data left	IB
D	Decadal averages only in original file - data replaced	IB
d	Decadal averages only in original file - but original data left	IB
E	Format error in original file - data replaced	IB
e	Format error in original file - but original data left	IB
H	Solar radiation as sunshine hours - data replaced	IB
h	Solar radiation as sunshine hours - but original data left	IB
M	Monthly averages only in original file - data replaced	IB
m	Monthly averages only in original file - but original data left	IB
N	No data in original file - data replaced	IB
n	No data in original file - but original data left	IB
R	Rate of change exceeded - data replaced	IB
r	Rate of change exceeded - but original data left	IB

VOLUME 2-2

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CERES–Millet

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CERES–Rice

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CROPGRO–DRY BEAN

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PREFACE

The information presented in the example and output sections of this Part is representative of the results you can produce from your copy of the DSSAT v3 crop models. These are examples only, however, and your results may vary slightly from the results you receive, due to the evolutionary nature of the crop models. Incremental improvements, many suggested by users as they calibrate and validate the models with their own data sets, are constantly being evaluated and implemented. Therefore, post-press changes to the models may reflect improvements implemented after printing of this Volume.

CHAPTER ONE. INTRODUCTION

The crop models developed under the auspices of the International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT) Project are process oriented computer models which simulate growth, development, and yield as a function of plant genetics, weather and soil conditions, and crop management selections. These include models for the following crops: aroids (*Colocasia esculenta L.* [taro] & *Xanthosoma sagittifolium L.*[tannier]), barley (*Hordeum vulgare L.*), cassava (*Manihot esculenta L.*), corn (*Zea mays L.*), dry bean (*Phaseolus vulgaris L.*), millet (*Pennisetum americanum L.*), peanut (*Arachis hypogea L.*), potato (*Solanum tuberosum L.*), rice (*Oryza sativa L.*), sorghum (*Sorghum bicolor L.*), soybean (*Glycine max [L.] Merr.*) and wheat (*Triticum eastivum L.*). In the Decision Support System for Agrotechnology Transfer (DSSAT) v2.1 (IBSNAT 1989; Jones et al. 1990) individual models existed for each crop (Table 1). As part of the move to DSSAT v3, crop models were combined to avoid coding duplication and other problems associated with model improvement. For the family of grain legume crops a generic model was developed called CROPGRO, which is being extended to include other crops, such as tomato. The grain cereals, except for CERES-Rice, were combined into a generic grain cereal model called CERES. Development of the root crop models will continue as separate models.

Previously, individual user's guides were developed for the crop models SOYGRO (Jones et al., 1989), PNUTGRO (Boote et al., 1989), BEANGRO (Hoogenboom et al., 1991), CERES-Wheat (Godwin et al., 1989), CERES-Maize (Ritchie et al., 1989), CERES-Barley (Otter-Nacke et al., 1991), and CERES-Rice (Singh et al., 1993). In DSSAT v3, one model user-interface was developed for use by all crop models, and thus, one user's guide.

Since, however, these crop models can also be run as stand-alone models, there is some flexibility as to how the executables, input and output files are organized on a computer disk. The organization of these files for running under both the DSSAT v3 Shell (Volume 1-3, Hunt et al. 1994) and as stand alones is described in Appendix C of this Part.

The operation of the crop models in DSSAT v3 using the DSSAT v3 Shell (Volume 1-3, Hunt et al. 1994) interface is described herein.

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TABLE 1. OLD AND NEW GENERATION CROP SIMULATION MODELS.

Crop	DSSAT v2.1 Model	DSSAT v3 Model	Reference
Cereals			
Barley	CERES-Barley	Generic CERES	Otter-Nacke et al. (1991)
Corn (Maize)	CERES-Maize	Generic CERES	Ritchie et al.(1989)
Millet	CERES-Millet	Generic CERES	Singh et al. (1991)
Rice	CERES-Rice	CERES-Rice	Singh et al. (1993)
Sorghum	CERES-Sorghum	Generic CERES	Alargarswamy and Ritchie (1991)
Wheat	CERES-Wheat	Generic CERES	Godwin et al. (1989)
Grain Legumes			
Dry bean	BEANGRO	CROPGRO	Hoogenboom et al (1994)
Peanut	PNUTGRO	CROPGRO	Boote et al. (1989)
Soybean	SOYGRO	CROPGRO	Jones et al. (1989)
Roots and Tubers			
Aroids	SUBSTOR-Aroids	N/A	Prasad et al. (1991)
Cassava	N/A	CROPSIM-Cassava	Matthews and Hunt (1994)
Potato	SUBSTOR-Potato	N/A	Griffin et al. (1993)

CHAPTER TWO. INPUTS AND OUTPUTS

The DSSAT v3 crop models incorporate the input and output ASCII file structures fully described in Volume 2-1 (Jones et al. 1994) of this book. This I/O system is considerably different than the crop model inputs and outputs structures found in DSSAT v2.1 (IBSNAT 1989, 1990).

WEATHER

Though daily weather formats are similar to those in DSSAT v2.1, additional features have been added to accommodate improved quality control of weather data. A space has been designated next to each data field for characters to document when data were filled from other sources and the reason for filling. The quality control options for weather data in DSSAT v3 are handled by WeatherMan, described in Volume 3-3 (Hansen et al. 1994) of this book. In the DSSAT v3 crop models, including CROPGRO and CERES, the name of the weather file is constructed internally from the weather file information contained in the experiment input file. The code for the weather file includes eight characters, such as UFGA8101, and the file UFGA8101.WTH would be constructed in the model code if observed weather data would be used as input, or the file UFGA8101.WTG would be constructed in the model code if externally generated weather data would be used as input. The model will look first in the current directory for this file. If the model is unable to locate the weather file in the current crop model data directory, the model will check the path specified by the DSSAT v3 path-declaration file (DSSATPRO.FLE). For a complete description of the weather file (FILEW) formats and structures, see Volume 2-1 (Jones et al. 1994) of this book.

SOIL

The soil file has also been changed in DSSAT v3. First, more information was added in an attempt to make the soil inputs more generally applicable by other crop models. For example, clay and silt percentages are now included, and new inputs were defined to allow for simulation of soil phosphorus dynamics. The first release of the DSSAT v3 models will not include the phosphorus module in any of the crop models. Secondly, all new models use the same soil file, whereas models in DSSAT V2.1 required a separate soil file for each crop. The new soil file is usually named SOIL.SOL, but the models will accept soil profile data in input files specific for each institute, e.g. UFSOL would contain soil profile information defined by the University of

Florida. The models will first look for the SOIL.SOL file in the "current" path, and if the model is unable to locate the SOIL.SOL file, the model will try to locate the UF.SOL file. The file name UF.SOL is constructed by the models based on the institute code of the institute at which the experiment was performed. For a complete description of the soil file (FILES) formats and structures, see Volume 2-1 (Jones et al. 1994) of this book.

Crop Management

In DSSAT v3, details of a crop experiment, such as field information, treatments, planting information, initial conditions, irrigation, residue and fertilizer management, and harvest information are contained in one single file. This single file is referred to as experiment details file or FILEX. A user can name FILEX based on institute id, site id, year, experiment number, and crop code; the naming convention is similar to the one of DSSAT V2.1 (IBSNAT, 1989; 1990). For example, the file UFGA8101.SBX is the file name for a soybean experiment conducted in 1981 at the University of Florida in Gainesville (UFGA). The experiment details file FILEX is divided into sections; a "*" designates each section, and the file uses the symbol "@ "in column 1 of lines that contain codes or headers for variables defined in the section following this header line. The file uses "!" to define comment lines; blank lines can also be used in the file to delineate data input blocks and these lines are ignored by the model when reading the experiment details file. For a complete description of the experiment details file (FILEX) formats and structures, see Volume 2-1 (Jones et al. 1994) of this book.

Simulation Control

Each DSSAT v3 experiment details file FILEX contains a *SIMULATION CONTROL section that fully specifies all options for a simulation run. This section also defines automatic management characteristics for planting, irrigation, fertilizer, residue, and harvest. These automatic management options allow the user to define management conditions for hypothetical "experiments." For a complete description of the Simulation Controls section of FILEX, see Volume 2-1(Jones et al. 1994) of this book.

Average Final Field Data

The DSSAT v3 models use two files for field observed data and other related information. The first file contains averages of field observations, and this information is used for comparison between model simulated data and field observed data to calibrate, validate and test the models. The field average observational data file is called FILEA. For the example

TABLE 2. AVERAGE FINAL FIELD DATA FILE. (FILEA = "UFGA7801.SBA")

*EXP.DATA (A): UFGA7801SB BRAGG, IRRIGATED & NON-IRRIGATED

@TRNO	HWAM	HWUM	H#AM	H#UM	LAIX	CWAM	BWAH	ADAT	MDAT	PD1T	PDFT	PWAM	HIAM	THAM
1	3041.	.1440	2223.	1.96	4.67	6068.	1958.	211	282	233	233	4009.	.501	75.85
2	1178.	.1230	969.	1.85	4.50	3491.	1756.	211	282	233	233	1602.	.337	73.53

used in the Crop Management section above, this file would be called UFGA8101.SBA. The format for FILEA in DSSAT v3 is different from the format of FILEA in DSSAT v2.1. Generally, the data in FILEA are in stored in columns, which are each 6 characters in width, with a header above each column indicating the type of data in that column. The crop model uses the same header information for its outputs, so that corresponding simulated and observed data can be matched regardless of the location of these columns in the input files. An abbreviation file (DATA.CDE) defines these headers, including appropriate units of the variables and values associated with those headers. These abbreviations are also used by the data handling components of DSSAT v3, graphics, and seasonal and sequence analysis programs. An example of a FILEA is shown in Table 2. For a description of FILEA formats and structures, see Volume 2-1 (Jones et al. 1994) of this book.

TIME-COURSE FIELD DATA

In addition to FILEA, a second file is used to store field data for within-season measurements. This time-course data file, FILET, can contain an unlimited number of 6-character columns. Data that were measured in the field can be stored in this file, and these can include both measured soil, plant, and pest information as a function of day of year. For example FILET, e.g. UFGA8101.SBT, is the time course file for an experiment conducted the University of Florida in Gainesville in 1981. An example of a FILET is shown in Table 3. For a description of FILET formats and structures, see Volume 2-1 (Jones et al. 1994) of this book.

OUTPUT FILES

Outputs from the models are written to the following files:

OVERVIEW.OUT which contains a copy of the output as shown on the computer screen during the simulation;

SUMMARY.OUT which contains a one line summary of the main developmental events, water and nitrogen variables, and yield and yield components;

GROWTH.OUT, which contains a summary of the growth balance variables over time;

WATER.OUT, which contains a summary of the soil and plant water variables over time;

NITROGEN.OUT, which contains a summary of the soil and plant nitrogen variables over time;

CARBON.OUT, which contains a summary of some of the main soil and plant carbon variables; and

PEST.OUT, which contains a summary of the pest variables as a function of time.

FILES GROWTH.OUT, WATER.OUT, NITROGEN.OUT, CARBON.OUT, and PEST.OUT contain time-series outputs at steps as small as one day or as large as specified by the user. Each file can be switched on or off, and the frequency of daily outputs can be specified in the Simulation Control section of FILEX. These output files are temporary and are erased and overwritten at the start of each new simulation run. Users, however, can select an option to save these files with experiment specific file names. This option can be fixed permanently through one variable in FILEX or interactively through the Sensitivity Analysis option. For example, the above described 1981 University of Florida experiment output files could be saved as UFGA8101.SBO, UFGA8191.SBS, UFGA8191.SBG, UFGA8101.SBW, UFGA8101.SBN, UFGA8101.SBC, and UFGA8101.SBD, respectively. For a description of these file formats and structures, see Volume 2-1 (Jones et al. 1994) of this book

TABLE 3. TIME-COURSE FIELD DATA FILE. (FILET = "UFGA7801.SBT")

*EXP.DATA (T): UFGA7801SB BRAGG, IRRIGATED & NON-IRRIGATED

@TRNO	DATE	LAID	SWAD	GWAD	LWAD	CWAD	PWAD	SHAD	SH%D	SLAD	HIAD
1	78194	.89	178	0.	266	444	0.	0.	0.00	334.6	0.000
1	78201	1.28	300	0.	366	667	0.	0.	0.00	349.7	0.000
1	78208	1.91	551	0.	656	1207	0.	0.	0.00	291.2	0.000
1	78215	2.86	943	0.	843	1786	0.	0.	0.00	339.3	0.000
1	78222	4.17	1561	0.	1187	2748	0.	0.	0.00	351.3	0.000
1	78229	3.90	1956	0.	1204	3160	0.	0.	0.00	323.9	0.000
1	78236	4.66	2947	0.	1723	4792	123	123	0.00	270.5	0.000
1	78243	4.47	3144	0.	1772	5224	308	308	0.00	252.3	0.000
1	78250	4.44	3303	182	1631	5740	805	623	22.60	272.2	0.030
1	78257	3.99	3326	754	1568	6507	1613	859	46.75	254.5	0.116
1	78264	4.67	3657	1912	1769	8586	3161	1249	60.49	264.0	0.222
1	78271	2.83	2732	2223	1180	7144	3232	1009	68.78	239.8	0.311
1	78278	2.09	2515	2730	858	7136	3763	1033	72.55	243.6	0.383
1	78285	.47	1851	2913	170	5866	3845	932	75.76	276.5	0.497
1	78292	.09	2064	3169	34	6270	4172	1003	75.96	264.7	0.505
2	78194	.75	160	0.	244	405	0.	0.	0.00	307.4	0.000
2	78201	1.08	251	0.	311	563	0.	0.	0.00	347.3	0.000
2	78208	1.81	535	0.	626	1161	0.	0.	0.00	289.1	0.000
2	78215	3.29	1080	0.	974	2054	0.	0.	0.00	337.8	0.000
2	78222	4.38	1663	0.	1261	2923	0.	0.	0.00	347.3	0.000
2	78229	4.30	2083	0.	1392	3475	0.	0.	0.00	308.9	0.000
2	78236	4.21	2556	0.	1517	4184	112	112	0.00	277.5	0.000
2	78243	4.50	2673	0.	1439	4431	319	319	0.00	312.7	0.000
2	78250	2.09	1998	42	838	3104	268	226	15.67	249.4	0.014
2	78257	3.24	2650	253	1220	4530	661	408	38.28	265.6	0.056
2	78264	2.30	2609	471	931	4440	901	430	52.28	247.0	0.106
2	78271	1.14	2113	775	498	3812	1200	425	64.58	228.9	0.203
2	78278	.85	1905	782	371	3398	1122	340	69.70	229.1	0.230
2	78285	.53	1922	1149	236	3732	1574	425	73.00	224.5	0.308
2	78292	.07	1590	1206	30	3250	1630	424	73.99	233.3	0.371

CHAPTER THREE. SYSTEM OVERVIEW

FLOW OF INFORMATION

The DSSAT v3 crop simulation models consist of three modules: model driver, input module and crop simulation module. Figure 1 presents a schematic overview of these modules. The main difference with the DSSAT v2.1 models is that the input and sensitivity analysis section of each model is now separated from its model simulation section. In DSSAT v3, one input and sensitivity module is used by all crop simulation models. When

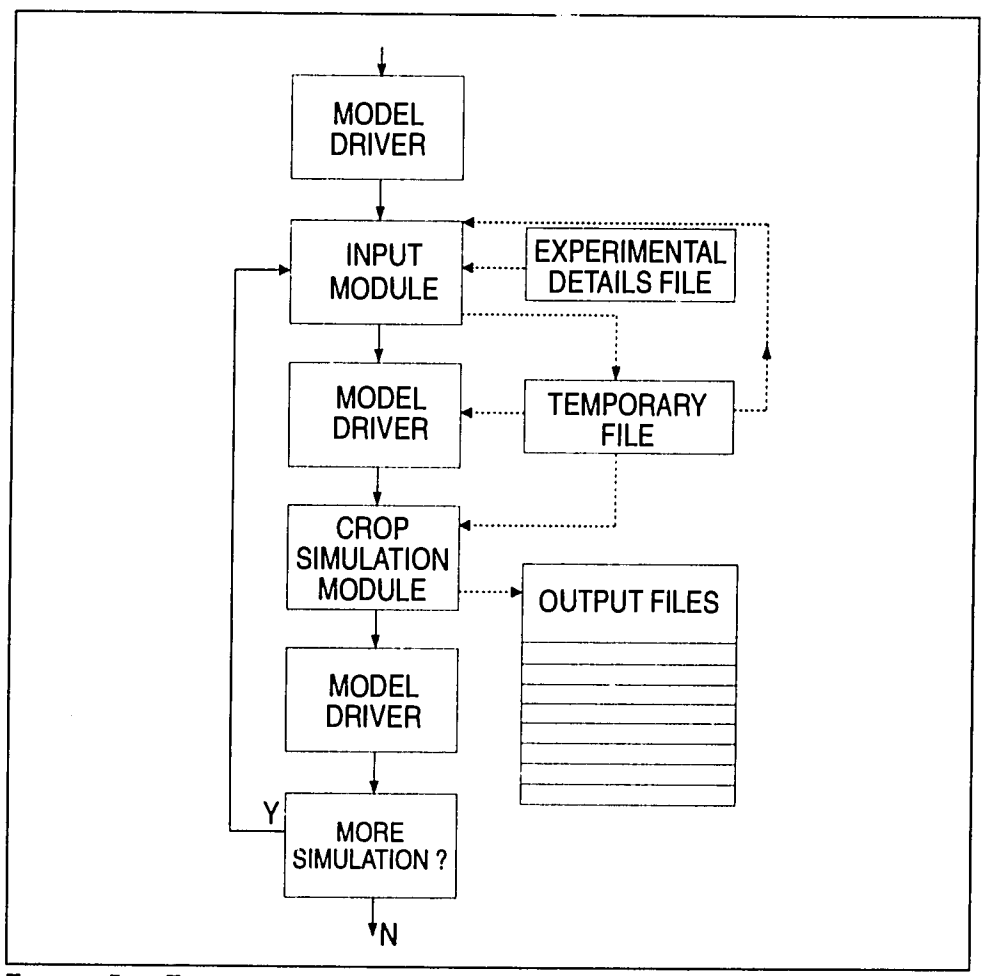

FIGURE 1. FLOW OF INFORMATION FOR THE CURRENT DSSAT v3 CROP SIMULATION MODELS.

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a user starts a DSSAT v3 model, the model driver program, MDRIV940.EXE, is executed. The driver program calls the model input module, MINPT940.EXE, which reads the experiment list file (EXP.LST) and experiment data file (FILEX). While reading these files, the input module displays various screens, including those for experiment and treatment selection options. When a user has selected and/or modified the options available in the sensitivity analysis section, a temporary file is written. Control is given back to the model driver and the simulation module is called (IBSNAT30.INP). The simulation module does not provide any interaction with the user; instead it reads the temporary input file, simulates growth over a season and outputs simulation results on the screen. Upon completion of a simulation, control is returned to the model driver, and a user can then choose to run another simulation run or terminate the simulation. The format of the temporary file (IBSNAT30.INP) is discussed later in this chapter.

Component Structure

Crop Model Driver

Because the crop model driver was developed to control the calling of the input and the crop simulation modules, all EXE files need to be located in the same directory for the system to work properly (Figure 2). Typically, this would be the C:\DSSAT3 directory. The models, however, can be run from any data directory, as long as the path where the EXE files are located is specified. To run a model, the driver is executed from the directory containing input data, and the names of the input module and the crop module are specified as command-line arguments. The default syntax is the following (see next page):

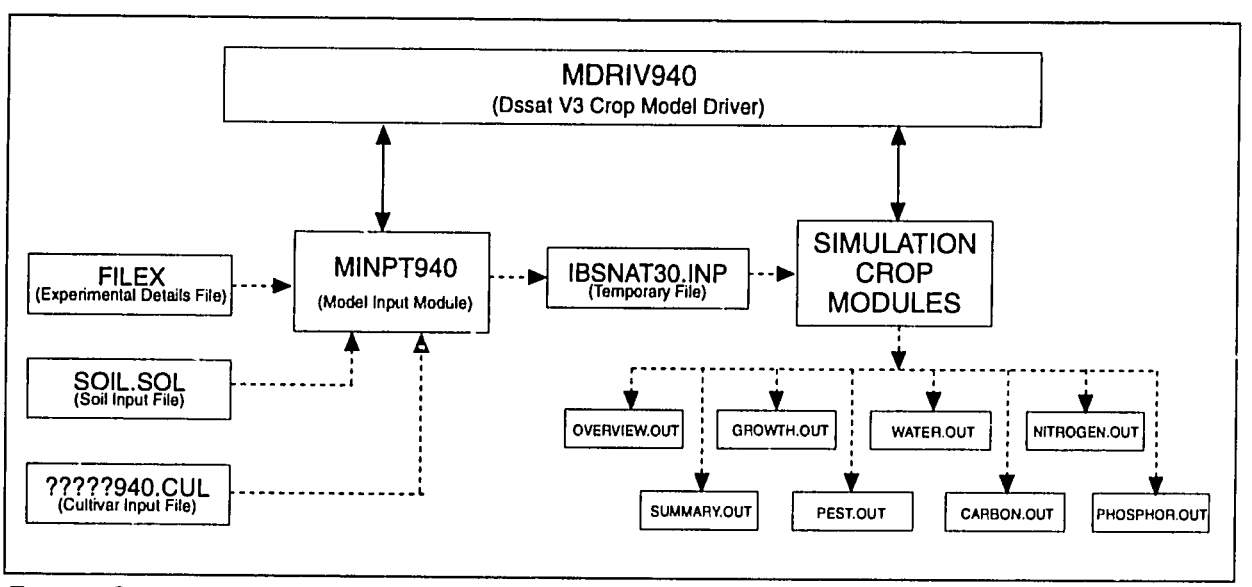


Figure 2. DSSAT v3 Crop Simulation Modules and Input/Output File Handling.

\PATH\MDRIV940.EXE MINPT940.EXE CRGRO940.EXE

where PATH is the path for all EXE files (e.g. C:\DSSAT3);
MDRIV940.EXE is the name of the model driver;
MINPT940.EXE is the name of the input module; and
CRGRO940.EXE is the name of the crop simulation module.
Current crop simulation modules available include :

GECER940.EXE	-	Generic CERES module for barley, maize, millet, sorghum, and wheat
RICER940.EXE	-	CERES -Rice module for rice
CRGRO940.EXE	-	Generic CROPGRO module for dry bean, peanut and soybean,
CSSIM940.EXE	-	CROPSIM-Cassava module for cassava.

Additional options can be included on the command line:

\PATH\MDRIV940.EXE MINPT940.EXE CRGRO940.EXE TYPEIO RNMODE

where TYPEIO is a one-character variable, used as a file type for transfer of information between the input module and crop simulation module. Options include :

I - A single treatment input file using FILEX format with no headers, blank lines or comment lines. TYPEIO = "I" is used by the GECER940.EXE, RICER940.EXE, and CRGRO940.EXE crop simulation modules.

X - FILEX single treatment format with headers and blank lines. TYPEIO = "X" is used by the CSSIM940.EXE crop simulation module.

RNMODE is a one-character variable, used to define the execution or operational mode of the model. Options include :

I - Interactive simulation, allowing for sensitivity analysis screen selections;

A - Run all treatments defined for one particular experiment;

G - Run in the genetic coefficient estimator mode, used with GenCalc only (see Volume 3-4, Hunt et al. 1994, of this book);

N - Run in the seasonal analysis mode, used with the seasonal analysis program only (see Volume 3-1, Thornton et al. 1994a, of this book);

Q - Run in the sequence analysis mode, used with the sequence analysis program only (see Volume 3-2, Thornton et al. 1994b, of this book);

S - Run in the spatial analysis mode with Geographic Information Systems (GIS) only;

F - Run in the farming systems analysis mode.

General users should not be concerned about these options, as they are controlled by individual driver programs.

For all RNMODE options, except "I," the experiment and treatment number can also be specified :

\PATH\MDRIV940.EXE MINPT940.EXE CRGRO940.EXE TYPEIO RNMODE EXPARG TRNARG

where EXPARG is the experiment number and TRNARG is the treatment number. Both EXPARG and TRNARG are integers.

The model driver program described here is normally used only for interactive simulations. Other components within DSSAT v3, such as the genetic coefficient calculator and seasonal analysis, sequence analysis and GIS programs, use their own driver programs to interface both with the model input module and crop simulation modules.

Model Input Module

The current DSSAT v3 input module was designed to handle both the reading of FILEX and error checking, as well as to make available options by which the user can modify specific inputs in the Sensitivity Analysis section. An example of this option will be presented later in this chapter. The function of the model input module is to read the experiment details file (FILEX), extract the required information to run one treatment, and to create a temporary input file to be read by the crop simulation module. This allows for the addition of other crop simulation models to the system, since only a temporary output file needs to be created in the prescribed format for use by the DSSAT v3 crop simulation models.

Without the model driver program, the following syntax is required to run the input module :

\PATH\MINPT940.EXE CRGRO940.EXE FILEIO TYPEIO RNMODE EXPARG TRNARG

where CRGRO940.EXE is the crop simulation module, with options as specified earlier; FILEIO is the name of the temporary input file used to transfer information between the input module and the crop simulation module -- this name is usually controlled by the driver program which runs the entire system.

Crop Simulation Module

When the crop simulation module is executed, it reads the temporary input file, IBSNAT30.INP. This single treatment input file was created by the input module and runs

a single season simulation. The syntax to run a crop simulation module, without the model driver program, is the following :

\PATH\CRGRO940.EXE FILEIO TYPEIO RNMODE REPARG

The options specified on the command line are the same as those discussed for the input module, except for REPARG, which is the run number of the current simulation. It is critical that the correct file type be specified for the temporary file, since it contains the reduced input information for the crop model. Normally, FILEIO will be "IBSNAT30.INP" and TYPEIO will be "I." TYPEIO can be set to "X" to create a single treatment version of FILEX, but only the CSSIM940.EXE crop simulation module will work with this option. The system's flexibility is such that when a new crop simulation module is added, only the input module needs to be modified to specify the input file type of the new crop simulation module and a subroutine added to write the new format.

Crop Model Execution

In the above section, "Component Structure," of this Chapter, detailed information for the various command line arguments is included. In general, however, model users can ignore these individual options, since they are handled internally by the DSSAT v3 Shell, batch programs, or driver programs. Under the SETUP menu in the DSSAT v3 Shell (see Volume 1-3, Hunt et al. 1994, of this book), the user defines each individual module; that is, the crop model driver program (MDDRIV940.EXE), the crop model inputs module (MINPT940.EXE) and one of the crop simulation modules (e.g., GECER940.EXE, RICER940.EXE, CRGRO940.EXE or CSSIM940.EXE). In addition the user defines the file type of the intermediate file, which is set to "I" by default. The remainder of the controls are then handled by the DSSAT v3 Shell.

If a user wants to run each module individually, all command line arguments need to be used correctly and input files need to be available, as some of the individual modules do not handle error checking.

Hardware And Software

The DSSAT v3 crop simulation models were developed on personal computers, using Microsoft DOS™ Versions 5 and 6, and the Microsoft Fortran Compiler™ Version 5.1. The modules are coded in Fortran 77 to remain compatible with other platforms. The crop models have also been successfully implemented on VAX and SUN computers.

The crop models perform best on computers with 80386 or 80486 processor and math-coprocessors. Minimum memory requirements are 512 KByte of Random Access Memory. Harddisk requirements are at least 1 MByte for all executable and data files.

CHAPTER FOUR.
CREATING INPUT FILES

Under the DSSAT v3 Shell main menu item, MODELS (see Volume 1-3, Hunt et al. 1994, of this book), there is a menu of crop models available, separated into grain cereals, grain legumes, root crops, and other crops (see Screen 1). A menu belonging to each group contains a listing of various crops or species for the group selected (see Screen 1 for those crops found under "Legumes"). Although in the DSSAT v3 system all three grain legume crops (dry bean, peanut, and soybean) are simulated with the same model (CROPGRO), users have the option to change the selected crop model through the SETUP menu in the DSSAT v3 Shell and replace it with their own model. Instructions for modifying the SETUP options are presented in Volume 1-3 (Hunt et al. 1994) of this book. If the soybean model is selected, for example, a menu appears (Screen 1), showing a list of available options in the logical sequence a user needs to follow in order to simulate a particular experiment.

Five options are available under each crop model selection :

1. Creating a model input file.
2. Listing and managing crop model input files.
3. Running the crop model.
4. Listing and managing crop model output files.
5. Graphing simulated results and experimental data.

```
DECISION SUPPORT SYSTEM FOR AGROTECHNOLOGY TRANSFER

DATA        MODELS      ANALYSES      TOOLS      SETUP/QUIT

            C Cereals
            L Legumes
            R
            O   D Dry bean
                S Soybean
                P
                  C Create
                  I Inputs
                  S Simulate
                  O Outputs
                  G Graph

Choose experiments, change inputs if required, and then simulate.

↑ ↓ → ←  moves through menu choices
ESC      moves to higher menu level                Version : 3.0
```

SCREEN 1.

Model Input File For Crop Management

The DSSAT v3 crop model input file (or the experiment details input file, FILEX) can be created through an interactive menu-driven program, XCreate, or through an ASCII text editor. It is important that the input file format be identical to that described in Volume 2-1 (Jones et al. 1994) of this book, including the use of "*" for header sections, "@" for header lines and "!" for comments. The input module uses these characters while reading FILEX for particular sections. It is strongly advised that the XCreate program be used to create FILEX (Screen 2) if a user is unfamiliar or uncomfortable with the strict formats of the input/output documentation (see Volume 2-1, Jones et al. 1994, of this book). Information on the XCreate program can be found in Volume 1-4 (Imamura 1994) of this book. An example of a model input file is found in Table 4.

Critical sections of FILEX include the following :

*TREATMENTS

This defines the treatments of an experiment and the associated treatment factor levels.

```
File  Experiment  Management  Controls  Options                Trt = 1 1 0 0
                                                                        [↕]
*EXP.DETAILS:UF(   Treatments          NON-IRRIGATED
                   Cultivars
*TREATMENTS        Fields              ----FACTOR LEVELS--------
@N R O C TNAME.    Soil Analysis       IC MP MI MF MR MC MT ML MH SM
 1 1 0 0 IRRIGA'   Initial Conditions   1  1  1  0  1  0  0  0  0  1
 2 1 0 0 NON -     Planting            1  1  1  0  1  0  0  0  0  1
                   Irrigation
*CULTIVARS         Fertilization
@C CR INGENO CN.   Residue
 1 SB IB0001 BR.   Tillage/Rotation
                   Chemicals
*FIELDS            Environment
@L ID_FIELD WST.   Harvest
ID_SOIL
 1 UFGA0001 UFG.                        FLDS  FLST SLTX  SLDP
IBSB91001                                  0 00000 -99    180
*INITIAL CONDIT
@C  PCR ICDAT  IC
 1   SB 78166  100   -99  1.00  1.00
@C ICBL  SH20  SNH4  SN03
 1    5 0.086   0.6   1.5
 1   15 0.086   0.6   1.5

F1 Help  F4 Mineral N  F7 Save  Alt-X Exit                          51264
```

Screen 2.

TABLE 4. CROP MODEL INPUT FILE. (FILEX = "UFGA7801.SBX")

```
*EXP.DETAILS: UFGA7801SB BRAGG, IRRIGATED & NON-IRRIGATED

*TREATMENTS                        -------------FACTOR LEVELS------------
@N R O C TNAME.................... CU FL SA IC MP MI MF MR MC MT ME MH SM
01 1 1 0 IRRIGATED                  1  1  0  1  1  1  0  1  0  0  0  0  1
02 1 1 0 NON - IRRIGATED            1  1  0  1  1  0  0  1  0  0  0  0  1

*CULTIVARS
@C CR INGENO CNAME
 1 SB IB0001 BRAGG

*FIELDS
@L ID_FIELD WSTA....  FLSA  FLOB  FLDT  FLDD  FLDS  FLST SLTX   SLDP ID_SOIL
 1 UFGA0001 UFGA7801 -99       0 DR000     0     0 00000 -99     180 IBSB910015

*INITIAL CONDITIONS
@C   PCR ICDAT  ICRT  ICND  ICRN  ICRE
 1    SB 78166   100   -99  1.00  1.00
@C  ICBL  SH2O  SNH4  SNO3
 1     5 0.086   0.6   1.5
 1    15 0.086   0.6   1.5
 1    30 0.086   0.6   1.5
 1    45 0.086   0.6   1.5
 1    60 0.086   0.6   1.5
 1    90 0.076   0.6   0.6
 1   120 0.076   0.6   0.5
 1   150 0.130   0.6   0.5
 1   180 0.258   0.6   0.5

*PLANTING DETAILS
@P PDATE EDATE  PPOP  PPOE  PLME  PLDS  PLRS  PLRD  PLDP  PLWT  PAGE  PENV  PLPH
 1 78166   -99  29.9  29.9     S     R    91     0   4.0   -99   -99 -99.0 -99.0

*IRRIGATION AND WATER MANAGEMENT
@I  EFIR  IDEP  ITHR  IEPT  IOFF  IAME  IAMN
 1  0.75   -99   -99   -99   -99   -99   -99
@I IDATE  IROP  IRVAL
 1 78181 IR001    13
 1 78230 IR001    13
 1 78235 IR001    13
 1 78237 IR001    13
 1 78240 IR001    11
 1 78242 IR001    11
 1 78244 IR001    11
 1 78246 IR001    11
 1 78250 IR001    11
 1 78253 IR001    11
 1 78256 IR001     8
 1 78259 IR001     8
```

```
 1 78262 IR001      8
 1 78265 IR001      8
 1 78269 IR001      7
 1 78272 IR001      8
 1 78279 IR001      7
 1 78283 IR001      8
 1 78294 IR001     10

*RESIDUES AND OTHER ORGANIC MATERIALS
@R RDATE  RCOD  RAMT  RESN  RESP  RESK  RINP  RDEP
 1 78166 RE001  1000   0.8    -9  -9            15

*SIMULATION CONTROLS
@N GENERAL     NYERS NREPS START YRDAY RSEED SNAME....................
 1 GE              1     1     S 78166  2150 BRAGG, IRRIGATED & NON-IR
@N OPTIONS     WATER NITRO SYMBI PHOSP POTAS DISES
 1 OP              Y     Y     Y     N     N     N
@N METHODS     WTHER INCON LIGHT EVAPO INFIL PHOTO
 1 ME              M     M     E     R     S     C
@N MANAGEMENT  PLANT IRRIG FERTI RESID HARVS
 1 MA              R     R     R     R     M
@N OUTPUTS     FNAME OVVEW SUMRY FROPT GROTH CARBN WATER NITRO MINER DISES  LONG
 1 OU              N     Y     Y     3     Y     Y     Y     Y     N     N     Y

@  AUTOMATIC MANAGEMENT
@N PLANTING   PFIRST PLAST PH2OL PH2OU PH2OD PSTMX PSTMN
 1 PL           155   200    40   100    30    40    10
@N IRRIGATION  IMDEP ITHRL ITHRU IROFF IMETH IRAMT IREFF
 1 IR            30    50   100 GS000 IR001    10  0.75
@N NITROGEN    NMDEP NMTHR NAMNT NCODE NAOFF
 1 NI            30    50    25 FE001 GS000
@N RESIDUES    RIPCN RTIME RIDEP
 1 RE           100     1    20
@N HARVEST    HFIRST HLAST HPCNP HPCNR
 1 HA             0   365   100     0
```

*CULTIVARS
This defines the crop (CR) and cultivar (INGENO) which will be simulated.

*FIELDS
This defines the weather station (WSTA) and soil profile (ID_SOIL) which will be used as inputs.

*INITIAL CONDITIONS
This defines the initial soil water (SH_2O) and nitrogen conditions at the start of simulation (SNH_4 + SNO_3).

*PLANTING DETAILS
This defines the planting date (PDATE), plant density (PPOP), row spacing (PLRS) and planting depth (PLDP) at planting.

*IRRIGATION AND WATER MANAGEMENT
This defines the dates (IDATE) and amounts (IRVAL) of irrigation applications.

*FERTILIZERS
This defines the dates (FDATE), amount (FAMN) and types (FMDC) of fertilizer applications.

*ENVIRONMENT MODIFICATIONS
This defines environmental modifications related to weather conditions.

*HARVEST DETAILS
This defines final harvest date ((HDATE) and other harvest parameters.

*RESIDUES AND OTHER ORGANIC MATERIALS
This defines initial residue from the previous crop present at the start of simulation.

The importance of the above sections depends on the treatment factor levels selected in the *TREATMENT section.

*SIMULATION CONTROLS
This section is critical, since it defines the various options available for simulation, such as water balance and nitrogen balance simulation, crop management options, and defines the output files and output frequency.

Volume 2-1 (Jones et al. 1994) of this book presents additional details about the specifics of each input section and the headers and header abbreviations for FILEX and various examples.

EXPERIMENT LIST FILE

The models require an experiment list file (FILEL) to display the various experiments available for simulation (Table 5). The XCreate program updates the experiment list after each new FILEX is created by a user. In addition, DSSAT v3 has an experiment File Manager utility that is accessed by selecting the "I Inputs" option under the MODELS menu of the DSSAT v3 Shell (Screen 1). The File Manager utility allows the user to either include or exclude a particular experiment from the experiment list file, and also includes options to edit a particular experiment data file and search and sort. For a description of this utility, see Volume 1-3 (Hunt et al. 1994) of this book.

TABLE 5. EXPERIMENT LIST FILE. (FILEL = "EXP.LST")

```
*EXPERIMENT LIST

@# FILENAME EXT ENAME
 1 IUCA7901 SBX WAYNE, IRRIGATED & NON-IRRIGATED
 2 UFGA7801 SBX BRAGG, IRRIGATED & NON-IRRIGATED
 3 UFGA7802 SBX BRAGG, IRR*INSECT DAMAGE
 4 UFGA7901 SBX IRRIGATION 3I
 5 UFGA8101 SBX COBB, IRRIGATED, VEG. & REPROD. STRESS
 6 UFQU7901 SBX BRAGG, WELL IRRIGATED
 7 UFQU7902 SBX BRAGG, DEFOLIATION STUDY
```

CHAPTER FIVE.
RUNNING THE CROP MODELS

Once a user has created a FILEX and the experiment list file (FILEL) has been updated, a crop model can be run, by selecting the "Simulate" option as shown in Screen 1. A screen displaying the name of the model, the model developers and the institutions which have been involved in model development will be presented. Screen 3 below, for CROPGRO, is an example of the screen which will be presented.

```
IBSNAT 3.0 Generic Input

CROPGRO 3.00 (94.0)

G. Hoogenboom, J.W. Jones, K.J. Boote, W.T. Bowen,
  N.B. Pickering, W.D. Batchelor, and J.W. White

The University of Georgia & University of Florida

CROPGRO simulates crop growth and development, soil
water dynamics and soil nitrogen dynamics in response
to weather, soil characteristics, cultivar character-
istics and crop management. This version simulates
soybean, peanut and drybean crops. It uses the
IBSNAT standard data formats and files for DSSAT v3.

                                    September 1994

Please press < ENTER > key (J) to continue
```

SCREEN 3.

Pressing the <ENTER> or <RETURN> key in this screen will present Screen 4 (on following page), which displays a list of experiment case studies that can be used for simulation.

```
                                                   INST.  SITE  YEAR EXPT.
   CROP EXPERIMENTAL CASE STUDIES                   ID    ID        NO
   ---- ------------------------                   ----  ----  ---- ----
1.  SB  WAYNE, IRRIGATED & NON-IRRIGATED            IU    CA   1979  01
2.  SB  BRAGG, IRRIGATED & NON-IRRIGATED            UF    GA   1978  01
3.  SB  BRAGG, IRR*INSECT DAMAGE                    UF    GA   1978  02
4.  SB  IRRIGATION 3I                               UF    GA   1979  01
5.  SB  COBB, IRRIGATED, VEG. & REPROD. STRESS      UF    GA   1981  01
6.  SB  BRAGG, WELL IRRIGATED                       UF    QU   1979  01
7.  SB  BRAGG, DEFOLIATION STUDY                    UF    QU   1979  02

   EXPERIMENT SELECTED ===>   1
   NEW SELECTION ?     --->   2
```

SCREEN 4.

What is displayed on Screen 4 is actually a listing of FILEL (see Table 5). Any one of these experiments can be selected for simulation. Each item in the list may represent an actual experiment or a hypothetical one created to predict how a crop would perform under specified conditions. For the example shown, Experiment "2" was selected, which was a soybean experiment, conducted in 1978 at the University of Florida in Gainesville

When this experiment is selected, Screen 5 (shown below) is presented.

```
                                          INST.  SITE  YEAR  EXPT. TRT.
   BRAGG, IRRIGATED & NON-IRRIGATED        ID    ID        NO   NO
   --------------------------------       ----  ----  ----  ---- ----
1. IRRIGATED                               UF    GA   1978  01    1
2. NON - IRRIGATED                         UF    GA   1978  01    2
3. RUN ALL TREATMENTS                      UF    GA   1978  01

   TREATMENT SELECTED ====>   1
   NEW SELECTION ?    ====>   1
```

SCREEN 5.

Screen 5 displays the treatments of Experiment "2" selected in Screen 4. For this experiment, there are two treatments, irrigated (Option 1) and non-irrigated (Option 2). In addition, in Screen 5, a user can choose to have the model simulate all treatments of the particular experiment (Option 3). For this example experiment, Option 1 was selected.

When the experiment and the treatment have been selected, Screen 6 (below) is presented.

```
What Would You Like To Do?

0. Run Simulation
1. Select Sensitivity Analysis Options.

CHOICE ?    [ Default = 0 ] ===> 0

Please enter Run  1 name : ===> Example
```

SCREEN 6.

In Screen 6, the user can choose to run either a simulation (Option 0) or a sensitivity analysis (Option 1). Option 1 is discussed in some detail in Chapter 7, "Management and Sensitivity Analysis Options." For this example, Option 0, "Run Simulation," was selected.

Following the selection of Option 0, a prompt, as shown in Screen 6, is displayed, and the user is asked to enter a run identifier. This identifier can be any combination of words or characters up to a maximum of 25. For this example, "Example" was entered.

```
SIMULATION OVERVIEW

RUN   1          : Example
MODEL            : CRGRO940 - SOYBEAN
EXPERMIMENT      : UFGA7801 SB     BRAGG, IRRIGATED & NON-IRRGATED
TREATMENT   1    : IRRIGATED

CROP             : SOYBEAN         CULTIVAR : BRAGG            -  MATURITY GROUP7
STARTING DATE    : JUN 15 1978
PLANTING DATE    : JUN 15 1978     PLANTS/m2 : 29.9     ROW SPACING :  91.cm
WEATHER          : UFGA   1978
SOIL             : IBSB910015      TEXTURE :       - Millhopper Fine Sand
SOIL INITIAL C   : DEPTH:180cm EXTR. H20:158.4mm N03: 22.9kg/ha  NH4: 16.5kg/ha
WATER BALANCE    : IRRIGATE ACCORDING TO FIELD SCHEDULE
IRRIGATION       :      190 mm IN     19 APPLICATIONS
NITROGEN BAL.    : SOIL-N, N-UPTAKE & DYNAMIC N-FIXATION SIMULATION
N FERTILIZER     :  NO FERTILIZER APPLIED
RESIDUE/MANURE   :     1000 kg/ha IN      1 APPLICATIONS
ENVIRONM. OPT.   : DAYL=       .0  SRAD=       .0  TMAX=       .0  TMIN=      .0
                 : RAIN=       .0  C02 = R 330.0  DEW =       .0  WIND=      .0
SIMULATION OPT   : WATER    :Y  NITROGEN:Y  N-FIX:Y  PESTS  :N  PHOTO  :C ET :R
MANAGEMENT OPT   : PLANTING:R  IRRIG    :R  FERT :N  RESIDUE:R  HARVEST:M WTH:M

Please press < ENTER > key to continue
```

SCREEN 7.

Screen 7 (above) displays an overview of the inputs and simulation data for the experiment selected in Screen 4. These data include crop, cultivar and maturity group information; start of simulation and planting dates; row and plant spacing; weather site and year; general soil profile information and initial conditions at the start of simulation; water balance simulation option and irrigation management; nitrogen balance simulation, nitrogen fertilizer management and organic residue; environmental or weather variable modifications; and a summary of simulation and management options.

```
SUMMARY OF SOIL AND GENETIC INPUT PARAMETERS

   SOIL  LOWER UPPER   SAT  EXTR  INIT   ROOT   BULK     pH    NO3    NH4    ORG
  DEPTH  LIMIT LIMIT   SW    SW    SW    DIST   DENS                        C
   cm    cm3/cm3   cm3/cm3    cm3/cm3          g/cm3          ugN/g  ugN/g    %
-------------------------------------------------------------------------------
  0-  5  .023  .086  .230  .063  .086   1.00   1.36   5.30   1.50    .60    .90
  5-  15 .023  .086  .230  .063  .086   1.00   1.40   5.40   1.50    .60    .69
 15-  30 .023  .086  .230  .063  .086    .50   1.46   5.70   1.50    .60    .28
 30-  45 .023  .086  .230  .063  .086    .29   1.47   5.80   1.50    .60    .20
 45-  60 .023  .086  .230  .063  .086    .29   1.47   5.80   1.50    .60    .20
 60-  90 .021  .076  .230  .055  .076    .38   1.43   5.90    .60    .60    .09
 90-120  .020  .076  .230  .056  .076    .13   1.48   5.90    .50    .60    .03
120-150  .027  .130  .230  .103  .130    .06   1.57   5.90    .50    .60    .03
150-180  .070  .258  .360  .188  .258    .03   1.79   5.90    .50    .60    .03

TOT-180   5.5  21.4  45.3  15.8  21.4  <--cm   -  kg/ha-->   22.9   16.5  38949
SOIL ALBEDO     :  .18     EVAPORATION LIMIT : 5.00        MIN. FACTOR  : 1.00
RUNOFF CURVE # :66.00      DRAINAGE RATE     :  .50        FERT. FACTOR :  .84

SOYBEAN CULTIVAR :IB0001-BRAGG                ECOTYPE :SB0701-MATURITY GROUP 7
CSDVAR :12.33  PPSEN  :  .32  EMG-FLW:19.50   FLW-FSD:17.00  FSD-PHM :36.00
WTPSD  : .200  SDPDVR : 2.05  SDFDUR :26.00   PODDUR :15.00  XFRUIT  : 1.00

Please press < ENTER> key to continue
```

SCREEN 8.

Screen 8 displays more detailed information about the selected experiment's soil profile characteristics and cultivar characteristics. These include the lower limit, drained upper limit and saturated water content, extractable soil water, initial soil water content, relative root distribution, bulk density, pH, initial NO_3 and NH_4, and organic carbon for each soil layer, and total amount in the profile. Also shown are some of the soil surface characteristics such as soil albedo, first stage evaporation limit, soil nitrogen mineralization factor, SCS runoff curve number, and a drainage rate. The fertility factor is currently used only in the grain legume models to account for mineral deficiencies not simulated in the current version of the model or unknown factors that limit growth in a particular soil.

The cultivar characteristics are crop specific and are discussed in Appendix A, "Genetic Coefficients." As shown in this example for soybean, cultivar coefficients include the critical short day for photoperiod sensitivity (CSDVAR); relative sensitivity to photoperiod (PPSEN); optimum number of days from emergence to flowering (EMG-FLW); optimum number of days from flowering to first seed (FLW-FSD); optimum number of days from first seed to physiological maturity (FSD-PHM), individual seed weight (WTPSD); number of seeds per pod (SDPDVR); seed filling duration (SDFDUR) and pod filling duration (PODDUR); and relative biomass partitioning between vegetative and reproductive structures (XFRUIT).

Screens 7 and 8 are displayed during the initialization of the model. Following these initialization screens, Screen 9 (shown on following page) is presented, which is displayed

during the actual model simulation. All the variables shown in this screen are predicted variables.

SIMULATED CROP AND SOIL STATUS AT MAIN DEVELOPMENT STAGES

RUN NO. 1 Example

DATE	CROP AGE	GROWTH STAGE	BIOMASS kg/ha	LAI	LEAF NUM.	ET mm	RAIN mm	IRRIG mm	SWATER mm	CROP kg/ha	N %	STRESS H2O	STRESS N
15 JUN	0	START SIM	0	.00	.0	0	0	0	158	0	.0	.00	.00
15 JUN	0	SOWING	0	.00	.0	0	0	0	158	0	.0	.00	.00
21 JUN	6	EMERGENCE	21	.03	.1	3	2	0	157	1	5.1	.00	.06
21 JUN	6	END JUVEN.	21	.03	.1	3	2	0	157	1	5.1	.00	.06
28 JUN	13	UNIFOLIATE	60	.11	1.2	11	10	0	157	3	5.1	.00	.26
2 JUL	17	FLOWER IND	116	.20	2.1	20	10	13	157	5	4.3	.03	.32
31 JUL	46	FIRST FLWR	1854	3.25	8.8	128	274	13	186	61	3.3	.00	.27
22 AUG	68	FIRST POD	4340	5.22	13.9	230	518	26	149	156	3.6	.00	.01
22 AUG	68	FIRST POD	4340	5.22	13.9	230	518	26	149	156	3.6	.00	.01
29 AUG	75	END MSNODE	5304	5.19	15.4	268	518	63	139	185	3.5	.00	.00
29 AUG	75	END LEAF	5304	5.19	15.4	268	518	63	139	185	3.5	.00	.00
1 SEP	78	FIRST SEEND	5710	5.13	15.4	285	518	85	138	196	3.4	.00	.00
1 OCT	108	END POD	7469	3.36	15.4	401	534	165	98	245	3.3	.13	.01
11 OCT	118	PHYS. MAT	7747	2.89	15.4	431	534	180	78	263	3.4	.32	.07
23 OCT	130	HARV. MAT	6107	.19	15.4	448	534	190	69	224	3.7	.47	.10
23 OCT	130	HARVEST	6107	.19	15.4	448	534	190	69	224	3.7	.47	.10

Please press < ENTER > key to continue

SCREEN 9.

Each model is initialized at the start of simulation date, as specified in the input file. All models operate at daily time steps; thus, growth, development and other variables are incremented daily. Each crop model predicts the critical growth stages for that particular crop as shown in Screen 9 (above) for soybean. At each stage, total biomass, leaf area index (LAI), total number of leaves on the main stem and total nitrogen (CROP) and nitrogen concentration (N) are shown. These variables relate mainly to the carbon and nitrogen balance of the models. In addition, some soil and plant water variables are shown, such as total evapotranspiration (ET), total rainfall received and irrigation applied, and plant extractable soil water. The last two columns in Screen 9 show plant water and nitrogen stress averages calculated from the time of the previous stage until the current stage.

When the last stage, e.g., "HARVEST" for this example, appears, the simulation has ended. The actual time it will take from the start of simulation, "START SIM," until final harvest, can vary from a few seconds to a few minutes, depending on computer hardware and the crop management options selected.

VARIABLE	PREDICTED	MEASURED
ANTHESIS DATE (dap)	46	45
FIRST PEG / POD (dap)	68	67
FIRST SEED (dap)	78	67
PHYSIOLOGICAL MATURITY (dap)	118	116
POD YIELD (kg/ha)	3941	4009.
SEED YIELD (Kg/ha)	2932	3041.
SHELLING PERCENTAGE (%)	74.41	75.85
WEIGHT PER SEED (g)	.133	.1440
SEED NUMBER (SEED/m2)	2202	2223.
SEEDS/POD	2.05	1.96
MAXIMUM LAI (m2/m2)	5.25	4.67
BIOMASS (kg/ha) AT ANTHESIS	1854	-99
BIOMASS N (kg N/ha) AT ANTHESIS	61	-99
BIOMASS (kg/ha) AT HARVEST MAT.	6107	6068.
STALK (kg/ha) AT HARVEST MAT.	2087	1958.
HARVEST INDEX (kg/ha)	.480	.501
FINAL LEAF NUMBER (MAIN STEM)	15.41	-99
SEED N (kg N/ha)	187	-99
BIOMASS N (kg N/ha)	224	-99
STALK N (kg N/ha)	20	-99
SEED N (%)	6.37	-99

Please press < ENTER> key to continue

SCREEN 10.

After the seasonal results are presented in Screen 9, model predicted data can be compared with experimental data for the main development stages, yield and yield components, and some of the nitrogen variables (Screen 10, above). When no experiment data are available for a particular stage, a "-99" is displayed for that item.

```
ENVIRONMENTAL AND STRESS FACTORS

-----------------------------------ENVIRONMENT-----------------STRESS----------
|--DEVELOPMENT PHASE--|-TIME-|-------WEATHER--------| |---WATER--| |-NITROGEN-|
                      DURA TEMP  TEMP  SOLAR PHOTOP PHOTO GROWTH PHOTO GROWTH
                      TION MAX   MIN   RAD  [day] SYNTH         SYNTH
                      days oC    oC    MJ/m2  hr
-----------------------------------------------------------------------------
Emergence -First Flower   40  33.04  22.20 19.34  13.74  .000  .004  .000  .273
First Flower-First Seed   32  33.33  21.71 19.55  13.03  .000  .000  .000  .006
First Seed - Phys. Mat.   40  31.95  19.39 16.82  11.98  .099  .179  .098  .022
Emergence  - Phys. Mat.  112  32.73  21.06 18.50  12.91  .035  .066  .035  .107

                                                  (0.0 = Minimum Stress
                                                   1.0 = Maximum Stress)

SOYBEAN      YIELD :      2932 kg/ha      [DRY WEIGHT]

Do you want to run more simulations?
Y or N ? [Default = "N"] ===> N
```

SCREEN 11.

Screen 11 (above), the final screen in this series, displays a summary of environmental variables derived during the main developmental stages, which include the vegetative growth phase until flowering, the vegetative and reproductive development growth phase from flowering until the start of seed growth, and the reproductive growth phase from beginning seed growth until physiological maturity. To simulate another treatment or another experiment, a user needs to enter a 'Y' at the prompt. An 'N' entry ends the crop model simulation and the user can then print out or graph the simulated results. For a description of the graphing and printing options, see Chapter 7, "Displaying Results."

Screens 7 through 11, which appear on the monitor during an interactive simulation, are stored in a model output file, OVERVIEW.OUT. This file, in ASCII text format, is 80 characters wide, making it easy to either edit this file or print it to a dot matrix or laser printer.

Example listings of the OVERVIEW.OUT file is shown in Table 6A for CERES-Maize and Table 6B for CROPGRO-Soybean.

TABLE 6A. CROP MODEL OUTPUT OVERVIEW FILE FOR CERES-MAIZE. (OUTO = "OVERVIEW.OUT")

```
*SIMULATION OVERVIEW FILE

*RUN   1          : Example CERES-Maize
 MODEL            : GECER940 - MAIZE
 EXPERIMENT       : UFGA8201 MZ    N X IRRIGATION, GAINESVILLE
 TREATMENT  4     : IRRIGATED HIGH NITROGEN

 CROP             : MAIZE          CULTIVAR : McCurdy 84aa
 STARTING DATE    : FEB 25 1982
 PLANTING DATE    : FEB 26 1982    PLANTS/m2 :  7.2     ROW SPACING :  61.cm
 WEATHER          : UFGA   1982
 SOIL             : IBMZ910014     TEXTURE : FSA   - Millhopper Fine Sand
 SOIL INITIAL C   : DEPTH:180cm EXTR. H2O:160.9mm  NO3: 14.9kg/ha  NH4: 21.1kg/ha
 WATER BALANCE    : IRRIGATE ACCORDING TO FIELD SCHEDULE
 IRRIGATION       :      264 mm IN    16 APPLICATIONS
 NITROGEN BAL.    : SOIL-N & N-UPTAKE SIMULATION; NO N-FIXATION
 N FERTILIZER     :      401 kg/ha IN     7 APPLICATIONS
 RESIDUE/MANURE   :     1000 kg/ha IN     1 APPLICATIONS
 ENVIRONM. OPT.   : DAYL=      .0  SRAD=      .0  TMAX=      .0  TMIN=      .0
                    RAIN=      .0  CO2 = R 330.0  DEW =      .0  WIND=      .0
 SIMULATION OPT   : WATER   :Y  NITROGEN:Y  N-FIX:N  PESTS  :N  PHOTO  :C  ET :R
 MANAGEMENT OPT   : PLANTING:R  IRRIG   :R  FERT :R  RESIDUE:R  HARVEST:M  WTH:M

*SUMMARY OF SOIL AND GENETIC INPUT PARAMETERS

   SOIL LOWER UPPER   SAT  EXTR  INIT   ROOT   BULK     pH    NO3    NH4    ORG
  DEPTH LIMIT LIMIT    SW    SW    SW   DIST   DENS                          C
   cm   cm3/cm3     cm3/cm3     cm3/cm3         g/cm3          ugN/g  ugN/g    %
-----------------------------------------------------------------------------------
   0-  5  .026  .096  .230  .070  .086   1.00   1.30   7.00    .60   1.50   2.00
   5- 15  .025  .086  .230  .061  .086   1.00   1.30   7.00    .60   1.50   1.00
  15- 30  .025  .086  .230  .061  .086    .80   1.40   7.00    .60   1.50   1.00
  30- 45  .025  .086  .230  .061  .086    .20   1.40   7.00    .60   1.50    .50
  45- 60  .025  .086  .230  .061  .086    .20   1.40   7.00    .60   1.50    .50
  60- 90  .028  .090  .230  .062  .076    .10   1.45   7.00    .60    .60    .10
  90-120  .028  .090  .230  .062  .076    .05   1.45   7.00    .60    .50    .10
 120-150  .029  .130  .230  .101  .130    .00   1.45   7.00    .60    .50    .04
 150-180  .070  .258  .360  .188  .258    .00   1.20   7.00    .60    .50    .24

TOT-180   6.2  22.3  45.3  16.1  21.4  <--cm   -  kg/ha-->   14.9   21.1  87080
SOIL ALBEDO    :  .18       EVAPORATION LIMIT : 2.00        MIN. FACTOR  : 1.00
RUNOFF CURVE # :60.00       DRAINAGE RATE     :  .65        FERT. FACTOR :  .80
MAIZE   CULTIVAR :IB0035-McCurdy 84aa        ECOTYPE :
P1      : 200.00  P2      :  .3000  P5     : 940.00
G2      : 700.00  G3      :  8.000  PHINT  : 75.000
```

*SIMULATED CROP AND SOIL STATUS AT MAIN DEVELOPMENT STAGES

RUN NO. 1 Example CERES-Maize

DATE	CROP AGE	GROWTH STAGE	BIOMASS kg/ha	LAI	LEAF NUM.	ET mm	RAIN mm	IRRIG mm	SWATER mm	CROP kg/ha	N %	STRESS H2O	STRESS N
25 FEB	0	Start Sim	0	.00	.0	0	0	0	152	0	.0	.00	.00
26 FEB	0	Sowing	0	.00	.0	1	0	0	151	0	.0	.00	.00
27 FEB	1	Germinate	0	.00	.0	1	0	0	151	0	.0	.00	.00
7 MAR	9	Emergence	29	.00	1.9	11	58	13	205	1	4.4	.00	.00
22 MAR	24	End Juveni	141	.30	7.5	23	60	23	161	5	3.9	.02	.00
27 MAR	29	Floral Ini	275	.52	9.0	35	103	23	179	11	3.9	.00	.01
12 MAY	75	75% Silkin	9251	4.64	23.7	214	361	142	165	194	2.1	.00	.03
22 MAY	85	Beg Gr Fil	11940	4.36	23.7	267	363	201	166	193	1.6	.00	.02
3 JUL	127	Maturity	23149	2.02	23.7	456	661	264	156	245	1.1	.00	.05
3 JUL	127	Harvest	23149	2.02	23.7	456	661	264	156	245	1.1	.00	.05

*MAIN GROWTH AND DEVELOPMENT VARIABLES

@ VARIABLE	PREDICTED	MEASURED
FLOWERING DATE (dap)	75	75
PHYSIOL. MATURITY (dap)	127	128
GRAIN YIELD (kg/ha)	13769	14060
WT. PER GRAIN (g)	.2971	0.309
GRAIN NUMBER (GRAIN/m2)	3916	3847.
GRAINS/EAR	543.90	496.
MAXIMUM LAI (m2/m2)	4.71	-99
BIOMASS (kg/ha) AT ANTHESIS	9251	-99
BIOMASS N (kg N/ha) AT ANTHESIS	194	-99
BIOMASS (kg/ha) AT HARVEST MAT.	23149	22001
STALK (kg/ha) AT HARVEST MAT.	11515	10120
HARVEST INDEX (kg/kg)	.595	-99
FINAL LEAF NUMBER	23.75	-99
GRAIN N (kg N/ha)	190	192.9
BIOMASS N (kg N/ha)	245	267.7
STALK N (kg N/ha)	55	74.8
SEED N (%)	1.64	1.60

*ENVIRONMENTAL AND STRESS FACTORS

DEVELOPMENT PHASE	TIME: DURATION days	ENVIRONMENT: WEATHER: TEMP MAX oC	TEMP MIN oC	SOLAR RAD MJ/m2	PHOTOP [day] hr	STRESS: WATER: PHOTO SYNTH	LEAF EXPAN.	NITROGEN: PHOTO SYNTH	LEAF EXPAN.
Emergence-End Juvenile	15	28.06	13.01	17.17	11.75	.002	.023	.004	.009
End Juvenil-Floral Init	5	27.00	15.98	12.66	12.05	.000	.000	.003	.006
Floral Init-End Lf Grow	46	27.23	13.93	18.66	12.80	.000	.000	.026	.064
End Lf Grth-Beg Grn Fil	10	31.67	15.18	23.28	13.51	.000	.000	.022	.055
Grain Filling Phase	39	32.57	20.52	20.06	13.82	.000	.000	.031	.076

(0.0 = Minimum Stress
1.0 = Maximum Stress)

MAIZE YIELD : 13769 kg/ha [219.3 bu/acre]

TABLE 6B. CROP MODEL OUTPUT OVERVIEW FILE FOR CROPGRO-SOYBEAN. (OUTO = "OVERVIEW.OUT")

```
*SIMULATION OVERVIEW FILE

*RUN   1          : Example CROPGRO - Soybean
 MODEL            : CRGRO940 - SOYBEAN
 EXPERIMENT       : UFGA7801 SB    BRAGG, IRRIGATED & NON-IRRIGATED
 TREATMENT  1     : IRRIGATED

 CROP             : SOYBEAN        CULTIVAR : BRAGG            -  MATURITY GROUP 7
 STARTING DATE    : JUN 15 1978
 PLANTING DATE    : JUN 15 1978    PLANTS/m2 : 29.9     ROW SPACING :  91.cm
 WEATHER          : UFGA   1978
 SOIL             : IBSB910015     TEXTURE : FSA   - Millhopper Fine Sand
 SOIL INITIAL C   : DEPTH:180cm EXTR. H2O:158.4mm  NO3: 22.9kg/ha  NH4: 16.5kg/ha
 WATER BALANCE    : IRRIGATE ACCORDING TO FIELD SCHEDULE
 IRRIGATION       :      190 mm IN    19 APPLICATIONS
 NITROGEN BAL.    : SOIL-N, N-UPTAKE & DYNAMIC N-FIXATION SIMULATION
 N FERTILIZER     :  NO FERTILIZER APPLIED
 RESIDUE/MANURE   :     1000 kg/ha IN     1 APPLICATIONS
 ENVIRONM. OPT.   : DAYL=       .0  SRAD=       .0  TMAX=       .0  TMIN=       .0
                    RAIN=       .0  CO2 = R 330.0  DEW =       .0  WIND=       .0
 SIMULATION OPT   : WATER    :Y  NITROGEN:Y  N-FIX:Y  PESTS  :N  PHOTO  :C  ET :R
 MANAGEMENT OPT   : PLANTING:R  IRRIG    :R  FERT :N  RESIDUE:R  HARVEST:M  WTH:M

*SUMMARY OF SOIL AND GENETIC INPUT PARAMETERS

   SOIL LOWER UPPER   SAT  EXTR  INIT   ROOT   BULK     pH    NO3    NH4    ORG
  DEPTH LIMIT LIMIT    SW    SW    SW   DIST   DENS                         C
   cm   cm3/cm3     cm3/cm3     cm3/cm3         g/cm3          ugN/g  ugN/g    %
-----------------------------------------------------------------------------------
   0-  5  .023  .086  .230  .063  .086   1.00   1.36   5.30   1.50    .60    .90
   5- 15  .023  .086  .230  .063  .086   1.00   1.40   5.40   1.50    .60    .69
  15- 30  .023  .086  .230  .063  .086    .50   1.46   5.70   1.50    .60    .28
  30- 45  .023  .086  .230  .063  .086    .29   1.47   5.80   1.50    .60    .20
  45- 60  .023  .086  .230  .063  .086    .29   1.47   5.80   1.50    .60    .20
  60- 90  .021  .076  .230  .055  .076    .38   1.43   5.90    .60    .60    .09
  90-120  .020  .076  .230  .056  .076    .13   1.48   5.90    .50    .60    .03
 120-150  .027  .130  .230  .103  .130    .06   1.57   5.90    .50    .60    .03
 150-180  .070  .258  .360  .188  .258    .03   1.79   5.90    .50    .60    .03

TOT-180   5.5  21.4  45.3  15.8  21.4  <--cm   -  kg/ha-->   22.9   16.5  38949
SOIL ALBEDO     :  .18        EVAPORATION LIMIT : 5.00        MIN. FACTOR  : 1.00
RUNOFF CURVE # :66.00         DRAINAGE RATE     :  .50        FERT. FACTOR :  .84
SOYBEAN CULTIVAR :IB0001-BRAGG                 ECOTYPE :SB0701-MATURITY GROUP 7
CSDVAR :12.33  PPSEN  :  .32  EMG-FLW:19.50  FLW-FSD:17.00  FSD-PHM :36.00
WTPSD  : .200  SDPDVR : 2.05  SDFDUR :26.00  PODDUR :15.00  XFRUIT  : 1.00
```

*SIMULATED CROP AND SOIL STATUS AT MAIN DEVELOPMENT STAGES

RUN NO. 1 Example CROPGRO - Soybean

DATE	CROP AGE	GROWTH STAGE	BIOMASS kg/ha	LAI	LEAF NUM.	ET mm	RAIN mm	IRRIG mm	SWATER mm	CROP kg/ha	N %	STRESS H2O	STRESS N
15 JUN	0	START SIM	0	.00	.0	0	0	0	158	0	.0	.00	.00
15 JUN	0	SOWING	0	.00	.0	0	0	0	158	0	.0	.00	.00
21 JUN	6	EMERGENCE	21	.03	.1	3	2	0	157	1	5.1	.00	.06
21 JUN	6	END JUVEN.	21	.03	.1	3	2	0	157	1	5.1	.00	.06
28 JUN	13	UNIFOLIATE	60	.11	1.2	11	10	0	157	3	5.1	.00	.26
2 JUL	17	FLOWER IND	116	.20	2.1	20	10	13	157	5	4.3	.03	.32
31 JUL	46	FIRST FLWR	1854	3.25	8.8	128	274	13	186	61	3.3	.00	.27
22 AUG	68	FIRST POD	4340	5.22	13.9	230	518	26	149	156	3.6	.00	.01
22 AUG	68	FIRST POD	4340	5.22	13.9	230	518	26	149	156	3.6	.00	.01
29 AUG	75	END MSNODE	5304	5.19	15.4	268	518	63	139	185	3.5	.00	.00
29 AUG	75	END LEAF	5304	5.19	15.4	268	518	63	139	185	3.5	.00	.00
1 SEP	78	FIRST SEED	5710	5.13	15.4	285	518	85	138	196	3.4	.00	.00
1 OCT	108	END POD	7469	3.36	15.4	401	534	165	98	245	3.3	.13	.01
11 OCT	118	PHYS. MAT	7747	2.89	15.4	431	534	180	78	263	3.4	.32	.07
23 OCT	130	HARV. MAT	6107	.19	15.4	448	534	190	69	224	3.7	.47	.10
23 OCT	130	HARVEST	6107	.19	15.4	448	534	190	69	224	3.7	.47	.10

*MAIN GROWTH AND DEVELOPMENT VARIABLES

@ VARIABLE	PREDICTED	MEASURED
ANTHESIS DATE (dap)	46	45
FIRST PEG / POD (dap)	68	67
FIRST SEED (dap)	78	67
PHYSIOLOGICAL MATURITY (dap)	118	116
POD YIELD (kg/ha)	3941	4009.
SEED YIELD (kg/ha)	2932	3041.
SHELLING PERCENTAGE (%)	74.41	75.85
WEIGHT PER SEED (g)	.133	.1440
SEED NUMBER (SEED/m2)	2202	2223.
SEEDS/POD	2.05	1.96
MAXIMUM LAI (m2/m2)	5.25	4.67
BIOMASS (kg/ha) AT ANTHESIS	1854	-99
BIOMASS N (kg N/ha) AT ANTHESIS	61	-99
BIOMASS (kg/ha) AT HARVEST MAT.	6107	6068.
STALK (kg/ha) AT HARVEST MAT.	2087	1958.
HARVEST INDEX (kg/kg)	.480	.501
FINAL LEAF NUMBER (MAIN STEM)	15.41	-99
SEED N (kg N/ha)	187	-99
BIOMASS N (kg N/ha)	224	-99
STALK N (kg N/ha)	20	-99
SEED N (%)	6.37	-99

*ENVIRONMENTAL AND STRESS FACTORS

DEVELOPMENT PHASE	TIME DURATION days	ENVIRONMENT WEATHER TEMP MAX oC	TEMP MIN oC	SOLAR RAD MJ/m2	PHOTOP [day] hr	STRESS WATER PHOTO SYNTH	GROWTH	NITROGEN PHOTO SYNTH	GROWTH
Emergence -First Flower	40	33.04	22.20	19.34	13.74	.000	.004	.000	.273
First Flower-First Seed	32	33.33	21.71	19.55	13.03	.000	.000	.000	.006
First Seed - Phys. Mat.	40	31.95	19.39	16.82	11.98	.099	.179	.098	.022
Emergence - Phys. Mat.	112	32.73	21.06	18.50	12.91	.035	.066	.035	.107

(0.0 = Minimum Stress
1.0 = Maximum Stress)

SOYBEAN YIELD : 2932 kg/ha [DRY WEIGHT]

CHAPTER SIX. DISPLAYING RESULTS

GENERAL FILE MANAGER

After finishing one or more simulation runs, a user can display simulated results in various formats using the DSSAT v3 General File Manager. In Screen 1, the option following "Simulate" is "Outputs." When this option is chosen, Screen 12 (shown below) is presented, which displays the General File Manager menu for handling the various simulation output files.

```
General File Manager - MODEL OUTPUTS                          Version 1.0
------------------------------------------------------------------------
                  - Files in Directory: C:\DSSAT3\SOYBEAN -

 L      FILE NAME       FILE HEADING
 ---------------------------------------------------------------------
 √      CARBON.OUT      *CARBON BALANCE OUTPUT FILE
 √      GROWTH.OUT      *GROWTH ASPECTS OUTPUT FILE
 √      NITROGEN.OUT    *NITROGEN BALANCE OUTPUT FILE
 √      OVERVIEW.OUT    *SIMULATION OVERVIEW FILE
 √      SUMMARY.OUT     UFGA7801SB BRAGG, IRRIGATED & NON-IRRIGATED
 √      WATER.OUT       *WATER BALANCE OUTPUT FILE

F1  - Help                  F4  - Search              F7  - Colour OFF
F2  - Institute Listing     F5  - Sort                F8  - Edit
F3  - Site Listing          F6  - Print               F9  - Remake List
Esc - Quit            L - Include/Exclude In Sublist  F10 - Edit Config File
```

SCREEN 12.

In Screen 12, the simulation output files are listed. The OVERVIEW.OUT file was discussed in Chapter 5. The file, SUMMARY.OUT, contains a one line summary for each simulation and is mainly used for applications, such as the seasonal and sequence analysis programs discussed in Volumes 3-1 (Thornton et al. 1994 a) and 3-2 (Thornton et al. 1994 b), respectively, of this book. Files GROWTH.OUT, WATER.OUT, NITROGEN.OUT, and CARBON.OUT contain time-dependent variables as simulated by the

crop models. Although these files can be edited, they are normally wider than 80 characters and fairly long, depending upon the number of simulations made by the user. The first 13 variables of each of the listed output files are identical for all crop models, with the first two variables being year-day of year and days after planting. Additional variables can be added as a function of each individual model. For more detailed information, see Volume 2-1 (Jones et al., 1994) of this book.

One of the features of the General File Manager allows the installation of a user's editor. By selecting the Edit option (key < F8>) and positioning the highlight bar over the file name, this output file can be edited. An option for a printout of this output file can also be selected from the editor. The General File Manager includes other options, which are discussed in Volume 1-3 (Hunt et al. 1994) of this book.

The crop models automatically overwrite existing output files. Thus, when a new crop model run is initiated, the old output files are erased and new output files are opened. To keep and save output files, a user can rename the generically-named model output files, or select an option under the Sensitivity Analysis section to store the output files, using a naming convention with Institute and Site code IDs similar to those used for the experiment input file.

Graphic Display

DSSAT v3 contains a Graphics option, shown in Screen 1. When this option is selected, the graphics display program, Wingraf is run. See Part 3 of this Volume (Volume 2-3, Chan et al. 1994) for a description of this program. Screen 13 (on the following page) displays the first Wingraf screen.

Wingraf allows the user to display the simulated data as a function of day of year or planting date. In addition, field-measured data are included in the graph, when available.

A user can graphically display growth and development variables: (GROWTH.OUT), soil and plant water and weather variables (WATER.OUT), soil and plant nitrogen variables (NITROGEN.OUT), pest and disease variables (PEST.OUT) and carbon balance and photosynthesis variables (CARBON.OUT). By selecting the menu option "User-Selected Variables" displayed in Screen 13, a user can also design a new list of variables by combining variables from previously listed options (see Screens 14 and 15).

For our example, the "Growth" option was selected in Screen 13, which produces a screen with a list of available variables for graphing (see Screen 14).

```
≡ Select Graph  Options  Exit
    Growth...
    Water...
    Nitrogen...
    Disease & Pests...
    Carbon...
    User-Selected Variables ▶
    Summary Validation      ▶
    Summary Response...

F1 Help   Esc Escape        X-Var.:        Simulation:
```

SCREEN 13.

Also in Screen 13, the "Options" menu item can be selected. From the "Options" sub-menu, a user can set the colors for graph plotting, such as graph background, item and line colors; change the label of the x-axis; choose type of x-y plotting; choose whether or not to have experimental and simulated data plotted; select the number of graph intervals; and the number of tics. More details about setting graph options can be found in Part 3 of this Volume (Volume 2-3, Chan et al. 1994).

```
 ≡ Select Graph   Options   Exit
[▪]                          GROWTH

 Variables                          Run Numbers
 [ ] Leaf number per stem           [X] Example
 [ ] Growth stage
 [ ] Leaf area index
 [X] Leaf dry weight (kg/ha)
 [X] Stem dry weight (kg/ha)
 [X] Grain dry weight (kg/ha)
 [X] Root dry weight (kg/ha)
 [X] Crop dry weight (kg/ha)
 [ ] Grain number (no/m2)
 [ ] Grain dry weight (mg/grain)
 [ ] Harvest index (grain/top)
 [ ] Pod dry weight (kg/ha)
 [ ] Pod number (no/m2)
 [ ] Photo water stress factor (0-1)
 [ ] Growth water stress factor (0-1)

 Previous   Next   X Variable   Graph   Reset   Option

F1 Help  Esc Escape          X Var.:                Simulation:
```

SCREEN 14.

In Screen 14 (above), a user can choose to have displayed up to 6 variable-run combinations. Press the NEXT button on this screen to present another screen (Screen 15, below) displaying additional variables available for graphing.

```
 ≡ Select Graph   Options   Exit
[▪]                          GROWTH

 Variables                          Run Numbers
 [ ] Nitrogen stress factor (0-1)
 [ ] Leaf N concentration (%)
 [ ] Shelling % (seed wt/pod st*100
 [ ] Pod harvest index (pod/top)
 [ ] Detached pod dry weight (kg/ha)
 [ ] Total pod dry weight (kg/ha)
 [ ] Specific leaf area Cm2/g)
 [ ] Canopy height (m)
 [ ] Canopy breadth (m;for 1 row)
 [ ] Nodule dry weight (kg/ha)
 [ ] Root depth (m)
 [ ] Root density,   0-5 cm (cm/cm3)
 [ ] Root density,  5-15 cm (cm/cm3)
 [ ] Root density, 15-30 cm (cm/cm3)
 [ ] Root density, 30-45 cm (cm/cm3)

 Previous   Next   X Variable   Graph   Reset   Option

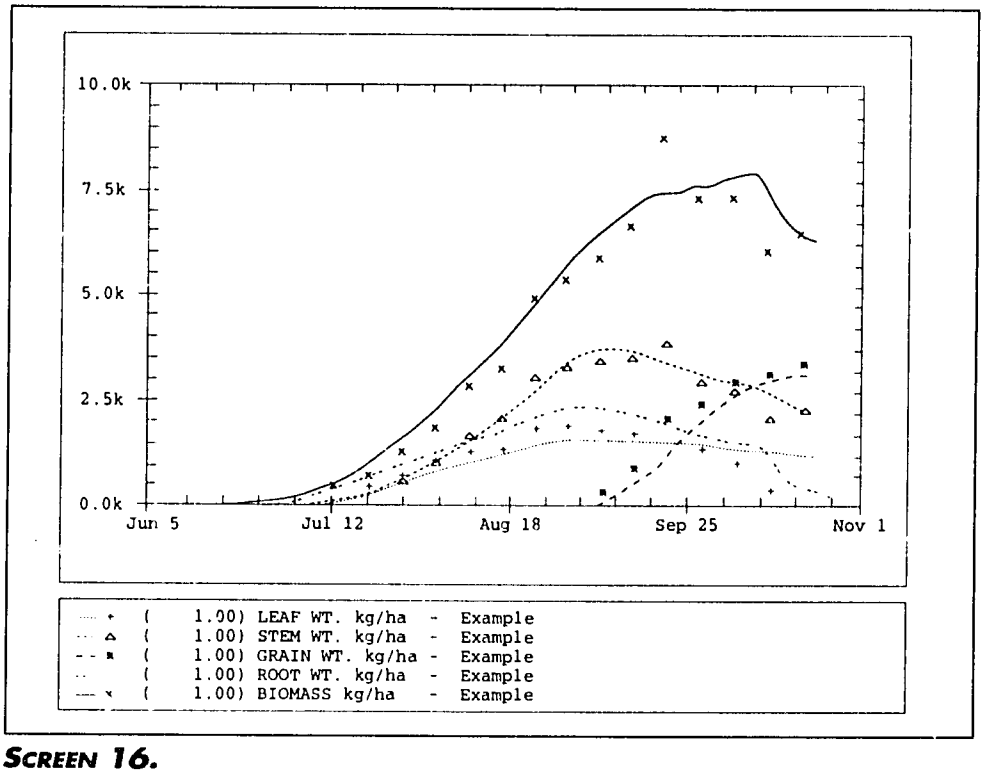
F1 Help  Esc Escape          X Var.: Time           Simulation: Default
```

SCREEN 15.

To select variables for display, click the mouse on a variable or hit the space bar. When all variables have been selected, use either the mouse or the <TAB> key to select the "Run Numbers" option. The default X-Variable is "day of year," but a user can change this to "days after planting" or to another variable with the X-VARIABLE button in Screen 16.

The OPTION button in Screens 14 and 15 is **only** available once a graph has been plotted. Then it can be used to make necessary modifications to the current graph, such as changing the x, y coordinates, modifying the multiplier for each plot, changing the min/max values, turning the graph grid line "On" or "Off" and printing the graph to a hard copy.

Use the <TAB> key or GRAPH button or the <SHIFT><G> keys to display the graph.



SCREEN 16.

Screen 16 shows an example graph with model predicted data depicted as lines and field-measured data as symbols. A detailed description of the Wingraf program can be found in Part 3 of this Volume (Volume 2-3, Chan et al. 1994).

CHAPTER SEVEN. MANAGEMENT AND SENSITIVITY ANALYSIS OPTIONS

So far only options to simulate either a field or hypothetical experiment have been discussed. In these two cases, the model uses the information provided in the experiment details file, FILEX (Table 4). A user can also interactively modify many of the input variables defined in the input files, including those in the experiment data file, weather file, soil file and genetics file. To do this, select Option 1, "Select Sensitivity Analysis Options," shown in Screen 6 (in Chapter 5). Screen 17, shown below, will be presented.

```
                MANAGEMENT / SENSITIVITY ANALYSIS
                =================================

The questions which follow relate to the initial
experiment and treatment you selected.  These
default values allow you to validate the simulation
results. To evaluate alternative management strategies
or make tactical or strategical decisions, you can
modify or change the default values.

If you choose not to change any of the default values,
press the ENTER key in response to the questions

Please press < ENTER > to continue  ===>
```

SCREEN 17.

The user needs to keep in mind that any changes made in the inputs in the screen which follows this one (Screen 18) might cause the model to give different simulation results compared to those derived from field measured data.

Previous Page Blank

```
MANAGEMENT / SENSITIVITY ANALYSIS OPTIONS
==========================================

 0. RETURN TO THE MAIN MENU

 1. Simulation Timing ........  JUN 15 1978
 2. Crop .....................  SOYBEAN              SBGR0940.SPE SBGR0940.CUL
 3. Cultivar .................  BRAGG                MAT : 7      MATURITY GROUP 7
 4. Weather ..................  UFGA                 OBSERVED     WMOD:N
 5. Soil .....................  IBSB910015
 6. Initial Conditions .......  AS REPORTED
 7  Planting .................  JUN 15 1978          ROW SP: 91. PLANTS/m2: 29.90
 8. Harvest ..................  ON REPORTED DATE(S)
 9. Water and Irrigation ....  ACCORDING TO FIELD SCHEDULE
10. Nitrogen .................  NOT FERTILIZED       N-FIX SIMULAT.
11. Phosphorus ...............  N/A
12. Residue ..................
13. Pest and Diseases ........
14. Crop Process Options ....  PEST & DISEASE INTERACTION NOT SIMULATED
15. Output Control ..........  H20:Y NIT:Y N-FIX:Y PEST:N PHOTO:C WTM:M ET:R
                               FREQ: 3 OVV:Y SUM:Y GROWTH:Y H20:Y NIT:Y PEST:N

SELECTION ?  [Default = 0] ===>
```

SCREEN 18.

Screen 18 shows the various categories of variables which can be modified.

SIMULATION TIMING

The "Simulation Timing and Control" menu (Screen 19 on the next page) allows the user to define when a simulation begins. In all cases, the start of simulation date and year (Options 1 and 2) has to be earlier than the planting date, since all model variables are initiated at the start of simulation date. During the period between start of simulation and the planting date only the soil water and nitrogen balances are simulated.

Option 3, "End of Simulation Date," allows the user to determine the last day of simulation, and although this normally should be set in the "Harvest" section, it could be set to "-99" in this menu.

Option 4, "Number of Years to be Simulated," allows the user to specify how many years will be simulated. This is normally set to "1." If, in the example screen shown, the "Number of Years" was set to "2," the model would conduct two simulations, one for 1978, and one for 1979. The user needs to be sure that weather data are available for the years for which the simulations are to be run.

```
SIMULATION TIMING AND CONTROL
=============================

0. Return to Main Menu

1. Start of Simulation Date ...........] JUN 15
2. Year of Simulation .................]   1978
3. End of Simulation Date .............]     -9
4. Number of Years to Be Simulated ....]      1
5. Initial Conditions .................] AS REPORTED


SELECTION (#) ? [ Default = 0 ] --->
```

SCREEN 19.

When Option 5, "Initial Conditions," is selected, Screen 20 (below) is presented.

```
INITIAL SOIL CONDITIONS
=======================

0. Return to Previous Menu

1. As Reported from Input Files ......................|
2. Simulated Output Conditions from Previous Run ....|


CURRENT INITIAL SOIL CONDITIONS ===> AS REPORTED
SELECTION (#) ? [ Default = 0 ] --->
```

SCREEN 20.

In Screen 20, a user can define whether the model initiates the variables at the start of each succeeding simulation (Option 1) or if the final conditions from a previous model run are to be used (Option 2). Selecting Option 2 in this screen is useful when simulating crop rotation studies.

CROP

The "Crop Selection and Modification" menu shown in Screen 21 (below) can currently be used only with the grain legume models.

```
              CROP SELECTION AND MODIFICATION
              ===============================

   0. Return to Previous Menu

   1. Crop Selection ....................[ SOYBEAN
   2. Crop Parameter File ...............[ SBGRO940.SPE


      SELECTION ? [ Default = 0 ] --->
```

SCREEN 21.

When Option 1, "Crop Selection," is selected is Screen 21, the system checks which crop species files are present and then displays Screen 22 (below).

When Option 2, "Crop Parameter File," is selected in Screen 21, the user can choose a dif-

```
IBSNAT 3.0 CROPS
================
 1)       DRY BEAN
 2)       PEANUT
 3)       SOYBEAN

SELECT CROP (#) ====> 1
```

SCREEN 22.

ferent crop species or parameter file as input. The default crop species file is "??GRO940.SPE," where ?? is either SB for soybean, PN for peanut, or BN for dry bean.

In Screen 22, the user can choose to change the crop to one of those listed.

CULTIVAR

The "Cultivar Selection and Modification" menu shown in Screen 23 (below) allows the user to modify inputs related to the cultivar.

```
CULTIVAR SELECTION AND MODIFICATION
===================================

0. Return to Previous Menu

1. Cultivar Selection ................[ IB0001 - BRAGG
2. Cultivar Parameter ................[ SBGRO940.CUL
3. Cultivar Parameter Modification ...|
4. Ecotype Selection .................[ SB701 - MATURITY GROUP 7


SELECTION ? [ Default = 0 ] ---> 1
```

SCREEN 23.

When Option 1, "Cultivar Selection," is selected, Screen 24 (on following page) is presented.

Option 2, "Cultivar Parameter File," allows the user to choose an alternate parameter file as input.

When Option 3, "Cultivar Parameter Modification" is selected, Screen 25 (on following page) is presented.

Option 4, "Ecotype Selection," is applicable only for the grain legume models, which use an ecotype file to represent the variables that are used to define a group of cultivars with the same growth and development characteristics. In Chapter 5, "New Crop Model Features," more information on the ecotype file is presented.

```
                                VARIETY SELECTION
                                =================

                                                          ECOTYPE   MATURITY
NO.  ENTRY    VARIETY                                      GROUP     GROUP
---  ------   --------------------                      -------   --------
 1)  990001   M GROUP    1                               SB0101      01
 2)  990002   M GROUP    2                               SB0201      02
 3)  990003   M GROUP    3                               SB0301      03
 4)  IB000?   WAYNE                                      SB0301      03
 5)  990004   M GROUP    4                               SB0401      04
 6)  990005   M GROUP    5                               SB0501      05
 7)  990006   M GROUP    6                               SB0601      06
 8)  990007   M GROUP    7                               SB0701      07
 9)  990008   M GROUP    8                               SB0801      08
10)  990009   M GROUP    9                               SB0901      09
11)  990010   M GROUP   10                               SB1001      10
12)  990011   M GROUP  000                               SB0001      00
13)  990012   M GROUP   00                               SB0001      00
14)  990013   M GROUP    0                               SB0001      00
15)  UC0001   ALTONA                                     SB0001      00

 More.... press < ENTER > key

16)  IB0001   BRAGG                                      SB0701      07
17)  IB0043   CLARK                                      SB0502      05
18)  IB0002   COBB                                       SB0801      08
19)  IB00E0   CUMBERLAND                                 INDETE      DE
20)  UC0002   MAPLE ARROW                                SB0001      00
21)  UC0003   MCCALL                                     SB0001      00
22)  IB0003   WAYNE                                      OB0301      03

     VARIETY SELECTED ===>    16
     NEW SELECTION ?  --->
```

SCREEN 24.

In Screen 24, the user can choose an alternate cultivar from the one defined in FILEX. For this example, variety number 16, "Bragg," is the default cultivar. A user can select any variety or cultivar by entering one of the numbers from the first column.

```
                CULTIVAR SPECIFIC COEFFICIENTS
                ==============================

CULTIVAR :      BRAGG
-------------------------------

Please Check the User's Guide for Definitions,
Units, and Ranges of Coefficients.

  1) CSDVAR:  12.330          2) FPSEN :     .320
  3) PH2T5 :  19.500          4) FL-SH :   11.000
  5) FL-SD :  17.000          6) SD-PM :   36.000
  7) FL-LF :  15.000          8) LFMAX :    1.022
  9) SLAVR : 350.000         10) SIZLF : 170.000
 11) XFRT  :   1.000         12) WTPSD :     .200
 13) SFDUR :  26.000         14) SDPDV :    2.050
 15) PODUR :  15.000

Please Enter Parameter # You Would Like To Modify [Default = 0] :
(Enter -1 to Save Values in File SBGRO930.CUL).
```

SCREEN 25.

In Screen 25, the user can modify all parameters which are defined in the cultivar file. This example screen displays the coefficients for the soybean cultivar "Bragg."

WEATHER

The "Weather Data Selection and Modification" menu allows the user to select and modify input variables related to the weather conditions (Screen 26, below).

```
          WEATHER DATA SELECTION AND MODIFICATION
          =======================================

0. Return to Previous Menu

1. Recorded/Simulated Data ............[ OBSERVED DATA
2. Weather Data Selection .............[ UFGA7801.WTH
3. Weather Data Path ..................[ C:\DSSAT3\WEATHER\
4. Enter Weather File Name Interactive.[ UFGA7801.WTH
5. Weather Data Modification ..........[ N


   SELECTION ? [ Default = 0 ] ---> 1
```

SCREEN 26.

In Screen 26, Option 1, "Recorded/Simulated Data," allows the user to define if either measured/observed weather data or generated weather data are to be used. In the case of generated data, the model generates these data internally through one of two weather generators that are part of the models, or by reading data from files which contain generated weather data (see Screen 27, on following page).

When Option 2, "Weather Data Selection," is selected, Screen 28 (on following page) is presented.

Option 3, "Weather Data Path," allows the user to define an alternate path where weather data files are located.

Option 4, "Enter Weather File Name Interactive," allows the user to enter an alternate file name. A user must be certain that this file exists; otherwise the model will not be able to simulate the selected management conditions. If a different weather year is selected, the system will modify all date-related inputs to the year selected.

Option 5, "Weather Data Modification," allows the user to interactively modify the weather variables by either adding or subtracting a constant number, multiplying one or more weather variables by a constant number, or setting one or more variables as constant. If 'Y' is selected for this Option, Screen 29 (on following page) is presented.

```
WEATHER INPUT METHODS
=====================

0. Return to Previous Menu

1. Field Observed Data ..............................|
2. Externally Simulated Data ........................|
3. Internally Generated Data ........................|


CURRENT WEATHER INPUT CONDITIONS ===> OBSERVED DATA
SELECTION (#) ? [ Default = 0 ]  --->
```

SCREEN 27.

```
WEATHER LOCATIONS                    LAT.     LONG   ELEV  YEAR   DATA SET
-----------------------------------------------------------------------------
 1) CIAT, PALMIRA, COLOMBIA          3.500  -76.400  -99.  1986   CCPA8601.WTH
 2) CIAT, PALMIRA, COLOMBIA          3.500  -76.400  -99.  1987   CCPA8701.WTH
 3) SUPHAN_BURI, THAILAND           14.500  100.100  -99.  1985   DTSP8501.WTH
 4) CNPAF, GOIANIA, BRAZIL         -16.300  -49.100  -99.  1987   EBGO8701.WTH
 5) ICTA, QUEZADA, GUATEMALA        14.300  -90.000  -99.  1989   IGQU8901.WTH
 6) IRRI, MUNOZ, PHILIPPINES        15.700  120.900  -99.  1985   IRMZ8501.WTH
 7) IRRI, MUNOZ, PHILIPPINES        15.700  120.900   50.  1986   IRMZ8601.WTH
 8) IRRI, PILA, PHILIPPINES         14.200  121.300   50.  1980   IPPI8001.WTH
 9) IRRI, PILA, PHILIPPINES         14.200  121.300   50.  1985   IPPI8501.WTH
10) IRRI, PILA, PHILIPPINES         14.200  121.300  -99.  1986   IPPI8601.WTH
11) CASTANA, IOWA, USA              42.200  -93.700  -99.  1979   IUCH7901.WTH
12) ASHLAND, KANSAS, USA            39.000  -97.000  -99.  1981   KSAS8101.WTH
13) KAJONDI_FARM, BURUNDI           -3.300   30.000   10.  1986   UBKA8601.WTH
14) GAINESVILLE, FLORIDA, USA       29.600  -82.400   10.  1976   UFGA7601.WTH
15) GAINESVILLE, FLORIDA, USA       29.600  -82.400        1978   UFGA7801.WTH

More... PRESS ENTER KEY

16) GAINESVILLE, FLORIDA, USA       29.600  -82.400   10.  1979   UFGA7901.WTH
17) GAINESVILLE, FLORIDA, USA       29.600  -82.400   10.  1980   UFGA8001.WTH
18) GAINESVILLE, FLORIDA, USA       29.600  -82.400   10.  1981   UFGA8101.WTH
19) GAINESVILLE, FLORIDA, USA       29.600  -82.400   10.  1982   UFGA8201.WTH
20) GAINESVILLE, FLORIDA, USA       29.600  -82.400   10.  1984   UFGA8401.WTH
21) GAINESVILLE, FLORIDA, USA       29.600  -82.400   10.  1985   UFGA8501.WTH
22) GAINESVILLE, FLORIDA, USA       29.600  -82.400   10.  1986   UFGA8601.WTH
23) QUINCY, FLORIDA, USA            30.600  -96.400  -99.  1979   UFQU7901.WTH

WEATHER DATA SELECTED ===>  15
ALTERNATE SELECTION ? --->
```

SCREEN 28.

Screen 28 (on preceding page) allows the user to select an alternate weather file as input. The screen displays a listing of the weather data locations available for this example's disk path. For this example, weather data from Gainesville, Florida, collected during 1978 (UFGA7801.WTH) are used (i.e., the number "15" was selected in Screen 28 and is presented next to Option 2 in Screen 26).

```
SELECT/REVISE WEATHER VARIABLES:
================================

0)  RETURN                      OFFSET  MULT.  VALUE
1)  Photoperiod (Day length)      .00    1.00
2)  Solar Radiation               .00    1.00
3)  Maximum Temperature           .00    1.00
4)  Minimum Temperature           .00    1.00
5)  Rainfall                      .00    1.00
6)  Carbon Dioxide                .00    1.00  330.00
7)  Humidity (dew point)          .00    1.00
8)  Wind speed                    .00    1.00

Relative adjustments of CO2 from a base value of    330. ppm.

PFD and Solar Radiation automatically changed together.

CHOICE ? < Default = 0 > ===>
```

SCREEN 29.

Screen 29 shows an overview of the weather variables which can be modified. In this example screen, the CO_2 concentration is set to 330 ppm, while none of the other variables are modified. When one of the variables is selected by its corresponding option number, Screen 30 (on following page) is presented.

```
Select modification option, then enter amount:

0)  NO CHANGE                ( ambient conditions )
1)  Additive Change          ( 3.0 = 3 higher )
2)  Subtractive Change       ( 3.0 = 3 lower )
3)  Multiplicative Change    ( 1.2 = 20% higher )
4)  Constant Value           ( 100 = constant of 100 )

<=== CHOICE? < Default = 0 >
```

SCREEN 30.

Screen 30 allows the user to choose one of the modification options listed in order to revise or alter the weather variable selected in Screen 29 (on preceding page).

SOIL

The "Soil Profile Selection and Modification" menu allows the user to modify input variables related to the soil profile characteristics (Screen 31, below).

```
   SOIL PROFILE SELECTION AND MODIFICATION
   =======================================

0. Return to Main Menu

1. Soil Profile Selection ............[ IBSB910015 - FSH
2. Soil Profile File .................[ SOIL.SOL
3. Soil Profile Path .................[ C:\DSSAT3\SOIL\
4. Soil Profile Layer Thickness ......|
5. Soil Profile Parameters ...........|
6. Soil Surface Parameters ...........|

   SELECTION ? [ Default = 0 ] ---> 1
```

SCREEN 31.

In Screen 31, Option 1, "Soil Profile Selection," allows the user to select an alternate soil profile as input. If this option is selected, Screen 32 (on following page) is presented. As can be seen in Screen 31, pedon number IBSB910015 "Millhopper Fine Sand" was selected from Screen 32. When an alternate soil profile is selected as input from that first presented in Screen 31, the user will be requested to redefine the initial soil conditions, because for many soils the initial conditions are soil profile specific (see Screen 34).

Option 2, "Soil Profile File" in Screen 31, allows the user to define an institute soil file as an alternate soil input file. For this example experiment, the institute is the University of Florida. Therefore the alternate soil file would be UFSOL.

Option 3, "Soil Profile Path," allows the user to define an alternate directory path for the soil file.

Option 4, "Soil Profile Layer Thickness," allows the user to modify the thickness of each soil profile layer. If this option is selected, Screen 33 (on following page) is presented.

Option 5, "Soil Profile Parameters," allows the user to modify the input values for the most important soil profile parameters. These include the drained upper limit, lower limit of plant extractable soil water, saturated water content, initial soil water content, bulk density, pH, soil organic carbon content, and rooting characteristics. If this option is selected, Screen 34 is presented.

Option 6, "Soil Surface Parameters," allows the user to modify the input values for the most important soil surface characteristics. These include soil albedo, first stage evaporation limit, runoff curve number, drainage rate, nitrogen mineralization factor, and growth reduction or fertility factor, which is only implemented in the grain legume models. If this option is selected, Screen 35 is presented.

```
                    SOILS IN THE DATA BASE
                    ======================
REF
NO.  TAXONOMY NAME                                          SOIL NUMBER
---  ----------------------------------------------------   -----------
 1)  Millhopper Fine Sand                                   IBSB910015
 2)  Orangeburg Sandy Loam                                  IBSB910017
 3)  Ida Silt Loam                                          IBSB910026
 4)  Millhopper Fine Sand                                   IBPN910015
 5)  Millhopper Fine Sand                                   IBMZ910014
 6)  Haynie                                                 IBWH910018
 7)  M3                                                     IBBN910030
 8)  San-Fernando                                           IBBN910038
 9)  Millhopper Fine Sand                                   IBBN910015
10)  UNKNOWN                                                GAPN930001
11)  ANDAQUEPTIC HAPLAQUOLL                                 IBRI910001
12)  VERTIC TROPAQUEPT                                      IBRI910002
13)  UPLAND                                                 IBRI910063
14)  Suphan Lowland                                         IBRI910071

     SELECTED SOIL TYPE ===>  1
     NEW SELECTION ?    --->
```

SCREEN 32.

Screen 32 shows a listing of some of the soil profiles available. More information on how to modify the initial conditions is described in the next section, "Initial Conditions," in this Chapter.

```
          LAYER DEPTH MODIFICATION
          ========================

     0)   RETURN TO THE MAIN MENU

     1)       .00 -    5.00........]    5.00 cm
     2)      5.00 -   15.00........]   10.00 cm
     3)     15.00 -   30.00........]   15.00 cm
     4)     30.00 -   45.00........]   15.00 cm
     5)     45.00 -   60.00........]   15.00 cm
     6)     60.00 -   90.00........]   30.00 cm
     7)     90.00 -  120.00........]   30.00 cm
     8)    120.00 -  150.00........]   30.00 cm
     9)    150.00 -  180.00........]   30.00 cm


          SELECTION ? [ Default = 0 ] ===>
```

SCREEN 33.

```
SOIL PROFILE MODIFICATION
=========================

0. Return to Main Menu

1. Drained Upper Limit ...............|
2. Lower Limit .......................|
3. Saturated Water Content ...........|
4. Initial Soil Water Content ........|
5. Bulk Density ......................|
6. pH ................................|
7. Soil Organic Carbon ...............|
8. Rooting Characteristics ...........|

SELECTION ? [ Default = 0 ] ===>
```

SCREEN 34.

```
SOIL SURFACE PARAMETERS
=======================

0. Return to Previous Menu

1. Soil Albedo ....................]    .180
2. Evaporation Limit ..............]   5.000
3. Runoff Curve Number ............]  66.000
4. Drainage Rate ..................]    .500
5. Mineralization Factor ..........]   1.000
6. Growth Reduction/Fertility Fac.]    .840

SELECTION (#) ? [ Default = 0 ] --->
```

SCREEN 35.

INITIAL CONDITIONS

The "Initial Conditions at Start of Simulation" menu allows the user to modify the input variables used to initialize the crop model when a simulation is started (Screen 36, below).

```
          INITIAL CONDITIONS AT START OF SIMULATION
          =========================================

 0. Return to Previous Menu

 1. Initial Soil Water Content ........................0
 2. Initial Soil N03 ..................................0
 3. Initial Soil NH4 ..................................0
 4. Growth Reduction Factor Due to Poor Soil Fertility ..]        .840
 5. Root Weight from Previous Crop ....................]     100.00
 6. Nodule Weight from Previous Crop ..................]        .00
 7. Previous Crop .....................................]         SB

  SELECTION ? [ Default = 0 ] --->
```

SCREEN 36.

In Screen 36, Options 1, 2 and 3, "Initial Soil Water Content," "Initial Soil NO3" and "Initial Soil NH4," respectively, allow the user to modify these variables for each layer. If Option 1 is selected, Screen 37 (on following page) is presented.

Option 4, "Growth Reduction Factor Due to Poor Soil Fertility," is used only in the grain legume models to adjust biomass growth for conditions which are currently not included in the crop process simulations.

Options 5, 6 and 7, "Root Weight from Previous Crop," "Nodule Weight from Previous Crop" and "Previous Crop," respectively, relate to crop residues remaining from previous crop and which are present at planting of the current crop. This information is needed when the soil nitrogen balance is simulated.

```
INITIAL SOIL WATER CONTENT
==========================

0) RETURN TO THE MAIN MENU

1)   0. -    5. cm ........]        .0860   cm3/cm3
2)   5. -   15. cm ........]        .0860   cm3/cm3
3)  15. -   30. cm ........]        .0860   cm3/cm3
4)  30. -   45. cm ........]        .0860   cm3/cm3
5)  45. -   60. cm ........]        .0860   cm3/cm3
6)  60. -   90. cm ........]        .0760   cm3/cm3
7)  90. -  120. cm ........]        .0760   cm3/cm3
8) 120. -  150. cm ........]        .1300   cm3/cm3
9) 150. -  180. cm ........]        .2580   cm3/cm3

SELECTION ? [ Default = 0 ] --->
```

SCREEN 37.

Screen 37 displays the variables which can be changed if Option 1, "Initial Soil Water Content" in Screen 36, is selected.

PLANTING

The "Planting Timing and Control" menu allows the user to define the conditions at planting (Screen 38, below).

```
PLANTING TIMING AND CONTROL
===========================

 0. Return to Main Menu

 1. Planting Date ......................]      JUN 15
 2. Year of Planting ...................]        1978
 3. Plant Population ...................]      29.900
 4. Row Spacing ........................]      91.000
 5. Row Direction ......................]        .000
 6. Planting Depth .....................]       4.000
 7. Planting Material Dry Weight .......]     -99.000
 8. Planting Method ....................]   SEED
 9. Planting Management ................]   ON REPORTED DATE
10. Automatic Planting Options .........|

   SELECTION (#) ? [ Default = 0 ] --->
```

SCREEN 38.

In Screen 38, Options 1 and 2, "Planting Date" and "Planting Year," respectively, allow the user to modify the planting date and year.

Options 3 and 4, "Plant Population" and "Row Spacing," respectively, allow the user to define plant density, row spacing and plant spacing.

Option 5, "Row Direction," is used only in the grain legume models to define light interception for the simulated leaf level photosynthesis processes.

Option 6, "Planting Depth," affects germination and emergence.

Option 7, "Planting Material Dry Weight," allows the user to define the initial weight of the root crops at planting.

Option 8, "Planting Method," allows the user to define planting method, strategy (e.g., seed, transplant, etc.)

Option 9, "Planting Management," allows the user to define when planting occurs; either at the specified date in Option 1 or 2 or through an automatic planting routine (Option 10).

Option 10, "Automatic Planting Options," allows the user to define a window for soil water and temperature which determine when soil conditions in the top of the profile are optimum for germination (see Screen 39, below). Delineation of soil water and temperature, within which planting can occur, can also be specified in Screen 39. It is important that the earliest planting date, defined in Screen 39, be a date after the start of simulation date, as defined in Screen 19.

```
AUTOMATIC PLANTING MANAGEMENT
=============================

0. Return to Previous Menu

1. Earliest Planting Date .......................] JUN  4 1978
2. Latest Planting Date .........................] JUL 19 1978
3. Lowermost Soil Water Content .................]      40.
4. Uppermost Soil Water Content .................]     100.
5. Management Depth For Soil Water ..............]      30.
6. Maximum Soil Temperature (Top 10 cm Avg).(°C)]       40.
7. Minimum Soil Temperature (Top 10 cm Avg).(°C)]       10.


START OF SIMULATION DATE IS AFTER THE START OF
THE AUTOMATIC PLANTING WINDOW.
PLEASE MODIFY PLANTING DATE OR SIMULATION WILL TERMINATE !


SELECTION (#) ? [ Default = 0 ] --->
```

SCREEN 39.

HARVEST

The "Harvest Timing and Control" menu allows the user to define the conditions for crop harvesting. The default for harvest is when the crop reaches harvest maturity, as shown in Screen 40 (below).

```
HARVEST TIMING AND CONTROL
==========================

0. Return to Main Menu

1. Harvest Management ..................]   AT HARVEST MATURITY
2. Harvest Date ........................]       -9     -9
3. Harvest Days after Planting .........]   -9
4. Harvest Stage .......................]   Harvest
5. Harvest Component ...................]
6. Harvest Size Group ..................]
7. Harvest Percentage ..................]   100.
8. Automatic Harvest Options ...........|


SELECTION (#) ? [ Default = 0 ] --->
```

SCREEN 40.

In Screen 40, Option 1, "Harvest Management," allows the user to define various management options. If this option is selected, Screen 41 (on following page) is presented.

Option 2, "Harvest Date," is active only when, in Screen 41, the user selects Option 2, "On Reported Date(s)." Then, Screen 40 is presented again and the user can select Option 2 and enter the harvest date.

Option 3, "Harvest Date After Planting," is active only when, in Screen 41, the user selects Option 3, "On Reported Days After Planting." Then, Screen 40 is presented again and the user can select Option 3 and enter the number of days after planting for the harvest date.

Option 4, "Harvest Stage," allows the user to select the phenological or development stage at which to harvest the crop and terminate the simulation.

Options 5, 6 and 7, "Harvest Component," "Harvest Size Group" and Harvest

Percentage," respectively, presented in this screen, are in the process of being developed. An option for "Multiple Harvests" is also under development.

When Option 8, "Automatic Harvest Options," is selected, Screen 42 (on following page) is presented, which allows the user to select conditions for harvest.

```
HARVEST MANAGEMENT STRATEGY
===========================

0. Return to Previous Menu

1. At Harvest Maturity ............................|
2. On Reported Date(s) ............................|
3. On Reported Days After Planting ................|
4. At Reported Growth Stage(s) ....................|
5. Automatic When Conditions are Satisfactory .....|

CURRENT HARVEST MANAGEMENT      ===> AT HARVEST MATURITY
SELECTION (#) ? [ Default = 0 ] --->
```

SCREEN 41.

Screen 41 allows the user to define various harvest management options. These include harvest at crop harvest maturity (Option 1 and the default for Option 1 in Screen 40); harvest on reported date (Option 2) or fixed day (Option 3); harvest at a particular developmental stage (Option 4); and an automatic harvest as a function of a set of crop and environmental conditions (Option 5).

```
AUTOMATIC HARVEST MANAGEMENT
============================

0. Return to Previous Menu

1. Earliest Harvest Date (Days after Maturity) .]        0
2. Latest Harvest Date   (Day of Year ) ........] DEC 31 1978
3. Product Harvested .......................(%)]     100.
4. Residue Harvested .......................(%)]       0.


SELECTION (#) ? [ Default = 0 ] --->
```

SCREEN 42.

Screen 42 shows the various conditions which can be set when the automatic harvest management option is selected in Screen 40.

WATER AND IRRIGATION

The "Water and Irrigation Management and Modification" menu allows the user to modify the various options and variables associated with the water balance simulation and irrigation applications (Screen 43, below).

```
WATER AND IRRIGATION MANAGEMENT AND MODIFICATION
================================================

0. Return to Main Menu

1. Water Balance Simulation ..........] Y
2. Irrigation Management .............] ACCORDING TO FIELD SCHEDULE
3. Automatic Irrigation Control ......] -9.000  -9.0
4. Automatic Irrigation-Fixed Amount..] -9.000 mm
5. Irrigation Efficiency .............]  .75
6. Enter Irrigation Interactive ......|
7. Water Output File .................] Y


SELECTION ? [ Default = 0 ] ===>
```

SCREEN 43.

Option 1, "Water Balance Simulation" in Screen 43 (on preceding page), allows the user to turn the water balance simulation on or off.

Option 2, "Irrigation Management," allows the user to define the various irrigation management options, and when selected, Screen 44 (below) is presented.

Options 3 and 4, "Automatic Irrigation Control" and "Automatic Irrigation - Fixed Amount," respectively, allow the user to define the automatic irrigation controls explained earlier. These two options can be modified only when an automatic irrigation strategy has been selected under Option 2.

Option 5, "Irrigation Efficiency," allows the user to determine how much water is actually applied. For example, for furrow irrigation or sprinkler irrigation not all water measured in the supplying pipes is actually applied to the field or plot.

Option 6, "Enter Irrigation Interactive," can only be accessed when, under Option 2, "Irrigation Management," the user selects "According to Field Schedule" (see example in Screen 43). When Option 6 is selected, Screen 45 is presented.

Option 7, "Water Output File," allows the user to either switch the soil and plant water output file on or off.

```
IRRIGATION MANAGEMENT STRATEGY
==============================

0. Return to Main Menu

1. Rainfed / Not Irrigated .......................|
2. Irrigate  According To Field Schedule ..........|
3. Automatic Irrigation / Refill Profile ..........|
4. Automatic Irrigation / Apply Fixed Amount ......|
5. No Water Stress / No Water Balance Simulation ..|

CURRENT IRRIGATION MANAGEMENT   ---> ACCORDING TO FIELD SCHEDULE
SELECTION (#) ? [ Default = 0 ] ===>
```

SCREEN 44.

In Screen 44, the user can select either rainfed with no supplemental irrigation (Option 1) or irrigate according to the field schedule (Option 2). In the latter case, the irrigation data

must be in FILEX. There are also two automatic irrigation options: Options 3 and 4.

Option 3 selects to refill the selected profile depth to the drained upper limit or field capacity.

Option 4 applies a fixed amount each time the system calls for an irrigation event. Both automatic irrigation events are controlled by a soil depth and a threshold value for extractable water, which can both be defined by the user.

Option 5, "No Water Stress/No Water Balance Simulation," allows the user to choose not to simulate the soil water balance, which is the same as setting the water balance simulation to 'N' in Screen 43.

INTERACTIVE DATA ENTRY FOR IRRIGATION
==========

#	Date	Amount (mm)	Irrigation Type
16	78272	8.0	Furrow, mm
17	78279	8.0	Furrow, mm
18	78283	8.0	Furrow, mm
19	78294	10.C	Furrow, mm

(E)dit, (A)dd and event, (D)elete, (Q)uit (↵ = Done)

SCREEN 45.

Screen 45 is an example screen listing the options available for adding irrigation interactively. In this screen, a user can either edit, add, or delete an irrigation event.

NITROGEN

The "Nitrogen Management and Modification" menu allows the user to modify variables and options associated with the soil nitrogen simulation (Screen 46, below).

```
      NITROGEN MANAGEMENT AND MODIFICATION
      ====================================

  0.  Return to Main Menu

  1.  Nitrogen Balance Simulation .......] Y
  2.  N-Fertilizer Management ...........] NOT FERTILIZED
  3.  Automatic Fertilizer Management ...]
  4.  Enter N-Fertilizer Interactive ....|
  5.  Nitrogen Fixation ..... ...........] N-FIX SIMULAT.
  6.  Nitrogen Fixation Characteristics..|
  7.  Nitrogen Output File ..............] Y

      SELECTION ? [ Default = 0 ] ===>
```

SCREEN 46.

Option 1, "Nitrogen Balance Simulation," allows the user to turn the soil nitrogen balance simulation on or off. Note that the water balance simulation must be set to 'Y' to simulate the soil nitrogen balance.

Option 2, "N-Fertilizer Management," allows the user to define the various nitrogen fertilizer management options. When this option is selected, Screen 47 (on following page) is presented.

Option 3 in Screen 48, "Automatic Fertilizer Management," can only be accessed if Option 3, "Automatic N-Fertilizer Application" in Screen 47, is selected. When Option 3 in Screen 47 is selected, Screen 48 is presented. The user makes his selection(s) in Screen 48 and a 'Y' is placed next to Option 3 in Screen 46.

Option 4, "Enter N-Fertilizer Interactive," can only be accessed if Option 2, "Apply N-Fertilizer According to Field Schedule" in Screen 47, is selected. The screen which defines interactive N-fertilizer applications is not shown, but is similar to the screen for irrigation management (Screen 45, on preceding page).

Options 5 and 6, "Nitrogen Fixation" and "Nitrogen Fixation Characteristics,", respectively, are only applicable for the grain legume models. When Option 5 is selected, Screen 49 is presented. When Option 6 is selected, Screen 50 is presented.

Option 7, "Nitrogen Output File," allows the user to either switch the soil and plant nitrogen output file on or off.

```
NITROGEN FERTILIZER MANAGEMENT STRATEGY
=======================================

0. Return to Main Menu

1. Not Fertilized ....................................|
2. Apply N-Fertilizer According to Field Schedule ...|
3. Automatic N-Fertilizer Application ...............|
4. No Nitrogen Stress / No N-Balance Simulation .....|

CURRENT IRRIGATION MANAGEMENT    ---> NOT FERTILIZED
SELECTION (#) ? [ Default = 0 ] ===>
```

SCREEN 47.

In Screen 47 (above), the user can select Option 1, "Not Fertilized," with no supplemental nitrogen fertilizer applied, or Option 2, "Fertilize According to the Field Schedule."

In the latter case, the nitrogen fertilizer data must be in FILEX. Please note that Option 4 in Screen 46, "Enter N-Fertilizer Interactive" can only be accessed if Option 2 in Screen 47 is selected. (See Option 4 for screen 46.)

Option 3 allows "Automatic Nitrogen Fertilizer Application" as a function of pre-set conditions. Please note that Option 3 in screen 46, "Automatic Fertilizer Management," can only be accessed if Option 3 in this screen is selected. (See Option 3 for Screen 46.) When Option 3 in Screen 46 is selected, Screen 48 (on following page) is presented.

Option 4 in Screen 47 allows the user to choose not to simulate the soil nitrogen balance, which is the same as setting Option 1 to 'N' in Screen 46.

```
AUTOMATIC NITROGEN FERTILIZER APPLICATION
=========================================

0. Return to Previous Menu

1. Threshold - Nitrogen Stree Factor ........(%)]   50.000
2. Amount of N-Fertilizer Per Application .kg/ha]   25.000
3. Application Depth ......................(cm)]   30.000
4. Material Code ..........................(#)] Ammonium nitrate


SELECTION (#) ? [ Default = 0 ] --->
```

SCREEN 48.

Screen 48 shows the various threshold levels which can be set for automatic nitrogen fertilizer applications. In this screen, the threshold value (Option 1) uses a nitrogen factor expressed on a relative basis between 0 and 100 percent, where "0" means that the plants are under complete nitrogen stress and "100" means that the plants are under no nitrogen stress.

Options 2, 3 and 4 allow the user to define the amount of nitrogen fertilizer to be applied, the application depth, and the type of nitrogen fertilizer, respectively, when the crop model calls for a nitrogen fertilizer application, as selected under the threshold level of Option 1.

```
NITROGEN FIXATION STRATEGY
==========================

0. Return to Previous Menu

1. No Nitrogen Fixation Simulation ..................|
2. Dynamic Nitrogen Fixation Simulation .............|
3. Unlimited Nitrogen Fixation Simulation ...........|

CURRENT NITROGEN FIXATION SELECTION ===> N-FIX SIMULAT.
SELECTION (#) ? [ Default = 0 ]      --->
```

SCREEN 49.

Screen 49 (above) shows the nitrogen fixation variables available when Option 5 in Screen 46 is selected. Please note that Option 5 in Screen 46 is available only for the grain legume models (soybean, peanut and drybean).

In Screen 49, Option 1, "No Nitrogen Fixation Simulation," allows the user to simulate a complete soil and plant nitrogen balance. However, plants will not fix nitrogen, which is similar to non-nodulating cultivars.

Option 2, "Dynamic Nitrogen Fixation Simulation," allows the user to simulate both a dynamic nitrogen uptake and nitrogen fixation as a function of soil and weather conditions.

Option 3, "Unlimited Nitrogen Fixation Simulation," allows the user to simulate a dynamic nitrogen uptake and assumes that the remainder of the nitrogen required for growth is available via N fixation.

```
NITROGEN FIXATION CHARACTERISTICS
=================================

0.  Return to Previous Menu

1.  Rhizobia Effectiveness ........]   1.000
2.  Rhizobia Number (Relative .....]   1.000


SELECTION (#) ? [ Default = 0 ] --->
```

SCREEN 50.

Screen 50 shows the nitrogen fixation characteristics which can be modified when Option 6 in Screen 46 is selected.

In Screen 50, Option 1, "Rhizobia Effectiveness," is a relative number between 0 and 1. An effectiveness of "1" means that the rhizobia are completely active with respect to nitrogen fixation.

Option 2, "Rhizobia Number," is also a relative number (0 to 1) which allows the user to determine the initial amount of rhizobia present at the start of simulation.

PHOSPHORUS

The "Phosphorus Management and Modification" menu is under development and is not available for the current DSSAT v3 crop models.

RESIDUE

The "Crop Residue Management at Start of Simulation" menu allows the user to modify variables related to crop residue at the start of simulation (Screen 51, below).

```
      CROP RESIDUE MANAGEMENT AT START OF SIMULATION
      ==============================================

 0.  Return to Main Menu

 1.  Residue Application Date ..............................]      78166
 2.  Residue Applied at Start of Simulation ................]     1000.0 kg/ha
 3.  Residue Nitrogen Concentration ........................]        .80 %
 4.  Residue Phosphorus Concentration ......................]        .00 %
 5.  Residue Incorporation .................................]     100.00 %
 6.  Residue Incorporation Depth ...........................]       15.0 cm
 7.  Residue Material Code .................................]      IB001
 8.  Root Weight from Previous Crop ........................]     100.00 kg/ha
 9.  Nodule Weight from Previous Crop ......................]        .00 kg/ha
10.  Previous Crop .........................................]         SB

    SELECTION (#) ? [ Default = 0 ] --->
```

SCREEN 51.

In Screen 51, Option 1, "Residue Application Date," uses the same date as the start of simulation date.

Options 2, 3, 4, 5 and 6 allow the user to define, respectively, the amount of residue applied, its nitrogen and phosphorus concentration, the amount of residue incorporated into the soil, and the incorporation depth.

Options 8 and 9, "Root Weight from Previous Crop" and "Nodule Weight from Previous Crop," respectively, allows the user to enter these values. Please note that the program assumes that all below ground material from a previous crop remains in the soil.

Option 10 allows the user to define the crop grown previously (e.g., the crop grown before the current crop).

Pest And Disease

The "Pest and Disease Selection and Modification" menu is currently available only in the grain legume models (Screen 52, below).

```
          PEST AND DISEASE SELECTION AND MODIFICATION
          ===========================================

0.  Return to Main Menu

1.  Pest & Disease Simulation .........] N
2.  Enter Pest Population or Damage ...|
3.  Pest Output File ..................] N


    SELECTION ? [ Default = 0 ] ===>
```

Screen 52.

In Screen 52, Option 1, "Pest & Disease Simulation," allows the user to turn the pest and disease simulation on or off.

Option 2, "Enter Pest Population or Damage," is not currently available. Information on how to manually edit or create a pest population or crop damage can be found in Appendix C herein.

Option 3, "Pest Output File," allows the user to switch the pest output file on or off.

Crop Process Options

The "Simulation Control and Modification" menu allows the user to control various internal process simulations of the models (Screen 53, below).

```
SIMULATION CONTROL AND MODIFICATION
===================================

0. Return to Main Menu

1. Water Balance Simulation ................] Y
2. Nitrogen Balance Simulation .............] Y
3. Nitrogen Fixation Simulation ............] N-FIX SIMULAT.
4. Phosphorus Balance Simulation ...........] N
5. Pest and Disease Interaction Simulation ..] Y
6. Weather Input Method ....................] OBSERVED DATA
7. Initial Conditions ......................] AS REPORTED
8. Photosynthesis Simulation Method ........] CANOPY PHOT
9. Evaporation Simulation Method ...........] PRIESTLEY-TAYLOR


SELECTION ? [ Default = 0 ] ===>
```

Screen 53.

In Screen 53, Options 1, 2, 3, 4, 5, 6 and 7 can be modified in their respective menus. For example, the options for the Water Balance simulation (Option 1) and Nitrogen Balance simulation (Option 2), can be found in the "Water and Irrigation" and "Nitrogen" sections, respectively, of this Chapter. Please note that Options 3, 5 and 8 are crop model or species specific.

OUTPUT CONTROL

The "Output File Options and Controls" menu allows the user to switch each output file (Options 2-9 in Screen 54, below) on or off.

```
              OUTPUT FILE OPTIONS AND CONTROLS
              ================================

  0.  Return to Main Menu

  1.  Video Output ....................................   I
  2.  Overview Output File ............................   Y
  3.  Summary Output File .............................   Y
  4.  Growth Output File ..............................   Y
  5.  Carbon Balance Output File ......................   Y
  6.  Water Balance Output File .......................   Y
  7.  Nitrogen Balance Output File ....................   Y
  8.  Mineral Nutrients Output File ...................   N
  9.  Pest Output File ................................   Y
 10.  Frequency of Simulation Output (in days)........   3
 11.  Save Output Files with Experiment Code .........   N
 12.  Write Output Files with Long Format ............   Y

     SELECTION ? [ Default = 0 ] ===>
```

SCREEN 54.

In Screen 54, Option 1, "Video Output," allows the user to control the model output to the computer screen or monitor. Only the "I", "Interactive Option," will actually display output on the computer screen. "I" is the default for Option 1.

When a "1" is entered (that is, the <1> key and then the <ENTER> key are pressed), indicating that NO video output is required, this menu screen will immediately go blank and all screen writes will be eliminated. If the user wishes to select this option (i.e., have no screen display), but also wishes to select any of the other options, it is recommended that the user first enter those options and then select Option 1. Otherwise, although other options in this screen can be selected after entering "1," the user will not see the menu and will have to work from memory.

Once a "1" is entered, press the <ENTER> key twice. A dialog box will be presented in which the user can enter a "run name" for the simulation. Press the <ENTER> key again. Simulation will begin, but nothing will be seen on the screen during the simulation. When simulation is completed, a message will be displayed on the screen informing the user of this.

NOTE: *If you select Option 1 and enter an "1," but wish to see this menu screen again, simply press "1" again. However, enter the second "1" BEFORE pressing the <ENTER> key twice, because after that is done, this screen cannot be refreshed.*

Option 2, "Overview Output File," allows the user to control the output file, OVERVIEW.OUT.

Option 3, "Summary Output File," allows the user to control the output file, SUMMARY.OUT. A 'Y' selection for this file will erase the file from the previous run and will create a new output file; an 'A' selection for this file will append the outputs of the current simulation to the already existing SUMMARY.OUT file and no headers will be written. A 'N' will cause this file not to be created.

Option 4, "Growth Output File," allows the user to control the output file, GROWTH.OUT.

Option 5, "Carbon Balance Output File," allows the user to control the output file, CARBON.OUT.

Option 6, "Water Balance Output File," controls the output file, WATER.OUT.

Option 7, "Nitrogen Balance Output File," allows the user to control the output file, NITROGEN.OUT.

Option 8, "Mineral Nutrients Output File," is not yet operational and will be implemented later to control the output file, PHOSPHOR.OUT.

Option 9, "Pest Output File," allows the user to control the output file, PEST.OUT. Please note that this option is available only in the grain legume models.

Option 10, "Frequency of Simulation Output," allows the user to control the output interval, in days, for those output files which contain time-series data, such as GROWTH.OUT, WATER.OUT, CARBON.OUT, NITROGEN.OUT, PHOSPHOR.OUT and PEST.OUT.

Option 11, "Save Output Files with Experiment Code," allows the user to save the files using the same file name as FILEX for that experiment, except for its last character, which must be a G, W, N, C, P or D, for growth, water, nitrogen, carbon, phosphorus, and pests and diseases, respectively. The default setting for Option 11 is 'N'.

Option 12, "Write Output Files with Long Format," writes the output file with additional variables besides the standard variables used for each model. Screens 14 and 15 in the "Graphic Display" section of Chapter 6 give an indication of some of the additional variables which are stored in file GROWTH.OUT if the long format is selected for the output files.

CHAPTER EIGHT.
PROBLEMS AND ERROR MESSAGES

Many types of personal micro-computers are available and it has not been possible to test the DSSAT v3 simulation models on all possible systems, hardware configurations or operating systems. System requirements to run DSSAT v3 and its crop models can be found in Chapter 2 of Volume 1-1 (Tsuji et al. 1994) of this book. A listing of important error messages is given in Table 7.

Some common problems which may occur:

1. One of the three required executable files, MDRIV940.EXE, MINPT940.EXE and one of the crop simulation modules, is missing.
2. The three required executable files are not located in the same directory.
3. The model is being run from a data directory rather than from the crop model data directory.
4. One of the input files is missing. Required files are :
   - EXP.LST – use the file manager in DSSAT v3 to recreate this file;
   - The experiment selected during the model run. Look for a file with an X extension, i.e., ????????.CRX, where ???????? includes the Institute code, Site code, year and experiment number and CR is the crop code, e.g., UFGA7801.SBX. The ????????.CRX should also be included in the EXP.LST file. This file can be created or edited with the XCreate program (see Volume 1-4, Imamura 1994, of this book) or added to the EXP.LST with the General File Manager (see Chapter 6 herein).
   - The cultivar file. This file is normally located either in the crop data directory or in the genotype directory of DSSAT v3 (C:\DSSAT3\GENOTYPE). The file name has the CUL extension, using the file name convention ????????.CUL, where ???????? is the crop model name and version, e.g., SBGRO940.CUL.
   - The ecotype file. This file is normally located either in the crop data directory or in the genotype directory of DSSAT v3 (C:\DSSAT3\GENOTYPE). The file name has the ECO extension, using the file name convention ????????.ECO, where ???????? is the crop model name and version e.g., SBGRO940.ECO.
   - The crop species file. This file is normally located either in the crop data directory or the genotype directory of DSSAT v3 (C:\DSSAT3\GENOTYPE). The file name has the SPE extension, using the file naming convention ????????.SPE, where ???????? is the crop model name and version, e.g., SBGRO940.SPE.
   - The soil file. This file is normally located either in the crop data directory or in the soil data directory of DSSAT v3 (C:\DSSAT3\SOIL). Look for a file with the SOL

extension. The general soil file name used in the crop models is SOIL.SOL.

- The weather file. This file is normally located either in the crop data directory or in the weather data directory of DSSAT v3 (C:\DSSAT3\WEATHER). Look for a file with the WTH extension, using the file name convention ????????.WTH, where ???????? includes the institute code, site code, and year, e.g., UFGA7801.WTH.
- The crop species in the *CULTIVAR section of FILEX is wrong. Check the code under "CR" in the *CULTIVAR section.
- The cultivar specified in the *CULTIVAR section is wrong or not included in the genotype file of the model. Check the code under INGENO in the *CULTIVAR section of FILEX. Also check the genotype file ???????.CUL. If the cultivar is currently not included in this file, use the genotype calculator program to add this cultivar to the cultivar list and to estimate the initial values for all genetic coefficients.
- The weather station specified in the *FIELDS section is wrong or the file is not included in either the model data directory or weather data directory. Check the code under WSTA in the *FIELDS section of FILEX.
- The soil profile identified in the *FIELDS section is wrong or the soil profile is not part of the soil file SOIL.SOL. Check the section under ID_SOIL in the *FIELDS section of FILEX.

Required model input data are explained in detail in Volume 2-1 (Jones et al., 1994) of this book, and example files are included with the required variables highlighted for the various options available for simulation.

The input section of the model includes detailed error checking routines. The most common error messages are listed in Table 7. These messages include the subroutine and the input file in which the error occurred, and in some cases also the line number of the input file. These messages also give you some information about the type of error which occurred. In many cases these errors can be corrected by editing FILEX using either the XCreate program (see Volume 1-4, Imamura 1994, of this book) or any other ASCII text editor.

There might be cases where the model gives a runtime error. These errors could either be due to a problem with the input file, such as a "0" where the model expects a number > 0, or other problems. However, in some cases, these errors can be caused by a combination of inputs which we have been unable to test during model development. If this happens, please make sure that your error is reproducible; that is, you can recreate the same error and error message using the same combination of input conditions. Please carefully document the problem, error message, combination of inputs and input files, and model version number and contact one of the model developers, a listing of whom can be found in Appendix D.

TABLE 7. IMPORTANT ERROR MESSAGES.

AUTFER 1
Error in Fertilizer Sensitivity Analysis Selection. Fix entry or batch file.

AUTIRR 1
Error in Irrigation Sensitivity Analysis Selection. Fix entry or batch file.

CROPGR 1
Incompatible input file format.

CROPGR 2
Planting date is before start of simulation date. Please fix input file.

MRUN 1
Specified weather data files not available. Please create files.

IDWTH 1
Error in Weather Sensitivity Selection entry. Fix entry or batch file.

IDWTH 2
End of File in Weather Sensitivity Selection entry. Fix entry or batch file.

INPUT 1
Error in Selection entry. Fix entry or batch file.

INPUT 2
Planting Date is Before Start of Simulation. Please Fix Input File.

IPCROP 1
Error in Crop Parameter Input File. End of File Reached.

IPECO 1
Error in Ecotype entry. Fix entry or batch file.

IPECO 2
Error in Ecotype entry. Fix ecotype input file.

IPECO 3
DEFAULT Ecotype not found. Fix ecotype input file.

IPECO 21
Ecotype input section not found. Please correct file.

IPENV 1
Incorrect format in environmental section. Check format.

IPEXP 1
Treatment input section not found. Please add to input file.

IPEXP 2
Error in Experiment Selection entry. Fix entry or batch file.

IPEXP 3
Error in Treatment Selection entry. Fix entry or batch file.

IPEXP 4
Simulation must begin on or before the planting date. Correct dates.

IPEXP 10
Error in crop input. Correct input file.

IPEXP 11
Error in cultivar input. Correct input file.

IPEXP 20
You selected a crop which can not be simulated by this model. Please ReExecute.

IPEXP 21
Experiment list input section not found. Please correct file.

IPEXP 22
Incorrect weather method option selected. Please correct file.

IPFERT 1
Fertilizer input section not found. Please add to input file.

IPFERT 2
Error in fertilizer inputs. Check format.

IPFERT 10
Error in date of fertilizer application input. Correct input file.

IPFERT 11
Error in depth of fertilizer application input. Correct input file.

IPFERT 12
Error in amount of N-fertilizer input. Correct input file.

IPFERT 13
Error in amount of P-fertilizer input. Correct input file.

IPFERT 14
Error in fertilizer code. Correct input file.

IPFLD 1
Field input section not found. Please add to input file.

IPFLD 2
Error in field inputs. Check format.

IPFLD 10
Error in weather station input. Correct input file.

IPFLD 11
Error in soil identification input. Correct input file.

IPHAR 1
Harvest input section not found. Please add to input file.

IPHAR 2
Error in harvest inputs. Check format.

IPHAR 3
Harvest growth stage not found. Please add to input file.

IPHAR 4
Reported harvest date not found. Please add to input file.

IPHAR 5
Reported harvest date after planting not found. Please add to input file.

IPHAR 10
Error in date of harvest input. Correct input file.

IPHAR 11
Error in harvest input. Correct input file.

IPHAR 12
Error in harvest stage code. Correct input file.

IPIRR 1
Irrigation input section not found. Please add to input file.

IPIRR 2
Error in irrigation inputs. Check format.

IPIRR 10
Error in date of irrigation input. Correct input file.

IPIRR 11
Error in amount of irrigation input. Correct input file.

IPIRR 12
Error in irrigation code. Correct input file.

IPPARM 21
Pest parameter input section not found. Please correct file.

IPPLNT 1
Planting input section not found. Please add to input file.

IPPLNT 2
Error in planting inputs. Check format.

IPPLNT 10
Error in planting date input. Check format.

IPPLNT 11
Error in plant population input. Check format.

IPPLNT 12
Error in row spacing input. Check format.

IPPLNT 13
Error in row orientation input. Check format.

IPRES 1
Residue input section not found. Please add to input file.

IPRES 2
Error in residue inputs. Check format.

IPRES 10
Error in date of residue application input. Correct input file.

IPRES 11
Error in amount of residue input. Correct input file.

IPRES 12
Error in amount of residue N input. Correct input file.

IPRES 13
Error in amount of residue P input. Correct input file.

IPRES 14
Error in amount of residue K input. Correct input file.

IPSLAN 1
Initial soil analysis section not found. Please add to input file.

IPSLAN 2
Error in initial soil analysis inputs. Check format.

IPSLAN 10
Error in initial bulk density inputs. Please check data.

IPSLAN 11
Error in initial organic carbon inputs. Please check data.

IPSLAN 12
Error in initial nitrogen inputs. Please check data.

IPSLIN 1
Initial soil input section not found. Please add to input file.

IPSLIN 2
Error in initial soil inputs. Check format.

IPSLIN 10
Error in initial soil water inputs. Please check data.

IPSLIN 11
Error in initial NH4 inputs. Please check data.

IPSLIN 12
Error in initial NO3 inputs. Please check data.

IPSLIN 13
Error in initial residue weight inputs. Please check data.

IPSLIN 14
Error in initial residue nodule weight inputs. Please check data.

IPSLIN 15
Error in inoculation efficiency data. Please check data.

IPSLIN 16
Error in fixation efficiency data. Please check data.

IPSIM 1
Simulation control section not found. Please add to input file.

IPSIM 2
Incorrect number of lines in simulation control section. Check format.

IPSIM 3
Impossible combination--for MEEVP='Z', MEPHO must be 'L'.

IPSOIL 1
Error in Soil Selection entry. Fix entry or batch file.

IPSOIL 2
More than 19 layers in the soil profile. Correct input file.

IPSOIL 3
Error in Soil Selection entry. Fix soil input file.

IPSOIL 4
End of soil file. Please add missing information to input file.

IPSOIL 5
Depth of second tier does not match the one of the first tier. Fix input file.

IPSOIL 6
Number of layers in second tier does not match the number in the first tier.

IPSOIL 21
Soil input section not found. Please correct file.

IPVAR 1
Error in Cultivar entry. Fix entry or batch file.

IPVAR 2
Error in Cultivar entry. Fix cultivar input file.

IPVAR 21
Genetics input section not found. Please correct file.

IPVAR 22
LFMAX is less than or equal 0. Please correct file.

IPVAR 23
SLAVAR is less than or equal 0. Please correct file.

IPVAR 24
XFRUIT is less than or equal 0. Please correct file.

IPVAR 25
WTPSD is less than or equal 0. Please correct file.

IPVAR 26
SDPDVR is less than or equal 0. Please correct file.

IPVAR 27
SFDUR is less than or equal 0. Please correct file.

IPVAR 28
PODUR is less than or equal 0. Please correct file.

IPWTH 1
Simulation date must be AFTER first available weather day. Correct dates.

IPWTH 2
Missing day in weather data file.

IPWTH 3
Missing or negative data in weather data file.

PLANT 1
Error in photosynthesis process option. Please correct input file.

PATH 1
Code not found in profile file DSSATPRO.FLE. Please correct file.

READA 1
Error in experiment data (averages) file. Could not find @TRNO header line.

READA 2
Error in experiment data (averages) file.

SEDLYR 1
Error in Soil Sensitivity Analysis Selection entry. Fix entry or batch file.

SEWTH 1
Error in Weather Sensitivity Analysis Selection. Fix entry or batch file.

SWFIX 1
Error in Fertilizer Sensitivity Analysis Selection. Fix entry or batch file.

SWINSC 1
Error in Initial Soil Sensitivity Analysis Selection. Fix entry or batch file.

SWIRR 1
Error in Irrigation Sensitivity Analysis Selection. Fix entry or batch file.

WEATHR 1
Weather method selected not available. Please fix input file.

WTHMOD 1
Weather modification created negative data in minimum data set. Check changes.

MISC -1
End-of-file encountered in input file.

MISC 6100
Integer overflow in input file. Check format.

MISC 6101
Invalid integer in input file. Check format.

MISC 6103
Invalid real in input file. Check format.

MISC 6205
A Edit descriptor expected for Character. Check format.

MISC 6206
Invalid format in input file. Check format.

MISC 6416
File not found. Create input file.

CHAPTER NINE.
NEW CROP MODEL FEATURES

NITROGEN BALANCE AND NITROGEN FIXATION (GRAIN LEGUME MODELS ONLY)

The soil N-balance in DSSAT v3 CERES models is the same as the soil N-balance of the individual CERES models in DSSAT v2.1 (Godwin and Jones, 1991). CROPGRO now also has detailed soil and plant nitrogen balance components, which include simulation of nitrogen uptake, nitrogen fixation, and nitrogen mobilization. Hoogenboom et al. (1990) incorporated the CERES-Wheat soil-N balance into SOYGRO V5.42 and added a nitrogen fixation component. This version of SOYGRO, called SOYNIT, underwent testing with 14 different data sets from the NiFTAL Project (Hoogenboom et al. 1990). These components were incorporated into CROPGRO and therefore the soybean, peanut, and dry bean models are now sensitive to soil-N and N-fixing dynamics. Users can run the models without simulating the soil nitrogen balance, and in this case, nitrogen is assumed to be non-limiting as was the case in the individual grain legume models. Also, users can select the soil nitrogen balance without simulating nodule growth and nitrogen fixation. In this case, soil nitrogen is taken up first each day, and any remaining nitrogen demand in the plant is met by allocating sufficient carbon to fix the nitrogen without considering limitations in the nitrogen-fixing mechanisms. Usually, both the soil nitrogen-balance and dynamic nitrogen-fixation are turned on, so that plant carbohydrate status, soil temperature, aeration, and limiting nodule mass can limit nitrogen fixation and simulate non-nodulating legume lines, such as those used in many nitrogen fixation experiments.

CROP ROTATIONS

An option exists which allows users to select whether to reinitialize the soil conditions after each run or to use the ending conditions from one simulation run as inputs to subsequent simulation runs. This feature allows for crop rotations to be studied, with carryover effects in the soil currently limited to crop residue, soil nitrogen, soil carbon, and soil water as a function of soil depth. Future additions will include phosphorus, other soil properties, and perhaps pest organisms. The Sequence Analysis program of DSSAT v3, described in Volume 3-2 (Thornton et al. 1994 b) of this book, allows users to specify crop rotations and to analyze results over long-term simulations.

Evapotranspiration Calculations

In the CERES and CROPGRO models, options exist for the Priestley-Taylor method (Priestley and Taylor, 1972) and the FAO-Penman method (Doorenbos and Pruitt 1975) for potential evapotranspiration calculation. The Priestley-Taylor method is the same as used in previous versions of the models and was described by Ritchie (1985). The use of the FAO-Penman method requires daily humidity and wind speed data, in addition to the minimum weather data set required previously (Penman, 1948). The DSSAT v3 weather file format includes columns for these data when they are available. However, when these additional inputs are not available or have not been measured, users should select the Priestley-Taylor method.

Photosynthesis Calculation Options (**Grain Legume Models Only**)

The CROPGRO model includes two options to compute daily canopy photosynthesis. The first option is based on a single calculation of daily light interception followed by a single calculation of daily canopy photosynthesis. The second option is based on hourly calculations of sunlit and shaded leaf light interception followed by hourly photosynthesis calculations. Using this option, the daily canopy calculation is based on a canopy light extinction coefficient, in contrast to table look-up values in the earlier GRO models. The same light response curve is still used in CROPGRO, but it was modified slightly. For the hourly calculations, the hedge-row photosynthesis model developed by Boote and Loomis (1991) was used, since it more accurately simulates the effects of row and plant spacing on light interception and growth, which is needed to simulate plant density studies. For the hedge-row model, relationships were needed to simulate height and width of canopies, and thus routines were added to crop species files relating to potential elongation of internodes to node position on the plants in order to compute canopy height and width growth.

Carbon Dioxide Effects

The CERES and CROPGRO models include the capability to simulate the effects of CO_2 on photosynthesis and water use. Internally in the models the daily potential transpiration calculations are being modified by the CO_2 concentration, based on the effects of CO_2 on stomatal conductivity (Peart et al., 1989). For the CERES and CROPGRO models, when the canopy photosynthesis model is used, a multiplicative modification is made to daily canopy photosynthesis as described by Curry et al. (1990). For the CROPGRO model, when the hedge-row photosynthesis model is selected, CO_2 is used to modi-

fy the leaf assimilation rate in a more mechanistic way, with an adaptation of the Farquhar et al. model by Pickering et al. (1993).

Climate Change Studies

The DSSAT v3 crop simulation models have the capability to modify daily weather data, read in from the weather file, as well as photoperiod (daylength). Each weather variable can be modified, by multiplying a constant times the input value and/or by adding a constant to it. This provides flexibility to change one or all weather variables, and includes the capability to set them to constant values similar to conditions as observed in growth chamber and other constant environment experiment studies. Users can specify the date that a given modification is to begin and can also define more than one entry if the experiment includes environment switching of any type. These options are included in a special environmental section of FILEX for any experiment and can also be changed interactively during any model run.

Weather Generators

The DSSAT v3 crop simulation models have built-in capabilities for simulating weather using either one of two weather generators. Coefficients for generating weather are stored in site-specific climate files, e.g. *.CLI, such as UFGA.CLI, where UFGA is the site of the weather station. One of the weather generators is SIMMETEO, as developed by Geng et al. (1986). SIMMETEO requires only monthly averages of solar radiation, maximum and minimum air temperatures, precipitation, and days with precipitation as inputs. SIMMETEO then computes coefficients and uses the WGEN weather generator to simulate daily data. The second weather generator is WGEN, as developed by Richardson (1985). WGEN requires more statistics as input than does SIMMETEO. Its monthly weather statistics can be computed from daily data for a number of years, preferably five or more complete historical weather years. The DSSAT v3 models' ability to simulate weather internally, using only monthly averages of variables, will greatly expand the application of these models to areas where the monthly data are all that will be available.

Species, Ecotype And Cultivar Inputs

The DSSAT v3 grain legume models have three files that quantify parameters for each grain legume crop. The earlier genetics file for each crop, e.g., GENETICS.SB9, used for soybean in SOYGRO V5.42 in DSSAT v2.1, was split into two files for DSSAT v3 and additional changes were made. One file is the CULtivar file; for example, SBGRO940.CUL. This file contains fewer genetic coefficients for soybean than SOY-

GRO V5.42. A second file is the ECOtype file; for example, SBGRO940.ECO, which contains coefficients that are thought to change among GROUPS of cultivars, but not for every cultivar. Thus the number of coefficients that have to be estimated for a new cultivar was reduced to 15. Since the coefficients in this file have to estimated for each cultivar that is to be simulated, they are discussed in more detail in Appendix A of this Part. A third file of parameters is the SPEcies file, designated by SPE, for example SBGRO940.SPE. This file is equivalent to the CROPPARM file in the earlier GRO models. In the naming convention for the cultivar file, ecotype file, and species file, the first two characters correspond to a particular species, and the following six characters represent the model used and its version number. For instance, the file, SBGRO940.*, designates the Soybean species, ecotype, and cultivar input files used in the GRO model (CROPGRO) released in 1994.

Both the generic CERES model and the CERES - Rice model use only the cultivar files and do not have either an ecotype file or a species file as input. The change in these models in DSSAT v3 from those of the older models is that the DSSAT v3 genetic files use the same file format as that of the new Input/Output file structures described in Volume 2-1 (Jones et.al 1994) of this book.

PEST EFFECTS (GRAIN LEGUME MODELS ONLY)

A generalized method for incorporating pest damage in the crop models was developed (Batchelor et al., 1993) for DSSAT v3. Twenty-one coupling points were identified in the CROPGRO model, and damage can be simulated by reducing various state and/or rate variables. Damage can also be induced by input or field-observed damage or for field-measured pest populations. Pest and pest damage coefficients are defined in a special pest input file (e.g., for soybean, SBGRO940.PST). These pest coefficients are defined through the coupling points in the crop model and the damage rates associated with a unit of pest input.

Field-observed pest damage or pest densities are input into the time course observed data file (FILET), which may include plant and soil variables, as well as pest damage levels (for example, UFGA8101.SBT). This approach was taken in order to facilitate a common way of handling field data in DSSAT v3. Users can also input hypothetical values of pest levels or pest damage in the time course file (FILEA) for an experiment in order to study damage effects on crop growth and yield. A detailed description of the method for incorporating pest damage into the DSSAT v3 models can be found in Appendix B of this Part.

CHAPTER TEN.
TEMPORARY MODEL INPUT FILE

In Figure 3 some of the crop simulation model interface options are shown. The model driver program distributed with DSSAT v3, i.e. MDRIV940.EXE, calls the model input module, i.e. MINPT940.EXE. The model input module reads the experiment details file FILEX and creates a temporary output file, called "IBSNAT30.INP." The input module has the option to create a temporary output file, using different formats. In Figure 3 three options are shown. Filetype is "I" for the CEGER940.EXE, CRGRO940.EXE, RICER940.EXE and CSSIM940.EXE models. Filetype "X" is also used by the CSSIM940.EXE model and could be used by other crop models if installed in DSSAT v3. A user-defined filetype could also be used for a new crop simulation module to link it to DSSAT v3. However, the input module would have to be modified to add this particular filetype to the system.

Filetype "X" is identical to the current Input/Output file format of FILEX, except that it includes only information for one treatment, rather than an entire experiment. Filetype "I" is similar to the current Input/Output file format of FILEX, except that it contains

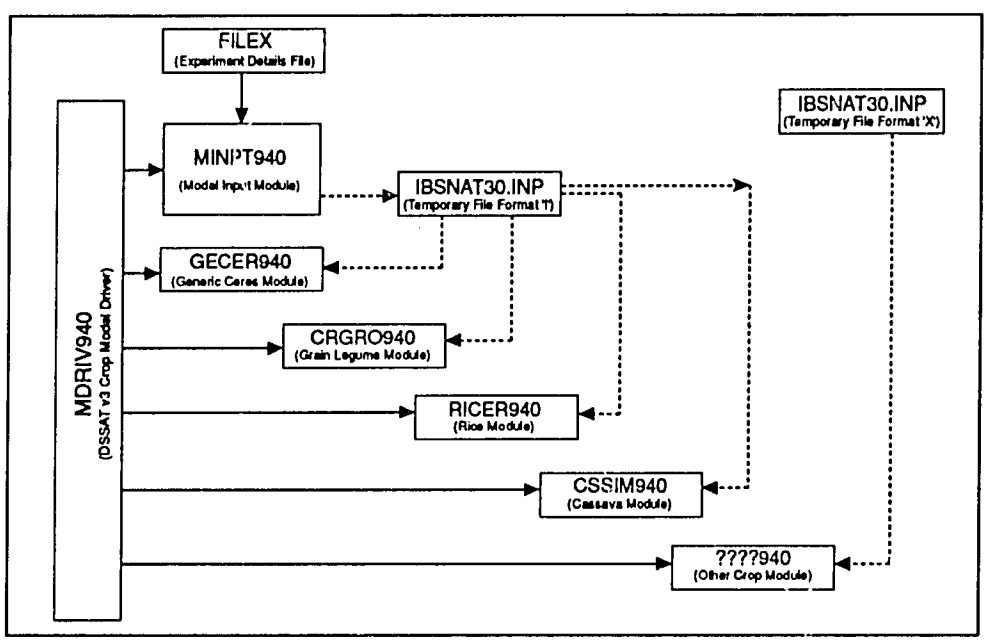


FIGURE 3. RELATIONSHIP BETWEEN THE TEMPORARY MODEL INPUT FILE AND THE VARIOUS CROP SIMULATION MODULES.

additional information with respect to location and names of input files, and all headers, comment lines, and blank lines have been deleted. An example of a typical temporary file is shown in Table 8. This file was generated using the same experimental and treatment selections discussed earlier in Chapter 5, "Running the Crop Model," herein. The example FILEX for this experiment is shown in Table 4.

All information shown in this file is required; if lines or headers are deleted the crop simulation models will not run.

The section "*MODEL INPUT FILE includes the run mode, i.e. interactive etc., run number, experiment number, i.e. entry number in the experiment list file EXP.LST, treatment number, and number of treatments in the selected experiment.

The section "*FILES" includes the name and path for respectively the crop simulation module, FILEX, FILEA, FILET, species file, ecotype file, cultivar file, pest file, soils file, weather file, and output files.

The section "*SIMULATION CONTROL" is identical to the simulation control section of FILEX, except that the headers have been deleted. Note that it also includes the automatic management section.

The section "*EXP.DETAILS" is identical to the experiment details section of FILEX, except for no header information.

The section "*TREATMENTS" only shows information for the actual treatment which is being simulated, while all level information has been deleted.

The sections "*CULTIVARS", "*FIELDS", "*INITIAL CONDITIONS", "*PLANTING DETAILS", "*IRRIGATION", "*FERTILIZERS", "*RESIDUES", "*ENVIRONMENT" and "*HARVEST" all only include the information for the actual treatment level which is simulated. The information for the other levels has been eliminated, and all headers have been deleted. If a particular section does not have any levels, such as "*HARVEST" shown in the example, the actual section header still needs to be included.

The "*SOIL" section includes the detailed soil profile description, including location, names, soil surface and soil layer information for the soil selected under the "*FIELDS" section. A blank line delineates the information for the first and second tier. The format

is the same as the format of the data stored in the actual soil profile file, except for the headers.

The "*CULTIVAR" section includes all the values of the variables for the particular cultivar selected under the "*CULTIVAR" section discussed earlier. The format is the same as the format of the data stored in the actual cultivar file, except for the headers.

The user needs to be aware that the crop simulation modules do not include error checking procedures. If the user decides to modify the format of his temporary file, or creates his own temporary file through different procedures, we can not guarantee that the crop simulation module will work properly.

TABLE 8. EXAMPLE OF A TEMPORARY CROP MODEL INPUT FILE, USING FILE FORMAT = "I" ("IBSNAT30.INP").

```
*MODEL INPUT FILE            I     1     2     1     2
*FILES
MODEL          CRGRO940.EXE
FILEX          UFGA7801.SBX
FILEA          UFGA7801.SBA
FILET          UFGA7801.SBT
SPECIES        SBGRO940.SPE C:\DSSAT3\GENOTYPE\
ECOTYPE        SBGRO940.ECO C:\DSSAT3\GENOTYPE\
CULTIVAR       SBGRO940.CUL C:\DSSAT3\GENOTYPE\
PESTS          SBGRO940.PST C:\DSSAT3\PEST\
SOILS          SOIL.SOL     C:\DSSAT3\SOIL\
WEATHER        UFGA7801.WTH C:\DSSAT3\WEATHER\
OUTPUT         OVERVIEW
*SIMULATION CONTROL
                  1     1     S 78166  2150 BRAGG, IRRIGATED & NON-IR
                  Y     Y     Y     N     N     N
                  M     M     E     R     S     C
                  R     R     N     R     M
                  N     Y     Y     3     Y     Y     Y     Y     N     N     Y
!AUTOMATIC MANAGEM
              78155 78200   40.  100.   30.   40.   10.
                30.   50.  100. GS000 IR001  10.0  .750
                30.   50.   25. FE001 GS000
               100.    1   20.
                  0 78365  100.    0.
*EXP.DETAILS
  2UFGA7801 SB BRAGG, IRRIGATED & NON-IRRIGATED
*TREATMENTS
  11 0 0 IRRIGATED
*CULTIVARS
   SB IB0001 BRAGG (7)
*FIELDS
   UFGA0001 UFGA7801 -99      0. DR000    0.    0. 00000 FSA    180. IBSB910015
*INITIAL CONDITIONS
      SB 78166  100.    0.  1.00  1.00          1
      5.  .086    .6   1.5
     15.  .085    .6   1.5
     30.  .086    .6   1.5
     45.  .086    .6   1.5
     60.  .086    .6   1.5
     90.  .076    .6    .6
    120.  .076    .6    .5
    150.  .130    .6    .5
    180.  .258    .6    .5
*PLANTING DETAILS
   78166   -99  29.9  29.9     S     R   91.    0.   4.0  -99.  -99. -99.0 -99.0
```

```
*IRRIGATION
    .750  -99.  -99.  -99.   -99   -99    .0
   78181 IR001   13.     0
   78230 IR001   13.     0
   78235 IR001   13.     0
   78237 IR001   13.     0
   78240 IR001   11.     0
   78242 IR001   11.     0
   78244 IR001   11.     0
   78246 IR001   11.     0
   78250 IR001   11.     0
   78253 IR001   11.     0
   78256 IR001    8.     0
   78259 IR001    8.     0
   78262 IR001    8.     0
   78265 IR001    8.     0
   78269 IR001    7.     0
   78272 IR001    8.     0
   78279 IR001    7.     0
   78283 IR001    8.     0
   78294 IR001   10.     0
*FERTILIZERS
*RESIDUES
   78166 RE001  1000   .80   .00   .00  100.   15.
*ENVIRONMENT
*HARVEST
*SOIL
 IBSB910015  SCS         FSA    180. Millhopper Fine Sand
 Gainesville USA          29.630 -82.370 Loamy,silic,hyperth Gross. Paleudults ( 15)
.18   5.0   .50   66.  1.00   .84 IB001 IB001 IB001
    5.        .023  .086  .230 1.000   7.4  1.36   .90 -99.0 -99.0 -99.0   .00   5.3 -99.0 -99.0
   15.        .023  .086  .230 1.000   7.4  1.40   .69 -99.0 -99.0 -99.0   .00   5.4 -99.0 -99.0
   30.        .023  .086  .230  .498  15.8  1.46   .28 -99.0 -99.0 -99.0   .00   5.7 -99.0 -99.0
   45.        .023  .086  .230  .294  28.0  1.47   .20 -99.0 -99.0 -99.0   .00   5.8 -99.0 -99.0
   60.        .023  .086  .230  .294  27.6  1.47   .20 -99.0 -99.0 -99.0   .00   5.8 -99.0 -99.0
   90.        .021  .076  .230  .380  17.5  1.43   .09 -99.0 -99.0 -99.0   .00   5.9 -99.0 -99.0
  120.        .020  .076  .230  .133    .3  1.48   .03 -99.0 -99.0 -99.0   .00   5.9 -99.0 -99.0
  150.        .027  .130  .230  .062    .1  1.57   .03 -99.0 -99.0 -99.0   .00   5.9 -99.0 -99.0
  180.        .070  .258  .360  .031    .0  1.79   .03 -99.0 -99.0 -99.0   .00   5.9 -99.0    .0

    5.    .0    .0    .0    .0    .0    .0    .0    .0
   15.    .0    .0    .0    .0    .0    .0    .0    .0
   30.    .0    .0    .0    .0    .0    .0    .0    .0
   45.    .0    .0    .0    .0    .0    .0    .0    .0
   60.    .0    .0    .0    .0    .0    .0    .0    .0
   90.    .0    .0    .0    .0    .0    .0    .0    .0
  120.    .0    .0    .0    .0    .0    .0    .0    .0
  150.    .0    .0    .0    .0    .0    .0    .0    .0
  180.    .0    .0    .0    .0    .0    .0    .0    .0
*CULTIVAR
IB0001 BRAGG (7)        SB0701 12.33  .320 19.50 10.00 15.00 35.50 15.00 1.022 350.0 170.0  1.00  .180
```

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APPENDIX A.
GENETIC COEFFICIENTS

Information on differences among crop genotypes are input to the model through genotype coefficient files. These files include BACER940.CUL for barley, MZCER940.CUL for maize, MLCER940.CUL for millet, SGCER940.CUL for sorghum, WHCER940.CUL for wheat, BNGRO940.CUL for dry bean, PNGRO940.CUL for peanut, SBGRO940.CUL for soybean, RICER940.CUL for rice, and CSSIM940.CUL for cassava. The coefficients stored in these files allow a single crop growth model to predict differences in development, growth and yield among cultivars when planted in the same environment. These genetic coefficients can be divided into those that relate to vegetative and reproductive development, to vegetative growth, and to reproductive growth.

DSSAT v3 contains a program called Generating Genetic Coeffiecients, or GenCalc (see Hunt et al., 1993; and Volume 3-4, Hunt et al.. 1994, of this book), which can be used to estimate the genetic coefficients for each species and new (or old) cultivars. The model user is therefore referred to this document for further detail about estimating these coefficients. Here, only the coefficients required for each species are defined, and an example for each species is given. Cultivar coefficients available for each species in DSSAT v3 are listed in this appendix.

CERES-BARLEY

Table 9 shows an example of the current cultivars defined for barley. Required genetic coefficients include :

VAR#	Identification code or number for a specific cultivar.
VAR-NAME	Name of cultivar.
ECO#	Ecotype code for this cultivar, points to the Ecotype in the ECO file (currently not used).
P1V	Relative amount that development is slowed for each day of unfulfilled vernalization, assuming that 50 days of vernalization is sufficient for all cultivars (0-9).

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P1D	Relative amount that development is slowed when plant are grown in a photoperiod 1 hour shorter that the optimum (which is considered to be 20 hours) (1-5).
P5	Relative grain filling duration based on thermal time (degree days above a base temperature of 1°C), where each unit increase above zero adds 40 degree days to an initial value of 300 degree days..
G1	Kernel number per unit weight of stem (less leaf blades and sheaths) plus spike at anthesis (1/g) (1-5).
G2	Kernel filling rate under optimum conditions (mg/day) (1-5).
G3	Non-stressed dry weight of a single stem (excluding leaf blades and sheaths) and spike when elongation ceases (g) (1-5).
PHINT	Phylochron interval; the interval in thermal time (degree days) between successive leaf tip appearances.

TABLE 9. GENETIC COEFFICIENTS FILE FOR CERES-BARLEY. (BACER940.CUL)

*BARLEY GENOTYPE COEFFICIENTS - GECER940 MODEL

@VAR#	VRNAME	ECO#	P1V	P1D	P5	G1	G2	G3	PHINT
!			1	2	3	4	5	6	7
IB0001	generic (2)	IB0001	.5	4.0	2.0	5.0	3.0	1.0	95.00
IB0002	generic (6)	IB0001	.5	4.0	2.0	5.0	3.0	4.0	95.00
IB0003	Golden Promise (	IB0001	.5	4.0	2.0	5.0	3.0	2.0	95.00
IB0004	Maris Mink (2)	IB0001	.5	3.0	2.0	5.0	3.0	2.0	95.00
IB0005	Aramir	IB0001	.5	3.4	2.0	3.0	3.0	3.0	95.00
IB0006	Georgie (2)	IB0001	.5	3.0	2.0	3.0	4.0	2.0	95.00
IB0007	Julia	IB0001	.5	7.0	5.0	3.5	3.0	2.0	95.00
IB0008	Union (2)	IB0001	.5	3.6	2.0	3.0	3.0	2.0	95.00
IB0009	Tellus	IB0001	.5	3.5	2.0	3.0	3.0	3.0	95.00
IB0010	Mona	IB0001	.5	1.5	2.0	3.0	3.0	3.0	95.00
IB0011	Lise	IB0001	.5	1.5	2.0	3.0	3.0	3.0	95.00
IB0012	Igri (2)	IB0001	6.0	3.0	2.0	2.0	4.0	3.0	95.00
IB0013	Video (2)	IB0001	6.0	3.0	2.0	4.0	5.0	2.5	95.00
IB0014	Maris Otter (2)	IB0001	3.0	4.5	2.0	5.0	3.0	2.0	95.00
IB0015	Proctor (2)	IB0001	.5	4.5	5.0	5.2	1.1	.7	95.00
IB0016	Berolina (2)	IB0001	.5	4.0	4.0	3.0	3.0	2.0	95.00
IB0017	Arena (2)	IB0001	.5	4.5	4.0	3.0	3.0	2.0	95.00
IB0018	Deba Abed	IB0001	.5	3.0	3.0	2.5	3.0	3.0	95.00
IB0019	Philip (6)	IB0001	.5	3.0	1.5	4.0	3.0	4.0	95.00
IB0020	Yokozuna (6)	IB0001	.5	3.0	2.0	3.0	5.0	4.0	95.00
IB0021	Andrea (6)	IB0001	6.0	3.0	3.0	3.0	3.0	4.0	95.00
IB0022	Marinka (2)	IB0001	6.0	3.0	3.0	3.0	3.0	2.0	95.00
IB0023	Catinka (6)	IB0001	6.0	3.0	3.0	3.0	3.0	4.0	95.00
IB0024	Sonate (2)	IB0001	6.0	3.0	3.0	3.0	3.0	2.0	95.00
IB0025	Tapir (6)	IB0001	6.0	3.0	3.0	3.0	3.0	4.0	95.00
IB0026	Franka (6)	IB0001	6.0	3.5	3.0	3.0	3.0	4.0	95.00
IB0027	Mammut (6)	IB0001	6.0	3.0	3.0	3.0	3.0	3.0	95.00
IB0028	Maris Puma	IB0001	6.0	3.0	3.0	3.0	3.0	3.0	95.00
IB0029	Optima (6)	IB0001	6.0	3.0	4.0	3.0	2.5	3.0	95.00
IB0030	Maris Badger	IB0001	.5	7.0	5.0	4.0	5.0	3.0	95.00
IB0040	Shabet	IB0001	3.0	1.0	5.0	4.0	3.0	2.0	95.00
IB0042	Ord Early	IB0001	3.0	3.0	1.0	2.2	3.5	4.0	95.00
IB0043	Ord Mid-Early	IB0001	3.0	3.0	1.0	2.2	3.5	4.0	95.00
IB0044	Ord Mid-Late	IB0001	3.0	3.0	1.0	2.2	3.5	4.0	95.00
IB0045	Ord Late	IB0001	3.0	3.0	1.0	2.2	3.5	4.0	95.00
IB0051	Azure (6)	IB0001	.5	1.0	3.5	4.0	3.0	4.0	95.00
IB0052	Bedford (2)	IB0001	.5	1.0	3.5	5.0	3.0	2.0	95.00
IB0053	Bumper (6)	IB0001	.5	1.0	3.5	4.0	3.0	4.0	95.00
IB0054	Hector (2)	IB0001	.5	1.0	3.5	4.0	3.0	2.0	95.00

IB0055	Larker (6)	IB0001	.5	1.0	3.5	4.0	3.0	4.0	95.00
IB0056	Robust (6)	IB0001	.5	1.0	3.5	4.0	3.0	4.0	95.00
IB0057	Summit (2)	IB0001	.5	1.0	3.5	4.0	3.0	2.0	95.00
IB0058	Bowman (6)	IB0001	.5	1.0	3.5	4.0	3.0	4.0	95.00
IB0059	Hazen (6)	IB0001	.5	1.0	3.5	4.0	3.0	4.0	95.00
IB0101	A. Abiad (2)	IB0001	.5	3.0	4.0	3.5	4.0	2.0	95.00
IB0102	Beecher (6)	IB0001	.5	2.5	4.0	2.2	3.5	4.0	95.00
IB0103	Algerie (2)	IB0001	.5	3.0	3.0	2.0	2.0	2.0	95.00

CERES-MAIZE

Table 10 shows an example of the current cultivars defined for corn. Required genetic coefficients include :

VAR#	Identification code or number for a specific cultivar
VAR-NAME	Name of cultivar
ECO#	Ecotype code for this cultivar, points to the Ecotype in the ECO file (currently not used).
P1	Thermal time from seedling emergence to the end of the juvenile phase (expressed in degree days above a base temperature of 8°C) during which the plant is not responsive to changes in photoperiod.
P2	Extent to which development (expressed as days) is delayed for each hour increase in photoperiod above the longest photoperiod at which development proceeds at a maximum rate (which is considered to be 12.5 hours).
P5	Thermal time from silking to physiological maturity (expressed in degree days above a base temperature of 8°C).
G2	Maximum possible number of kernels per plant.
G3	Kernel filling rate during the linear grain filling stage and under optimum conditions (mg/day).
PHINT	Phylochron interval; the interval in thermal time (degree days) between successive leaf tip appearances.

TABLE 10. GENETIC COEFFICIENTS FILE FOR CERES-MAIZE. (MZCER940.CUL)

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*MAIZE GENOTYPE COEFFICIENTS -- GECER940 MODEL
!
@VAR#  VRNAME            ECO#     P1    P2    P5    G2    G3 PHINT
!                                  1     2     3     4     5     6
IB0001 CORNL281         IB0001 110.0 0.300 685.0 825.4  6.60 75.00
IB0002 CP170            IB0001 120.0 0.000 685.0 825.4 10.00 75.00
IB0003 LG11             IB0001 125.0 0.000 685.0 825.4 10.00 75.00
IB0004 F7 X F2          IB0001 125.0 0.000 685.0 825.4 10.00 75.00
IB0005 PIO 3995         IB0001 130.0 0.300 685.0 825.4  8.60 75.00
IB0006 INRA             IB0001 135.0 0.000 685.0 825.4 10.00 75.00
IB0007 EDO              IB0001 135.0 0.300 685.0 825.4 10.40 75.00
IB0008 A654 X F2        IB0001 135.0 0.000 685.0 825.4 10.00 75.00
IB0009 DEKALB XL71      IB0001 140.0 0.300 685.0 825.4 10.50 75.00
IB0010 F478 X W705A     IB0001 140.0 0.000 685.0 825.4 10.00 75.00
IB0011 DEKALBXL45       IB0001 150.0 0.400 685.0 825.4 10.15 75.00
IB0012 PIO 3382         IB0001 160.0 0.700 890.0 750.0  8.50 75.00
IB0013 B59*OH43         IB0001 162.0 0.800 685.0 784.0  6.90 75.00
IB0014 F16 X F19        IB0001 165.0 0.000 685.0 825.4 10.00 75.00
IB0015 WASHINGTON       IB0001 165.0 0.400 715.0 750.0 11.00 75.00
IB0016 B14XOH43         IB0001 172.0 0.300 685.0 825.4  8.50 75.00
IB0017 R1*(N32*B14)     IB0001 172.0 0.800 685.0 825.4 10.15 75.00
IB0018 B60*R71          IB0001 172.0 0.800 685.0 710.4  7.70 75.00
IB0019 WF9*B37          IB0001 172.0 0.800 685.0 825.4 10.15 75.00
IB0020 B59*C103         IB0001 172.0 0.800 685.0 825.4 10.15 75.00
IB0021 Garst 8702       IB0001 175.0 0.200 960.0 778.0  6.00 75.00
IB0022 B14*C103         IB0001 180.0 0.500 685.0 825.4 10.15 75.00
IB0023 B14*C131A        IB0001 180.0 0.500 685.0 825.4 10.15 75.00
IB0024 PIO 3720         IB0001 180.0 0.800 685.0 825.4 10.00 75.00
IB0025 WASH/GRAIN-1     IB0001 185.0 0.400 775.0 760.0 12.00 75.00
IB0026 A632 X W117      IB0001 187.0 0.000 685.0 825.4 10.00 75.00
IB0027 Garst 8750       IB0001 190.0 0.200 930.0 810.0  6.30 75.00
IB0028 TAINAN-11        IB0001 200.0 0.800 670.0 730.0  6.80 75.00
IB0029 PIO 3541         IB0001 200.0 0.300 800.0 700.0  8.50 75.00
IB0030 PIO 3707         IB0001 200.0 0.700 800.0 590.0  6.30 75.00
IB0031 PIO 3475         IB0001 200.0 0.700 800.0 725.0  8.60 75.00
IB0032 PIO 3382         IB0001 200.0 0.700 800.0 650.0  8.50 75.00
IB0033 PIO 3780         IB0001 200.0 0.760 685.0 600.0  9.60 75.00
IB0034 PIO 3780*        IB0001 200.0 0.760 685.0 725.0  9.60 75.00
IB0035 McCurdy 84aa     IB0001 200.0 0.300 940.0 700.0  8.00 75.00
IB0036 C281             IB0001 202.0 0.300 685.0 825.4  5.80 75.00
IB0037 SWEET CORN       IB0001 210.0 0.520 625.0 825.0 10.00 75.00
IB0038 Garst 8555       IB0001 215.0 0.400 890.0 800.0  9.00 75.00
IB0039 PIO 3901         IB0001 215.0 0.760 600.0 560.0  9.00 75.00
IB0040 B8*153R          IB0001 218.0 0.300 760.0 575.0  8.80 75.00
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IB0041	Garst 8808	IB0001	220.0	0.400	780.0	780.0	8.50	75.00
IB0042	B73 X MO17	IB0001	220.0	0.520	880.0	730.0	10.00	75.00
IB0043	PIO 511A	IB0001	220.0	0.300	685.0	645.0	10.50	75.00
IB0044	W69A X F546	IB0001	240.0	0.300	685.0	825.4	10.00	75.00
IB0045	A632 X VA26	IB0001	240.0	0.300	685.0	825.4	10.00	75.00
IB0046	W64A X W117	IB0001	245.0	0.000	685.0	825.4	8.00	75.00
IB0047	PIO 3147	IB0001	255.0	0.760	685.0	834.0	10.00	75.00
IB0048	WF9*B37	IB0001	260.0	0.800	710.0	825.4	6.50	75.00
IB0049	NEB 611	IB0001	260.0	0.300	720.0	825.0	9.00	75.00
IB0050	PV82S	IB0001	260.0	0.500	750.0	600.0	8.50	75.00
IB0051	PV76S	IB0001	260.0	0.500	750.0	600.0	8.50	75.00
IB0052	PIO 3183	IB0001	260.0	0.500	750.0	600.0	8.50	75.00
IB0053	CESDA-28	IB0001	260.0	0.500	669.0	780.0	7.10	75.00
IB0054	B14*OH43	IB0001	265.0	0.800	665.0	780.0	6.90	75.00
IB0055	MCCURDY 6714	IB0001	265.0	0.300	825.0	825.4	9.80	75.00
IB0056	FM 6	IB0001	276.0	0.520	867.0	616.0	10.70	75.00
IB0057	TOCORON-3	IB0001	276.0	0.520	867.0	600.0	8.12	75.00
IB0058	NC+59	IB0001	280.0	0.300	750.0	825.0	10.00	75.00
IB0059	H6	IB0001	310.0	0.300	685.0	825.4	10.00	75.00
IB0060	H610(UH)	IB0001	300.0	0.520	920.0	580.0	6.40	75.00
IB0061	PB 8	IB0001	300.0	0.520	990.0	400.0	7.00	75.00
IB0062	B56*C131A	IB0001	318.0	0.500	700.0	805.0	6.40	75.00
IB0063	PIO X 304C	IB0001	320.0	0.520	940.0	625.0	6.00	75.00
IB0064	H.OBREGON	IB0001	360.0	0.800	685.0	825.4	10.15	75.00
IB0065	SUWAN-1	IB0001	380.0	0.600	780.0	750.0	7.00	75.00

CERES-MILLET

Table 11 shows an example of the current cultivars defined for millet. Required genetic coefficients include :

VAR#	Identification code xor number for a specific cultivar
VAR-NAME	Name of cultivar
ECO#	Ecotype code for this cultivar, points to the Ecotype in the ECO file (currently not used).
P1	Thermal time from seedling emergence to the end of the juvenile phase (expressed in degree days above a base temperature of 10°C) during which the plant is not responsive to changes in photoperiod.
P2O	Critical photoperiod or the longest day length (in hours) at which development occurs at a maximum rate. At values greater than P2O, the rate of development is reduced.
P2R	Extent to which phasic development leading to panicle initiation (expressed in degree days) is delayed for each hour increase in photoperiod above P2O.
P5	Thermal time (degree days above a base temperature of 10°C) from beginning of grain filling (3-4 days after flowering) to physiological maturity.
G1	Scaler for relative leaf size.
G4	Scaler for partitioning of assimilates to the panicle (head).
PHINT	Phylochron interval; the interval in thermal time (degree days) between successive leaf tip appearances.

TABLE 11. GENETIC COEFFICIENTS FILE FOR CERES-MILLET. (MLCER940.CUL)

```
*MILLET GENOTYPE COEFFICIENTS - GECER940 MODEL
!
!
@VAR#  VRNAME              ECO#     P1    P20    P2R     P5     G1     G4  PHINT
!                                    1      2      3      4      5      6      7
IB0033 BJ104               IB0001 120.0 13.40 145.0 340.0   1.50   1.00  95.00
IB0034 CZH-859             IB0001 170.0 12.10 138.0 420.0   2.13   0.50  95.0
IB0035 CZP-87              IB0001 136.0 12.40 130.0 370.0   2.10   0.50  95.00
IB0036 CZMP-2              IB0001 135.0 12.60 140.0 370.0   2.00   0.50  95.00
IB0037 MBH-110             IB0001 140.0 12.50 148.0 365.0   2.12   0.50  95.00
IB0038 RCB-2               IB0001 136.0 12.10 135.0 365.0   2.14   0.50  95.00
IB0039 CZP-78              IB0001 136.0 12.10 125.0 362.0   2.00   0.50  95.00
IB0040 CZP-85              IB0001 142.0 12.30 130.0 380.0   2.15   0.50  95.00
IB0041 WCC-75              IB0001 160.0 12.00 142.0 422.0   2.10   0.50  95.00
IB0042 CZP-84              IB0001 138.0 12.20 128.0 360.0   2.30   0.50  95.00
IB0043 CZH-83-J1           IB0001 136.0 12.60 130.0 350.0   2.30   0.50  95.00
IB0044 CIVT                IB0001 120.0 12.00 142.0 590.0   1.00   0.50  95.00
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CERES-SORGHUM

Table 12 shows an example of the current cultivars defined for sorghum. Required genetic coefficients include :

VAR#	Identification code or number for a specific cultivar.
VAR-NAME	Name of cultivar.
ECO#	Ecotype code for this cultivar, points to the Ecotype in the ECO file (currently not used).
P1	Thermal time from seedling emergence to the end of the juvenile phase(expressed in degree days above a base temperature of 8°C) during which the plant is not responsive to changes in photoperiod.
P2O	Critical photoperiod or the longest day length (in hours) at which development occurs at a maximum rate. At values higher than P2O, the rate of development is reduced.
P2R	Extent to which phasic development leading to panicle initiation (expressed in degree days) is delayed for each hour increase in photoperiod above P2O.
P5	Thermal time (degree days above a base temperature of 8°C) from beginning of grain filling (3-4 days after flowering) to physiological maturity.
G1	Scaler for relative leaf size.
G2	Scaler for partitioning of assimilates to the panicle (head).
PHINT	Phylochron interval; the interval in thermal time (degree days) between successive leaf tip appearances.

TABLE 12. GENETIC COEFFICIENTS FILE FOR CERES-SORGHUM. (SGCER940.CUL)

*SORGHUM GENOTYPE COEFFICIENTS - GECER940 MODEL
!

@VAR#	VRNAME	ECO#	P1	P2O	P2R	P5	G1	G2	PHINT
!			1	2	3	4	5	6	7
IB0001	RIO	IB0001	430.0	11.60	24.0	540.0	.0	6.0	49.00
IB0002	9188	IB0001	393.0	13.00	23.0	540.0	.0	6.0	49.00
IB0003	BRANDES	IB0001	374.0	11.00	116.0	540.0	.0	6.0	49.00
IB0004	MN1500	IB0001	495.0	11.80	139.0	540.0	.0	6.0	49.00
IB0005	HEGARI	IB0001	273.0	11.50	136.0	540.0	.0	6.0	49.00
IB0006	100M	IB0001	291.0	11.00	127.0	540.0	.0	6.0	49.00
IB0007	80M	IB0001	337.0	12.60	262.0	540.0	.0	6.0	49.00
IB0008	60M	IB0001	337.0	12.80	290.0	540.0	.0	6.0	49.00
IB0009	SM100	IB0001	365.0	13.00	45.0	540.0	.0	6.0	49.00
IB0010	SM80	IB0001	356.0	12.00	74.0	540.0	.0	6.0	49.00
IB0011	SM60	IB0001	365.0	12.20	74.0	540.0	.0	6.0	49.00
IB0012	REDLON	IB0001	393.0	12.50	30.0	540.0	.0	6.0	49.00
IB0013	CAPROCK	IB0001	393.0	12.80	84.0	540.0	.0	6.0	49.00
IB0014	ATx378XRTx7000	IB0001	384.0	11.30	24.0	540.0	.0	6.0	49.00
IB0015	ATx623	IB0001	380.0	13.00	35.0	540.0	.0	6.0	49.00
IB0016	RTx430	IB0001	400.0	13.00	123.0	540.0	.0	6.0	49.00
IB0017	ATx623XRTx430	IB0001	390.0	13.00	35.0	540.0	.0	6.0	49.00
IB0018	BTx3197	IB0001	411.0	13.00	108.0	540.0	.0	6.0	49.00
IB0019	RTx7078	IB0001	421.0	14.40	221.0	540.0	.0	6.0	49.00
IB0020	TX 610	IB0001	180.0	16.50	1.0	580.0	22.0	6.0	49.00
IB0021	WHEATLAND	IB0001	365.0	12.50	30.0	540.0	.0	6.0	49.00
IB0022	ATx399XRTx430	IB0001	393.0	12.80	40.0	540.0	.0	6.0	49.00
IB0023	ATx378XRTx430	IB0001	411.0	12.50	20.0	540.0	.0	6.0	49.00
IB0024	ATx623XRTx7000	IB0001	374.0	13.00	14.0	540.0	.0	6.0	49.00
IB0025	38M	IB0001	291.0	13.00	12.0	540.0	.0	6.0	49.00
IB0026	CSH-1	IB0001	410.0	13.60	40.0	540.0	3.0	5.5	49.00
IB0027	DE KALB 46	IB0001	325.0	15.50	30.0	540.0	9.0	6.0	49.00
IB0028	PIONEER 8333	IB0001	325.0	15.50	30.0	540.0	11.0	6.0	49.00
IB0029	DK	IB0001	200.0	15.50	12.0	540.0	.0	6.0	49.00
IB0030	PIONEER 8515	IB0001	275.0	15.50	30.0	500.0	.0	6.0	49.00
IB0031	RS 626	IB0001	300.0	15.50	30.0	400.0	.0	6.0	49.00
IB0032	DK- E57	IB0001	325.0	15.50	30.0	450.0	13.0	6.0	49.00
IB0040	RS610	IB0001	460.0	12.50	90.0	600.0	5.0	6.0	49.00
IB0041	NK212	IB0001	420.0	15.50	30.0	500.0	13.0	6.0	49.00
IB0042	PIONEER 846	IB0001	480.0	12.50	190.0	650.0	5.0	5.0	49.00
IB0043	CSH-6	IB0001	410.0	13.60	40.0	510.0	7.0	4.5	49.00
IB0044	CSH-6	IB0001	320.0	13.50	180.0	540.0	7.0	5.5	49.00
IB0046	M-35-1	IB0001	320.0	14.00	45.6	556.0	15.0	4.5	49.00
IB0047	SPV-504	IB0001	310.0	13.00	35.0	554.0	15.0	4.5	49.00
IB0048	CSH-5	IB0001	255.0	13.50	40.5	490.0	10.0	5.5	49.00
IB0049	CSH-9	IB0001	225.0	13.50	45.1	573.0	10.0	5.5	49.00
IB0050	SPH-388	IB0001	232.0	12.50	43.7	590.0	10.0	4.5	49.00

CERES-WHEAT

Table 13 shows an example of the current cultivars defined for wheat. Required genetic coefficients include :

VAR#	Identification code or number for a specific cultivar.
VAR-NAME	Name of cultivar.
ECO#	Ecotype code for this cultivar, points to the Ecotype in the ECO file (currently not used).
P1V	Relative amount that development is slowed for each day of unfulfilled vernalization, assuming that 50 days of vernalization is sufficient for all cultivars.
P1D	Relative amount that development is slowed when plants are grown in a photoperiod 1 hour shorter than the optimum (which is considered to be 20 hours).
P5	Relative grain filling duration based on thermal time (degree days above a base temperature of 1°C), where each unit increase above zero adds 20 degree days to an initial value of 430 degree days.
G1	Kernel number per unit weight of stem (less leaf blades and sheaths) plus spike at anthesis (1/g).
G2	Kernel filling rate under optimum conditions (md/dy).
G3	Non-stressed dry weight of a single stem (excluding leaf blades and sheaths) and spike when elongation ceases (g).
PHINT	Phylochron interval; the interval in thermal time (degree days) between successive leaf tip appearances.

TABLE 13. GENETIC COEFFICIENTS FILE FOR CERES-WHEAT. (WHCER940.CUL)

*WHEAT GENOTYPE COEFFICIENTS - GECER940 MODEL
!

@VAR#	VRNAME	ECO#	P1V	P1D	P5	G1	G2	G3	PHINT
!			1	2	3	4	5	6	7
IB0001	CONDO (DURUM)	IB0001	.5	1.5	2.0	5.3	1.9	1.9	95.00
IB0002	WARED	IB0001	.5	2.7	2.0	5.0	1.8	1.9	95.00
IB0003	WALDRON	IB0001	.5	2.7	2.0	5.0	1.7	1.9	95.00
IB0004	ELLAR	IB0001	.5	2.7	2.0	4.7	1.8	1.9	95.00
IB0005	BUTTE	IB0001	.5	2.7	2.0	2.8	2.4	1.9	95.00
IB0006	WARD (DURUM)	IB0001	.5	1.5	2.0	3.6	1.6	1.9	95.00
IB0030	RONGOTEA	IB0001	.5	2.7	2.0	1.6	3.9	1.7	95.00
IB0031	KOPARA	IB0001	.5	2.7	2.0	1.6	3.9	1.7	95.00
IB0032	BOUNTY	IB0001	6.0	3.7	2.1	3.2	2.5	1.7	95.00
IB0033	MOULIN	IB0001	6.0	3.9	2.1	3.8	2.1	1.8	95.00
IB0034	AVALON	IB0001	6.0	4.0	2.0	3.0	2.7	1.7	95.00
IB0178	CENTURK	IB0001	6.0	2.5	2.0	4.3	1.7	1.2	95.00
IB0221	HERON	IB0001	.5	2.3	2.0	2.0	2.0	4.0	95.00
IB0222	SHERPA	IB0001	.5	3.1	1.0	3.5	2.5	5.0	95.00
IB0223	GABO	IB0001	.5	3.1	2.5	1.8	3.0	5.0	95.00
IB0224	BENCUBBIN	IB0001	.5	4.5	2.5	1.2	3.0	4.9	95.00
IB0326	GAMENYA	IB0001	.5	3.3	6.0	4.6	2.7	4.9	95.00
IB0333	SST	IB0001	3.0	3.0	4.0	4.4	4.9	1.7	95.00
IB0368	TRIUMPH	IB0001	6.0	1.9	2.0	2.8	1.6	1.9	95.00
IB0411	CARIBO	IB0001	6.0	4.4	2.0	4.0	3.1	2.6	95.00
IB0446	IMPROVED TRIUMPH	IB0001	6.0	1.3	2.0	2.8	4.1	1.9	95.00
IB0459	LANCER	IB0001	6.0	1.7	2.0	2.8	1.6	1.9	95.00
IB0460	LEEDS	IB0001	6.0	2.7	2.0	2.8	1.6	1.9	95.00
IB0469	STURDY	IB0001	6.0	1.0	2.0	3.9	2.3	1.5	95.00
IB0470	NOR.KING #812	IB0001	6.0	1.0	2.0	3.9	2.3	1.9	95.00
IB0487	SCOUT 66	IB0001	6.0	2.4	2.0	3.8	2.4	1.3	95.00
IB0488	NEWTON	IB0001	6.0	2.5	3.5	3.4	2.6	1.4	95.00
IB0489	NEWANA	IB0001	.5	4.5	3.0	4.8	3.3	1.7	95.00
IB0494	GAGE	IB0001	6.0	2.2	2.0	2.8	1.6	1.9	95.00
IB0495	KOLIBRI	IB0001	.5	3.3	2.5	4.0	3.1	2.1	95.00
IB0496	KLEIBER	IB0001	.5	3.0	3.0	3.6	3.1	2.1	95.00
IB0500	TAM 105	IB0001	6.0	3.3	2.5	2.8	3.0	1.8	95.00
IB0501	IMIA 66	IB0001	6.0	2.7	2.0	2.8	1.6	1.9	95.00
IB0510	PAHA	IB0001	6.0	2.7	2.0	2.8	1.6	1.9	95.00
IB0515	ROLETTE	IB0001	6.0	2.7	2.0	2.8	1.6	1.9	95.00
IB0519	WANSER	IB0001	6.0	2.7	2.0	3.0	3.1	1.9	95.00
IB0536	COULEE	IB0001	6.0	2.7	2.0	2.8	1.6	1.9	95.00
IB0541	TAM W 101	IB0001	3.0	3.0	2.5	4.1	3.0	1.8	95.00
IB0542	NUGAINES	IB0001	6.0	2.7	3.0	5.5	3.6	2.3	95.00
IB0543	PAWNEE	IB0001	6.0	2.6	2.0	2.8	1.6	1.9	95.00
IB0547	CLOUD	IB0001	6.0	2.0	2.0	2.8	1.6	1.9	95.00

IB0548	TRISON	IB0001	6.0	2.7	2.0	2.8	1.6	1.9	95.00
IB0551	ARTHUR	IB0001	6.0	2.7	2.0	4.2	2.1	1.9	95.00
IB0552	TITAN	IB0001	3.0	2.0	4.5	4.3	3.1	1.9	95.00
IB0553	FRANKENMUTH	IB0001	6.0	2.7	2.0	3.8	1.6	1.9	95.00
IB0555	ISRAEL SW	IB0001	.5	3.0	4.5	2.9	4.7	2.6	95.00
IB0563	EAGLE	IB0001	6.0	3.5	2.0	3.2	3.0	1.9	95.00
IB0599	VONA	IB0001	6.0	3.1	2.5	3.9	1.6	1.7	95.00
IB0610	SAGE	IB0001	6.0	2.7	2.0	2.8	1.6	1.9	95.00
IB0700	BEZOSTAYA	IB0001	6.0	2.9	5.0	4.3	3.1	1.9	95.00
IB0701	MIRONOVSKAYA	IB0001	6.0	2.9	5.0	4.8	3.1	1.9	95.00
IB0702	ROUGHRIDER	IB0001	6.0	2.9	5.0	4.8	3.1	1.9	95.00
IB0777	ESTANZ. DORADO	IB0001	1.0	4.0	2.0	3.0	3.0	3.0	95.00
IB1001	ATLE	IB0001	6.0	2.7	2.0	1.3	1.6	1.9	95.00
IB1002	CAPELLE DESPREZ	IB0001	6.0	4.2	2.0	1.7	2.9	3.7	95.00
IB1003	JUFY 2	IB0001	6.0	2.7	2.0	2.8	1.6	1.9	95.00
IB1004	LELY	IB0001	6.0	3.5	2.0	4.8	2.8	4.4	95.00
IB1005	DONATA	IB0001	6.0	3.5	2.0	4.4	3.0	1.7	95.00
IB1006	MARIS HOBBIT	IB0001	6.0	2.7	2.0	3.6	3.1	3.6	95.00
IB1007	MARIS HUNTSMAN2	IB0001	6.0	2.9	2.0	3.9	3.9	2.2	95.00
IB1008	TALENT	IB0001	6.0	3.3	3.5	3.5	3.8	1.9	95.00
IB1009	HYSLOP	IB0001	6.0	2.7	2.0	3.0	1.6	1.9	95.00
IB1010	LUKE	IB0001	6.0	2.7	2.0	2.8	1.3	1.9	95.00
IB1011	ARMINDA	IB0001	6.0	2.7	2.0	4.3	4.6	1.9	95.00
IB1012	CAPITOLE	IB0001	6.0	3.2	2.5	3.1	3.6	1.0	95.00
IB1013	TOP	IB0001	6.0	3.5	3.5	3.2	3.3	1.9	95.00
IB1014	COURTOT	IB0001	6.0	3.3	2.5	3.4	3.1	1.0	95.00
IB1015	MARIS FUNDEN	IB0001	6.0	3.5	4.0	2.8	2.7	1.9	95.00
IB1015	STEPHENS	IB0001	6.0	3.3	2.5	3.5	6.8	2.7	95.00
IB1016	YAMHILL	IB0001	6.0	3.3	2.5	3.9	5.5	2.8	95.00
IB1017	MARIS HUNTSMAN	IB0001	6.0	3.5	4.0	3.9	3.0	2.2	95.00
IB1018	HD2160(INDIA)	IB0001	.5	3.3	2.5	4.0	2.9	2.4	95.00
IB1019	FARO	IB0001	6.0	3.3	2.5	4.3	4.9	2.6	95.00
IB1020	NIMBUS	IB0001	6.0	3.3	2.5	4.6	4.0	2.1	95.00
IB1021	SCHIROKKO	IB0001	.5	3.3	2.5	4.7	3.4	2.0	95.00
IB1022	ARKAS	IB0001	.5	3.3	2.5	4.0	3.1	2.1	95.00
IB1023	TURBO	IB0001	.5	3.3	2.5	4.8	3.3	2.1	95.00
IB1024	MARIS MARDLER	IB0001	6.0	3.3	2.5	4.8	3.3	2.1	95.00
IB1025	STARKEII	IB0001	6.0	3.3	1.0	4.0	2.4	2.1	95.00
IB1500	MANITOU	IB0001	.5	3.2	.0	4.9	1.8	1.7	95.00
IB1907	MEXIPAK	IB0001	.5	3.0	2.0	2.9	3.0	1.7	95.00
IB1908	SONALIKA	IB0001	.5	1.8	3.5	4.0	1.9	1.7	95.00
IB1909	NOVI SAD	IB0001	.5	3.5	2.0	4.0	1.3	1.7	95.00
IB2001	ANZA	IB0001	.5	3.4	2.0	3.5	2.7	4.4	95.00
IB2004	COKER 6815	IB0001	6.0	1.0	2.0	4.1	3.1	1.9	95.00
IB2006	NADADORES	IB0001	.5	2.7	2.0	2.8	1.6	1.9	95.00
IB2008	PENJAMO	IB0001	.5	2.7	2.0	2.8	1.6	1.9	95.00
IB2011	PLAINSMAN	IB0001	6.0	2.7	2.0	2.8	1.6	1.9	95.00

IB2012	PRODURA	IB0001	.5	3.1	2.5	3.3	3.3	5.3	95.00
IB2013	TAMU	IB0001	6.0	2.7	2.0	2.8	1.6	1.9	95.00
IB2014	WALDRON	IB0001	.5	1.5	2.0	2.8	1.6	1.9	95.00
IB2123	EGRET	IB0001	.5	3.0	2.0	2.6	3.3	2.7	95.00
IB2124	WW33G	IB0001	.5	3.0	2.0	3.7	1.8	2.4	95.00
IB4000	SQUAREHD MASTER	IB0001	6.0	4.7	2.0	1.1	2.2	1.9	95.00
IB4001	JUFY1	IB0001	.5	3.0	2.0	1.8	2.5	3.9	95.00
IB9800	FREDERICK	IB0001	6.0	2.7	2.0	3.8	1.6	1.9	95.00

CROPGRO-DRY BEAN

Table 14 shows an example of the current cultivars defined for dry bean. Required genetic coefficients include :

VARTY — Also VAR#; the identification code or number for a specific cultivar.

VRNAME — Name of cultivar.

ECONO — Also ECO#; the ecotype code for this cultivar, points to the Ecotype in the ECO (BNGRO940.ECO) file.

CSDVAR — Also CSDL; critical daylength below which reproductive development proceeds unaffected by daylength, and above which development rate is reduced in proportion to hours above CSDVAR (h).

PPSEN — Slope of relative rate of development for daylengths above CSDVAR, or sensitivity to photoperiod (1/h).

PH2T5 — Also EM-FL; the time from end of juvenile phase to first flower in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).

PHTHRS(6) — Also FL-SH; the time from first flower to first pod greater than 0.5 cm in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).

PHTHRS(8) — Also FL-SD the time from first flower to first seed in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).

PHTHRS(10) — Also SD-PM the time from first seed to physiological maturity in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).

PHTHRS(13) — Also FL-LF the time from first flower to end of leaf growth in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).

LFMAX	Maximum leaf photosynthesis rate at saturated light level, optimal temperature (micromol (CO_2 /m^2s))
SLAVAR	Specific leaf area (SLA) for new leaves during peak vegetative growth for cultivar I, modified by environmental factors (cm^2/g).
SIZLF	Maximum size of fully expanded leaf on the plant under standard growing conditions (3 leaflets), cm^2
XFRUIT	Maximum fraction of daily available gross photosynthesis (PG) which is allowed to go to seeds plus shells for cultivar I, varies from 0 - 1.
WTPSD	Maximum weight per seed under non-limiting substrate (g).
SFDUR	Seed filling duration for a cohort of seed (photothermal days).
SDPDVR	Also SDPDV; average seed per pod under stnadard growing conditions.
PODUR	Photothermal days for cultivar to add full pod load under optimal conditions, used to compute rate of pod and flower addition.

TABLE 14. GENETIC COEFFICIENTS FILE FOR CROPGRO-DRY BEAN. (BNGRO940.CUL)

*DRYBEAN GENOTYPE COEFFICIENTS - CRGRO94 MODEL

@VAR#	VRNAME	ECO#	CSDL	PPSEN	EM-FL	FL-SH	FL-SD	SD-PM	FL-LF	LFMAX	SLAVR	SIZLF	XFRT	WTPSD	SFDUR	SDPDV	PODUR
!			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
990006	MesoAm Hab 2 & 3	MESIND	12.17	0.000	32.0	2.0	9.0	24.00	18.00	1.00	320.	133.0	1.00	0.230	14.0	5.20	8.0
990001	Andean Habit 1	ANDDET	12.17	0.050	24.5	2.0	11.0	25.50	16.00	1.00	295.	133.0	1.00	0.550	11.0	3.50	3.5
990002	Andean Habit 2	ANDIND	12.17	0.05	26.0	4.0	11.0	26.50	18.00	1.00	350.	133.0	1.00	0.600	11.0	3.50	3.5
990003	Andean Habit 3	ANDIND	12.17	0.050	30.0	4.5	9.5	28.00	22.00	1.00	350.	133.0	1.00	0.650	20.0	4.20	5.0
990004	Andean Habit 4	ANDIND	12.17	0.050	34.0	5.0	9.0	34.00	34.00	1.00	350.	133.0	1.00	0.650	22.0	5.20	6.0
990005	Meso Amer. Hab.1	MESDET	12.17	0.000	27.0	4.0	9.0	22.00	16.00	1.00	350.	133.0	1.00	0.230	16.0	5.20	5.0
990007	Mex Highland H 3	MEXHIL	12.17	0.050	27.0	4.0	8.0	26.00	20.00	1.00	350.	133.0	1.00	0.440	17.0	3.20	5.0
IB0001	Porillo Sintet	MESIND	13.17	0.008	32.0	2.0	9.0	23.00	18.00	1.00	320.	133.0	1.00	0.210	15.0	5.20	10.0
IB0002	BAT 477+	MESIND	12.17	0.000	32.0	2.0	9.0	24.00	18.00	1.00	320.	133.0	1.00	0.230	14.0	5.20	8.0
IB0003	Seafarer	MESDET	12.17	0.000	25.0	5.0	09.0	23.00	22.00	1.00	350.	133.0	1.00	0.180	17.0	5.00	8.0
IB0004	C-20	MESIND	12.17	0.000	32.0	5.0	09.0	24.00	22.00	1.00	350.	133.0	1.00	0.170	17.0	5.00	8.0
IB0005	FAT 881	MESIND	12.17	0.000	33.0	2.0	9.0	24.00	18.00	1.00	300.	133.0	1.00	0.230	14.0	5.20	8.0
IB0006	ICTA-Ostua	MESIND	12.17	0.000	27.0	3.0	8.0	23.00	22.00	1.00	295.	133.0	1.00	0.200	17.0	5.40	5.0
IB0007	Rabia de Gato	MESIND	12.17	0.040	24.0	3.0	8.0	21.00	22.00	1.00	295.	133.0	1.00	0.180	17.0	5.40	5.0
IB0008	TURBO-III	MESIND	12.17	0.050	30.0	4.0	9.0	23.00	22.00	1.00	295.	133.0	1.00	0.180	17.0	4.00	5.0
IB0010	Carioca (G4017)	MESIND	12.17	0.000	33.5	3.0	11.0	24.00	18.00	0.90	270.	133.0	1.00	0.250	15.0	5.00	6.5
IB0011	Isabella	ANDDET	12.17	0.000	25.0	3.0	8.0	20.00	9.00	1.00	295.	133.0	1.00	0.290	15.0	3.50	10.0
IB0012	Manitou	ANDDET	12.17	0.000	28.0	3.0	8.0	23.00	9.00	1.00	295.	133.0	1.00	0.550	15.0	3.50	10.0
IB0013	Redkloud	ANDDET	12.17	0.000	24.5	2.0	11.0	25.50	7.00	1.00	305.	133.0	1.00	0.550	11.0	3.50	3.5
IB0014	Canadian Wonder	ANDDET	12.17	0.000	24.5	2.0	11.0	25.50	7.00	1.00	295.	133.0	1.00	0.550	11.0	3.50	3.5

CROPGRO-PEANUT

Table 15 shows an example of the current cultivars defined for peanut. Required genetic coefficients include :

VARTY — Also VAR#; the identification code or number for a specific cultivar.

VRNAME — Name of cultivar.

ECONO — Also ECO#; the ecotype code for this cultivar, points to the Ecotype in the ECO (PNGRO940.ECO) file.

CSDVAR — Also CSDL; critical daylength below which reproductive development proceeds unaffected by daylength, and above which development rate is reduced in proportion to hours above CSDVAR (h).

PPSEN — Slope of relative rate of development for daylengths above CSDVAR, or sensitivity to photoperiod (1/h).

PH2T5 — Also EM-FL; the time from end of juvenile phase to first flower in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).

PHTHRS(6) — Also FL-SH; the time from first flower to first peg, in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).

PHTHRS(8) — Also FL-SD the time from first flower to first seed in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).

PHTHRS(10) — Also SD-PM the time from first seed to physiological maturity in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).

PHTHRS(13) — Also FL-LF the time from first flower to end of leaf growth in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).

LFMAX	Maximum leaf photosynthesis rate at saturated light level, optimal temperature (micromol (CO_2 /m^2s))
SLAVAR	Specific leaf area (SLA) for new leaves during peak vegetative growth for cultivar I, modi-fied by environmental factors (cm^2/g).
SIZLF	Maximum size of fully expanded leaf on the plant under standard growing conditions (3 leaflets), cm^2
XFRUIT	Maximum fraction of daily available gross photosynthesis (PG) which is allowed to go to seeds plus shells for cultivar I, varies from 0 - 1.
WTPSD	Maximum weight per seed under non-limiting substrate (g).
SFDUR	Seed filling duration for a cohort of seed (photothermal days).
SDPDVR	Also SDPDV; average seed per pod under stnadard growing conditions.
PODUR	Photothermal days for cultivar to add full pod load under optimal conditions, used to compute rate of pod and flower addition.

TABLE 15. GENETIC COEFFICIENTS FILE FOR CROPGRO-PEANUT. (PNGR094.CUL)

*PEANUT GENOTYPE COEFFICIENTS - CRGRO940 MODEL

@VAR#	VRNAME	ECO#	CSDL	PPSEN	EM-FL	FL-PG	FL-SD	SD-PM	FL-LF	LFMAX	SLAVR	SIZLF	XFRT	WTPSD	SFDUR	SDPDV	PODUR
!			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
990001	V EARLY SPANISH	PN0006	11.84	0.00	18.4	6.5	17.0	83.70	73.20	1.30	230.	20.0	0.95	0.575	37.0	1.70	35.0
990002	EARLY VALENCIA	PN0007	11.84	0.00	18.4	6.5	17.0	83.70	73.20	1.30	230.	20.0	0.95	0.575	37.0	1.70	35.0
990003	MEDIUM VIRGINIA	PN0005	11.84	0.00	18.4	6.5	17.0	83.70	73.20	1.30	230.	20.0	0.95	0.575	37.0	1.70	35.0

CROPGRO-SOYBEAN

Table 16 shows an example of the current cultivars defined for soybean. Required genetic coefficients include :

VARTY — Also VAR#; the identification code or number for a specific cultivar.

VRNAME — Name of cultivar.

ECONO — Also ECO#; the ecotype code for this cultivar, points to the Ecotype in the ECO (SBGRO940.ECO) file.

CSDVAR — Also CSDL; critical daylength below which reproductive development proceeds unaffected by daylength, and above which development rate is reduced in proportion to hours above CSDVAR (h).

PPSEN — Slope of relative rate of development for daylengths above CSDVAR, or sensitivity to photoperiod (1/h).

PH2T5 — Also EM-FL; the time from end of juvenile phase to first flower in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).

PHTHRS(6) — Also FL-SH; the time from first flower to first pod greater than 0.5 cm in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).

PHTHRS(8) — Also FL-SD the time from first flower to first seed in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).

PHTHRS(10) — Also SD-PM the time from first seed to physiological maturity in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).

PHTHRS(13) — Also FL-LF the time from first flower to end of leaf growth in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).

LFMAX	Maximum leaf photosynthesis rate at saturated light level, optimal temperature (micromol (CO_2 /m^2s))
SLAVAR	Specific leaf area (SLA) for new leaves during peak vegetative growth for cultivar I, modified by environmental factors (cm^2/g).
SIZLF	Maximum size of fully expanded leaf on the plant under standard growing conditions (3 leaflets), cm^2
XFRUIT	Maximum fraction of daily available gross photosynthesis (PG) which is allowed to go to seeds plus shells for cultivar I, varies from 0 - 1.
WTPSD	Maximum weight per seed under non-limiting substrate (g).
SFDUR	Seed filling duration for a cohort of seed (photothermal days).
SDPDVR	Also SDPDV; average seed per pod under stnadard growing conditions.
PODUR	Photothermal days for cultivar to add full pod load under optimal conditions, used to compute rate of pod and flower addition.

TABLE 16. GENETIC COEFFICIENTS FILE FOR CROPGRO-SOYBEAN. (SBGRO940.CUL)

*SOYBEAN GENOTYPE COEFFICIENTS - CRGRO940 MODEL

@VAR#	VRNAME	ECO#	CSDL	PPSEN	EM-FL	FL-SH	FL-SD	SD-PM	FL-LF	LFMAX	SLAVR	SIZLF	XFRT	WTPSD	SFDUR	SDPDV	PODUR
!			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
990001	M GROUP 1	SB0101	13.84	0.203	17.0	6.0	13.0	32.00	30.00	1.022	350.	180.0	1.00	0.18	22.0	2.05	10.0
990002	M GROUP 2	SB0201	13.59	0.249	17.4	6.0	13.5	33.00	30.00	1.022	350.	180.0	1.00	0.18	22.0	2.05	10.0
990003	M GROUP 3	SB0301	13.40	0.285	19.0	6.0	14.0	34.00	30.00	1.022	350.	180.0	1.00	0.18	22.0	2.05	10.0
990004	M GROUP 4	SB0401	13.09	0.294	19.4	7.0	15.0	34.50	30.00	1.022	350.	180.0	1.00	0.18	22.0	2.05	10.0
990005	M GROUP 5	SB0501	12.83	0.303	19.8	8.0	15.5	35.00	15.00	1.022	350.	180.0	1.00	0.18	22.0	2.05	10.0
990006	M GROUP 6	SB0601	12.58	0.311	20.2	9.0	16.0	35.50	15.00	1.022	350.	180.0	1.00	0.18	22.0	2.05	10.0
990007	M GROUP 7	SB0701	12.33	0.320	20.8	10.0	16.0	36.00	15.00	1.022	350.	180.0	1.00	0.18	22.0	2.05	10.0
990008	M GROUP 8	SB0801	12.07	0.330	21.5	10.0	16.0	36.00	15.00	1.022	350.	180.0	1.00	0.18	22.0	2.05	10.0
990009	M GROUP 9	SB0901	11.88	0.340	23.0	10.0	16.0	36.50	15.00	1.022	350.	180.0	1.00	0.18	22.0	2.05	10.0
990010	M GROUP 10	SB1001	11.78	0.349	23.5	10.0	16.0	37.00	15.00	1.022	350.	180.0	1.00	0.18	22.0	2.05	10.0
990011	M GROUP 000	SB0001	14.60	0.129	15.5	5.0	12.0	29.50	30.00	1.022	350.	180.0	1.00	0.18	22.0	2.05	10.0
990012	M GROUP 00	SB0001	14.35	0.148	16.0	5.0	12.0	30.00	30.00	1.022	350.	180.0	1.00	0.18	22.0	2.05	10.0
990013	M GROUP 0	SB0001	14.10	0.171	16.8	6.0	13.0	31.00	30.00	1.022	350.	180.0	1.00	0.18	22.0	2.05	10.0
UC0001	ALTONA (00)	SB0001	14.42	0.148	17.5	7.5	14.0	33.00	33.00	1.022	350.	180.0	1.00	0.18	16.0	2.05	12.0
UC0002	MAPLE ARROW (00)	SB0001	14.42	0.148	17.8	7.0	13.0	33.50	33.00	1.022	350.	180.0	1.00	0.18	16.0	2.05	10.5
UC0003	MCCALL (00)	SB0001	14.42	0.148	17.0	5.5	12.0	34.00	33.00	1.022	350.	180.0	1.00	0.18	16.0	2.05	[illegible].0
IB0011	EVANS (0)	SB0001	14.00	0.171	16.8	6.5	12.4	33.00	31.00	1.022	360.	180.0	1.00	0.18	24.0	2.05	12.0
IB0037	ELGIN-87 (2)	SB0201	13.65	0.240	17.4	6.0	10.7	33.00	31.50	1.022	380.	150.0	1.00	0.18	20.0	2.05	10.0
IB0003	WAYNE (3)	SB0302	13.50	0.226	21.0	8.0	15.5	30.00	25.00	1.022	380.	135.0	1.00	0.16	20.0	2.20	21.0
IB0009	WILLIAMS (3)	SB0301	13.45	0.285	20.5	9.0	16.0	30.00	30.00	1.022	350.	120.0	1.00	0.18	24.0	2.50	15.0
IB0010	WILLIAMS-82 (3)	SB0301	13.45	0.285	19.5	8.0	15.0	31.50	30.00	1.022	350.	120.0	1.00	0.18	24.0	2.50	10.0
IB0043	CLARK (4)	SB0502	12.83	0.303	18.0	9.0	15.0	32.00	30.00	1.022	390.	200.0	1.00	0.18	20.0	2.10	12.0
IB0008	FORREST (5)	SB0501	12.83	0.303	22.6	7.0	14.5	33.00	15.00	1.022	350.	140.0	1.00	0.18	23.0	2.05	9.0
IB0001	BRAGG (7)	SB0701	12.33	0.320	19.5	10.0	15.0	35.50	15.00	1.022	350.	170.0	1.00	0.18	22.0	2.05	10.0
IB0006	RANSOM (7)	SB0701	12.37	0.320	18.0	10.0	16.0	32.00	15.00	1.022	350.	170.0	1.00	0.18	22.0	2.05	10.0
IB0002	COBB (8)	SB0801	12.25	0.330	21.0	9.0	16.0	37.00	15.00	1.022	380.	180.0	1.00	0.15	22.0	1.90	10.0
IB0033	PAPILLON (9)	SB0901	11.88	0.340	28.0	6.0	11.0	30.00	15.00	1.022	350.	180.0	1.00	0.18	22.0	2.05	20.0
IB0012	JUPITER (10)	SB0901	11.88	0.340	28.9	7.0	13.5	31.50	15.00	1.022	350.	180.0	1.00	0.18	22.0	2.05	20.0

CERES-RICE

Table 17 shows an example of the current cultivars defined for rice. Required genetic coefficients include :

VAR#	Identification code or number for a specific cultivar.
VAR-NAME	Name of cultivar.
ECO#	Ecotype code for this cultivar, points to the Ecotype in the ECO file (currently not used).
P1	Time period (expressed as growing degree days [GDD] in ^{o}C above a base temperature of 9°C) from seedling emergence during which the rice plant is not responsive to changes in photoperiod. This period is also referred to as the basic vegetative phase of the plant.
P2O	Critical photoperiod or the longest day length (in hours) at which the development occurs at a maximum rate. At values higher than P2O developmental rate is slowed, hence there is delay due to longer day lengths.
P2R	Extent to which phasic development leading to panicle initiation is delayed (expressed as GDD in ^{o}C) for each hour increase in photoperiod above P2O
P5	Time period in GDD (^{o}C) from beginning of grain filling (3 to 4 days after flowering) to physiological maturity with a base temperature of 9°C.
G1	Potential spikelet number coefficient as estimated from the number of spikelets per g of main culm dry weight (less lead blades and sheaths plus spikes) at anthesis). A typical value is 55.
G2	Single grain weight (g) under ideal growing conditions, i.e. nonlimiting light, water, nutrients, and absence of pests and diseases.
G3	Tillering coefficient (scaler value) relative to IR64 cultivar under ideal conditions. A higher tillering cultivar would have coefficient greater than 1.0.
G4	Temperature tolerance coefficient. Usually 1.0 for varieties grown in normal environments. G4 for japonica type rice growing in a warmer environment would be 1.0 or greater. Likewise, the G4 value for indica type rice in very cool environments or season would be less than 1.0.

TABLE 17. GENETIC COEFFICIENTS FILE FOR CERES-RICE. (RICER940.CUL)

```
*RICE GENOTYPE COEFFICIENTS - RICER940 MODEL
!
@VAR#  VAR-NAME........   ECO#    P1   P2R    P5   P2O    G1    G2    G3    G4
!                                  1     2     3     4     5     6     7     8
!
IB0001 IR 8               IB0001 880.0  52.0 550.0  12.1  65.0 .0280  1.00  1.00
IB0002 IR 20              IB0001 500.0 166.0 500.0  11.2  65.0 .0280  1.00  1.00
IB0003 IR 36              IB0001 450.0 149.0 350.0  11.7  68.0 .0230  1.00  1.00
IB0004 IR 43              IB0001 720.0 120.0 580.0  10.5  65.0 .0280  1.00  1.00
IB0005 LABELLE            IB0001 318.0 189.0 550.0  12.8  65.0 .0280  1.00  1.00
IB0006 MARS               IB0001 698.0 134.0 550.0  13.0  65.0 .0280  1.00  1.00
IB0007 NOVA 66            IB0001 389.0 155.0 550.0  11.0  65.0 .0280  1.00  1.00
IB0008 PETA               IB0001 420.0 240.0 550.0  11.3  65.0 .0280  1.00  1.00
IB0009 STARBONNETT        IB0001 880.0 164.0 550.0  13.0  65.0 .0280  1.00  1.00
IB0010 UPLRI5             IB0001 620.0 160.0 380.0  11.5  50.0 .0220  0.60  1.00
IB0011 UPLRI7             IB0001 760.0 150.0 450.0  11.7  65.0 .0280  1.00  1.00
IB0012 IR 58              IB0001 460.0   5.0 420.0  13.5  60.0 .0250  1.00  1.00
IB0013 SenTaNi (???)      IB0001 320.0  50.0 550.0  10.0  70.0 .0300  1.00  1.00
IB0014 IR 54              IB0001 350.0 125.0 520.0  11.5  60.0 .0280  1.00  1.00
IB0015 IR 64              IB0001 500.0 160.0 450.0  12.0  60.0 .0250  1.00  1.00
IB0016 IR 60(Est)         IB0001 490.0 100.0 320.0  11.5  75.0 .0275  1.00  1.00
IB0017 IR 66              IB0001 500.0  50.0 490.0  12.5  62.0 .0265  1.00  1.00
IB0018 IR 72x             IB0001 400.0 100.0 580.0  12.0  76.0 .0230  1.00  1.00
IB0019 RD 7 (cal.)        IB0001 603.3 150.0 452.5  11.2  65.0 .0230  1.00  1.00
IB0020 RD 23 (cal.)       IB0001 310.3 140.0 370.0  11.2  53.0 .0230  1.00  1.00
IB0021 CICA8              IB0001 700.0 120.0 360.0  11.7  60.0 .0270  1.00  1.00
IB0022 LOW TEMP.SEN       IB0001 400.0 120.0 420.0  12.0  60.0 .0250  1.00  0.80
IB0023 LOW TEMP.TOL       IB0001 400.0 120.0 420.0  12.0  60.0 .0250  1.00  1.25
IB0024 17 BR11,T.AMAN     IB0001 740.0 180.0 400.0  10.5  55.0 .0250  1.00  0.90
IB0025 18 BR22,T.AMAN     IB0001 650.0 110.0 400.0  12.0  60.0 .0250  1.00  1.00
IB0026 19 BR 3,T.AMAN     IB0001 650.0 110.0 420.0  12.0  65.0 .0250  1.00  1.00
IB0027 20 BR 3,BORO       IB0001 650.0  90.0 400.0  13.0  65.0 .0250  1.00  1.00
IB0029 CPIC8              IB0001 380.0 150.0 300.0  12.8  38.0 .0210  1.00  1.00
IB0030 LEMONT             IB0001 500.0  50.0 300.0  12.8  60.0 .0207  1.00  1.00
IB0031 RN12               IB0001 380.0  50.0 300.0  12.8  40.0 .0199  1.00  1.15
IB0032 TW                 IB0001 360.0  50.0 290.0  12.8  55.0 .0210  1.00  1.00
IB0115 IR 64              IB0001 540.0 160.0 490.0  12.0  50.0 .0250  1.10  1.00
IB0116 HEAT SENSITIVE     IB0001 460.0   5.0 390.0  13.5  62.0 .0250  1.00  1.15
IB0118 IR 72              IB0001 560.0  20.0 390.0  13.5  60.0 .0250  1.00  1.00
```

CROPSIM-CASSAVA

Table 18 shows an example of the current cultivars defined for cassava. Required genetic coefficients include :

DUB1 Duration of branch 1 phase (Biological day* from germination to first branch)

DUBR Duration of branch 2 and greater phases (Biological day* between branches)

DESP Development, sensitivity to photoperiod (h^{-1}) (0=insensitive)

PHCX Photosynthesis, canopy, maximum rate (g dm/m^2 d^{-1})

S#PE Stem number per plant at emergence (#)

S#FX Shoot number per fork, maximum (#)

S#PX Shoot number per plant, maximum (#)

SWNX Stem weight to node weight ration (fr)

L#IS Leaf number, increase rate, standard (leaves (shoot-1) Biological day*-1)

L#IP Leaf number, increase period (Biological day* after emergence)

LALX Leaf area, maximum, (cm^2/leaf)

LAXA Leaf area, maximum, age at which reached (Biological day* after emergence)

LAL3 Leaf area, 300 days after emergence (cm^2/leaf)

LAWS Leaf area to weight ration, standard (cm^2/g)

LFLI Leaf life (Day)

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* *Biological days are equivalent to chronological days at the optimum temperature and daylength, and with no water or nutrient limitations.*

TABLE 18. GENETIC COEFFICIENTS FILE FOR CROPSIM-CASSAVA. (CSSIM940.CUL)

*CASSAVA GENOTYPE COEFFICIENTS -CSSIM940 MODEL

!

@VAR#	VRNAME.....	TYPE	DUB1	DUBR	DESP	PHCX	S#PE	S#FX	S#PX	SWNX	L#IS	L#IP	LALX	LAXA	LAL3	LAWS	LFLI
!			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
990001	Default	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0001	MCol-1120	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0002	MCol-22	1	44.4	58.8	0	20.0	1.2	3.60	28	.650	0.85	330	300	60	50	180	130
UC0003	MCl-113	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0004	MMex-59	1	41.3	29.4	0	24.0	1.0	2.80	35	.750	1.21	212	450	60	50	250	65
UC0005	Popayan	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0006	MCol-1684	1	14.7	24.8	0	27.5	1.0	2.61	27	.590	0.94	370	220	55	40	270	45
UC0007	MVen-77	1	49.4	42.9	0	27.5	1.0	2.95	25	.760	1.13	353	450	70	35	270	75
UC0008	MPtr-26	1	64.7	50.0	0	27.5	1.0	3.00	20	.708	1.45	294	450	70	50	220	75
UC0009	MCol-638	1	44.4	28.2	0	23.5	1.0	2.95	52	.700	1.10	235	350	60	35	220	80
UC0010	Ceiba	1	32.4	35.3	0	26.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0011	JD2	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0012	MAus-1	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0013	MAus-10	1	14.7	41.2	0.25	25.0	3.0	3.09	50	0.76	1.21	235	240	45	70	350	161
UC0014	MAus-13	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0014	MAus-15	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0016	[illegible]-19	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0017	MAus-22	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0018	MAus-7	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0019	MAus-8	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0020	MCol-1438	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0021	MCol-1468	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0022	MCol-1501	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0023	MCol-1505	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0024	MCol-1513	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0025	MCol-72	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0026	MMex-11	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0027	TMS-30572	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0028	Nina	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0029	Pata	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0030	SM1-150	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0031	Betawi	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70
UC0032	CM-507-37	1	44.1	35.3	0	27.5	1.0	3.00	30	.650	1.21	235	300	60	50	240	70

! Notes:

! Palta (1984): MMex59,MVen218,MCol1684 are vigorous cultivars;

! MCol72,MCol22,MCol638 are less vigorous.

! CM507-37: hybrid see El-Sharkaway & Cock (1987).

! TMS 30572 in Gutierrez et al (1987).

APPENDIX B. IMPLEMENTING PEST DAMAGE

In DSSAT v3, the pest damage routines have been implemented only in the CROPGRO models (Batchelor et al., 1993). In order to use the damage routines, the type of damage, as well as the amount of damage, must be input by the user. The damage routines were structured to provide flexibility in collecting damage data. Two different methods can be used to describe damage. In typical farm operations, pest population data can be collected through field scouting, and damage can be computed if pest feeding rates are known. In other instances, the actual amount of damage can be measured. This latter approach is useful when pest populations are difficult to measure, or when the source of damage is unknown. Predefined pest definitions can be used to convert scouting report data on pest populations, or observed damage, into daily damage, which is subsequently applied to the crop model. Predefined damage definitions can be used to convert observed levels of damage into daily damage that is subsequently applied to the crop model. New pest or damage definitions can be developed for a wide range of damage types. Currently, damage can be applied to 21 different plant components in CROPGRO.

PEST DAMAGE METHODOLOGY

Twenty one state and/or rate variables, called coupling point (see Table 19), were identified as targets for pest damage. Damage is applied to each coupling point by the coupling point damage variable (or PCPID, described in the following section). There is a unique coupling point damage variable for each coupling point. The user supplies information that is used by the crop model to compute daily damage, which is then applied to the desired coupling point through the coupling point damage variable.

Four different types (or variable PCTID, described in the following section) can be defined to describe observed damage data:

1. Daily Absolute Damage rate,
2. Percent Observed Damage,
3. Daily Percent Damage rate, and
4. Daily Absolute Damage rate with pest competition and food preference effects.

Table 19 shows the allowable damage types available for each coupling point. The coupling point damage variable (PCPID) contains the amount of damage (PDCF1) and the damage type descriptor (PCTID) tells CROPGRO how to apply the damage to the coupling point.

TABLE 19. COUPLING POINTS AND DAMAGE TYPES USED TO APPLY DAMAGE IN THE CROPGRO CROP MODELS.

Coupling point	Units[1]	Available damage types[2]	Coupling point damage variable
leaf area index	$m^2\ m^{-2}$	1,2,3,4	LAD
leaf mass	$g\ m^{-2}$	1,2,3,4	LMD
stem mass	$g\ m^{-2}$	1,2,3,4	SMD
root mass	$g\ m^{-2}$	1,3,4	RMD
root length	$cm\ cm^{-2}$	1,3,4	RLF
root length volume	$cm\ cm^{-3}$	1,3,4	RLV
small seed number	$no.\ m^{-2}$	1,3,4	SDNS
large seed number	$no.\ m^{-2}$	1,3,4	SDNL
mature seed number	no. m-2	1,3,4	SDNM
small seed mass	$g\ m^{-2}$	1,3,4	SDMS
large seed mass	$g\ m^{-2}$	1,3,4	SDML
mature seed mass	$g\ m^{-2}$	1,3,4	SDMM
small shell number	$no.\ m^{-2}$	1,3,4	SHNS
large shell number	$no.\ m^{-2}$	1,3,4	SHNL
mature shell number	$no.\ m^{-2}$	1,3,4	SHNM
small shell mass	$g\ m^{-2}$	1,3,4	SHMS
large shell mass	$g\ m^{-2}$	1,3,4	SHML
mature shell mass	$g\ m^{-2}$	1,3,4	SHMM
whole plant	$no\ m^{-2}$	1,3	WPD
assimilate	$g\ m^{-2}$	1,3	ASM
necrotic leaf area index	$cm^2\ cm^{-2}$	1,3	PDLA

1 *Per unit ground area*

2 *Where damage type are: (1) Daily Absolute Damage rate, (2) Percent Observed Damage, (3) Daily Percent Damage rate, and (4) Daily Absolute Damage rate with pest competition and food preference effects*

The type of damage selected depends upon the type of damage data that can be collected. Number 1, "Absolute Daily Damage," is useful when pest population data can be collected. If pest populations and feeding rates are known, daily damage to coupling points can be computed in units of mass per unit area. Number 2, "Percent Observed Damage," typically occurs when observations of plant components are compared between some scientific treatment and control. For example, defoliation can occur in one treatment, resulting in a percent difference in leaf mass between a treatment and control. In this case, the source of damage may not be known; while time series measurements describing the percent

reduction between treatment and control is known. Number 3, "Daily Percent Damage," rate is useful when damage can be measured as percent on a daily basis. For instance, in a manual defoliation study, 33 percent and 66 percent defoliation may be applied on a particular day during the season. In this case, damage is applied as a percent daily damage. Another example would be the application of a shade cloth that blocks 80 percent of incoming light, resulting in an 80 percent reduction in daily assimilate production during the period of shading. Number 4, "Daily Absolute Damage" rate is intended to be used for insects that compete for feeding sites. If insect demand for the primary food source is high relative to supply, some damage is partitioned to secondary food sources.

Pest Damage Data Files

Two data files are used to define the pest linkage. A field-specific record of observed pest or pest damage levels is contained in the time series file (FILET) associated with each experiment. A typical FILET with recorded pest populations is shown in Table 20. Each column has a 4 character header that is unique for each pest (the PID variable, described below). The first two columns in this file contain the treatment number and observation date. The measured level of pest and/or damage is input in a column containing a 4 character header abbreviation for the pest or damage. This approach for recording observed pest and damage levels follows a typical field scouting record format. The steps required to define a pest progress file are as follows.

1. Put a header in the header column of FILET that matches the pest identifier (PID; see Tables 21-23 for dry bean, peanut and soybean, respectively) for the pest defined in the pest coefficient file.
2. Input the year and day of year in the first two columns of FILET for pest observation dates.
3. Input population level or damage level in FILET in the pest column corresponding to the observation date.

Observed pest and damage reported in the pest progress file (FILET) must have a corresponding definition in the pest coefficient file (*.PST). This crop-specific pest coefficient file defines individual pests or damage in terms of coupling points and feeding rates. Feeding rate coefficients, which have designated units, provide a means of converting from pest population to damage to coupling points. The pest coefficient files, distributed with the CROPGRO model for dry bean, peanut, and soybean are shown in Tables 21-23.

The following columns are included in these pest coefficient files.

1st column: pest number (LN);
2nd column: pest identifier (PID);
3rd column: pest name (PNAME);
4th column: damage characterization type (PCTID);
5th column: coupling point identifier (PCPID), defined in Table 19;
6th column: feeding rate coefficient (PDCF1);
7th column: additional coefficient (PDCF2, currently not implemented.
8th column: units of the feeding rate coefficient (Units); and
9th column: source for damage rates (Source).

To add a new pest or damage type to the pest coefficient file, the user must contact the model developer (see Appendix D of this Part).

TABLE 20. TYPICAL TIME SERIES FILE (FILET) CONTAINING EXAMPLES OF PEST PROGRESS DATA FOR SIX PEST AND DAMAGE TYPES[1] FOR SOYBEAN.

*EXP.DATA (T): UFBI9101SB Drew field drought study

@TRNO	DATE	CEW6	SL6	VC5	VC6	SHAD	GC5
1	91147	0.0	1.5	0.25	0.4	30.0	0.0
1	91154	0.5	2.8	0.25	0.6	30.0	0.6
1	91161	0.9	3.3	0.1	1.2	0.0	0.1
1	91168	1.5	6.4	0.0	1.6	-99	0.0
1	91175	0.2	0.5	0.0	1.8	-99	0.0
1	91181	0.0	1.2	0.0	1.0	-99	0.0
1	91188	-99	1.5	-99	0.2	-99	0.0
1	91195	-99	3.3	-99	0.0	-99	0.0

[1] *The pest names defined by these pest header are: CEW6 - 6th instar corn earworm; SL6 - 6th instar soybean looper; VC5- 5th instar velvetbean caterpillar; VC6 - 6th instar velvetbean caterpillar; SHAD - percent canopy shading by shade cloth; and GC5 - 5th instar green cloverworm. Each pest and damage is defined in the pest coefficient file.*

TABLE 21. A TYPICAL PEST COEFFICIENT FILE FOR DRY BEAN. (BNGRO940.PST)

LN	PID	PNAME	PCTID	PCPID	PDCF1	PFCF2	Units	Source
01	EMP	Empoasca kramerii	4	SDNS	10.0000000	0.0000	no./larva/d	estimated
				SDNL	2.50000000	0.0000	no./larva/d	estimated
				LAD	0.00505000	0.0000	m2/larva/d	estimated
02	APN2	4 Instar Apion	1	SDNS	10.0000000	0.0000	no./larva/d	estimated
			1	SDNL	2.50000000	0.0000	no./larva/d	estimated
03	APN4	4 Instar Apion	1	SDNS	10.0000000	0.0000	no./larva/d	estimated
			1	SDNL	2.50000000	0.0000	no./larva/d	estimated
04	HL2	Heliothis	1	SDNS	10.0000000	0.0000	no./larva/d	estimated
05	HL4	Heliothis	1	SDNS	10.0000000	0.0000	no./larva/d	estimated
06	HL6	Heliothis	1	SDNS	10.0000000	0.0000	no./larva/d	estimated
07	EPN	Epinotia	4	SDNS	15.0000000	0.0000	no./m2/d	estimated
				SDNM	5.00000000	0.0000	no./m2/d	estimated
08	WFL	Bemisia (white fly)	1	LMD	2.00000000	0.0000	g/larva/day	estimated
09	BSM	Bean stem maggot	1	RLV	1.00000000	0.0000	cm/cm2/lar/d	estimated
10	PCLA	Obs.% defoliation	2	LAD	1.00000000	0.0000	%	estimated
11	PSTM	Obs.% Stem damage	2	SMD	1.00000000	0.0000	%	estimated
12	PDLA	% Diseased Leaf Area	3	PDLA	1.00000000	0.0000	%/day	estimated
13	PRP	% Reduction in Photo	3	ASM	1.00000000	0.0000	%/day	estimated
14	PLAI	% daily LAI dest.	3	LAD	1.00000000	0.0000	%/day	estimated
15	PLM	% daily Leaf Mass	3	LMD	1.00000000	0.0000	%/day	estimated
16	PWP	% Whole Plants	3	WPD	1.00000000	0.0000	%/day	estimated
17	PSDN	% All Seed Dest.	3	SDNL	1.00000000	0.0000	%/day	estimated
				SDNS	1.00000000	0.0000	%/day	estimated
				SDNM	1.00000000	0.0000	%/day	estimated
18	PSHN	% All Shell Dest.	3	SHNL	1.00000000	0.0000	%/day	estimated
				SHNS	1.00000000	0.0000	%/day	estimated
				SHNM	1.00000000	0.0000	%/day	estimated
19	PPDN	% All Pod Dest.	3	PPDN	1.00000000	0.0000	%/day	estimated
20	PRTM	% Root mass dest.	3	RMD	1.00000000	0.0000	%/day	estimated

TABLE 22. A TYPICAL PEST COEFFICIENT FILE FOR PEANUT. (PNGRO940.PST)

LN	PID[1]	PNAME	PCTID	PCPID	PDCF1	PFCF2	Units	Source
01	CEW6	Corn Earworm[2]	1	LAD	0.00505000	0.0000	m2/larva/d	Szmedra et al. 1988
02	VBC5	5 Instar Velvetbean[3]	1	LAD	0.00081000	0.0000	m2/larva/d	Reid, 1975
03	VBC6	6 Instar Velvetbean	1	LAD	0.00144000	0.0000	m2/larva/d	Reid, 1975
04	SL4	Soybean Looper[4]	1	LAD	0.00044000	0.0000	m2/larva/d	Reid and Green 1975
05	SL5	Soybean Looper	1	LAD	0.00071000	0.0000	m2/larva/d	Reid and Green 1975
06	SL6	Soybean Looper	1	LAD	0.00124000	0.0000	m2/larva/d	Reid and Green 1975
07	FAW	Fall Armyworm	1	LMD	2.00000000	0.0000	g/larva/d	estimated
08	RTWM	rootworm	1	RLV	1.00000000	0.0000	cm/cm2/lar/d	estimated
09	PCLA	Obs.% defoliation	2	LAD	1.00000000	0.0000	%	estimated
10	PSTM	Obs.% Stem damage	2	SMD	1.00000000	0.0000	%	estimated
11	PDLA	% Diseased Leaf Area	3	PDLA	1.00000000	0.0000	%/day	estimated
12	PRP	% Reduction in Photo	3	ASM	1.00000000	0.0000	%/day	estimated
13	PLAI	% daily LAI dest.	3	LAD	1.00000000	0.0000	%/day	estimated
14	PLM	% daily Leaf Mass	3	LMD	1.00000000	0.0000	%/day	estimated
15	PWP	% Whole Plants	3	WPD	1.00000000	0.0000	%/day	estimated
16	PSDN	% All Seed Dest.	3	SDNL	1.00000000	0.0000	%/day	estimated
				SDNS	1.00000000	0.0000	%/day	estimated
				SDNM	1.00000000	0.0000	%/day	estimated
17	PSHN	% All Shell Dest.	3	SHNL	1.00000000	0.0000	%/day	estimated
				SHNS	1.00000000	0.0000	%/day	estimated
				SHNM	1.00000000	0.0000	%/day	estimated
18	PPDN	% All Pod Dest.	3	PPDN	1.00000000	0.0000	%/day	estimated
19	PRTM	% Root mass dest.	3	RMD	1.00000000	0.0000	%/day	estimated

[1] *Pest identifier or abbreviation for the pest or damage type.*
[2] *Corn Earworm (Heliothis Zea.)*
[3] *Velvetbean Caterpillar (Anticarsia gemmatalis)*
[4] *Soybean Looper (Pseudoplusia includens)*

TABLE 23. A TYPICAL PEST COEFFICIENT FILE FOR SOYBEAN. (SBGRO940.PST)

LN	PID[1]	PNAME	PCTID	PCPID	PDCF1	PFCF2	Units	Source
01	CEW6	Corn Earworm[2]	4	SDNS	10.0000000	0.0000	no./larva/d	Batchelor et al.1989
				SDNL	2.50000000	0.0000	no./larva/d	Szmedra et al. 1988
				LAD	0.00505000	0.0000	m2/larva/d	Szmedra et al. 1988
02	VBC5	5 Instar Velvetbean[3]	1	LAD	0.00081000	0.0000	m2/larva/d	Reid, 1975
03	VBC6	6 Instar Velvetbean	1	LAD	0.00144000	0.0000	m2/larva/d	Reid, 1975
04	SL4	Soybean Looper[4]	1	LAD	0.00044000	0.0000	m2/larva/d	Reid and Green 1975
05	SL5	Soybean Looper	1	LAD	0.00071000	0.0000	m2/larva/d	Reid and Green 1975
06	SL6	Soybean Looper	1	LAD	0.00124000	0.0000	m2/larva/d	Reid and Green 1975
07	SGSB	Stinkbug[5]	4	SDNS	15.0000000	0.0000	no./m2/d	Batchelor et al. 1989
				SDNM	5.00000000	0.0000	no./m2/d	Batchelor et al. 1989
08	FAW	Fall Armyworm	1	LMD	2.00000000	0.0000	g/larva/day	estimated
09	RTWM	rootworm	1	RLV	1.00000000	0.0000	cm/cm2/lar/d	estimated
10	PCLA	Obs.% defoliation	2	LAD	1.00000000	0.0000	%	estimated
11	PSTM	Obs.% Stem damage	2	SMD	1.00000000	0.0000	%	estimated
12	PDLA	% Diseased Leaf Area	3	PDLA	1.00000000	0.0000	%/day	estimated
13	PRP	% Reduction in Photo	3	ASM	1.00000000	0.0000	%/day	estimated
14	PLAI	% daily LAI dest.	3	LAD	1.00000000	0.0000	%/day	estimated
15	PLM	% daily Leaf Mass	3	LMD	1.00000000	0.0000	%/day	estimated
16	PWP	% Whole Plants	3	WPD	1.00000000	0.0000	%/day	estimated
17	PSDN	% All Seed Dest.	3	SDNL	1.00000000	0.0000	%/day	estimated
				SDNS	1.00000000	0.0000	%/day	estimated
				SDNM	1.00000000	0.0000	%/day	estimated
18	PSHN	% All Shell Dest.	3	SHNL	1.00000000	0.0000	%/day	estimated
				SHNS	1.00000000	0.0000	%/day	estimated
				SHNM	1.00000000	0.0000	%/day	estimated
19	PPDN	% All Pod Dest.	3	PPDN	1.00000000	0.0000	%/day	estimated
20	PRTM	% Root mass dest.	3	RMD	1.00000000	0.0000	%/day	estimated

[1] *Pest identifier or abbreviation for the pest or damage type.*
[2] *Corn Earworm (Heliothis Zea.)*
[3] *Velvetbean Caterpillar (Anticarsia gemmatalis)*
[4] *Soybean Looper (Pseudoplusia includens)*
[5] *Southern Green Stinkbug (Nezara virdula L.)*

Examples of Pest Data Files for Various Experiments

Example 1 (Corn Earworm Damage in Soybean)

In this example, damage resulting from 6th instar corn earworm (PID = CEW6) was applied to both irrigated and non-irrigated treatments in the soybean experiment UFGA7802.SBX. In the experiment, treatments 1 and 2 contained irrigated and non-irrigated Bragg soybean without pest damage. In treatments 3 and 4, pest damage due to observed levels of corn earworm was applied to the irrigated and non-irrigated treatments. It was assumed that the CEW6 population was measured through periodic field scouting, which resulted in the scouting report shown in Table 24.

In order to apply the pest damage in the model, the following steps were followed:

1. Checked to ensure that the pest was defined in the pest coefficient file (SBGRO940.PST) (see Table 23);
2. Entered the observed population levels in FILET (UFGA7802.SBT); and
3. Set the PEST damage option to 'Y' in FILEX (UFGA7802.SBX).

The steps described in the preceding section, "Pest Damage Data Files" were followed to add the pest population observations to FILET. As part of Step 2, a column was added in FILET, UFGA7802.SBT, using a text editor, containing the CEW6 header for corn earworm (or the PID) (see Table 25). The CEW6 header in FILET must match the unique 4 character pest identifier (PID) for corn earworm in the pest coefficient file,

Table 24. Corn Earworm Population Data Collected from Field Scouting for the Soybean Experiment UFGA7802.

Day of year	Corn earworm population, no. m^{-2}
222	0.0
229	0.5
236	1.0
243	2.5
250	5.5
257	11.1
264	14.1
271	13.1
278	0.5
285	0.8
292	0.9

TABLE 25. TIME SERIES FILE FOR THE SOYBEAN EXPERIMENT UFGA7802 SHOWING 6TH INSTAR CORN EARWORM POPULATION LEVELS (CEW6).

*EXP.DATA (T): UFGA7802SB BRAGG, IRR*INSECT DAMAGE

@TRNO	DATE	LAID	SWAD	GWAD	LWAD	CWAD	PWAD	SHAD	SH%D	SLAD	HIAD	CEW6
1	78194	.89	178	0.	266	444	0.	0.	0.00	334.6	0.0	0.0
1	78201	1.28	300	0.	366	667	0.	0.	0.00	349.7	0.0	0.0
1	78208	1.91	551	0.	656	1207	0.	0.	0.00	291.2	0.0	0.0
1	78215	2.86	943	0.	843	1786	0.	0.	0.00	339.3	0.0	0.0
1	78222	4.17	1561	0.	1187	2748	0.	0.	0.00	351.3	0.0	0.0
1	78229	3.90	1956	0.	1204	3160	0.	0.	0.00	323.9	0.0	0.0
1	78236	4.66	2947	0.	1723	4792	123	123	0.00	270.5	0.0	0.0
1	78243	4.47	3144	0.	1772	5224	308	308	0.00	252.3	0.0	0.0
1	78250	4.44	3303	182	1631	5740	805	623	22.60	272.2	0.030	0.0
1	78257	3.99	3326	754	1568	6507	1613	859	46.75	254.5	0.116	0.0
1	78264	4.67	3657	1912	1769	8586	3161	1249	60.49	264.0	0.222	0.0
1	78271	2.83	2732	2223	1180	7144	3232	1009	68.78	239.8	0.311	0.0
1	78278	2.09	2515	2730	858.0	7136	3763	1033	72.55	243.6	0.383	0.0
1	78285	.47	1851	2913	170.0	5866	3845	932	75.76	276.5	0.497	0.0
1	78292	.09	2064	3169	34.0	6270	4172	1003	75.96	264.7	0.505	0.0
2	78194	.75	160	0.	244	405	0.	0.	0.00	307.4	0.0	0.0
2	78201	1.08	251	0.	311	563	0.	0.	0.00	347.3	0.0	0.0
2	78208	1.81	535	0.	626	1161	0.	0.	0.00	289.1	0.0	0.0
2	78215	3.29	1080	0.	974	2054	0.	0.	0.00	337.8	0.0	0.0
2	78222	4.38	1663	0.	1261	2923	0.	0.	0.00	347.3	0.0	0.0
2	78229	4.30	2083	0.	1392	3475	0.	0.	0.00	308.9	0.0	0.0
2	78236	4.21	2556	0.	1517	4184	112	112	0.00	277.5	0.0	0.0
2	78243	4.50	2673	0.	1439	4431	319	319	0.00	312.7	0.0	0.0
2	78250	2.09	1998	42	838	3104	268	226	15.67	239.4	0.014	0.0
2	78257	3.24	2650	253	1220	4530	661	408	38.28	265.6	0.056	0.0
2	78264	2.30	2609	471	931	4440	901	430	52.28	247.0	0.106	0.0
2	78271	1.14	2113	775	498	3812	1200	425	64.58	228.9	0.203	0.0
2	78278	.85	1905	782	371	3399	1122	340	69.70	229.1	0.230	0.0
2	78285	.53	1922	1149	236	3732	1574	425	73.00	224.5	0.302	0.0
2	78292	.07	1590	1206	30	3250	1630	424	73.99	233.3	0.371	0.0
3	78194	.89	178	0.	266	444	0.	0.	0.00	334.6	0.0	0.0
3	78201	1.28	300	0.	366	667	0.	0.	0.00	349.7	0.0	0.0
3	78208	1.91	551	0.	656	1207	0.	0.	0.00	291.2	0.0	0.0
3	78215	2.86	943	0.	843	1786	0.	0.	0.00	339.3	0.0	0.0
3	78222	4.17	1561	0.	1187	2748	0.	0.	0.00	351.3	0.0	0.0
3	78229	3.90	1956	0.	1204	3160	0.	0.	0.00	323.9	0.0	0.5
3	78236	4.66	2947	0.	1723	4792	123	123	0.00	270.5	0.0	1.0
3	78243	4.47	3144	0.	1772	5224	308	308	0.00	252.3	0.0	2.5
3	78250	4.44	3303	182	1631	5740	805	623	22.60	272.2	0.030	5.5
3	78257	3.99	3326	754	1568	6507	1613	859	46.75	254.5	0.116	11.1
3	78264	4.67	3657	1912	1769	8586	3161	1249	60.49	264.0	0.222	14.1
3	78271	2.83	2732	2223	1180	7144	3232	1009	68.78	239.8	0.311	13.1
3	78278	2.09	2515	2730	858	7136	3763	1033	72.55	243.6	0.383	0.5
3	78285	.47	1851	2913	170	5866	3845	932	75.76	276.5	0.497	0.8
3	78292	.09	2064	3169	34	6270	4172	1003	75.96	264.7	0.505	0.9

SBGRO940.PST (see Table 23). This file is in used by the model to match the pest population with the pest coefficients. The header must be left-justified in the columns in FILET as described in Volume 2-1 (Jones et al. 1994) of this book for FILET formats. Next, the observed population levels were placed in UFGA7802.SBT (Table 25). (Note that the populations were entered in treatments 3 and 4. During the simulation, daily populations are linearly interpolated between observations entered in this file.) Finally, the DISES option was set to 'Y' and the pest output was turned on ((DIOUT = 'Y') in the Simulation Controls section of UFGA7802.SBX, as shown in Table 26.

TABLE 26. SIMULATION CONTROL SECTION OF FILE UFGA7802.SBX SHOWING THE DISEASE SIMULATION OPTION (DISES) SET TO 'Y' TO ENABLE PEST DAMAGE SIMULATION.

```
*SIMULATION CONTROLS
@N GENERAL      NYERS NREPS START YRDAY RSEED SNAME....................
 1 GE               1     1     S 78166  2150 BRAGG, IRRIGATED & NON-IR
@N OPTIONS      WATER NITRO SYMBI PHOSP POTAS DISES
 1 OP               Y     Y     Y     N     N     Y
@N METHODS      WTHER INCON LIGHT EVAPO INFIL PHOTO
 1 ME               M     M     E     R     S     C
@N MANAGEMENT   PLANT IRRIG FERTI RESID HARVS
 1 MA               R     R     R     R     M
@N OUTPUTS      FNAME OVVEW SUMRY FROPT GROUT CAOUT WAOUT NIOUT MIOUT DIOUT  LONG
 1 OU               N     Y     Y     3     Y     Y     Y     Y     N     Y     Y
```

EXAMPLE 2 (VELVETBEAN CATERPILLAR DEFOLIATION DAMAGE IN SOYBEAN)

The experiment UFQU7902 contained two soybean treatments. An insecticide was used in the control treatment and a second treatment was not sprayed. Periodic measurements of leaf area index showed severe defoliation due to velvetbean caterpillar larva occurred in the untreated treatment. In this experiment, pest population data were not collected; however, percent defoliation measured for the damaged treatment is shown in Table 27. In this experiment, defoliation can be simulated by specifying the percent observed defoliation over time.

To simulate damage, the following steps were taken:

1. Checked to ensure that the pest was defined in the pest coefficient file (SBGRO940.PST) (see Table 23);
2. Entered the observed defoliation in FILET (UFQU7902.SBT); and
3. Set the PEST damage option to 'Y' in FILEX (UFQU7902.SBX).

The steps described in the section, "Pest Damage Data Files," were followed to add the pest observations to FILET. The PID for percent cumulative leaf area damage is PCLA. The PCPID was leaf area index, indicated by the CROPGRO leaf area index damage variable, LAD (Table 19). The PCTID selected was "2," which indicates that damage will be entered in FILET as observed defoliation. The crop model will compute the daily

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TABLE 27. PERCENT DEFOLIATION MEASURED AT DIFFERENT OBSERVATION DATES FOR THE SOYBEAN EXPERIMENT UFQU7902. DEFOLIATION OCCURRED DUE TO VELVETBEAN CATERPILLAR POPULATION; HOWEVER, THE POPULATION LEVEL WAS UNKNOWN.

Day of year	Observed defoliation,
241	0.0
248	22.6
255	56.1
262	50.0
271	52.5
276	57.1
283	57.9
288	61.7
292	53.3
295	71.4
303	100.0

damage required to obtain this level of defoliation on the observation dates. The damage coefficient is 1.0, so that the damage recorded in FILET will be directly applied to one or more variables in the model. This means that these variables in the model are proportionally reduced by the same percent as entered for these coefficients in FILET. When a damage type, such as this one, is defined, direct measures of damage are typically recorded in the time series file and the damage coefficient is set to 1.0.

A column with the header PCLA was entered in the time series file UFQU7902.SBT. Percent damage on each observation date was entered for treatment 2 as shown in Table 28. The crop model linearly interpolates between observations to obtain daily levels of observed damage. An entry of "-99" indicates that data were not available. Thus, CROPGRO skips that entry for linear interpolation of daily damage. Finally, the DISES variable in the Simulation Controls section of UFQU7902.SBX was set to 'Y' as shown in Table 26.

TABLE 28. TIME SERIES DATA FILE FOR THE SOYBEAN EXPERIMENT UFQU7902 SHOWING OBSERVED DEFOLIATION LEVELS (PCLA) RESULTING FROM VELVETBEAN CATERPILLAR DAMAGE.

*EXP.DATA (T): UFQU7902SB BRAGG, WELL IRRIGATED (defoliation)

@TRNO	DATE	LAID	SWAD	GWAD	LWAD	CWAD	PWAD	SHAD	SH%D	SLAD	PCLA
1	79234	4.15	1945	0	1214	3228	0	0	0.00	323.5	-99
1	79241	5.48	2650	0	1659	4455	132	132	0.00	327.6	-99
1	79248	5.53	3075	60	1925	5491	566	506	10.60	298.8	-99
1	79255	5.54	3509	303	1718	6755	1357	1054	15.24	293.4	-99
1	79262	5.32	3435	777	1866	7395	1988	1211	39.08	269.8	-99
1	79271	4.04	3362	1319	1481	7351	2509	1190	48.59	272.4	-99
1	79276	4.25	3103	1943	1540	7635	3013	1070	64.49	279.8	-99
1	79283	3.92	3754	2635	1659	9372	4039	1404	65.24	248.3	-99
1	79288	3.85	3601	3313	1600	9957	4883	1570	67.85	261.2	-99
1	79292	1.36	2633	3039	592	7578	4267	1228	71.22	200.6	-99
1	79295	0.54	2084	3896	148	7666	5406	1510	72.07	243.2	-99
1	79303	0.47	2388	3541	140	7345	4763	1222	74.34	241.0	-99
2	79234	5.00	-99	0	1540	-99	0.	-99	-99	-99	0.0
2	79241	5.20	-99	0	1540	-99	100	-99	-99	-99	0.0
2	79248	4.10	-99	0	1600	-99	600	-99	-99	-99	22.6
2	79255	2.50	-99	300	1096	-99	1200	-99	-99	-99	56.1
2	79262	2.70	-99	700	1185	-99	1800	-99	-99	-99	50.0
2	79271	1.90	-99	1000	859	-99	1950	-99	-99	-99	52.5
2	79276	1.80	-99	1600	948	-99	2500	-99	-99	-99	57.1
2	79283	1.50	-99	2100	740	-99	3200	-99	-99	-99	57.9
2	79288	1.30	-99	2300	592	-99	3600	-99	-99	-99	65.7
2	79292	0.70	-99	2400	266	-99	3400	-99	-99	-99	75.3
2	79295	0.20	-99	3000	88	-99	4200	-99	-99	-99	85.4
2	79303	0.00	-99	-99	0.	-99	-99	-99	-99	-99	100.0
2	79304	0.00	-99	-99	0.	-99	-99	-99	-99	-99	100.0
2	79305	0.00	-99	-99	0.	-99	-99	-99	-99	-99	100.0

EXAMPLE 3 (LEAFSPOT DISEASE IN PEANUT)

In this third example, an experiment was conducted to determine the effect of late leafspot on peanut pod yield. In the control treatment, a fungicide was sprayed following extension guidelines to obtain good control of leafspot disease throughout the growing season. In the second treatment, no leafspot control measures were taken. Observed defoliation between the control and disease treatments were taken periodically throughout the growing season. Percent diseased leaf area was also measured on each treatment. Defoliation and percent diseased leaf area for the disease treatment were recorded as shown in Table 29.

As in the previous examples, the following steps were taken to link this damage to the crop model:

1. Checked to ensure that the pest was defined in the pest coefficient file (PNGRO940.PST) (see Table 22);
2. Entered observed defoliation and percent diseased leaf area in FILET (UFGA8602.PNT); and
3. Set PEST damage option to 'Y' in FILEX (UFGA8602.PNX).

TABLE 29. OBSERVED PERCENT DEFOLIATION AND PERCENT DISEASED LEAF AREA COLLECTED FROM FIELD SCOUTING FOR THE PEANUT EXPERIMENT UFGA8602.

Days after planting(DAP)	Percent observed defoliation (PCLA)	Percent diseased leaf area (PDLA)
218	0.0	0.0
230	0.0	0.25
232	4.8	0.28
238	17.3	1.49
246	25.5	41.3
254	26.0	58.8
260	28.0	56.5
266	29.5	75.7
274	31.2	90.1
280	32.0	88.5
288	30.5	99.1
294	29.0	98.6
302	-99	100.0

The steps described in the section, "Pest Damage Data Files," were followed to add the pest observations to FILET. The PID for this damage is PDLA (see Table 22). The associated coupling point damage variable (PCPID) is also PDLA, which reduces healthy leaf area in the crop model (Table 19), and subsequently photosynthetic capacity. The damage characterization type (PCTID) is "3" since diseased leaf area is described as a percent per day.

After the two damage types were confirmed defined in the pest coefficient file (PNGRO940.PST; Table 22), the observed levels of damage were input in the time series file, UFGA8602.PNT, in columns corresponding to the four character pest identification codes PCLA and PDLA (Table 30). Daily values of damage will be generated by the model through linearly interpolating between observations. Finally, the DISES variable in the Simulation Controls section of UFGA8602.PNX was set to 'Y' to simulate pest damage in the same manner as shown in Table 26.

TABLE 30. TIME SERIES FILE FOR THE PEANUT EXPERIMENT UFGA8602 SHOWING OBSERVED LEVELS OF DEFOLIATION (PCLA) AND DISEASED LEAF AREA (PDLA) DUE TO LEAFSPOT DISEASE.

*EXP.DATA (T): UFGA8602PN RAINFED, FLORUNNER,GOOD DISEASE CONTROL

@TRNO	DATE	L#SD	PCLA	PDLA	LAID	P#AD	SWAD	GWAD	LWAD	CWAD	PWAD	ATPW	DTPW	SHAD	G#AD	HIPD	SH%D	SLAD	GWGD
1	86176	7.4	0.0	0.0	0.29	0.	85.	0.	137.	222.	0.	0.	0.	0.	0.0	0.000	0.0	215.	0.0
1	86190	10.6	0.0	0.0	1.14	0.	397.	0.	492.	889.	0.	0.	0.	0.	0.0	0.000	0.0	231.	0.0
1	86204	14.8	0.0	0.0	2.48	19.	1332.	0.	1164.	2509.	13.	13.	0.	13.	0.0	0.005	0.0	213.	0.0
1	86211	15.6	0.0	0.0	3.16	32.	1714.	0.	1526.	3306.	67.	67.	0.	67.	0.0	0.020	0.0	209.	0.0
1	86218	17.1	0.0	0.0	5.52	226.	3049.	56.	2248.	5545.	248.	248.	0.	192.	67.5	0.045	20.7	246.	83.0
1	86230	21.0	0.0	0.0	5.64	273.	3411.	264.	2440.	6528.	678.	678.	0.	414.	197.1	0.104	36.1	231.	133.9
1	86232	21.8	0.0	0.0	6.50	461.	4052.	486.	2640.	7683.	990.	990.	0.	504.	331.6	0.129	48.8	246.	146.6
1	86238	23.3	0.0	0.0	7.34	468.	4696.	900.	3153.	9322.	1474.	1474.	0.	574.	400.8	0.158	60.6	232.	224.6
1	86246	25.0	0.0	0.02	7.55	630.	4572.	1449.	3078.	9812.	2162.	2162.	0.	713.	519.3	0.220	67.0	246.	279.0
1	86254	26.5	0.0	0.0	7.75	797.	5073.	2375.	3457.	11958	3429.	3429.	0.	1054.	684.2	0.287	69.3	225.	347.1
1	86260	28.8	0.0	0.08	6.85	583.	4548.	2477.	2966.	10896	3381.	3381.	0.	904.	724.2	0.310	73.0	231.	342.0
1	86266	27.0	0.0	0.01	8.06	860.	5568.	3492.	3640.	13850	4642.	4642.	0.	1150.	868.8	0.335	75.6	221.	401.9
1	86274	29.0	0.0	0.06	6.75	694.	4764.	3343.	2903.	12108	4450.	4440.	10.	1097.	760.0	0.367	75.2	232.	439.9
1	86280	28.0	0.0	0.07	4.53	602.	5076.	4168.	2030.	12512	5416.	5405.	11.	1237.	833.8	0.432	77.1	223.	499.9
1	86288	29.8	0.0	0.13	4.67	794.	5438.	4413.	2223.	13189	5687.	5528.	159.	1115.	869.9	0.419	79.6	210.	507.3
1	86294	31.5	0.0	0.57	4.85	640.	5530.	4289.	2644.	13477	5683.	5503.	180.	1214.	808.4	0.408	77.9	183.	530.6
1	86302	30.5	0.0	0.15	4.57	604.	5667.	4638.	2342.	13748	6190.	5739.	451.	1101.	861.0	0.417	80.8	196.	526.4
2	86176	7.6	0.0	0.0	0.29	0.	85.	0.	137.	222.	0.	0.	0.	0.	0.0	0.000	0.0	215.	0.0
2	86190	10.8	0.0	0.0	1.14	0.	397.	0.	492.	889.	0.	0.	0.	0.	0.0	0.000	0.0	231.	0.0
2	86204	14.3	0.0	0.0	2.45	12.	1366.	0.	1165.	2538.	7.	7.	0.	7.	0.0	0.003	0.0	211.	0.0
2	86211	15.6	0.0	0.0	4.03	247.	1940.	0.	1662.	3692.	90.	90.	0.	90.	0.0	0.024	0.0	243.	0.0
2	86218	16.8	0.0	0.0	5.28	224.	2933.	33.	2253.	5421.	235.	235.	0.	232.	37.0	0.043	12.8	235.	89.2
2	86230	21.7	0.0	0.25	6.18	378.	3767.	436.	2513.	7217.	937.	937.	0.	501.	281.0	0.130	45.0	245.	155.2
2	86232	21.8	4.8	0.28	6.02	365.	3832.	419.	2503.	7229.	895.	895.	0.	475.	293.6	0.124	46.4	241.	142.7
2	86238	23.7	17.3	1.49	5.94	549.	4106.	915.	2608.	8269.	1554.	1554.	0.	639.	431.8	0.188	59.0	228.	211.9
2	86246	25.5	41.3	4.22	4.24	552.	4616.	1438.	1807.	8438.	2015.	2015.	0.	577.	487.3	0.239	71.0	235.	295.1
2	86254	26.0	58.8	5.05	2.34	627.	4872.	1933.	1076.	8486.	2538.	2538.	0.	605.	523.2	0.299	76.2	218.	369.4
2	86260	28.0	56.5	4.77	2.10	564.	4161.	2588.	995.	8568.	3412.	3412.	0.	824.	646.7	0.398	75.8	211.	400.2
2	86266	29.5	75.7	4.15	1.75	786.	5448.	2973.	886.	10224	3890.	3890.	0.	917.	705.4	0.380	76.5	197.	421.5
2	86274	31.2	90.1	4.88	0.52	454.	3732.	2921.	270.	7664.	3718.	3662.	56.	741.	588.1	0.478	79.6	190.	396.7
2	86280	32.0	88.5	9.17	0.40	706.	3804.	3477.	234.	8355.	4409.	4316.	93.	839.	741.2	0.516	80.7	173.	469.1
2	86288	30.5	99.1	7.89	0.04	394.	3473.	2300.	19.	6258.	3876.	2766.	1110.	466.	441.0	0.442	83.2	188.	521.5
2	86294	29.0	98.6	0.0	0.04	342.	3241.	2195.	36.	5926.	4439.	2649.	1790.	454.	404.5	0.447	82.8	94.	542.6
2	86302	0.0	100.0	0.0	0.00	17.	3087.	111.	0.	3223.	2538.	1[illegible]6.	2402.	25.	22.9	0.042	62.[illegible]	0.	484.7

APPENDIX C.
RUNNING MODELS UNDER THE DSSAT V3 SHELL AND AS STAND-ALONE EXECUTABLES

RUNNING UNDER THE DSSAT V3 SHELL

When running the models under the DSSAT v3 Shell (see Volume 1-3, Hunt et al. 1994, of this book, for a description of the Shell), the location of the various files are obtained from a file-locator file in the DSSAT v3 directory named DSSATPRO.FLE (see the Appendix to Volume 1 for a listing of this file). Each crop model is designed to first check the local directory (from where the model is run) for input files. If it does not find them in the local path, the model modules will open the DSSATPRO.FLE file to find the path of soil, weather, and crop coefficient files. Table 31 lists the various modules and files required for running the crop models and the default paths for running them under DSSAT the DSSAT v3 Shell. Note, however, that DSSAT v3 users can change these paths through the SETUP menu found under the DSSATv3 Shell (Volume 1-3, Hunt et al. 1994).

TABLE 31. SUGGESTED ORGANIZATION OF FILES FOR EXECUTION OF CROP MODELS UNDER THE DSSAT V3 SHELL, USING CROPGRO-SOYBEAN AS AN EXAMPLE.

Path	Module or File Type	File Name
C:\DSSAT3	Model Driver Module	MDRIV940.EXE
C:\DSSAT3	Model Input Module	MINPT940.EXE
C:\DSSAT3	Model Executable Module	CRGRO940.EXE
C:\DSSAT3	Graphic Program	WINGRAF.EXE
C:\DSSAT3	Variable Definition File	DATA.CDE
C:\DSSAT3	File Containing Paths	DSSATPRO.FLE
C:\DSSAT3\GENOTYPE	Crop Cultivar Coefficient File	SBGRO940.CUL
C:\DSSAT3\GENOTYPE	Crop Species Coefficient File	SBGRO940.SPE
C:\DSSAT3\GENOTYPE	Crop Ecotype Coefficient File	SBGRO940.ECO
C:\DSSAT3\SOIL	Soil Data File	SOIL.SOL
C:\DSSAT3\WEATHER	Weather Data Files	UFGA7801.WTH
C:\DSSAT3\SOYBEAN	Management Inputs (FILEXs)	UFGA7801.SBX
C:\DSSAT3\SOYBEAN	Observed Field Data (Averages)	UFGA7801.SBA
C:\DSSAT3\SOYBEAN	Observed Field Data (Seasonal)	UFGA7801.SBT
C:\DSSAT3\SOYBEAN	List of Experiments	EXP.LST
C:\DSSAT3\SOYBEAN	List of Available Weather Data	WTH.LST
C:\DSSAT3\SOYBEAN	Model Output Files	GROWTH.OUT, etc.

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Running as Stand-alone Executables

When running the DSSAT v3 crop models in stand-alone mode, all input and output data files are stored in one directory on a disk, and the executable modules are stored in a separate disk directory. One could also combine all executables with the input and output data. Table 32 lists the different files needed to run the crop models in a stand-alone mode and a suggested path structure. The example files are listed for soybean using the CROPGRO module, however a similar structure could be used for other models.

Table 32. Suggested Organization of Files for Stand-alone Execution of Crop Models, Using CROPGRO-Soybean as an Example.

Path	Module or File Type	File Name
C:\CROPGRO	Model Driver Module	MDRIV940.EXE
C:\CROPGRO	Model Input Module	MINPT940.EXE
C:\CROPGRO	Model Executable Module	CRGRO940.EXE
C:\CROPGRO	Graphic Program	WINGRAF.EXE
C:\CROPGRO	Variable Definition File	DATA.CDE
C:\CROPGRO	Batch File to Run Crop Model	GRO.BAT
C:\CROPGRO	Batch File to Run Graphics	GRAPH.BAT
C:\CROPGRO\SOYBEAN	Soil Data File	SOIL.SOL
C:\CROPGRO\SOYBEAN	Weather Data Files	UFGA7801.WTH
C:\CROPGRO\SOYBEAN	Management Inputs (FILEXs)	UFGA7801.SBX
C:\CROPGRO\SOYBEAN	Observed Field Data (Averages)	UFGA7801.SBA
C:\CROPGRO\SOYBEAN	Observed Field Data (Seasonal)	UFGA7801.SBT
C:\CROPGRO\SOYBEAN	List of Experiments	EXP.LST
C:\CROPGRO\SOYBEAN	List of Available Weather Data	WTH.LST
C:\CROPGRO\SOYBEAN	Crop Cultivar Coefficient File	SBGRO940.CUL
C:\CROPGRO\SOYBEAN	Crop Species Coefficient File	SBGRO940.SPE
C:\CROPGRO\SOYBEAN	Crop Ecotype Coefficient File	SBGRO940.ECO
C:\CROPGRO\SOYBEAN	Model Output Files	GROWTH.OUT, etc.

APPENDIX D.
CONTACTS FOR CROP MODEL INFORMATION

CROP MODEL DRIVER AND CROP MODEL INPUTS PROGRAM

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GRAPHING SIMULATED & EXPERIMENT DATA

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CHAPTER ONE. INTRODUCTION

A graphics program was written for DSSAT v3 to provide users with the capability to easily plot graphs that are routinely used during the development and validation of crop models. This program, called Graphing Simulated and Experiment Data, or Wingraf, adheres to the file definitions and data formats of DSSAT v3 described in Volume 2-1 (Jones et.al 1994) of this book. It is similar in operation to the graphics package in DSSAT v2.1 (IBSNAT 1989), but with notable functional and operational differences. Functionally, it allows users to plot time series graphs, Y versus X graphs, (such as grain weight vs. biomass), end of season responses (such a as yield vs. irrigation amount), and observed vs. simulation crop performance relationships for validation purposes. Operationally, users can use a mouse or keyboard commands to select variables. They can print the graph or save it to a file, change screen colors and graph scales, and create combinations of graphs that were not possible in v2.1.

The basic design of Wingraf is based on a set of codes that are used as headers over each column of data. For example, a simulated results data file may have a column of data with a header LAID, which refers to time-course values of leaf area index (LAI). If there is a corresponding field observation data file, the Wingraf program will search that file for a column of data with LAID as a header. It will then display a plot of LAI vs. time, with simulated data graphed by connecting points and observed data plotted by symbols. If the program does not find LAID in the observed data file, it will just plot simulated results. It can also be used to plot experimental data only.

A set of codes for crop, soil, and weather data are included with DSSAT v3 (see Appendix C of Volume 2-1, Jones et al. 1994, of this book for a listing of these codes). Note that these codes (left column) are followed by a short description which is used to label graphs, and a longer description with units. These codes are not rigid. Users may add their own codes and definitions to the file named DATA.CDE (see Appendix C of Volume 2-1, Jones et al. 1994, of this book), and Wingraf will correctly label any data that has this new code as a header. Note, however, that the DSSAT v3 crop models use the codes as defined in Appendix C of Volume 2-1 (Jones et al. 1994) of this book. If other crop models use other codes, this file could be changed accordingly.

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CHAPTER TWO. PROGRAM OVERVIEW

GUIDELINES

GENERAL

Wingraf was developed to run under the DSSAT v3 Shell (see Volume 1-3, Hunt et al. 1994, of this book) or as a stand-alone program (see note below). It uses TurboVision[1] for the user interface routines. The user interfaces with the program via menus and dialog boxes and the program displays information via windows. Wingraf supports the use of a mouse, provided a mouse driver has been loaded prior to the execution of this program. Both mouse and keyboard commands can be used in Wingraf, but the user interface is most easily exploited by the use of the mouse, and as such, examples cited in this Part refer to mouse actions. If using a keyboard, however, nearly all menu choices may be selected by use of the <ALT> key as well as with the highlighted letter of the menu option. The <TAB> and <SHIFT><TAB> keys can be used for moving through choices in dialog boxes.

NOTE: *When running Wingraf as a stand-alone program, the options to execute the program are as follows:*

1. *If running Wingraf under the Wingraf program directory, type "WINGRAF".*
2. *If running Wingraf under the data file directory, type "\DSSAT3\WINGRAF" at the DOS System C> prompt.*
3. *If the Wingraf program directory is included in the system's PATH, type "WINGRAF" at the DOS System C> prompt.*

SCREEN "BUTTONS"

In all Wingraf screens, where multiple buttons are available (e.g., the OK button in Screen 1, on following page, or the PREVIOUS, NEXT, X VARIABLE, GRAPH, RESET, OPTION buttons in Screen 3 in Chapter 3), you may "press" these by one of two methods:

1) If using a mouse, click on the button.
2) If using the keyboard, highlight the button using the <TAB> and <SHIFT> <TAB> keys and then press the <ENTER> key.

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[1] TurboVision is a registered trademark of Borland International, Inc.

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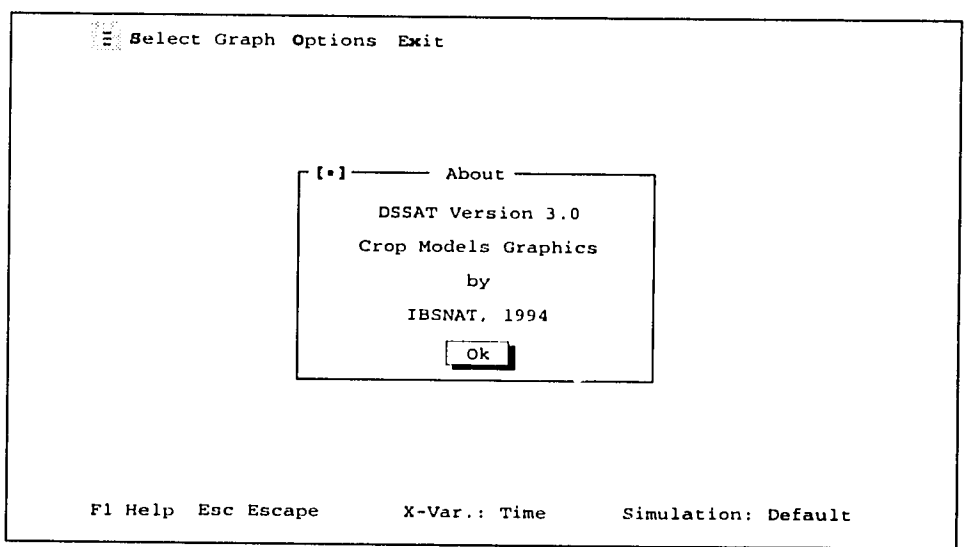
MENU STRUCTURE

The Wingraf main menu options are selected by a single click with a mouse on a menu choice, which will either execute an action, present a submenu, or display a dialog box requiring further user input. From the keyboard, use the arrow keys to move through and highlight the main menu items. Press the <ENTER> key when the menu item you wish to open is highlighted.

Selecting the "≡" symbol in the upper left corner of the Wingraf main menu display, allows you to exit Wingraf, or alternatively, to display the "About" screen (Screen 1, below).

A context-sensitive help function is provided throughout the entire program. The <F1> key invokes the help system.



SCREEN 1

HARDWARE

Wingraf requires a minimum configuration of a 286SX or better processor running EMM386 with expanded memory with a math-coprocessor. DOS version 5.0 or higher is recommended. Wingraf requires 640K of random access memory (RAM), with a minimum of 420K free RAM running under the DSSAT v3 Shell. Wingraf supports most text and graphics display modes, but VGA color is recommended for clarity. In addition, if hardcopy output is needed, a supported printer is required.

CHAPTER THREE. EXECUTE PROGRAM

Wingraf can be accessed through the DSSAT v3 Shell under three different entry points. To display graphs of measurements made within the growing season (time series graphs) and summary responses, open the Wingraf program under the Shell's DATA main menu item. To do this, highlight DATA and then select the "X Experiment" option by using the mouse, pressing the <X> key or by moving the highlight bar with the arrow keys to the"X Experiment" option and pressing the <ENTER> key. From the "X Experiment" menu, select the "Utilities" option. A list of three menu options will be presented. Select the "G Graph" menu option and then select a crop from the window that is presented. The Wingraf main menu screen will be presented (see Screen 2 in Chapter 4).

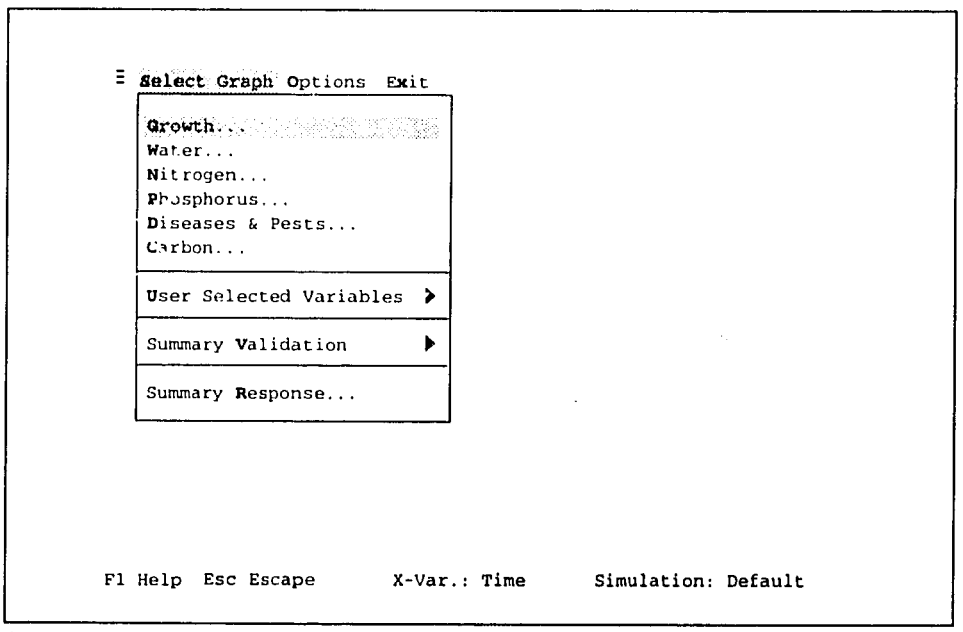
To plot simulated and experimental data, open Wingraf under the Shell's MODEL main menu item. Please note that you must first run one of the DSSAT v3 crop models listed under the MODEL menu item before using the Wingraf program or no simulated data will be available for graphing.

Wingraf is found in two places under the MODEL main menu item. The first can be found by selecting the "O Other" item from the list of options in the pull-down MODEL menu. Select this item and a submenu of various options is presented, including "G Graph." Select "G Graph" to open Wingraf. Alternatively, after selecting one of the crop models in the MODEL pull-down menu, a third tier menu is presented, which includes "G Graph." Again, select "G Graph" to open Wingraf.

When "G Graph" is selected from these selection points, the Wingraf main menu screen is presented (see Screen 2 in Chapter 4). The top line of this screen, with SELECT GRAPH, OPTIONS and EXIT, is the menu bar. Each item in this menu bar has a related pull-down menu. To access these menus, click on the menu item with the mouse and the pull-down menus will be presented. With the keyboard, use the arrow keys to move through the menu bar and the pull-down menus under each will be presented. To select items in these menus, either click on one with the mouse, use the arrow keys to highlight an item in the pull-down menu and press the <ENTER> key or press the first letter of the item. For example, press <G> to open "Growth" under the Select Graph menu bar item.

CHAPTER FOUR. GRAPH MENU

Under the SELECT GRAPH menu item are displayed the primary plotting functions in Wingraf (Screen 2, below). Growth, water, nitrogen, diseases and pests, and carbon output files are directly supported and use the DSSAT v3 standard output files, GROWTH.OUT, WATER.OUT, NITROGEN.OUT, PEST.OUT, and CARBON.OUT, respectively. The phosphorus option is included for compatibility with future model outputs.



SCREEN 2.

GROWTH, WATER, NITROGEN, PHOSPHORUS, DISEASES & PESTS, CARBON OPTIONS

Selecting one of these options enables the user to plot a graph for the selected function. The screens presented when any one of these options is selected are similar. Thus, the screens for "Growth" will be used for illustration. When the "Growth"option is selected, Screen 3, on the following page, is presented.

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```
Select Graph Options Exit
[▪]                                GROWTH
Variables                                  Run Numbers
[ ] Leaf number per stem                   [X] IRRIGATED
[ ] Growth stage                           [X] NON - IRRIGATED
[ ] Leaf area index
[X] Leaf dry weight (kg/ha)
[ ] Stem dry weight (kg/ha)
[X] Grain dry weight (kg/ha)
[ ] Root dry weight (kg/ha)
[X] Crop dry weight (kg/ha)
[ ] Grain number (no/m2)
[ ] Grain dry weight (mg/grain)
[ ] Harvest index (grain/top)
[ ] Pod dry weight (kg/ha)
[ ] Pod number (no/m2)
[ ] Photo water stress factor (0-1)
[ ] Growth Water stress factor (0-1)
[ ] Nitrogen stress factor (0-1)

 Previous   Next   X Variable   Graph   Reset   Option

F1 Help  Esc Escape        X-Var.: Time        Simulation: Default
```

SCREEN 3.

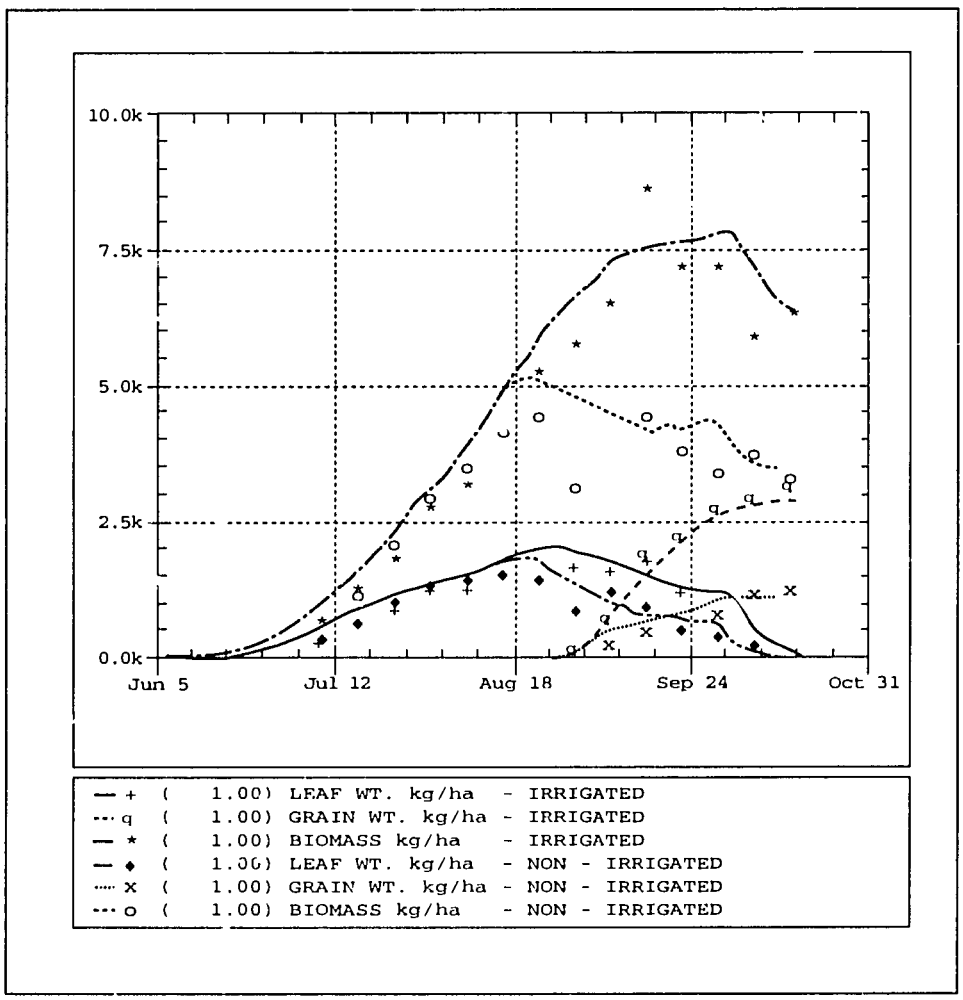
SELECTING PLOTS

In Screen 3, users may select up to 6 plots for each graph. These six plots may be one variable with six runs, six variables with one run, or any combination of variables and runs up to 6. Selecting the RESET button will reset all current selections.

In example Screen 3, two variables, "Leaf dry weight (kg/ha)" and "Crop dry weight (kg/ha)," have been selected and two runs, "IRRIGATED" and "NON-IRRIGATED."

Pressing the GRAPH button displays the graph of these variables and runs (see Screen 4, on following page).

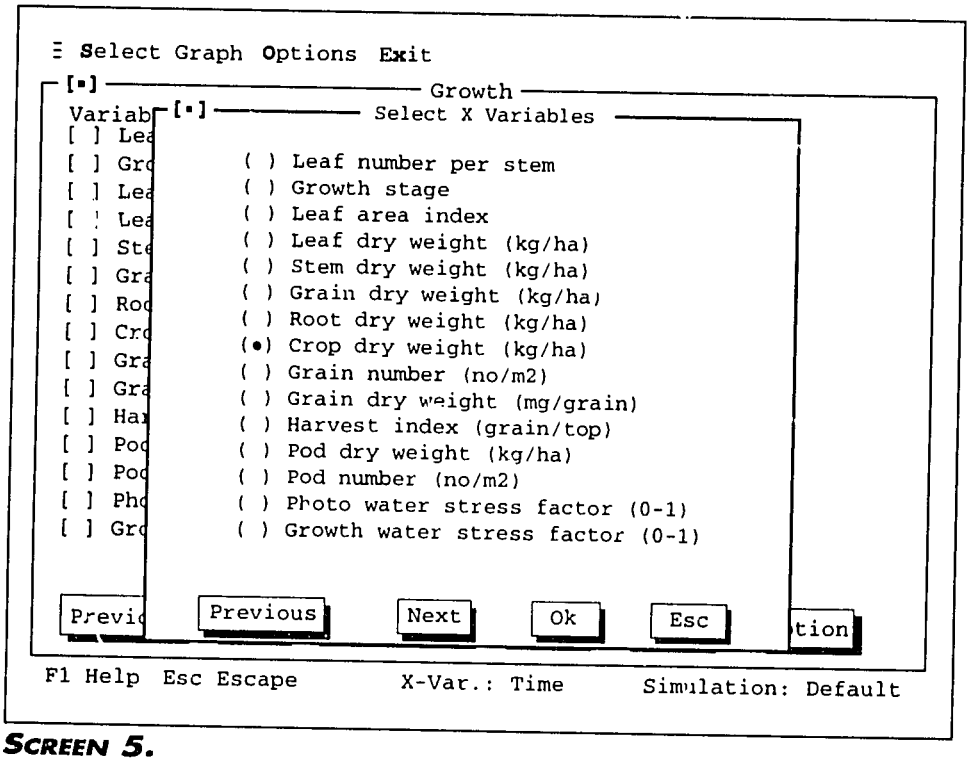
NOTE: The OPTION button on the status line in Screen 3 is grayed out and will not be selectable until the first graph has been plotted.



SCREEN 4.

X-VARIABLE

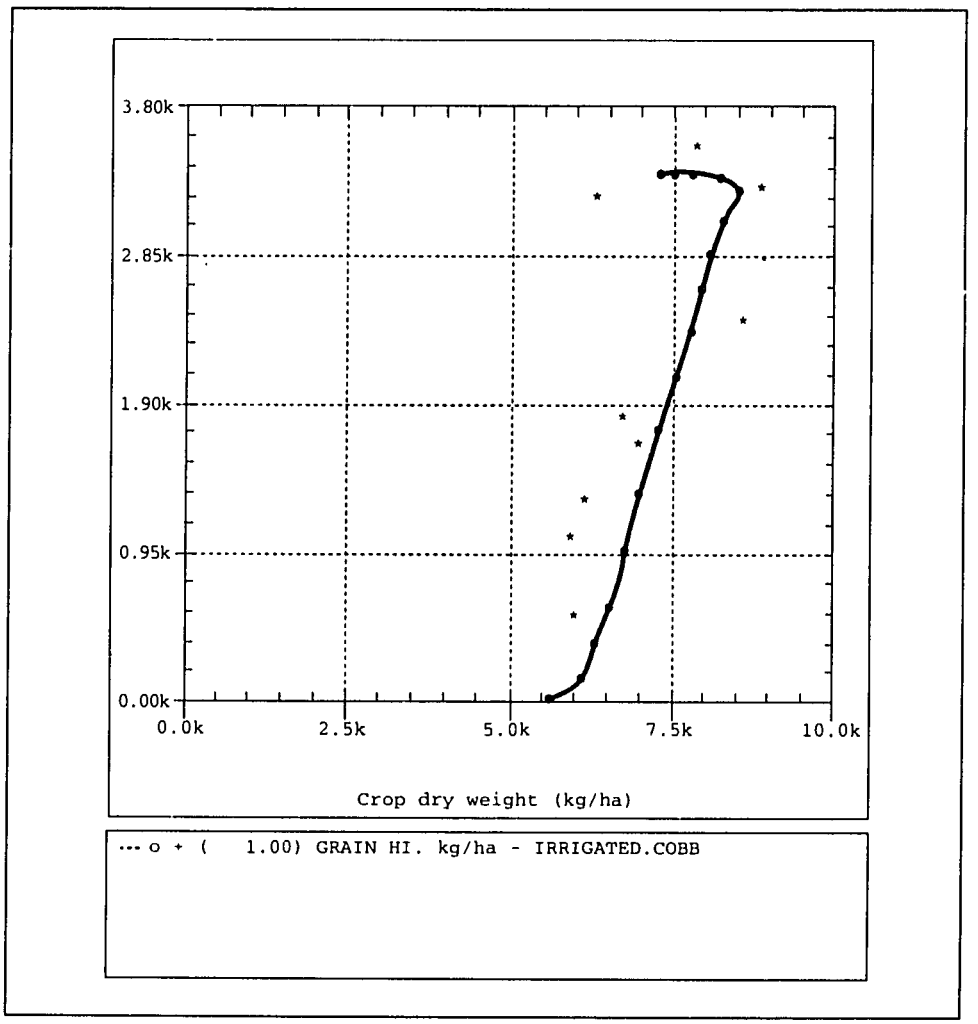
The default setting for graph plotting is the variables selected (for example, those selected in Screen 3) versus time. Users can specify an X-variable other than "time" by pressing the X VARIABLE button (see Screen 3). Screen 5, on the following page, will be presented.



SCREEN 5.

In Screen 5, the X-variable, "Crop dry weight," has been selected. Pressing the OK button in this screen, will display this variable next to "X-Var:" on the status line in Screen 3. Pressing the GRAPH button in Screen 3 will display this case of Y vs X, as shown in Screen 6, on the following page.

To reset the X variable back to time, select the X VARIABLE button again and press the <ESC> key.



SCREEN 6.

OPTION "BUTTON"

Once a graph has been plotted for selected variables, the OPTION button on the status line (see Screen 3) will no longer be grayed out and will be selectable.

Functions under the OPTION button (see Screen 7, on following page) allow a user to make necessary modifications to the current graph.

"Display Graph Again" will display the modified graph again.

"Change Min/Max" allows the parameters for the X and Y axes to be changed (see Screen 8, on following page).

```
Select Graph Options Exit
[•] ------------------------ GROWTH ------------------------
Variables                          Run Numbers
[X] Leaf number per stem           [X] IRRIGATED
[X] Growth stage                   [X] NON-IRRIGATED
[X] Leaf area index
[ ] Leaf dry weight (kg/ha)
[ ] Stem dry weight (kg/ha)
[ ] Grain dry weight (kg/ha)
[ ] Root dry weight (kg/ha)
[ ] Crop dry weight (kg/ha)
[ ] Grain number (no/m2)
[ ] Grain dry weight (mg/grain)
[ ] Harvest index (grain/top)
[ ] Pod dry weight (kg/ha)
[ ] Pod number (no/m2)
[ ] Photo water stress factor (0-1)
[ ] Growth Water stress factor (0-1)

Display Graph Again    F7
Change Min/Max...
Modify Multipliers...
Grid ON                F4
Output Graph           F8
Print Graph Data       F9

Previous  Next  X Variable  Grap

F1 Help  Esc Escape        X-Var.: Time        Simulation: Default
```

SCREEN 7.

"Modify Multipliers" allows the user to modify the default multiplication factor for each plot (see Screen 9, on following page). Altering multipliers allows variables of widely disparate scaling to be shown on the same graph.

"Grid ON" toggles the plotting of grid lines On/Off.

```
Select Graph Options Exit
[•] ------------------------ GROWTH ------------------------
Variables                          Run Numbers
[X] Leaf number per stem           [X] IRRIGATED
[X] Grow [•] ---------- Change Min. & Max. ----------
[X] Leaf
[ ] Leaf
[ ] Stem   Min X:      160.0000     Max X:      309.0000
[ ] Grai
[ ] Root   Min Y:        0.0000     Max Y:       16.0000
[ ] Crop
[ ] Grai
[ ] Grai
[ ] Harv
[ ] Pod
[ ] Pod                 Ok          Esc
[ ] Phot
[ ] Grow

Previous  Next  X Variable  Graph  Reset  Option

F1 Help  Esc Escape        X-Var.: Time        Simulation: Default
```

SCREEN 8.

```
Select Graph Options Exit
[•]                                GROWTH
Variabl [•]          Change Multipliers
[X] Lea
[X] Gro
[X] Lea        Multiplier #1:                1.00
[ ] Lea
[ ] Ste        Multiplier #2:                1.00
[ ] Gra
[ ] Roo        Multiplier #3:                1.00
[ ] Cro
[ ] Gra        Multiplier #4:                1.00
[ ] Gra
[ ] Har        Multiplier #5:                1.00
[ ] Pod
[ ] Pod        Multiplier #6:                1.00
[ ] Pho
[ ] Gro                 Ok          Esc

Previous  Next  X Variable  Graph  Reset  Option
F1 Help  Esc Escape        X-Var.: Time       Simulation: Defaul
```

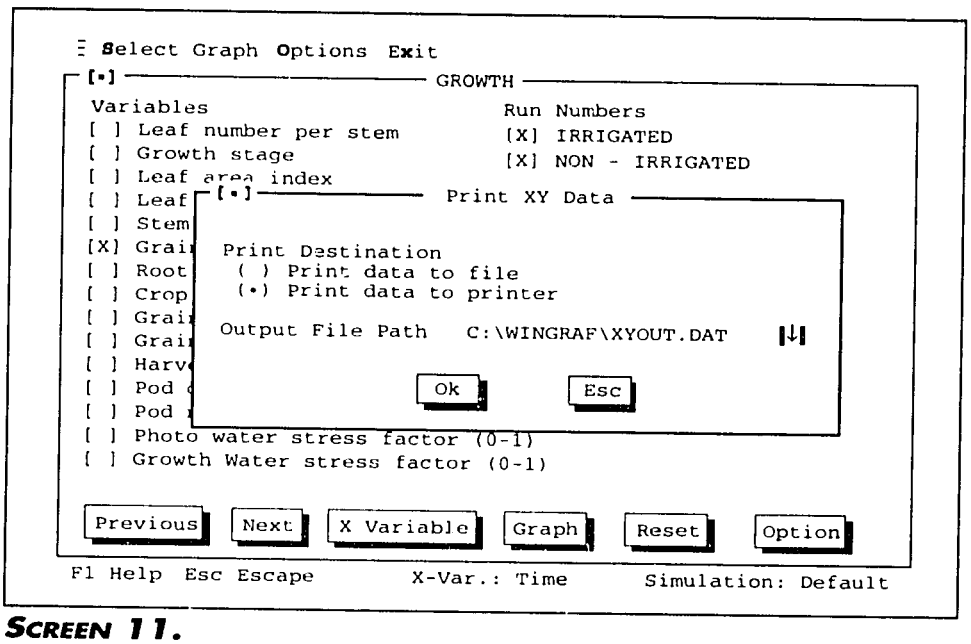
SCREEN 9.

"Output Graph" allows the user to output the current graph to either a printer or a disk file (see Screen 10, below).

```
Select Graph Options Exit
[•]                                GROWTH
Variables                          Run Numbers
[X] Leaf number per stem           [X] IRRIGATED
[X] Growth stage                   [X] NON - IRRIGATED
[X] Leaf area index
[ ] Leaf dry weight (kg/ha)
[ ] Stem dry wei [•]          Confirm
[ ] Grain dry we
[ ] Root dry wei        Output: Screen Dump
[ ] Crop dry wei        Device: HP Laser Jet
[ ] Grain number             Port: LPT1
[ ] Grain dry we
[ ] Harvest inde
[ ] Pod dry weig        Ok          Cancel
[ ] Pod number (
[ ] Photo water
[ ] Growth Water stress factor (0-1)

Previous  Next  X Variable  Graph  Reset  Option
F1 Help  Esc Escape        X-Var.: Time       Simulation: Default
```

SCREEN 10.

"Print Graph Data" allows the user to send the current plot data (and observed data, if present) to the printer or a disk file (see Screen 11, below) in an X-Y format (see Table 1 for an example file of the plot data).



SCREEN 11.

TABLE 1. EXAMPLE FILE OF SIMULATED AND OBSERVED DATA USED TO PLOT THE GRAPH FOR THE GROWTH VARIABLE, "GRAIN DRY WEIGHT" (GWAD).

-------SIMULATED DATA--------				-------OBSERVED DATA--------			
@Day	GWAD	Day	GWAD	Day	GWAD	Day	GWAD
@ X1	Y1	X2	Y2	OX1	OY1	OX2	OY2
166	0.000	166	0.000	194	0.000	194	0.000
169	0.000	169	0.000	201	0.000	201	0.000
172	0.000	172	0.000	208	0.000	208	0.000
175	0.000	175	0.000	215	0.000	215	0.000
178	0.000	178	0.000	222	0.000	222	0.000
181	0.000	181	0.000	229	0.000	229	0.000
184	0.000	184	0.000	236	0.000	236	0.000
187	0.000	187	0.000	243	0.000	243	0.000
190	0.000	190	0.000	250	182.000	250	42.000
193	0.000	193	0.000	257	754.000	257	253.000
196	0.000	196	0.000	264	1912.000	264	471.000
199	0.000	199	0.000	271	2223.000	271	775.000
202	0.000	202	0.000	278	2730.000	278	782.000
205	0.000	205	0.000	285	2913.000	285	1149.000
208	0.000	208	0.000	292	3169.000	292	1206.000
211	0.000	211	0.000				
214	0.000	214	0.000				
217	0.000	217	0.000				
220	0.000	220	0.000				
223	0.000	223	0.000				
226	0.000	226	0.000				
229	0.000	229	0.000				
232	0.000	232	0.000				
235	0.000	235	0.000				
238	0.000	238	0.000				
241	0.000	241	0.000				
244	0.000	244	0.000				
247	29.000	247	29.000				
250	142.000	250	128.000				
253	323.000	253	261.000				
256	580.000	256	418.000				
259	938.000	259	556.000				
262	1290.000	262	634.000				
265	1589.000	265	689.000				
268	1870.000	268	779.000				
271	2127.000	271	836.000				
274	2314.000	274	940.000				
277	2549.000	277	1031.000				
280	2695.000	280	1070.000				
283	2764.000	283	1098.000				
286	2836.000	286	1118.000				
289	2872.000	289	1129.000				
292	2891.000						
294	2899.000						

USER-SELECTED VARIABLES OPTION

When this option is selected, a submenu with two menu items is presented. These allow you to create a file for graph plotting and to define your own list of variables for graphing.

DEFINE

With this menu item, users can create a file for graph plotting provided the file format follows the output file format specified in Part 1 of this Volume (Volume 2-1, Jones et al. 1994). A user-defined file may contain many of the predefined variables in DATA.CDE (see Appendix C of Volume 2-1, Jones et al. 1994). If additional variables are to be plotted, the user may append variable codes and definitions to the DATA.CDE file.

USER-SELECTED

With this menu item, users can select their own variables from those found in the GROWTH, WATER, NITROGEN, DISEASES, PESTS, and CARBON output files. When this item is selected, a window similar to Screen 12, below, is presented. Screen 12 is an example screen showing the list of variables for the GROWTH output file. The right-hand lists presents the Wingraf default GROWTH variables. The list on the left

```
Select Graph Options Exit
[•]──────────────── User-Selected - (GROWTH) ────────────────
Variables                                User-Selected
[ ] Leaf number per stem                 [ ] Leaf area index
[ ] Growth stage                         [ ] Leaf dry weight (kg/ha)
[X] Leaf area index                      [ ] Avg plant transpiriation (mm/d)
[X] Leaf dry weight (kg/ha)              [ ] Avg evapotranspiriation (mm/d)
[ ] Stem dry weight (kg/ha)              [ ] Avg potential evapotr (mm/d)
[ ] Grain dry weight (kg/ha)             [ ] P in grain (%)
[ ] Root dry weight (kg/ha)              [ ] Lable P Pool (kg/ha)
[ ] Crop dry weight (kg/ha)              [ ] Active P Pool (kg/ha)
[ ] Grain number (no/m2)                 [ ] Stable P Pool (kg/ha)
[ ] Grain dry weight (mg/grain)          [ ] Percent C in leaf (%)
[ ] Harvest index (grain/top)            [ ] Percent C in stem (%)
[ ] Pod dry weight (kg/ha)
[ ] Pod number (no/m2)
[ ] Photo water stress factor (0-1)
[ ] Growth Water stress factor (0-1)

      Previous     Next     Ok     Esc     Reset

F1 Help  Esc Escape        X-Var.: Time        Simulation: Default
```

SCREEN 12.

presents GROWTH output variables which the user may select. After defining the variable list, by putting an "x" beside those variables to be used, users may plot graphs of variables from different variable groups. In this way, key variables from different output files can be displayed simultaneously.

SUMMARY VALIDATION OPTION

This option allows you to visually compare simulated and measured results for a given experiment. Two options are available for summary validations (Screen 13. below). In each case, the model output file, OVERVIEW.OUT, is used.

```
Select Graph Options Exit

Growth...
Water...
Nitrogen...
Phosphorus...
Diseases & Pests...
Carbon...

User Selected Variables ▶

Summary Validation ▶

Single plotting...
Double plotting...

F1 Help  Esc Escape        X-Var.: Time        Simulation: Default
```

SCREEN 13.

SINGLE PLOTTING

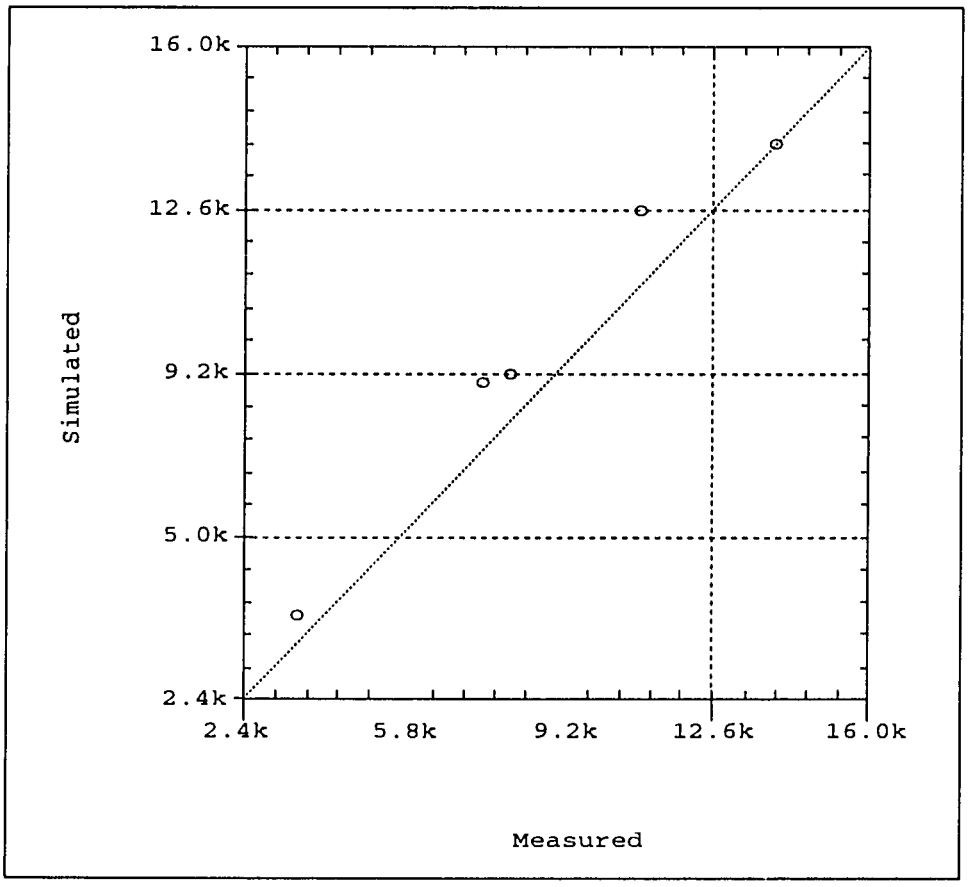
Use "Single Plotting" to select one, and only one, of the variables listed when this menu item is selected (see Screen 14, on following page) for simulated versus observed data plotting. Observed data would be those found in FILEA (see Volume 2-1, Jones et al. 1994, for a description of this file) for a particular experiment. For example, FILEA for experiment UFGA8601.SBX, would be file, UFGA8601.SBA.

When "Single Plotting" is selected, Screen 14 (on following page) is presented.

```
Select Graph Options Exit
[•]                          OVERVIEW
Variables
( ) ANTHESIS DATE (dap)
( ) FIRST PEG / POD (dap)
( ) FIRST SEED (dap)
( ) PHYSIOLOGICAL MATURITY (dap)
( ) POD YIELD (kg/ha)
(•) SEED YIELD (kg/ha)
( ) SHELLING PERCENTAGE (%)
( ) WEIGHT PER SEED (g)
( ) SEED NUMBER (SEED/m2)
( ) SEEDS/POD
( ) MAXIMUM LAI (m2/m2)
( ) BIOMASS (kg/ha) AT ANTHESIS
( ) BIOMASS N (kg N/ha) AT ANTHESIS
( ) BIOMASS (kg/ha) AT HARVEST MAT.
( ) STALK (kg/ha) AT HARVEST MAT.

 Previous    Next    Graph    Reset    Option
F1 Help  Esc Escape                Simulation: Default
```

SCREEN 14.

In Screen 14, "Seed Yield," has been selected as the variable to be plotted for simulated vs. observed (or measured). Pressing the GRAPH button will display this graph, as shown in Screen 15, on following page.



SCREEN 15.

DOUBLE PLOTTING

Use "Double Plotting" to select only one X and only one Y variable of the variables listed when this menu item is selected (see Screen 16, on following page) for X vs. Y plotting.

```
≡ Select Graph Options Exit
[▪]──────────────────── OVERVIEW ────────────────────
X Variables                          Y Variables
[ ] ANTHESIS DATE (dap)              [ ] ANTHESIS DATE (dap)
[ ] FIRST PEG / POD (dap)            [ ] FIRST PEG / POD (dap)
[ ] FIRST SEED (dap)                 [ ] FIRST SEED (dap)
[ ] PHYSIOLOGICAL MATURITY (dap)     [ ] PHYSIOLOGICAL MATURITY (dap)
[ ] POD YIELD (kg/ha)                [ ] POD YIELD (kg/ha)
[X] SEED YIELD (kg/ha)               [X] SEED YIELD (kg/ha)
[ ] SHELLING PERCENTAGE (%)          [ ] SHELLING PERCENTAGE (%)
[ ] WEIGHT PER SEED (g)              [ ] WEIGHT PER SEED (g)
[ ] SEED NUMBER (SEED/m2)            [ ] SEED NUMBER (SEED/m2)
[ ] SEEDS/POD                        [ ] SEEDS/POD
[ ] MAXIMUM LAI (m2/m2)              [ ] MAXIMUM LAI (m2/m2)
[ ] BIOMASS (kg/ha) AT ANTHESIS      [ ] BIOMASS (kg/ha) AT ANTHESIS
[ ] BIOMASS N (kg N/ha) AT ANTHESIS  [ ] BIOMASS N (kg N/ha) AT ANTHESIS
[ ] BIOMASS (kg/ha) AT HARVEST MAT.  [ ] BIOMASS (kg/ha) AT HARVEST MAT.
[ ] STALK (kg/ha) AT HARVEST MAT.    [ ] STALK (kg/ha) AT HARVEST MAT.

   Previous     Next     Graph     Reset     Option

F1 Help  Esc Escape        X-Var.: Time        Simulation: Default
```

SCREEN 16.

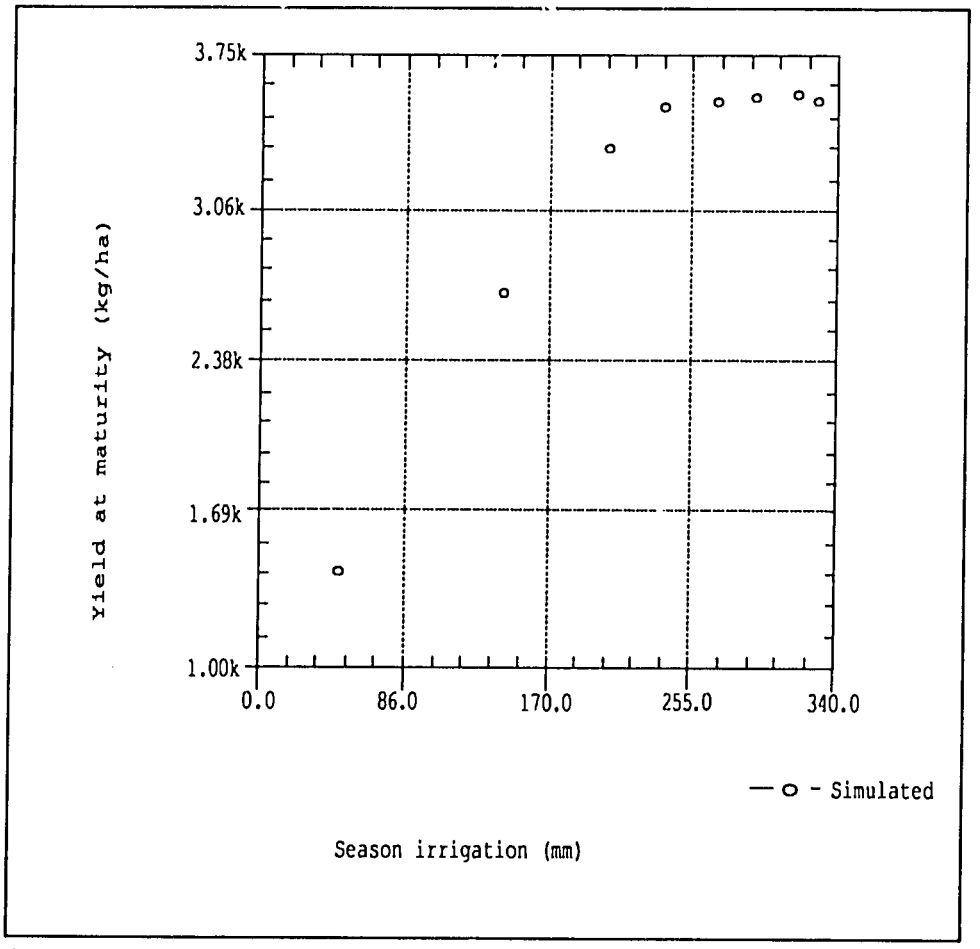
SUMMARY RESPONSE OPTION

This option is used for summary graph plotting. Only one X and one Y variable can be selected for graph plotting. When this option is selected, Screen 17 (on following page) is presented.

```
Ξ Select Graph Options Exit
[•]──────────────────────── SUMMARY ────────────────────────

X Variables                          Y Variables
[ ] Simulation start date (YRDOY)    [ ] Simulation start date (YRDOY)
[ ] Planting date (YRDOY)            [ ] Planting date (YRDOY)
[ ] Anthesis date (YRDOY)            [ ] Anthesis date (YRDOY)
[ ] Physical maturity date (YRDOY)   [ ] Physical maturity date (YRDOY)
[ ] Harvest date (YRDOY)             [ ] Harvest date (YRDOY)
[ ] Planting material wt (kg dm/ha   [ ] Planting material wt (kg dm/ha
[ ] Tops wt at maturity (kg dm/ha)   [ ] Tops wt at maturity (kg dm/ha)
[ ] Yield at maturity (kg dm/ha)     [X] Yield at maturity (kg dm/ha)
[ ] Yield at harvest (kg/dm/ha)      [ ] Yield at harvest (kg/dm/ha)
[ ] By-product harvest (kg dm/ha)    [ ] By-product harvest (kg dm/ha)
[ ] Wt at maturity (mg dm/unit)      [ ] Wt at maturity (mg dm/unit)
[ ] Number at maturity (no/m2)       [ ] Number at maturity (no/m2)
[ ] Number at maturity (no/unit)     [ ] Number at maturity (no/unit)
[ ] Irrigation applications (no)     [ ] Irrigation applications (no)
[X] Season irrigation (mm)           [ ] Season irrigation (mm)

   Previous     Next     Graph     Reset     Option

F1 Help  Esc Escape        X-Var.: Time       Simulation: Default
```

SCREEN 17.

In Screen 17, "Season irrigation" has been selected as the X-variable and "Yield at maturity" as the Y-variable. Pressing the GRAPH button will display this graph, as shown in Screen 18, on following page.



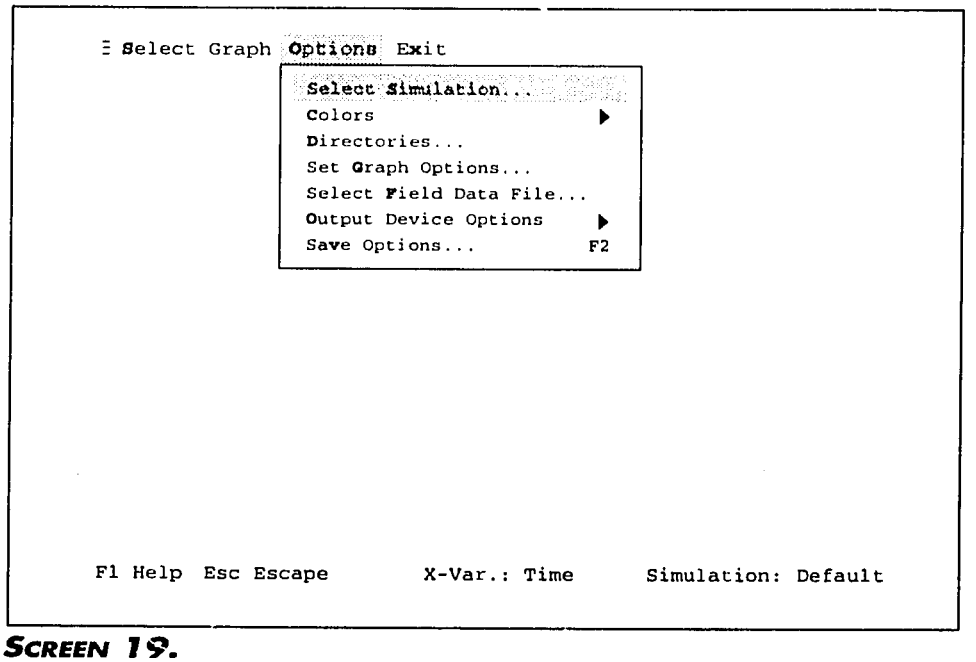
SCREEN 18.

In Screen 18, the example graph displays "Yield at harvest" plotted against "Season irrigation."

CHAPTER FIVE. OPTIONS MENU

The OPTIONS menu item allows the user to select previously run simulations and to modify the operation, look and feel of Wingraf. The user may define most of the operational parameters, configure Wingraf, and select previous simulations (Screen 15).

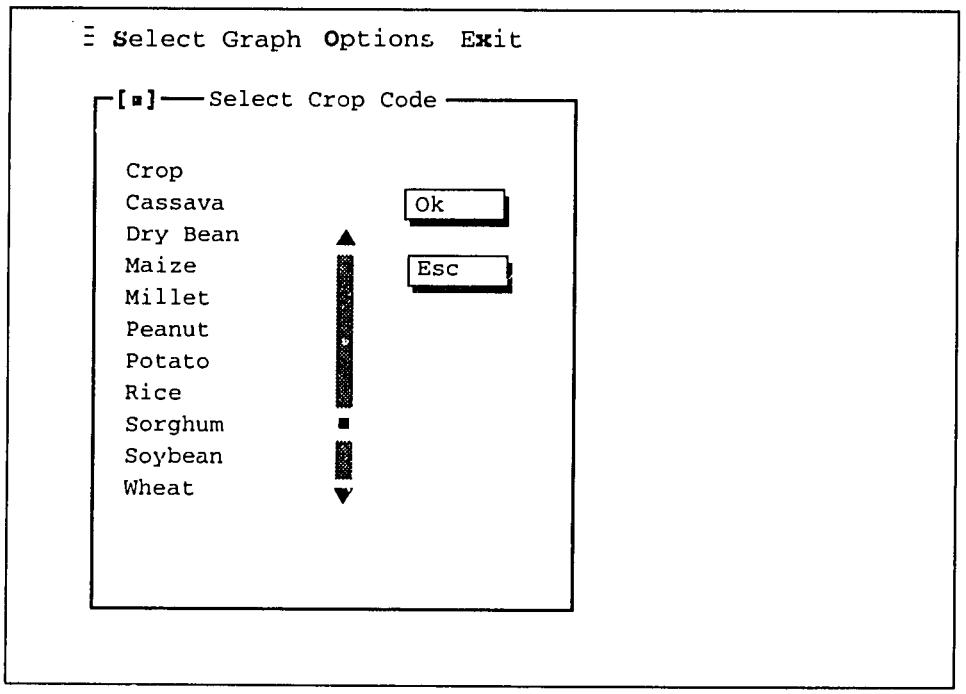
When the OPTIONS menu item is selected, the pull-down menu shown in Screen 19 (below) is displayed.



SCREEN 19.

SELECT SIMULATION OPTION

With this option, users can select previously simulated results provided the default output file names have been changed. Selecting this option opens the crop dialog box shown in Screen 20 (on following page).



SCREEN 20.

If simulations have been run for any of the crops listed in this box and the output file names have been changed from the default names (e.g., from GROWTH.OUT), then selecting one will present a listing of output files. For example, if Soybean is selected from the crop code dialog box in Screen 20, and the output names have been changed, then those files will be displayed. For the UFGA7801-Soybean experiment, these might be, UFGA7801.SBG, UFGA7801.SBW, UFGA7801.SBN for GROWTH.OUT, WATER.OUT, NITROGEN.OUT, respectively.

When one of the crops listed is selected and simulations have been run with output names changed, then Screen 21 (on following page) will appear.

If no previous simulation results have been saved with the experiment-coded file names described above, a message will appear on the screen to inform the user of this.

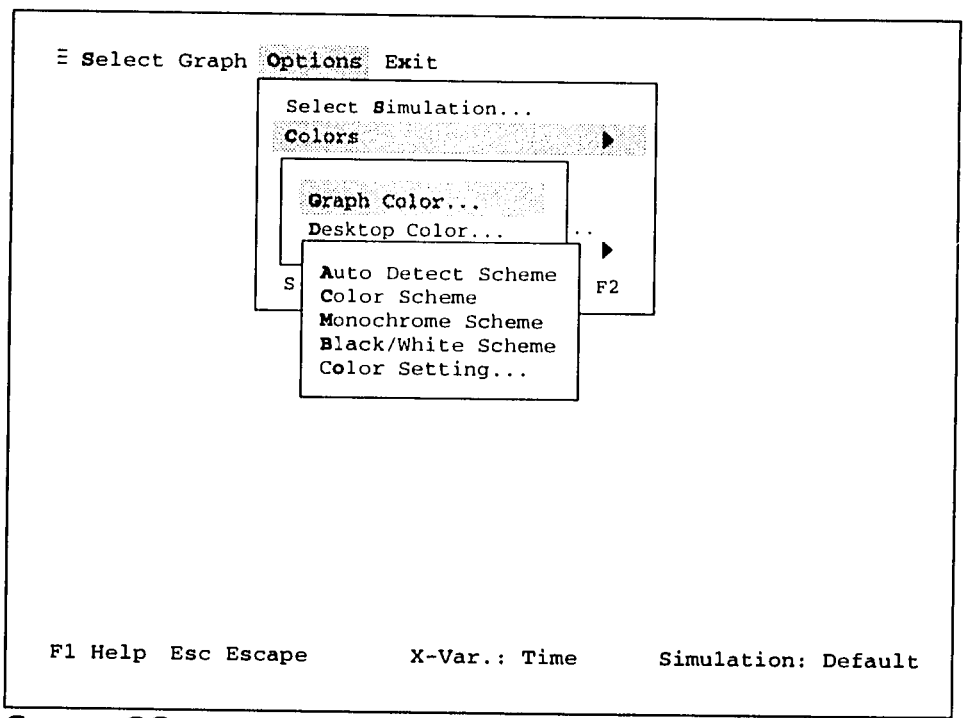
```
≡ Select Graph Options Exit

        Select Crop Code
   Crop
   Cassava          Ok
   Dry Bean   [•]— Select Simulation Result
   Maize
   Millet
   Peanut     Simulation Result      Ok
   Potato     IUCA7901
   Rice       UFGA7801               Esc
   Sorghum    UFGA7901
   Soybean    UFGA8101
   Wheat      UFGA8501
              UFQU7901

F1 Help  Esc Escape        X-Var.: Time      Simulation: Default
```

SCREEN 21.

In Screen 21, a listing of available simulation results is presented. Any listed simulation may be chosen and then plotted.

COLORS OPTION

Colors for both graphics and the desktop may be selected by choosing the Colors menu option (Screen 22, below).



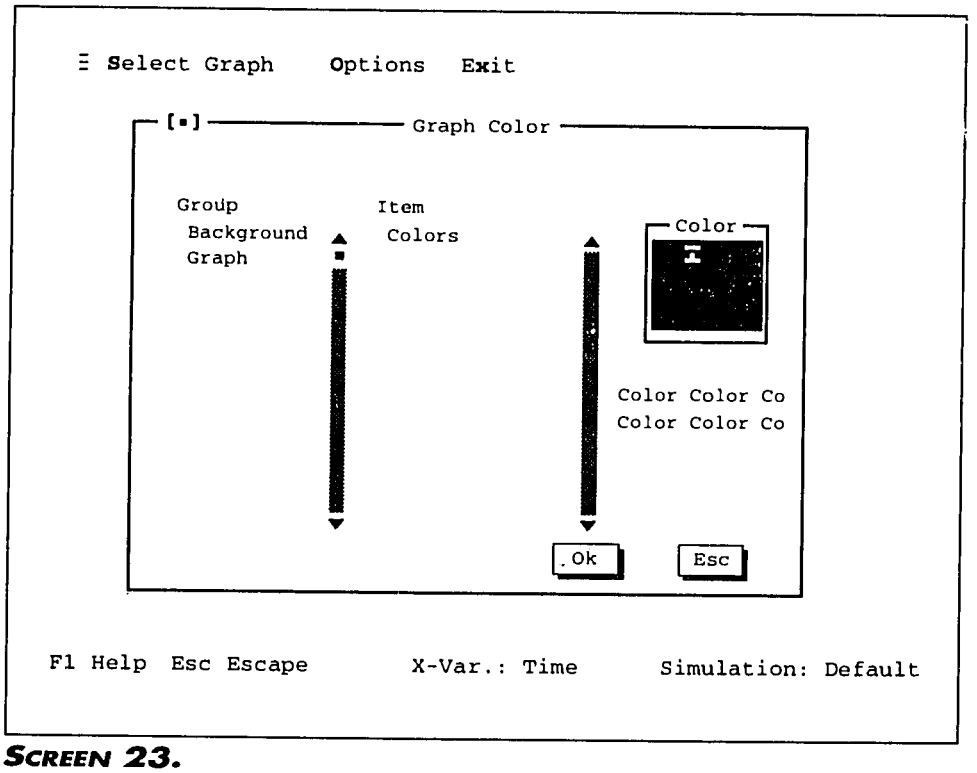
SCREEN 22.

GRAPH COLOR

Select "Graph Color" to define the colors used for graph plotting, such as graph background and line color. When "Graph Color" is selected, a listing of color schemes is presented (see Screen 22, above).

Select one of the first four items listed and the graph background and line color will be adjusted to that described in each listing. For example, if "Auto Detect Scheme" is selected, the program will use its default colors. Or, if "Black/White Scheme" is selected, the program will convert colors to black and white.

If "Color Setting" is selected, the user may customize the colors used according to his/her individual preference. When this menu item is selected, Screen 23 (on following page) will be presented.



SCREEN 23.

DESKTOP COLOR

Use "Desktop Color" to customize the desktop color scheme as well as the color setting for individual desktop displays. When "Desktop Color" is selected, a screen similar to the one shown in Screen 23 (above) will be presented, in which a user can select colors for background color of the desktop, dialog boxes, menus, the viewer and so on.

DIRECTORIES OPTION

This option allows the user to change the default path for graph plotting. When this option is selected, Screen 24, below, is presented. The Graphics Program Path, which can also be changed in Screen 24, will not normally need to be changed.

```
Select Graph    Options  Exit

[•]──────── Change Default Data Path ────────

  Default Data Path:      C:\DSSAT3\SOYBEAN\
  Graphics Program Path:  C:\DSSAT3\SOYBEAN\

                 Ok        Esc

F1 Help  Esc Escape       X-Var.: Time      Simulation: Default
```

SCREEN 24.

SET GRAPH OPTIONS

This option allows the user to specify various graph options as shown in Screen 25, below.

```
Ξ Select Graph     Options  Exit

        [•]                Graph Options

        X-Axis Label                Experimental data
         (•) Day of Year             (•) Plot
         ( ) Days after planting     ( ) Don't plot
                                     ( ) Prompt if available

        X vs Y Plotting             Simulated Data
         ( ) Connect points          (•) Plot
         ( ) Symbols                 ( ) Don't plot
         (•) Both symbols & points

        Num of Intervals:    4   Tics/Interval:    5

                        Ok        Esc

F1 Help  Esc Escape        X-Var.: Time      Simulation: Default
```

SCREEN 25.

Make selections in Screen 25 and then press the OK button to save them. Press the ESC button if you do not wish to save your selections.

NOTE: *If under the Simulated Data option, "Don't plot" has been selected, then the pull-down menu under the SELECT GRAPH menu item of the Wingraf main menu screen will change as shown in Screen 26, on following page.*

```
Select Graph     Options  Exit
  Field Data...
  Summary Response...

F1 Help  Esc Escape        X-Var.: Time       Simulation: Default
```

SCREEN 26.

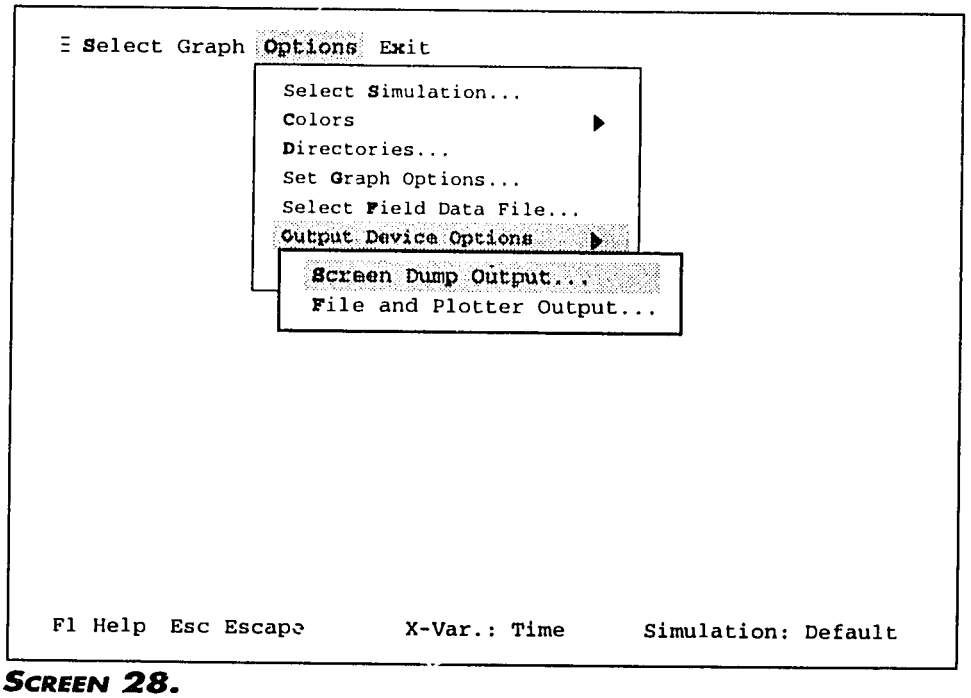
When "Don't plot" is selected from the Simulated Data options in Screen 25, you must open the "Field Data" menu item under SELECT GRAPH and select a field data file for graph plotting. When "Field Data" is selected, Screen 27 (below) is presented with a listing of data files available.

```
Select Graph   Options  Exit

[■] ── Select Experimental Data File

Data File Name
 IUCA7901.SBT                    Ok

Files                            Cancel
 IUCA7901.SBT
 UFGA7801.SBT
 UFGA7901.SBT
 UFGA8101.SBT
 UFGA8501.SBT
 UFQU7901.SBT
 ..\

C:\DSSAT3\EXPER\SOYBEAN\??.????.SBT
IUCA7901.SBT 14389    Apr 13, 1994 10:00am

F1 Help  Esc Escape        X-Var.: Time       Simulation: Default
```

SCREEN 27.

Output Device Options

This option allows the user to configure both screen dump output and plotter/file output When this option is selected, Screen 28 (below) is presented..



Screen 28.

Screen Dump Output

Use "Screen Dump Output" to set up the graph output option as a screen-dump and to select a printer device, printer port, orientation, and other options shown in Screen 29 (on following page).

```
Select Graph   Options  Exit

[•] ———— Screen Dump Options ————

Printer Driver                Printer I/O Plot
 ( ) Epson MX                  (•) LPT 1
 ( ) Epson LQ                  ( ) LPT 2
 ( ) Epson Fx                  ( ) COM 1
 ( ) Toshiba P                 ( ) COM 2
 (•) HP Laser Jet
 ( ) HP Ink Jet               Orientation
                               (•) Portrait
                               ( ) Landscape
Resolution (0-3):  1.00

X Multi. ( >=1 ): 1.00       Y Multi. ( >=1 ): 1.00

                 Ok        Esc

F1 Help  Esc Escape        X-Var.: Time       Simulation: Default
```

SCREEN 29.

FILE AND PLOTTER OUTPUT

Use "File and Plotter Output" to select the graph output option to file output or to both plotter output and file output (see Screen 30, below). The output file can be in either HPGL or Postscript format. The graph file can be imported into other graphic editors, word processing program or drawing programs for further modification.

```
Select Graph   Options  Exit

[•] ———— Plotter/File Output Options ————

Plotter Type                  Orientation
 (•) HPGL                      (•) Portrait
 ( ) Postscript                ( ) Landscape

Plotter Com Port              Plotter Output Option
 (•) COM1                      ( ) Both Plotter & File
 ( ) COM2                      (•) File Output Only

File Name:
C:\DSSAT3\SOYBEAN\OUTPUT00.GRA

                 Ok        Esc

F1 Help  Esc Escape        X-Var.: Time       Simulation: Default
```

SCREEN 30.

SAVE GRAPH OPTIONS

Changes made with the "Set Graph Options" or "Save Options" menu items under OPTIONS in the Wingraf main menu saves selected configurations to the file called GRAPH.INI. Normally, Wingraf configuration data will be handled and updated through the Wingraf menu structure. You may wish, however, to edit GRAPH.INI with a text editor. Thus, a listing of the contents of GRAPH.INI which pertains to Wingraf is shown in Table 2.

Two sections of GRAPH.INI hold configuration data for Wingraf and for the default output device. Under the [WINGRAF] section of the GRAPH.INI file, defaults for plotting in Wingraf are defined. Specifically, they are:

gcolor0 to gcolor7:	Refer to the default color palette for plotting.
interval:	Number of major divisions on the X and Y axis.
tics:	Number of tic marks between the major divisions.
days:	'D' for day after planting date; 'Y' for day of year.
symbols:	'C' for connect symbols with lines; 'S' for plotting. symbols alone; or "B" for both symbols and lines.
thickness:	'T' for thick lines; 'N' for normal width lines
plot:	'P' for plot simulated data; 'D' for don't plot simulated data.
exp:	'A' for always plot experimental data; 'N' for never plot; or 'P' for prompt when data are available.

Under the [Device] section of the INI file, defaults for the selected output device in Wingraf are defined. Specifically, they are:

output:	'S' for screen Dump; 'P' for plotter and file output; or 'F' for file alone.
driver:	"0" for Epson MX; "1" for Epson LQ; "2" for Epson FX; "3" for Toshiba P; "4" for HP Laser Jet; or "5" for HP Ink Jet.
plotter:	"0" for HPGL or "1" for Postscript.
port:	"0" for LPT1; "1" for LPT2; "2" for COM1; or "3" for COM2.
orientation:	"0" for Portrait or "1" for Landscape.
resolution:	Resolution.
xmult:	X-multiplier.
ymult:	Y-multiplier.
file:	Name for file output.

TABLE 2. EXAMPLE OF A WINGRAF GRAPH.INI FILE.

```
[WINGRAF]
gcolor0=1
gcolor1=15
gcolor2=14
gcolor3=12
gcolor4=15
gcolor5=10
gcolor6=11
gcolor7=13
interval=4
tics=5
days=Y
symbols=B
thickness=T
plot=P
exp=N
[Device]
output=F
driver=1
plotter=1
port=2
orientation=0
resolution=1.00
xmult=1.00
ymult=1.00
file=C:\WINGRAF\OUTPUT00.GRA
```

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Hunt, L.A., J.W. Jones, P.K. Thornton, G. Hoogenboom, D.T. Imamura, G.Y. Tsuji and U. Singh. 1994. Accessing data, models and application programs. *In*: Tsuji, G.Y., G. Uehara and S. Balas (eds.). DSSAT v3. Vol. 1-3. University of Hawaii, Honolulu, HI.

International Benchmark Sites Network for Agrotechnology Transfer Project. 1989. Decision Support System for Agrotechnology Transfer Version 2.1 (DSSAT V2.1). Dept. Agronomy and Soil Sci.; College of Trop. Agr. and Human Resources; University of Hawaii; Honolulu, HI.

Jones, J.W., L.A. Hunt, G. Hoogenboom, D.C. Godwin, U. Singh, G.Y. Tsuji, N. Pickering, P.K. Thornton, W.T. Bowen, K.J. Boote and J.T. Ritchie. 1994. Input and output files. *In:* Tsuji, G.Y., G. Uehara and S. Balas (eds). DSSAT v3. Vol. 2-1. University of Hawaii, Honolulu, HI.

Volume 3

DSSAT version 3

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IBSNAT, The International Benchmark Sites Network for Agrotechnology Transfer, is a network consisting of the contractor (University of Hawaii), its subcontractors and many global collaborators. Together they have created a network of national, regional and international agricultural research for the transfer of agrotechnology among global partners in both developed and lesser developed countries.

From 1982 to 1987, IBSNAT was a program of the U.S. Agency for International Development under a cost-reimbursement Contract, No. DAN-4054-C-00-2071-00, with the University of Hawaii. From 1987 to 1993, the contract was replaced with a Cooperative Agreement, No. DAN-4054-A-00-7081-00, between the University of Hawaii and USAID.

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DSSAT v3

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VOLUME 3-2
SEQUENCE ANALYSIS

VOLUME 3-3
WEATHERMAN

VOLUME 3-4
GENOTYPE COEFFICIENT CALCULATOR

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VOLUME 3-1

SEASONAL ANALYSIS

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CHAPTER ONE. INTRODUCTION

The Seasonal Analysis program allows the user to perform comparisons of simulations obtained by running the DSSAT v3 crop models with different combinations of inputs. A simulation experiment, which may be made up of many treatments and may be replicated through time using different weather years, is set up by the user, the models are run, and the user can then analyze the results using the seasonal analysis program. The "seasonal" aspect of the driver and analysis programs relates to the fact that what is being run are experiments of single cropping seasons; while these may be replicated, there are no carry-over effects from one season or crop to the subsequent season or crop. Those types of experiments can be simulated and analyzed using the sequence driver and analysis programs (see Volume 3-2, Thornton et al. 1994, of this book for a description of these programs).

Seasonal Analysis is useful for comparing methods of managing a crop in particular environments, such as different planting dates, varieties, or fertilizer application regimes, for example. If such comparisons are made across many different types of weather years, then the variability associated with crop performance, as a function of the interactions between weather and other factors of the physical environment, can be isolated and quantified. The information produced can be used to help pre-screen a wide variety of different options, the most promising of which might then warrant further evaluation and, eventually, field testing.

There are three basic steps involved in Seasonal Analysis:

1. The creation of an appropriate model input file;
2. Running the crop model(s) using a special controller program called the seasonal analysis driver;
3. Analyzing the results of the simulation using the Seasonal Analysis program.

The links between these steps are shown in Figure 1. Seasonal analyses are run from the DSSAT v3 Shell (see Volume 1-3, Hunt et al. 1994, of this book) under the menu item ANALYSES. The three steps are explained in Chapter 2 herein.

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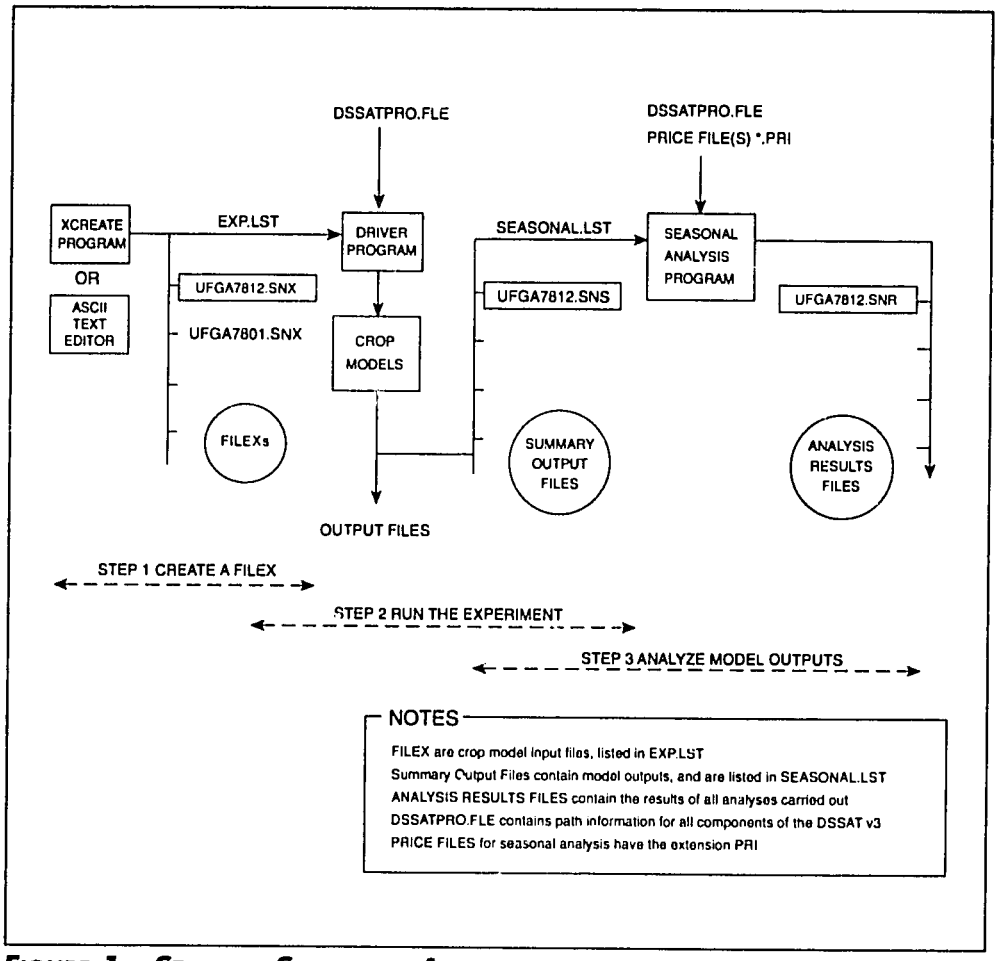


FIGURE 1. STEPS IN SEASONAL ANALYSIS.

SYSTEM REQUIREMENTS

The useable portion of your system's 640 Kb RAM should be at least 520 Kb in size for the models to run and for the analysis program and graphics to work.

If the driver or analysis program still does not work properly, one problem may be associated with the number of BUFFERS and FILES defined in CONFIG.SYS. These will need to be set to at least 20 each.

Replicated seasonal simulations on an 8086 or 80286 system may take a great deal of time. In such cases, the number of replicates should be kept to a minimum. Seasonal analysis, like the rest of the DSSAT3, will operate without a math coprocessor, but this is not recommended.

CHAPTER TWO. CREATING MODEL INPUT FILES FOR SEASONAL ANALYSIS

The program XCreate (see Volume 1-4, Imamura 1994, of this book for a description of this program) can be used to create model input files (FILEXs) for running seasonal analyses. (For a description of FILEX, see Volume 2-1, Jones et al. 1994, of this book.) Alternatively, these files can be created using an ASCII text editor. The advantage of using the program XCreate is that the experiment listing file EXP.LST is updated automatically (see Volume 2-1, Jones et al. 1994, of this book for a description of EXP.LST). If you create a seasonal analysis FILEX yourself using an ASCII editor, then you must either update EXP.LST yourself, or run the File Manager Utility program (by opening the SEASONAL — "Inputs" menu items of the DSSAT v3 Shell) for the FILEX to be accessible to the seasonal analysis driver.

Seasonal analysis model input files created with XCreate have the extension SNX. You may also put FILEXs that refer to a particular crop in EXP.LST, using the "Experiment" option mode of FILEX creation found in the XCreate program. Thus you could run a FILEX called UFGA9201.MZX, as long as this file was listed in the listing file EXP.LST in the directory that contains the seasonal analysis input files, which is usually DSSAT3\SEASONAL (see Table 1 for an example of the EXP.LST file).

TABLE 1. SEASONAL EXPERIMENT LISTING FILE EXP.LST.

```
*EXPERIMENT LIST

@# FILENAME EXT ENAME
 1 UFGA7801 SNX GAINESVILLE, SOYBEAN, IRRIGATED AND RAINFED
 2 UFGA7802 SNX EXAMPLE SEASONAL ANALYSIS, SB+MZ
 3 UFGA7805 SNX PLANTING DATE EXPERIMENT, 1978 BRAGG, GNV
 4 UFGA8201 SNX GAINESVILLE, FLORIDA, MAIZE, IR*N-FERT
 5 UFGA7812 SNX GAINESVILLE, FLORIDA, SB IRRIGATION EXPERIMENT
```

An example of a seasonal analysis FILEX is shown in Table 2. Though not all of the SIMULATION CONTROL blocks of FILEX appear in Table 2, you can print a full listing of this file, UFGA7812.SNX, found on the DSSAT v3 distribution diskette. Refer to the shaded portions in Table 2 when reading the following paragraphs.

In the *TREATMENTS section of the file, treatments are specified as for a regular experiment. You need to ensure that the treatment numbers are in ascending, consecutive order (treatment numbers are specified in the two columns with header @N). In Seasonal Analysis, the options "R," "O" and "C" should always be left at their default values of 1, 0 and 0, respectively.

Because the example experiment UFGA7812SN is a comparison of automatic irrigation schedules, the example found in Table 2 requires 6 simulation control sections, as specified by the simulation control factor levels SM, under *TREATMENTS.

In the *SIMULATION CONTROLS blocks in Table 2, there are a number of simulation control options that are generally important for Seasonal Analyses. These are described as follows.

NYERS

NYERS is the number of replicates for the experiment and should have a value between 1 and 30. You may need to check the availability of historical weather data files if you are running a number of replicates and the weather data switch WTHER (one of the METHODS options found in the *SIMULATION CONTROLS block) is set to "M" (measured). In this case, make sure that you have at least NYERS+1 complete years of historical weather data available. Most often, seasonal analyses are run using simulated weather with this switch set to "W" (as set in Table 2) or "S." "W" is for the WGEN (Richardson and Wright 1984) weather generator and "S" is for the SIMMETEO (Geng et al. 1988) weather generator. In either of these cases, the climate file for the site (with extension CLI) will be used by the model.

NREPS

NREPS should be left at the default value of 1. It has no meaning for Seasonal Analysis.

RSEED

RSEED is the random number seed for weather generation. RSEED is used only if the WTHER option is set to "W" or "S." If you start a simulation from the same starting date (SDATE) with the same seed, you will obtain the same sequence of random numbers, and hence the same sequence of daily weather.

TABLE 2. PART OF MODEL INPUT FILE UFGA7812.SNX.

```
*EXP.DETAILS: UFGA7812SN GAINESVILLE, FLORIDA, SB IRRIGATION EXPERIMENT

*TREATMENTS                        -------FACTOR LEVELS-------
@N R O C TNAME....................CU FL SA IC MP MI MF MR MC MT ME MH SM
 1 1 0 0 RAINFED                    1  1  0  1  1  0  0  1  0  0  0  0  1
 2 1 0 0 AUTOMATIC 90%              1  1  0  1  1  0  0  1  0  0  0  0  2
 3 1 0 0 AUTOMATIC 70%              1  1  0  1  1  0  0  1  0  0  0  0  3
 4 1 0 0 AUTOMATIC 50%              1  1  0  1  1  0  0  1  0  0  0  0  4
 5 1 0 0 AUTOMATIC 30%              1  1  0  1  1  0  0  1  0  0  0  0  5
 6 1 0 0 AUTOMATIC 10%              1  1  0  1  1  0  0  1  0  0  0  0  6

*CULTIVARS
@C CR INGENO CNAME
 1 SB IB0001 BRAGG

*FIELDS
@L ID_FIELD WSTA....  FLSA  FLOB  FLDT  FLDD  FLDS  FLST SLTX  SLDP ID_SOIL
 1 UFGA0001 UFGA7801 -99       0 IB000     0     0 00000 -99    180 IBSB910015

*INITIAL CONDITIONS
@C   PCR ICDAT  ICRT  ICND  ICRN  ICRE
 1    SB 78166   100   -99  1.00  1.00
@C  ICBL  SH2O  SNH4  SNO3
 1     5 0.086   0.6   1.5
 1    15 0.086   0.6   1.5
 1    30 0.086   0.6   1.5
 1    45 0.086   0.6   1.5
 1    60 0.086   0.6   1.5
 1    90 0.076   0.6   0.6
 1   120 0.076   0.6   0.5
 1   150 0.130   0.6   0.5
 1   180 0.258   0.6   0.5

*PLANTING DETAILS
@P PDATE EDATE  PPOP  PPOE  PLME  PLDS  PLRS  PLRD  PLDP  PLWT  PAGE  PENV  PLPH
 1 78166   -99  29.9  29.9     S     S    91     0   4.0   -99   -99 -99.0 -99.0

*RESIDUES AND OTHER ORGANIC MATERIALS
@R RDATE  RCOD  RAMT  RESN  RESP  RESK  RINP  RDEP
 1 78166 IB001  1000  0.80 -9.00 -9.00   100    15

*SIMULATION CONTROLS
@N GENERAL     NYERS NREPS START SDATE RSEED SNAME....................
 1 GE             20     1     S 78166  9875
@N OPTIONS     WATER NITRO SYMBI PHOSP POTAS DISES
 1 OP             Y     Y     Y     N     N     N
@N METHODS     WTHER INCON LIGHT EVAPO INFIL PHOTO
 1 ME             W     M     E     R     S     C
@N MANAGEMENT  PLANT IRRIG FERTI RESID HARVS
 1 MA             R     N     R     R     M
@N OUTPUTS     FNAME OVVEW SUMRY FROPT GROTH CARBN WATER NITRO MINER DISES  LONG
 1 OU             Y     N     A    10     N     N     N     N     N     N     N
```

```
@  AUTOMATIC MANAGEMENT
@N PLANTING    PFRST PLAST PH2OL PH2OU PH2OD PSTMX PSTMN
 1 PL            155   200    40   100    30    40    10
@N IRRIGATION  IMDEP ITHRL ITHUR IROFF IMETH IRAMT IREFF
 1 IR             30    50   100 IB001 IB001    10  0.75
@N NITROGEN    NMDEP NMTHR NAMNT NCODE NAOFF
 1 NI             30    50    25 IB001 IB001
@N RESIDUES    RIPCN RTIME RIDEP
 1 RE            100     1    20
@N HARVEST     HFRST HLAST HPCNP HPCNR
 1 HA              0   365   100     0

@N GENERAL     NYERS NREPS START SDATE RSEED SNAME....................
 2 GE             20     1     S 78166  9875
@N OPTIONS     WATER NITRO SYMBI PHOSP POTAS DISES
 2 OP             Y     Y     Y     N     N     N
@N METHODS     WTHER INCON LIGHT EVAPO INFIL PHOTO
 2 ME             W     M     E     R     S     C
@N MANAGEMENT  PLANT IRRIG FERTI RESID HARVS
 2 MA             R     A     R     R     M
@N OUTPUTS     FNAME OVVEW SUMRY FROPT GROTH CARBN WATER NITRO MINER DISES  LONG
 2 OU             Y     N     A    10     N     N     N     N     N     N     N

@  AUTOMATIC MANAGEMENT
@N PLANTING    PFRST PLAST PH2OL PH2OU PH2OD PSTMX PSTMN
 2 PL            155   200    40   100    30    40    10
@N IRRIGATION  IMDEP ITHRL ITHUR IROFF IMETH IRAMT IREFF
 2 IR             30    90   100 IB001 IB001    10  0.75
@N NITROGEN    NMDEP NMTHR NAMNT NCODE NAOFF
 2 NI             30    50    25 IB001 IB001
@N RESIDUES    RIPCN RTIME RIDEP
 2 RE            100     1    20
@N HARVEST     HFRST HLAST HPCNP HPCNR
 2 HA              0   365   100     0

@N GENERAL     NYERS NREPS START SDATE RSEED SNAME....................
 6 GE             20     1     S 78166  9875
@N OPTIONS     WATER NITRO SYMBI PHOSP POTAS DISES
 6 OP             Y     Y     Y     N     N     N
@N METHODS     WTHER INCON LIGHT EVAPO INFIL PHOTO
 6 ME             W     M     E     R     S     C
@N MANAGEMENT  PLANT IRRIG FERTI RESID HARVS
 6 MA             R     A     R     R     M
@N OUTPUTS     FNAME OVVEW SUMRY FROPT GROTH CARBN WATER NITRO MINER DISES  LONG
 6 OU             Y     N     A    10     N     N     N     N     N     N     N
```

```
@  AUTOMATIC MANAGEMENT
@N PLANTING    PFRST PLAST PH2OL PH2OU PH2OD PSTMX PSTMN
 6 PL            155   200    40   100    30    40    10
@N IRRIGATION  IMDEP ITHRL ITHUR IROFF IMETH IRAMT IREFF
 6 IR             30    10   100 IB001 IB001    10  0.75
@N NITROGEN    NMDEP NMTHR NAMNT NCODE NAOFF
 6 NI             30    50    25 IB001 IB001
@N RESIDUES    RIPCN RTIME RIDEP
 6 RE            100     1    20
@N HARVEST     HFRST HLAST HPCNP HPCNR
 6 HA              0   365   100     0
```

FNAME

FNAME is one of the OUTPUTS switches found in the *SIMULATION CONTROLS blocks. If this switch is set to "N," then the summary output file from the model runs will be named SUMMARY.SNS. If FNAME is set to "Y," then the summary output file name will be the same as the model FILEX name, except that the last letter of the extension will be changed from "X" to "S." Thus, for the experiment FILEX shown in Table 2 which has the name UFGA7812.SNX, the summary output file will be named UFGA7812.SNS since the switch FNAME is set to "Y."

SUMRY

SUMRY is one of the OUTPUTS switches found in the *SIMULATION CONTROLS blocks. For seasonal simulations, this controller should always be set to "A" (append); otherwise the summary output file will be successively overwritten by each treatment and earlier outputs will be lost. In Table 2, the other OUTPUT switches are set to "N" to prevent within-season output from the models. Since seasonal simulations with many replicates can produce prodigious quantities of output data, it makes sense to turn these output files off, unless you need them specifically.

You should note that if there are multiple simulation control sections in FILEX, then the driver program will use the values of NYERS, WTHER, RSEED, FNAME and SUMRY that pertain to the lowest valid simulation control level in the file. In other words, the value of NYERS, the number of replicates, in the lowest simulation control factor level (SM=1), is used for all other treatments; in Table 2, for example, NYERS is set to 20. You could not, therefore, run an experiment that has 4 replicates for Treatment 1 and 10 replicates for Treatment 2, for instance; this would not make much sense anyway.

For the specific experiment in Table 2, the first treatment is set up as a rainfed treatment (see *TREATMENTS). Thus the IRRIG switch, which is a MANAGEMENT option in the *SIMULATION CONTROLS block is set to "N" for "no irrigation" in block 1(i.e., N=1).

For subsequent treatments, automatic irrigation is to be applied, but the threshold at which water is applied, in terms of the percentage of soil water in the profile, is changed; this is the primary experimental variable. In the second *SIMULATION CONTROLS block (i.e., N=2) in Table 2, the IRRIG switch is set to "A" for "automatic". The corresponding information in the AUTOMATIC MANAGEMENT section of the file, under IRRIGATION, shows that IMDEP is set to 30 and ITHRL to 90. Thus irrigation will be applied automatically when available soil water is less than or equal to a value of 90 percent

(ITHRL) of what the soil can hold in the top 30 cm of the profile (IMDEP). Compare this with the *SIMULATION CONTROLS block number 6 (i.e., N=6)) where, under AUTOMATIC MANAGEMENT, ITHRL has a value of 10 (i.e., the soil water trigger will operate when available water reaches 10 percent of field capacity in the top 30 cm). Note that all other switches in each of the SIMULATION CONTROLS blocks in Table 2 are the same.

In general, you may mix crops in a seasonal analysis FILEX. Thus you can compare performance of different crops in the same experiment. Treatment 1 might involve maize, and Treatment 2 dry bean, for example.

CHAPTER THREE. RUNNING SEASONAL ANALYSIS EXPERIMENTS

OVERVIEW

The seasonal analysis driver program takes the FILEX selected or created by the user, and runs through each treatment in the experiment, calling the appropriate crop model. It is very important to understand that the seasonal driver can be used for any experiment that does not involve a sequence. Thus, as far as the driver is concerned, it makes no difference if FILEX describes a real 10-treatment single year experiment, or if it describes a hypothetical 4-treatment simulation experiment to be replicated twenty times. The driver can thus be used to generate replicated experiment output files, or it may simply be used to run all the treatments pertaining to a real-world experiment automatically.

The driver is a FORTRAN program that allows the user to pick a specific entry from EXP.LST (i.e., a particular FILEX; see Volume 2-1, Jones et al. 1994, of this book for a description of EXP.LST). This FILEX is then read and various controls are set. Each treatment specified in this FILEX is then run in its order of appearance in the *TREATMENTS section of the FILEX. The appropriate model is called for each treatment (the model is run under the command of the driver program), and it will be run for as many replicates as are specified by NYERS in the FILEX. When all the treatments of the selected simulation or real-world experiment have been run, the results listing file SEASONAL.LST (see the example in Table 3) is updated with the name and description of the summary output file produced. The user can then quit the program or choose another FILEX for running with the seasonal driver.

The seasonal driver can be run in a stand-alone mode or through the DSSAT v3 Shell (see Volume 3-1, Hunt et al. 1994, of this book for a description of the Shell). It is important

---

TABLE 3. SUMMARY OUTPUT LISTING FILE SEASONAL.LST.

```
*SEASONAL LIST

@# FILENAME EXT ENAME

 1 UFGA7801 SNS GAINESVILLE, SOYBEAN, IRRIGATED AND RAINFED
 2 UFGA7802 SNS EXAMPLE SEASONAL ANALYSIS, SB+MZ
 3 UFGA7812 SNS GAINESVILLE, FLORIDA, SB IRRIGATION EXPERIMENT
```


Previous Page Blank

to note that in whichever mode the driver is run, the program expects to find all the model program(s) in the same directory. In the case of the DSSAT v3 Shell, this will generally be the C:\DSSAT3 directory. If model executable files are not found in that directory, then an error message is printed and the user must arrange the executable files so that this condition is met. The file DSSATPRO.FLE (see the Appendix to Volume 1 of this book for a description of this file) is also expected to be in this same directory, with appropriate pointers to the relevant directories.

From within DSSAT v3, the current directory for seasonal runs will generally be DSSAT3\SEASONAL, where such files as EXP.LST, SEASONAL.LST and appropriate FILEXs are stored.

The file EXP.LST may contain up to 99 experiments, a limit imposed by the file structure. Up to 99 treatments may be simulated using the driver (again a limit imposed by FILEX), but it should be noted that the seasonal analysis program has a limit of handling a maximum of 20 treatments and 30 replicates (i.e., a total of 600 separate model runs).

An Example

On activating the "Simulate" option under the "Seasonal" window (Screen 1, following page) from the DSSAT v3 Shell main menu item ANALYSES, the driver program is activated, and after an introductory screen the user is presented with the following screen (Screen 2, following page). Screen 2 contains the contents of the file EXP.LST, the listing file in the current directory of selected FILEXs for seasonal analysis. This lists the file name, crop group code (generally "SN" for seasonal analysis, although it may be any valid crop code), and a file description. The description may be up to 60 characters long; if it is shorter, the description is padded with full stops. The file description is obtained from columns 26 through 85 of the first line of FILEX (see Table 2).

If the colors on the screen are difficult to see (such as when the program is being run on a monochrome laptop computer), you can force the program to display screens in monochrome by pressing the <ALT>-<F2> keys. Note that you cannot reverse the color scheme during a session with the program, nor is your preference stored from one session to another.

Use the mouse or cursor arrow keys to choose the Gainesville soybean irrigation experiment FILEX, UFGA7812.SNX (used in the example in Table 2). If the chosen FILEX cannot be found, an error message is printed on the screen, and the menu reappears for making another choice.

```
DECISION SUPPORT SYSTEM FOR AGROTECHNOLOGY TRANSFER

DATA        MODEL        ANALYSES        TOOLS        SETUP/QUIT

                         S Seasonal
                         Q
                           C Create
                           I Inputs
                           S Simulate
                           O Outputs
                           A Analyze

Run the appropriate crop model(s) using a controlling 'driver' program.

↑ ↓ → ←   moves through menu choices
ESC       moves to higher menu level                Version: 3.0
```

SCREEN 1.

```
DSSAT Version 3.0 Cropping Season Analysis

 FILE    EXT ENAME
 UFGA7801 SNX GAINESVILLE, SOYBEAN, IRRIGATED AND RAINFED........
 UFGA7802 SNX EXAMPLE SEASONAL ANALYSIS, SB+M2...................
 UFGA7805 SNX PLANTING DATE EXPERIMENT, 1978 BRAGG, GNV..........
 UFGA8201 SNX GAINESVILLE, FLORIDA, MAIZE, IR*N-FERT.............
 UFGA7812 SNX GAINESVILLE, FLORIDA, SB IRRIGATION EXPERIMENT.....

F1 (Help)                                          306432 Mem
```

SCREEN 2.

Once a valid FILEX name is selected, the driver checks to see if there is an existing output file with the same name in the current directory (this is controlled within FILEX, see above). If there is, then the user is warned that the output file will be overwritten. Press <Y> to continue regardless, or <N> to quit the program to allow you to rename or move the existing output file.

Once past Screen 2, the driver will issue appropriate commands and call up the crop model(s). The initial model-produced screen warns the user not to touch the keyboard. Once simulations are under way, each model run is summarized on the screen, so that the user can chart progress of the experiment (Screen 3, below, shows the first 20 simulations associated with model input file UFGA7812.SNX). Experiments with many treatments and/or many replicates may take a great deal of time to simulate, especially on older personal computers. No keyboard input should be made, unless an error occurs, until the simulations have finished.

To abort the simulation runs before they have finished, press the <ESC> key or <CTRL-BREAK>.

For each FILEX simulated, the driver updates or creates a listing file which stores the names of the summary results files (in similar fashion to EXP.LST, which stores the names of available FILEXs in the current directory). This file, SEASONAL.LST, is of the same format (Table 3), and is used by the analysis program described in the next section. Two other messages may appear on the final screen:

RUN	TRT	FLO dap	MAT dap	TOPWT kg/ha	SEEDW kg/ha	TRAIN mm	TIRR mm	CET mm	PESW mm	TNUP ----kg/ha-----	TNLC	TNLF	TSON kg/ha	TSOC t/ha
1	SB 1	47	116	5880	2905	849	0	446	141	18	21	27	3836	39
2	SB 1	46	118	7489	3565	834	0	509	84	18	19	27	3838	39
3	SB 1	46	116	6692	3166	904	0	489	117	18	21	27	3836	39
4	SB 1	46	121	5931	2939	502	0	452	138	34	3	28	3837	39
5	SB 1	46	117	7175	3602	718	0	491	135	26	14	28	3834	39
6	SB 1	47	119	5802	2942	833	0	479	111	17	19	28	3838	39
7	SB 1	47	119	6203	3415	611	0	466	141	27	8	30	3837	39
8	SB 1	47	118	6392	3210	513	0	455	90	30	6	29	3837	39
9	SB 1	46	119	6986	3280	872	0	486	92	17	23	26	3835	39
10	SB 1	46	116	6980	3214	557	0	487	71	23	9	31	3838	39
11	SB 1	47	118	6632	3329	445	0	449	115	34	1	29	3837	39
12	SB 1	46	118	5566	2808	462	0	446	92	29	4	29	3839	39
13	SB 1	47	[illegible]	6403	3253	819	0	501	125	19	17	29	3836	39
14	SB 1	46	116	6448	3140	527	0	432	80	24	8	31	3838	39
15	SB 1	47	[illegible]	7030	3457	803	0	481	101	24	18	26	3835	39
16	SB 1	46	[illegible]	6900	3388	534	0	473	89	28	7	31	3836	39
17	SB 1	46	[illegible]	4905	2287	493	0	423	157	29	3	31	3839	39
18	SB 1	46	[illegible]	7110	3521	828	0	517	144	23	17	29	3833	39
19	SB 1	46	[illegible]	6787	3479	684	0	478	86	20	15	29	3838	39
20	SB 1	46	113	4863	1798	689	0	412	98	16	17	27	3841	39

SCREEN 3.

1. If FNAME was set to "N," then the summary output file produced by the model(s), SUMMARY.OUT, was renamed to SUMMARY.SNS; the program tells you that this has been done;
2. If the summary output file of the appropriate name does not appear in SEASONAL.LST, then SEASONAL.LST is updated, and the program tells you that this has been done.

Press any key to continue. You will then be asked if you want to run another experiment. Respond by pressing the <N> or <ENTER> keys to exit the program, or the <Y> key to return to the opening screen showing file EXP.LST, where another experiment can be chosen and simulated (see Screen 2). You may simulate as many FILEXs as you like, one after the other, without exiting the driver program.

Simulation results are stored in the summary output file, in this example UFGA7812.SNS. The first 20 simulation records of this file are shown in Table 4.

Information and Error Messages

A number of information and error messages are produced by the driver program. In the list that follows, each message is preceded by a single-digit code and a three digit message/error number. If the single-digit code is "0," then this is a fatal error, and the program exits. If the code is "1," then the program will continue, as the error may not be fatal. Information messages have code "1" also.

0 001 Cannot find experiment file.
The FILEX experiment listing file could not be found in the current directory.

0 002 No entries found in file.
The FILEX experimental listing file was found, but it contains no valid entries.

1 003 Cannot find file :
The specified file cannot be found (non-fatal).

0 004 Error reading :
An undefined read error occurred when attempting to read the file. The problem is usually caused by incorrect format of the file.

0 005 No valid treatments found in file.
No valid treatments were found in the FILEX selected.

TABLE 4. SUMMARY OUTPUT FILE UFGA7812.SNS, (FIRST 20 DATA RECORDS ONLY).

Columns 1-86

*SUMMARY : UFGA7812SN GAINESVILLE, FLORIDA, SB IRRIGATION EXPERIMENT

!IDENTIFIERS						.DATES					DRY WEIGHTS.	
@RP	TN	ROC	CR	TNAM	FNAM	SDAT	PDAT	ADAT	MDAT	HDAT	DWAP	CWAM
1	1	100	SB	RAINFED	UFGA0001	78166	78166	78213	78282	78294	67	5880
2	1	100	SB	RAINFED	UFGA0001	79166	79166	79212	79284	79296	67	7489
3	1	100	SB	RAINFED	UFGA0001	80166	80166	80212	80282	80294	67	6692
4	1	100	SB	RAINFED	UFGA0001	81166	81166	81212	81287	81299	67	5931
5	1	100	SB	RAINFED	UFGA0001	82166	82166	82212	82283	82295	67	7175
6	1	100	SB	RAINFED	UFGA0001	83166	83166	83213	83285	83297	67	5802
7	1	100	SB	RAINFED	UFGA0001	84166	84166	84213	84285	84297	67	6203
8	1	100	SB	RAINFED	UFGA0001	85166	85166	85213	85284	85296	67	6392
9	1	100	SB	RAINFED	UFGA0001	86166	86166	86212	86285	86297	67	6986
10	1	100	SB	RAINFED	UFGA0001	87166	87166	87212	87282	87294	67	6980
11	1	100	SB	RAINFED	UFGA0001	88166	88166	88213	88284	88296	67	6632
12	1	100	SB	RAINFED	UFGA0001	89166	89166	89212	89284	89296	67	5566
13	1	100	SB	RAINFED	UFGA0001	90166	90166	90213	90283	90295	67	6403
14	1	100	SB	RAINFED	UFGA0001	91166	91166	91212	91282	91294	67	6448
15	1	100	SB	RAINFED	UFGA0001	92166	92166	92213	92283	92295	67	7030
16	1	100	SB	RAINFED	UFGA0001	93166	93166	93212	93283	93295	67	6900
17	1	100	SB	RAINFED	UFGA0001	94166	94166	94212	94283	94295	67	4905
18	1	100	SB	RAINFED	UFGA0001	95166	95166	95212	95283	95295	67	7110
19	1	100	SB	RAINFED	UFGA0001	96166	96166	96212	96283	96295	67	6787
20	1	100	SB	RAINFED	UFGA0001	97166	97166	97212	67279	97291	67	4863

Columns 87-176

.....WATER.....													.NITROGEN....	
HWAM	HWAH	BWAH	HWUM	H#AM	H#UM	IR#M	IRCM	PRCM	ETCM	ROCM	DRCM	SWXM	NI#M	NICM
3565	3565	3924	171	2083	2.05	0	0	834	509	35	365	84	0	0
3166	3166	3526	143	2218	2.05	0	0	904	489	38	419	117	0	0
2939	2939	2992	163	1806	2.05	0	0	502	452	1	70	138	0	0
3602	3602	3573	183	1972	2.05	0	0	718	491	8	243	135	0	0
2942	2942	2860	174	1695	2.05	0	0	833	479	11	390	111	0	0
3415	3415	2788	165	2070	2.05	0	0	611	466	13	150	141	0	0
3210	3210	3181	166	1934	2.05	0	0	513	455	9	117	90	0	0
3280	3280	3706	177	1849	2.05	0	0	872	486	22	431	92	0	0
3214	3214	3766	171	1878	2.05	0	0	557	487	5	153	71	0	0
3329	3329	3304	170	1953	2.05	0	0	445	449	1	39	115	0	0
2808	2808	2759	163	1719	2.05	0	0	462	446	1	81	92	0	0
3253	3253	3149	162	2013	2.05	0	0	819	501	43	309	125	0	0
3140	3140	3309	142	2213	2.05	0	0	527	432	27	145	80	0	0
3457	3457	3573	175	1973	2.05	0	0	803	481	13	365	101	0	0
3388	3388	3512	161	2104	2.05	0	0	534	473	3	128	89	0	0
2287	2287	2618	155	1474	2.05	0	0	493	423	4	68	157	0	0
3521	3521	3588	169	2081	2.05	0	0	828	517	20	305	144	0	0
3479	3479	3308	184	1894	2.05	0	0	684	478	27	252	86	0	0
1798	1798	3064	105	1705	2.05	0	0	689	412	29	309	98	0	0

Columns 177-252

						ORGANIC MATTER...			PHOSPHORUS.....			
NFXM	NUCM	NLCM	NIAM	CNAM	GNAM	RECM	ONAM	OCAM	PO#M	POCM	CPAM	SPAM
280	18	21	27	214	185	1000	3836	39	0	0	0	0
337	18	19	27	265	227	1000	3838	39	0	0	0	0
302	18	21	27	235	202	1000	3836	39	0	0	0	0
288	34	3	28	220	187	1000	3837	39	0	0	0	0
321	26	14	28	263	229	1000	3834	39	0	0	0	0
292	17	19	28	219	187	1000	3838	39	0	0	0	0
310	27	8	30	250	217	1000	3837	39	0	0	0	0
301	30	6	29	241	204	1000	3837	39	0	0	0	0
329	17	23	26	251	209	1000	3835	39	0	0	0	0
313	23	9	31	243	205	1000	3838	39	0	0	0	0
308	34	1	29	249	212	1000	3837	39	0	0	0	0
282	29	4	29	207	179	1000	3839	39	0	0	0	0
308	19	17	29	238	207	1000	3836	39	0	0	0	0
303	24	8	31	240	200	1000	3838	39	0	0	0	0
316	24	18	26	256	220	1000	3835	39	0	0	0	0
311	28	7	31	251	216	1000	3836	39	0	0	0	0
254	29	3	31	176	146	1000	3839	39	0	0	0	0
324	23	17	29	262	224	1000	3833	39	0	0	0	0
331	20	15	29	260	222	1000	3838	39	0	0	0	0
240	16	17	27	150	115	1000	3841	39	0	0	0	0

0 006 Error in *SIMULATION CONTROL factor levels.
The FILEX specified by the user is defective in one of the following ways: a) FNAME was not set or not found; b) NREPS was not set or not found; or c) the simulation control factor level with the lowest number specified by the user did not have a corresponding *SIMULATION CONTROLS block in the file.

0 007 Error in *CULTIVAR factor levels in file :
A cultivar factor level was specified in the selected FILEX that did not have a corresponding cultivar description in the *CULTIVARS section of the file.

1 008 Model runs completed!

1 009 SUMMARY.OUT renamed to SUMMARY.SNS.

1 010 SEASONAL.LST updated, added file.
Specified summary output file added to the listing file.

0 011 A required file was not found .. aborting.
This usually refers to the absence of the file DSSATPRO.FLE, which could not be found.

0 012 Excessive path length error.
You need to reduce the path length as specified in DSSATPRO.FLE for the crop model "cc" (e.g. MZ). Path lengths as specified in the DSSATPRO.FLE must be less than 36 characters in total length, including drive letter, colon, and leading and trailing slashes (\). If these paths are modified using the SETUP menu of the DSSAT v3 Shell (see Volume 1-3, Hunt et al. 1994, of this book for a description of the SETUP menu), then there is no problem, as the screens will not allow you to enter paths longer than this. If you modify DSSATPRO.FLE with a text editor, then you need to ensure that this total length is not exceeded.

0 013 No code error.
The crop code specified (e.g. MZ) could not be found in the file DSSATPRO.FLE. This will occur if a cultivar is specified in FILEX that does not have a valid crop code.

0 014 Read error in file :
An undefined read error occurred when reading the specified file; check the format of the file.

0 020 A problem was encountered executing another program.
The driver was not able to execute another program. Check the free RAM that you have on your computer, and increase it if possible by unloading unnecessary resident programs (e.g., a network).

0 021 A problem was encountered erasing a file.
The specified file could not be erased.

0 022 A problem was encountered copying a file.
The specified file could not be copied successfully.

1 055 Problem in finding the appropriate help screen.
The required help screen or the help screen file, SEADRV.HLP, could not be found.

1 100 Error!
Undetermined error.

CHAPTER FOUR.
ANALYZING SEASONAL ANALYSIS EXPERIMENTS

OVERVIEW

Having produced a summary simulation output file from a seasonal experiment, the next step is to analyze this and compare treatments (these treatments may or may not be replicated, but in seasonal analysis there will usually be a number of replicates). A brief overview of the analysis program's capabilities follows, together with some general usage notes. It should be noted that the analysis program can handle a maximum size of 30 replicates or 20 treatments.

Figure 2 shows the major menu options available. The program does the following.

Biophysical Analysis. Calculates means, standard deviations, maxima and minima by treatment for any or all of the 35 summary output file variables. These can be plotted as box plots, cumulative function plots, or as mean-variance diagrams. All graphs can be screen dumped to a printer or output to a file for plotting.

Economic Analysis. Calculates means, standard deviations, maxima and minima by treatment of economic returns, and plots these as box plots, cumulative function plots, or mean-variance diagrams. Prices and costs can be changed within a session, and price-cost variability can be included in the analysis. Formal strategy evaluation of all treatments, if

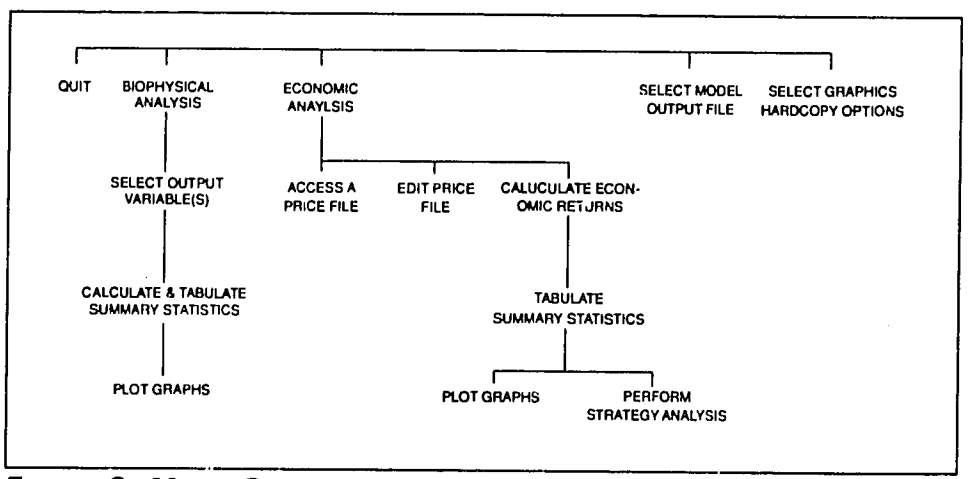


FIGURE 2. MENU OPTIONS FOR THE SEASONAL ANALYSIS PROGRAM.

Previous Page Blank

required, is carried out using mean-Gini stochastic dominance (see Appendix B herein). Any number of summary output files can be analyzed during one session with the program. The user can also control the type and format of hardcopy outputs from the graphics produced.

While these analyses are being performed, results are written to a results file. At the completion of the session, the user can access this file and use the data contained within in any way required. For example, it could be edited for importing into a graphics, spreadsheet or statistics program.

An Example

The Seasonal Analysis program is called from the ANALYSES main menu of the DSSAT v3 Shell (Screen 4, below) and then from the "Seasonal"–"Analyze" submenus. After an introductory screen, the main menu appears on Screen 5 (on following page).

First you must select a cropping season file to analyze (i.e., a summary output file from a previously-run simulation). On selecting this item, the program searches SEASONAL.LST, the listing file that contains the available model summary output files in the current directory (see Table 3). These are presented to the user (see Screen 6, on following page). Note that the entries in SEASONAL.LST do not have to match the entries

```
DECISION SUPPORT SYSTEM FOR AGROTECHNOLOGY TRANSFER

DATA        MODEL        ANALYSES        TOOLS        SETUP/QUIT

                         S Seasonal
                         Q
                           C Create
                           I Inputs
                           S Simulate
                           O Outputs
                           A Analyze

<None>                   Analyze model outputs.

 ↑ ↓ → ←  moves through menu choices
 ESC      moves to higher menu level                Version: 3.0
```

Screen 4.

```
DSSAT Version 3.0 Cropping Season Analysis Tool

 Main Menu
 Select a cropping season file for analysis

 Analyse Biophysical variables
 Analyse Economic variables

 Modify hardcopy options
 About VARAN2....

 Exit

F1 (Help)                                          214240 Mem
```

SCREEN 5.

in EXP.LST, either in number or in order; you may have run and analyzed the experiments in a different order, for example.

As for the driver program, if the colors on the screen are difficult to see (such as

```
DSSAT Version 3.0 Cropping Season Analysis Tool

 Main Menu
   FILE   EXT ENAME
   UFGA7801 SNS GAINESVILLE, SOYBEAN, IRRIGATED AND RAINFED ........
   UFGA7802 SNS EXAMPLE SEASONAL ANALYSIS, SB+MZ ...................
   UFGA7812 SNS GAINESVILLE, FLORIDA, SB IRRIGATION EXPERIMENT .....
 Modify hardcopy options
 About VARAN2 ....

 Exit

F1 (Help)                                          214240 Mem
```

SCREEN 6.

when the program is being run on a monochrome laptop computer), you can force the program to display screens in monochrome by pressing the <ALT>-<F2> keys. Again, note that you cannot reverse the color scheme during a session with the program, nor is your preference stored from one session to another.

Use the mouse or cursor keys to select the third file, UFGA7812.SNS, in Screen 6. After the file is selected, the program gives the user the opportunity to change the name of the analysis results file. By default, this file name will be the same as the summary output file, except the last letter of the extension will be "R" (for "results"). Note that file names are preserved across all three steps of the seasonal analysis procedure: if the model FILEX is UFGA7812.SNX, then simulation results from the model(s) are saved in UFGA7812.SNS, and analysis results in UFGA7812.SNR. If you want to change the results file name, enter a new name (8 characters maximum). Do not add the extension; this is added automatically, and cannot be changed, and will always be "ccR" where "cc" is the crop code (usually SN for seasonal analysis).

The next screen presented (Screen 7, on following page) summarizes the simulation runs found in the chosen summary output file. The experiment code, crop group and file title are displayed, with a treatment-by-treatment listing of treatment title, file ID, the number of replicates, and the appropriate crop pertaining to each treatment. If there are problems with the summary output file, for instance an unequal number of replicates because of model failure for some reason in some treatments, these problems will usually be apparent at this stage. Such errors are usually trapped by the analysis program and result in a warning message to the user and termination of the program.

Press any key to continue, and the main menu of the Analysis program appears again (Screen 5). The items in this menu are illustrated in turn.

Analyze Biophysical Variables

On choosing the main menu option, "Analyze Biophysical Variables," in Screen 5, with the mouse or cursor keys, a list of the variables available for analysis appears (Screen 8, on following page). This is a listing of all the 35 output variables written to the summary output file. You can scroll up and down this list using the <↑> and <↓> keys on the keyboard. Choose variable number 9, "HAR YIELD kg/ha (i.e., harvest yield)," in Screen 8 by placing the cursor bar over the variable in the list and select it by pressing the space bar. A tick mark in the bracket to the right of the variable indicates that this is the variable selected. The space bar can be used to toggle the selection off and on.

```
DSSAT Version 3.0 Cropping Season Analysis Tool

File Title: GAINESVILLE, FLORIDA, SB IRRIGATION EXPERIMENT
Experiment Code: UFGA7812  Crop Group: SN  Runs : 120  Replications : 20

Treat        Title            Field     Reps    Crop

  1  RAINFED............ UFGA0001    20      SB
  2  AUTOMATIC 90%...... UFGA0001    20      SB
  3  AUTOMATIC 70%...... UFGA0001    20      SB
  4  AUTOMATIC 50%...... UFGA0001    20      SB
  5  AUTOMATIC 30%...... UFGA0001    20      SB
  6  AUTOMATIC 10%...... UFGA0001    20      SB

F1 (Help)   Press any key to continue..   214240 Mem
```

SCREEN 7.

```
DSSAT Version 3.0 Cropping Season Analysis Tool

Main Menu
Analysis                                  le for analysis
 1 START SIM day     [ ]
 2 PLANTING day      [ ]
 3 ANTHESIS day      [ ]
 4 MATURITY day      [ ]
 5 HARVET day        [ ]
 6 SOWING WT kg/ha   [ ]
 7 TOPS WT. kg/ha    [ ]
 8 MAT YIELD kg/ha   [ ]
 9 HAR YIELD kg/ha   [ ]
10 BYPRODUCT kg/ha   [ ]
11 WEIGHT mg/unit    [ ]
12 NUMBER #/m2       [ ]
13 NUMBER #/unit     [ ]
14 IRRIG APPS #      [ ]
15 IRRIG mm          [ ]
16 PRECIP mm         [ ]
17 ET TOTAL mm       [ ]
18 RUNOFF mm         [ ]
        ↑↓
F1 (Help)                                 214240 Mem
```

SCREEN 8.

DSSAT Version 3.0 Cropping Season Analysis Tool

Variable : HAR YIELD kg/ha

Treatment	Field	Crop	Mean	St.Dev.	Min	Max
1 RAINFED.....	UFGA0001	SB	3134.9	443.9	1798.0	3602.0
2 AUTOMATIC 90%.....	UFGA0001	SB	3529.2	144.1	3219.0	3761.0
3 AUTOMATIC 70%.....	UFGA0001	SB	3528.3	145.7	3219.0	3761.0
4 AUTOMATIC 50%.....	UFGA0001	SB	3539.8	122.9	3249.0	3759.0
5 AUTOMATIC 30%.....	UFGA0001	SB	3506.1	109.9	3241.0	3725.0
6 AUTOMATIC 10%.....	UFGA0001	SB	3228.0	287.0	2530.0	3602.0

17 ET TOTAL mm [ ]
18 RUNOFF mm [ ]
↑↓

F1 (Help) Press any key to continue.. 214240 Mem

SCREEN 9.

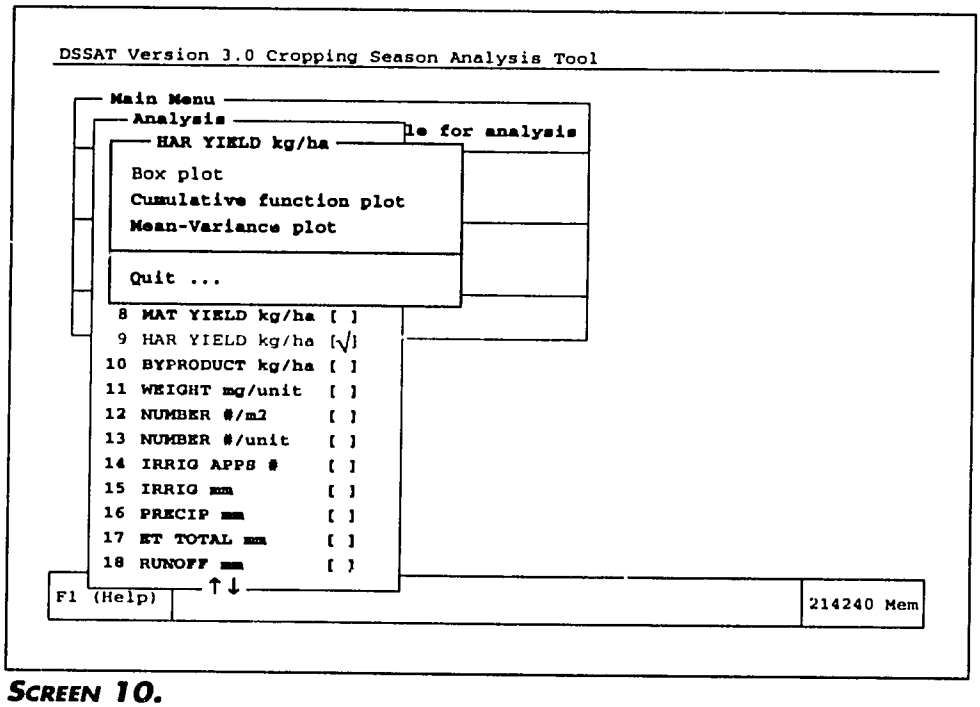
The program calculates various statistics and presents them on screen (see Screen 9, above). These values show, by treatment, the mean, standard deviation, minimum, and maximum harvest yield obtained from running the soybean simulation model. Screen 9 shows the results obtained from the simulation of the automatic irrigation experiment at Gainesville, Florida, UFGA7812.SNX, and referred to above. As might be expected for this simulation, mean soybean yield increased as the irrigation threshold increased (i.e., more water was applied to the crop).

Press any key to continue, and the Graphics main menu appears (Screen 10, on following page). Three types of graphs can be plotted, described as follows.

GRAPHICS MAIN MENU

OPTION 1. BOX PLOT

If this option is selected in Screen 10, a list of all the treatments is presented (by default, all treatments are selected for plotting box plots when this option is selected). All of the treatments can be selected at once by pressing the <+> key, or they can be selected individually by using the space bar as described before under Screen 8. (To deselect all treatments, press the <-> key.) After treatment selection (use the default for this example), press the <ENTER> key and a box plot appears (see Screen 11, on second following page). This is a way of assessing visually the variability of the output variable under consideration. For



SCREEN 10.

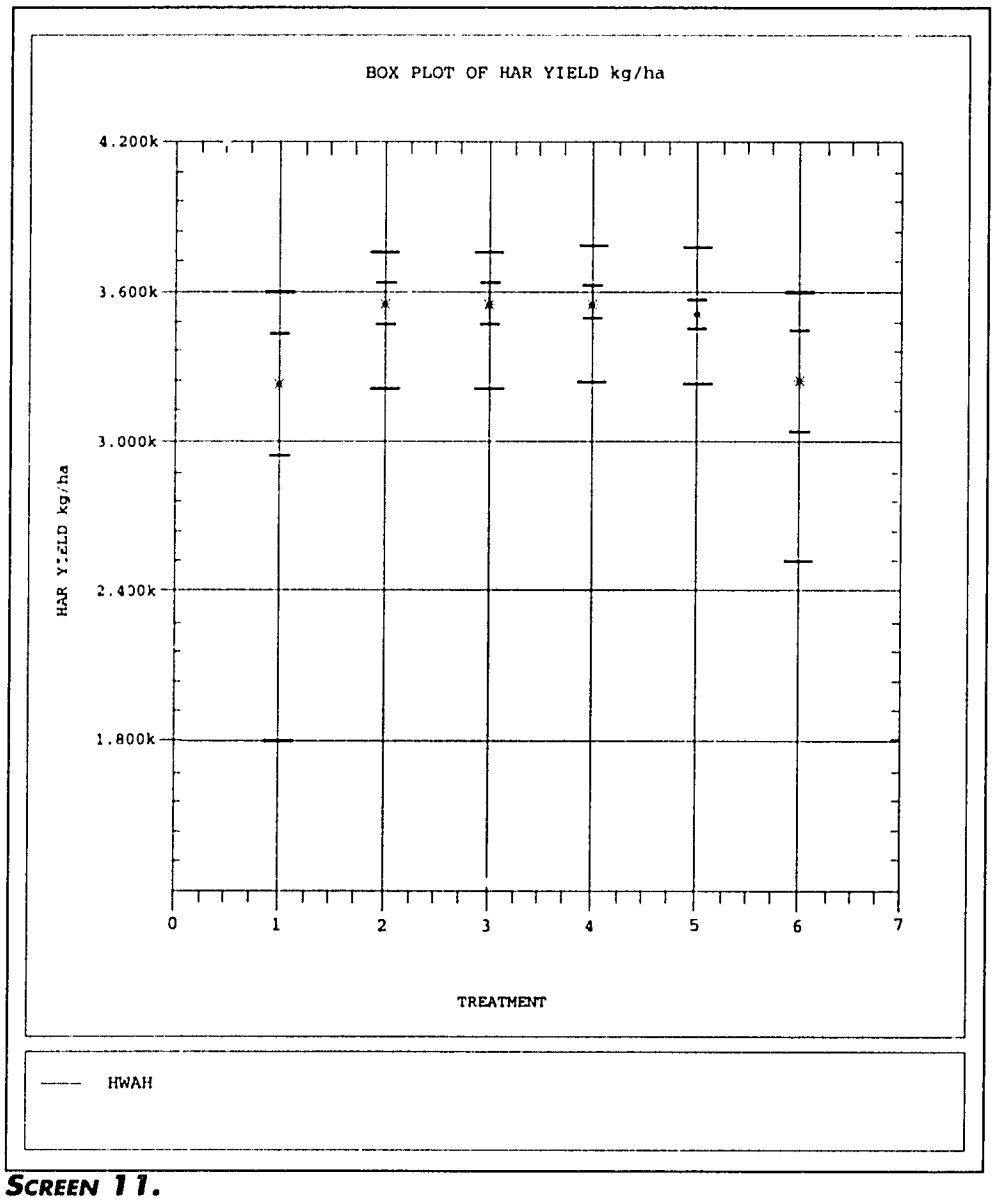
the distribution of the variable for each treatment selected, the 0th (the lowest single short line), 25th (the lower of the short lines connected by the vertical bar), 50th (the star), 75th (the upper of the short lines connected by the vertical bar), and 100th (the upper single short line) percentiles are plotted. Visually, these box plots are sometimes clearer than cumulative probability curves if there are many treatments. The 50th percentile is the median of each output variable distribution, not the mean; but for symmetrical distributions, the median will often not differ greatly from the mean value. Note the effect of irrigation treatment on the distribution of soybean yield.

This graph may be plotted on your printer by pressing the <P> key while the graph is on the screen. If the graph does not plot, you may need to change hardcopy settings (refer to the section below, "Graphics Hardcopy Setup"). Depending on the printer and the resolution used, there may be a delay of a few seconds while this is done; wait for the graph to show on the screen again before continuing.

NOTE: To return to the Analysis program from any graph, press any key.

OPTION 2. CUMULATIVE FUNCTION PLOT

When this option is selected in Screen 10, output variables by treatment are plotted as



SCREEN 11.

cumulative function plots. (Cumulative function plots are sometimes called cumulative probability function (CPF) plots or cumulative distribution function plots – these are the same.) Here, the output distribution for each treatment is ordered from smallest to largest, and plotted against equal increments of cumulative probability.

After selecting this option, the treatment selection screen appears, allowing the user to select which treatments are to be plotted in this way (see Screen 12, on following page). A

```
DSSAT Version 3.0 Cropping Season Analys s Tool
Main Menu
Analysis                                  e for analysis
HAR YIELD kg/ha
CPF Graph - 6 Max
1  RAINFED............ UFGA0001   [√]
2  AUTOMATIC 90%...... UFGA0001   [√]
3  AUTOMATIC 70%...... UFGA0001   [√]
4  AUTOMATIC 50%...... UFGA0001   [√]
5  AUTOMATIC 30%...... UFGA0001   [√]
6  AUTOMATIC 10%...... UFGA0001   [√]
10 BYPRODUCT kg/ha [ ]
11 WEIGHT mg/unit  [ ]
12 NUMBER #/m2     [ ]
13 NUMBER #/unit   [ ]
14 IRRIG APPS #    [ ]
15 IRRIG mm        [ ]
16 PRECIP mm       [ ]
17 ET TOTAL mm     [ ]
18 RUNOFF mm       [ ]
↑↓
F1 (Help)                                   214240 Mem
```

Screen 12.

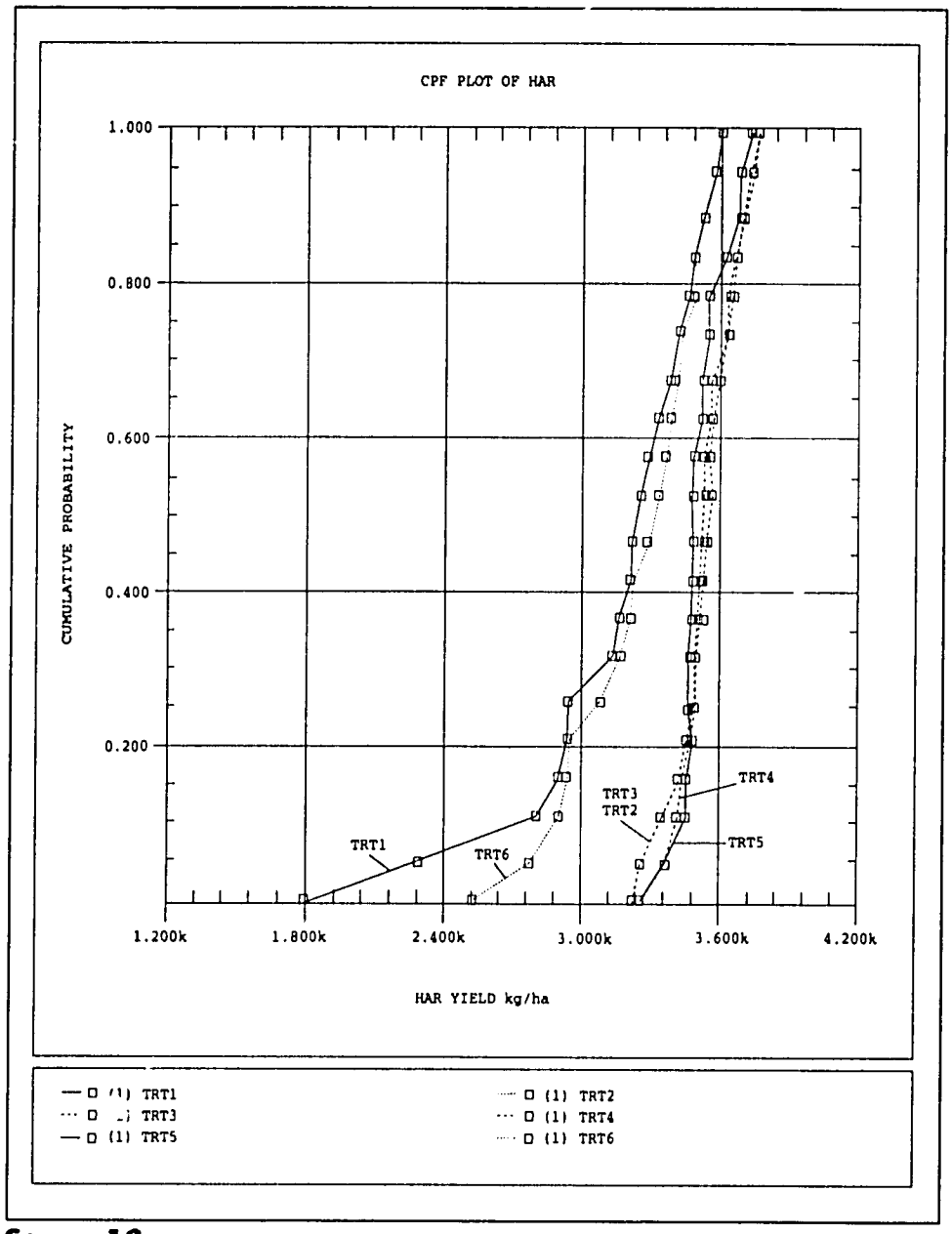
maximum of six cumulative function plots may be graphed at any time, and you can select or deselect all the treatments at once with the <+> or <-> key (as described before under Screen 8), or individual treatments with the space bar. If more than six treatments are selected, the program will plot the first six treatments selected, and the rest will be ignored.

For the example, keep all treatments selected (as illustrated in Screen 12) and press the <ENTER> key. The resulting plot is shown in Screen 13 (on following page). To print the graphs, press the <P> key; press the <ENTER> key to return to the Graphics main menu (Screen 10)

Option 3. Mean-Variance Plot

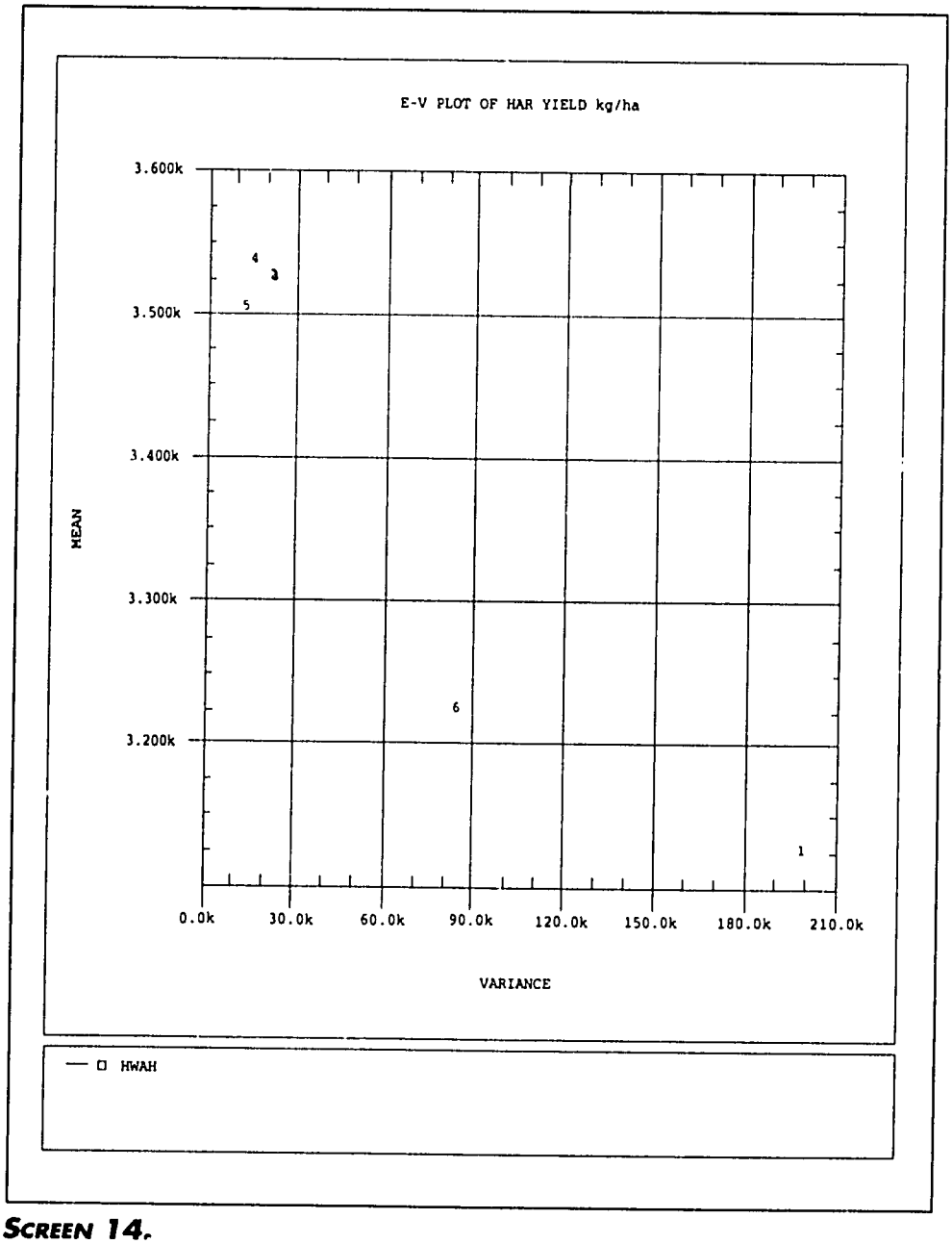
When this option in Screen 10 is selected, output variables may be plotted in mean-variance space. The calculated mean is plotted against the variance for the output variable of interest, and the treatment numbers themselves are drawn on the graph. A maximum of 20 treatments may be plotted in this way. Such graphs are another way of giving an indication of the relative variability associated with each treatment, and are useful for visualizing the tradeoffs that must sometimes be made between striving for a higher mean value while increasing the variability (as described by the variance) for the output of interest.

Choose the mean-variance plot option to produce the plot (Screen 14, on second following page). Note the high variance and comparatively low mean for the rainfed treatment,



SCREEN 13.

Treatment Number 1. There is little to choose between Treatments 2, 3, and 4, in terms of their mean and variance. It seems fairly clear that if the irrigation threshold is at least 50 percent of field capacity, then soybean yields are not limited by water availability in this experiment.



SCREEN 14.

The y-axis for such a plot is always scaled automatically, and care will sometimes be needed in interpretation, as the difference between the means (i.e., the difference from the top to the bottom of the scale) may not be very much, and will sometimes be much less than appears from a cursory glance at the graph. To print the plot, press the <P> key, or press the <ENTER> key to return to the Graphics main menu (Screen 10).

NOTE: *To calculate statistics for all variables in the summary output file, select all the variables from the variable menu (Screen 8) with the <+> key. This will result in means, standard deviations, maxima and minima being calculated for all 35 output variables. Results will be written to the results file, not the screen. If you want to see results and/or graphs on the screen, choose individual variables to analyze one by one. Before quitting the Analysis program, you are given the option to print the results file if you require.*

Analyze Economic Variables

Choosing the main menu option, "Analyze Economic Variables," in Screen 5, allows the analysis of the treatments in economic terms. When this option is selected, the Economic Evaluation main menu (Screen 15, on following page) is presented. There are three major options in Screen 15, described as follows:

Economic Evaluation Main Menu

Option 1. Access A Price File

Before economic evaluation can be undertaken, the program must have access to a price-cost file that details the costs and prices to be used for the analysis. The program will try to read an appropriate price-cost file by itself without input from the user, but other options are also available. When "Access price file" is selected from Screen 15, Screen 16 (on following page) is presented; the price-file options available from this screen are described below.

- Tied Price-Cost Files. Use a price file, with extension PRI, that is tied to the experiment FILEX (in this example, file UFGA7812.PRI). This file option might be used when you have a complicated experiment and you wish to preserve the prices and costs that pertain to the experiment.

- Default Price-Cost File. A default price file, distributed with DSSAT v3, called DEFAULT.PRI, can be used. This default file may be as simple or as complicated as the user requires.

- User-Specified Price-Cost File. You can browse the directory structure of your hard disk and highlight the file you want to use. The directory can be browsed using the arrow keys and pressing the <ENTER> key for the highlighted selection. Alternatively, the mouse can be used to move the highlight bar and the right-hand mouse button will select the highlighted file.

```
DSSAT Version 3.0 Cropping Season Analysis Tool

 Main Menu
   FILE   EXT ENAME
   Access a price file (current file UFGA7812.PRI)
   Edit price file for sensitivity analysis
   Calculate economic returns

   Quit ...

 Exit

F1 (Help)                                          214240 Mem
```

SCREEN 15.

If no price-cost file can be found, or if no tied price-cost file exists, then the program will generate a tied price-cost file using default values. These values can be edited as required (see following section).

```
DSSAT Version 3.0 Cropping Season Analysis Tool

 Main Menu
   Options
     Price File Access
     Use C:\DSSAT3\ECONOMIC\UFGA7812.PRI
     Use C:\DSSAT3\ECONOMIC\DEFAULT.PRI
     Select a new price file

     Quit
 Exit

F1 (Help)                                          214240 Mem
```

SCREEN 16.

Format and Content of Price-Cost Files. The format of the default price-cost file DEFAULT.PRI for seasonal analysis is shown in Table 5, together with a listing of the headers that appear in the file. The eleven prices and costs that are currently included are as follows.

	Cost or Price	*Units*	*Associated Model Output*
1	Price of harvest product (e.g., grain)	$/t	yield, t/ha
2	Price of harvest byproduct	$/t	byproduct yield, t/ha
3	Base production costs	$/ha	–
4	Nitrogen fertilizer cost	$/kg	N applied, kg/ha
5	Cost per N fertilizer application	$	No. of N applications
6	Irrigation costs	$/mm	irrigation applied, mm
7	Cost per irrigation application	$	No. of irrigation applications
8	Seed cost	$/kg	seed sown, kg/ha
9	Cost of organic amendments	$/t	residue applied, t/ha
10	Phosphorus fertilizer cost	$/kg	P applied, kg/ha
11	Cost per P fertilizer application	$	No. of P applications

Note that costs and prices can be negative or positive; this might apply particularly to harvest byproduct, where a negative income is posited (i.e., it costs the farmer money to remove the byproduct – straw or stover, for example). Any monetary units can be used; so "$" can be thought of as "money in general" rather than "dollars."

Economic evaluation of the treatments can take account of price and cost variability. Details on how this is done within the program are given in Appendix A.

Seasonal analysis price files, as shown in Table 5, contain 5 lines per section: a header line, a line containing the distribution type for each of the 11 prices and costs, and three lines of parameters describing the distributions (i.e., PAR1, PAR2, PAR3). Distribution types are described by the variable IDIS, and can have the following values:

< 0 Ignored: the variable is not used in the analysis
0 Fixed: a deterministic or nonvariable price or cost is used
1 Uniform: U(a,b,), a=lower, b=upper bound, third parameter ignored
2 Triangular: T(a,b,c), a=lower, b=mode, c=upper bound
3 Normal: N(x,s,), x=mean, s=standard deviation, third parameter ignored

TABLE 5. PRICE-COST FILE DEFAULT.PRI.

```
* PRICE-COST_FILE : DEFAULT FOR SEASONAL ANALYSIS

! if IDIS=-1, cost/price component is ignored in analysis
! if IDIS= 0, fixed value in PAR1
! if IDIS= 1, uniform variate (PAR1=lower, PAR2=upper bound)
! if IDIS= 2, triangular variate (PAR1=lower, PAR2=mode, PAR3=upper bound)
! if IDIS= 3, normal variate (PAR1=mean, PAR2=st. dev.)

! File sectioned by crop.  A crop's treatment sections must be contiguous.

* MZ
* TREATMENT 1
@PRAM   GRAN    BYPR    BASE    NFER    NCOS    IRRI    IRCO    SCOS    RESM    PCOS    PFER
IDIS     3       0       0       0       0       0       0       0      -1      -1      -1
PAR1  160.00   10.00  240.00    0.45   12.00     .50   12.50     .46     .00     .00     .00
PAR2   16.00     .00     .00     .00     .00     .00     .00     .00     .00     .00     .00
PAR3     .00     .00     .00     .00     .00     .00     .00     .00     .00     .00     .00

* SB
* TREATMENT 1
@PRAM   GRAN    BYPR    BASE    NFER    NCOS    IRRI    IRCO    SCOS    RESM    PCOS    PFER
IDIS     3       0       0       0       0       0       0       0      -1      -1      -1
PAR1  320.00    0.00  390.00    0.45   12.00     .50   12.50     .46     .00     .00     .00
PAR2   32.00     .00     .00     .00     .00     .00     .00     .00     .00     .00     .00
PAR3     .00     .00     .00     .00     .00     .00     .00     .00     .00     .00     .00

* BN
* TREATMENT 1
@PRAM   GRAN    BYPR    BASE    NFER    NCOS    IRRI    IRCO    SCOS    RESM    PCOS    PFER
IDIS     3       0       0       0       0       0       0       0      -1      -1      -1
PAR1  360.00    0.00  380.00    0.45   12.00     .50   12.50     .46     .00     .00     .00
PAR2   36.00     .00     .00     .00     .00     .00     .00     .00     .00     .00     .00
PAR3     .00     .00     .00     .00     .00     .00     .00     .00     .00     .00     .00
```

Headers:

PRAM Parameter
IDIS Distribution type (see file header)
PAR1 Distribution parameter 1
PAR2 Distribution parameter 2
PAR3 Distribution parameter 3

GRAN Price of grain, $/t
BYPR Price of harvest byproduct, $/t
BASE Base production costs, $/ha
NFER Nitrogen fertilizer cost, $/kg
NCOS Cost per N fertilizer application, $
IRRI Irrigation cost, $/mm
IRCO Cost per irrigation application, $/ha
SCOS Seed cost, $/kg
RESM Cost of organic amendments, $/t
PCOS Phosphorus fertilizer cost. $/kg
PFER Cost per P fertilizer application, $

Note that if IDIS equals 1, 2, or 3, then the prices and costs are stochastic.

Figure 3 shows the general shapes of the three stochastic price-cost distributions that may be used (uniform, triangular, and normal).

If you specify a large number (more than three) of stochastic prices and costs, and your computer is not of the fastest, the economic analysis program may take a long time to run. Usually it is best to use only a few stochastic prices and costs.

The price-cost file is sectioned by crop, then by treatment number within crop (see Table 5). You may have multiple treatment sections per crop; you may specify more than one

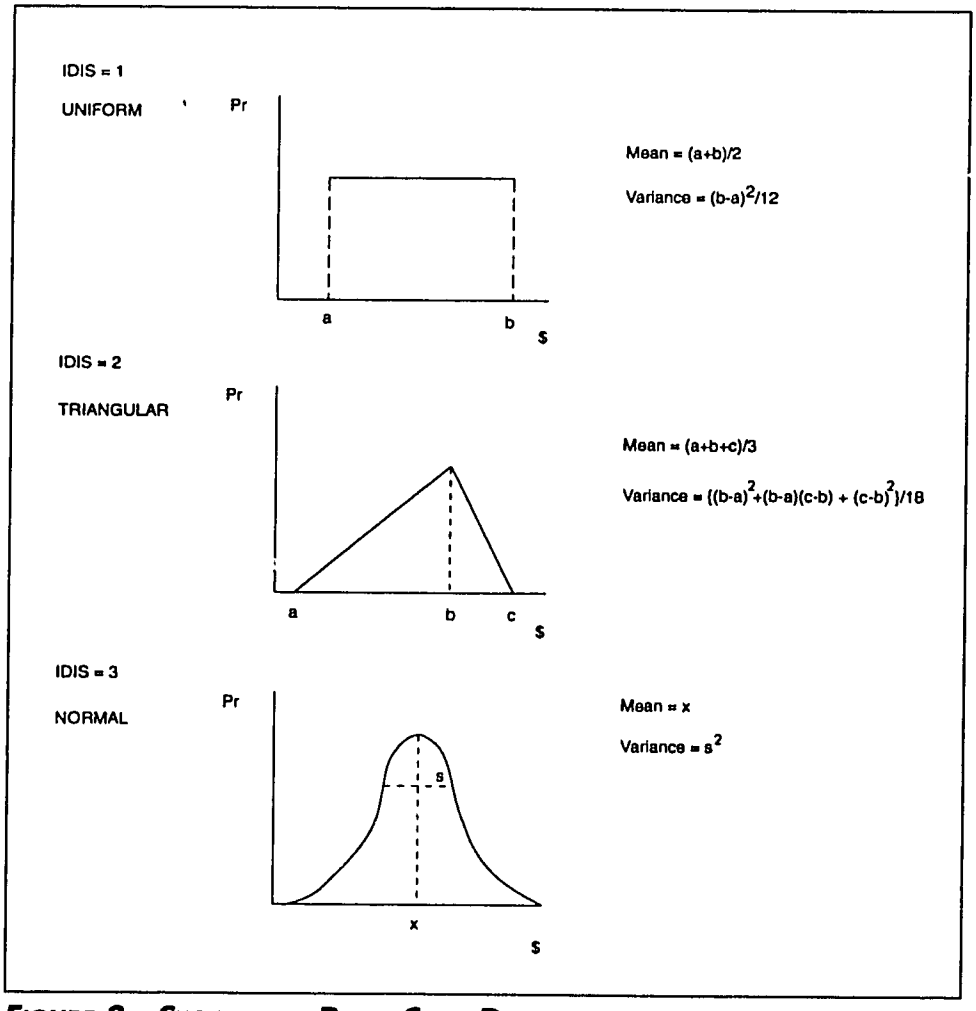


FIGURE 3. STOCHASTIC PRICE-COST DISTRIBUTIONS.

treatment number, or you may specify the keyword ALL, in the * TREATMENT line of a crop section. Thus, for example, "* TREATMENT ALL" and "* TREATMENT 1 2 3" are valid; the treatment numbers and keyword ALL should simply be space-delimited; the exact format does not matter. If you have * TREATMENT ALL, this will ensure that those costs and prices will be used for all treatments pertaining to that crop. A fatal error occurs if there is no appropriate crop section in the price-cost file. Thus if you use the DEFAULT.PRI price-cost shown in Table 5 to analyze a wheat experiment, you will need to add a *WH section to the file.

As noted above, if a section with ALL in the treatment header is found, then that section will be used for all the prices and costs for that crop. The program will match treatment numbers by section if it can. If treatment numbers in FILEX cannot be matched directly with the treatment sections in the price-cost file, then the program will use the next highest treatment number section that has been specified in the price-cost file. If you are unsure about the prices and costs used in any analysis, you can refer to the analysis results file, where the prices and costs used in each analysis are written out explicitly.

Option 2. Edit Price File for Sensitivity Analysis

The second option, "Edit price file for sensitivity analysis" in Screen 15 allows the user to make changes to a price-cost file. When this option is selected, you have the choice to edit each treatment separately or all of them together. Select all the treatments using the <+> key or select one at a time using the space bar. Press the <ENTER> key. The next screen presented (Screen 17, on following page) shows the current values of costs and prices. Press any key to continue. Screen 18 (on second following page) will be presented, from which you can select the cost-price variable to change. For example, to change the grain price, select this item. A submenu will give you the choice of distribution (or it may be fixed or ignored), and you will be prompted for the appropriate distribution parameters.

If you have made any changes, restore the original values of prices and costs so that the screen appears as in Screen 17. To do this, either reset any values changed using the menus, or exit this part of the program and then reenter it. Then select the "Done with changes" option or press the <ESC> key to return to the Economic Evaluation menu (Screen 15).

Option 3. Calculate Economic Returns

When this option is selected from Screen 15, the program will calculate the mean, standard deviation, maximum and minimum value of net return or gross margin per hectare for

```
DSSAT Version 3.0 Cropping Season Analysis Tool

              Cost-Price Sensitivity Analysis: All Treatments

 No.   Cost-Price        Distribution -------------- Values --------------
  1 Grain price - -  $/t  Normal          av  320.00 sd   32.00
  2 Harvest byprod - $/t  Fixed                .00
  3 Base prod costs $/ha  Fixed             345.00
  4 N fert cost - - $/kg  Fixed                .45
  5 N cost per appl - $   Fixed              12.00
  6 Irrig cost - -  $/mm  Fixed                .50
  7 Irr cost per appl  $  Fixed              12.50
  8 Seed cost - - - $/kg  Fixed                .46
  9 Organic amends - $/t  Ignored
 10 P fert cost - - $/kg  Ignored
 11 P cost per appl - $   Ignored

F1 (Help)   Press any key to continue..   214240 Mem
```

SCREEN 17.

each treatment (see Screen 19, on following page), using the costs and prices specified. Note that for the example, returns per hectare are highly variable; note also that returns per

```
DSSAT Version 3.0 Cropping Season Analysis Tool

              Cost-Price Sensitivity Analysis: All Treatments

 No.   Cost-Price        Distribution -------------- Values --------------
 Edit?                   Normal          av  320.00 sd   32.00
 Grain price - -  $/t    Fixed                .00
 Harvest byprod - $/t    Fixed             345.00
 Base prod cost  $/ha    Fixed                .45
 N fert cost - - $/kg    Fixed              12.00
 N cost per appl -  $    Fixed                .50
 Irrig cost - -  $/mm    Fixed              12.50
 Irr cost per appl  $    Ignored              .46
 Seed cost - - - $/kg    Ignored
 Organic amends - $/t    Ignored
 P fert cost - - $/kg
 P cost per appl -  $
 Done with changes

F1 (Help)                                 214240 Mem
```

SCREEN 18.

DSSAT Version 3.0 Cropping Season Analysis Tool

Economic Analysis
Money per Hectare

Treatment	Field	Crop	Mean	St.Dev.	Min	Max
1 RAINFED.....	UFGA0001	SB	623.2	236.9	65.7	1045.0
2 AUTOMATIC 90%.....	UFGA0001	SB	356.5	191.3	20.6	671.6
3 AUTOMATIC 70%.....	UFGA0001	SB	534.0	187.1	210.6	811.8
4 AUTOMATIC 50%.....	UFGA0001	SB	607.0	187.2	307.4	933.5
5 AUTOMATIC 30%.....	UFGA0001	SB	668.8	189.4	345.0	982.1
6 AUTOMATIC 10%.....	UFGA0001	SB	637.7	191.8	243.4	990.5

F1 (Help) | Press any key to continue.. | 214240 Mem

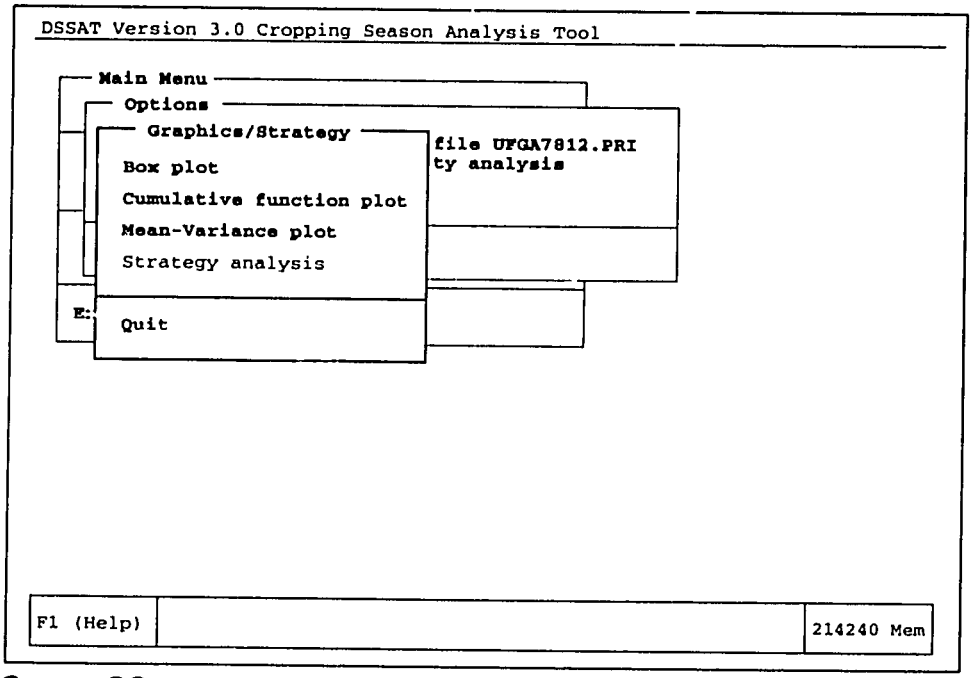
SCREEN 19.

hectare decrease markedly as more irrigation is applied. Heavily irrigated treatments are clearly economically wasteful in this situation for the costs and prices used (which are fictitious and for illustrative purposes only).

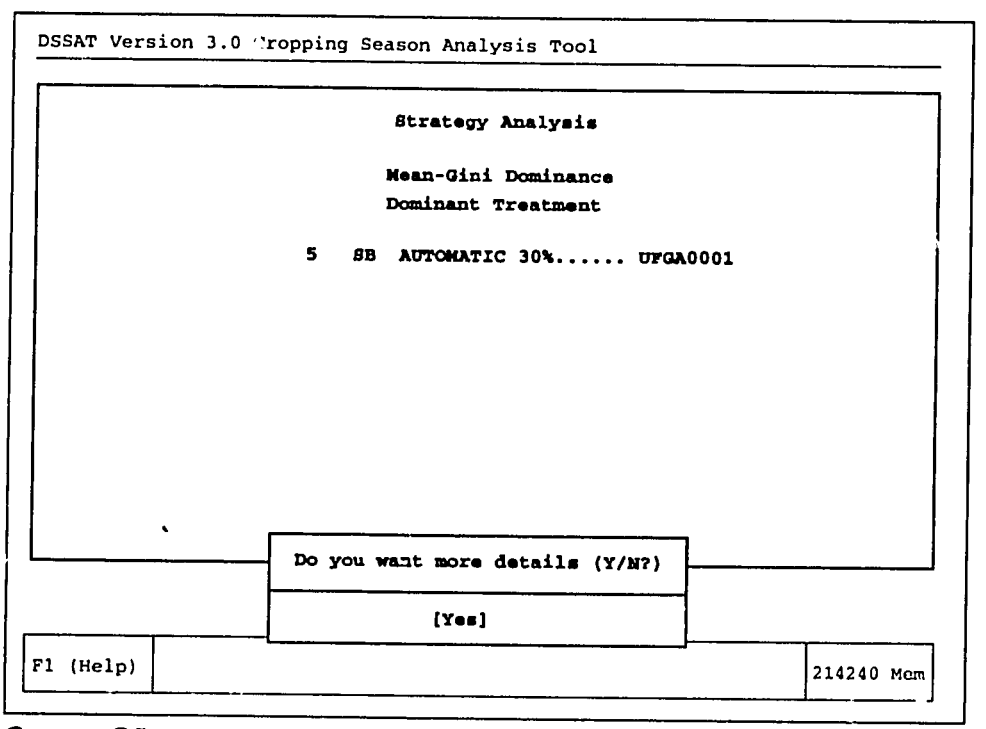
From within Screens 17, 18 or 19, press any key to continue, and the economics Graphics/Strategy menu appears (Screen 20, on following page). The first three options in Screen 20 operate in exactly the same way as described for the biophysical variables in the section entitled, "Analyze Biophysical Variables." The fourth option in Screen 20, "Strategy Analysis," is described as follows.

STRATEGY ANALYSIS – MEAN-GINI DOMINANCE

When the "Strategy Analysis" option is selected in Screen 20, the resulting screen (Screen 21, on following page) lists the mean-Gini dominant treatment of the experiment, in terms of the costs and prices used to analyze it. Appendix B discusses strategy analysis in some detail. Basically, however, a dominant treatment is one that would be preferred by a decision maker over the other ("dominated") treatments, if various things are assumed about the decision maker's attitudes and preferences. It is a form of decision analysis that takes account of the risk involved. Note that the dominant strategy (Treatment 5, displayed on Screen 21) produced the highest mean return per hectare ($668.80/ha, as shown on Screen 19).



SCREEN 20.



SCREEN 21.

Results of the calculations carried out to establish this mean-Gini dominance can be viewed by pressing the <Y> or <ENTER> keys. Screen 22 displayed below, lists the mean return for each treatment, the mean return minus its gini coefficient, and whether the treatment is efficient (or dominant) or not. In the example shown, note that the extra cost of irrigating frequently is not justified in terms of the added benefit of more yield. This example is discussed in more detail in Appendix B.

NOTE: *You should be careful in interpreting the output of Strategy Analysis, as the assumptions may not always be valid. It is, however, a useful tool for helping you to "pre-screen" a wide variety of options and identifying those options or treatments that merit further investigation. Of course, there may be many reasons why a dominant treatment is not appropriate for a particular farmer; further analyses outside the confines of the DSSAT3 will always be required before much can be said about the feasibility of particular management options in any particular situation.*

Another case where you should exercise great care in interpretation is when you are investigating the economic benefits of fertilizer use. You may have the situation where you are running a treatment with the nitrogen routines of the crop models turned off. If you analyze such a treatment economically, then you will often obtain abnormally large economic returns, apparently with no N inputs to the system!

You should also exercise caution when interpreting the economic benefits to fertilizer use in terms of a

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Strategy Analysis
Mean-Gini Dominance: E(x) mean return $/ha
Γ(x) Gini ceofficient $/ha

	Treatment	Field	E(x)	E(x) - Γ x)	Efficient (Yes/No)
1	SB RAINFED.....	UFGA0001	623.2	486.9	N
2	SB AUTOMATIC 90%.....	UFGA0001	356.5	244.2	N
3	SB AUTOMATIC 70%.....	UFGA0001	534.0	424.3	N
4	SB AUTOMATIC 50%.....	UFGA0001	607.0	496.9	N
5	SB AUTOMATIC 30%.....	UFGA0001	668.8	558.1	N
6	SB AUTOMATIC 10%.....	UFGA0001	637.7	526.2	Y
					N

F1 (Help) | Press any key to continue | 214240 Mem

SCREEN 22.

simulated N response curve, for example. The economic optimum N application rate will often be overestimated using the model, simply because the crop model and the economic analysis will usually assume that "all other things are equal". Of course, they are not; the inputs required to obtain a general yield level of 1 t of cereal per hectare and those required to obtain 7 t per hectare are likely to be very different (more labor for weed, pest, and disease control, etc). This highlights the general observation that running a simulation experiment is trivial; interpreting the output produced requires great care.

Press any key in Screen 22 to return to the Graphics/Strategy menu (Screen 20). Choose the "Quit" option in Screen 20 twice (or hit the <ESC> key twice) to return to the Seasonal Analysis main menu (Screen 5).

Modify Hardcopy Options

On choosing the main menu option, "Modify Hardcopy Options," in Screen 5, with the mouse or cursor keys, you can change the way in which hardcopies of the graphs are produced on your printer or plotter. The screen that appears (Screen 23, on following page) when this option is selected, lists the current graphics hardcopy options. These are stored in an ASCII file called GRAPH.INI (see Table 6). The various controller options can be changed from Screen 2, simply by selecting the option to change and choosing any of the valid options (thus your printer port might be LPT2 rather than LPT1). After making any changes to the controller options in this screen, you can select to abandon the changes you have made, or you can save the changes to the file GRAPH.INI.

Normally, configuration of the graphics program will be carried out through the configuration menu in the Seasonal and Sequence Analysis programs. You may wish to edit GRAPH.INI with a text editor, however. The section of GRAPH.INI that holds configuration data for the graphics program is under the [WMGraf] section of the INI file. Defaults for plotting are defined in this section, in the format "keyword=" followed by a string, integer, or real variable. Specifically, the keyword definitions and possible values are:

gcolor[0..7]: refers to the default color palette for plotting. Values are 0 to 15.
interval: number of major divisions on the X and Y axis (-9 chooses Autoscaling)
tics: number of tic marks between the major divisions (-9 chooses Autoscaling)
driver: an integer value of 0 to 33 is specified. The printer/plotter options are listed in Table 7.

```
DSSAT Version 3.0 Cropping Season Analysis Tool

 Main Menu
  Hardcopy
  Printer driver        : HP LaserJet/DeskJet B&W 150 dpi
  Printer port          : LPT1:
  Orientation           : Portrait
  X Multiplier          :  1.00
  Y Multiplier          :  1.00
  File name             : C:\DSSAT3\SEASONAL\VARAN200.GRA

  Save changes and exit
  Abandon changes and exit

F1 (Help)                                          214240 Mem
```

SCREEN 23.

TABLE 6. SAMPLE SECTION OF GRAPH.INI.

```
[WMgraf]
color0=1
color1=15
color2=14
color3=12
color4=15
color5=10
color6=11
color7=13
interval=-9
tics=-9
driver=7
port=0
orientation=0
fontsize=6
xmult=1.00
ymult=1.00
usetics=Y
usekeyword=1
file=OUTPUT
```

port:	0 for LPT1:, 1 for LPT2:, 2 for COM1:, 3 for COM2:, or 4 for redirection of output to a file
orientation:	0 for portrait or 1 for landscape
fontsize:	fontsize for labels (1 to 20)
xmult:	X multiplier
ymult:	Y multiplier
file:	name for file output if port=4

The printer types supported by the graphics program are shown in Table 7.

TABLE 7. PRINTER TYPES SUPPORTED BY THE GRAPHICS PROGRAM.

Driver Number	Driver Description
0	Epson 9 Pin 60 x 72 dpi
1	Epson 9 Pin 120 x 72 dpi
2	Epson 9 Pin 240 x 216 dpi
3	Epson 24 Pin 180 x 180 dpi
4	Epson 24 Pin 360 x 180 dpi
5	Epson 24 Pin 360 x 360 dpi
6	HP LaserJet/DeskJet B&W 100 dpi
7	HP LaserJet/DeskJet B&W 150 dpi
8	HP LaserJet/DeskJet B&W 300 dpi
9	HP DeskJet 500C 100 dpi 8 color
10	HP DeskJet 500C 150 dpi 8 color
11	HP DeskJet 500C 300 dpi 8 color
12	HP PaintJet 90 dpi B&W
13	HP PaintJet 180 dpi B&W
14	HP PaintJet 90 dpi 16 color
15	HP PaintJet 180 dpi 8 color
16	HP PaintJet 180 dpi 16 color (XL)
17	HP ThinkJet 192 dpi
18	HP 7475A Plotter A size paper
19	HP 7475A Plotter B size paper
20	HP 7475A Plotter A4 size paper
21	HP 7475A Plotter A3 size paper
22	HP 7550 Plotter A size paper
23	HP 7550 Plotter B size paper
24	HP 7550 Plotter A4 size paper
25	HP 7550 Plotter A3 size paper
26	HP 7440 Plotter A4 size paper
27	HP 7470 Plotter A3 size paper
28	HP LaserJet HPGL Mode A size paper
29	HP LaserJet HPGL Mode B size paper
30	PostScript Printer Courier
31	PostScript Printer Helvetica
32	PostScript Printer Times
33	PostScript Printer Symbol

Legends for the graphics program are taken from a DSSAT v3 file called DATA.CDE (see Table 8). (For a description of the DATA.CDE file, see the Appendix to Volume 1 of this book.) This file lists, among other things, the headers, abbreviations, and definitions of the 35 output variables in the summary model output file that can be analyzed using the seasonal analysis program, in the section headed by the *SUMMARY keyword.

TABLE 8. EXPERIMENT DATA CODES FILE DATA.CDE — SUMMARY SECTION ONLY.

```
*EXPERIMENTAL DATA CODES

*SUMMARY
SDAT START SIM day    Simulation start date (YRDOY)
PDAT PLANTING day     Planting date (YRDOY)
ADAT ANTHESIS day     Anthesis date (YRDOY)
MDAT MATURITY day     Physiol maturity date (YRDOY)
HDAT HARVEST day      Harvest date (YRDOY)
DWAP SOWING WT kg/ha  Planting material wt (kg dm/ha)
CWAM TOPS WT. kg/ha   Tops wt at maturity (kg dm/ha)
HWAM MAT YIELD kg/ha  Yield at maturity (kg dm/ha)
HWAH HAR YIELD kg/ha  Yield at harvest (kg dm/ha)
BWAH BYPRODUCT kg/ha  By-product harvest (kg dm/ha)
HWUM WEIGHT mg/unit   Wt at maturity (mg dm/unit)
H#AM NUMBER #/m2      Number at maturity (no/m2)
H#UM NUMBER #/unit    Number at maturity (no/unit)
IR#M IRRIG APPS #     Irrigation applications (no)
IRCM IRRIG mm         Season irrigation (mm)
PRCM PRECIP mm        Season precipitation (mm)
ETCM ET TOTAL mm      Season evapotranspiration (mm)
ROCM RUNOFF mm        Season surface runoff (mm)
DRCM DRAINAGE mm      Season water drainage (mm)
SWXM EXTR WATER cm    Extr water at maturity (cm)
NI#M NITR APPL #      Number of N applications (no)
NICM TOT N APP kg/ha  Total inorganic N appl (kg/ha)
NFXM N FIX kg/ha      N fixed during season (kg/ha)
NUCM N UPTAKE kg/ha   N uptake during season (kg/ha)
NLCM N LEACH kg/ha    N leached during season (kg/ha)
NIAM SOIL IN N kg/ha  Soil inor-N at maturity (kg/ha)
CNAM CROP N kg/ha     Tops N at maturity (kg/ha)
GNAM PRODUCT N kg/ha  Product N at maturity (kg/ha)
RECM RESIDUE kg/ha    Total residue applied (kg/ha)
ONAM ORGANIC N kg/ha  Org soil N at maturity (kg/ha)
OCAM ORGANIC C t/ha   Org soil C at maturity (t/ha)
PO#M P APPL #         Number of P applications (no)
POCM TOT P APP kg/ha  Total P applied (kg/ha)
CPAM CROP P kg/ha     Tops P at maturity (kg/ha)
SPAM SOIL P kg/ha     Soil P at maturity (kg/ha)
```

Selecting Another Input File for Analysis

Having analyzed one simulation summary file, you can choose to analyze another file in Screen 5. Note that a new analysis results (SNR) file will be produced for each summary output file (SNS) you analyze. You can choose to print the results file at this stage in the program, if you require (see following paragraph).

When you have concluded all the analysis you require, quit the program from the main menu screen (Screen 5). A message will appear with a reminder of the path and name of the log file containing analysis results that has just been produced (an example of part of such a file is shown in Table 9). This file can be edited as required, and the data imported into any application capable of reading ASCII text files for whatever purpose you require. Before you exit the program, you are given the option of printing this file. You should be aware that the file may be very long, however, if you have carried out many analyses.

Information and Error Messages

A number of information and error messages are produced by the Seasonal Analysis program. In the list that follows, each message is preceded by a single-digit code and a three digit message/error number. If the single-digit code is "0," then this is a fatal error, and the program exits. If the code is "1," then the program will continue, as the error may not be fatal. Information messages have code "1" also. Some of these messages are self-explanatory. Others are indications of serious problems and you should check your file formats.

0 001 Cannot find directory file :
The summary output listing file could not be found in the current directory.

0 002 No entries found in file :
The summary output listing file could be found, but no valid entries were found in it.

1 003 Cannot find file :
The specified file cannot be found in the appropriate directory.

0 004 Error reading :
An error occurred during file reading; this is usually due to incorrect format of the specified file.

0 007 Cannot access file :
The specified file cannot be found in the appropriate directory.

TABLE 9. PART OF SEASONAL ANALYSIS RESULTS FILE UFGA7812.SNR.

*SN_ANALYSIS_LOG : UFGA7812SN GAINESVILLE, FLORIDA, SB IRRIGATION EXPERIMENT

Date: 20 Apr, 1994 Time: 11:48:18

Input file : C:\DSSAT3\SEASONAL\UFGA7812.SNS

BIOLOGICAL VARIABLES

Calculated Values: Variable = HAR YIELD kg/ha

	treatment	field	crop	mean	st.dev
1	RAINFED.....	UFGA0001	SB	3134.90	443.91
2	AUTOMATIC 90%.....	UFGA0001	SB	3529.20	144.06
3	AUTOMATIC 70%.....	UFGA0001	SB	3528.30	145.71
4	AUTOMATIC 50%.....	UFGA0001	SB	3539.75	122.89
5	AUTOMATIC 30%.....	UFGA0001	SB	3506.15	109.92
6	AUTOMATIC 10%.....	UFGA0001	SB	3228.00	286.99

			percentiles				
treat	0th	10th	25th	50th	75th	90th	100th
1	1798.0	2755.9	2941.3	3233.5	3425.5	3525.4	3602.0
2	3219.0	3338.5	3468.0	3548.5	3632.5	3696.7	3761.0
3	3219.0	3336.9	3461.5	3543.0	3637.0	3695.9	3761.0
4	3249.0	3407.5	3482.8	3527.5	3629.5	3694.5	3759.0
5	3241.0	3431.2	3460.8	3481.0	3542.8	3679.2	3725.0
6	2530.0	2892.3	3047.8	3304.0	3430.5	3525.4	3602.0

BIOLOGICAL VARIABLES

Calculated Values: Variable = IRRIG APPS #

	treatment	field	crop	mean	st.dev
1	RAINFED.....	UFGA0001	SB	.00	.00
2	AUTOMATIC 90%.....	UFGA0001	SB	22.25	3.99
3	AUTOMATIC 70%.....	UFGA0001	SB	10.80	2.76
4	AUTOMATIC 50%.....	UFGA0001	SB	6.65	2.11
5	AUTOMATIC 30%.....	UFGA0001	SB	3.10	1.71
6	AUTOMATIC 10%.....	UFGA0001	SB	.65	.81

			percentiles				
treat	0th	10th	25th	50th	75th	90th	100th
1	.0	.0	.0	.0	.0	.0	.0
2	12.0	18.8	20.8	22.0	25.0	27.0	30.0
3	6.0	8.8	9.0	10.5	11.3	15.1	17.0
4	3.0	4.9	5.0	6.0	8.3	9.1	11.0
5	.0	1.9	2.0	3.0	4.0	6.0	7.0
6	.0	.0	.0	.0	1.0	2.0	2.0

1 008 Read error in subroutine GETCOD, file :
An error occurred in reading the specified file.

0 009 Code could not be found :
The program attempted to find the specified code in the DSSATPRO.FLE, but could not find it. The pathname associated with the code specifies the location of the graphics program for the seasonal analysis graphics.

1 012 Treatments are not numbered consecutively from 1 :
The treatments in the summary output file selected are not numbered consecutively starting with a treatment number of 1. Treatment numbers in the file can be edited to prevent this happening; a better solution is to edit treatment numbers in the relevant FILEX itself.

1 013 Cannot find file :
The specified file cannot be found.

1 014 Must have at least 2 replicates for a CPF plot
To plot cumulative probability functions, you must have a distribution with at least 2 values or replicates.

0 015 A problem was encountered generating a price file! Restart now..
An internally generated price file could not be completed.

1 020 A problem was encountered executing another program
The program was not able to execute another program; check the free RAM that you have on your computer, and increase it if possible by unloading unnecessary resident programs (e.g. a network).

1 021 A problem was encountered copying a file
The specified file could not be copied successfully.

1 022 A problem was encountered erasing a file
The specified file could not be erased successfully.

1 023 Error in TUKEY.FOR
An error occurred when calculating percentiles of a distribution.

1 024 READ Error in file :
A read error occurred in the specified file; check the format of the file.

1 025 Unequal treatment reps in file :
Unequal treatment replicates were found in the selected summary output file; exit and fix the file to avoid this message.

1 026 READ Error in DATA.CDE
An error occurred when reading the file DATA.CDE; check that it is complete and the format is correct.

1 027 All variances are zero
The variances for the selected treatments are zero.

1 028 Total number of runs exceeds 600
See message 031.

1 029 Number of treatments exceeds 20
See message 031.

1 030 Number of replicates exceeds 30
See message 031.

1 031 File is too big to analyze:
This error message arises in conjunction with one of three other messages, and refers to the fact that the selected summary output file is too large with respect to total number of runs (error message 028), number of treatments (error message 029), or number of replicates (error message 030).

1 032 Analysis results written to the file :
Analysis results have been written to the specified file.

1 033 Output written to :
Program output has been written to the specified file.

1 034 For graphics, choose variables one at a time !
To produce graphs of model outputs, choose single variables.

1 035 Output already written to :
Output for this variable has already been written to the analysis results file.

1 036 For graphics, choose single variables
As for message 034.

1 037 The program has no access to a price file. Access one!

0 038 Error in filename :
Error in filename specification.

1 039 Crop code not matched in price file :
There was no section in the price file corresponding to the specified crop code; you must edit the file so that this section exists.

1 040 Read error in price file :
Check the format of the price file; a read error occurred.

0 041 Cannot find file :
Specified file cannot be found.

0 042 Error in :

0 043 Read error in file :
Read error in the specified file.

0 044 Must have at least 2 replicates for a CPF plot!
See message 014.

1 045 Error in TUKEY.FOR; <Enter> to quit
See message 023.

0 046 ERIC2 size problem
Array overflow error.

1 047 A price file must be accessed using opt. 1 before using this option
You must access a price file before attempting to carry out the economic calculations.

0 048 Error in CONVOL.FOR!
Error in combining distributions.

1 049 All variances are zero; <Enter> to continue
See message 027.

1 050 Cannot find a file .. choose again :

1 051 You must first select an analysis!
Select one of the analysis options before continuing.

1 052 All data are ZERO. Plotting causes unpredictable behavior!

1 055 Problem in finding the appropriate help screen
The appropriate help screen could not be found.

1 058 There were no matching files found!

1 060 The requested subdirectory to be searched doesn't exist!!!

1 100 Error!
Undetermined error.

1 131 You MUST turn on the printer now or the program will crash!

1 148 A problem was encountered in trying to print a file!
The results file could not be printed successfully.

REFERENCES

The following references contain more details on strategy analysis:

Anderson, J. R., J.L. Dillon and J.B. Hardaker. 1977. Agricultural Decision Analysis. Iowa State University Press.

Buccola, S. T. and A. Subaei. 1984. Mean-Gini analysis, stochastic efficiency and weak risk aversion. Australian Journal of Agricultural Economics 28, 77-86.

Fawcett, R. H. and P.K. Thornton. 1990. Mean-Gini dominance in decision analysis. IMA Journal of Mathematics Applied in Business and Industry 6, 309-317.

Halter, A. N. and G.W. Dean. 1971. Decisions under uncertainty with research applications. South-Western Publishing Company, Cincinnati, OH.

Raiffa, H. 1968. Decision Analysis. Addison Wesley, Reading, MA.

The Seasonal Analysis program is outlined in the following:

Thornton, P. K. and G. Hoogenboom. 1994. A computer program to analyze single-season crop model outputs. Agronomy Journal (*in press*).

Details on FILEX creation and editing may be found in:

Imamura, D.T. 1994. Creating management files to run crop models & document experiments. *In:* Tsuji, G.Y., G. Uehara and S. Balas (eds). DSSAT v3. Vol. 1-4. University of Hawaii, Honolulu, HI.

Other References:

Geng, S., J.S. Auburn, E. Brandsetter and B. Li. 1988. A program to simulate meterological variables: Documentation for SIMMETEO. Agronomy Progress Report No. 204. Dept. of Agronomy and Range Sci., Univ. of California, Davis. CA.

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Hunt, L.A., J.W. Jones, P.K. Thornton, G. Hoogenboom, D.T. Imamura, G.Y. Tsuji and U. Singh. 1994. Accessing data, models and application programs. *In*: Tsuji, G.Y., G. Uehara and S. Balas (eds.). DSSAT v3. Vol. 1-3. University of Hawaii, Honolulu, HI.

Jones, J.W., L.A. Hunt, G. Hoogenboom, D.C. Godwin, U. Singh, G.Y. Tsuji, N. Pickering, P.K. Thornton, W.T. Bowen, K.J. Boote and J.T. Ritchie. 1994. Input and output files. *In:* Tsuji, G.Y., G. Uehara and S. Balas (eds). DSSAT v3. Vol. 2-1. University of Hawaii, Honolulu, HI.

Richardson, C.W. and D.A. Wright. 1984. WGEN: a model for generating daily weather variables. United States Department of Agriculture, Agricultural Research Sevice, ARS-8, Washington, DC.

Thornton, P.K., P.W. Wilkens, G. Hoogenboom and J.W. Jones. 1994. Sequence analysis. *In:* Tsuji, G.Y., G. Uehara and S. Balas (eds). DSSAT v3. Vol. 3-2. University of Hawaii, Honolulu, HI.

APPENDIX A.
COMBINING YIELD AND PRICE DISTRIBUTIONS

If the user specifies price and cost variability, the Seasonal Analysis program proceeds by combining the simulated distributions of biophysical outputs with the user-specified distributions of costs and prices. The method used is illustrated below for a simulated yield distribution made up of seven replicates.

Gross margin or net return calculations involve simple algebra, in the simplest case no more than the following:

Return = Price * Yield - Costs of production

The simulation models can produce a distribution of yields. If price is defined as a distribution also, then a way has to be found to estimate the new distribution for the quantity "price times yield." Similarly, distributions may have to be subtracted from each other to produce the "final" distribution of returns per hectare. The analysis program does this as follows.

The values of the relevant biophysical outputs (yield, residue, and so forth) for each replicate are combined algebraically with the inverse of the appropriate analytical cumulative probability function that is used to describe the particular cost or price, using five equi-distant percentiles of the CPF (the 0th, 25th, 50th, 75th, and 100th percentiles). The inverse of a cumulative probability distribution is an algebraic expression whereby the value of the random variable associated with any value of cumulative probability can be calculated. The distribution vector containing the values of gross margin or net return per hectare, which is then of length 5*n, where n is the number of replicates, is sorted and collapsed to length n by linear interpolation.

Each algebraic operation on the distributions is done separately for each stochastic price or cost. The final distribution of returns per hectare will contain the same number of members as there were yields in the original yield distribution (i.e., number of replicates).

One point to bear in mind is that the method of combining distributions is not exact, but an approximation. You may find that the mean of the distribution of returns per hectare derived using one or more stochastic price or cost will be somewhat different from the

mean when all prices and costs are fixed. This is to be expected, but the differences should not be large, and ranking of treatments should not be greatly affected.

An Illustration

Step 1

Order the 7-member simulated yield distribution from smallest to largest:

yield Y, t/ha:	0.90	1.60	1.90	2.10	2.40	2.50	3.10

Step 2

Assume grain price is described by a triangular distribution with minimum value \$90/t, mode \$110/t, and maximum value \$120/t; calculate the following percentiles from the inverse of the triangular distribution:

percentile :	0.0	25.0	50.0	75.0	100.0
price P, \$/t :	90.0	102.2	107.3	111.3	120.0

Step 3

Multiply each yield by each of the five price percentiles to form a vector of length 35; then order this from smallest to largest:

n :	1	2	3	4	....	34	35
P*Y:	81.00	91.98	96.57	100.17	....	345.03	372.00

Step 4

From the distribution of P*Y, described by 35 values, calculate by linear interpolation the following percentiles of the distribution, so that for 7 values of yield, we obtain 7 values of P*Y:

percentile:	0.0	16.7	33.3	50.0	66.7	83.3	100.0
P*Y :	81.00	153.76	192.73	225.00	254.33	282.00	372.00

APPENDIX B.
THREE DECISION CRITERIA

The stochastic efficiency rules are an important class of decision criteria, and are particularly suited to the analysis of simulation model output. These have their basis in Bernoullian utility theory, and differ in the assumptions that are made about the decision maker's attitude to risk. (Refer to the "Reference" section in this Part for sources of information on the issues discussed in this appendix). These rules were developed to tackle the problem of portfolio selection in investment theory, but are now firmly- entrenched tools for risk analysis in all sorts of applications. All involve a pair-wise comparison of random variables, and strictly speaking, these should relate to financial gains and losses. The result of the analysis is an efficient set of treatments. The efficient set contains a subset of treatments that are superior (there may be one only, but sometimes there will be more than one efficient treatment). Three variations are described briefly below.

MEAN-VARIANCE (EV) ANALYSIS

For two risky prospects, A and B, with means E(.) and variances V(.) respectively, then A dominates B if

$$E(A) = E(B) \text{ and } V(A) < V(B) \text{ or if}$$
$$V(A) = V(B) \text{ and } E(A) > E(B).$$

A is then said to be EV-efficient. If prospects are plotted in EV space (V the ordinate, E the abscissa), then utility increases in a north-westerly direction. EV analysis assumes that the decision maker has a quadratic utility function for gains and losses, and/or that the risky prospects are distributed normally (or at least distributed symmetrically). These are often untenable assumptions, and the EV criterion has fairly weak discriminatory power (i.e., the efficient sets tend to be large).

STOCHASTIC DOMINANCE (SD) ANALYSIS

For two risky prospects, A and B, A dominates B by first-order stochastic dominance (FSD) if the Cumulative Distribution Function (CDF) of gains from A lies to the right of the CDF of B over the entire probability interval 0 to 1.

If the CDFs of A and B intersect, then no dominance by FSD can be established. If, how-

ever, the area between the two CDFs below the point of intersection is greater than the area between the two CDFs above the point of intersection, then A dominates B by second-order stochastic dominance (SSD); otherwise, no dominance can be established, and both A and B are second-order efficient.

For FSD, no assumptions are made about the attitude of the decision maker to risk; for SSD, it is assumed the decision maker is averse to risk to some unknown degree. No assumptions need be made about the distributional properties of the random variables, either.

Mean-Gini Dominance (MGD) Analysis

For two risky prospects, A and B, A dominates B by MGD if:

$$E(A) >= E(B) \text{ and } E(A) - \Gamma(A) >= E(B) - \Gamma(B)$$

with strict inequality for one of these expressions, where E(.) is the mean, and Γ(.) is the Gini coefficient of distributions A and B (which is half the value of Gini's mean difference: the absolute expected difference of a pair of randomly selected values of the variable).

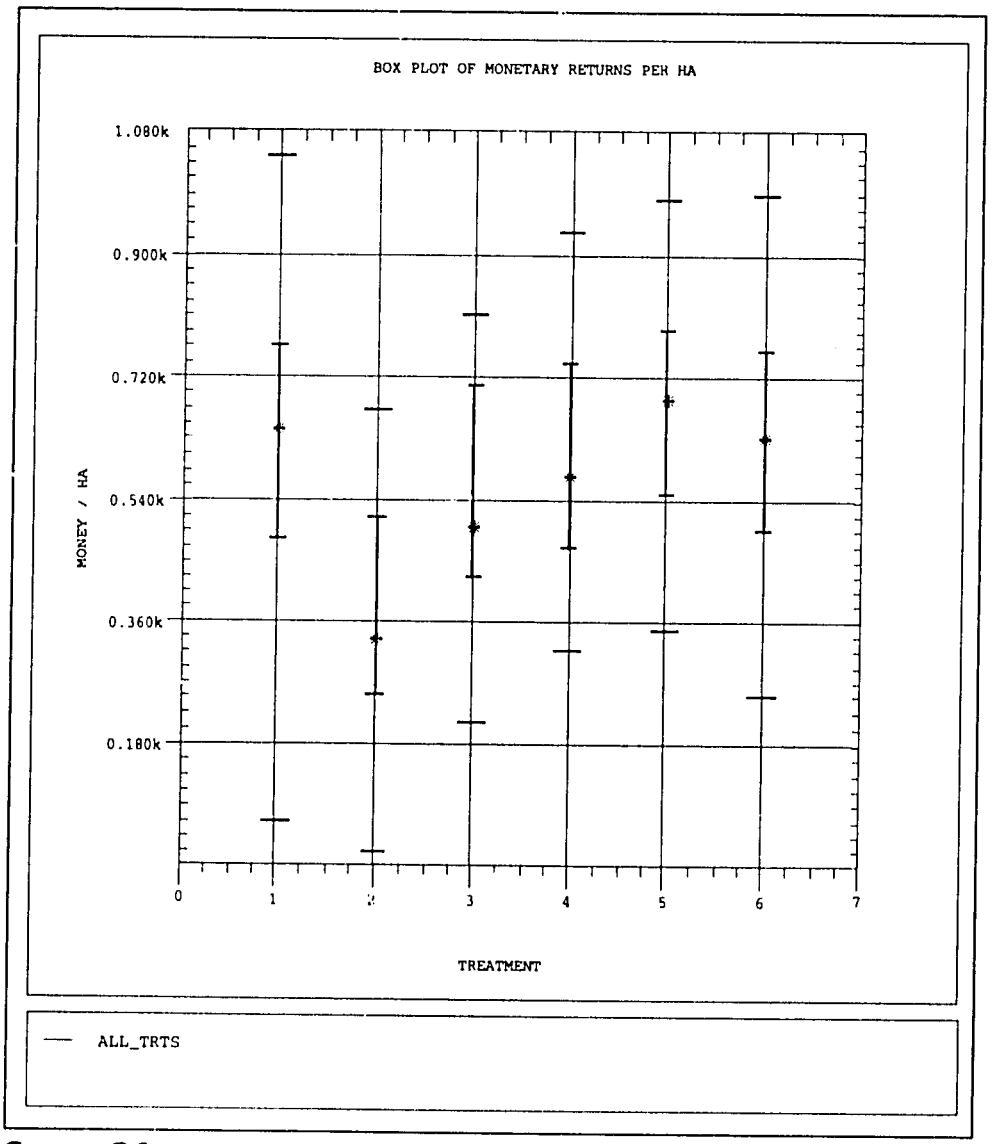
MGD, like SSD, assumes that the decision maker is averse to risk, but unlike SSD, the extremely risk-averse are excluded from the analysis. It is thus a more discriminating decision rule than SSD (since the MGD efficient set is usually smaller), and computationally, MGD is generally much easier to establish than SSD.

An Example

In the seasonal analysis program, E-V analysis can be carried out visually from E-V plots of economic returns, and mean-Gini analysis may be carried out by choosing the appropriate menu options. (Notes on first- and second-degree stochastic dominance are included for interest's sake for those readers familiar with DSSAT Version 2.1).

To illustrate, consider again the example obtained by analyzing the file UFGA7812.SNS using the costs and prices as in the distribution version of UFGA7812.PRI.

The box plot in Screen 24 (on following page) shows the impact of large amounts of irrigation on monetary returns per hectare. If you look at the amount of irrigation water applied in the six treatments (Screen 25, on 2nd following page) and compare this with the yields obtained (see Screen 9), it is clear that much of the water applied in Treatments 2, 3,



SCREEN 24.

and 4 is wasted; only a small amount of supplemental irrigation is required to alleviate most of the water stress that may occur in most years.

The same can be seen in terms of the number of irrigation applications made in each treatment (Screen 26, on following page). We can conclude that the cost of irrigation water per mm, the cost of each irrigation application, and the limited yield response to heavy irrigation applications, combine in such a way that the most profitable option of the six considered is to apply irrigation at a threshold of 30 percent of field capacity.

DSSAT Version 3.0 Cropping Season Analysis Tool

Variable : IRRIG mm

Treatment	Field	Crop	Mean	St.Dev.	Min	Max
1 RAINFED.....	UFGA0001	SB	.0	.0	.0	.0
2 AUTOMATIC 90%.....	UFGA0001	SB	239.7	43.0	131.0	325.0
3 AUTOMATIC 70%.....	UFGA0001	SB	170.5	44.0	93.0	266.0
4 AUTOMATIC 50%.....	UFGA0001	SB	135.1	42.6	61.0	224.0
5 AUTOMATIC 30%.....	UFGA0001	SB	77.5	43.2	.0	177.0
6 AUTOMATIC 10%.....	UFGA0001	SB	19.1	24.0	.0	59.0

17 ET TOTAL mm [ ]
18 RUNOFF mm [ ]
↑↓

F1 (Help) Press any key to continue.. 214240 Mem

SCREEN 25.

DSSAT Version 3.0 Cropping Season Analysis Tool

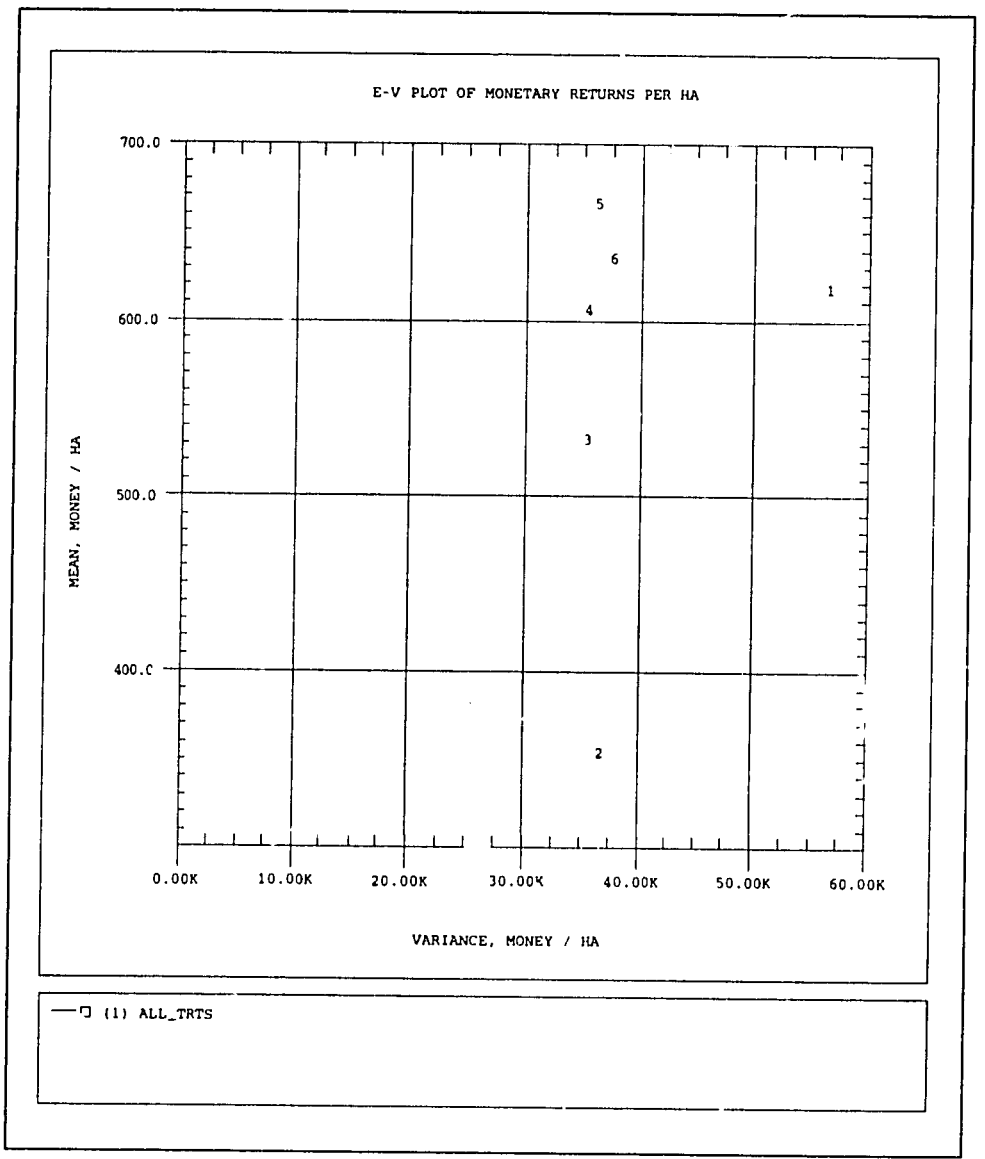
Variable : IRRIG APPS #

Treatment	Field	Crop	Mean	St.Dev.	Min	Max
1 RAINFED.....	UFGA0001	SB	.0	.0	.0	.0
2 AUTOMATIC 90%.....	UFGA0001	SB	22.3	4.0	12.0	30.0
3 AUTOMATIC 70%.....	UFGA0001	SB	10.8	2.8	6.0	17.0
4 AUTOMATIC 50%.....	UFGA0001	SB	6.7	2.1	3.0	11.0
5 AUTOMATIC 30%.....	UFGA0001	SB	3.1	1.7	.0	7.0
6 AUTOMATIC 10%.....	UFGA0001	SB	.6	.8	.0	2.0

17 ET TOTAL mm [ ]
18 RUNOFF mm [ ]
↑↓

F1 (Help) Press any key to continue.. 204240 Mem

SCREEN 26.



SCREEN 27.

In terms of strategy analysis, the mean-Gini dominance calculations are shown in Screen 22 of the main text. As noted above, the dominant strategy also has the highest mean monetary return. In mean-Gini dominance, this will always be the case, but it will sometimes happen that the variability associated with this "high-mean" treatment will be so great that it will be joined in the efficient set by another treatment with lower mean but lower variability. In such a case, no decision can be made with respect to which of the efficient treatments is better without knowing more about the preferences and attitudes of the particular decision maker. In any case, you should always remember that there is a

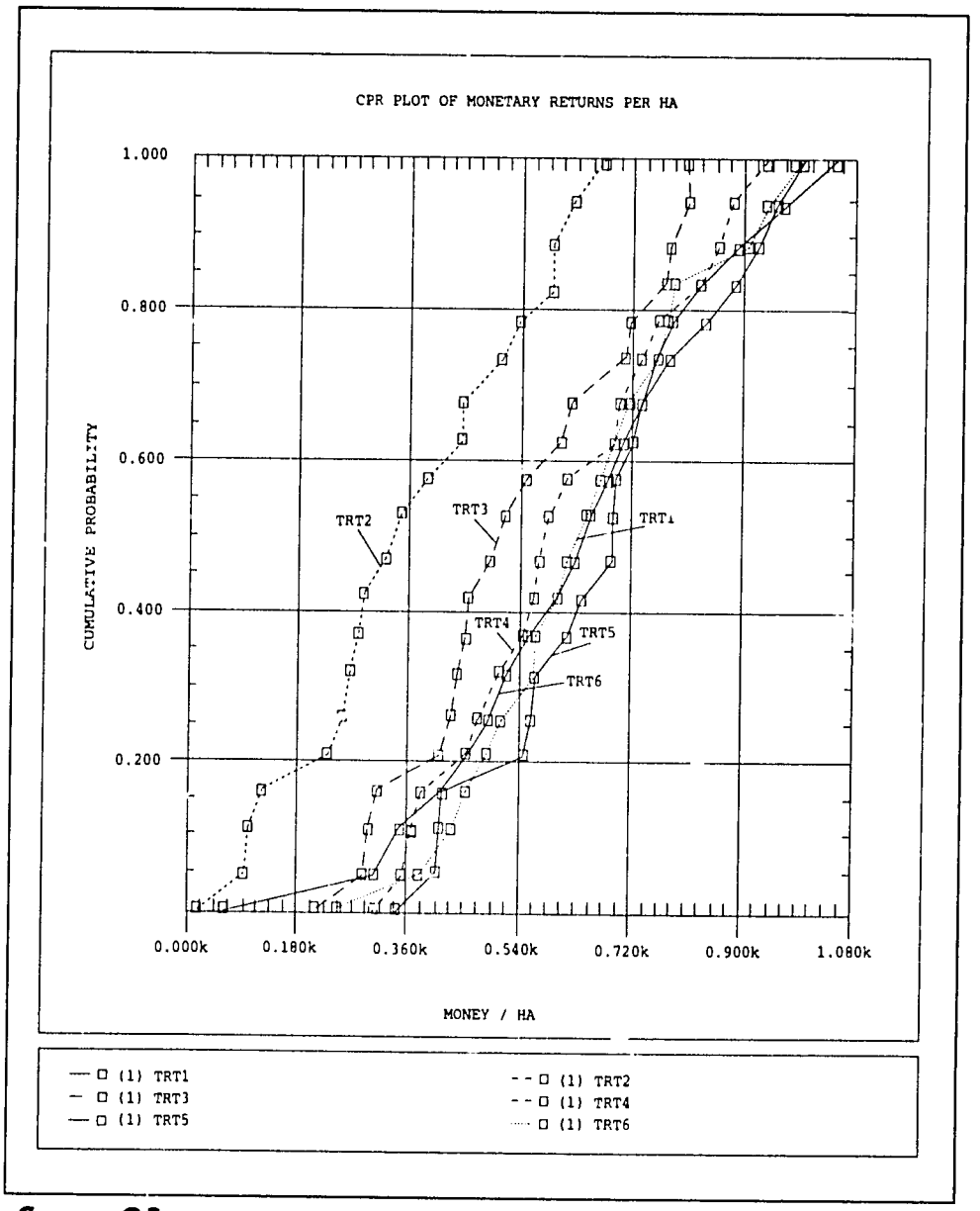
variety of sources of error in simulation experiments: errors in input data and errors in model specification, to name but two. Treatments with similar economic (or even biological performance) are likely to be "statistically indistinguishable" in terms of the model's inherent errors, in any case; there is then little point in applying increasingly sensitive analytical procedures in an attempt to distinguish what is probably indistinguishable.

Visual inspection of the six treatments for mean-variance dominance can be done for this experiment (see Screen 27, on previous page). Treatment 5 has the highest mean, but note from Screen 19 of the main text that the standard deviation (and hence the variance) of Treatments 3 and 4 are lower than that for Treatment 5. According to strict application of the E-V rules, Treatments 5, 4, and 3 are E-V efficient. The differences in simulated variances are very small between these three treatments, however. You should be careful not to be dogmatic in interpretation, and bear in mind the errors in the model and the model input data.

For purposes of comparison, inspection of the CPF plot of monetary returns for the six treatments (Screen 28, on following page) shows that none of the treatments is dominant by first-order stochastic dominance, since the CPF for Treatment 5 crosses the CPFs of Treatments 1 and 6. Further analysis (outside the DSSAT v3) shows that Treatment 5 is efficient or dominant according to second-order stochastic dominance.

As might be expected, the efficient sets of treatments according to the various stochastic efficiency rules are related (see Buccola and Subaei (1984) for more details). In essence, MG-efficient treatments and FSD/SSD efficient treatments are members of the EV-efficient set; further, MG efficient treatments are members of the FSD/SSD efficient set. To put it another way, EV-efficient sets tend to be larger than FSD/SSD efficient sets, which in turn tend to be larger than MG-efficient sets.

One more point to bear in mind is that for comparison purposes, calculations are made, and the analysis is carried out, on a per hectare basis. While making for simplicity, this implies even more about the particular nature of the decision maker's attitudes and preferences, but is often forgotten or ignored. Strictly speaking, these types of decision analysis relate to gains and losses of money in relation to total wealth. For further details, consult Raiffa (1968).


CPR PLOT OF MONETARY RETURNS PER HA
1.000
0.800
0.600
0.400
0.200
CUMULATIVE PROBABILITY
0.000k
0.180k
0.360k
0.540k
0.720k
0.900k
1.080k
MONEY / HA
TRT1
TRT2
TRT3
TRT4
TRT5
TRT6
(1) TRT1
(1) TRT2
(1) TRT3
(1) TRT4
(1) TRT5
(1) TRT6

SCREEN 28.

VOLUME 3-2

SEQUENCE ANALYSIS

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CHAPTER ONE. INTRODUCTION

The Sequence Analysis program allows the user to carry out simulations of crop rotations or crop sequences (i.e., any combination of crops grown one after another) using the DSSAT v3 crop models, and then to analyze the results. A simulation experiment involving a crop rotation may be replicated through time using different weather sequences; the experiment is set up by the user, the appropriate models are run using a special program called the driver, and the user can then analyze the results using the sequence analysis program. The "sequence" aspect of the driver and analysis programs relates to the fact that what is being run are experiments of multiple cropping seasons; the carry-over of soil water and nutrient status is effected from one season or crop to the subsequent season or crop.

To clarify the terminology, a number of definitions are set out below:

Sequence: relates to the growing of particular crops, one after another over time, where the carry-over effects from one crop to the next, whatever they may be, are taken into account. A sequence may thus relate to the growing of maize planted every year for 10 years; a sequence may be a short rotation of maize planted every season followed by beans grown in the same wet season or calendar year; or a sequence may consist of a four-year crop rotation, for example.

Treatment: any particular sequence run over a number of years; treatment 1 might refer to maize grown every year for 10 years with low exogenous nitrogen fertilizer input; treatment 2 the same, with high nitrogen input; treatment 3, a maize-bean cropping system in alternate seasons with low nitrogen input; and so on.

Replicate: a repetition of the same sequence treatment run over the same conditions apart from weather. In a real field experiment, two sequence replicates might refer to neighboring plots run with the same weather conditions, or the sequences might be replicated with respect to time: replicate 1 grown over the period 1981-1985, and replicate 2 from 1986 to 1990. In the same way that computer experimentation can produce "pure" replication of single season performance by using multiple year weather sequences, so computer experimentation can produce pure replication of sequences, where starting conditions and management are identical, but variation arises out of different weather sequences over the years of interest and out of any intrinsic stochasticity that may be built into the model.

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Variation: for a simulation model with no intrinsic stochasticity (such as the CERES or CROPGRO models), the sources of variation in a computer experiment arise from the following: (a) between treatments; (b) between replicates; (c) within sequences (i.e., between different years of the various sequence replicates). As for replicated computer experiments run over single seasons, the only sources of error that exist are model error and input data error, ultimately, as opposed to field experiments, where errors arise from measurement, micro-variations in soil and climate, and the rest. This "pure" replication can be difficult to analyze and interpret in the case of cropping sequences.

The driver program is capable of running up to 10 "treatments" or sequences. The analysis program, however, is capable of analyzing only one treatment at a time. Thus no direct treatment comparisons are possible using the analysis program. The major reason for this is to help foster "healthy skepticism" of sequence simulation results. At the current time, the sequence capabilities of the IBSNAT crop models have not been extensively tested. It is envisaged that most users of the sequence capability of the models will be interested in addressing "what if..." questions related to agricultural system performance. However, analysis results of multiple treatment sequence experiments are written to an ASCII file, and you can analyze these in any way you see fit outside the confines of DSSAT v3. You could, for example, compare and contrast different sequence strategies directly, although you should exercise care in interpreting the results you obtain.

There are three basic steps involved in Sequence Analysis:

1. The creation of an appropriate model input file;
2. Running the crop model(s) using the sequence driver;
3. Analyzing the results of the simulations using the analysis program.

The links between these steps are shown in Figure 1. Sequence analyses are run from the DSSAT v3 Shell (see Volume 1-3, Hunt et al. 1994, of this book for a description of the Shell) under the main menu item, ANALYSES. The three steps are explained in Chapter 2 herein.

System Requirements

The useable portion of your system's 640 Kb RAM should be at least 540 Kb in size for the models to run and for the analysis program and graphics to work.

If the driver or analysis program still does not work properly, one problem may be associat-

ed with the number of BUFFERS and FILES defined in CONFIG.SYS. These will need to be set to at least 20 each.

Replicated sequence simulations on an 8086 or 80286 system may take a great deal of time. Sequence Analysis, like the rest of DSSAT v3, will operate without a math coprocessor, but this is not recommended.

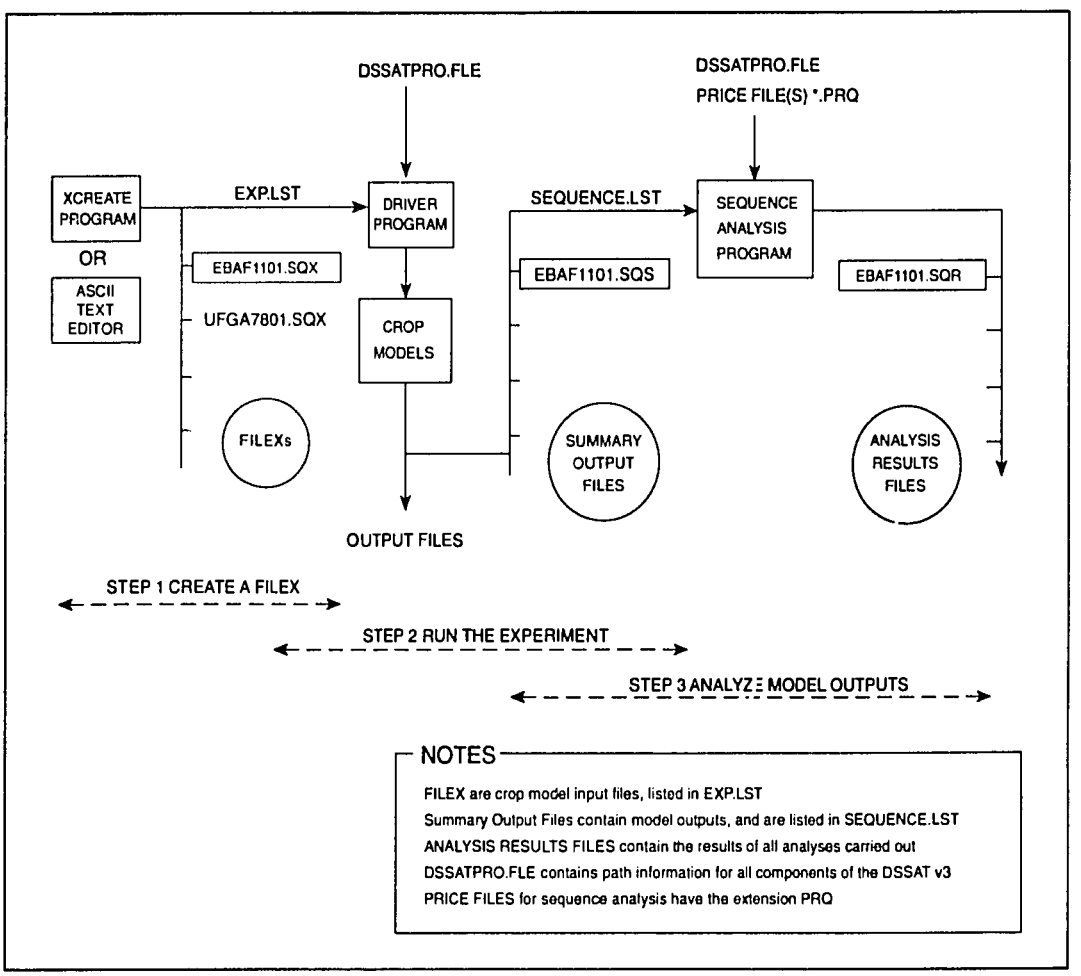

FIGURE 1. STEPS IN SEQUENCE ANALYSIS.

CHAPTER TWO. CREATING MODEL INPUT FILES FOR SEQUENCE ANALYSIS

The utility program XCreate that is provided with the DSSAT v3 software can be used to create model input files for running sequence analyses (see Volume 1-4, Imamura 1994, of this book for a description of the XCreate program). These model input files are referred to as FILEXs (see Volume 2-1, Jones et al. 1994, of this book for a description of this file). Alternatively, these files can be created using an ASCII text editor. The advantage of using the program XCreate is that the experiment listing file EXP.LST (see Volume 2-1, Jones et al. 1994, of this book for a description of this file) is updated automatically. If you create a sequence analysis FILEX yourself, you must either update EXP.LST or run the File Manager Utility program (accessed using the "Sequence — Inputs" menu items of the DSSAT v3 Shell; see Volume 1-3, Hunt et al. 1994, of this book for a description of the Shell) for the FILEX to be accessible to the system. The format of EXP.LST is shown in Table 1.

FILEX FOR SEQUENCE ANALYSIS

Sequence analysis model input files created with XCreate have the extension SQX. An example of a sequence analysis FILEX is shown in Table 2. There are some important differences in the way in which a sequencing FILEX is set up, compared with experiment or seasonal FILEXs. In the *TREATMENTS section of the file, instead of setting up a number of treatments, you specify a rotation "germ"; this is the sequence of crops that will be repeated over and over again. In Table 2, for instance, the "germ" consists of maize, followed by fallow (i.e., no crop is planted, but the models will simulate the soil water and nutrient processes on a daily basis until the next crop is planted). Note that the treatment

TABLE 1. SEQUENCE EXPERIMENT LISTING FILE EXP.LST.

```
*EXPERIMENT LIST

@# FILENAME EXT ENAME
 1 UFGA7803 SQX SEQUENCE ANALYSIS, SIMPLE MULTI-TREAT FILE, 5:5
 2 UFGA7804 SQX BN-BN YR 1, SB YR 2 EXAMPLE, 10:5
 3 EBAF1101 SQX MA-FA, 30 YRS, 15 REPS, NO N
```


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number (@N) is 1 for both rotation components. Each rotation component is assigned a number in ascending order, starting from 1 (the R column). Thus maize is the first component (R = "1"), and fallow is the second (R = "2"). The variables O and C in sequencing FILEXs should always be set to "1" and "0," respectively. These are options that have not yet been implemented.

The rotation germ will be repeated for as many seasons as are specified in the *SIMULATION CONTROLS section of the FILEX, under NYERS (one of the GENERAL options found in this section). In Table 2, NYERS is "30," so the rotation will be continued for 30 years.

This example FILEX specifies that maize is to be planted on day 305 (from PDATE in the *PLANTING DETAILS section of the file; note that PLANT under MANAGEMENT options in the *SIMULATION CONTROLS block 1 (i.e., N ="1") is set to "R" for "recorded") in each year of simulation. Once the maize is mature, the fallow model will be run, until the maize model is called for planting in the next year.

This FILEX also specifies that there are to be 15 replicates of this sequence (refer to NREPS under GENERAL options in *SIMULATION CONTROLS block 1). Weather for the site EBAF is to be simulated using WGEN (refer to WTHER under the METHOD options in *SIMULATION CONTROLS block 1; this is set to "W").

You will notice that there are two simulation control blocks in this FILEX. In general, it is highly recommended that you specify as many simulation control blocks as there are rotation components. So if you specify 7 rotation components, it is safest to specify 7 simulation control blocks.

For sequence experiments, you should note that the values of NYERS, NREPS, START, YRDAY, RSEED, all the OPTIONS variables, WTHER, and all the OUTPUTS variables are taken from the *SIMULATION CONTROLS block with the lowest VALID number. The values of these variables in any other *SIMULATION CONTROLS block are ignored. Thus in Table 2, the random number seed RSEED, for example, in block 1 equals 3517; in block 2, RSEED equals 2150. Since block 1 is a valid block number (i.e., in the *TREATMENTS section SM is specified as "1" for the first component), then the values appearing here will be used. Block 2 is also valid, but the values of NYERS, etc., will be ignored. In general, you may specify simulation controls as you would for experiment or seasonal FILEXs; thus you may specify automatic planting, etc.

TABLE 2. A SAMPLE FILEX FOR CROP SEQUENCING: EBAF1101.SQX.

```
*EXP.DETAILS: EBAF1101SQ MAIZE-FALLOW, 30 YEARS, 15 REPS, NO N

*TREATMENTS                                   ----FACTOR LEVELS----
@N R O C TNAME.................... CU FL SA IC MP MI MF MR MC MT ME MH SM
 1 1 1 0 Maize component            1  1  0  1  1  0  0  1  0  0  0  0  1
 1 2 1 0 Fallow component           1  2  0  0  0  0  0  0  0  0  0  1  2

*CULTIVARS
@C CR INGENO CNAME
 1 MZ IB0058 NC+59
 2 FA IB0001

*FIELDS
@L ID_FIELD WSTA.... FLSA  FLOB  FLDT  FLDD  FLDS  FLST  SLTX   SLDP IB_SOIL
 1 EBAF0001 EBAF        -99       0 IB000     0     0 00000 -99     180 IBMZ910032

*INITIAL CONDITIONS
@C   PCR ICDAT  ICRT ICND  ICRN  ICRE
 1    MZ 11244   100  -99  1.00  1.00
@C  ICBL  SH20  SNH4 SNO3
 1     5 0.265   0.6  1.5
 1    10 0.265   0.6  1.5
 1    20 0.265   0.6  1.5
 1    30 0.248   0.6  1.5
 1    40 0.248   0.6  1.5
 1    50 0.248   0.6  1.5
 1    60 0.248   0.6  1.5
 1    70 0.248   0.6  1.5
 1    80 0.248   0.6  1.5
 1   100 0.248   0.6  1.0
 1   120 0.248   0.6  1.0

*PLANTING DETAILS
@P PDATE EDATE  PPOP  PPOE  PLME  PLDS  PLRS  PLRD  PLDP  PLWT  PAGE  PENV  PLPH
 1 11305   -99   6.2   6.2     S     R    80     0   5.0   -99   -99 -99.0 -99.0

*RESIDUES AND OTHER ORGANIC MATERIALS
@R RDATE  RCOD  RAMT  RESN  RESP  RESK  RINP  RDEP
 1 11300 IB001  5000   0.8    -9    -9          15

*HARVEST DETAILS
@R HDATE  HSTG  HCOM  HSIZ   HPC
 1 12304                   100.0

*SIMULATION CONTROLS
@N GENERAL     NYERS NREPS START YRDAY RSEED SNAME....................
 1 GE             30    15     S 11244  3517 MZ component
@N OPTIONS     WATER NITRO SYMBI PHOSP POTAS DISES
 1 OP               Y     Y     Y     N     N     N
```

```
@N METHODS      WTHER INCON LIGHT EVAPO INFIL PHOTO
 1 ME               W     M     E     R     S     C
@N MANAGEMENT  PLANT IRRIG FERTI RESID HARVS
 1 MA               R     N     R     R     M
@N OUTPUTS      FNAME OVVEW SUMRY FROPT GROTH CARBN WATER NITRO MINER DISES  LONG
 1 OU               Y     N     A     7     N     N     N     N     N     N     N

@  AUTOMATIC MANAGEMENT
@N PLANTING    PFIRST PLAST PH2OL PH2OU PH2OD PSTMX PSTMN
 1 PL             288   360    40   100    30    40    10
@N IRRIGATION  IMDEP ITHRL ITHRU IROFF IMETH IRAMT IREFF
 1 IR              30    50   100 IB001 IB001    10  0.75
@N NITROGEN    NMDEP NMTHR NAMNT NCODE NAOFF
 1 NI              30    50    25 IB001 IB001
@N RESIDUES    RIPCN RTIME RIDEP
 1 RE             100     1    20
@N HARVEST    HFIRST HLAST HPCNP HPCNR
 1 HA               0   365   100     0

@N GENERAL      NYERS NREPS START YRDAY RSEED SNAME....................
 2 GE              30    15     S 11244  2150 FA component
@N OPTIONS      WATER NITRO SYMBI PHOSP POTAS DISES
 2 OP               Y     Y     Y     N     N     N
@N METHODS      WTHER INCON LIGHT EVAPO INFIL PHOTO
 2 ME               W     M     E     R     S     C
@N MANAGEMENT  PLANT IRRIG FERTI RESID HARVS
 2 MA               R     N     R     R     R
@N OUTPUTS      FNAME OVVEW SUMRY FROPT GROTH CARBN WATER NITRO MINER DISES  LONG
 2 OU               Y     N     A     7     N     N     N     N     N     N     N

@  AUTOMATIC MANAGEMENT
@N PLANTING    PFIRST PLAST PH2OL PH2OU PH2OD PSTMX PSTMN
 2 PL             155   200    40   100    30    40    10
@N IRRIGATION  IMDEP ITHRL ITHRU IROFF IMETH IRAMT IREFF
 2 IR              30    50   100 IB001 IB001    10  0.75
@N NITROGEN    NMDEP NMTHR NAMNT NCODE NAOFF
 2 NI              30    50    25 IB001 IB001
@N RESIDUES    RIPCN RTIME RIDEP
 2 RE             100     1    20
@N HARVEST    HFIRST HLAST HPCNP HPCNR
 2 HA               0   365   100     0
```

Refer to the *TREATMENTS section in Table 2. Factor levels are specified as for experiment or seasonal FILEXs. Thus, we have to specify a cultivar level (CU) for each rotation component (even fallow, although this is a dummy value). The rotation is grown in the same plot of land (FL = "1" for both rotation components). Initial conditions (IC) are specified for the maize component (IC = "1;" note that these are the conditions that will pertain at the start of each sequence; in subsequent seasons, "initial conditions" in terms of soil water and ammonium and nitrate levels are output by the preceding fallow model). Planting of maize takes place according to the *PLANTING DETAILS section 1 (MP = "1" for maize). Crop residue is applied at the start of the sequence according to the values specified in *RESIDUES section 1 (MR = "1"). The maize crop is controlled by the simulation controls in SM="1."

For the fallow component, the cultivar and field is specified (CU = "2" and FL = "1") as shown in Table 2. Simulation control is specified (SM = "2"; see above). A harvest details factor level is REQUIRED for any fallow component (MH = "1"). This is necessary to tell the fallow model when to stop. In the HDATE slot (harvest date) found in the *HARVEST DETAILS section, you must specify a year and date for the fallow model to halt. This must be specified so that it precedes the planting date, PDATE, of the next crop found in the *PLANTING DETAILS section, if planting is done as recorded (i.e., if PLANT = "R," as it does in Table 2 in the @N MANAGEMENT section of the *SIMULATION CONTROLS block for the maize crop). If planting should be automatic (PLANT = "A"), then you should specify a value of HDATE such that it precedes or is equal to the first date of the planting window for the next crop; this would be specified in PFIRST in the AUTOMATIC MANAGEMENT section of the relevant *SIMULATION CONTROLS block.

Note that in Table 2, HDATE is set to 12304. The year must be set to 12, since the maize is first planted in 1911 (i.e. we have to look ahead to the next maize crop), and day 304 precedes the planting date PDATE of 305.

Remember that this is a hypothetical sequence simulation; years have to be specified, and the FILEX in Table 2 assumes that the crop is planted in 1911. The actual year that the simulation starts is up to the user, since simulated weather is to be used.

Note that you could specify a year of fallow in the experiment simply by setting HDATE to 13304.

Timing Controls

One of the most difficult things to define is the control of timing by the driver and the crop models when run in sequence. Time is controlled internally in the models and the driver. All that is required from FILEX is that there is enough information to specify what happens exactly for the first germ of the rotation. In subsequent run-throughs of the germ, the years of planting, fertilizer additions, etc., will be automatically updated.

It is important that you understand how these operate for sequencing,because some users may want to set up sequence FILEXs manually. Some practice will probably be needed in this. The table below may help to make things clearer; it shows the first few iterations of the sequence specified in Table 2:

Run Number	Crop	Started		Finished		
		Year	Day	Year	Day	
1	MZ	1911	244	1912	059	} germ 1
2	FA	1912	060	1912	304	} "
3	MZ	1912	305	1913	057	} germ 2
4	FA	1913	058	1913	304	} "
5	MZ	1913	305	1914	049	} germ 3
etc.						

"Started" refers to the date when the appropriate crop model was called; "finished" refers to when the appropriate crop model ended its run. The maize model "finished" its run once maturity had been reached; this is dependent on weather, to some extent, so that it may vary from one year to the next. The fallow model thus started at different dates, but it finished on the same day each year, as specified by HDATE. Note also that the starting date of simulation is day 244 of 1911, specified by YRDAY in *SIMULATION CONTROLS block 1. Initial conditions relate to this date also (ICDAT = 11244 in the *INITIAL CONDITIONS section), and residue is added to the system on day 300 of 1911 (RDATE = 11300 in the *RESIDUES section). Planting of maize, however, first takes place on day 305 of 1911, and on day 305 of each year thereafter (PDATE = 11305 in the *PLANTING DETAILS section).

Simulation Control Options

There are a number of simulation control options in FILEX that are generally important for sequence analyses (refer to the *SIMULATION CONTROLS block number 1 (i.e., N = 1) in Table 2). These are described as follows.

NYERS

NYERS is the length of the sequence in years; it has a different meaning from NYERS in Seasonal Analysis (refer to Part 1 of this Volume, Volume 3-1, Thornton et al. 1994). NYERS may have a value between 1 and 50. Sequence experiments will normally be run using simulated weather (i.e., where the variable WTHER, one of the METHOD options, is set to "W" or "S"). If you have a real long-term experiment, this will presumably be unreplicated in terms of weather; you may then use WTHER set to "M" ("measured" weather). If for any reason you want to run a replicated sequence using historical weather, you would have to set up the FILEX to have multiple treatments with a different *FIELDS block for each replicate; you would specify the germ for each treatment, and specify a different historical weather file to start the run with under the "WSTA...." header variable in each *FIELDS control block. You would then need to check the availability of historical weather data files.

NREPS

NREPS specifies the number of replicates of the rotation or crop sequence. It may vary from 1 to 20. The impact of replication on the stability of simulation results is very important, and is addressed in the Appendix to this Part.

CAUTION: You are highly recommended to read the Appendix before using any of the sequence capabilities of DSSAT v3; it is easy to produce misleading results from analysis of simulated sequence experiments.

RSEED

RSEED is the random number seed for weather generation. With the same seed, you will obtain the same sequence of random numbers, and hence the same sequence of daily weather, if you start from the same starting date of simulation (SDATE). RSEED is used only if WTHER is set to "W" or "S." When sequences are replicated, the initial RSEED used is incremented to Rnew from the value in FILEX according to:

$$Rnew = RSEED + 5(i-1)$$

where *i* is the replicate number. If you run into problems, this will allow you to be able to calculate the value of the random number seed that gave rise to the problem, generate the offending weather sequence, and, hopefully, reproduce and isolate the problem.

FNAME

If this switch is set to "N," then the summary output file from the model runs will be named SUMMARY.SQS. If FNAME is set to "Y," then the summary output file name will be the same as the model FILEX name, except that the last letter of the extension will be changed from X to S. Thus for the experiment FILEX in Table 2, which has the name EBAF1101.SQX, the summary output file will be named EBAF1101.SQS, since the switch FNAME is set to "Y."

SUMRY

For sequence simulations, this controller should always be set to A (append), otherwise the summary output file will be successively overwritten by each treatment and earlier outputs lost. In Table 2, all the other OUTPUTS options are set to "N," to prevent output from the models. Since sequence simulations with many replicates can produce prodigious quantities of output data, it makes sense to turn these output files off, unless you need them specifically.

Although setting up sequence FILEXs may seem complicated, it is rather flexible. The distribution diskette of the Sequence Analysis program contains two other sequence FILEXs that illustrate some of this flexibility. UFGA7803.SQX contains a simple multiple treatment experiment. Treatment 1 involves soybean and fallow, and Treatment 2 bean and fallow. Pay special attention to the values of N and R in the *TREATMENTS section of this file.

Another FILEX that is distributed with the DSSAT v3 software is UFGA7804.SQX. This is a more complicated rotation involving two bean crops in one season followed by soybean in the next. The rotation germ is thus specified as BN1 - FA1 - BN2 - FA2 - SB1 - FA3, spanning two seasons. Each fallow is distinct and must be so treated in the analysis (see Chapter 4 herein).

You may specify rotations with up to 9 distinct components. The sequence driver will operate even if no fallows are specified between each crop component. However, you are highly recommended to specify fallows between each crop component. It is also generally a good idea to make the sequence length exactly divisible by the germ length; thus, if your germ describes a four-year rotation, set NYERS to a multiple of four. This will avoid possible confusion when using the Sequence Analysis program.

CHAPTER THREE.
RUNNING SEQUENCE ANALYSIS EXPERIMENTS

OVERVIEW

The Sequence Analysis driver program takes the FILEX selected or created by the user, and runs through the rotation germ until NYERS have elapsed, calling the appropriate crop model.

The driver is a FORTRAN program that allows the user to pick an entry from EXP.LST (i.e., a particular FILEX; see Volume 2-1, Jones et al. 1994, of this book for a description of the EXP.LST file). The FILEX is then read and various controls are set. Each rotation component specified in the FILEX is then run in its order of appearance in the *TREATMENTS block of the FILEX. The appropriate model is called for each component (the model is run under the command of the driver program), and it will be run for as many years as are specified by NYERS and for as many replicates as are specified by NREPS in the FILEX. When all runs have been completed, the results listing file SEQUENCE.LST (see the example in Table 3) is updated with the name and description of the summary output file produced. The user can then quit the program or choose another FILEX for running under the sequence driver.

The sequence driver can be run in a stand-alone mode or through the DSSAT v3 Shell (Volume 1-3, Hunt et al.1994, of this book). It is important to note that in which ever mode the driver is run, the program expects to find the model program(s) in the same directory. If model executable files are not found in that directory, then an error message is printed and the user must arrange the executable files so that this condition is met. The file DSSATPRO.FLE (see the Appendix to Volume 1 of this book for a description of this file) also expected to be in this same directory, with appropriate pointers to the relevant directories for the crop model executable files.

TABLE 3. SUMMARY MODEL OUTPUT LISTING FILE SEQUENCE.LST.

```
*SEQUENCING LIST

@# FILENAME EXT ENAME

 1 UFGA7803 SQS SEQUENCE ANALYSIS, SIMPLE MULTI-TREAT FILE, 5:5
 2 UFGA7804 SQS BN-BN YR 1, SB YR 2 EXAMPLE, 10:5
 3 EBAF1101 SQS MZ-FA, 30 YRS, 15 REPS, NO N
```

From within DSSAT v3, the current directory for sequence runs will usually be C:\DSSAT3\SEQUENCE, where such files as EXP.LST, SEQUENCE.LST and appropriate FILEXs are stored.

The file EXP.LST may contain up to 99 experiments, a limit imposed by the file structure. It should be borne in mind that the sequence analysis program has a limit of being able to handle a maximum of 20 replicates and a total of 1000 separate model runs.

An Example

On activating the "Simulate" option under the "Sequence" window (Screen 1, below), the driver program is activated, and the user is presented with Screen 2 (on following page). Screen 2 contains the contents of the file EXP.LST, the listing file in the current directory of current or selected FILEXs for sequence analysis. This lists the file number, file name, crop group code ("SQ" for sequence analysis), and description. The description may be up to 60 characters long; if it is shorter, the description is padded with full stops. The file description is obtained from columns 26 through 85 of the first line of FILEX (see Table 2).

If the colors on the screen are difficult to see (such as when the program is being run on a monochrome laptop computer), you can force the program to display screens in mono-

```
DECISION SUPPORT SYSTEM FOR AGROTECHNOLOGY TRANSFER

DATA        MODEL       ANALYSES      TOOLS       SETUP/QUIT

                        S Seasonal
                        Q Sequence
                          C Create
                          I Inputs
                          S Simulate
                          O Outputs
                          A Analyze

Run the appropriate crop model(s) using a controlling 'driver' program.

↑ ↓ → ←   moves through menu choices
ESC       moves to higher menu level                Version: 3.0
```

Screen 1.

```
DSSAT Version 3.0 Crop Sequencing Driver

 FILE    EXT ENAME
 UFGA7803 SQX SEQUENCE ANALYSIS, SIMPLE MULTI-TREAT FILE, 5:5 ....
 UFGA7804 SQX BN-BN YR 1, SB YR 2 EXAMPLE, 10:5 ..................
 EBAF1101 SQX MZ-FA, 30 YRS, 15 REPS, NO N .......................

F1 (Help)                                          71440 Mem
```

SCREEN 2.

chrome by pressing the <ALT>-<F2> keys. Note that you cannot reverse the color scheme during a session with the program, nor is your preference stored from one session to another.

If the chosen FILEX cannot be found, an error message is printed on the screen, and the menu reappears for making another choice.

Select the third FILEX, EBAF1101.SQX, in Screen 2, using the cursor keys or the mouse, and press the <ENTER> key. This is the same FILEX shown in Table 2.

Having chosen a valid FILEX name, the driver checks to see if there is an existing output file with the same name in the current directory (this is controlled within FILEX; see previous discussion). If there is, then the user is warned that the output file will be overwritten. Press the <ENTER> or <Y> key to continue regardless, or else press the <N> key to quit the program so you can rename or move the existing output file.

Once past Screen 2, the driver will issue appropriate commands and call up the crop model(s). The initial model-produced screen warns the user not to touch the keyboard.

Once simulations are under way, each model run is summarized on the screen, so that the user can chart progress of the experiment. Sequence experiments over many years and/or with many replicates may take a great deal of time to simulate, especially on older personal computers. No keyboard input should be made, unless an error occurs.

To abort the simulation runs before they have finished, press the <ESC> key or press <CTRL-BREAK>.

For each FILEX simulated, the driver updates or creates a listing file which stores the names of the summary results files (in similar fashion to EXP.LST, which stores the names of available FILEXs in the current directory). This file, SEQUENCE.LST, is of the same format (Table 3), and is used by the analysis program described in the next section. Two other messages may appear on the final screen:

1. If FNAME was set to "N," then the summary output file produced by the model(s), SUMMARY.OUT, was renamed to SUMMARY.SQS; the program tells you that this has been done;
2. If the summary output file of the appropriate name does not appear in SEQUENCE.LST, then SEQUENCE.LST is updated, and the program tells you that this has been done.

Press the <ENTER> key to exit the program, or the <Y> key to return to Screen 2, showing file EXP.LST, where another experiment can be chosen and simulated. You may simulate as many FILEXs as you like, one after the other, without exiting the driver program.

Simulation results are stored in the summary output file, in this example EBAF1101.SQS (the first 20 data records of this file are shown in Table 4).

Information and Error Messages

A number of information and error messages are produced by the sequence driver program. In the list that follows, each message is preceded by a single-digit code and a three digit message/error number. If the single-digit code is "0," then this is a fatal error, and the program exits; if "1," then the program will continue, as the error may not be fatal. Information messages have code 1 also.

0 001 Cannot find experiment file :
The FILEX experiment listing file could not be found in the current directory.

TABLE 4. SUMMARY OUTPUT FILE EBAF1101.SQS (FIRST 20 DATA RECORDS ONLY).

Columns 1-74

*SUMMARY : EBAF1101SQ

!IDENTIFIERS						DATES				
@RP	TN	ROC	CR	TNAM	FNAM	SDAT	PDAT	ADAT	MDAT	HDAT
1	1	110	MZ	Maize component	EBAF0001	11244	11305	12010	12059	12059
2	1	210	FA	Fallow component	EBAF0001	12060	-99	-99	-99	12304
3	1	110	MZ	Maize component	EBAF0001	12305	12305	13010	13057	13057
4	1	210	FA	Fallow component	EBAF0001	13058	-99	-99	-99	13304
5	1	110	MZ	Maize component	EBAF0001	13305	13305	14006	14049	14049
6	1	210	FA	Fallow component	EBAF0001	14050	-99	-99	-99	14304
7	1	110	MZ	Maize component	EBAF0001	14305	14305	15008	15055	15055
8	1	210	FA	Fallow component	EBAF0001	15056	-99	-99	-99	15304
9	1	110	MZ	Maize component	EBAF0001	15305	15305	16007	16055	16055
10	1	210	FA	Fallow component	EBAF0001	16056	-99	-99	-99	16304
11	1	110	MZ	Maize component	EBAF0001	16305	16305	17009	17058	17058
12	1	210	FA	Fallow component	EBAF0001	17059	-99	-99	-99	17304
13	1	110	MZ	Maize component	EBAF0001	17305	17305	18010	18056	18056
14	1	210	FA	Fallow component	EBAF0001	18057	-99	-99	-99	18304
15	1	110	MZ	Maize component	EBAF0001	18305	18305	19008	19056	19056
16	1	210	FA	Fallow component	EBAF0001	19057	-99	-99	-99	19304
17	1	110	MZ	Maize component	EBAF0001	19305	19305	20006	20051	20051
18	1	210	FA	Fallow component	EBAF0001	20052	-99	-99	-99	20304
19	1	110	MZ	Maize component	EBAF0001	20305	21006	21006	21053	21053
20	1	210	FA	Fallow component	EBAF0001	21054	-99	-99	-99	21304

Columns 75-164

DRY WEIGHTS								WATER						
DWAP	CWAM	HWAM	HWAH	BWAH	H#WM	H#AM	H#UM	IR#M	IRCM	PRCM	ETCM	ROCM	DRCM	SWXM
27	5430	2006	2006	3734	348	487	78.6	0	0	1213	499	89	542	144
0	0	0	0	0	0	0	.00	0	0	615	221	45	352	141
29	2848	870	870	2112	369	200	32.2	0	0	1012	415	46	533	159
0	0	0	0	0	0	0	.00	0	0	559	194	54	325	144
27	4813	1748	1748	3336	342	432	69.7	0	0	632	382	26	225	143
0	0	0	0	0	0	0	.00	0	0	677	233	87	373	128
29	2537	824	824	1841	370	188	30.4	0	0	1070	384	86	565	162
0	0	0	0	0	0	0	.00	0	0	502	197	27	301	139
27	5061	1970	1970	3396	353	471	76.0	0	0	712	385	37	282	147
0	0	0	0	0	0	0	.00	0	0	454	198	28	236	139
34	1252	164	164	1114	434	32	11.2	0	0	1004	355	60	587	141
0	0	0	0	0	0	0	.00	0	0	641	226	41	376	139
28	2987	913	913	2215	356	217	35.0	0	0	940	404	50	469	157
0	0	0	0	0	0	0	.00	0	0	554	201	65	305	139
28	5498	2111	2111	3714	358	498	80.3	0	0	798	380	51	351	155
0	0	0	0	0	0	0	.00	0	0	493	217	19	276	136
26	3581	1292	1292	2490	335	326	52.5	0	0	807	369	64	349	161
0	0	0	0	0	0	0	.00	0	0	673.	229	79	386	141
29	4126	1450	1450	2901	368	333	53.7	0	0	851	400	42	398	152
0	0	0	0	0	0	0	.00	0	0	617	203	51	363	152

Columns 165-252

NITROGEN								ORGANIC MATTER			PHOSPHORUS			
NI#M	NICM	NFXM	NUCM	NLCM	NIAM	CNAM	GNAM	RECM	ONAM	OCAM	PO#M	POCM	CPAM	SPAM
0	0	0	26	22	24	26	12	5000	4260	43	0	0	0	0
0	0	0	0	14	40	0	0	3734	4221	42	0	0	0	0
0	0	0	13	29	24	13	6	0	4199	42	0	0	0	0
0	0	0	0	16	44	0	0	2112	4162	42	0	0	0	0
0	0	0	24	15	24	24	12	0	4139	42	0	0	0	0
0	0	0	0	13	42	0	0	3336	4098	41	0	0	0	0
0	0	0	12	31	23	12	5	0	4077	41	0	0	0	0
0	0	0	0	11	48	0	0	1841	4040	41	0	0	0	0
0	0	0	27	15	22	27	13	0	4017	40	0	0	0	0
0	0	0	0	11	36	0	0	3396	3980	40	0	0	0	0
0	0	0	5	30	23	5	1	0	3960	40	0	0	0	0
0	0	0	0	15	48	0	0	1114	3921	39	0	0	0	0
0	0	0	14	29	23	14	6	0	3898	39	0	0	0	0
0	0	0	0	10	42	0	0	2215	3863	39	0	0	0	0
0	0	0	26	13	22	26	13	0	3842	39	0	0	0	0
0	0	0	0	13	31	0	0	3714	3806	38	0	0	0	0
0	0	0	19	17	20	19	10	0	3788	38	0	0	0	0
0	0	0	0	13	43	0	0	2490	3752	38	0	0	0	0
0	0	0	20	19	22	20	9	0	3731	38	0	0	0	0
0	0	0	0	15	34	0	0	2901	3695	37	0	0	0	0

0 002 No entries found in file :
The FILEX experimental listing file was found, but it contains no valid entries.

1 003 Cannot find file :
The specified file cannot be found (non-fatal).

0 004 Error reading :
An undefined read error occurred when attempting to read the file. The problem is usually caused by incorrect format of the file.

0 005 No valid treatments found in file :
No valid treatments were found in the FILEX selected.

0 006 Error in *SIMULATION CONTROL factor levels :
The FILEX specified by the user is defective in one of the following ways: FNAME was not set or not found, NREPS was not set or not found, or the simulation control factor level with the lowest number specified by the user did not have a corresponding *SIMULATION CONTROL block in the file.

0 007 Error in *CULTIVAR factor levels in file :
A cultivar factor level was specified in the selected FILEX that did not have a corresponding cultivar description in the *CULTIVARS block of the file.

1 008 Model runs completed!

1 009 SUMMARY.OUT renamed to SUMMARY.SQS

1 010 SEQUENCE.LST updated, added file :
Specified summary output file added to the listing file.

0 011 A required file was not found .. aborting :
This usually refers to the absence of the file DSSATPRO.FLE, which could not be found.

0 012 Excessive path length error :
You need to reduce the path length as specified in DSSATPRO.FLE for the crop model "cc" (e.g. MZ). Path lengths as specified in the DSSATPRO.FLE must be less than 36 characters in total length, including drive letter, colon, and leading and trailing slashes (\). If these paths are modified using the SETUP menu of the DSSAT3 shell, then there is no problem, as the screens will not allow you to enter paths longer than this. If you modify DSSATPRO.FLE with a text editor, then you need to ensure that this total length is not exceeded.

0 013 No code error :
The crop code specified (e.g. MZ) could not be found in the file DSSATPRO.FLE. This will occur if a cultivar is specified in FILEX that does not have a valid crop code.

0 014 Read error in file :
An undefined read error occurred when reading the specified file; check the format of the file.

0 015 Rotation Option feature not yet implemented; file :
The specified FILEX contained a value for the rotation option "O" other than 1; exit and fix the file.

0 016 SEQDRV: READ error, file :
A read error occurred while the sequence driver was reading the specified file.

0 017 SEQDRV:
A sequence driver error occurred; check the format of FILEX.

0 018 Last model run could not be completed as specified
Check the format and contents of FILEX; if this error occurs, then the simulation summary output file may not be analyzable.

0 019 This run mode is not yet implemented

0 020 A problem was encountered executing another program
The driver was not able to execute another program; check the free RAM that you have on your computer, and increase it if possible by unloading unnecessary resident programs (e.g. a network).

0 021 A problem was encountered erasing a file
The specified file could not be erased.

0 022 A problem was encountered copying a file
The specified file could not be copied successfully.

1 055 Problem in finding the appropriate help screen
The required help screen, or the help screen file SEQDRV.HLP, could not be found.

1 100 Error!
Undetermined error.

CHAPTER FOUR. ANALYZING SEQUENCE ANALYSIS EXPERIMENTS

OVERVIEW

Having produced a summary simulation output file from a sequence experiment, the next step is to analyze this (the experiment may or may not be replicated). A brief overview of the analysis program's capabilities follows, together with some general usage notes. It should be noted that the analysis program can handle a maximum of 1000 separate model runs.

Figure 2 shows the major menu options available. The program does the following.

Biophysical Analysis. Calculates means, standard deviations, maxima and minima by year and by rotation component for any of the 35 summary output file variables (a list of these is shown in Table 7). These can be plotted as box plots, cumulative function plots, mean-variance diagrams, coefficient of variation plots, or variance plots. All graphs can be screen dumped to a printer or output to a file for plotting.

Economic Analysis. Calculates means, standard deviations, maxima and minima by year and by rotation component of economic returns, and plots these as box plots, cumulative function plots, or mean-variance diagrams. Prices and costs can be changed within a session, and price-cost variability can be included in the analysis. Simple probability analysis can be carried out, where the user specifies a threshold level of economic returns per hectare; the probability of the specified sequence failing to meet this threshold in each sequence year is then calculated and can be plotted.

Any number of summary output files can be analyzed sequentially during one session with the program. The user can also control the way in which hardcopy outputs are produced from the graphics program.

While these analyses are being performed, results are written to a results file. The file can be printed from within the program, if required. At the completion of the session, the user can access this file and use the data contained within in any way required. For example, it could be edited for importing into a graphics, spreadsheet or statistics program.

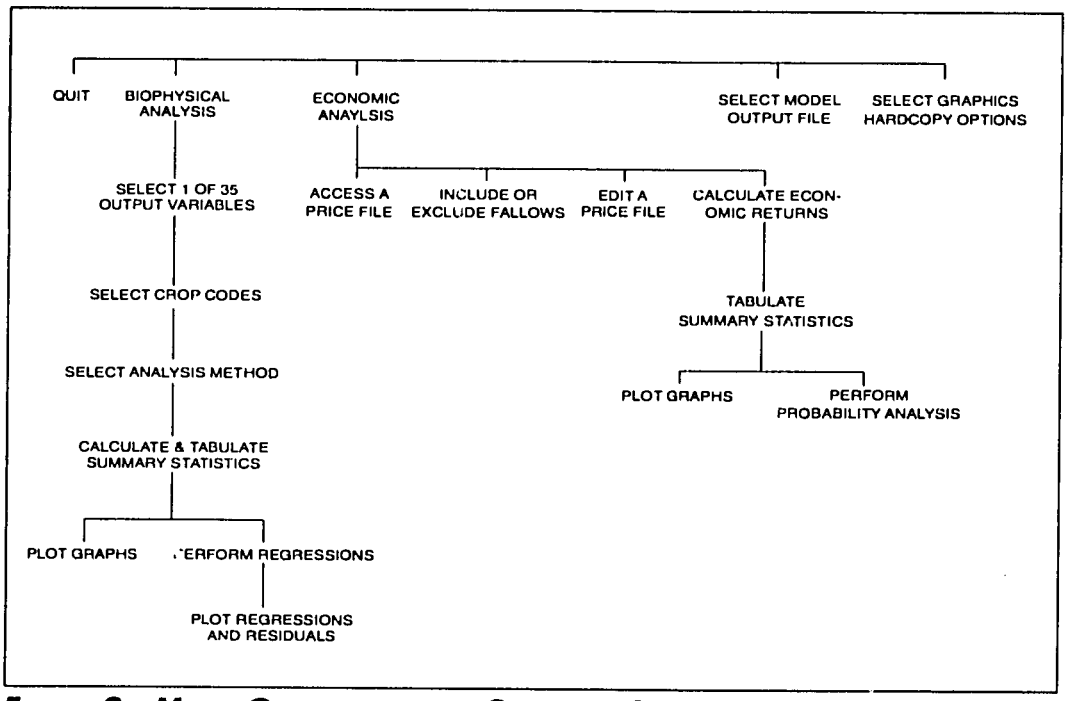


FIGURE 2. MENU OPTIONS FOR THE SEQUENCE ANALYSIS PROGRAM.

AN EXAMPLE

The analysis program is called from the ANALYSES main menu item of the DSSAT v3 Shell and then the "Sequence–Analyze" submenus (Screen 3, on following page). After an introductory screen, the main menu screen (Screen 4, on following page) is presented.

First you must select a sequence output file to analyze (i.e., a summary output file from a previously-run simulation). On selecting this item, the program searches SEQUENCE.LST, the listing file that contains the available model summary output files in the current directory (Table 3). These are presented to the user (see Screen 5). Note that the entries in SEQUENCE.LST do not have to match the entries in EXP.LST, either in number or in order; you may have run and analyzed the experiments in a different order, for example.

Use the mouse or cursor keys to select the file EBAF1101.SQS in Screen 5. The program then gives the user the opportunity to change the name of the analysis results file. By default, this will be the same as the summary output file, except the last letter of the extension will be "R" (for "results"). Note that file names are preserved across all three steps of the sequence analysis procedure: if the model FILEX is EBAF1101.SQX, then simulation

```
DECISION SUPPORT SYSTEM FOR AGROTECHNOLOGY TRANSFER

DATA        MODEL        ANALYSES        TOOLS        SETUP/QUIT

                         S Seasonal
                         Q Sequence
                            C Create
                            I Inputs
                            S Simulate
                            O Outputs
                            A Analyze

                    Analyze model outputs.

↑ ↓ → ←  moves through menu choices
ESC      moves to higher menu level                Version: 3.0
```

SCREEN 3.

results from the model(s) are saved in EBAF1101.SQS, and analysis results in EBAF1101.SQR. If you want to change the results file name, enter a new name (8 characters maximum). Do not add the extension; this is added automatically, and cannot be

```
DSSAT Version 3.0 Crop Sequencing Analysis

  Main Menu
  Select a cropping season file for analysis

  Analyse Biophysical variables
  Analyse Economic variables

  Modify hardopy options
  About SUSTAIN2 ....

  Exit

F1 (Help)                                        71440 Mem
```

SCREEN 4.

changed, and will always be "ccR" where "cc" is the crop code (usually SQ for sequence analysis).

If the summary output file chosen contains more than 1 treatment, you will be asked to select which treatment to analyze. If there are more than 10 treatments in the file, then you may select only from amongst the first 10; the rest will be ignored.

The next screen presented (Screen 6, on following page) summarizes the simulation runs found in the chosen summary output file. The experiment code, number of runs and replicates, starting and ending year of the sequence, the number of model runs per replicate, the number of runs per rotation (i.e., the number of crop components as specified in FILEX), and the crop codes used, are shown to the user. If there are problems with the summary output file, for instance an unequal number of replicates because of model failure for some reason, these problems will usually be apparent at this stage. Such errors are usually trapped by the analysis program and result in a warning message to the user and termination of the program.

Note that in the "Crop Codes Used" portion of Screen 6, each crop code is followed by an integer. This is to allow analyses to be made on each separate crop component specified in the original FILEX that controlled the sequence experiment. In some rotations,

```
DSSAT Version 3.0 Crop Sequencing Analysis

 Main Menu
  FILE    EXT ENAME
  UFGA7803 SQS SEQUENCE ANALYSIS, SIMPLE MULTI-TREAT FILE, 5:5 ....
  UFGA7804 SQS BN-BN YR 1, SB YR 2 EXAMPLE, 10:5 ..................
  EBAF1101 SQS MZ-FA, 30 YRS, 15 REPS, NO N ......................
 Modify hardcopy options
 About SUSTAIN2 ....

 Exit

F1 (Help)                                                  71440 Mem
```

SCREEN 5.

```
DSSAT Version 3.0 Crop Sequencing Analysis

                    Input File Analysis

          Experiment Code    : EBAF  11  01
          Number of runs     :  900
          Number of reps     :   15
          Starting year      : 1911
          Ending year        : 1941
          Runs per rep       :   60
          Runs per rotation  :    2
          Crop Codes Used    :  MZ1  FA1

F1 (Help)        Press any key to continue..        71440 Mem
```

SCREEN 6.

you may have 2 or more fallow components (one between maize and beans and another between beans and maize, for example). In both biological and economic terms, these fallows may be quite different, and need to be treated separately.

On pressing any key to continue, the main menu of the analysis program appears again (Screen 4). The items in this menu are illustrated in turn.

ANALYZE BIOPHYSICAL VARIABLES

On choosing the main menu option, "Analyze Biophysical Variables," in Screen 4, with the mouse or cursor keys, a list of the variables available for analysis appears (Screen 7, on following page). This is a listing of all the 35 output variables written to the summary output file. You can scroll up and down this list using the <↑> and <↓> arrow keys on the keyboard. Choose the variable, "HAR YIELD kg/ha ," in Screen 7 by placing the cursor bar over the variable in the list and pressing the <ENTER> key.

The next screen presented (Screen 8, on following page) asks you to choose a crop code for analysis. Choose the MZ1 component (multiple crop codes are discussed below). Thus, we have now selected to look at maize yields.

```
DSSAT Version 3.0 Crop Sequencing Analysis

 Main Menu
  Analysis                    ason file for analysis
   START SIM day
   PLANTING day               ariables
   ANTHESIS day               iables
   MATURITY day
   HARVEST day                ns
   SOWING WT kg/ha
   TOPS WT. kg/ha
   MAT YIELD kg/ha
   HAR YIELD kg/ha
   BYPRODUCT kg/ha
   WEIGHT mg/unit
   NUMBER #/m2
   NUMBER #/unit
   IRRIG APPS #
   IRRIG mm
   PRECIP mm
   ET TOTAL mm
   RUNOFF mm
   ↑↓
F1 (Help)                                          71440 Mem
```

SCREEN 7.

```
DSSAT Version 3.0 Crop Sequencing Analysis

 Main Menu
  Analysis                    ason file for analysis
   Crop codes
    1 MZ1          [√]       iables
    2 FA1          [ ]       bles
   HARVEST day                ns
   SOWING WT kg/ha
   TOPS WT. kg/ha
   MAT YIELD kg/ha
   HAR YIELD kg/ha
   BYPRODUCT kg/ha
   WEIGHT mg/unit
   NUMBER #/m2
   NUMBER #/unit
   IRRIG APPS #
   IRRIG mm
   PRECIP mm
   ET TOTAL mm
   RUNOFF mm
   ↑↓
F1 (Help)                                          71440 Mem
```

SCREEN 8.

DSSAT Version 3.0 Crop Sequencing Analysis

Trends Over Time

Variable : HAR YIELD kg/ha
Crop Code(s) : MZ1

Sequence Year	Mean	St.Dev.	Min	Max
1911.0	2223.9	406.0	1708.0	3041.0
1912.0	1087.5	394.2	517.0	1992.0
1913.0	1401.0	559.2	480.0	1987.0
1914.0	1242.3	674.8	183.0	2530.0
1915.0	1206.8	587.8	132.0	1970.0
1916.0	1323.1	614.0	164.0	2102.0
1917.0	971.6	621.6	80.0	1955.0
1918.0	913.9	500.1	114.0	2111.0
1919.0	1107.2	632.0	400.0	2467.0
1920.0	1291.9	539.4	129.0	2363.0

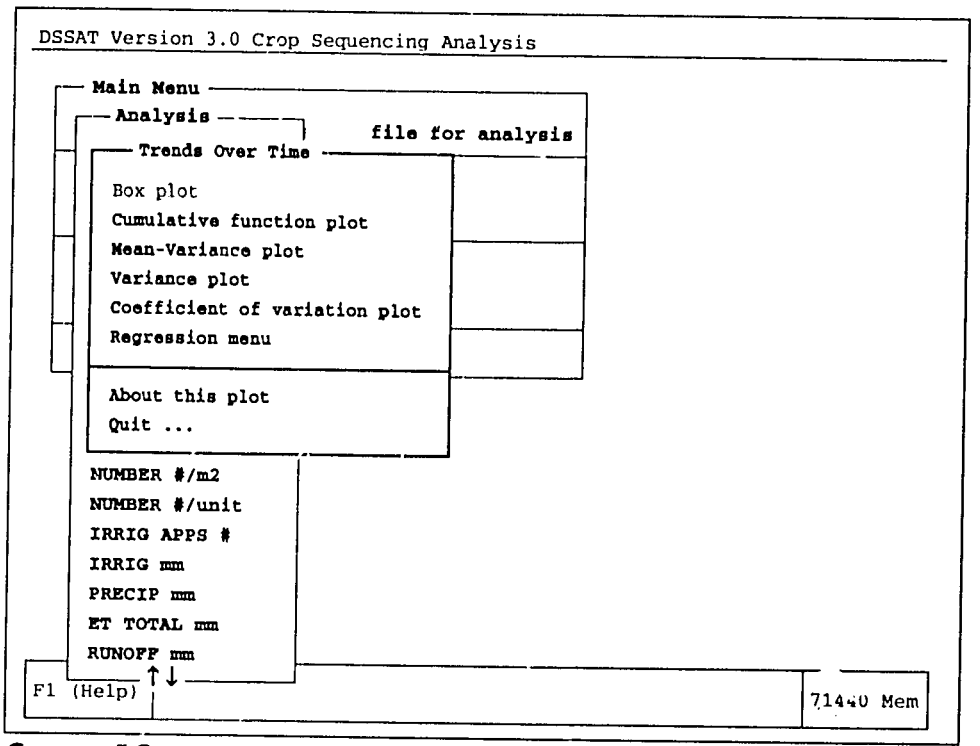
17 ET TOTAL mm [ ]
18 RUNOFF mm [ ]
↑↓

F1 (Help) Press any key to see more .. 71440 Mem

SCREEN 9.

The next screen (Screen 9, above) shows the results of the calculations by the program. The screen is headed "Trends Over Time," as the trends in maize yields may well be what we are interested in. The output variable is shown (yield per hectare), together with the pertinent crop code (maize). For each appearance of the chosen crop component, the program displays the mean, standard deviation and minimum and maximum values of the selected variable. In the example, maize was grown each season, so an annual yield is displayed for the years 1911 to 1940 (remember, the year numbers are purely for convenience in this example). The experiment was replicated; if there were only one replicate, then the standard deviation would be zero, and the mean, the minimum and the maximum yield would be identical.

Press any key to continue, and repeat until the Graphics-Regression main menu screen appears (Screen 10, on following page). If at any time you forget which variable you are looking at or which crop components are being analyzed, move the cursor bar to the "About this plot" option to remind yourself. Five types of graphs can be plotted, described as follows.



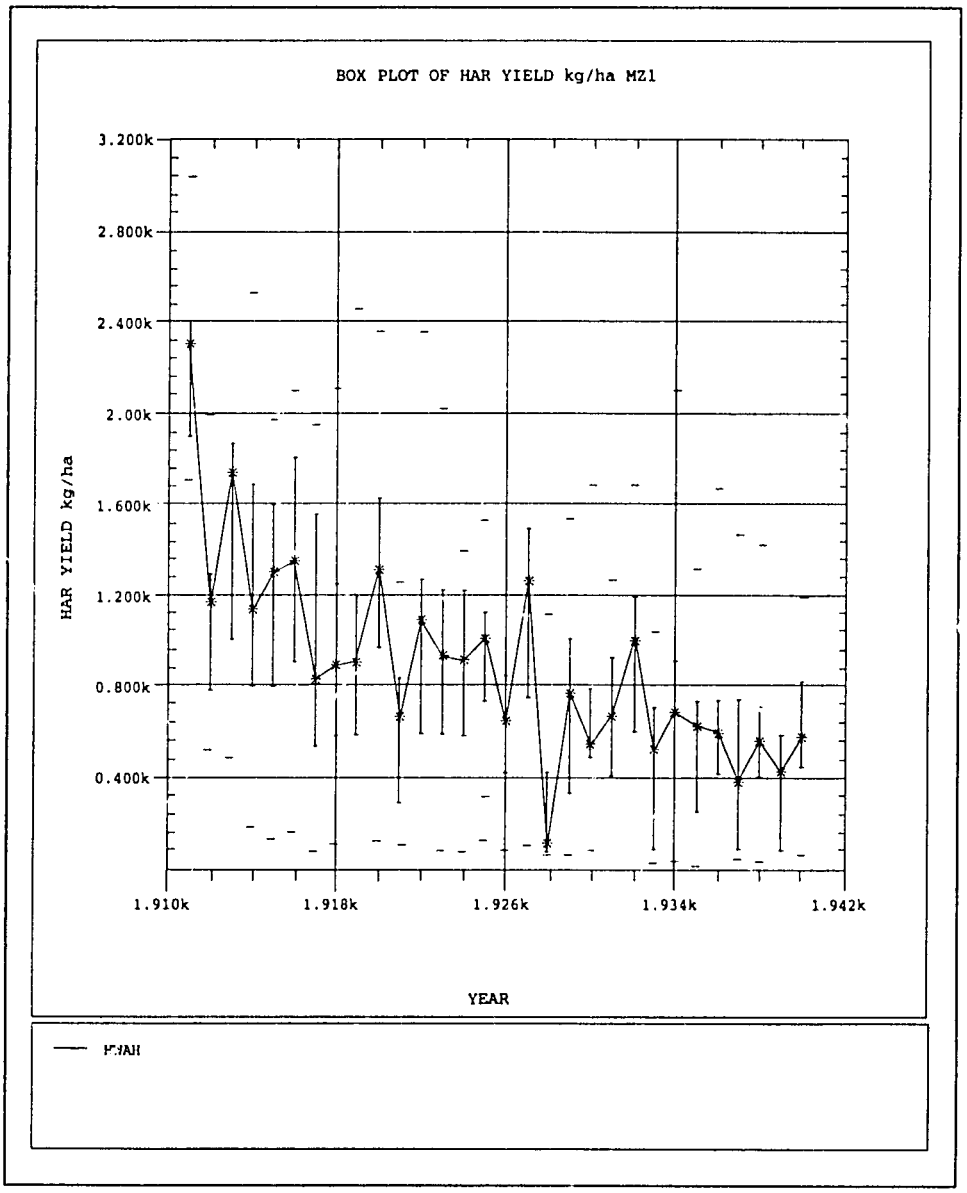
Screen 10.

Graphics-Regression Main Menu

Option 1. Box Plot

If this option is selected in Screen 10, a box plot appears (Screen 11, on following page). (by default, all years are selected for plotting box plots). The box plot is a way of assessing visually the variability over time of the output variable under consideration. For the distribution of the model output variable selected, the 0th (the lowest single short line), 25th (the lower of the short lines connected by the vertical bar), 50th (the star), 75th (the upper of the short lines connected by the vertical bar), and 100th (the upper single short line) percentiles are plotted. The 50th percentile is the median of each output variable distribution, not the mean; but for symmetrical distributions, the median will often not differ greatly from the mean value.

This graph may be plotted on your printer by pressing the <P> key while the graph is on the screen. If the graph does not plot, you may need to change hardcopy settings (refer to the section, "Graphics Hardcopy Setup"). Depending on the printer and the resolution used, there may be a delay of a few seconds while this is done; wait for the graph to show on the screen again before continuing.



SCREEN 11.

NOTE: To return to the analysis program from any graph, press any key.

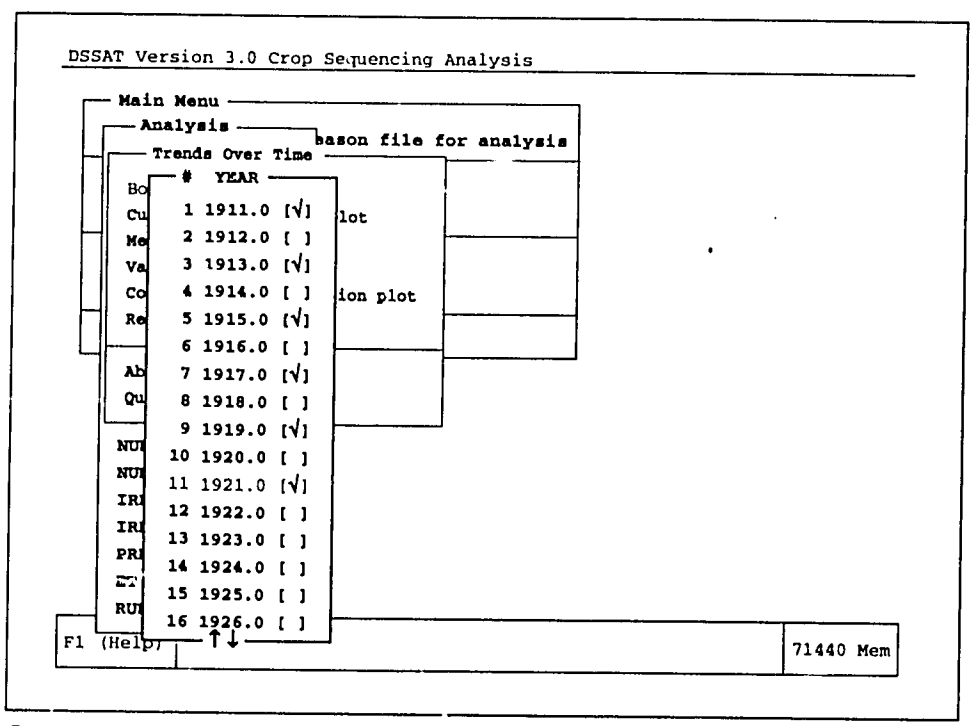
OPTION 2. CUMULATIVE FUNCTION PLOT

When this option is selected in Screen 10, output variables by year or season may also be plotted as cumulative function plots. (Cumulative function plots are sometimes called cumulative probability function (CPF) plots or cumulative distribution function plots –

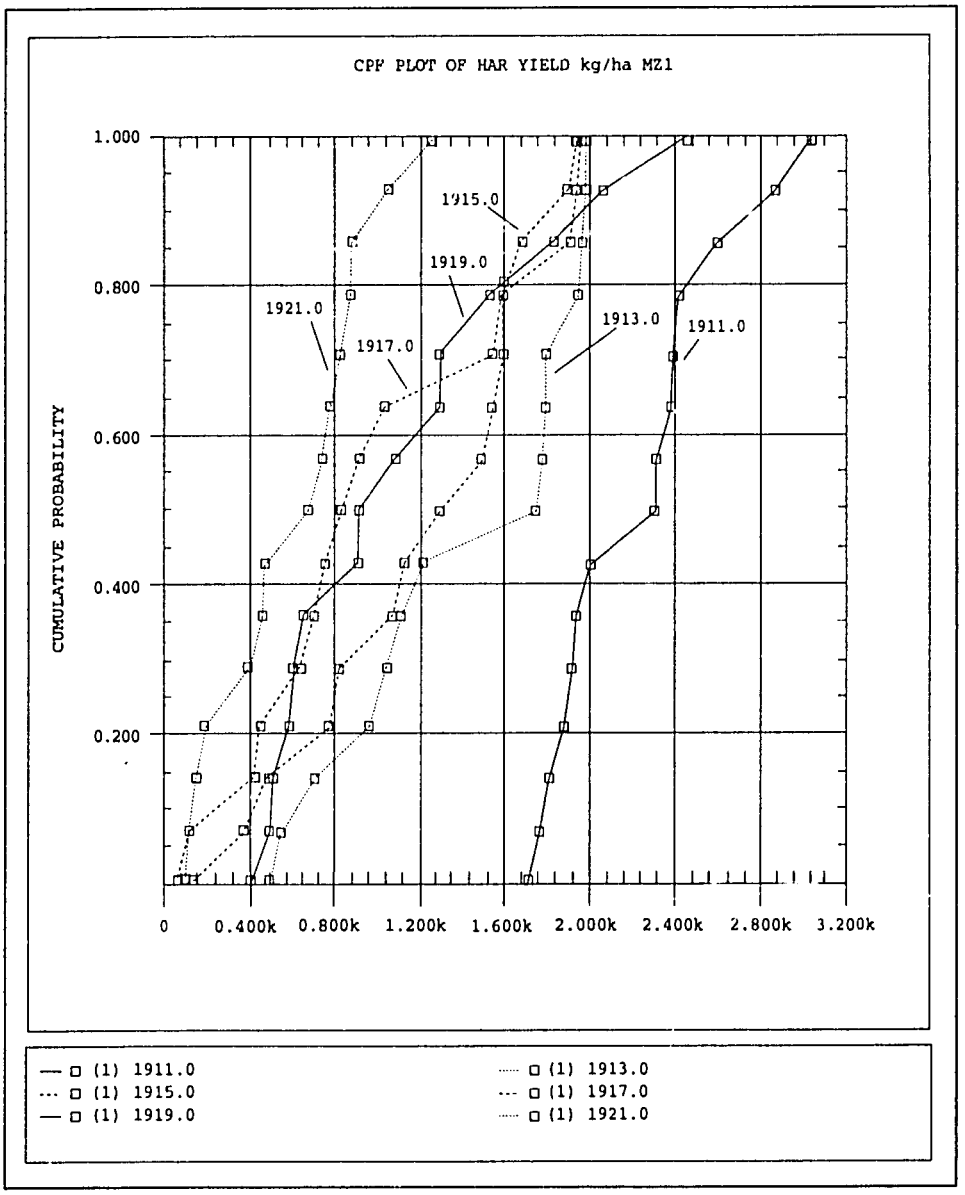
these are the same.) Here, the distribution for the chosen output variable for each season or year is ordered from smallest to largest, and plotted against equal increments of cumulative probability.

After selecting this option, the year selection screen appears (Screen 12, below), allowing the user to select which years' values are to be plotted in this way. A maximum of six CPF plots may be graphed at any time, to reduce the confusion of the plot. You can select or deselect years all at once with the <+> or the <-> key, or individually with the space bar. If more than six years are selected, the program will plot the first six years selected; the rest will be ignored.

For the example, select the years 1911, 1913, 1915, 1917, 1919, and 1921 (as shown in Screen 12), and press the <ENTER> key. The resulting plot is shown in Screen 13 (on following page). To print, press the <P> key, or press the <ENTER> key to return the Graphics-Regression main menu (Screen 10).



SCREEN 12.



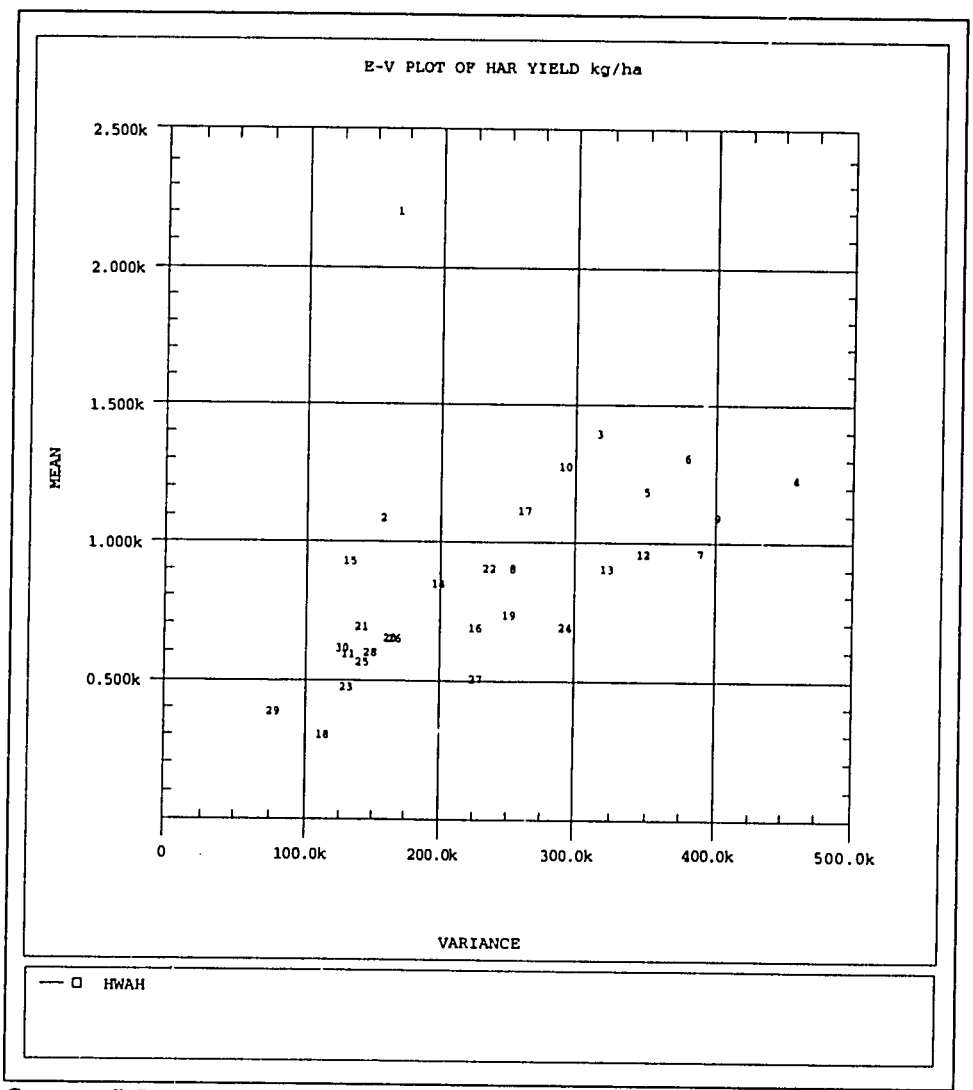
SCREEN 13.

OPTION 3. MEAN-VARIANCE PLOT

When this option in Screen 10 is selected, output variables may be plotted in mean-variance space. The calculated mean is plotted against the variance for the output variable of interest, and the sequence year numbers themselves are drawn on the graph. All the seasons available may be plotted in this way, or you may choose a subset of seasons to avoid confusion on the graph. Such graphs are another way of giving an indication of the variability associated with each season in the sequence, and are useful for visualizing the trade-

offs that must sometimes be made between striving for a higher mean value while increasing the variability (as described by the variance) for the output of interest.

Choose the mean-variance plot option to produce the plot (Screen 14, below). The y-axis for such a plot is always scaled automatically, and care will sometimes be needed in interpretation, as the difference between the means (i.e., the difference from the top to the bottom of the scale) may not be very much, and will sometimes be much less than appears from a cursory glance at the graph. To print the plot, press the <P> key, or press any key to return to the Graphics-Regression main menu (Screen 10).

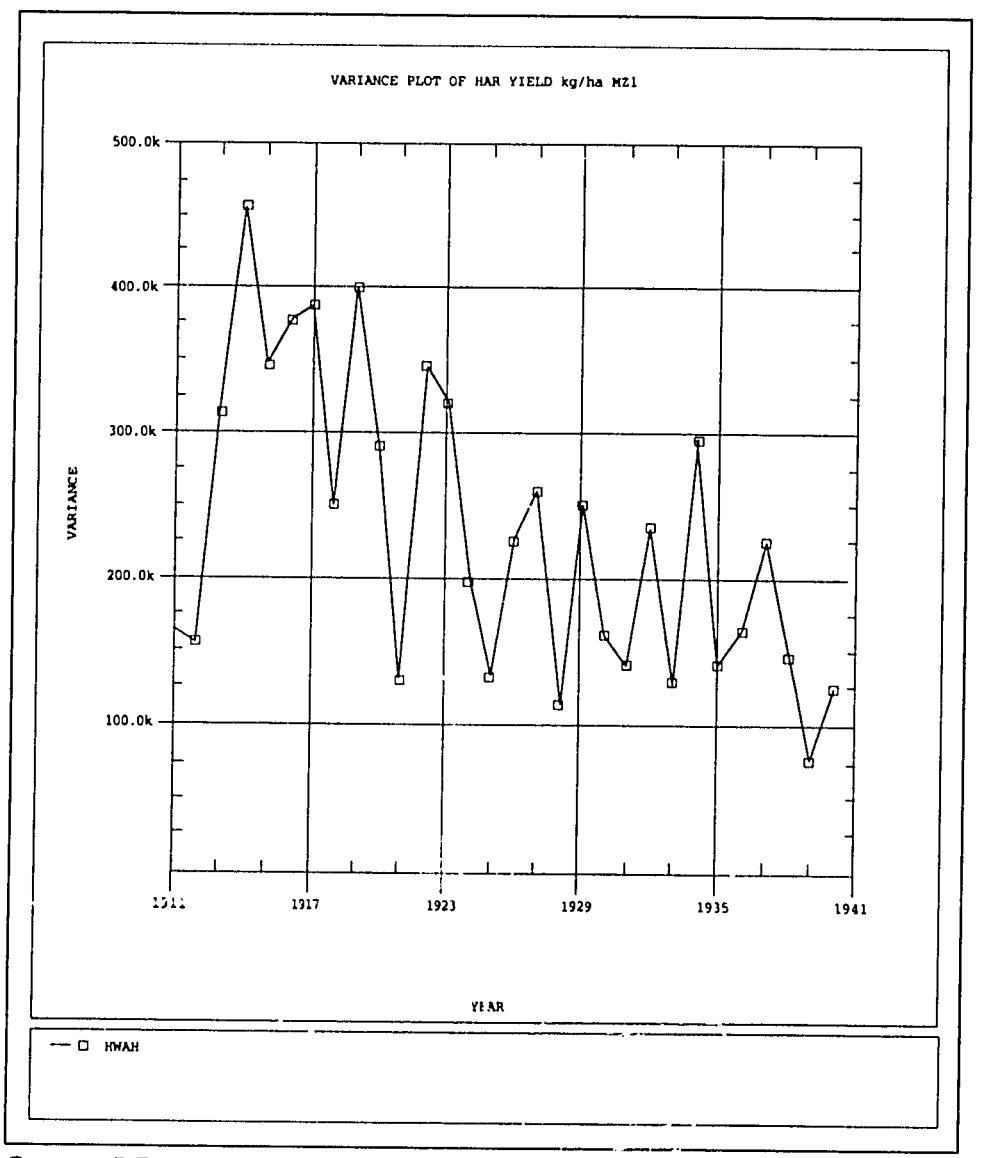


SCREEN 14.

OPTION 4. VARIANCE PLOT

If this option is selected in Screen 10, a time series is produced (Screen 15, below) of the variance of the output variable chosen over the length of the sequence. The variance will often be of use in determining whether variability in the system is increasing or decreasing over time. If it is increasing, then this may be an indication of long-term problems in the system leading to unsustainable performance, for example.

There will be some output variables where no change in variance is expected over time,

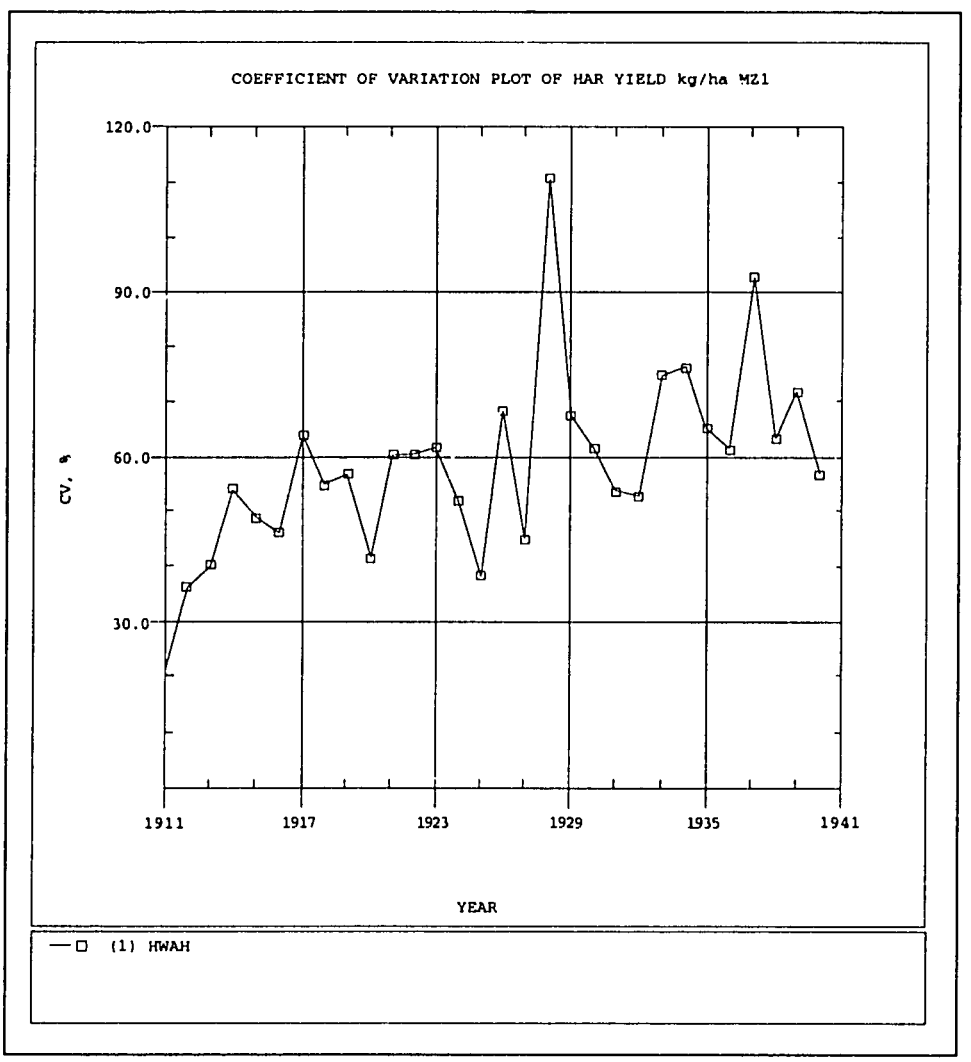


SCREEN 15.

such as in seasonal rainfall. If there is a clear trend in seasonal rainfall and you have used one of the weather generators, for example, this is clear indication of a serious problem (BUT refer to the Appendix). Return to the Graphic-Regression main menu (Screen 10) by pressing any key.

OPTION 5. COEFFICIENT OF VARIATION PLOT

The fifth graphics option in Screen 10 allows you to plot the coefficient of variation of the selected output variable, calculated as (s/x) * 100, where s is the standard deviation and x the mean, against time. This type of plot can give a useful indication of changes in relative



SCREEN 16.

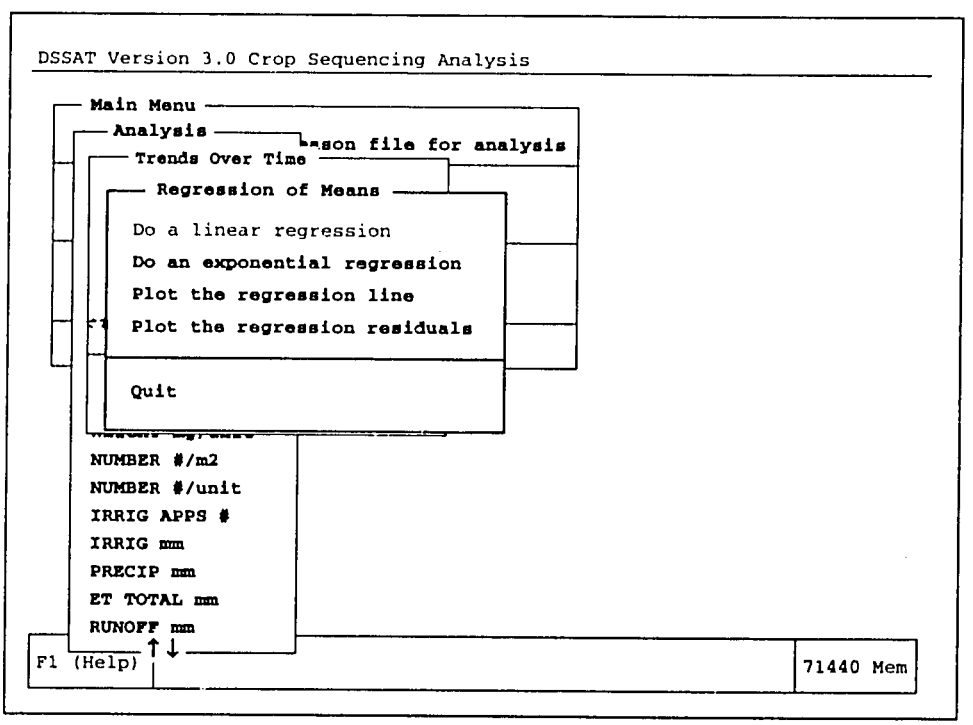
variability through time. Screen 16 (on previous page) shows an example for maize yield. Note that although mean yield decreased through time, relative variability, as measured by the coefficient of variation, increased markedly.

Return to the Graphics-Regression main menu (Screen 10) by pressing any key.

OPTION 6. REGRESSION MENU

Choose the "Regression Menu" option in Screen 10. The screen that appears (Screen 17, below) gives you the option of calculating a linear or exponential regression on the means of the seasonal output variable. The regression line with the original means can be plotted, as can the residuals from the regression.

If you have not yet read the Appendix then please do so now. It cannot be over-emphasized that the potential to produce spurious results is high at this stage in the analysis program. To reiterate a major conclusion of the Appendix to this PART, the chances of obtaining a meaningful regression of means with less than 10 replicates of the sequence are slim. You are urged to exercise caution in interpreting such analyses, and this is not something the program can do — your own common sense must prevail.



SCREEN 17.

REGRESSION MENU

From the regression menu, you must first choose to do a regression before plotting it or the residuals.

Linear Regression. To illustrate, choose the option, "Do a linear regression,"in Screen 17. The resulting screen (Screen 18, below) gives the output, in terms of the calculated constant or intercept, the slope or gradient, the quantity r^2, the standard error of the gradient, and a t-test that tests the hypothesis that the gradient is significantly different from 0. The meaning of these outputs is as follows (from Snedecor and Cochran, 1980).

The program performs a simple least-squares regression and fits the following line to the data points:

$$y = mx + c$$

where y is the output variable under consideration (here, yield), m is the slope or gradient, x is the year number, and c is a constant (the y-axis intercept, or the value of y when x equals zero). The quantity r^2 can be interpreted as the estimated proportion of the variance of y that can be attributed to its linear regression on x. The hypothesis that the gra-

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DSSAT Version 3.0 Crop Sequencing Analysis

                 Regression of Means

              Variable : HAR YIELD kg/ha
          Crop Code(s) : MZ1
                  Type : Linear

        Constant  =      66358.4100
        Gradient  =        -34.0009
        R-squared =           .6039
        Standard error of gradient          =  5.212
        T-test of gradient: significant at p =   .000

IRRIG APPS #
IRRIG mm
PRECIP mm
ET TOTAL mm
RUNOFF mm
F1 (Help)                                    71440 Mem
```

SCREEN 18.

dient is significantly different from zero (i.e., a trend exists) can be tested by

$$t = m/s_m$$

where t is distributed as Student's t with n-2 degrees of freedom (s_m is the standard error of the gradient and n is the number of data points).

The model fitted,

$$y = \alpha + \beta x + \varepsilon$$

where ε is a random variable drawn from $N(0,\sigma_{x.y}^2)$, makes a number of assumptions, including the following:

1. For each specific X there is a normal distribution of Y from which sample values of Y are drawn at random;
2. The normal distributions of Y for specific X are independent;
3. The normal distributions of Y for specific X all have the same variance $\sigma_{x.y}^2$.

All these assumptions are often violated when looking at trends in sequences: the distribution of yields for any sequence year will often not be normal; the sequence distributions are not independent, since yields in one year will be dependent to some extent on yields in previous years; and the variances of output distributions often change markedly over the length of the sequence.

For these reasons, great care is needed in interpreting the regressions. A quick idea of the likely significance of the regression can be gained from inspection of the value of r^2; for the 10 or 20 data points that will often be used in the program, any value less than 0.5 or so will indicate that the regression is not statistically significant.

In the example in Screen 18, the regression suggests that the slope or gradient is negative (i.e., on average, there is a trend for maize yields to decrease by 34 kg/ha each season). The standard error of the gradient is not large, compared with its value. The slope is significantly different from zero, according to the t-test. The regression explains a fair proportion of the variability in mean yield, since the value of r^2 is moderate (0.6).

Exponential Regression. The exponential regression option operates in the same way, by fitting the linear transformation

$$\ln(y) = \ln(c) + mx$$

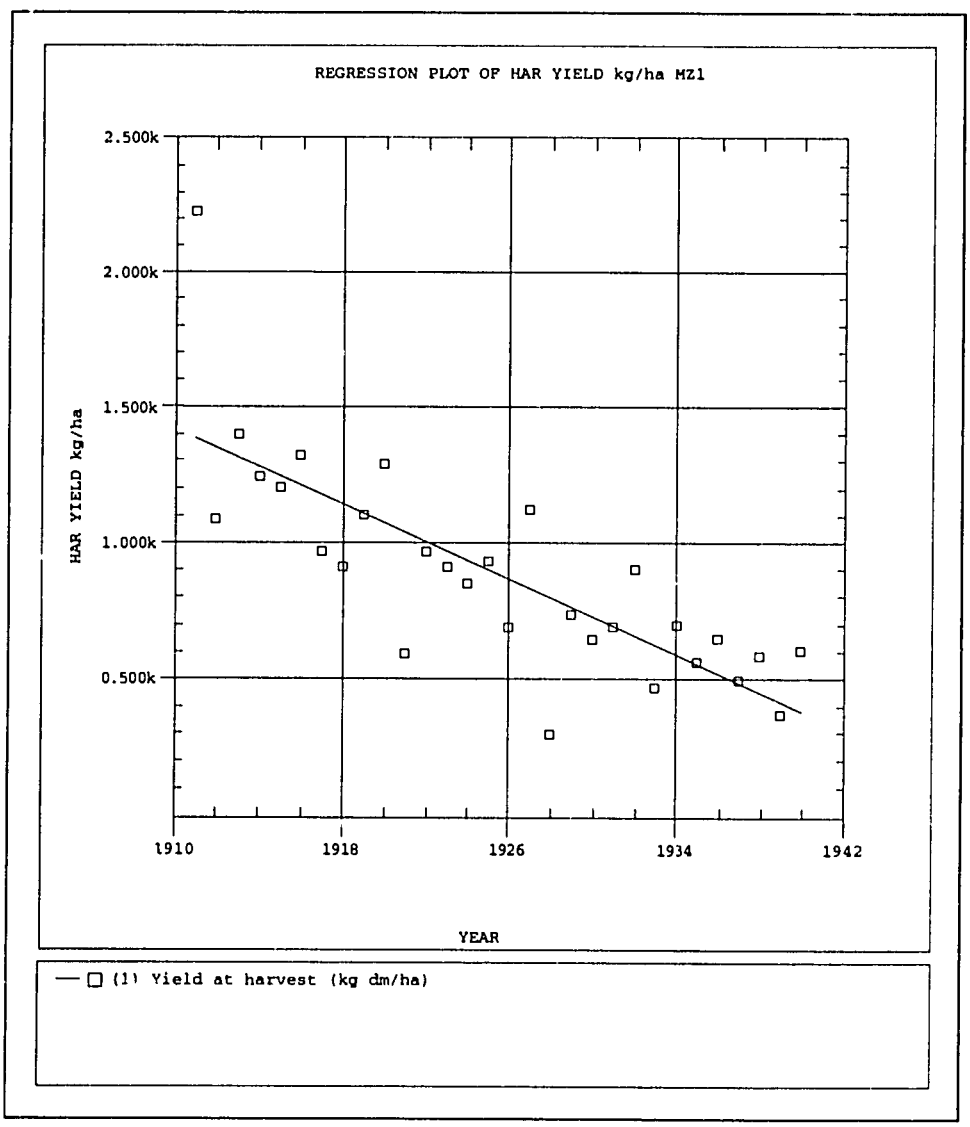
of the exponential function

$$y = c * \exp(mx),$$

notation as above.

Plot the Regression Line. Having fitted a regression, the regression line can be plotted; choose this option from the Regression menu (Screen 17) to produce the plot (Screen 19, below). The fitted line is shown together with the seasonal means as small boxes. Note that the yield for 1911 is much higher than its regressed value. This is largely due to the 5 t/ha of crop residue added at the start of each sequence replicate (see Table 2).

Press any key to return to the Regression menu.



SCREEN 19.

Plot the Regression Residuals. Now choose to plot the residuals (Screen 20, on following page). These are the deviations of the points Y from the fitted line,

$$d_{y.x} = Y - \hat{Y} = y - mx$$

where Y is the regressed value of output and $\hat{Y}$ is the simulated value from the crop model. No trends or patterns should be discernible in the residuals; such patterns are evidence of serious violations of the assumption of statistical independence in particular, and the resulting regression should be discarded or treated with caution.

To sum up, despite the patina of "objectivity" that may be given to your simulated results using regression to find trends, you should exercise great care in interpreting the outputs from the regression option. As noted above, there is no substitute for common sense.

Analyzing More Than One Crop at a Time

The analysis program has the option for analyzing more than one crop at a time. To illustrate, return to the Analyses main menu (Screen 4), again select the option, "Analyze Biophysical Variables," and then choose the variable precipitation (PRECIP mm) from Screen 7, and pick both crop codes as shown in Screen 21 (on second following page.)

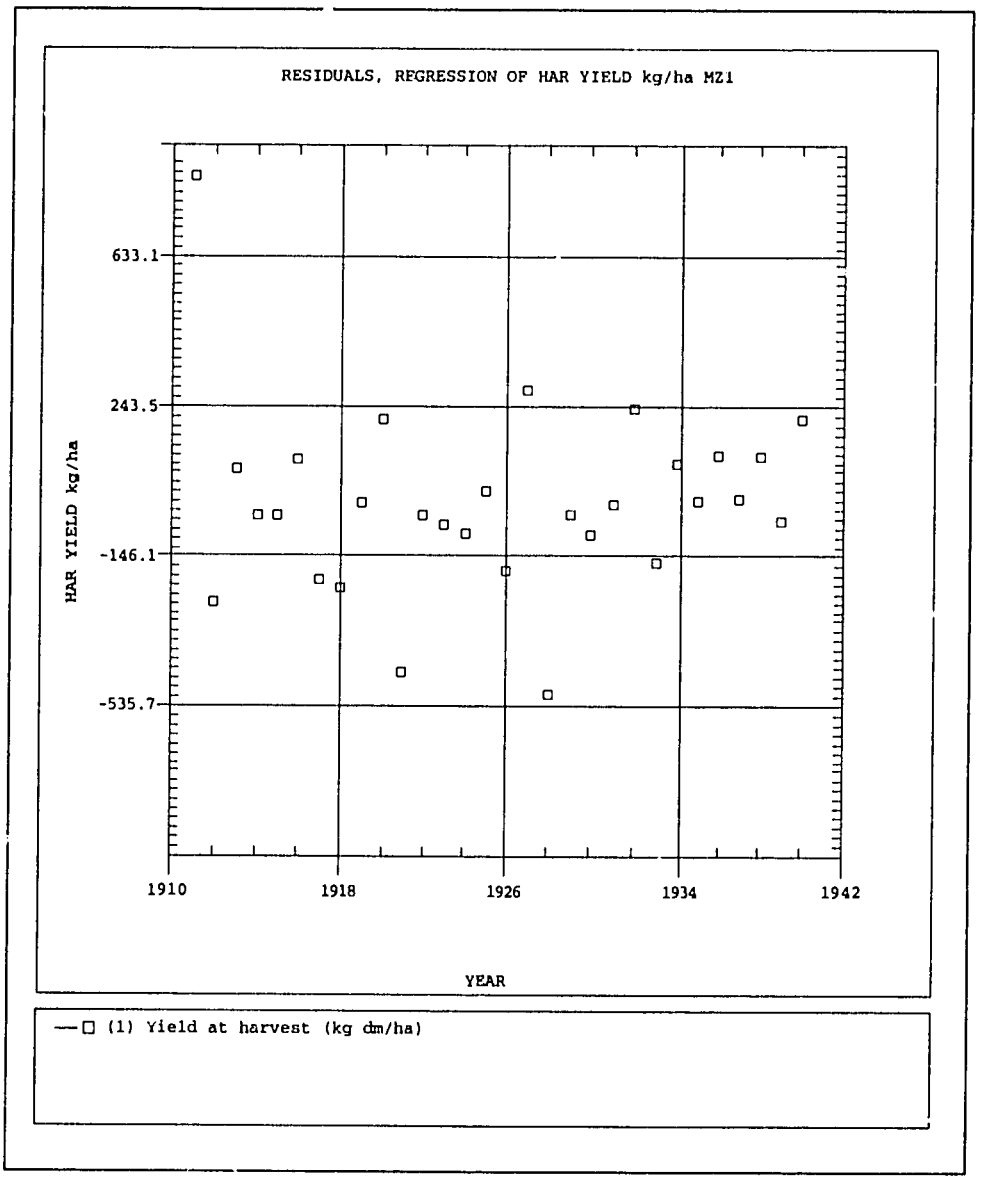
The resulting screen warns you that you have picked multiple crop codes. In the subsequent screen (Screen 22, on second following page), you have to make a choice as to how the program will analyze these multiple crops. There are three options, described as follows.

Option 1 - Additive. The values of the output variable for all selected crops will be simply added together to provide a grand total by year of the output of interest;

Option2 - Average. The values of the output variable for all selected crops will be averaged to provide a single "mean" value of the output of interest for the relevant calendar year;

Option 3 - Time Series. Each value of the output variable for all selected crop codes will be treated independently to provide a time series of the output of interest.

Which option you choose will depend on the output variable and what you are trying to achieve. It is important to understand the differences in these three options. For example, it may make sense to add total fertilizer applied across different crops; it may not make much sense to add bean yields and maize yields if grown in the same growing season in the same calendar year.



SCREEN 20.

Choose the "Time series" option in Screen 22 for looking at precipitation for the maize-fallow experiment. The resulting screen (Screen 23, on second following page) lists the mean, standard deviation, minimum and maximum rainfall by sequence year. Note that the sequence years have non-zero decimal points. The time series is produced by treating maize and fallow separately; for the first replicate, maize was harvested on day 59 in 1912 (see Table 4, data record 1, under HDAT), with a cumulative rainfall mean of 1213 mm (Table 4, data record 1, under PRCM). For all 15 replicates, the mean harvest date was

57V

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DSSAT Version 3.0 Crop Sequencing Analysis

 Main Menu
  Analysis                    ason file for analysis
   Crop codes
    1 MZ1          [√]        iables
    2 FA1          [√]        bles
   HARVEST day                 ns
   SOWING WT kg/ha
   TOPS WT. kg/ha
   MAT YIELD kg/ha
   HAR YIELD kg/ha
   BYPRODUCT kg/ha
   WEIGHT mg/unit
   NUMBER #/m2
   NUMBER #/unit
   IRRIG APPS #
   IRRIG mm
   PRECIP mm
   ET TOTAL mm
   RUNOFF mm
   ↑↓
F1 (Help)                                          71440 Mem
```

SCREEN 21.

```
DSSAT Version 3.0 Crop Sequencing Analysis

 Main Menu
  Analysis                    ason file for analysis
   Analysis
    Additive                  ariables
    Average                   iables
    Time series               ns
   SOWING WT kg/ha
   TOPS WT. kg/ha
   MAT YIELD kg/ha
   HAR YIELD kg/ha
   BYPRODUCT kg/ha
   WEIGHT mg/unit
   NUMBER #/m2
   NUMBER #/unit
   IRRIG APPS #
   IRRIG mm
   PRECIP mm
   ET TOTAL mm
   RUNOFF mm
   ↑↓
F1 (Help)                                          71440 Mem
```

SCREEN 22.

day 55.8 (you can check this by analyzing the maize harvest date). Thus the sequence year number is calculated as 1912+(55.8/365), or 1912.2 to one decimal place (Screen 23).

The first fallow period of the first replicate stopped on day 304 in 1912, as it did for each year subsequently (Table 4): remember that planting of maize took place on day 305 each year. The mean sequence year number for the fallow rainfall total is thus calculated as 1912+(304/365), or 1912.8 to one decimal place. These are the year numbers that are used in all subsequent plots. Thus a box plot of precipitation shows a time series of these cumulative rainfall occurrences (see Screen 24, on following page).

You may notice that the rainfall amount for the maize crop in 1911 - 1912 appears higher than in other years. This is explained by the fact that in 1911, simulation with the maize model started on day 244 (Tables 2 and 4); in all other years, the maize model was run from day 305. Thus in 1911, the rainfall total covers a longer period than in any of the other years. This again illustrates the care that is needed in the interpretation of analysis results and the importance of understanding the nature of your crop sequence.

Now return to the Crop Code menu (Screen 21), choose MZ1 and FA1 as before, but this

DSSAT Version 3.0 Crop Sequencing Analysis

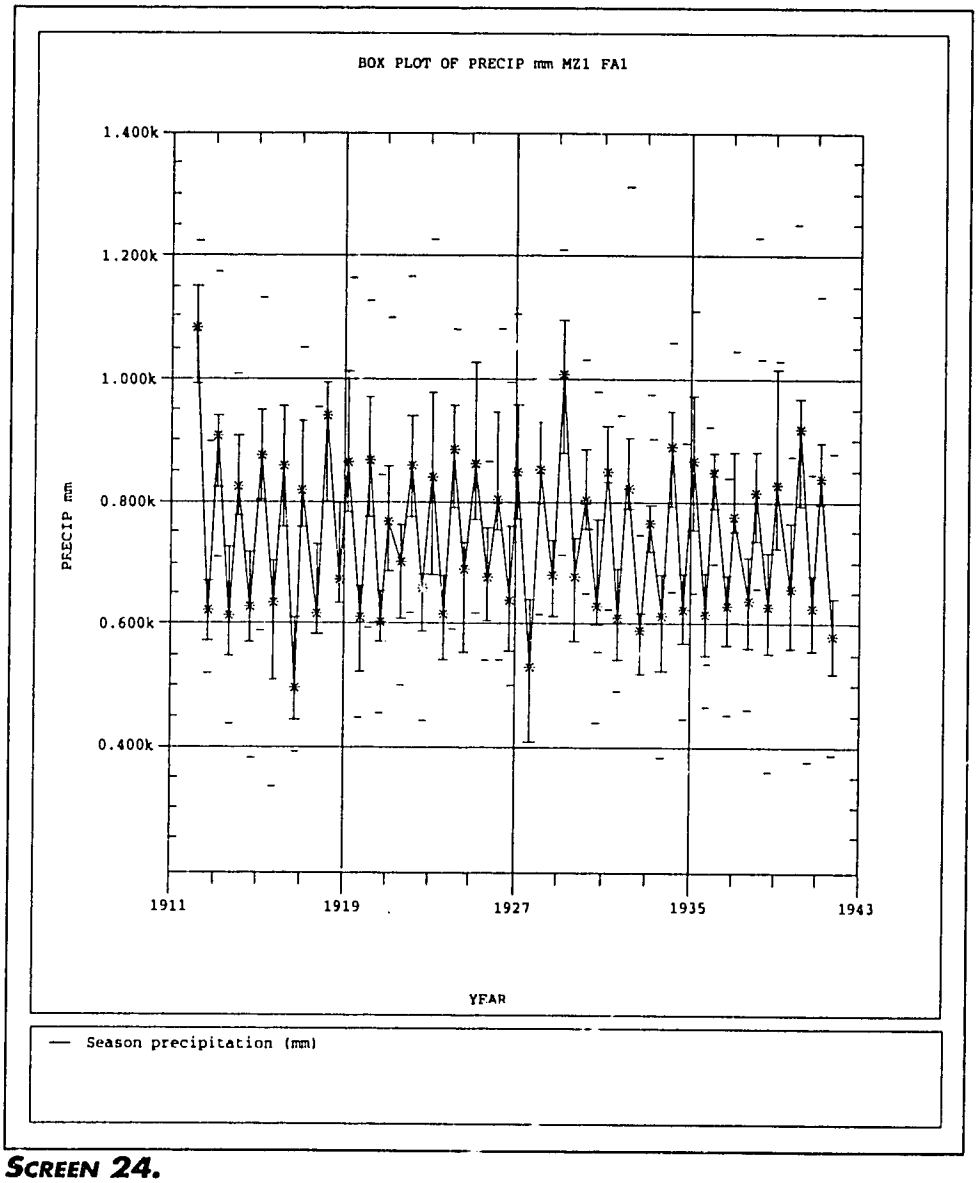
Trends Over Time

Variable : PRECIP mm
Crop Code(s) : MZ1 FA1

Sequence Year	Mean	St.Dev.	Min	Max
1912.2	1050.9	137.3	763.0	1222.0
1912.8	638.1	100.1	519.0	898.0
1913.2	893.1	113.5	711.0	1174.0
1913.8	636.3	134.8	438.0	914.0
1914.1	846.6	99.2	632.0	1007.0
1914.8	631.2	124.8	380.0	850.0
1915.2	872.5	157.2	589.0	1131.0
1915.8	614.7	145.8	336.0	892.0
1916.2	880.7	141.4	712.0	1182.0
1916.8	557.8	163.2	392.0	981.0

F1 (Help) ↑↓ Press any key to see more .. 71440 Mem

SCREEN 23.



SCREEN 24.

time choose Analysis Option 1 (Additive) in Screen 22. Observe the differences in the tabular output and the plot; "maize" and "fallow" precipitations are added together by the calendar year in which they occurred (according to harvest dates in the summary output file).

Now do the same thing, but choose Analysis Option 2 (Average) in Screen 22; the average values will be produced by calendar year. Note that this analysis has little meaning here, but it is useful for understanding the differences in the analysis options.

The analysis program thus has the flexibility to analyze different combinations of rotation components. Again, you should be careful in interpreting the results, as they may not always be meaningful or useful.

Analyze Economic Variables

Option 2, "Analyze Economic Variables," in the Sequence Analysis main menu (Screen 4) allows the analysis of the sequence in economic terms. On choosing this option, the Economic Evaluation main menu appears (Screen 25, on following page). There are four major options, described below.

Economic Evaluation Main Menu

Option 1. Access a Price File

Before economic evaluation can be undertaken, the program must have access to a price-cost file that details the costs and prices to be used for the analysis. The program will try to read an appropriate price-cost file by itself, but various options are open to the user. Select this option to get to the next menu, Screen 26 (on following page).

* Tied Price-Cost Files: Use a price file, extension PRQ, that is "tied" or directly related to the experiment FILEX (in the example, EBAF1101.PRQ). This option might be used when you have a complicated experiment and you wish to preserve the prices and costs that pertain to the experiment.

* Default Price-Cost File: A default price file, called DEFAULT.PRQ, can be used (this file is distributed with the DSSAT3). This default can be as simple or as complicated as the user requires (its format is shown in Table 5).

* User-Specified Price-Cost File: The user can browse the hard disk directory structure and find an appropriate PRQ file that will be used in the analysis.

```
DSSAT Version 3.0 Crop Sequencing Analysis

 Main Menu
   Economic Evaluation
     Access a price file (current file EBAF1101.PRQ)
     Choose to include fallow periods in analysis
     Edit price file for sensitivity analysis
     Do analysis
     Quit ...
 Exit

F1 (Help)                                          71440 Mem
```

SCREEN 25.

```
DSSAT Version 3.0 Crop Sequencing Analysis

 Main Menu
   Economic Evaluation
     Price File Access
       Use C:\DSSAT3\ECONOMIC\DEFAULT.PRQ
       Use C:\DSSAT3\ECONOMIC\
       Select a new price file
       Quit
 Exit

F1 (Help)                                          71440 Mem
```

SCREEN 26.

Format and Content of Price-Cost Files. The format of the default price-cost file DEFAULT.PRQ for sequence analysis is shown in Table 5, together with a listing of the headers that appear in the file. The eleven prices and costs that are currently included are as follows.:

Cost or Price	*Units*	*Associated Model Output*
1 Price of harvest produc (e.g., grain)	$/t	yield, t/ha
2 Price of harvest byproduct	$/t	byproduct yield, t/ha
3 Base production costs	$/ha	–
4 Nitrogen fertilizer cost	$/kg	N applied, kg/ha
5 Cost per N fertilizer application	$	No. of N applications
6 Irrigation costs	$/mm	irrigation applied, mm
7 Cost per irrigation application	$	No. of irrigation applications
8 Seed cost	$/kg	seed sown, kg/ha
9 Cost of organic amendment	$/t	residue applied, t/ha
10 Phosphorus fertilizer cost	$/kg	P applied, kg/ha
11 Cost per P fertilizer application	$	No. of P applications

Note that costs and prices can be negative or positive; this might apply particularly to harvest byproduct, where a negative income is posited (i.e., it costs the farmer money to remove the byproduct — straw or stover, for example). Any monetary units can be used; so "$" can be thought of as "money in general" rather than "dollars."

Economic evaluation of the sequence can take account of price and cost variability. Details on how this is done within the program are given in Appendix A to Part 1 (Seasonal Analysis) of this Volume.

Sequence analysis price files, as shown in Table 5, can contain many lines per section: a header line, a line containing a value that is used for generating stochastic values, and a time series of values. Stochastic generation of values is controlled as follows:

0 Fixed: a deterministic or non-variable price or cost is used

>1 A normal variate is assumed, from the distribution N(x,s), where x is the mean value that appears in the time series, and s is the standard deviation. The value stored in the file is the standard deviation expressed as a percentage of the mean, i.e., the coefficient of variation.

TABLE 5. PART OF THE DEFAULT SEQUENCE PRICE FILE, DEFAULT.PRQ.

```
* PRICE-COST_FILE : DEFAULT FOR SEQUENCE ANALYSIS

! Line for which YRDOY=# is %SD of price/cost

* MZ
@YRDOY    GRAN     BYPR     BASE     NFER     NCOS     IRRI     IRCO     SCOS     RESM     PCOS     PFER
     #   10.00     0.00     0.00     0.00      .00     0.00      .00      .00      .00      .00      .00
1978001  130.00    10.00   155.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00
1979001  130.00    10.00   155.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00
1980001  130.00    10.00   155.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00
1981001  130.00    10.00   155.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00
1982001  130.00    10.00   155.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00
1983001  130.00    10.00   155.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00
1985001  130.00    10.00   155.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00
1986001  130.00    10.00   155.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00
1987001  130.00    10.00   155.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00
1988001  130.00    10.00   155.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00
1989001  130.00    10.00   155.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00
1990001  130.00    10.00   155.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00
1991001  130.00    10.00   155.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00
1992001  130.00    10.00   155.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00
1993001  130.00    10.00   155.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00
1994001  130.00    10.00   155.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00
1995001  130.00    10.00   155.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00

* SG
@YRDOY    GRAN     BYPR     BASE     NFER     NCOS     IRRI     IRCO     SCOS     RESM     PCOS     PFER
     #   10.00     0.00     0.00     0.00      .00     0.00      .00      .00      .00      .00      .00
1978001  330.00    10.00   395.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00
1979001  330.00    10.00   395.00      .50    12.00      .50    15.00     0.50     0.00      .00      .00
```

Headers:

YRDOY Date of price or cost, year (YR) and day number (DOY)

GRAN Price of grain, $/t

BYPR Price of harvest byproduct, $/t

BASE Base production costs, $/ha

NFER Nitrogen fertilizer cost, $/kg

NCOS Cost per N fertilizer application, $

IRRI Irrigation cost, $/mm

IRCO Cost per irrigation application, $/ha

SCOS Seed cost, $/kg

RESM Cost of organic amendments, $/t

PCOS Phosphorus fertilizer cost, $/kg

PFER Cost per P fertilizer application, $

If you specify a large number (more than three) of stochastic prices and costs, and your computer is not one of the fastest, the economic analysis program may take a long time to run. Usually it is best to use only a few stochastic prices and costs.

The price-cost file is sectioned by crop as shown in Table 5. You may have different sections for different sequence components of the same crop; thus MZ1 and MZ2 might share the same set of prices and costs, or you could have two sections, one headed "*MZ1" and one "*MZ2." If no integer is specified with the crop code, it is assumed to be a general section, and will be used for all component numbers with that crop code.

Option 2. Choose to Include/Exclude Fallow Periods in Analysis

The second option in the Economic Evaluation menu (Screen 25) allows the user to decide whether to include or exclude the effects of fallow periods in the analysis. Selecting this option toggles the text from "include" to "exclude" or vice-versa. Fallow periods often have some economic cost, and you may want to incorporate these into the analysis. If you include them, then you must have a fallow section in the cost-price file you are using.

Option 3. Edit Price File for Sensitivity Analysis

When you choose this option in Screen 25, the program loads the default editor and the price file that has been selected. You may then make changes to the price file, save it, and exit to the analysis program. The editor that the program will load is the editor specified in the SETUP menu item of the DSSAT Shell (see Volume 1-3, Hunt et al. 1994, of this book for a description of the SETUP menu item). You should be careful when making edits in the price file that you preserve the format of the file, otherwise you may obtain error messages when the analysis program tries to read the modified file.

Option 4. Do Analysis (calculate economic returns)

When this option is selected from Screen 25, the program will calculate the mean, standard deviation, maximum and minimum value of net return or gross margin per hectare for each sequence year using the costs and prices specified. The first set of results are for total returns (Screen 27, on following page), including all the crop components in the sequence (or excluding fallows, if you have selected this option). Once these results have been tabulated, you may want to view the returns arising from each separate crop component. If so, select <Yes> at this point to be presented with tables of returns by crop component.

DSSAT Version 3.0 Crop Sequencing Analysis

Total Return per Hectare

	Mean	St.Dev.	Min	Max
Year 1911	230.04	84.66	102.55	430.76
Year 1912	41.77	73.82	-62.64	228.98
Year 1913	85.28	92.87	-65.55	229.98
Year 1914	65.05	114.94	-95.57	320.76
Year 1915	56.40	95.37	-103.03	226.15
Year 1916	74.49	100.17	-99.50	246.28
Year 1917	24.89	101.02	-113.56	223.78
Year 1918	18.40	89.13	-105.71	251.42
Year 1919	47.88	109.34	-73.25	313.52
Year 1920	73.33	95.61	-103.87	293.66

F1 (Help) | Press any key to continue.. | 71440 Mem

SCREEN 27.

You then have the option to plot some results. The plot menu (Screen 28, below) allows you to do box plots of economic returns by crop component or total returns (all crop

DSSAT Version 3.0 Crop Sequencing Analysis

Main Menu
Economic Evaluation
Plot Menu
file EBAF1101.PRQ)
ods in analysis
ty analysis

Box Plot of Returns - MZ1
Box Plot of Returns - FA1

Box Plot of Total Returns
Probability Analysis
Review results

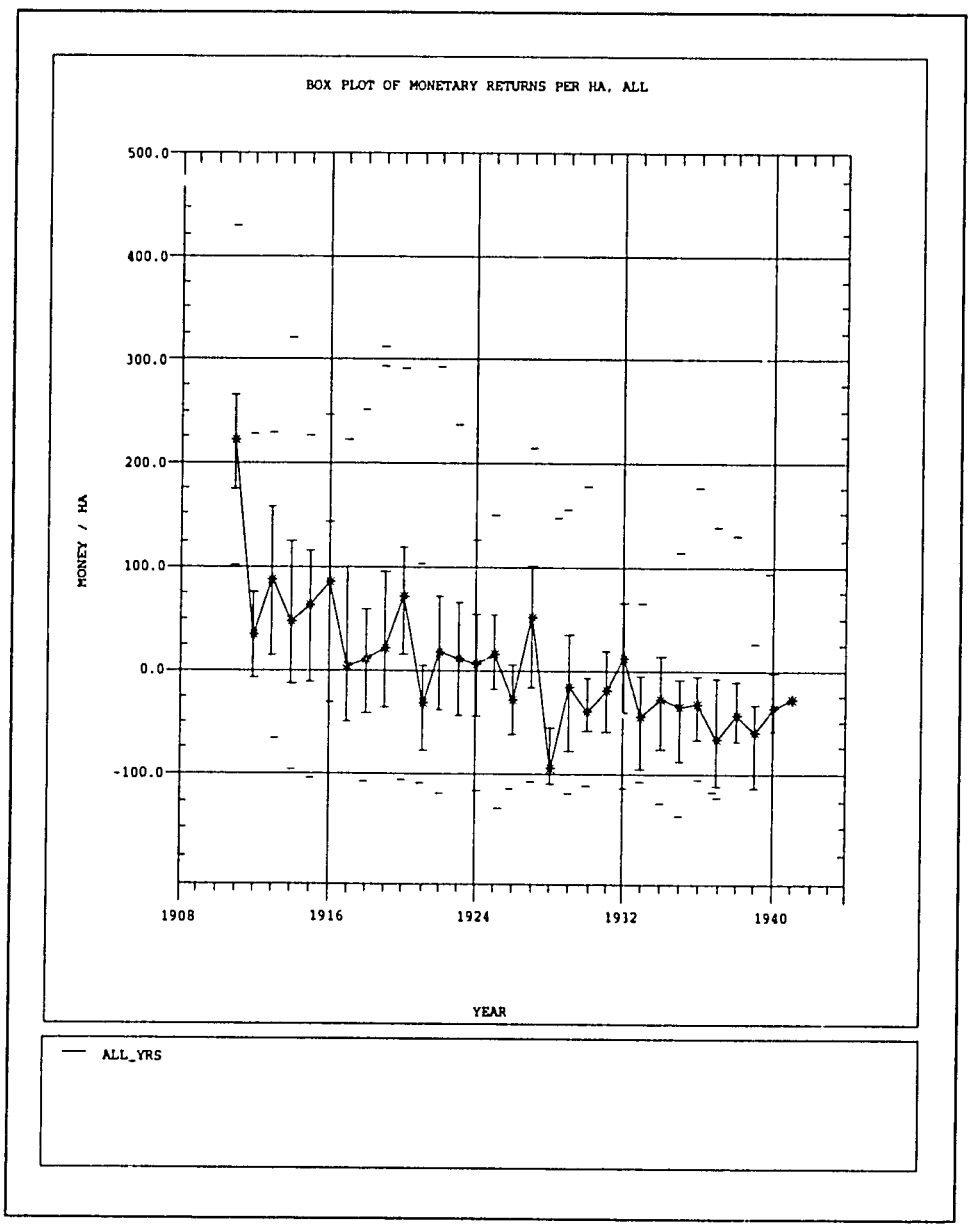
Exit economic analysis

F1 (Help) | 71440 Mem

SCREEN 28.

- components included in the analysis). Select the option, "Box Plot of Total Returns," in Screen 28 and the resulting box plot for all years is shown in Screen 29 (below), in the same way as for the biophysical variable box plots described above.

Return to the plot menu (Screen 28). Select the "Probability Analysis" option; the resulting screen is shown as Screen 30 (on following page). Again, you may do a probability



SCREEN 29.

```
DSSAT Version 3.0 Crop Sequencing Analysis

 Main Menu
  Economic Evaluation
   Plot Menu                    ile EBAF1101.PRQ)
    Probability Analysis        s in analysis
     Returns -- MZ1             analysis
     Returns -- FA1
     Total returns
   Review results
  Exit economic analysis

F1 (Help)                                          71440 Mem
```

SCREEN 30.

analysis by crop component or for total returns (all components together). Select the "Total returns" option. You are then asked to enter a critical return, $/ha, in Screen 31 (below). This might be a threshold value of returns that the sequence is required to gener-

```
DSSAT Version 3.0 Crop Sequencing Analysis

 Main Menu
  Economic Evaluation
   Plot Menu                    ile EBAF1101.PRQ)
    Probability Analysis        s in analysis
     Returns -- MZ1             analysis
     Returns -- FA1
     Total returns
   Review r
  Exit eco
    Variable        : Enter critical return, $/HA
    Current Value   :       .000
    Maximum Value   :   430.765
    Minimum Value   :  -134.196
    Now Value       : 0.0 ■■■■■■

F1 (Help)                                          71440 Mem
```

SCREEN 31.

ate. In some situations, the probability of failing to generate a certain level of returns from an enterprise is an important criterion of viability; if this probability of failure increases through time, then this raises serious questions concerning the long-term viability of the crop sequence or rotation. The probability analysis performed is one way of addressing this issue.

Having selected the critical return (Screen 31; enter a value of $0/ha here), the program will calculate the probability each year of failing to meet this critical return. The resulting screen (Screen 32, below) shows the probability of the sequence failing to generate positive returns per hectare in each sequence year. Press any key to complete the display of the table. You are then asked if you want to plot these probabilities. Enter <Y> to produce the plot in Screen 33 (on following page).

The costs and prices used in the example are hypothetical (and are also constant throughout the sequence from 1911 to 1940; edit the file EBAF1101.PRQ to see this). As might be expected in such circumstances, reductions in mean yields result in increased probabilities of negative returns across the years of the sequence.

DSSAT Version 3.0 Crop Sequencing Analysis

Probability of Obtaining < .00 $/Ha

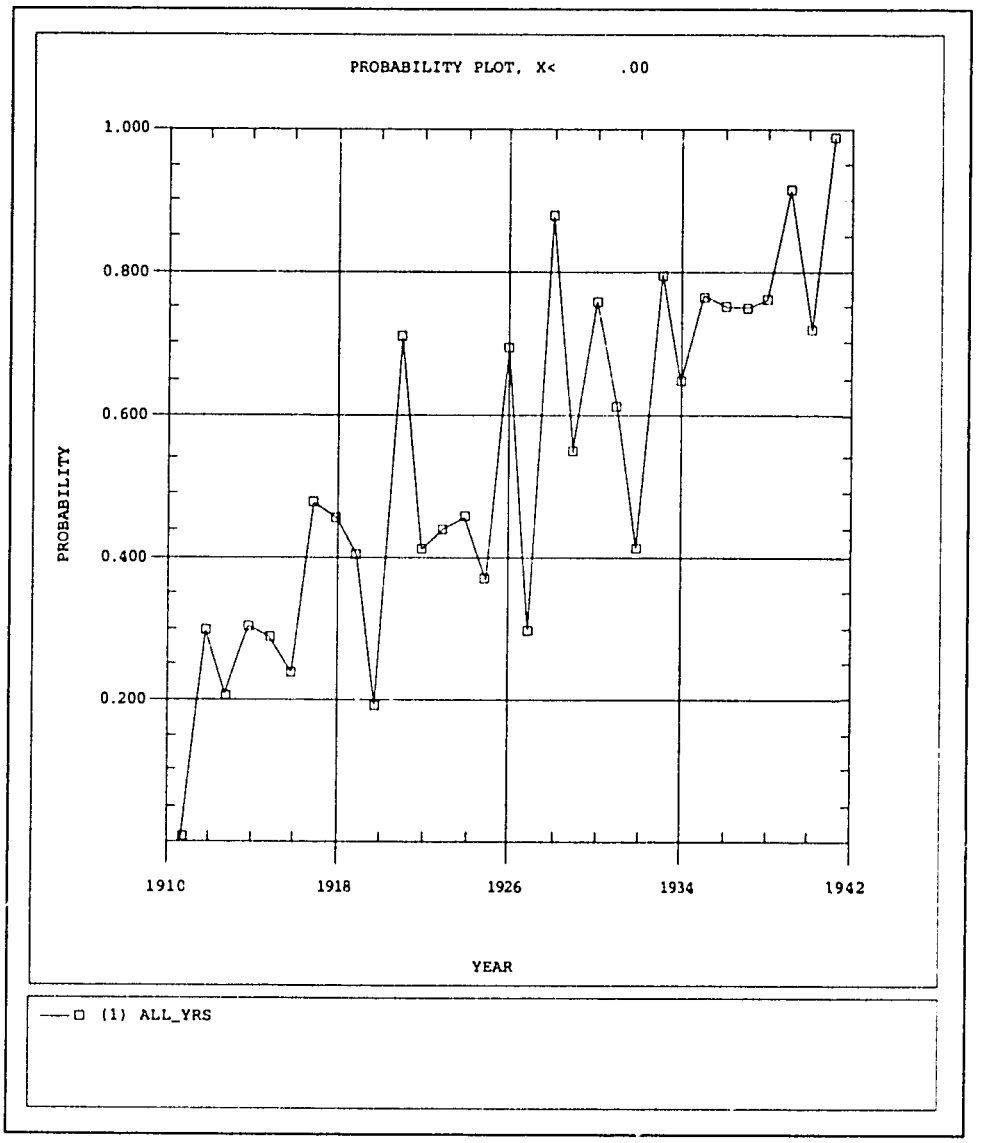
Component	Year	Probability
ALL	1911	.000
ALL	1912	.297
ALL	1913	.207
ALL	1914	.303
ALL	1915	.291
ALL	1916	.240
ALL	1917	.480
ALL	1918	.458
ALL	1919	.408
ALL	1920	.192

Do you want to plot this (Y/N)?

[NO]

F1 (Help) 71440 Mem

SCREEN 32.



SCREEN 33.

Press any key, then press <Escape> three times to return to the Analysis Main Menu (Screen 4).

MODIFY HARDCOPY OPTIONS

Select this option in the Sequence Analysis main menu in Screen 4 to change the way in which hardcopies of graphs are produced on your printer or plotter. The screen that appears (Screen 34, on following page) lists the current graphics hardcopy options. These

```
DSSAT Version 3.0 Crop Sequencing Analysis

 Main Menu
  Hardcopy
   Printer driver      : HP LaserJet/DeskJet B&W 150 dpi
   Printer port        : LPT1:
   Orientation         : Portrait
   X Multiplier        :  1.00
   Y Multiplier        :  1.00
   File name           : C:\DSSAT3\SEQUENCE\VARAN200.GRA

   Save changes and exit
   Abandon changes and exit

F1 (Help)                                          71440 Mem
```

SCREEN 34.

are stored in an ASCII file called GRAPH.INI (see Table 6). The various controller options can be changed from this screen, simply by selecting the option to change and choosing any of the valid options (thus your printer port might be LPT2 rather than LPT1). On finishing, you can abandon the changes you have made, or you can save the changes to the file GRAPH.INI.

Normally, configuration of the graphics program will be carried out through the configuration menu in the sequence and seasonal analysis programs. You may wish to edit GRAPH.INI with a text editor, however. The section of GRAPH.INI that holds configuration data for the graphics program is under the [WMGraf] section of the INI file. Defaults for plotting are defined in this section, in the format "keyword=" followed by a string, integer, or real variable. Specifically, the keyword definitions and possible values are as follows:

gcolor[0..7]:	refers to the default color palette for plotting. Values are 0 to 15.
interval:	number of major divisions on the X and Y axis ("-9" chooses Autoscaling)
tics:	number of tic marks between the major divisions ("-9" chooses Autoscaling)
driver:	an integer value of 0 to 33 is specified. The printer/plotter options are listed in Table 7.

port:	0 for LPT1:, 1 for LPT2:, 2 for COM1:, 3 for COM2:, or 4 for redirection of output to a file
orientation:	0 for portrait or 1 for landscape
fontsize:	fontsize for labels (1 to 20)
xmult:	X multiplier
ymult:	Y multiplier
file:	name for file output if port=4

The printer types supported by the graphics program are shown in Table 7.

You may also need to be aware that legends for the graphics program are taken from a DSSAT3 file called DATA.CDE (see Table 8 and Appendix C to Volume 2-1, Jones et al. 1994, of this book). This lists, among other things, the headers, abbreviations, and definitions of the 35 output variables in the summary model output file that can be analyzed using the seasonal analysis program, in the section headed by the *SUMMARY keyword.

TABLE 6. SAMPLE SECTION OF GRAPH.INI.

```
[WMgraf]
color0=1
color1=15
color2=14
color3=12
color4=15
color5=10
color6=11
color7=13
interval=-9
tics=-9
driver=7
port=0
orientation=0
fontsize=6
xmult=1.00
ymult=1.00
usetics=Y
usekeyword=1
file=OUTPUT
```

TABLE 7. PRINTER TYPES SUPPORTED BY THE GRAPHICS PROGRAM.

Driver Number	Driver Description
0	Epson 9 Pin 60 x 72 dpi
1	Epson 9 Pin 120 x 72 dpi
2	Epson 9 Pin 240 x 216 dpi
3	Epson 24 Pin 180 x 180 dpi
4	Epson 24 Pin 360 x 180 dpi
5	Epson 24 Pin 360 x 360 dpi
6	HP LaserJet/DeskJet B&W 100 dpi
7	HP LaserJet/DeskJet B&W 150 dpi
8	HP LaserJet/DeskJet B&W 300 dpi
9	HP DeskJet 500C 100 dpi 8 color
10	HP DeskJet 500C 150 dpi 8 color
11	HP DeskJet 500C 300 dpi 8 color
12	HP PaintJet 90 dpi B&W
13	HP PaintJet 180 dpi B&W
14	HP PaintJet 90 dpi 16 color
15	HP PaintJet 180 dpi 8 color
16	HP PaintJet 180 dpi 16 color (XL)
17	HP ThinkJet 192 dpi
18	HP 7475A Plotter A size paper
19	HP 7475A Plotter B size paper
20	HP 7475A Plotter A4 size paper
21	HP 7475A Plotter A3 size paper
22	HP 7550 Plotter A size paper
23	HP 7550 Plotter B size paper
24	HP 7550 Plotter A4 size paper
25	HP 7550 Plotter A3 size paper
26	HP 7440 Plotter A4 size paper
27	HP 7470 Plotter A3 size paper
28	HP LaserJet HPGL Mode A size paper
29	HP LaserJet HPGL Mode B size paper
30	PostScript Printer Courier
31	PostScript Printer Helvetica
32	PostScript Printer Times
33	PostScript Printer Symbol

TABLE 8. EXPERIMENT DATA CODES FILE DATA.CDE – SUMMARY SECTION ONLY.

```
*EXPERIMENTAL DATA CODES

*SUMMARY
SDAT START SIM day    Simulation start date (YRDOY)
PDAT PLANTING day     Planting date (YRDOY)
ADAT ANTHESIS day     Anthesis date (YRDOY)
MDAT MATURITY day     Physiol maturity date (YRDOY)
HDAT HARVEST day      Harvest date (YRDOY)
DWAP SOWING WT kg/ha  Planting material wt (kg dm/ha)
CWAM TOPS WT. kg/ha   Tops wt at maturity (kg dm/ha)
HWAM MAT YIELD kg/ha  Yield at maturity (kg dm/ha)
HWAH HAR YIELD kg/ha  Yield at harvest (kg dm/ha)
BWAH BYPRODUCT kg/ha  By-product harvest (kg dm/ha)
HWUM WEIGHT mg/unit   Wt at maturity (mg dm/unit)
H#AM NUMBER #/m2      Number at maturity (no/m2)
H#UM NUMBER #/unit    Number at maturity (no/unit)
IR#M IRRIG APPS #     Irrigation applications (no)
IRCM IRRIG mm         Season irrigation (mm)
PRCM PRECIP mm        Season precipitation (mm)
ETCM ET TOTAL mm      Season evapotranspiration (mm)
ROCM RUNOFF mm        Season surface runoff (mm)
DRCM DRAINAGE mm      Season water drainage (mm)
SWXM EXTR WATER cm    Extr water at maturity (cm)
NI#M NITR APPL #      Number of N applications (no)
NICM TOT N APP kg/ha  Total inorganic N appl (kg/ha)
NFXM N FIX kg/ha      N fixed during season (kg/ha)
NUCM N UPTAKE kg/ha   N uptake during season (kg/ha)
NLCM N LEACH kg/ha    N leached during season (kg/ha)
NIAM SOIL IN N kg/ha  Soil inor-N at maturity (kg/ha)
CNAM CROP N kg/ha     Tops N at maturity (kg/ha)
GNAM PRODUCT N kg/ha  Product N at maturity (kg/ha)
RECM RESIDUE kg/ha    Total residue applied (kg/ha)
ONAM ORGANIC N kg/ha  Org soil N at maturity (kg/ha)
OCAM ORGANIC C t/ha   Org soil C at maturity (t/ha)
PO#M P APPL #         Number of P applications (no)
POCM TOT P APP kg/ha  Total P applied (kg/ha)
CPAM CROP P kg/ha     Tops P at maturity (kg/ha)
SPAM SOIL P kg/ha     Soil P at maturity (kg/ha)
```

Selecting Another Input File for Analysis

Having analyzed one simulation summary file, you can choose to analyze another file in Screen 5. If you choose to do so, you have the option to print the summary results file that you have generated during the session for the particular summary output file. Note that a new analysis results (SQR) file will be produced for each summary output file (SQS) you analyze. A sample of part of this file is reproduced in Table 9. This file can be edited as required, and the data imported into any application capable of reading ASCII text files for whatever purpose you require.

Information and Error Messages

A number of information and error messages are produced by the sequence analysis program. In the list that follows, each message is preceded by a single-digit code and a three digit message/error number. If the single-digit code is "0," then this is a fatal error, and the program exits. If the code is "1," then the program will continue, as the error may not be fatal. Information messages have code "1" also. Some of these messages are self-explanatory. Others are indications of serious problems, and you should check your file formats.

0 001 Cannot find directory file :
The summary output listing file could not be found in the current directory.

0 002 No entries found in file :
The summary output listing file could be found, but no valid entries were found in it.

1 003 Cannot find file :
The specified file cannot be found in the appropriate directory.

0 004 Error reading :
An error occurred during file reading; this is usually due to incorrect format of the specified file.

0 007 Cannot access file :
The specified file cannot be found in the appropriate directory.

1 008 Read error in subroutine GETCOD, file :
An error occurred in reading the specified file.

0 009 Code could not be found :
The program attempted to find the specified code in the DSSATPRO.FLE, but could not find it. The pathname associated with the code specifies the location of the graphics program for the sequence analysis graphics

TABLE 9. PART OF SEQUENCE ANALYSIS RESULTS FILE EPAF1101.SQR.

*SQ_ANALYSIS_LOG : EBAF1101SQ

Date: 21 Apr, 1994 Time: 10:45:13

Input file : C:\DSSAT3\SEQUENCE\EBAF1101.SQS ————————

Analysis of Treatment Number 1

Input File Analysis

Experiment Code : EBAF 11 01
Number of runs : 900
Number of reps : 15
Starting year : 1911
Ending year : 1941
Runs per rep : 60
Runs per rotation: 2

Calculated Values: Variable = HAR YIELD kg/ha MZ1

Year	Mean	St.Dev
1911.0	2223.87	405.99
1912.0	1087.53	394.24
1913.0	1401.67	559.15
1914.0	1242.33	674.78
1915.0	1206.80	587.82
1916.0	1323.13	614.01
1917.0	971.60	621.63
1918.0	913.87	500.09
1919.0	1107.20	631.99
1920.0	1291.93	539.44
1921.0	595.13	360.27
1922.0	971.87	588.37
1923.0	916.47	566.53
1924.0	853.87	444.65
1925.0	935.80	363.33
1926.0	693.20	475.74
1927.0	1129.73	510.32
1928.0	304.27	338.10
1929.0	740.53	500.52
1930.0	650.47	402.82
1931.0	694.87	376.09
1932.0	911.07	485.26

1933.0	478.20	360.78
1934.0	703.80	540.22
1935.0	571.47	376.15
1936.0	657.40	406.53
1937.0	508.33	476.07
1938.0	599.80	384.26
1939.0	384.80	278.99
1940.0	618.87	356.37

	Percentiles						
Year	0th	10th	25th	50th	75th	90th	100th
1911.0	1708.0	1786.2	1903.0	2309.0	2403.0	2761.2	3041.0
1912.0	517.0	647.2	781.0	1167.0	1298.0	1446.8	1992.0
1913.0	480.0	606.2	999.0	1748.0	1869.5	1969.6	1987.0
1914.0	183.0	442.0	791.0	1142.0	1688.5	2082.2	2530.0
1915.0	132.0	418.0	794.0	1294.0	1594.0	1923.2	1970.0
1916.0	164.0	521.6	897.5	1346.0	1812.5	2026.6	2102.0
1917.0	80.0	239.8	531.5	829.0	1563.5	1812.6	1955.0
1918.0	114.0	432.6	573.5	882.0	1249.0	1296.2	2111.0
1919.0	400.0	499.0	590.0	911.0	1411.5	1969.2	2467.0
1920.0	129.0	719.0	965.0	1325.0	1640.5	1763.4	2363.0
1921.0	109.0	131.0	287.0	669.0	842.0	978.6	1261.0
1922.0	68.0	251.2	592.5	1098.0	1290.0	1418.8	2370.0
1923.0	84.0	133.4	588.0	930.0	1226.0	157[illegible].6	2026.0
1924.0	83.0	247.8	579.0	912.0	1232.5	1393.6	1404.0
1925.0	129.0	545.0	736.5	1018.0	1130.0	1324.6	1541.0
1926.0	88.0	131.6	424.0	660.0	831.0	1368.6	1697.0
1927.0	115.0	581.0	456.5	1264.0	1509.5	1714.2	1917.0
1928.0	67.0	82.6	90.5	117.0	430.0	783.8	1123.0
1929.0	68.0	96.0	331.5	740.0	1012.5	1445.2	1552.0
1930.0	94.0	219.6	496.0	558.0	780.5	1068.6	1704.0
1931.0	90.0	217.6	417.0	677.0	934.5	1215.2	1280.0
1932.0	88.0	296.2	605.0	1019.0	1205.0	1476.4	1705.0
1933.0	36.0	74.2	101.5	527.0	712.0	939.8	1051.0
1934.0	43.0	96.4	396.0	701.0	911.5	1220.4	2116.0
1935.0	25.0	89.4	257.0	640.0	748.0	966.6	1338.0
1936.0	129.0	201.6	421.5	610.0	749.5	1106.0	1693.0
1937.0	54.0	74.2	100.5	390.0	749.5	1189.6	1488.0
1938.0	47.0	143.0	415.5	574.0	722.0	1102.8	1447.0
1939.0	46.0	67.4	89.0	449.0	601.0	694.4	827.0
1940.0	80.0	117.2	466.0	593.0	811.0	1126.2	1216.0

Regression of Means Output

Type = Exponential

constant = 78.2470 gradient = -.0372 r-squared =.6053
s yx = 236.041200 SE of gradient = 4.978952
T-test of gradient: t = .0075 prob of greater value = .994

Year	HAR YIELD kg/ha	Residual	Estimate
1911.	2223.8670	821.9390	1401.9280
1912.	1087.5330	-263.2627	1350.7960
1913.	1401.6670	100.1375	1301.5290
1914.	1242.3330	-11.7258	1254.0590
1915.	1206.8000	-1.5211	1208.3210
1916.	1323.1330	158.8826	1164.2510
1917.	971.6000	-150.1877	1121.7880
1918.	913.8666	-167.0073	1080.8740
1919.	1107.2000	65.7482	1041.4520
1920.	1291.9330	288.4659	1003.4670
1921.	595.1334	-371.7352	966.8685
1922.	971.8666	40.2621	931.6045
1923.	916.4667	18.8397	897.6270
1924.	853.8666	-11.0217	864.8884
1925.	935.8000	102.4562	833.3438
1926.	693.2000	-109.7501	802.9501
1927.	1129.7330	356.0688	773.6645
1928.	304.2667	-441.1804	745.4470
1929.	740.5333	22.2745	718.2588
1930.	650.4667	-41.5955	692.0621
1931.	694.8666	28.0454	666.8212
1932.	911.0667	268.5660	642.5006
1933.	478.2000	-140.8671	619.0671
1934.	703.8000	107.3115	596.4885
1935.	571.4667	-3.2664	574.7330
1936.	657.4000	103.6289	553.7711
1937.	508.33[illegible]3	-25.2404	533.5737
1938.	599.8000	85.6870	514.1130
1939.	384.8000	-110.5623	495.3623
1940.	618.8666	141.5714	477.2952

1 016 Bad crop code (record #, file):
Crop code found in the specified file that is not valid.

1 017 More than 9 crop codes found in file
The summary output file contained more than 9 crop codes, its current limit.

1 018 Sequence length exceeds 50 years
The summary output file is too long to analyze.

0 019 Multiple Treatments Found in File :
Two or more sequence treatments were found in the summary output file. You must choose which one to analyze.

1 020 A problem was encountered executing another program
The program was not able to execute another program; check the free RAM that you have on your computer, and increase it if possible by unloading unnecessary resident programs (e.g., a network).

1 023 Error in TUKEY.FOR
An error occurred when calculating percentiles of a distribution.

1 024 READ Error in file :
A read error occurred in the specified file; check the format of the file.

1 026 READ Error in DATA.CDE
An error occurred when reading the file DATA.CDE; check that it is complete and the format is correct.

1 028 Total number of runs exceeds 1000
See message 031.

1 029 Total number of years exceeds 50
See message 031.

1 030 Number of replicates exceeds 20
See message 031.

1 031 File is too big to analyze:
This error message arises in conjunction with one of three other messages, and refers to the fact that the selected summary output file is too large with respect to total number of runs (error message 028), number of years (error message 029), or number of replicates (error message 030).

1 032 Analysis results written to the file :
Analysis results have been written to the specified file.
Program output has been written to the specified file.

0 038 Error in filename :
Error in filename specification.

1 039 Crop code not matched in price file :
There was no section in the price file corresponding to the specified crop code; you must edit the file so that this section exists.

1 040 Read error in price file :
Check the format of the price file; a read error occurred.

0 041 Cannot find file :
Specified file cannot be found.

0 042 Error in :

0 043 Read error in file :
Read error in the specified file.

0 044 Must have at least 2 replicates for a CPF plot!

0 046 ERIC2 size problem
Array overflow error.

1 047 A price file must be accessed using opt. 1 before using this option
You must access a price file before attempting to carry out the economic calculations.

1 049 All variances are zero; <Enter> to continue

1 050 Cannot find a file .. choose again :

1 051 You must first select a model output file!
Select one of the analysis options before continuing.

1 052 More than 10 treatments found; rest ignored
The simulation summary output file contains more than 10 treatments; you may choose one of the first 10 only.

1 053 You must choose a treatment .. or loop forever!!

1 055 Problem in finding the appropriate help screen
The appropriate help screen could not be found.

1 058 There were no matching files found!

1 060 The requested subdirectory to be searched doesn't exist!!!

1 070 No valid data;
For the crop code(s) and output variable selected, there are no valid data.

1 071 Error in regression routine (divide by zero or inputs out of range)
Problem in regression calculations; check the summary output file.

1 072 Reported regression outputs will not be meaningful;
Problem in regression.

1 073 Do a regression before plotting!
You must do a regression before you can plot the results.

1 074 All residuals are zero

0 075 File DATA.CDE not found

0 076 Error in JNO
Problem in counter in summary output file; check its format.

1 077 You must choose at least ONE crop code from this list;

1 078 Multiple crop codes chosen .. Choose method of analysis

1 079 No data found as specified
No data could be found for the variable and crop code(s) chosen.

1 080 All data found are zero
No non-zero data could be found for the variable and crop code(s) chosen.

1 081 Problem in ECONO2
Problem in price-cost calculations.

1 082 You may select up to FOUR crop codes with this option

1 082 This is not implemented yet!

1 083 Box plot of total returns NOT available for only one crop!

1 100 Warning!
General warning message.

1 131 You MUST turn on the printer now or the program will crash!

1 148 A problem was encountered in trying to print a file!
The results file could not be printed successfully.

REFERENCES

The Sequence Analysis program is outlined in the following:

Thornton, P.K., G. Hoogenboom, P.W. Wilkens P W and W.T. Bowen. 1994. A computer program to analyze multi-season crop model outputs. Agronomy Journal (*in press*).

A good source of general information on regression is:

Snedecor, G.W. and W.G. Cochran. 1980. Statistical Methods. Iowa State University Press, Ames, IA.

Other References:

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APPENDIX.
THE STABILITY OF OUTPUT VARIABLES FROM REPLICATED SEQUENCE EXPERIMENTS

The main conclusion of this appendix can be stated simply: to obtain relatively stable estimates of output means and variances from replicated sequence experiments, you should use as many replications as possible. In practice, you should always use at least 10, and preferably nearer to 20 (the limit of the program).

Sequence outputs may be very unstable with fewer than 10 replicates. The major implication of this is that it will be possible for users to draw erroneous conclusions from insufficiently replicated sequence experiments. It is easy to show this with a computer program that "simulates" a crop model by drawing a random sample from a normal distribution (with mean 6 and standard deviation 1.5) to represent yield, does this for 12 "years" in sequence, and replicates this sequence as often as required, from 1 to 100. The null hypothesis of NO TREND OVER THE SEQUENCE is thus true.

Results are shown in Figure 3. In the first graph, with a sample size of 100 (100 replicates), there is no apparent trend (nor should there be, as there is none), and the maxima and minima of each distribution from one season to the next do not vary greatly. The other graphs show what happens to random samples with fewer and fewer replicates (20, 10, and 5, respectively). It can be seen that the plots become progressively more erratic; note the increasingly variable maxima and minima, and the highly variable spread of the median. With only 5 replicates we apparently have an upward trend of the median.

The sequence analysis program was written with two main hypotheses in mind:

1. Cropping systems that have some sort of problem will eventually exhibit decreasing performance levels over time, be it in terms of yields or economic returns;
2. Some cropping systems will have problems over long periods of time that are exhibited in terms of increases in variability over the sequence.

The analyses included in the program are designed to allow the user to identify these types of problems. There may be situations where a simple graph of yields over time is sufficient to say with certainty, this is not a viable sequence. Other situations may not be so cut and dried.

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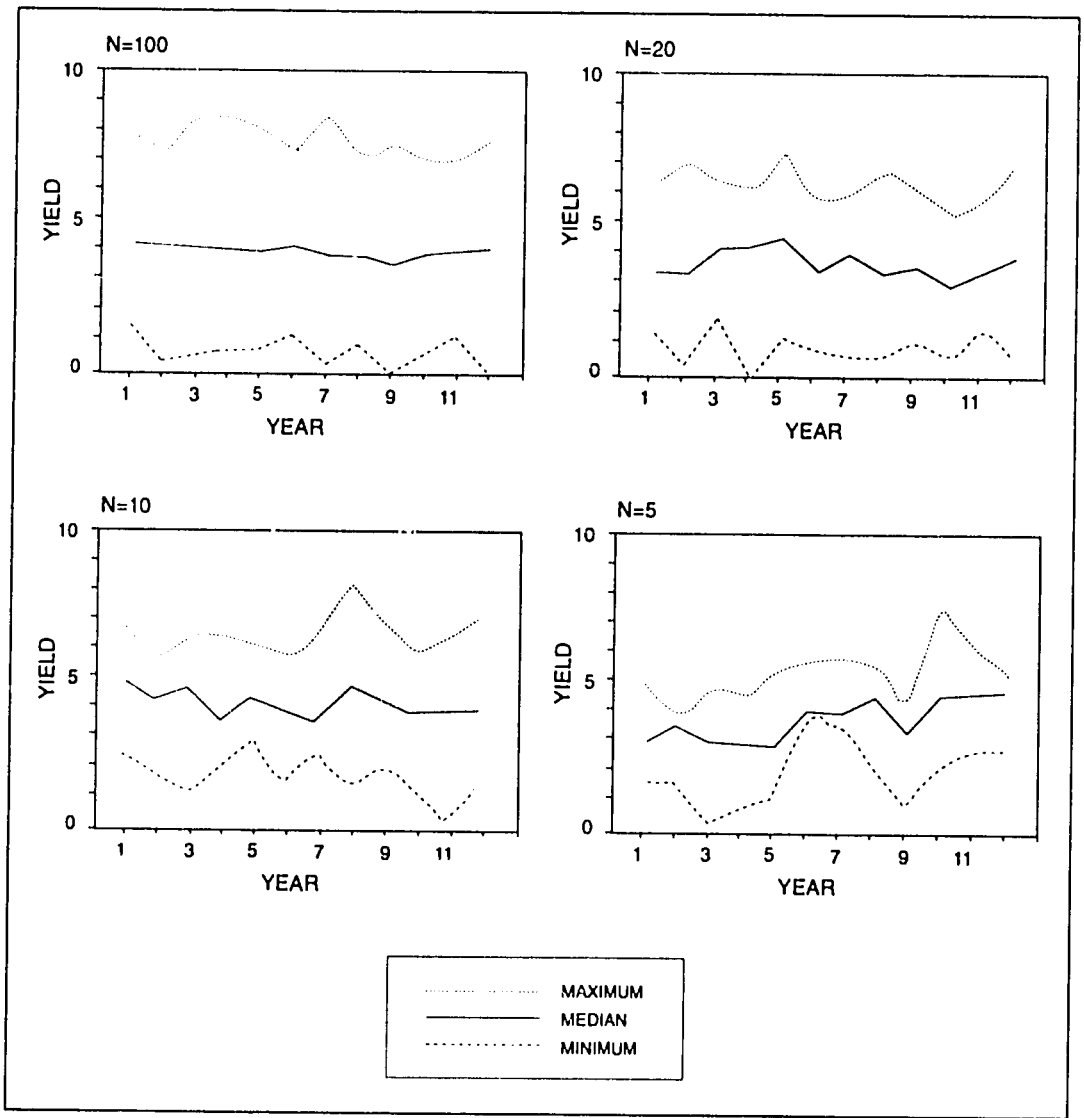

FIGURE 3. "SIMULATED" SEQUENCE OUTPUTS FOR N = 100, 20, 10 AND 5, RESPECTIVELY.

As noted in the introduction to this document, the sequencing capabilities of the DSSAT v3 crop models have not been extensively tested, and this is another reason for exhibiting caution with regard to the conclusions you draw from any simulated sequence experiment.

VOLUME 3-3

WEATHERMAN

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CHAPTER ONE. INTRODUCTION

Daily weather data are commonly used as input to mathematical models used in water related projects and agriculture. While the models expect the data to be complete and reliable, raw data from a weather station, or even a reliable secondary supplier of weather data, are often flawed. Common data problems include format errors, missing data, unreasonable values, data recorded in different units than needed, and data in an inconvenient format. Often there are no data available for a specific site, or a particular variable is not in the available weather record.

IBSNAT has focused on the development of crop models and software tools such as the DSSAT to aid research and development in agriculture. Available and reliable weather data are essential for good predictions using these crop models. The IBSNAT project has specified a minimum daily weather data set and format for use with the crop models. In DSSAT v2.1, (IBSNAT 1986), the required daily variables were solar radiation ($MJ/m^2/d$), maximum temperature (^oC) minimum temperature (^oC), and rainfall (mm). An extended DSSAT v2.1 data set included photosynthetically active radiation (PAR, $mol/m^2/d$). DSSAT v3 uses the same minimum weather data set and allows optional variables, such as PAR, dew point (^oC) and wind speed (m/s). (For a description of DSSAT v3 file formats, see Volume 2-1, Jones et al. 1994, of this book)

PROGRAM DESCRIPTION

The WeatherMan program is designed to simplify or automate many of the tasks associated with handling, analyzing, and preparing weather data for use with crop models or other simulation software. WeatherMan can be used either as a stand-alone package or called from within the DSSAT v3 Shell (for a description of the Shell, see Volume 1-3, Hunt et al. 1994, of this book). WeatherMan has the ability to translate both the format and units of daily weather data files, check for errors on import, and fill-in missing or suspicious values on export. WeatherMan can also generate complete sets of weather data comprising solar radiation, maximum and minimum temperature, rainfall, and photosynthetically active radiation. Summary statistics can be computed and reported in tables. The summary statistics or daily data can be viewed graphically.

WeatherMan is written in Borland Pascal v.7 (Borland, 1993). The user interface in WeatherMan was developed using the object-oriented Turbo Vision libraries provided

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with Borland Pascal and includes standard pull-down menus; dialog boxes with push buttons, input lines, check boxes, radio buttons and scrolling dynamic lists; and context-sensitive, cross-referencing online help. The user interface functions with both keyboard and mouse.

Overview of Functions

The WeatherMan's main menu items are: FILE, STATION, IMPORT/ EXPORT, GENERATE, ANALYZE, OUTPUT, AND QUIT. The FILE menu accesses a user-selectable text editor for data entry and correction, accesses the operating system (DOS), and allows the current weather data directory to be changed. A new weather station is selected from the STATION menu. The IMPORT/EXPORT menu handles the conversion of file formats and units when importing and exporting weather into or from an archive data file. Importing data refers to reading a new weather data file and storing the data in an internal, archive data file. Exporting data refers to creating a new weather data file and writing data from the archive weather data file to a new data file in a prescribed format. WeatherMan checks for and flags format or range errors on import. On export, data flagged as missing or suspect can be replaced with estimates using several methods. The GENERATE menu permits generation of synthetic sequences of solar radiation, maximum and minimum temperature, rainfall, and photosynthetically active radiation for any duration. The ANALYZE menu includes the computation of summary statistics and the ability to display the results using tables or graphs. The OPTIONS menu allows the user to customize and save the current configuration. The user can terminate a WeatherMan session using QUIT from the main menu or selecting the option, "Exit," under the FILE menu.

System Requirements

WeatherMan is designed to run on an IBM compatible PC with DOS v3.1 or later and with at least 280 kB of available conventional RAM to work with 5 weather variables. Each additional variable requires about 12 kB of additional RAM. WeatherMan will store its overlay in expanded memory if it is available. It will be slower without expanded memory and require more conventional memory. We recommend at least 300 kB of available expanded memory when running WeatherMan. While a math co-processor is not required, it is recommended. A hard disk is recommended. Archive weather data occupies about 14 kB of disk space per year for five variables. Standard video drivers are detected automatically. Graphs can be output to several printers, plotters, and file formats.

CHAPTER TWO. GETTING STARTED

STARTING WEATHERMAN

WeatherMan can be run either from the DSSAT v3 Shell or as a stand-alone program. From the DSSAT v3 Shell, call the WeatherMan by using the cursor keys to select the DATA main menu item and then the submenu items, "Weather" and then "Utilities." Alternatively, WeatherMan can be called by typing WM from the DSSAT3 directory, or from any directory if \DSSAT3 is identified in the DOS PATH variable.

The opening screen of the WeatherMan has a main menu on the top line, a blank desktop in the center, and a status line on the bottom. An example of the startup screen appearance is given in Screen 1 (below).

WEATHERMAN USER INTERFACE

The WeatherMan interface is written in Borland Pascal's Turbo Vision and generally follows the Microsoft Windows protocols. A mouse or a few standard keystrokes are used to access WeatherMan's features (Table 1).

```
File  Station  Import/Export  Generate  Analyze  Options  Quit        12:35:59

F1 Help  F10 Menu  Stn: CCQU
```

SCREEN 1.

TABLE 1. USER INTERFACE ITEMS AND THEIR FUNCTIONS IN WEATHERMAN.

Item	*Function*
Main menu	Accessed with the <ALT>-hotkey sequence, e.g., <ALT>-<F>, accesses the FILE main menu item. Or press the <F10> key to select the menu and use the cursor keys.
Menu item	Press the hotkey letter or highlight the item using cursor keys, and use the <ENTER> key or left mouse button. Menu items (or sub-menus) do not require the <ALT> sequence.
Dialog box	A window that prompts for some user response. A dialog box may contain push buttons, input lines, input lists, radio buttons, or check boxes. In general, these items may be selected with a mouse, <TAB>, <SHIFT>-<TAB), or an <ALT>-hotkey combination.
Push button	A rectangular button that is activated by a mouse double-click or pressing the <ENTER> key. Most dialog boxes contain at-least OK and CANCEL buttons.
Input line	A highlighted bar that accepts string or numeric data. The cursor, <INSERT>, and <DELETE> keys are active in an input line.
Input list	An input line followed by a down arrow icon opens a dialog box with a list of permissible entries. Activate by selecting the icon with a mouse or selecting the input line, and pressing the down cursor key.
Radio button	Radio buttons, (●), allow you to select one item from a set of options. Select with a mouse, up and down cursor keys and the <SPACE> bar, or an <ALT>-hotkey combination.
Check box	Check boxes, i.e., [X], allow you to select any combination from a set of options. Select the same way as radio buttons.
<F1>	Context sensitive help.
CANCEL button	Ignores choice and returns to previous menu.
OK button	Accepts choice and exits the current dialog box or continues the process.
<ESC>	Equivalent to CANCEL.

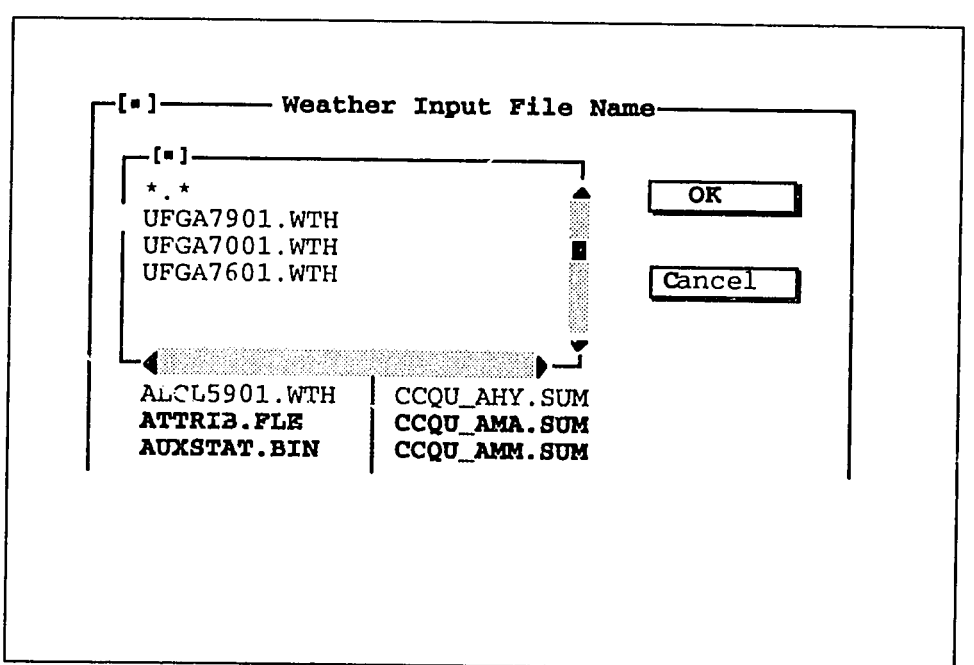
<ENTER>	Accepts highlighted choice and performs function. For most dialog boxes the default option is OK. For data entry dialog boxes, pressing the <ENTER> key is equivalent to pressing the <TAB> key.
L mouse button	Left button on the computer mouse. A single click highlights an item. Double click is equivalent to pressing the <ENTER> key.
R mouse button	Right button on the computer mouse. Equivalent to CANCEL.
<TAB>	Move to the next data entry cell.
<SHIFT>-<TAB>	Move to the previous data entry cell.
<HOME>	Move to first data entry cell.
<END>	Move to the last data entry cell.
Down arrow	Same as using <TAB> key in data entry dialog boxes. When an input line shows a down arrow icon, activates history or list dialog box with choices listed for selection. The history dialog box displays previous selections.
Up arrow	Same as using the <SHIFT>-<TAB> keys in data entry dialog boxes.
<CTRL>-right arrow	Move to next data column.
<CTRL>-left arrow	Move to previous data column.
[■]	Click on [■] icon to close dialog box or window. An alternative to using the <ESC> key or CANCEL button.
<ALT>-<X>	Exit /Quit.
<ALT>-<Q>	Exit /Quit.

Where the dialog box displays a Down Arrow (↓) symbol, it is important to distinguish between the <TAB> and Down Arrow keys. The <TAB> and <SHIFT>-<TAB> keys are used for moving around the dialog box without the mouse, while the Down Arrow key activates a history list of previous choices or a list of available choices. An example of a history list is given in Screen 2 (below) for the choice of a weather input file name.

The previously selected file names are shown in the history list as UFGA7601.WTH, UFGA7801.WTH and UFGA7901.WTH. A file is selected by pressing the <ENTER> key with the name highlighted. Use of history lists helps speed up the selection process and avoid typing errors.

Common Dialog Boxes

A list dialog box is presented when you wish to select a weather station, select a file for import or export, select a file format, or select a file to edit or invert. An example of this type of dialog box, for selecting a weather station, is given in Screen 3 (on following page). The file mask on the first line may be restricted for particular operations. In selecting a weather station, a 4-letter name is expected and a .CLI extension is automatically appended. Selecting a file for import or export allows any legal DOS file name and extension.



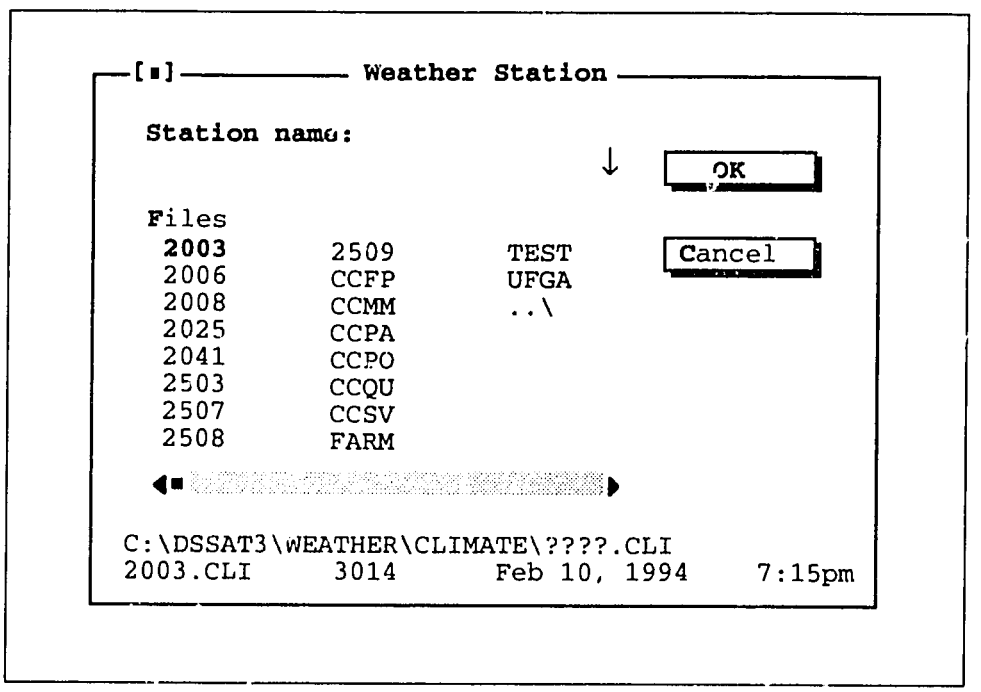
Screen 2.

For a format file, any legal DOS name is accepted and the default extension of .FMT is appended. The "Format Name" dialog box has an additional Edit button that is explained in that section in Chapter 4. Files from other directories can also be listed by selecting a directory. An example of the "Weather Station" dialog box is given in Screen 3 (below).

Three kinds of archive files for a single station can exist: Raw (or observed), Filled, and Generated. The raw archive file is generally retained, while filled and generated archive files may be automatically deleted upon exiting the WeatherMan, depending on the options selected under the OPTIONS main menu item for "Temporary files" (see also the section entitled "Generate Menu" in Chapter 4). The archive file(s) are stored in the climate directory specified in DSSATPRO.FLE or in OPTION\"Directories" (see Chapter 4).

When an operation (e.g., "Export," "Statistics") can be performed on more than one type of data, an additional dialog box is used to clarify which archive file to use. An example of the "Archive File Type" dialog box is given in Screen 4 (on following page).

For several operations, a time period can be selected. The general form of the "Time Period" dialog box (see Screen 5, on following page) has both starting and ending dates



SCREEN 3.

```
Archive File Type

Archive types found:
 (•) Observed data
 ( ) Generated data
 ( ) Filled data

        [ OK ]
```

SCREEN 4.

where the dates are in year and day-of-year format. In some cases the date may be year and month (see the "Graphics Menu" section in Chapter 4) or just the year (see the "Generate Menu" section in Chapter 4). The time period section may also be part of another larger dialog box. An example of the "Time Period" dialog box with year and day-of-year format is given in Screen 5 (below).

```
Time Period

                    Year    Day of year
Starting date:      1980        1
Ending date:        1987      365

        [ OK ]
```

SCREEN 5.

Steps for Cleaning and Converting Weather Data

One of the main uses of WeatherMan is to develop complete daily weather data sets from raw data with missing data and incorrect values. Several steps are required to complete this process and obtain weather data files that are complete and in the desired format. The minimum requirements for cleaning and reformatting data are given in Table 2.

TABLE 2. LIST OF ESSENTIAL STEPS FOR CREATING A COMPLETE DAILY WEATHER DATA FILE WITH THE CORRECT FORMAT AND UNITS FROM RAW DATA IN WEATHERMAN.

1. Define weather station name and enter site characteristics.
   a. Select the menu item Station|Select Station and enter a 4-character code for the new station.
   b. Enter the requested descriptive information for the new station in the form presented on the screen.

2. Import one or more raw data files.
   a. Select the menu item Import/Export and Import Single File items.
   b. Create a format definition for the data file that is being imported when prompted for selecting a file format. Select NEW format and EDIT buttons to create the format. Enter the requested information about the format (number of header lines, dates, variable and units and columns for variables). Then select the SAVE button and give the defined format a new 4-character name. Usually one would name the format so that it describes the source of raw data.
   c. After saving the format, select OK on the screen and data from the raw data file will be read into an internal file named Station_GEN.WTD, where Station_GEN is the name of the weather station.

3. Compute weather generator parameters for the site.
   a. Select Generate button, followed by Calculate Parameters.
   b. Select the button for Both Sets of Parameters. This will calculate the necessary parameters for the weather generators so that missing data can be filled in the exported data file.

4. Export the weather data.
   a. Select the Import/Export and Export Yearly Files buttons. Select the OBSERVED DATA button.
   b. When prompted, enter starting and ending dates for the data to be exported.
   c. For exporting daily weather data to be used in DSSAT v3, select the IBSNAT3 format file. Exported files will normally be located in the directory C:\DSSAT3\WEATHER and will be named according to the file naming conventions of DSSAT v3 (e.g., ????yy01.WTH, where ???? is the weather station code and yy is the year).

CHAPTER THREE. INTRODUCTORY TUTORIAL

In this introductory tutorial, you are going to define a new weather station, import weather data and export data to a file of different format. You are also going to generate data, analyze both data sets and compare them using both tables and graphs.

In this tutorial, the nomenclature IMPORT/EXPORT|"Import single file" means go to the IMPORT/EXPORT menu item of the DSSAT v3 Shell, and then select the "Import single file" menu item from this menu. Selection is performed by highlighting the item and pressing the <ENTER> key, or double-clicking on the item with the left mouse button, or using the keyboard shortcut keys (i.e., <ALT>-<I> then <S>). Any of the three methods will work. Additional information is given in the section "WeatherMan User Interface" in Chapter 2.

BROWSE THE MENU AND ONLINE HELP

Pressing the <F1> key provides context-sensitive, cross-referenced help. Look there first if questions arise while doing the exercise. Abbreviated help is displayed on the status line at the bottom of the screen. Pressing the <ESC> key or selecting the CANCEL button will allow you to back out of most processes. Go to the FILE main menu item and select "About" (i.e., FILE|"About"). Press the <F1> key to read an introductory screen describing WeatherMan. Highlight "User interface" and double-click or press the <ENTER> key to read about use of the keyboard and mouse. Help for cross-referenced topics can generally be accessed in the same way.

SELECT A NEW STATION

Go to the STATION main menu item and open "Select station" (i.e., STATION|"Select station"). Enter "CCQU" for the station name. The "CC" is the ID for the institute, CIAT (Centro Internacional de Agricultura Tropical, Cali, Colombia), and the "QU" is the ID for the station location, Quilichao. When you select a new (i.e., nonexistent) station, a dialog box, similar to Screen 6 appears, but with default values in each field. The user should enter the values shown in Screen 6 for this example.

NOTE: *When the information for a weather station has already been entered, the Screen 6 dialog box would not appear the next time that station is selected. "CCQU" must not be on the distribution disks.*

```
[•]──────────── Station Data ────────────

Location:      Quilichao,NorthCauca,Colombia

Latitude (degrees):                          3.080
Longitute (degrees):                       -76.520
Elevation (m):                               990.0
Angstrom coefficient A:                       0.25
Angstrom coefficient B:                       0.50
Reference height (m):                         2.00
Wind reference height (m):                    4.00
Mean annual temperature (°C):                 24.0
Temperature amplitude (°C):                    0.5
Start of growing season (day):                   1
Duration of growing season (days):             365

      [ OK ]                          [ Cancel ]
```

SCREEN 6.

IMPORT DAILY WEATHER FILES

Select STATION | "Edit monthly means." The "-99" indicates a missing value. Select the CANCEL button or press the <ESC> key to return to the main menu.

Go to IMPORT/EXPORT | "Import single file." Import the file, CCQU1980.DAT by selecting it from the list. Since the format of CCQU1980.DAT does not match any of the format files distributed with WeatherMan, you will need to create a new format definition file. You will be asked for a format. Type or highlight NEW and select the EDIT button. Screen 7 (on following page), the "Edit File Format" dialog box, will be presented. Select the VIEW FILE button in Screen 7 to view the imported file. The "File Viewer" dialog box will be presented with the file CCQU1980.DAT in the viewer. Note the number of header lines in the file presented, and the starting position and width (in characters) of the data field for each variable. You can select variable names and units from lists by selecting the down arrow icon or by highlighting an input line and pressing the down cursor key. When you have entered the format information in the Viewer, the "Edit File Format" dialog box should look like Screen 7.

Select the SAVE FORMAT button and save the format as "CCQU." Then proceed with importing by selecting the OK button. If you have enabled the "Preview Formats" option

```
File  Station  Import/Export  Generate  Analyze  Options  Quit        14:39:35
[•]──────────────────────── Edit File Format ──────────────────────────────
 Header output option:                  Format name:   CCQU
  ( ) None
  ( ) IBSNAT v.3                        Date:     First      Position  Length
  ( ) IBSNAT v.2                          Year    1980         1        4
  (•) Variable names                      Month     1          6        2
  ( ) From header file                    Day       1          9        2
 No. header lines:    2

   Variable  Units          Pos.  Len.     Variable  Units          Pos.  Len.
 1  TMAX  ↓   °F        ↓    33    5    7        ↓            ↓     0     0
 2  TMIN  ↓   °F        ↓    26    5    8        ↓            ↓     0     0
 3  RAIN  ↓   inch      ↓    12    5    9        ↓            ↓     0     0
 4  SUNH  ↓   Hrs       ↓    20    4   10        ↓            ↓     0     0
 5        ↓              ↓     0    0   11        ↓            ↓     0     0
 6        ↓              ↓     0    0   12        ↓            ↓     0     0

      OK          Cancel          View file          Save format
```

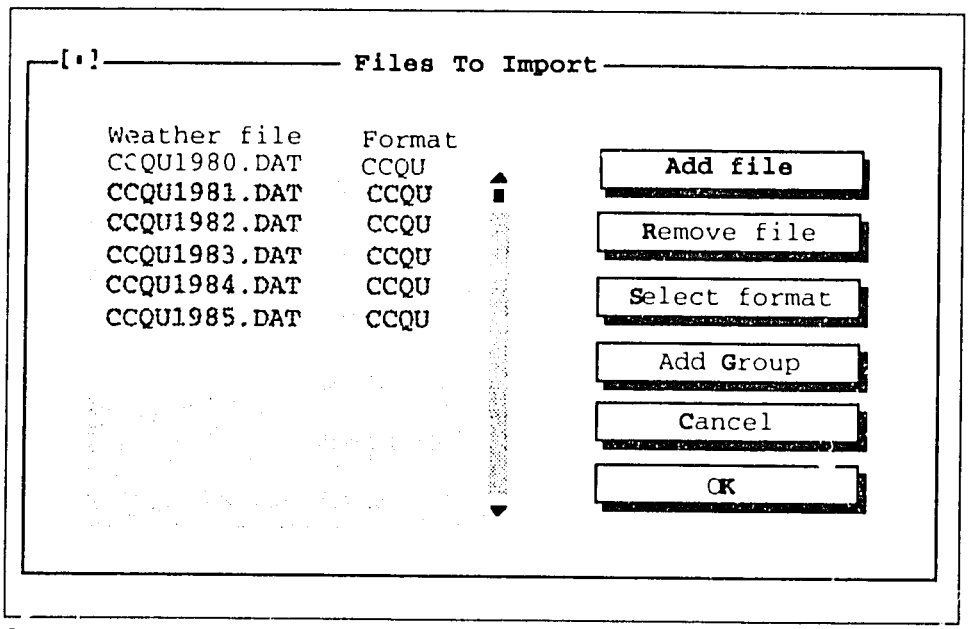
SCREEN 7.

under "Import Options," you will be presented with a "Format Preview" dialog box, similar to the one shown in Screen 20.

Now import the rest of the files as a group using the CCQU format that you just created.

Go to IMPORT/EXPORT | "Import multiple files" to import the rest of the files as a group, using the "CCQU" format that you just created. To do this, select "Add Group" in the dialog box presented. Enter the file mask, CCQU*.DAT. You will then be asked to select a format for the group of files being imported. After selecting the format from the list presented when the SELECT FORMAT button is pressed, a listing of files, as shown in Screen 8 (on following page), which match the CCQU*.DAT mask, will appear in Screen 8.

Select the OK button to import all of the files in the list. You will then be asked if you want to calculate monthly means. Select "No" since you will do that in the next step.



SCREEN 8.

CALCULATE WEATHER GENERATOR PARAMETERS

Go to GENERATE|"Calculate parameters," to calculate parameters for both the WGEN and SIMMETEO weather generators. Use the <F1> key to see the differences between WGEN and SIMMETEO. For a more complete description of these two generators, see the section "Generate Menu" in this Chapter .

Go to STATION|"Edit monthly means" to view the monthly means which are used as parameters for SIMMETEO. The WGEN parameters cannot be viewed or edited directly from WeatherMan. They are, however, saved in a file (CCQU.CLI in the climate directory) and can be edited from the DSSAT v3 Shell (see Volume 1-3, Hunt et al. 1994, of this book for a description of the Shell).

GENERATE WEATHER DATA

Go to GENERATE|"Generate data." Select SIMMETEO and simulate data for the same period of time as the data that you imported. This period of time becomes the defaults in the "Generate Weather Data" dialog box (Screen 30).

Calculate Statistics

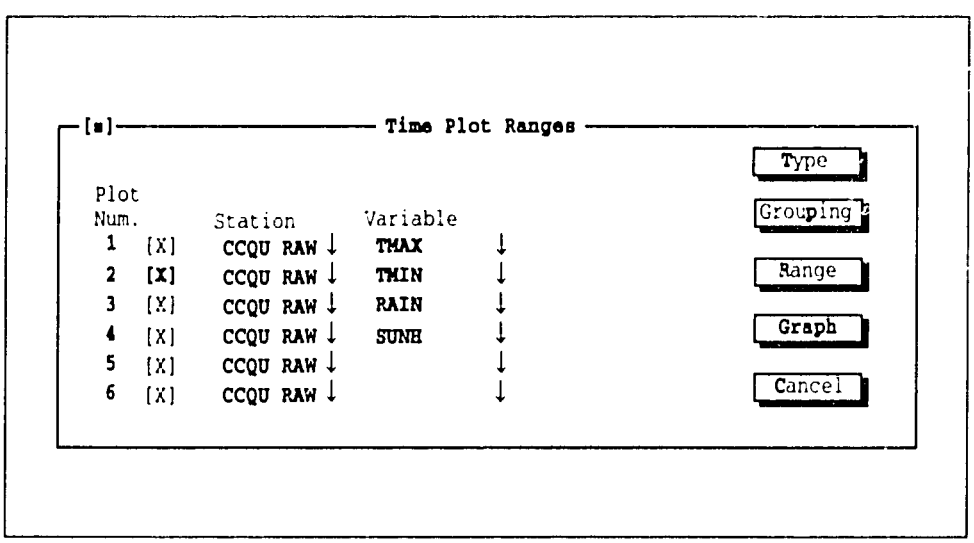
Go to ANALYZE|"Statistics." Select all statistics types and time groupings by checking all of the boxes, using a mouse or cursor keys and press the <SPACE> bar. Then, select the OK button to calculate statistics. Go to ANALYZE|"Report" to view the statistics files. Print only the monthly summary moments file. Highlight the appropriate items in the "Summary Statistics" or "View/Print Statistics" dialog box (see Screen 32 or Screen 33, respectively, in Chapter 4) and use the <F1> key if you need help understanding a statistic type or time grouping.

Calculate Statistics for the Generated Data

Go again to ANALYZE|"Statistics." Select "Only moments" under Type of Statistic, and "Only Monthly Summary" under Grouping. When you are asked for the type of archive file, select "Generated data." View and print the results for the generated data. (***NOTE:*** *Check the file header to make sure it is statistics for generated, not observed data.)*

Graph Observed Daily Temperature

Go to ANALYZE|"Graph." Screen 9 (below) is presented. The initial default plots are always daily time series for observed data. Select the plot ranges with minimum and maximum temperature (TMIN and TMAX) by checking the check boxes at the left, using the <TAB> key and <SPACE> bar. Disable all other plot ranges in Screen 9.



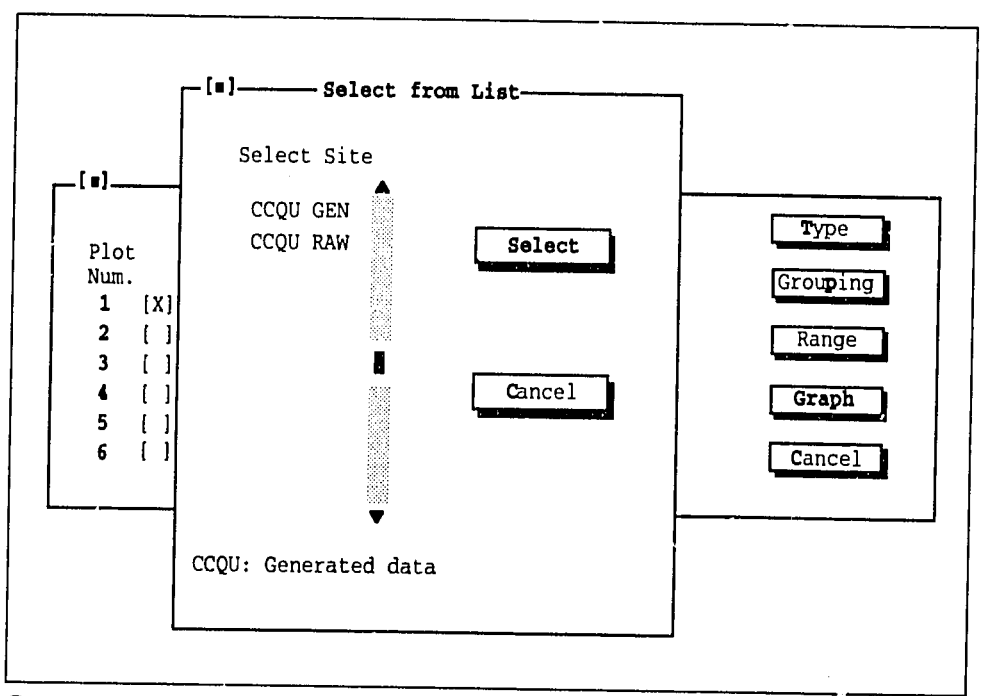
Screen 9.

To view the graph, select the GRAPH button. If the graph is cluttered, you can plot a specified range of dates by selecting the RANGE button. Print the graph by pressing the <P> key while the graph is displayed. (Printing will take several minutes.) Pressing the <G> key toggles the grid lines on or off. Press any other key to return to Screen 9.

Graph Statistics for Observed and Generated Data

As an example graph, we will compare monthly means for maximum daily temperature for observed and generated data, and for wet days and dry days. In the screen presented (Screen 9) when ANALYZE|"Graph" is selected, press the GROUPING button and then the "Monthly summary" time grouping. Highlight the station for the first plot range and use the down arrow icon to select statistics for generated data (CCQU GEN) from the list as shown in Screen 10 (below).

When Screen 11 (on following page) is presented, move to the field under "Variable" in Plot Num. 1 and select mean maximum temperature (TMAX Mean) from the list of available variables in the same way that you selected the station. Finally, move to the field under "Wet State" and select DRY. Repeat the process for the next 3 plot ranges. For



SCREEN 10.

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```
[■]──────────────────── Time Plot Ranges ────────────────────────────
                                                          Type
 Plot                                      Wet
 Num.        Station       Variable        State
  1   [X]    CCQU GEN ↓    TMAX MEAN ↓     DRY   ↓       Grouping
  2   [X]    CCQU GEN ↓    TMAX MEAN ↓     WET   ↓
  3   [X]    CCQU RAW ↓    TMAX MEAN ↓     DRY   ↓       Range
  4   [X]    CCQU RAW ↓    TMAX MEAN ↓     WET   ↓
  5   [ ]    CCQU RAW ↓                ↓   ALL   ↓       Graph
  6   [ ]    CCQU RAW ↓                ↓   ALL   ↓
                                                          Cancel
```

Screen 11.

Plot Num. 2, specify TMAX Mean on WET days for generated data. For Plot Num. 3 and 4, specify TMAX Mean on DRY days and WET days for raw data. After you have specified the four plot ranges, the dialog box will look like Screen 11 (above).

Graph and print the results. Note the similarity between observed and generated maximum temperatures and the effect that rain (i.e. WET vs. DRY state) has on maximum temperature.

Export Daily Weather Files

Go to IMPORT/EXPORT|"Export yearly files." Select the predefined DSSAT v3 format file. Single-year files will be named automatically using a default naming convention. For this example, the first file exported will be called CCQU8001.WTH, containing data for 1980. Use FILE|"Edit" to access an external editor to view the newly created CCQU8001.WTH. Also view the original file that you imported (CCQU1980.DAT) and note the changes in format and units.

You are now familiar with the basic features of WeatherMan. Additional details on each menu in the WeatherMan main menu screen are described in Chapter 4.

CHAPTER FOUR. WEATHERMAN REFERENCE GUIDE

VARIABLES

WeatherMan works with a specific set of daily weather variables (Table 3). The set of variables, default range check values (minimum, maximum and maximum daily change), associated units, and unit conversion factors (multiplier and offset) are specified in a file, called WM.VAR. Variables are stored in their default units in the archive files. If you wish to add or change variables or units, please contact the authors for assistance.

FILE MENU

The FILE menu item found on the WeatherMan main menu gives access to an editor, DOS functions, and additional help. The FILE pull-down menu is shown in Screen 12 (below) and its options are described as follows.

EDIT

The "Edit"option accesses a text editor so that data files can be viewed and edited. The user can use his/her own editor by changing the default under the OPTIONS|"Directories" menus.

```
File  Station  Import/Export  Generate  Analyze  Options  Quit      14:55:44
 Edit
 Invert
 Change dir.
 DOS shell
 About
 Exit  Alt-X
```

SCREEN 12.

Previous Page Blank

TABLE 3. WEATHERMAN VARIABLES AND ASSOCIATED UNITS.

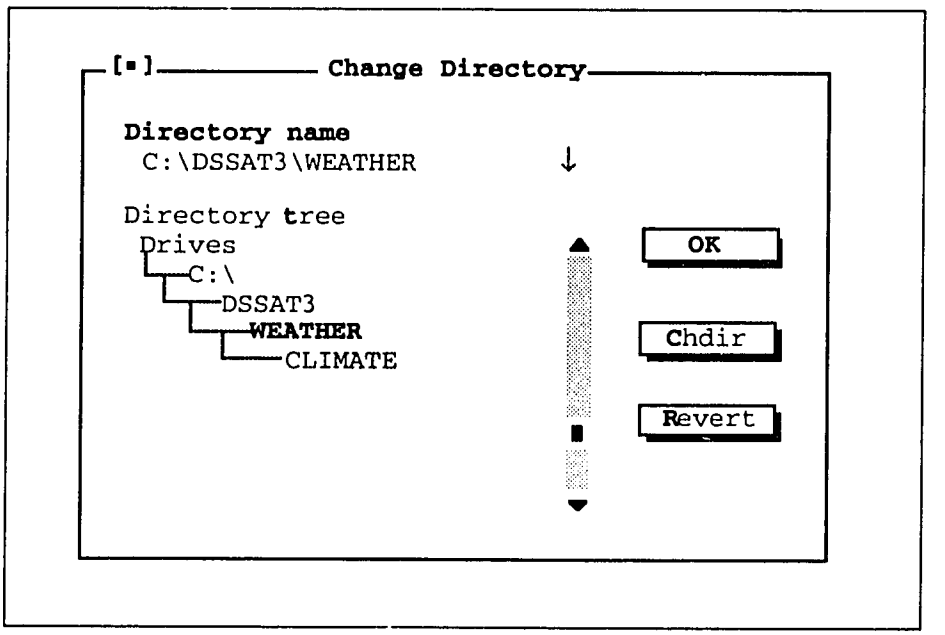
Variable	Description	Default unit	Other units
SRAD	Total daily solar radiation	MJ/m^2	cal/cm^2, $W\text{-}h/m^2$
TMAX	Maximum daily air temperature	°C	°F, °K
TMIN	Minimum daily air temperature	°C	°F, °K
RAIN	Total daily precipitation	mm	cm, inch
DEWP	Dew point temperature or vapor pressure	°C	°F, °K, Pa, kPa, MPa, mbar, bar
WIND	Total daily wind run	km	Miles, m/s, Knots
SUNH	Total daily sunshine hours	%Hrs	n/N, Hrs
PAR	Total daily photosynthetic radiation	Mol/m^2	
TDRY	Dry bulb air temperature at 9 am	°C	°F, °K
TWET	Wet bulb air temperature at 9 am	°C	°F, °K
EVAP	Total daily pan evaporation	mm	cm, inch

INVERT

The "Invert" option is a utility that reverses the order of lines in a text file (required for the output of some dataloggers which record in reverse chronological order).

CHANGE DIR.

The "Change dir." menu option will change the current directory to another weather data directory. The "Change Directory" dialog box is given in Screen 13 (below).



SCREEN 13.

The dialog box shown in Screen 13 applies to the data directory, where the daily weather data files are kept. The CHDIR button will change the directory tree to display the directories below the one that is highlighted. The REVERT button restores the tree to the one presented on entry into the dialog box. The OK button accepts the highlighted directory as the new data directory. The down arrow on the first line activates the history list of previously chosen data directories. The "Change dir." menu option is equivalent to changing the weather data directory under the OPTIONS | "Directories" menus.

DOS SHELL

Selecting the "Dos shell" menu option allows you to leave the WeatherMan program temporarily, without removing the program from the computer's RAM. This function is use-

ful for performing DOS functions like RENAME, DELETE or COPY files. When you have finished any of these functions and wish to return to the WeatherMan program, type EXIT at the DOS prompt.

About

The "About" option displays additional information about the WeatherMan program. The opening screen gives the credits. Introductory information about the program can be accessed by pressing the <F1> key from the "About" dialog box presented when "About" is selected.

Exit

The "Exit" option allows you to exit the Weatherman program. You may also exit by pressing the <ALT>-< X> keys.

Station Menu

The STATION menu allows you to select a weather station and get general and climate information for the station. Most operations in WeatherMan require the selection of a weather station name. Two permanent files, located in the climate directory, are identified by the station name. A climate file (.CLI) contains descriptive information about the site, monthly weather generator coefficients, range check values and counts of valid and flagged data. The format of the climate files is given in Appendix B. The station name also identifies an archive file (.WTD) that has a standard format and set of units; this is required by most of the functions in WeatherMan (e.g., data checking, data-fill, weather generators, statistics, graphics). The archive file is also used for storage of imported data. If the user only wants to convert data file formats or change units of the variables using the "Convert" option under the IMPORT/EXPORT main menu item, then a permanent archive file is not retained. The STATION pull-down menu window is displayed in Screen 14 (on following page).

In Screen 14, after a weather station has been selected, the 4-letter station ID code is displayed on the first line of the menu window and also on the status line at the bottom of the screen. The example station ID code is "UFGA" in Screen 14. The menu options in the STATION menu are described as follows.

Select Station:

The "Select station:" option shown in Screen 14 displays a list of all climate (CLI) files in the climate directory. This dialog box uses the "File List" dialog box but only allows a 4-

```
File  Station  Import/Export  Generate  Analyze  Options  Quit      12:16:49
      Select station:    UFGA
      Edit station information
      Edit monthly means
      Calculate monthly means

F1 Help  Stn: UFGA | Select or input a weather station ID.
```

SCREEN 14.

letter station name. Selecting the OPTIONS main menu item and then the "Update" option after selecting the station from this menu, places the selected station name in the program's configuration file and automatically loads it the next time WeatherMan is started.

Whenever a new weather station is selected, the user is requested to input general information regarding the new station. These data items are listed in Table 4 along with an explanation of each item. Please note that the station's latitude is absolutely essential.

EDIT STATION INFORMATION

When the "Edit station information" option is selected in Screen 14, the "Station Data" dialog box (see Screen 15, on second following page) for entering additional data or editing existing data is presented.

EDIT MONTHLY MEANS

When a new station is selected, a user may select the "Edit monthly means" option in order to enter the monthly means of the weather variables for this station. An example of a "Monthly Means and Rainfall" data entry dialog box is given in Screen 16 (on second following page)

Although you do not need to enter the monthly means of the variables listed in Screen 16, many of the options for generating data filling in missing data during Export will be dis-

TABLE 4. WEATHER STATION INFORMATION REQUIRED FOR A NEW STATION.

Latitude (degrees)	Station latitude (+=N, -=S).
Longitude (degrees)	Station longitude (+=E, -=W).
Elevation (m)	Station elevation above mean sea level.
Angstrom coefficient A	Coefficient A in equation: SRAD = (A + B * n/N) * R_E, where R_E is extraterrestrial radiation and n is duration of bright sunshine, and N is daylength.
Angstrom coefficient B	Coefficient B in equation: SRAD = (A + B * n/N) * R_E.
Reference height (m)	Height of meteorological sensors above ground.
Wind reference height (m)	Height of anemometer above ground.
Mean annual temperature (°C)	Mean annual average daily temperature.
Temperature amplitude (°C)	Half the range of monthly means for average daily temperature.
Start of growing season (d)	Mean day-of-year for last frost.
Duration growing season (d)	Mean time from last frost to first frost.

abled until it has been completed. An alternative to manual data entry is to calculate the means from the daily data in the raw archive file. Monthly climate statistics are available from several secondary data sources (eg. Conway, et al., 1963; NOAA, 1974; Rudloff, 1981). The last two items in the dialog box shown in Screen 16 allow you to document the data source and the data collection period.

CALCULATE MONTHLY MEANS

The "Calculate monthly means" option in Screen 14 allows you to compute means from the data in the raw archive file. This is a reasonable option if there are sufficient reliable data in the archive file or if there are no available climate data. The user is given a warning message if there are less than five years of reliable data in the archive file. Calculating monthly means is equivalent to estimating the SIMMETEO parameters from the Generate menu (see the "Generate Menu" section in this Chapter). The "Calculate monthly means" option will overwrite manually-entered data.

```
[•]──────────────── Station Data ────────────────

Location:      Gainesville,Florida

Latitude (degrees):                          29.630
Longitute (degrees):                        -82.370
Elevation (m):                                10.0
Angstrom coefficient A:                       0.25
Angstrom coefficient B:                       0.50
Reference height (m):                         1.00
Wind reference height (m):                    3.00
Mean annual temperature (°C):                 20.9
Temperature amplitude (°C):                    7.5
Start of growing season (day):                   1
Duration of growing season (days):             365

      OK                                    Cancel
```

SCREEN 15.

Monthly mean hours of bright sunshine and Angstrom coefficients (Prescott, 1940) are included to aid in the estimation of missing daily solar radiation data where daily hours of

```
File  Station  Import/Export  Generate  Analyz  Options  Quit    12:51:39
[•]──────────────── Monthly Means and Rain all ────────────────
```

Mon	--mean monthly values-- SRAD (MJ/m2)	TMAX (°C)	TMIN (°C)	Total rain (mm)	Number of wet day	Mean SUNH (%)	Angstrom coef. A (Y-int)	B (slope)
1	10.9	19.3	5.7	94.2	8.	-99.0	0.250	0.500
2	13.4	21.2	7.2	118.3	8.	-99.0	0.250	0.500
3	17.2	24.3	10.0	109.8	8.	-99.0	0.250	0.500
4	21.4	28.0	13.5	78.7	5.	-99.0	0.250	0.500
5	22.3	30.9	17.1	101.1	7.9	-99.0	0.250	0.500
6	20.8	32.5	20.6	165.9	12.4	-99.0	0.250	0.500
7	20.3	33.1	21.9	175.1	16.5	-99.0	0.250	0.500
8	18.8	32.9	21.9	201.9	16.2	-99.0	0.250	0.500
9	16.6	31.6	20.6	136.2	11.3	-99.0	0.250	0.500
10	14.6	28.6	16.3	56.9	6.5	-99.0	0.250	0.500
11	12.0	24.5	11.5	59.3	6.0	-99.0	0.250	0.500
12	9.9	21.5	7.9	69.3	6.8	-99.0	0.250	0.500

```
Source:Calculated_from_daily_data   1st year: 1980  No. years: 25

                OK                          Cancel

F1 Help  Stn: UFGA  | Mean solar radiation (MJ/m2/d) for month.
```

SCREEN 16.

bright sunshine (SUNH) are available. If SUNH data are not available in the archive file, "Calculate monthly means" will use the Angstrom coefficients entered in the "Station Data" dialog box as defaults (see Screen 15). If SUNH is available but daily radiation (SRAD) is not, then monthly Angstrom coefficients will be estimated by the relationship proposed by Rietveld (1978). If sufficient (>5yr) records with both SRAD and SUNH are found for a month, then Angstrom coefficients will be calculated for that month directly by linear regression.

Import/Export Menu

The IMPORT/EXPORT menu item found on the WeatherMan main menu allows you to perform all the necessary data manipulation for inserting data into an archive file and extracting it into other files. The IMPORT/EXPORT pull-down menu is shown in Screen 17 (below) and its options are described as follows.

File Formats

The "File format" option allows you to define the format of the target weather data file to be imported or the destination file to be exported. These formats are saved in files with .FMT extensions. For example, format definition files for DSSAT v2.1 (IBSNAT2.FMT) and DSSAT v3 (IBSNAT3.FMT) are distributed with the WeatherMan. A blank format, NEW.FMT, is provided as a template for constructing new format definition files. Format

```
File  Station  Import/Export  Generate  Analyze  Options  Quit      14:08:26
              Convert format
              Import single file
              Import multiple files
              Import options
              Edit range checks

              Export single file
              Export yearly files
              Export options
              Data fill options
```

Screen 17.

files specify columns of data, units for each data column, date formats (i.e., year/month/day or year/day of year), and file header options. Users can edit these formats and save the changes under new or existing names.

The "Format Name" dialog box that appears during Import, Export, and Convert operations is a variation of the "File List" dialog box (see Screen 10) with an additional EDIT button. The EDIT button allows the user to view, edit, and save format files. If a name is entered that doesn't match an existing format, the user will be prompted to edit a blank template format, NEW, and save it under the desired name. The "Edit File Format" dialog box presented when the EDIT button is pressed is shown in Screen 18 (below).

In Screen 18, the format name is displayed in the top right corner window. The "Header output option" in the top left region of the screen controls what header lines are added to a file during an Export operation. The header can match DSSAT v3 or v2.1 standards, consist of variable names right-justified in the columns in which the variables will be written, or can be read from a text file. Just below the "Header output option" is the "No. header lines:" which is the number of non-blank header lines to be skipped during Import.

The format for the date is entered in the upper right hand corner in Screen 18. For Import, the date of the first data point should be entered only if dates are not explicitly

```
File  Station  Import/Export  Generate  Analyze  Options  Quit        14:39:35
[•]──────────────────────── Edit File Format ────────────────────────────────
Header output option:                  Format name:   IBSNAT3
 ( ) None
 (•) IBSNAT v.3                        Date:     First      Position  Length
 ( ) IBSNAT v.2                          Year    1990         1         2
 ( ) Variable names                      Month     1          0         0
 ( ) From header file                    Day       1          9         3
No. header lines:   4

  Variable  Units        Pos.  Len.     Variable  Units        Pos.  Len.
1 SRAD  ↓   MJ/m²   ↓    7     5    7      ↓          ↓      0     0
2 TMAX  ↓   °C      ↓   13     5    8      ↓          ↓      0     0
3 TMIN  ↓   °C      ↓   19     5    9      ↓          ↓      0     0
4 RAIN  ↓   mm      ↓   25     5   10      ↓          ↓      0     0
5       ↓           ↓    0     0   11      ↓          ↓      0     0
6       ↓           ↓    0     0   12      ↓          ↓      0     0

     [ OK ]        [ Cancel ]      [ View file ]      [ Save format ]
```

SCREEN 18.

given in the import file. The date format can be year, month and day-of-month or year and day-of-year. The day-of-year format is inferred from a length of 0 for month and a length ≥3 for the day.

Up to 12 variables can be imported in any order and with any units. The variables and their units are entered in the lower left-hand windows in Screen 18. The choice of variables and their units is made with lists that are activated by the down arrow or double clicking with the left mouse button on the appropriate cell in these windows. Moving from cell-to-cell is achieved with the <TAB> and <SHIFT>-<TAB> keys or single-clicking with the left mouse button. Based on the chosen variable, the list will reflect valid units. For example, for temperature variables only temperature units are listed (°C, °F, °K). The variables in the list and their associated units and conversion factors are contained in an external file (WM.VAR). Please contact the authors if you want to modify the list of variables.

The VIEW FILE button provides a file viewer to facilitate the choice of the position and length of the variables in the data file (see Screen 19, below).

The SAVE FORMAT button provides access to a "File List" dialog box so that a new or modified format can be saved to a file for subsequent use. The OK button will accept any format changes for the current IMPORT/EXPORT session but will not save them to a

```
File  Station  Import/Export  Generate  Analyze  Options  Quit        09:42:09
                              Edit File Format
Header output option:          Format name:   IBSNAT3
 ( ) None
 ( ) IBSNAT v.3                Date:      First       Position  Length
 ( ) IBSNAT v.2                   Year      1900        1         2
 ( ) Variable names               Month        1        0         0
 ( ) From header file             Day          1        3         3
No. header lines:   4

  Variable  Units          Pos.  Len.      Variable  Units          Pos.  Len.
1 SRAD      MJ/m2           7     5    7                            0     0
2 TMAX      °C             13     5    8                            0     0
3 TMIN      °C             19     5    9                            0     0
4 RAIN      mm             25     5   10                            0     0
5                           0     0   11                            0     0
6                           0     0   12                            0     0
[•]          C:\DSSAT3\WEATHER\UFGA8001.WTH                          [↑]
*WEATHER : GAINESVILLE,FLORIDA,USA

@ INSI      LAT     LONG  ELEV   TAV   AMP REFHT WNDHT
  UFGA   29.630  -82.370    10  20.9   7.5  2.00  3.00

F1 Help  F10 Menu  Stn: UFGA
```

SCREEN 19.

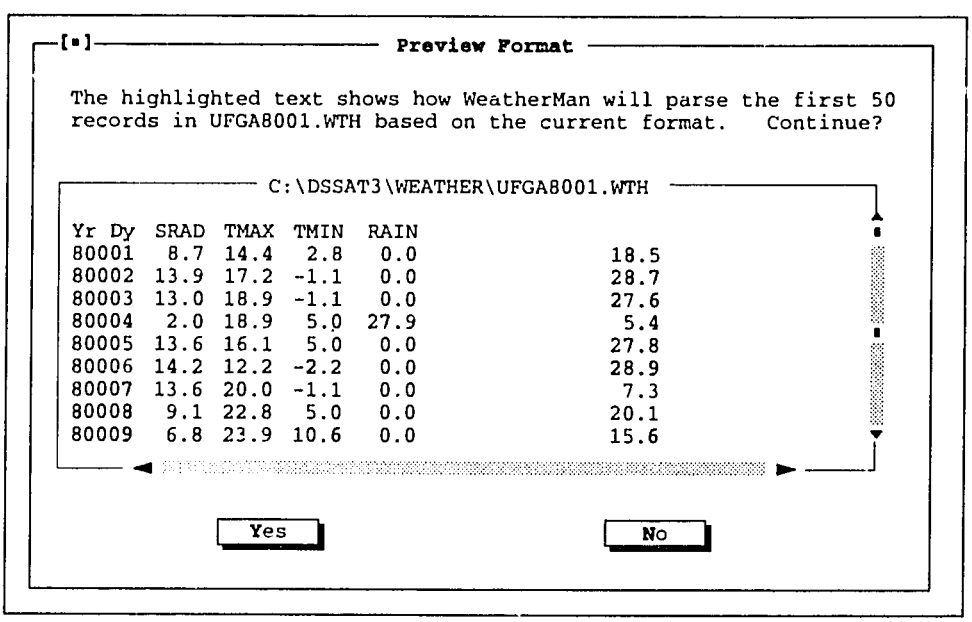
file, so when you quit the operation, any changes you have made to the format will be lost.

The VIEW FILE button displays the file in conjunction with a ruler as shown in Screen 19.

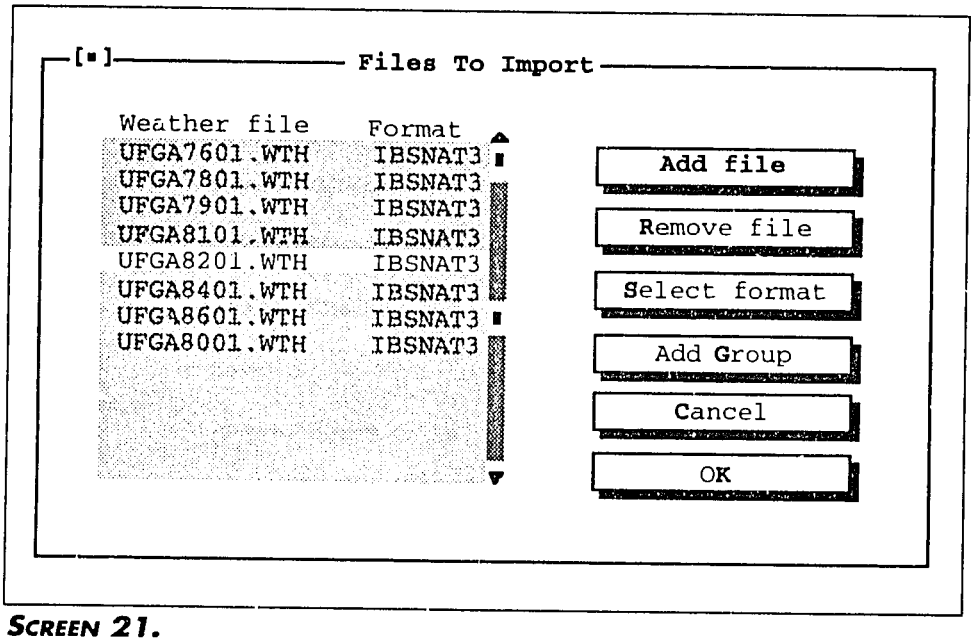
If a format is being edited during an Import operation and the "Preview formats" option is enabled (with a tick mark) in the "Import Options" dialog box (see Screen 24), then a "Preview Format" dialog box (Screen 20, below) will be presented when either the OK or the SAVE button is pressed. The "Preview Format" dialog box displays a file viewer which shows the first 50 records of the weather file. The columns where the program, using the current format, will look for variables are labeled and highlighted.

Convert Format

The "Convert format" option found in the IMPORT/EXPORT pull-down menu (see Screen 17) allows you to convert a weather data file from one format and set of units to another without defining a weather station. A permanent archive file for the raw data is not retained, and range checking and data fill are not performed. When converting a weather file format, the user will be prompted to: (1) select the target file to convert from, (2) select a format name for the target file, (3) select the destination file name to convert to, and (4) select a format for the destination file. The file names and format names are selected using the "File List" dialog box (see Screen 10 or Screen 21, on following page).



Screen 20.

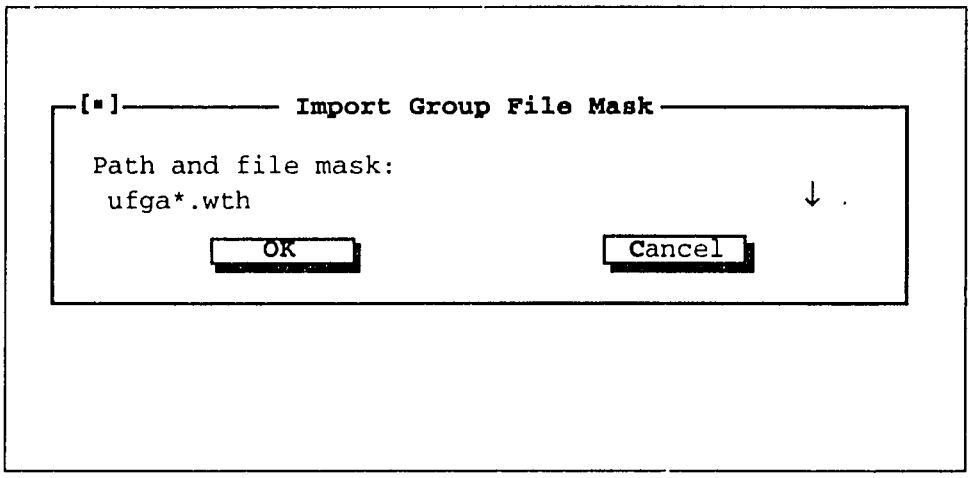


SCREEN 21.

IMPORT...

The "Import..." option can be used to import a single file or a set of files into an archive file. The "Import single file" option uses the standard "File List" dialog box to select a import file name and format. These steps are identical to the first two steps discussed in the above "Convert format" section. The "Import multiple files" option builds a list of files and their corresponding formats. This feature is useful where the weather variables are stored in different files with different formats, or for a group of files with the same format. The "Files To Import" dialog box presented when this option is selected is shown in Screen 21.

In Screen 21, the ADD FILE button activates the IMPORT/EXPORT "File Name" dialog box and adds a file to the list displayed in the left-hand window of this screen. The REMOVE FILE button can be used to delete a highlighted file from the list. The first file chosen is inserted into the list with a format of "none." The SELECT FORMAT button activates the "Format Name" dialog box and the user can access the "Edit File Format" dialog box using the EDIT button in that dialog box. Adding subsequent files automatically assigns them the format name of the highlighted line. This feature facilitates adding several files with the same format to the list. The format of a highlighted file may also be modified from the SELECT FORMAT button. Files in the list are imported sequentially when the OK button is selected.



SCREEN 22.

A group of files with similar names can also be added using the ADD GROUP button in Screen 21. This feature is especially useful for importing many one-year file of the same format. Since a file mask is used to define the group, unwanted file names are occasionally inserted in the list, but these are easily removed by use of the REMOVE FILE button. The "Import Group File Mask" dialog box used to define the group is shown in Screen 22 (above).

If the "Preview formats option" is enabled under the "Import Options" dialog box (Screen 24), a "Preview Format" dialog box (Screen 20) will be presented before each file is imported.

On"Import," variables that have errors or are suspect are automatically flagged (see the section "Import Options" in this Chapter and Screen 23 to change this setting). The flags used are lower case letters. When an original value is filled-in, its flag is converted to upper case. The flags and their meaning are listed in Table 5.

At the end of the "Import" process, a summary report is given indicating the quantity and quality of data in the raw archive file. An example of this report is displayed in the "Import Statistics" dialog box as shown in Screen 23 (on following page).

IMPORT OPTIONS

The options for import can be changed using the "Import options" menu item from Screen 17 which accesses the "Import Options" dialog box presented in Screen 24 and explained in Table 6.

TABLE 5. EXPLANATION OF ERROR CODES USED TO FLAG SUSPECT OR ERRONEOUS DATA.

Class	Description	Import code	Filled code
Range check	Above maximum	a	A
Range check	Below minimum	b	B
Range check	Greater than maximum daily change	r	R
Conversion	Missing value	n	N
Conversion	Format error	e	E

When range checking is turned on, the variables are checked against a maximum value, a minimum value, and a maximum rate of change from one day to the next. The values inserted in the raw archive file are not changed but marked with an appropriate range check flag (see the "Import" section above). Default range values are provided for a new weather station and these can be edited using the "Edit range checks" option found in Screen 17 to access the "Edit Check Ranges" dialog box. An example of the "Edit Check Ranges" dialog box is shown in Screen 25 (on second following page).

[▪] Import Statistics

Records in UFGA.WTD

	TOTAL	SRAD	TMAX	TMIN	RAIN	PAR
TOTAL :	43380	8676	8676	8676	8676	8676
VALID :	43089	8670	8673	8675	8676	8395
MISSING:	277	0	0	0	0	277
ERROR :	0	0	0	0	0	0
ABOVE :	1	0	0	0	0	1
BELOW :	12	6	3	0	0	3
RATE :	1	0	0	1	0	0

OK

SCREEN 23.

TABLE 6. EXPLANATION OF IMPORT OPTIONS.

Option	Explanation
Format name:	The default action is to prompt for a format name. If the only file formats used are the DSSAT v2.1 or DSSAT v3 formats, the format name can be fixed as IBSNAT v2 or IBSNAT v3, respectively.
Check ranges:	The default is to perform range checking. The variables are checked for extreme values and the unaltered values are inserted in the raw data archive file and marked with a flag (see Edit Range Checks below). Import operations can speeded up without range checking and it can be performed later on the whole archive file using an option in the Analyze menu.
Overwrite existing data:	If this option is enabled, when the existing and new data both have valid values for the same dates, the new values will replace the existing values. Turning off this option causes the existing value to be retained under the same circumstances.
Prompt for non-numerics:	The default action is to prompt the user to give a numeric value to replace each new non-numeric string encountered (e.g., "TRACE" can be replaced with '0.0' for rainfall.) Turning off this option causes blanks to be treated as missing values and non-numeric characters to be treated as format errors.
Preview formats:	The default action is to present a "Preview Format" dialog box (Screen 20) every time a file is imported or a format is edited during Import. Turning-off this option prevents the "Preview Format" dialog box from being displayed.

```
[▪]——— Import Options ———

Format name:
 (•) Prompt for name.
 ( ) IBSNAT3
 ( ) IBSNAT2

Other options:
 [X] Check ranges.
 [X] Overwrite existing data.
 [X] Prompt for non-numerics.
 [X] Preview formats

      OK          Cancel
```

SCREEN 24.

All variables in Screen 25 are in the archive file units except for solar radiation (SRAD) and photosynthetically active radiation (PAR) which are in percent of extraterrestrial radiation. Updated ranges are saved to the weather station climate file. The DEFAULTS button restores the default values.

```
[▪]——— Edit Check Ranges ———

Variable Minimum  Maximum  MaxRate
 SRAD*     5.0     85.0     70.0
 TMAX      5.0     40.0     20.0
 TMIN    -20.0     30.0     20.0
 RAIN      0.0    600.0    500.0
 DEWP      0.0     25.0      5.0
 WIND      0.0    500.0    300.0
 SUNH      0.0    100.0     90.0
 PAR *     5.0     85.0     70.0
 TDRY      0.0     35.0     20.0
 TWET      0.0     25.0     20.0
 EVAP      0.0     15.0     15.0

*Radiation in % of extraterrestrial.

   OK        Defaults      Cancel
```

SCREEN 25.

EXPORT...

The "Export..." option in Screen 17 can be used to export a single file or a set of yearly files. The "Export single file" option uses the "Archive Type" dialog box (Screen 4) (if the raw archive file is not the only type), "Time Period" dialog box (Screen 5), and the "File List" dialog box (Screen 2) to select an export file name and format. The "Export yearly file" option uses the same dialog boxes, but the file export names are built automatically based on the DSSAT v2.1 or DSSAT v3 file naming conventions. The files can easily be renamed using the DOS RENAME command. Access to the "Edit Format" dialog box is from the "Format File" dialog box.

During "Import," errors or suspect values in the raw archive file are marked with a flag indicating the source of the error. On "Export," if a data item is filled in, the value's error flag is converted to an upper case letter. This reminds the user that the value was filled-in and the cause of the error. Error flag definitions are listed in Table 5.

EXPORT OPTIONS

The options for export can be changed using the"Export options" menu item which accesses the "Export Options" dialog box presented in Screen 26 (on following page) and discussed in Table 7.

When any of the data fill options are turned on in Screen 26 by placing an 'x' in the left-hand box in the "Other options:" menu list, there are a number of ways in which the data fill can be implemented. These options are accessed from the "Data fill" options menu item that invokes the" Data Fill Options" dialog box given in Screen 27 (on following page) and discussed in Table 8.

GENERATE MENU

The GENERATE menu item found on the WeatherMan main menu allows estimation of the weather generator parameters and subsequent generation of daily weather data. The weather generators used are adaptations of WGEN (Richardson and Wright, 1984) and SIMMETEO (Geng et al. 1986; Geng and Auburn, 1988). The SIMMETEO generator is embodied in the WGEN generator but uses a different input section. The resulting WGEN/SIMMETEO is a translation of the FORTRAN version used internally in the DSSAT v3 crop models. In this version of WeatherMan, both generators are restricted to generating the DSSAT v2.1 extended weather data set of solar radiation, maximum temperature, minimum temperature, rainfall, and PAR.

```
                    [•]—— Export Options ————————
                    Format name:
                     (•) Prompt for name.
                     ( ) IBSNAT3
                     ( ) IBSNAT2

                    Yearly file
                    naming conventions:
                     (•) IBSNAT v.3
                     ( ) IBSNAT v.2

                    Other options:
                     [X] Fill missing data.
                     [X] Fill range errors.
                     [ ] Fill missing dates.
                     [ ] Export data flags.

                       OK          Cancel

  F1 Help  Stn: UFGA | Prompt for a format name on export.
```

SCREEN 26.

```
File  Station  Import/Export  Generate  Analyze  Options  Quit      14:19:23
        [•]———————————— Data Fill Options ————————————
        Data fill method:
         (•) Generate missing data with WGEN or SIMMETEO.
         ( ) Monthly means and stochastic rainfall generations.

        Solar radiation (SRAD and PAR):
         ( ) Use method selected above to estimate radiation.
         (•) Estimate radiation from sunshine hours.

        Short (≤ 7 day) data gaps:
         ( ) Use method selected above to fill data.
         (•) Estimate missing data using 10-day running mean.

        Model for weather generation:
         ( ) WGEN
         (•) SIMMETEO

         Random seed for generator (1 to 32767):        3823

              OK                          Cancel

F1 Help  Stn: UFGA | Use a stochastic generator to fill missing data.
```

SCREEN 27.

TABLE 7. EXPLANATION OF EXPORT OPTIONS.

Option	Explanation
Format name:	The default action is to prompt for a format name. If the only file formats used are the DSSAT v2.1 or DSSAT v3 formats, the format name can be fixed as IBSNAT v2 or IBSNAT v3, respectively.
Yearly file naming convention:	The default is to use the DSSAT v3 file naming convention. The other option is to use the DSSAT v2 convention. The file naming conventions are (Station = 4 characters, yr = 2 characters): For DSSAT v2.1, use IBSNAT v2: Station + '0112.W' + yr (raw) Station + 'GEN.W' + yr (generated) For DSSAT v3, use IBSNAT v3: Station + yr + '01.WTH'(raw) Station + yr + '01.WTG' (generated)
Fill missing data:	The default is to fill missing data. If missing data are not filled, the value is written as -99.0 on output.
Fill range errors:	The default is to replace data that are flagged for range errors. This option is only in effect if Fill Missing Data is checked. If range errors are not filled, the original value is written on output.
Fill missing dates:	The default is to fill missing dates with sequential dates and fill variable values. If Fill Missing Dates is disabled, missing dates in the raw archive file will also exist in the output file.
Export Data Flags:	The default is to export the error flags as lower case if data are not filled and upper case if they were filled. If data are filled and error flags are not exported, there will be no indication that the data have been

TABLE 8. EXPLANATION OF DATA FILL OPTIONS.

Option	Explanation
Data fill method:	There are two generic data fill methods for all data. Solar radiation and short periods of missing data have additional methods. The first method is to generate all missing data with the WGEN or SIMMETEO weather generators (see Generator section). The second method uses monthly means from the climate file for all variables except rainfall; a simple stochastic generator is used for rainfall. Using monthly means for rainfall is not an option since it would cause severe problems with any water balance model if all days had some rainfall. Both methods only fill solar radiation, maximum and minimum temperature, rainfall, and PAR.
Solar radiation:	The default is to use the generic method selected above. An alternative is to estimate solar radiation using the Angstrom coefficients in the climate file. Sunshine hours data must be available in the raw archive file to use this method.
Short (≤ 7 Day) data gaps:	The default is to use the generic data fill method given above. An alternative is to use a 10-day running mean for gaps that are less than 7 days long. This may give a more realistic estimate of the actual average values for that period than using long-term means. For data gaps longer than 7 days, the above data fill methods will still be used.
Model for weather generation:	The default is to use the SIMMETEO model since it requires only the monthly means in the climate file. The WGEN model provides better estimates of variability if it has been parameterized from at least five years of good quality daily data. Model parameters must be in the climate file to use this option (see Generator section).

The DSSAT v3 modifications of WGEN/SIMMETEO use standard deviations rather than coefficients of variation which makes the generators more stable than the original versions. Monthly input parameters are now used for all variables, with linear interpolation computed internally. The modified SIMMETEO model uses monthly climate parameters and regression equations (Geng, et al. 1988; Geng and Auburn, 1986; Pickering et al. 1988) to compute the standard deviations.

The GENERATE menu provides the utilities necessary for estimating the generator parameters and generating daily data. The GENERATE menu is shown in Screen 28 (below) and its options are described as follows.

CALCULATE PARAMETERS

When the "Calculate parameters" option shown in Screen 28 is selected, the "Calculate Parameters" dialog box, shown in Screen 29 (on following page), is presented.

From Screen 29, the parameters for WGEN or SIMMETEO can be computed separately or together. A standard "Time Period" dialog box (i.e., "Starting" and "Ending" dates) is included in the dialog box shown in Screen 29, allowing you to choose a particular time period if desired. The default is to use all the data in the archive file, and the dates presented when Screen 29 appears should represent the range of dates available in the archive file. The computed monthly parameters are recorded in the climate file. Estimating the SIMMETEO parameters is equivalent to calculating monthly means from the STATION

```
File  Station  Import/Export  Generate  Analyze  Options  Quit      14:55:44
                             Calculate parameters
                             Generate data
```

SCREEN 28.

```
[■]── Calculate Parameters ──────
Model:
 (•) WGEN generator parameter
 ( ) SIMMETEO monthly means
 ( ) Both sets of parameters

                        Day of
                Year     year
Starting date:  1980       1

Ending date:    1987     365

   OK              Cancel
```

SCREEN 29.

menu (see Screen 14)—both calculate the same statistics. If the monthly means in the climate file are from a longer and more reliable record than the daily data, the user should not estimate SIMMETEO's parameters since the monthly means in the climate file will be overwritten. Estimating generator parameters is a reasonable option if there are sufficient reliable data in the raw archive file or if there are no available climate data. The user is warned if there are less than five years of reliable data in the archive file.

GENERATE DATA

The "Generate data" menu item accesses the "Generate Weather Data" dialog box which is shown in Screen 30 (on following page).

Generated data are output to an archive file called Station_GEN.WTD. This file is usually treated as a temporary file for the duration of the WeatherMan session (see the following section entitled, "Options Menu" and the subsection "Temporary Files" for a description of how to change from a temporary file). Either the WGEN or SIMMETEO generator can be used to generate daily data. The standard "Time Period" dialog box is inserted to choose the years to be generated; only full years can be generated. The default action is to match the time period of the raw archive file, although any time period can be specified. For comparing yearly time series graphically, matching the dates is a good choice. Just because generated and raw data have the same time period does not mean that the generated data predict the raw daily data; only the means are predicted on average. A random number seed is generated and inserted in the dialog box shown in Screen 30. To generate an identical sequence of weather data, the same random number seed should be specified.

```
[•]- Generate Weather Data

Model:
 (•) WGEN
 ( ) SIMMETEO

Starting year:     1980

Ending year:       1987

Random seed (1 to 32767):
            3919

   OK          Cancel
```

SCREEN 30.

ANALYZE MENU

The ANALYZE menu item found on the WeatherMan main menu allows you to calculate and present summary statistics in both tabular and graphical form. It also repeats the range check and data fill functions that are normally done automatically on IMPORT or EXPORT. Analysis is performed on raw, filled or generated data. The ANALYZE menu is shown in Screen 31 (on following page) and its options described as follows.

RANGE CHECK AND DATA FILL

The "Range check" and "Data fill" options listed in Screen 31 offer you another way to perform functions normally done on IMPORT or EXPORT.

Range check. The "Range check" option permits the range checking analysis to be done on the complete raw archive file. After the check is done, the results are given in an "Import Statistics" dialog box similar to the dialog box for IMPORT (see Screen 23). This re-checking process is useful when IMPORT has been done with incorrect range check values or if range checking had been turned off during IMPORT. It is also useful for identifying a reasonable set of range check values for a weather station by iteratively setting the range check values and viewing the results.

```
File  Station  Import/Export  Generate  Analyze  Options  Quit      14:55:44
                                        ┌──────────────────┐
                                        │Range check       │
                                        │Data fill         │
                                        ├──────────────────┤
                                        │Statistics        │
                                        │Report            │
                                        ├──────────────────┤
                                        │Graph             │
                                        └──────────────────┘
```

SCREEN 31.

Data fill. The "Data fill" option creates a filled archive file called Station_FIL.WTD. This file is usually treated as a temporary file for the duration of the WeatherMan session (see the following section entitled, "Options Menu" and the subsection "Temporary Files" for a description of how to change from a temporary file). The filled archive file can be analyzed and compared with the raw data to check the data fill algorithms.

STATISTICS

The "Statistics" menu item listed in Screen 31 provides algorithms for summarizing the data in various ways. When this option is selected, the "Archive Type" dialog box is presented (Screen 32, on following page). This dialog box allows you to choose raw, filled, or generated archive files.

Statistics are output to summary files and are usually treated as temporary files for the duration of the WeatherMan session (see the following section entitled, "Options Menu" and the subsection "Temporary Files" for a description of how to change from a temporary file). The SUM files are also used for the "Report" and "Graph" options under the ANALYZE menu. The "Time Period" dialog box allows the user to choose the time period to be analyzed. The default action is to analyze the whole archive file.

In Screen 32, there are four types of statistics to select from: "Moments," "Percentiles," "Distribution" and "Time structure." The default choice is to calculate moments only. "Moments" includes means, standard deviations, and skewness coefficient. "Percentiles"

```
[•]──────── Summary Statistics ────────

Type of Statistic:      Grouping:
[X] Moments             [X] Monthly summary
[ ] Percentiles         [ ] Monthly time series
[ ] Distibution         [ ] Yearly time series
[ ] Time structure

                   Year  Day of year
Starting date:     1980        1

Ending date:       1987      365

   OK                        Cancel
```

SCREEN 32.

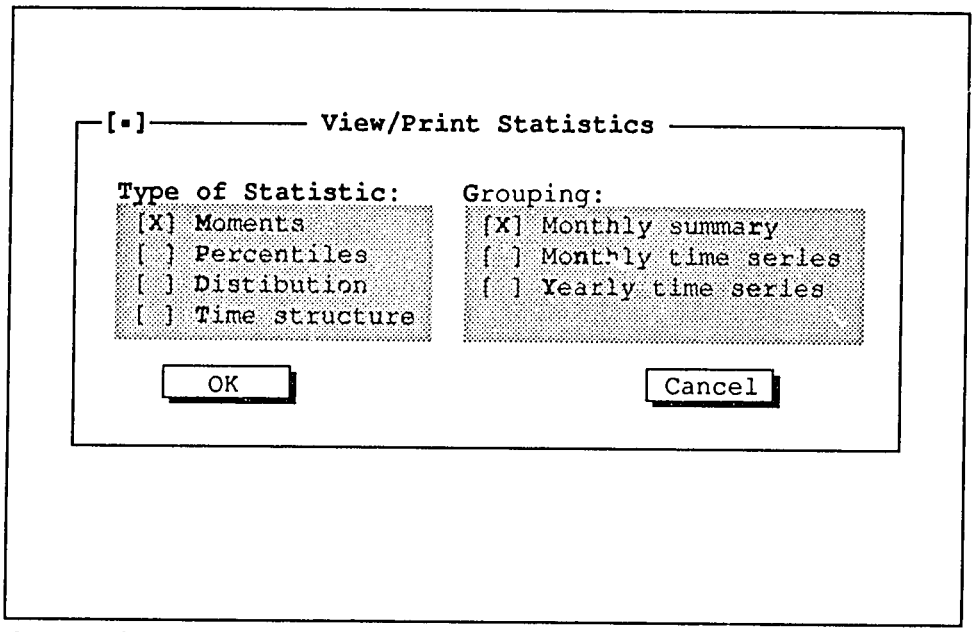
are the 0, 25, 50, 75, and 100 percentiles. "Distribution" includes both histograms and cumulative probabilities. "Time structure" includes autocorrelograms for all variables except rainfall, and has conditional probabilities for rainfall. All statistics are automatically computed for wet, dry and for all days, except "Time structure" which uses all days.

Also in Screen 32, three statistics groupings can be selected: "Monthly summary," "Monthly time series" and "Yearly time series." A fourth grouping comprised of all data combined, is automatically performed with the monthly summary. The time series analyses are relatively slow since they require considerable sorting prior to output. The default grouping is monthly summary. Table 9 describes these groupings in more detail.

REPORT

The "Report" option provides a way to view and print the summary (SUM) files created under "Statistics." When this option is selected, the "View/Print Statistics" dialog box shown in Screen 33 (on following page) is presented.

Screen 33 has the same Type and Grouping choices as the "Summary Statistics" dialog box shown in Screen 32. As a default, the same boxes are checked in Screen 33 as were checked in Screen 32 since those summary files already exist. If all the selected options have been previously analyzed, the files are viewed sequentially. Up to 12 summary files



SCREEN 33.

are possible for each type of archive file. When the OK button is pressed in Screen 33, the "Summary File" dialog box shown in Screen 34 (on following page) is presented.

The user can scroll both vertically and horizontally through the SUM file displayed in Screen 34. If the PRINT button in Screen 34 is pressed, the SUM file displayed in the window is printed to the parallel printer port. The OK button displays the next file while the CANCEL button aborts the viewing process.

TABLE 9. EXPLANATION OF STATISTICS TIME GROUPINGS.

Grouping	*Explanation*
All data combined	Pools all data together (computed automatically with monthly summary).
Monthly summary	Pools all the data from each month together (eg. all of January's, all of February's etc).
Monthly time series	Each month analyzed separately.
Yearly time series	Each year analyzed separately.

```
File  Station  Import/Export  Generate  Analyze  Options  Quit
[•]──────────────────────── Summary File ────────────────────────
──────────────────────────── UFGA_AMA.SUM ──────────────────────
! Monthly summary moments for station UFGA observed data.

*SRADDRY

@  MTH  SDMN  SDSD  SDSK  SDKT
     1  11.9   2.9  -0.9   0.3
     2  14.8   3.7  -0.9   0.3
     3  18.8   4.1  -0.8   0.0
     4  22.7   3.8  -1.1   1.6
     5  23.4   3.8  -1.1   1.2
     6  22.4   3.6  -0.8   0.3
     7  22.0   3.4  -0.9   1.0
     8  20.3   2.9  -0.8   0.6
     9  17.7   3.3  -1.0   0.8
    10  15.4   3.4  -0.9   0.7

              [ OK ]        [ Print ]        [ Cancel ]

F1 Help  Stn: UFGA | Use cursor keys or mouse to scroll, <Esc> or icon to quit.
```

SCREEN 34.

Variable names that appear in summary files are given in Appendix A.

GRAPH

The "Graph" option provides access to a graphics package to plot both the data in the archive files and in the statistics (SUM) files. The following six graph types are available: Time Plot, Box Plot, Histogram, Cumulative Distribution, Autocorrelation, and Rainfall Probability. Within each graph type, up to six plots can be defined (except for the Box Plot and Auto correlation which allow only a single plot), but only the checked plots will actually be plotted. A plot definition dialog box is used to create combinations of weather stations, variables, wet states, and time ranges. A default set of plots is automatically loaded into this dialog box. The down arrow or mouse can be used to access lists for the Station, Variable and Wet state columns. Only valid choices are displayed. For example, if statistics have not been calculated for a particular weather station, the statistics variables for that station will not be displayed. In addition, the Wet state column is not visible for a daily time grouping. The wet state refers to the occurrence of rainfall; choices are Wet, Dry, or All.

An example of a plot definition dialog box is given in Screen 35 (on following page) for a "Time Plot Range" where six plots are defined and two (TMAX and TMIN) are checked for plotting.

```
[•]──────────────────── Time Plot Range ──────────────────────
                                                   Type
 Plot
 Num.      Station      Variable                   Grouping
  1  [X]   UFGA RAW ↓   SRAD      ↓
  2  [ ]   UFGA RAW ↓   TMAX      ↓                Range
  3  [ ]   UFGA RAW ↓   TMIN      ↓
  4  [ ]   UFGA RAW ↓   RAIN      ↓                Graph
  5  [ ]   UFGA RAW ↓   PAR       ↓
  6  [ ]   UFGA RAW ↓             ↓                Cancel
```

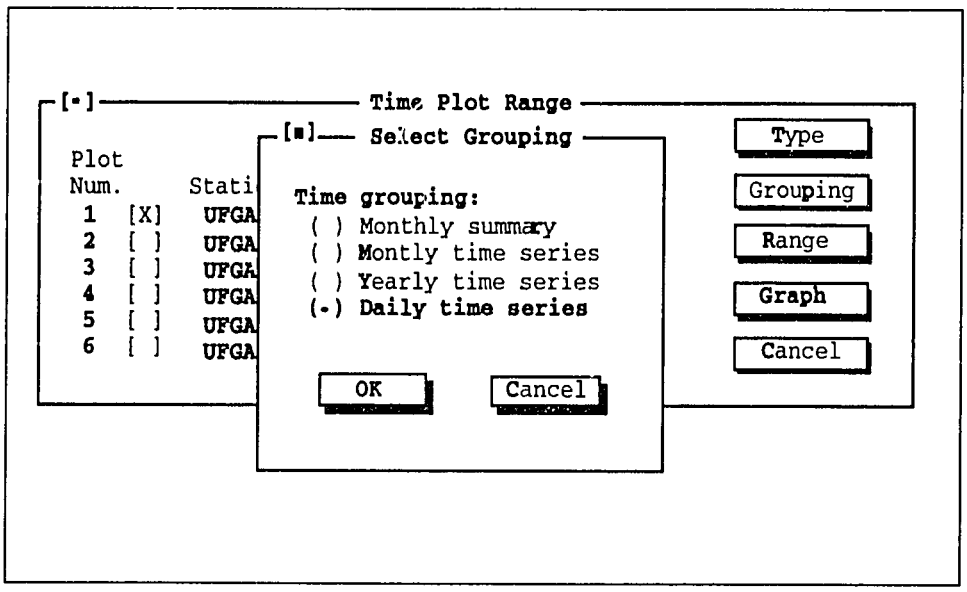
SCREEN 35.

The TYPE , GROUPING and RANGE buttons in Screen 35 control the graph choices, while the GRAPH button displays the graph, and the CANCEL button exits the dialog box. The TYPE button provides a choice of six graph types in the "Graph Type" dialog box that overlays the plot definition dialog box as shown in Screen 36 (below).

The GROUPING button accesses a "Select Grouping" dialog box similar to the right hand side of the "Summary Statistics" (Screen 32) or "View/Print Statistics" (Screen 33)

```
[•]──────────────────────────────────────────────────────────
                 [•]──── Graph Type ────
                                                   Type
 Plot            Type of Graph:
 Num.      Stati   (•) Time plot                   Grouping
  1  [X]   UFGA     ( ) Box plot
  2  [ ]   UFGA     ( ) Histogram                   Range
  3  [ ]   UFGA     ( ) Cumul. distribution
  4  [ ]   UFGA     ( ) Autocorrelation             Graph
  5  [ ]   UFGA     ( ) Rainfall probability
  6  [ ]   UFGA                                     Cancel
                    OK        Cancel
```

SCREEN 36.



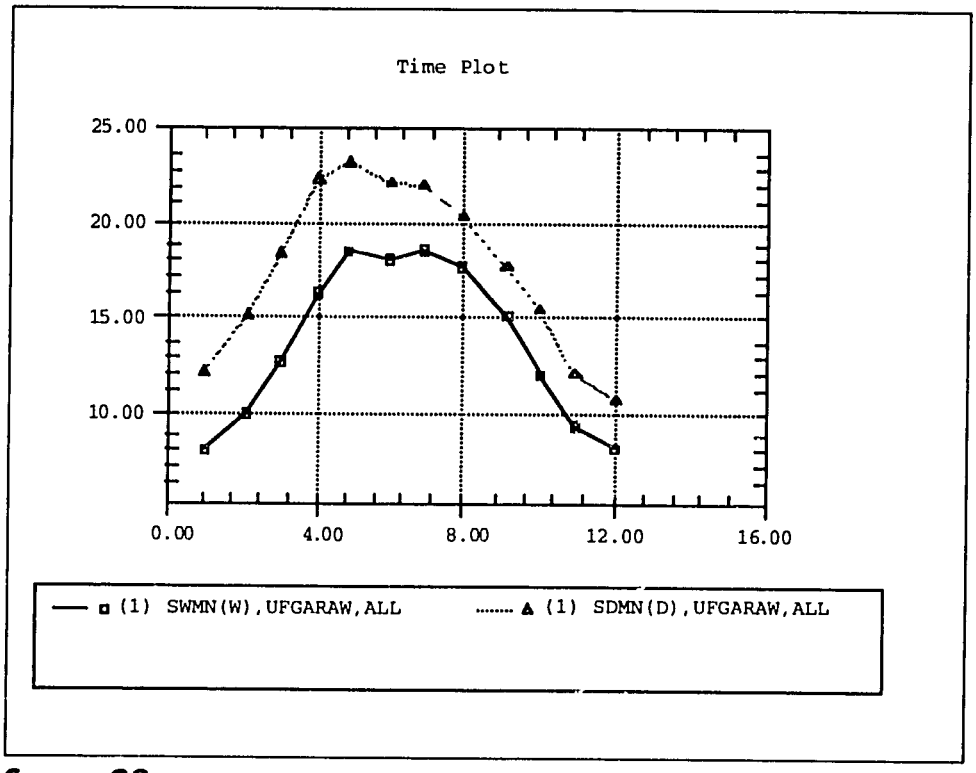
SCREEN 37.

dialog boxes. Choices for Grouping are the same as in Screen 32 and 33, except there is an additional option: "Daily time series." In some of the graph types, the "Daily time series" option is replaced with an "All data" combined option, which pools all the available data together. An example of the "Select Grouping" dialog box is shown in Screen 37 (above) for a "Time plot."

The RANGE button in Screen 37 selects a global time period for the graph using the Time Period described in Chapter 2 in the section on "Common Dialog Boxes In WeatherMan." Extreme limits on the time period are given as defaults in year, day-of-year format (1800/001 to 2099/366) because it is impossible to determine all the possible time periods for combinations of plots. Only feasible ranges will be plotted. The GRAPH button calls the graphics program (WMGRAF.EXE) and plots the data.

An example of a graph generated by WeatherMan is shown in Screen 38 (on following page). Screen 38 shows a daily time series of mean solar radiation in $MJ/m^2/day$ on wet-days, SWMN, and on dry days, SDMN, over a 12-month period..

In Screen 38, the lower portion of the graphic screen contains a legend describing the data plotted. The legend contains a representation of the lines and symbols used for each plot, a multiplier for scaling the y-axis, and a brief text description of the variable. In general, the first 4 characters are the variable type. If a "W," "D," or "A" appears in parentheses, it



SCREEN 38.

represents wet state (i.e., wet, dry, or all). The next four characters following the first comma are the station name, followed by "RAW" (observed data), "GEN" (generated data), or "FIL" (observed data with any missing or suspect data filled-in). The text following the final comma represents the time period (month, year, or "ALL"). Variable names that appear in graphs are defined in Appendix A.

OPTIONS MENU

The OPTIONS menu item found on the WeatherMan main menu allows you to change and save options and defaults. The OPTIONS menu is shown in Screen 39 (on following page) and its options are described as follows.

NOTE: *Unless the "Update options" option is selected first, the menu options listed in Screen 38 are only for the WeatherMan session you are currently working in.*

```
File  Station  Import/Export  Generate  Analyze  Options  Quit   14:50:09
                                         ┌──────────────────────┐
                                         │ Display mode         │
                                         │ Colors               │
                                         ├──────────────────────┤
                                         │ Directories          │
                                         │ Temporary files      │
                                         ├──────────────────────┤
                                         │ Graph colors         │
                                         │ Graph output         │
                                         ├──────────────────────┤
                                         │ Update options       │
                                         └──────────────────────┘
```

SCREEN 39.

DISPLAY MODE

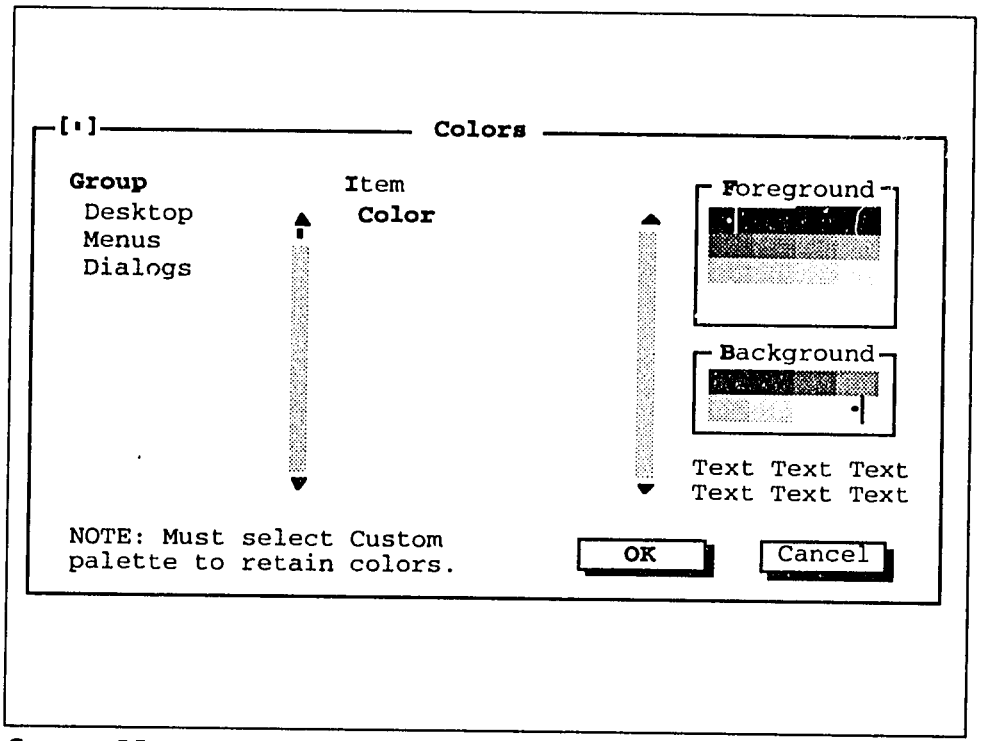
When the "Display mode" option is selected, the "Video Mode" dialog box shown in Screen 40 (below) is presented.

The "Video mode" window in Screen 40 is best left on "Autodetect" unless the program has difficulty selecting the correct mode and a manual choice of an alternative mode or

```
[■]──────── Video Mode ────────
 Video mode:
  (•) Autodetect mode
  ( ) Color palette
  ( ) Black & White palette
  ( ) Monochrome palette
  ( ) Custom palette

      [ OK ]        [ Cancel ]
```

SCREEN 40.



SCREEN 41.

color palette gives a better screen appearance. The LCD and plasma screens used on some portable computers often look better using a "Black and White palette" than with the automatically detected color mode. In addition, the "Colors" option in Screen 39 allows you to create a custom color palette. You may change the WeatherMan program default colors by doing the following: 1) select the "Colors" option, and choose your custom colors (see Screen 41, above, and the section "Colors" below); 2) select the "Display mode" option (Screen 39) and select "Custom palette" in Screen 40; 3) press the OK button; and 4) select the "Update" menu option from the OPTIONS menu. From that point on, whenever WeatherMan is started, your customized colors will be active.

COLORS

The "Colors"option gives you access to the "Colors" dialog box which permits the default colors for the desktop (background), menus and dialog boxes to be changed. In order for these colors to remain in effect in subsequent WeatherMan sessions, following the description on how to do this in the above section, "Display mode." The "Colors" dialog box is shown in Screen 41 (above).

```
[•]──────────────── Directories ────────────────

      [X] Obtain directories from DSSATPRO.FLE.

Weather data:        C:\DSSAT3\WEATHER\

Climate files:       C:\DSSAT3\WEATHER\CLIMATE\

Graphics program:    C:\DSSAT3\

Graphic output:      C:\DSSAT3\WEATHER\

Editor path & file:  C:DOS\EDIT.COM
Editor command line

              [ OK ]              [ Cancel ]
```

SCREEN 42.

DIRECTORIES

When the "Directories" option in Screen 39 is selected, the "Directories" dialog box, shown in Screen 42 (above), is presented. This dialog box permits you to change the default directories and editor.

All the information listed in Screen 42 can also be obtained from the DSSAT v3 profile file called DSSATPRO.FLE (see Volume 1-3, Hunt et al. 1994, of this book for a description of this file). When the "Obtain directories from DSSATPRO.FLE" box in Screen 42 is checked, directories that conflict with those in DSSATPRO.FLE are disregarded. This box should generally be checked only when running WeatherMan under DSSAT v3.

The directory, name, and any command line options for the user's favorite editor can replace the default editor.

TEMPORARY FILES

When the "Temporary files" option is selected, the "Temporary File Options" dialog box, shown in Screen 43 (on following page), is presented. From this dialog box, you can control the status of temporary files.

The files that are temporary are filled and generated archive (WTD) files and statistics

```
[•]— Temporary File Options

Filled and generated
archived files:
 (•) Discard at end of session.
 ( ) Prompt for each file.
 ( ) Keep at end of session.

Summary statistics files:
 (•) Discard at end of session.
 ( ) Prompt for each file.
 ( ) Keep at end of session.

      OK          Cancel
```

SCREEN 43.

(SUM) files. These files should normally be deleted to avoid wasting disk space, but may be retained if desired. For example, generation and analysis of a very long weather record may justify keeping the generated and statistics files.

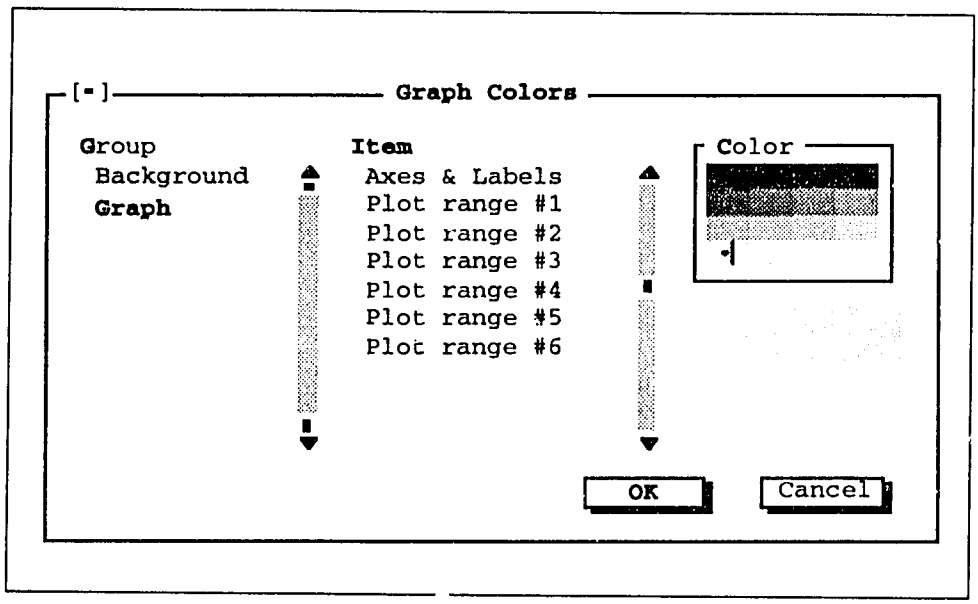
GRAPH COLORS AND GRAPH OPTIONS

Both "Graph colors," and "Graph options" allows you to set graph options.

Graph colors. When the "Graph colors" option is selected, a "Graph Colors" dialog box dialog, as shown in Screen 44 (on following page), is presented, which allows you to set the colors of the background and graph (lines).

Graph output. When the "Graph output" option is selected, the"Graph Output Options" dialog box, shown in Screen 45 (on following page) is presented. In this dialog box, you can specify the device, port and orientation for hardcopy output.

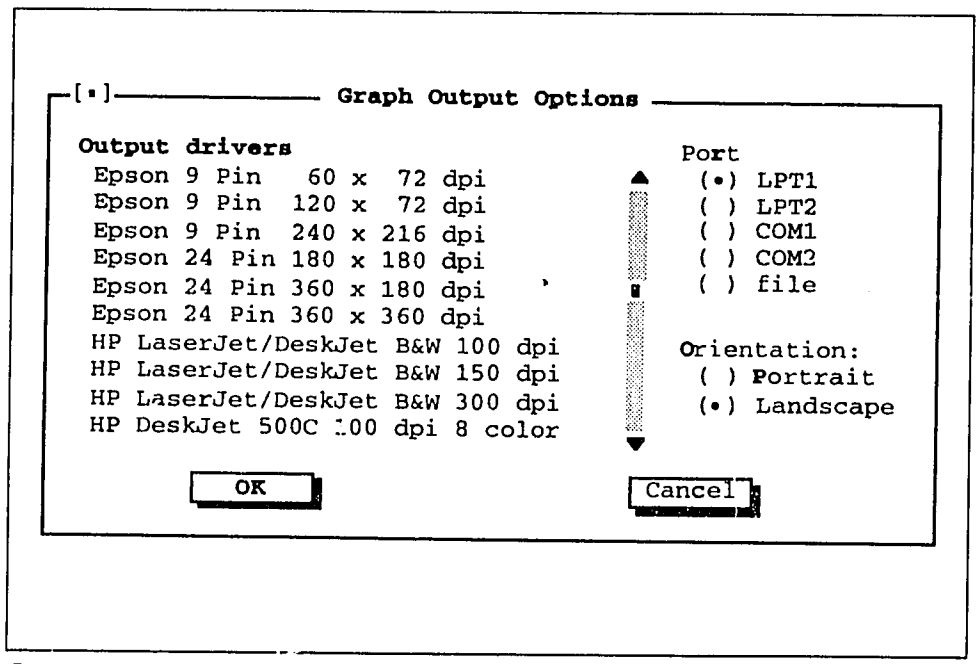
In Screen 45, you can select an output device type/resolution/paper size combination from the scrolling list. If a "file" is selected as the output port (see the options under the "Port" window), the user is prompted for a file name using a standard "File List" dialog box prior to entering the graphics program from the ANALYZE|"Graph" menu item.



SCREEN 44.

UPDATE OPTIONS

Selecting the "Update options" menu item allows you to save the options you have selected. All WeatherMan options are saved to the configuration file WM.CFG while Graphics



SCREEN 45.

program options are saved to DEVICE.FLE and GCONFIG.FLE. These options are then used the next time WeatherMan is started.

QUIT MENU

When the QUIT menu item is selected from the WeatherMan main menu, you can choose to exit the program. You may also use the <ALT>-<Q> key sequence as a short-cut key sequence to quit. The user may also use the shortcut-key options, <ALT>-<X> or <ALT>-<FX>, under the FILE menu to quit the WeatherMan program.

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APPENDIX A.
ABBREVIATIONS USED IN WEATHERMAN

Daily Weather Variables

SRAD	Total daily solar radiation.
TMAX	Maximum daily air temperature.
TMIN	Minimum daily air temperature.
RAIN	Total daily precipitation.
DEWP	Dew point temperature or vapor pressure.
WIND	Total daily wind run.
SUNH	Total daily sunshine hours.
PAR	Total daily photosynthetic radiation.
TWET	Wet bulb air temperature at 9 a.m.
EVAP	Total daily pan evaporation.

Summary Files

Time variables

DOC	Number of days since January 1, 1801.
MTH	Month (1 - January, 2 - February, etc.).
MNO	Month number, counting from the first month in the data set.
YR	Year of century (eg., 94 can represent 1994).
YRNO	Year number, counting from the first year in the data set.

Moments

The first character in moment variables represents the weather variable type. The second represents wet state. The final two represent the type of statistic.

S___	Total daily solar radiation.
X___	Maximum daily air temperature.
N___	Minimum daily air temperature.
R___	Total daily precipitation.
P___	Total daily photosynthetic radiation.
_D__	Dry days (i.e., without precipitation).
_W__	Wet days (i.e., with precipitation).

_A__	All days
__MN	Mean.
__SD	Standard deviation.
__SK	Skewness coefficient.
__KT	Kurtosis coefficient.

PERCENTILES

P0	Minimum.
P25	25th percentile.
P50	Median.
P75	75th percentile.
P100	Maximum.

DISTRIBUTION

BINi	The relative frequency of observations falling within the ith interval.

TIME STRUCTURE

SDEV	Standard deviation.
LAGi	Lag i (i=0..5) autocorrelation coefficients.
PW	Probability of a wet day.
PWW	Probability of a wet day following a wet day.
PDW	Probability of a wet day following a dry day.
PWWW	Probability of a wet-wet-wet sequence.
PDWW	Probability of a dry-wet-wet sequence.
PWDW	Probability of a wet-dry-wet sequence.
PDDW	Probability of a dry-dry-wet sequence.

APPENDIX B.
CLIMATE FILE FORMAT

The climate file contains summary information on a site in five sections. The *CLIMATE section contains characteristics of the location. The *MONTHLY AVERAGES section contains monthly means and Angstrom coefficients used by the SIMMETEO weather generator. The *WGEN PARAMETERS section contains the monthly distribution parameters used by the WGEN weather generator. The *RANGE CHECK VALUES section contains the values used to check for outliers and suspect data during the Import process. The *FLAGGED DATA COUNT section contains counts of total, erroneous, and suspect data in the archive file.

*CLIMATE

LAT	Latitude, degrees north.
LONG	Longitude, degrees east.
ELEV	Elevation, m.
TAV	Mean annual temperature, °C.
AMP	Half of the mean temperature difference between the warmest and coolest month.
SRAY	Mean annual daily solar radiation, $MJ/m^2/day$.
TMXY	Mean annual daily maximum temperature, °C.
TMNY	Mean annual daily minimum temperature, °C.
RAIY	Mean annual daily rainfall, mm.
START	Mean day of year of the first frost-free day.
DURN	Mean number of days between the last and the first frost.
ANGA	Intercept A in the Angstrom equation (Prescott, 1940).
ANGB	Multiplier B in the Angstrom equation (Prescott, 1940).
REFHT	Height of weather instruments above ground, m.
WNDHT	Height of annemometer above ground, m.
GSST	First year of observed weather data.
GSDU	Number of years of observed weather data.

*MONTHLY AVERAGES

MONTH	Month (1 - January, 2 - February, etc.).
SAMN	Mean daily solar radiation for month, $MJ/m^2/day$.
XAMN	Mean daily maximum temperature for month, °C.
NAMN	Mean daily minimum temperature for month, °C.
RTOT	Mean total rainfall for month, mm.
RNUM	Mean number of days with rainfall for month.
SHMN	Mean daily hours of bright sunshine for month, percent of daylength.
AMTH	Intercept A in the Angstrom equation for month.
BMTH	Multiplier B in the Angstrom equation for month.

*WGEN PARAMETERS

MTH	Month (1 - January, 2 - February, etc.).
SDMN	Mean daily solar radiation on dry days, $MJ/m^2/day$.
SDSD	Standard deviation of solar radiation on dry days.
SWMN	Mean daily solar radiation on wet days, $MJ/m^2/day$.
SWSD	Standard deviation of solar radiation on wet days.
XDMN	Mean daily maximum temperature on dry days, °C.
XDSD	Standard deviation of maximum temperature on dry days.
XWMN	Mean daily maximum temperature on wet days, °C.
XWSD	Standard deviation of maximum temperature on wet days.
NAMN	Mean daily minimum temperature, °C.
NASD	Standard deviation of minimum temperature.
ALPHA	Alpha coefficient of gamma distribution for rainfall.
RTOT	Total rainfall, mm.
PDW	Probability of a wet day following a dry day.
RNUM	Mean number of days with rainfall.

*RANGE CHECK VALUES

MIN	Minimum value for range check.
MAX	Maximum value for range check.
RATE	Maximum change between days for range check.

*FLAGGED DATA COUNT

BEGYR	Year of first daily weather record.
BEGDY	Day of year of first daily weather record.
ENDYR	Year of last daily weather record.
ENDDY	Day of year of last daily weather record.
TOTAL	Total number of observations.
VALID	Number of observations without error flags.
MISSING	Number of missing values.
ERROR	Number of values with non-numeric strings encountered.
ABOVE	Number of values above the maximum.
BELOW	Number of values below the minimum.
RATE	Number of values with greater than maximum change from previous day.

VOLUME 3-4

GENOTYPE COEFFICIENT CALCULATOR

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CHAPTER ONE. INTRODUCTION

The Genotype Coefficient Calculator (or GenCalc) was developed to facilitate determination of the genotype coefficients that are made use of by the IBSNAT crop models (Hunt, 1988; Hunt et al., 1993). The first released version of the software was distributed earlier (Hunt et al., 1993; Hunt and Pararajasingham, 1993) with focus on the crop models distributed with Version 2.1 of the IBSNAT software package called DSSAT. DSSAT v3, however, has new crop models and new data standards and thus there was a need for GenCalc to be upgraded to facilitate use with the new models. The changes required are minor, but for consistency it was thought best to issue a users guide that relates specifically to the Version 3 series of models.

GenCalc V3.0 can be used with any model that is constructed to accord with certain basic requirements (Appendix 1). In particular, it requires genotype coefficient files that conform to the standard structures defined in Volume 2-1, Jones et al. 1994, of this book, and a crop model output file, OVERVIEW.OUT, that contains a list of simulated and measured values for 'key' variables. In use, it requires that a user respond to a number of prompts. Information to help with the choices is displayed on most screens.

PROGRAM COMPONENTS

GenCalc encompasses a number of components, as depicted in flow chart form in Figure 1. The components are described as follows.

PROGRAMS

GENCALC.EXE.	The shell program that sets up the various control files, activates the overall control program, and runs the appropriate model (BASIC).
GENCON.EXE.	A control program that reads simulated and measured data from one of the model output files (OVERVIEW.OUT) and then, if needed, changes the appropriate genotype coefficient to bring simulated values closer to the measured data (FORTRAN).
GENMEANS.EXE.	An 'averaging' program that calculates means for coefficient values from individual experiments (BASIC).

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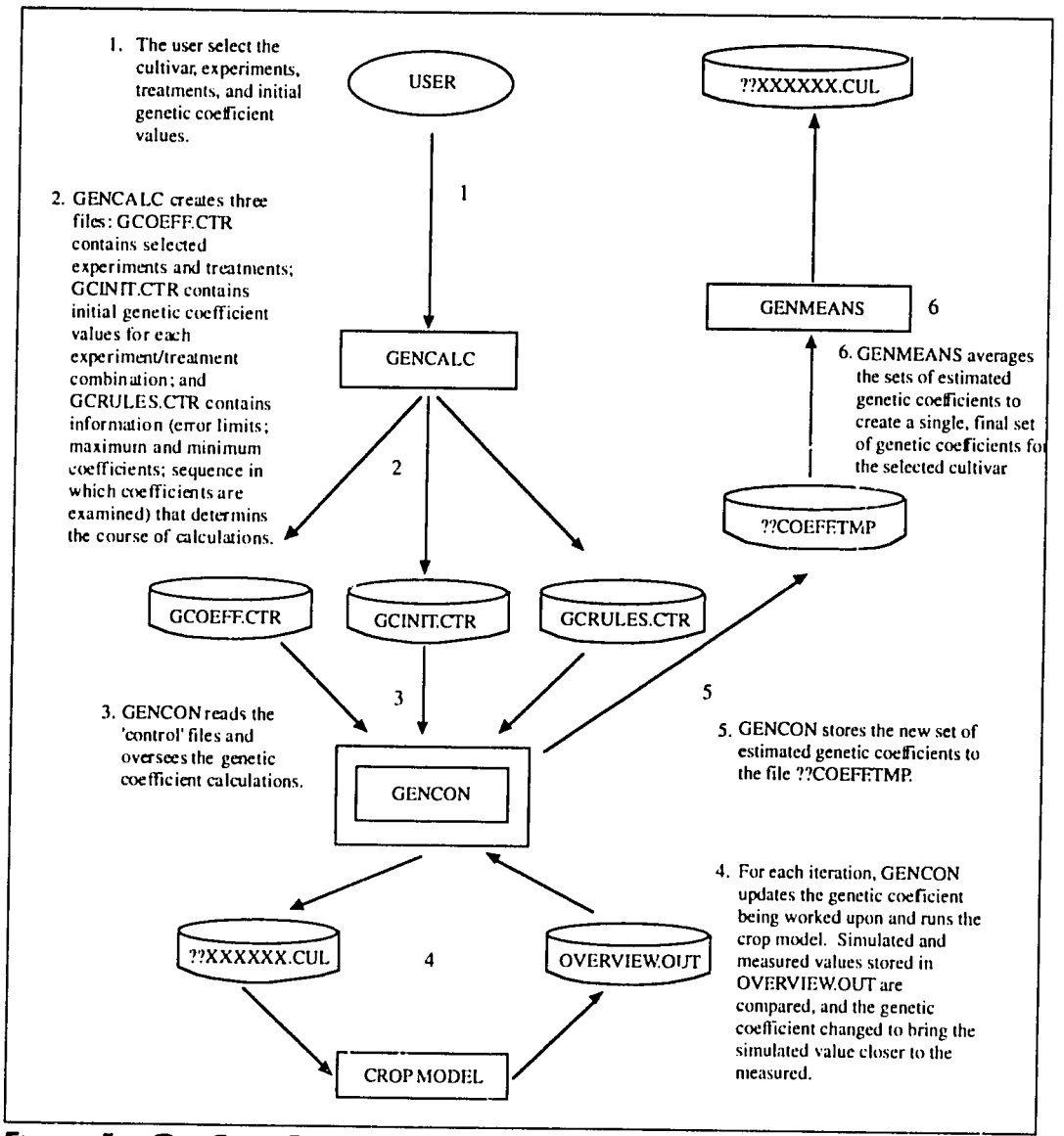

FIGURE 1. GENCALC COMPONENTS.

The BASIC programs require a run-time module, BRUN45.EXE. It's path must be referenced in the path statement in the AUTOEXEC.BAT file.

FILES

DSSATPRO.FLE — A profile (configuration) file that indicates the name and location on disk of programs and files that are used by GenCalc. The file

is detailed in Appendix B, along with procedures for making changes to it. In DSSAT v3, GenCalc is located in directory C:\DSSAT3. For stand-alone use, the directory in which it is located could be chosen at the user's discretion. In all cases, however, the directory must be referenced by adding a 'SET' statement to the AUTOEXEC.BAT file. For a C:\DSSAT3 location, the required statement would be: SET DSSAT3 = C:\DSSAT3.

GCRULES.FLE — A file containing the rules that govern the sequence of genotype coefficient calculations for different crops. This file can be located in any directory, but the directory must be referenced in the configuration file. Contents of the file are copied to a temporary file (GCRULES.CTR) that is used during computation.

??COEFF.TMP and ENDPOINT.TMP — Files generated internally at each new model run. The ?? indicates a crop code such as 'WH' for wheat. The calculated genotype coefficient values are stored in ??COEFF.TMP while end point information (simulated and measured values at completion) is stored in ENDPOINT.TMP for each coefficient. Information in these files is displayed for perusal at the completion of a genotype coefficient calculation session.

REQUIREMENTS

In DSSAT v3, the file designated as FILEA required in addition to those which are necessary for running the DSSAT v3 models. The naming convention for these files and for FILEA is described in Volume 2-1, Jones et al. 1994, of this book. FILEA contains experimental data used to determine the goodness-of-fit of simulated results. The following data must be present in FILEA:

Peanut:

- Flowering date
- Maturity date
- Seed yield
- Biomass at maturity
- Seed number/m^2
- Seed number per pod
- Seed dry weight
- First pod date
- Full pod date
- Pod yield (dry)

Maize:
Silking date
Maturity date
Grain yield (dry)
Biomass at maturity
Grain number/m^2
Grain number per ear
Grain weight (dry)

Soybean:
Flowering date
Maturity date
Grain yield
Biomass at maturity (no leaves)
Grain number/m^2
Grain number per pod
Grain dry weight

Wheat:
Anthesis date
Maturity date
Grain yield (dry)
Biomass at maturity
Grain number/m^2
Grain number per spike
Grain weight (dry)

The files that contain the genotype coefficients for the models used with the calculator are named as ??XXXYY0.CUL, where "??" is the crop identification code, "XXX" is the model abbreviation and "YY" is the version number of the model. Genotype coefficient values calculated from model runs, at the user's discretion, may be entered into this cultivar file. As described under the GenCalc operation (see Step 5 in Chapter 4), the genotype coefficient values from the cultivar file are copied to the GCINIT.CTR file for display as initial values for the genotype in question. (The GCINIT.CTR file is explained in Figure 1). For the case where a genotype that is not present in the cultivar file is included in an experiment, the user must use an editor to enter into the cultivar file a unique number and name and an initial 'guess' at the genotype coefficients.

System Requirements

GenCalc will run on any IBM or IBM-compatible computer with MS-DOS v3.0 and later. A hard disk drive with approximately 2 Mb free disk space is required. For stand-alone installation, GenCalc requires the creation (if not already present) of a directory C:\DSSAT3. The DSSATPRO.FLE described in the Components section of this guide and Appendix B must be placed in this directory. GenCalc also uses a number of subdirectories under C:\DSSAT3, namely GENOTYPE, PEANUT, SOYBEAN, and WHEAT. The GenCalc component programs together with the crop model executable programs are placed in the DSSAT3 subdirectory, while the crop model input files are placed in subdirectories named after the crop in question. Model and crop specific genotype coefficients files (??XXXYY0.CUL files) and the GCRULES.FLE are placed in the GENOTYPE subdirectory. All could be changed, as long as the location of the configuration file (DSSATPRO.FLE) remains the same as that of the program executables.

CHAPTER TWO.
GETTING STARTED

GenCalc can be run from the DSSAT v3 Shell or as a stand-alone program. (See Volume 1-3, Hunt et al. 1994b, of this book for a description of the Shell.) From the DSSAT v3 Shell, open the DATA main menu, select "Genotype" from the menu (see Screen 1, below) and then select "Calculate" from the submenu presented. The first screen of the GenCalc program (Screen 3) will be presented.

To run GenCalc as a stand-alone program, refer to Hunt and Pararajasingham (1994).

Transfer experiment data sets with genotypes you wish to examine into the appropriate directory (e.g., wheat data into C:\DSSAT3\WHEAT), and use an editor to add the experiment(s) to the list in the EXP.LST file. (See Appendix A for an example of this file and Volume 2-1, Jones et al. 1994, for this book for a description of this file.) These data sets must be complete with weather and soils data and with data in the cultivar file.

```
DECISION SUPPORT SYSTEM FOR AGROTECHNOLOGY TRANSFER

   DATA        MODEL       ANALYSES       TOOLS       SETUP/QUIT

 B Background
 X Experiment
 G Genotype
 W Weather
 S Soil
 P Pest
 E Economic

Cultivar, ecotype, and species information.

 ↑ ↓ → ←   moves through menu choices
 ESC       moves to higher menu level                Version: 3.0
```

SCREEN 1.

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CHAPTER THREE. RUNNING GENCALC

When GenCalc is opened from the DSSAT v3 Shell DATA main menu, Screen 2 (below) is presented. Follow the procedure in the steps listed below to determine the coefficients for one genotype. This procedure is often followed in determining coefficients, but it is not the only one. It should thus be viewed as a starting point, not as a *fixed recipe*. Users may develop a different approach, as experience is gained, or they may miss some steps. Users should also be aware that some errors may cause the software to enter an endless loop. Should this appear to happen, turn off the computer or re-boot by pressing <CTR>-<ALT>-<DEL>.

DETERMINE GENETIC COEFFICIENTS

1. In Screen 2, press the <I> key. This directs the genotype coefficient calculator to determine values for specific experiment/treatment combinations.

2. Select a crop in Screen 3 (on following page) for the genotype you wish to calculate

```
GENOTYPE COEFFICIENT CALCULATOR                                VERSION : 3

  The calculator can be used to determine coefficients for individual
  treatments, or to calculate averages from previous determinations.

  PRESS

    'I' for INDIVIDUAL determinations

    'A' for AVERAGES calculations

    'Q' to QUIT

  NB Please ensure that any datasets to be used are 'model tested'.

  Determine genotype coefficients for one or more experiments; calculate
  average values after determining coefficients for several experiments.
```

SCREEN 2.

Previous Page Blank

```
G.C.CALCULATOR - INDIVIDUAL                                    VERSION : 3

  PRESS:

    B   for   BARLEY     D   for   DRY BEAN     A   for   AROIDS
    I   for   MILLET     Y   for   SOYBEAN      C   for   CASSAVA
    M   for   MAIZE      P   for   PEANUT       T   for   POTATO
    R   for   RICE
    S   for   SORGHUM
    W   for   WHEAT

    O   for   OTHER                        ESC for previous screen

  NB. The model installed must meet Gencalc requirements.  If you
      are unsure, exit and check Model and Gencalc documentation.

  Determine genotype coefficients for one or more experiments; calculate
  average values after determining coefficients for several experiments.
```

SCREEN 3.

3. Decide whether to delete the contents of individual values file (??COEFETMP) from previous GenCalc sessions. As the message on the screen indicates, the contents of this file must be deleted from time to time to keep the file size manageable.

4. When a crop is selected (e.g., M = Maize) in Screen 3, a list of genotypes available for that crop for analysis is presented in Screen 4 (on following page). Select one of the genotypes from the list.

5. After a genotype is selected in Screen 4, examine the list of genotype coefficients from the GCINIT.CTR file which will be displayed in a screen similar to Screen 5 (on following page). In example Screen 5, the coefficients shown are for maize. The coefficients displayed in this screen will be used as initial values for the first run of the calculator. Abbreviations are listed in the file GENCOEFFABV in the c:\DSSAT3\GENOTYPE directory (see Appendix C). If satisfied with the coefficients listed, press "Y" to accept the values. Or, press "N" to modify the values of one or more of the coefficient(s) for use in the first model run.

   When "N" is selected in Screen 5, Screen 6 (on 2nd following page) is presented, in which you can alter the coefficient values. When values for all the coefficients listed are acceptable, press "Y" at the Screen 5 prompt.

```
G.C.CALCULATOR - INDIVIDUAL                                  VERSION : 3

  CROP: Maize                          MODEL: GECER930

  No Name
   1 PIO 3382
   2 McCurdy 84aa
   3 H610(UH)
   4 PIO x 304C

  Enter NUMBER to select genotype: press ENTER for previous screen --->

Determine genotype coefficients for one or more experiments; calculate
average values after determining coefficients for several experiments.
```

SCREEN 4.

6. In the next dialog box presented, respond with an "N" to the prompt, 'Calculate ALL coefficients?'. And at the next prompt, respond with a "Y" to calculate only the DEVELOPMENT (those concerned with the duration of the life cycle) coefficients.

7. Screen 7 (on following page) will be presented which lists experiments which include

```
G.C.CALCULATOR - INDIVIDUAL                                  VERSION : 3

  CROP: Maize                          MODEL: GECER930

  Current coefficients are:
    P1     P2     P5     G2     G3  PHINT
  1      2      3      4      5      6
  320.   .520   940.   625.   6.00   75.0
  Use these for first simulation of new run ?

  Press : Y or N

Generally, the displayed coefficients should be used for the first run;
changed for susequent runs.  This helps in obtaining multi-site fits.
```

SCREEN 5.

```
G.C.CALCULATOR - INDIVIDUAL                                  VERSION : 3

CROP: Maize                          MODEL: GECER940

Current coefficients are:
  P1    P2    P5    G2    G4 PHINT
1     2     3     4     5     6
320.  .520  940.  625.  6.00  75.0
Which coefficient to change ?
ENTER 1,2 etc. -->

Generally, the displayed coefficients should be used for the first run;
changed for subsequent runs.  This helps in obtaining multi-site fits.
```

SCREEN 6.

the selected genotype. Choose experiments to be used for genotype coefficient calculation by typing either "Y" or "N" to the prompt for each experiment.

8. The treatments for each experiment selected will be displayed in Screen 8 (on following page). Choose all or some treatment(s) in the chosen experiments for genotype coefficient calculation by responding appropriately ("Y" or "N") to the prompts on the screen.

```
G.C.CALCULATOR - INDIVIDUAL                                  VERSION : 3

CROP: Maize                          MODEL: GECER940

The selected genotype was included in experiment: IBWA8301

Accept this experiment ?

Press : Y or N

Generally it is preferable to work first with few experiments and/or
treatments, then to proceed using the coefficients so determined.
```

SCREEN 7.

```
G.C.CALCULATOR - INDIVIDUAL                                  VERSION : 3

CROP: Maize                          MODEL: GECER940

The selected genotype was included in experiments:  IBWA8301
....... in the following treatments:

1  2  3

Accept all treatments ?   Press : Y or N

Generally it is preferable to work first with few experiments and/or
treatments, then to proceed using the coefficients so determined.
```

SCREEN 8.

9. In the dialog box next presented, type an "N" at the prompt, 'Selection of runs for this genotype complete?' because you want to set up another sequence of calculation for the genotype in question but with different initial coefficients.

   Screen 5 will again be presented (see Step 5). Change one of the coefficient(s) by 20 to 30% as described under Step 5.

   When the prompt 'Selection of runs for this genotype complete?' reappears, respond with "N" again to bring up the initial genotype coefficients list, but this time decrease the appropriate coefficient by 10 to 20%.

   NOTE: *Setting an array of initial values for particular coefficient(s) is necessary to develop data for examination of variation in the values fitted for the varying coefficient(s).*

10. Now at the prompt, 'Selection of runs for this genotype complete?', type "Y"to proceed with the genotype coefficient calculation. The calculator will run the appropriate crop model, and data indicating the goodness-of-fit between predicted and actual data will be displayed on the screen as calculations proceed. For each set of calculations, final coefficient values and end point information are stored in files (??COEFF.TMP and ENDPOINT.TMP, respectively) so that these are available for subsequent viewing.

```
G.C.CALCULATOR - INDIVIDUAL                                  VERSION : 3

CROP: Maize                                  MODEL: GECER930

All calculations completed ...

PRESS:  C  to view COEFFICIENTS
        E  to view END POINTS
        O  to view OUTPUTS

        A  to calculate AVERAGES

ENTER to proceed to the next menu

It is generally desirable to examine the endpoints.  If the fit was
not good, the process should be repeated with new initial values.
```

SCREEN 9.

11. When calculations are completed, press the <C> key in Screen 9 (above) to view the array of coefficients calculated for each set of calculations in the ??COEFF.TMP file (Screen 10, below). While viewing these final coefficient values, pay particular attention to the codes assigned by GenCalc, if at all, to each of the calculated genotype coefficients (see Appendix C for a description of these codes). Growth coefficients

```
*MAIZE COEFFICIENTS

@NGENO EXPMENT  R RUN T ETYPE      P1     P2     P5    G2    G3 PHINT
IB0063 IBSI8001 2  1  1 IB0001   320.D.5200D 940.D 625.U6.000U75.00U
IB0063 IBSI8001 2  1  2 IB0001   320.D.5200D 940.D 625.U6.000U75.00U
IB0063 IBWA8301 2  1  1 IB0001   340. .5200M 940.M 625.U6.000U75.00U
IB0063 IBWA8301 2  1  2 IB0001   340. .5200M 940.M 625.U6.000U75.00U
IB0063 IBWA8301 2  1  3 IB0001   340. .5200  940.M 625.U6 000U75.00U


F1ABORT F2UNDO F3PRINT F4MARK F5CUT F6PASTE F7EXIT F8DEL EOL F9DEL L F10DEL L I
```

SCREEN 10.

will have a "U" immediately following the numerical value. This indicates that the particular coefficient was not determined during the iterative calculations of the current session. The remaining coefficients should have no associated letter. If this is the case, press the exit key of your editor and proceed to Step 12. If, however, the development coefficients were associated with a letter, which may occur when the initial coefficients were either close to the maximum/minimum values, or were considerably different from the real values, proceed through the following steps:

11a. Screen 10 shows an an example ??COEFF.TMP file for maize. Make a note of the letter and the coefficient value for each coefficient listed which has a letter. The letter "M" indicates that the calculated coefficient reached the maximum or minimum value defined in the GCRULES.FLE file, while an "R" indicates that the maximum number of runs specified in the GCRULES.FLE file was reached before an acceptable end point was reached. Other codes that may appear are defined in Appendix C.

11b. Exit Screen 10 by pressing the <F7> key if using the editor (TVED.EXE) distributed with DSSAT v3. If you are using an editor of choice, use the required key to exit the screen. You will be returned to Screen 9.

11c. Now in Screen 9, press the <E> key to view the end-points in the ENDPOINT.TMP file (see Screen 11, below). For each coefficient with an associated letter noted in Screen 10, make a note as to whether the simulated value is greater or less than the measured value.

*GENOTYPE COEFFICIENT CALCULATION - END POINT COMPARISONS.

EXPERIMENT	TRTMT	COEFF	NAME	SIMULATED	MEASURED	REFERENCE TRAIT(S)
IBSI8001	1	3	DESP (P2)	61.000	.000	SILKING DATE
IBSI8001	1	1	DUJU (P1)	61.000	.000	SILKING DATE
IBSI8001	1	2	DUGF (P5)	111.000	.000	MATURITY DATE
IBSI8001	2	3	DESP (P2)	61.000	.000	SILKING DATE
IBSI8001	2	1	DUJU (P1)	61.000	.000	SILKING DATE
IBSI8001	2	2	DUGF (P5)	111.000	.000	MATURITY DATE
IBWA8301	1	3	DESP (P2)	76.000	79.000	SILKING DATE
IBWA8301	1	1	DUJU (P1)	78.000	79.000	SILKING DATE
IBWA8301	1	2	DUGF (P5)	137.000	139.000	MATURITY DATE
IBWA8301	2	3	DESP (P2)	76.000	79.000	SILKING DATE
IBWA8301	2	1	DUJU (P1)	78.000	79.000	SILKING DATE
IBWA8301	2	2	DUGF (P5)	137.000	135.000	MATURITY DATE
IBWA8301	3	3	DESP (P2)	76.000	78.000	SILKING DATE
IBWA8301	3	1	DUJU (P1)	78.000	78.000	SILKING DATE
IBWA8301	3	2	DUGF (P5)	137.000	136.000	MATURITY DATE

F1ABORT F2UNDO F3PRINT F4MARK F5CUT F6PASTE F7EXIT F8DEL EOL F9DEL L F10UDEL L I

SCREEN 11.

11d. Exit Screen 11 by pressing the <F7> key. You will again be returned to Screen 9.

11e. Press the <ENTER> key in Screen 9 to continue.

11f. Screen 12 (below) will be presented. Press the <G> key to return to the genotype selection screen (Screen 4).

11g. Choose the same genotype as selected before in Screen 4.

11h. If the letter from the??COEFF.TMP file (Screen 10) for a coefficient was an "R," respond with an "N" to the prompt, 'Use these for first simulation of new run?'. Then in the dialog box which appears, change the value for the appropriate coefficient. Increase the value by approximately 30% if the simulated value was less than the measured; decrease the value similarly if the inverse. Then proceed as from Step 6.

If the letter was an "M," proceed as from Step 5, but when the Coefficient Selection screen (Screen 6) is reached, press the <ENTER> key and edit the rules file. For the coefficient(s) in question, reduce the minimum (MNCEF) or increase the maximum (MXCEF) for rule set 2 of the crop in question, depending on whether the coefficient value noted in Step 11a was near the minimum or maximum. Then exit the rules file and proceed as indicated in Step 6.

```
G.C.CALCULATOR - INDIVIDUAL                                VERSION : 3

PRESS:

   G  to select more GENOTYPES

   C  to select another CROP

ENTER to return to the main menu

Determine genotype coefficients for one or more experiments; calculate
average values after determining coefficients for several experiments.
```

SCREEN 9.

12. If the coefficient calculations proceeded to completion satisfactorily, press the <ENTER> key and you will be prompted in the next screen for selection of another genotype of the same crop, for the selection of another crop, or for return to the main menu. Press the <ENTER> key to return to the GenCalc main menu (Screen 2), and once within the main menu, press "A" for the calculation of average coefficients from previous determinations. Selecting "A" allows you to calculate the AVERAGES of coefficients calculated from various experiments using the Steps above. If desired, you may replace coefficient values in the cultivar file with these values (see Step 20).

13. The calculator will then prepare a list of coefficients calculated for the genotype in question in previous specific experiment/treatment runs (Screen 13, below). Each of these runs is assigned a sequence number in the listing (RUN column) as shown in Screen 10, along with a number denoting whether all (1), development (2) or growth (3) coefficients were determined (R column). A column headed with a "T" contains the number of the treatment used for the particular set of coefficient calculations.

14. In Screen 13, select a run number. Once a run number is chosen, mean coefficients are calculated from individual values obtained for different experiments and treatments but with the same initial coefficient values, along with their respective coefficients of variation. These values are displayed, together with values currently in the cultivar

```
G.C.CALCULATOR - AVERAGES                                    VERSION : 3

CODE   EXPMENT  R RUN T ETYPE    P1      P2     P5     G2     G3 PHINT
IB0063 IBSI8001 2  1  1 IB0001  320.D.5200D 940.D 625.U6.000U75.00U
IB0063 IBSI8001 2  1  1 IB0001  320.D.5200D 940.D 625.U6.000U75.00U
IB0063 IBSI8001 2  2  1 IB0001  320.D.5200D 940.D 625.U6.000U75.00U
IB0063 IBSI8001 2  2  2 IB0001  320.D.5200D 940.D 625.U6.000U75.00U
IB0063 IBWA8301 2  1  1 IB0001  340. .5200M 940.M 625.U6.000U75.00U
IB0063 IBWA8301 2  1  2 IB0001  340. .5200M 940.M 625.U6.000U75.00U
IB0063 IBWA8301 2  1  3 IB0001  340. .5200M 940.M 625.U6.000U75.00U
IB0063 IBWA8301 2  2  1 IB0001  340. .5200M 940.M 625.U6.000U75.00U
IB0063 IBWA8301 2  2  2 IB0001  340. .5200M 940.M 625.U6.000U75.00U
IB0063 IBWA8301 2  2  3 IB001   340. .5200  940.M 625.U6.000U75.00U

Which RUN to select ? [ Enter number from RUN column ] -->

Main coefficients for different experiments and initial values.
Initial values are referenced in the 'Run' column. T=treatments.
```

SCREEN 13.

```
G.C.CALCULATOR - AVERAGES                                    VERSION : 3

GENOTYPE: P10 X 304C
                1      2      3      4      5      6
                P1     P2     P5     G2     G3  PHINT
Old values:  320.   .520   940.   625.   6.00   75.0
New vlues:   340.   .520   .000   .000   .000   .000
C.V.'s:        0      0      0      0      0      0

Treatments:    3      1      0      0      0      0

Number of experiments :  1

SELECT an additional run ?  [ PRESS Y or N ]

Coefficient values determined for differnet experiments and one set
of initial values. Coefficients of variation if more than 3 values.
```

SCREEN 14.

file, in Screen 14 (above). Coefficients that were not estimated, or for which calculations were terminated before an acceptable end-point was reached, are displayed as zeros. These coefficients would have had a letter associated with them in the ??COEFF.TMP file (see Step 11).

15. In the dialog box at the bottom of Screen 14, press "Y" to select an additional run.

16. Press "Y" again when the second set of coefficients has been calculated. Press "Y" and "3" to select results from the third run.

17. This time press "N" at the prompt in Screen 14 to indicate that run selection is complete.

18. At this stage a list of standard deviations for coefficients in the different runs is presented. Select the one with the lowest standard deviation for the 'target' coefficient.

19. A list of 'new' and 'old' mean coefficient values is now displayed. In this list, coefficients that were not calculated will have been replaced by those in the cultivar file. Press "Y" at the prompt to accept all values.

20. Respond with a "Y" to the prompt asking whether or not to replace the 'old' values in the cultivar file.

21. Respond with an "N" to the prompt asking if you wish to edit the cultivar file, although including notes in the cultivar file may be useful for future reference.

22. At this stage, the process should be repeated from Step 1 to calculate the growth coefficients for the cultivar in question. Exit the averaging program and press the <ENTER> key to display the prompts to select another genotype or a different crop. Press the <G> key to select a genotype and repeat the process.

23. Respond with an "N" response to the prompt "Calculate DEVELOPMENT coefficients only." Follow this by a "Y" response to the prompt "Calculate GROWTH coefficients only" in Step 6. Continue with Step 7.

Repeat the process for the GROWTH coefficients. Upon completion, you should have both the DEVELOPMENT and GROWTH coefficients needed to run the appropriate crop model.

DISCUSSION

The above step-by-step instructions cover the basics of GenCalc operation. The various options available in GenCalc, however, make it possible to determine genotype coefficients in a number of different ways. Users should be aware of this and should experiment with procedures that may be more appropriate for their own specific conditions. Users should also be aware that it may not be possible to 'fit' coefficients for some data sets. Should this appear to be the case, a user is encouraged to contact the authors and to provide them with a copy of the data set being used. Such communication will help both with development of the GenCalc software and with further enhancement of the crop models.

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APPENDIX A.
GENCALC MODEL REQUIREMENTS

For use with GenCalc, models must satisfy a number of basic requirements, as summarized below in Table 1. Details of these requirements are provided below:

1. The name of the EXE file should be built in accord with a convention in which the first two spaces are for a standard crop code (e.g., SB for soybeans; WH for wheat), and the next six are for an abbreviated model name and number (e.g., SBGRO941 for the soybean 'GRO' model, 94 version, modification 1).

2. Input and simulator components of the model should obtain basic run control information from the command line after the executable file name. For the simulator component, which may be the only component of some models, required information encompasses:(a) the name of the experiment details/simulator control file, (b) a symbol to indicate the nature of the experiment details file (e.g., 'X' for a standard experiment details file [see Volume 2-1, Jones et al. 1994, of this book for a description of this file]), (c) a symbol for the mode of model operation (a 'G', programmed in the model to turn off all prompts), (d) a run number and (e) a number indicating the treat-

TABLE 1. REQUIREMENTS FOR CROP MODELS TO WORK UNDER GENCALC.

Aspect	*Requirement*
Model name	According to convention (e.g. GECER930 for the generic CERES model)
Command line(s)	With basic information for running the driver, input and/or simulator components of the model.
Input files	*.CUL file with genotype coefficients. File name linked to the Model EXE name according to convention
Output files	OVERVIEW.OUT file with table of predicted and measured data
Experiment details, soil and weather files	Standard (Jones et al., 1994).
Experiment data file	Standard 'A' files with averages from one or more experiments (Jones et al., 1994).

Previous Page Blank

ment to be used. The latter two items may be omitted, in which case the run number will be assigned a value of one, and the first treatment encountered will be simulated. The information should be conveyed as in the example which follows:

C:\CRGRO940.EXE XFILE.RUN X G 1 3
where CRGRO940.EXE is the name of the simulator; XFILE.RUN is the name of the file containing the experimental details; X is the experiment details file type; G is the simulator 'mode' switch (G indicates that all prompts should be switched off); 1 is the run number; and 3 is the number of the treatment to be used for simulation.

For the inputs component, where present, the required information encompasses the name of the file to be generated, its type, an inputs program 'mode' switch, and reference numbers for the experiment and treatment to be used. This required information should be conveyed as follows:

C:\MINPT940.EXE XFILE.RUN X G 1 3
where MINPT940.EXE is the name of the inputs program; XFILE.RUN is the name of the file to be generated to transfer data to the simulator; X is the type of transfer file to be generated; G is the inputs 'mode' switch (G indicates that all prompts should be switched off); 1 is the experiment number (as in the EXP.LST file); and 3 is the treatment number.

For models which need to run with their own 'driver', the command line would need to be structured as in the example below:

C:\MDRIVE940.EXE MINPT940.EXE CRGRO940.EXE X G 1 3
where MDRIV940.EXE is the name of the model 'driver'; MINPT940.EXE is the name of the inputs program (reader); CRGRO940.EXE is the name of the simulator; X is the type of transfer file; G is the 'mode' switch for input and simulator components; 1 is the experiment number (as in the EXP.LST file); and 3 is the treatment number.

3. The model should use a genotype coefficient file (or cultivar file) that is named in accord with the EXE file name, but that has a zero (0) in position 8 and an extension 'CUL'. The format of this file should accord with the standards laid down by Hunt et al. (1993) and in Volume 2-1 (Jones et al. 1994) of this book . In this standard, each line begins with 6 spaces for a cultivar identification code (the first two items should be the code for the Institute that assigned the number), a blank, 17 spaces for the culti-

var name, a blank, 5 spaces for a type identifier (e.g., an identifier for highland or lowland bean ecotypes), and then data in a (1X, F5.?) format (i.e., 1 blank, followed by 5 spaces for a real variable with the required number of decimals). An example of a Cultivar file is shown in Table 2.

4. The model should produce an output file that is named OVERVIEW.OUT and that contains a list of simulated and measured values of 'key' variables. This file could contain additional information, but the structure and heading of this list, which could appear early or late in the file, should be as shown in Table 3.

5. The model should use standard files (Jones et al., 1994) to obtain required information on experimental conditions and experimental results. An example is shown in Table 4.

TABLE 2. EXAMPLE OF A CULTIVAR (GENOTYPE) COEFFICIENT FILE.

*WHEAT GENOTYPE COEFFICIENTS

!

@NGENO	NAME	TYPE	DUGF	DESV	DESP	GNUM	GGRO	GNUS	BIOM
IB0002	WARED	WH6X	470.	.0030	.0054	30.00	1.00	.67	1.
IB0003	WALDRON	WH6X	470.	.0030	.0054	30.00	1.00	.67	1.
IB0004	ELLAR	WH6X	470.	.0030	.0054	28.50	1.00	.67	1.
IB0005	BUTTE	WH6X	470.	.0030	.0054	19.00	1.35	.67	1.
IB0006	WARD	WH6X	470.	.0030	.0030	23.00	1.00	.67	1.
IB0030	RONGOTEA	WH6X	470.	.0030	.0054	13.00	1.70	.60	1.
IB0031	KOPARA	WH6X	470.	.0030	.0054	13.00	1.70	.60	1.
IB0032	BOUNTY	WH6X	472.	.0330	.0074	21.00	1.35	.60	1.
IB0033	MOULIN	WH6X	472.	.0330	.0078	24.00	1.35	.63	1.

TABLE 3. EXAMPLE OF THE REQUIRED SECTION OF THE OVERVIEW.OUT FILE.

MAIN CROP VARIABLES :

@VARIABLES	PREDICTED	MEASURED
ANTHESIS DATE	91178	91179
MATURITY DATE	91207	91207
GRAIN YIELD (kg dm/ha)	7489	1234
GRAIN WEIGHT (mg dm)	27.0	20.5
GRAIN NUMBER (no/m2)	27771	-99
GRAINS PER SPIKE (no)	65.3	-99.0
MAX. LAI	3.0	-99.0
BIOMASS (kg dm/ha)	12879	099
STRAW (kg dm/ha)	5390	-99
GRAIN N (%)	2.07	2.86
BIOMASS N (kg/ha)	171.8	-99.0
STRAW N (kg/ha)	16.9	-99.0
GRAIN N (kg/ha)	154.9	-99.0

TABLE 4. EXAMPLE OF AN EXPERIMENT DETAILS FILE.

```
*EXP.DETAILS: KSAS8101WH  NITROGEN  3N*2I  (GODWIN)

*GENERAL
@PEOPLE
 WAGGER,M.G. KISSEL,D
@ADDRESS
 DEPT.AGRONOMY,KANSAS STATE UNIV,MANHATTAN,KANSAS
@SITE
 ASHLAND,KS,USA  39.0;-97.0;226;CFA
@NOTES
 Documented in Wagger,M.G. 1983 Nitrogen cycling in the plan-soil system.
 Ph.D. thesis, Kansas State Univ.

*TREATMENTS                          ----------FACTOR LEVELS----------------
@N R O C TNAME                       CU FL SA IC MP MI MF  MR  MC   MT ME ME
 1 1 1 0 N1*I1 0-N;DRYLAND            1  1  0  1  1  1  1   1   0    0  0  0
 2 1 1 0 N2*I1 60-N;DRYLAND           1  1  0  1  1  1  2   1   0    0  0  0
 3 1 1 0 N3*I1 180-N;DRYLAND          1  1  0  1  1  1  3   1   0    0  0  0
 4 1 1 0 N1*I2 0-N;IRRIGATED          1  1  0  1  1  2  1   1   0    0  0  0
 5 1 1 0 N2*I2 60-N;IRRIGATED         1  1  0  1  1  2  2   1   0    0  0  0
 6 1 1 0 N3*I2 180-N;IRRIGATED        1  1  0  1  1  2  3   1   0    0  0  0

*CULTIVARS
@C CR INGENO CNAME
 1 WH IB0488 NEWTON

*FIELDS
@L ID_FIELD  WSTA      FLSA FLOB FLDT FLDD FLDS FLST SLTX SLDP ID_SOIL
 1 KSAS0001  KSAS        0    0    0    0    0    0    0  180 KSAS81IF01

*INITIAL CONDITIONS
@C PCR ICDAT  ICRT
 1  WH  81279  1200
@CICBL  SH20   SNH4  SNO3
 1    5  0.205   3.4  9.8
 1   15  0.205   3.4  9.8
 1   30  0.170   3.2  7.3
 1   60  0.092   2.5  5.1
 1   90  0.065   2.2  4.7
 1  120  0.066   2.7  4.3
 1  150  0.055   2.7  4.3
 1  180  0.066   2.7  4.3
```

*PLANTING DETAILS

@P	PDATE	EDATE	PPOP	PPOE	PLME	PLDS	PLRS	PLRD	PLDP
1	81289	-99	162.0	162.0	0	R	-99	-99	5.5

*IRRIGATION AND WATER MANAGEMENT

@I	IEFF
1	1.00

@I	IDATE	IROP	RVAL
2	82096	1	65
2	82110	1	78
2	82117	1	70

*FERTILIZERS (INORGANIC)

@F	FDATE	FMCD	FACD	FDEP	FAMN
2	81289	1	-99	15	60
3	81289	1	-99	15	90
3	82056	1	-99	1	90

*RESIDUES AND OTHER ORGANIC MATERIALS

@R	RDATE	RCOD	RAMT	RESN	RESP	RESK	RINP	RDEP
1	81279	1	6500	1.14	-99	-99	-99	15

APPENDIX B.
CONFIGURATION FILE (DSSATPRO.FLE)

The DSSATPRO.FLE file holds path statements to allow the shell program, GenCalc.EXE, to locate directories where necessary programs and/or files are stored, together with the names of programs required by GenCalc. The configuration file has three or four fields of information. The first field holds letter abbreviations or 'keys' that allow the shell program to identify the appropriate row of information. Abbreviations related to crop models in this field have an 'M' (Model) followed by the standard two letter abbreviation of the crop for which a simulation model is available in GenCalc. Abbreviations related to data (input files) for a particular crop model have the letter D (Data) preceded by the standard abbreviation for the crop concerned. In addition to the above, the paths for the rules file (GCRULES.FLE) and the text editor (TVED.EXE, shipped with DSSAT v3, or editor of choice) are also specified in the configuration file. The 3-letter 'key' for the rules file is CRD (CRop Data) while that for the editor is TOE (TOol for Editing).

The second field in the configuration file contains the drive in which the information is located (e.g. C:) while the third field consists of the complete path for the program or file required while running GenCalc. The paths shown in Table 5 are for the programs and files included on the distribution diskette; they could be changed if a user wishes to store the model programs and model input files in directories of his/her choice. In such a case, the user must change the appropriate path/s in the configuration file to match the 'new' location of the programs and/or input files. This may be accomplished simply by editing the configuration file with TVED.EXE or the editor installed in a user's computer. Care must be exercised while editing not to change the abbreviations in the linkage field. Edit the appropriate path/s and once done save the configuration file into the C:\DSSAT3 directory.

The fourth field contains program or file names; it is not present when the row contains directory information alone. The fourth field is the one that would have to be changed if a user wishes to install a replacement crop model. Naturally, such a model should conform in other respects to the requirements of GenCalc. To install, the names of the EXE files for the model in question should be entered in the fourth field of the appropriate row of information. Version 3.0 allows for the use of models that consist of separate 'driver', input and simulator components, so that the names of all three components must be entered into the appropriate row, together with a symbol that is recognized by the inputs

program and indicates the 'type' of file that should be produced to transfer information to the simulator module. Where a model does not have one of the components, a zero should be entered in place of the missing executable file name(s).

The configuration file also permits the loading of 'new' crop and appropriate data files. To do this, the appropriate abbreviations for the model and model input files must be inserted in the first field, and drive path and file name information in the subsequent fields of the configuration file. See Volume 2-1 (Jones et al. 1994) of this book for standard abbreviations of various crops.

TABLE 5. EXAMPLE CONTENTS OF THE DSSATPRO.FLE FILE.

```
MMZ    C: \DSSAT3 MDRIV940.EXE MINPT940.EXE GECER940.EXE I
MPN    C: \DSSAT3 MDRIV940.EXE MINPT940.EXE CRGRO940.EXE I
MSB    C: \DSSAT3 MDRIV940.EXE MINPT940.EXE CRGRO940.EXE I
MWH    C: \DSSAT3 MDRIV940.EXE MINPT940.EXE GECER940.EXE I
MZD    C: \DSSAT3\MAIZE
PND    C: \DSSAT3\PEANUT
SBD    C: \DSSAT3\SOYBEAN
WHD    C: \DSSAT3\WHEAT
TOE    C: \DSSAT3 TVED.EXE
CRD    C: \DSSAT3\GENOTYPE
```

APPENDIX C. ABBREVIATIONS

Abbreviations used in GenCalc coefficient (??COEFF.TMP) files:

Abbreviation	*Definition*
D	No data available for comparison
M	Coefficient at maximum or minimum value
N	No response to changes in coefficient
R	Run number at a maximum
U	Coefficient not determined (not called for in rules file)