Volume 3

DSSAT version 3

Editors:

Gordon Y. Tsuji
Goro Uehara
Sharon Balas

International Benchmark Sites Network for Agrotechnology Transfer
University of Hawaii, Honolulu, Hawaii

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.

Correct Citation: G.Y. Tsuji, G. Uehara and S. Balas (eds.). 1994. DSSAT v3. University of Hawaii, Honolulu, Hawaii.

Library of Congress 94-19296
ISBN 1-886684-03-0 (Volume 3)
ISBN 1-886684-00-6 (3 Volume Set)

DSSAT v3

VOLUME 3

Volume 3-1
Seasonal Analysis

Volume 3-2
Sequence Analysis

Volume 3-3
WeatherMan

Volume 3-4
Genotype Coefficient Calculator

TABLE OF CONTENTS

Volume 3-1. Seasonal Analysis 1

Chapter One. Introduction 3

System Requirements 4

Chapter Two. Creating Model Input Files for Seasonal Analysis 5

Chapter Three. Running Seasonal Analysis Experiments 13

Overview 13

An Example 14

Information and Error Messages 17

Chapter Four. Analyzing Seasonal Analysis Experiments 23

Overview 23

An Example 24

Analyze Biophysical Variables 26

Graphics Main Menu 28

Analyze Economic Variables 34

Economic Evaluation Main Menu 34

Modify Hardcopy Options 44

Selecting Another Input File for Analysis 48

Information and Error Messages 48

References 55

Appendix A. Combining Yield and Price Distributions 57

An Illustration 58

Appendix B. Three Decision Criteria 59

Mean-Variance (EV) Analysis 59

Stochastic Dominance (SD) Analysis 59

Mean-Gini Dominance (MGD) Analysis 60

An Example 60

Figures

Figure 1. **Steps in Seasonal Analysis** 4

Figure 2. **Menu Options for the Seasonal Analysis Program** 23

Figure 3. **Stochastic Price-Cost Distributions** 38

Tables

Table 1. **Seasonal Experiment Listing File EXP.LST** 5

Table 2. **Part of Model Input File UFGA7812.SNX** 7

Table 3. **Summary Output Listing File SEASONAL.LST** 13

Table 4. **Summary Output File UFGA7812.SNS (First 20 Data Records Only)** 18

Table 5. **Price-Cost File DEFAULT.PRI** 37

Table 6. **Sample Section of GRAPH.INI** 45

Table 7. **Printer Types Supported by the Graphics Program** 46

Table 8. **Experiment Data Codes File DATA.CDE – Summary Section Only** 47

Table 9. **Part of Seasonal Analysis Results File UFGA7812.SNR** 49

Volume 3-2. Sequence Analysis 67

Chapter One. Introduction 69

System Requirements 70

Chapter Two. Creating Model Input Files for Sequence Analysis 73

FILEX for Sequence Analysis 73

Timing Controls 78

Simulation Control Options 79

Chapter Three. Running Sequence Analysis Experiments 81

Overview 81

An Example 82

Information and Error Messages 84

Chapter Four. Analyzing Sequence Analysis Experiments 89

Overview 89

An Example 90

Analyze Biophysical Variables 93

Graphics-Regression Main Menu 96

Analyzing More than One Crop at a Time 107

Analyze Economic Variables 112

Economic Evaluation Main Menu 112

Modify Hardcopy Options 121

Selecting Another Input File for Analysis 126

Information and Error Messages 126

References 133

Appendix. The Stability of Output Variables from Replicated Sequence Experiments 135

Figures

Figure 1. Steps in Sequence Analysis 71

Figure 2. Menu Options for the Sequence Analysis Program 90

Figure 3. "Simulated" Sequence Outputs for N = 100, 20, 10, and 5, Respectively. 136

Tables

Table 1. Sequence Experiment Listing File EXP.LST 73

Table 2. A Sample FILEX for Crop Sequencing: EBAF1101.SQX 75

Table 3. Summary Model Output Listing File SEQUENCE.LST 81

Table 4. Summary Output File EBAF1101.SQS (First 20 Data Records Only) 85

Table 5. Part of the Default Sequence Price File, DEFAULT.PRQ 115

Table 6. Sample Section of GRAPH.INI 123

Table 7. Printer Types Supported by the Graphics Program 124

Table 8. Experiment Data Codes File DATA.CDE – Summary Section Only 125

Table 9. Part of Sequence Analysis Results File EPAF1101.SQR 127

VOLUME 3-3. WEATHERMAN 137

CHAPTER ONE. INTRODUCTION 139

PROGRAM DESCRIPTION 139

OVERVIEW OF FUNCTIONS 140

SYSTEM REQUIREMENTS 140

CHAPTER TWO. GETTING STARTED 141

STARTING WEATHERMAN 141

WEATHERMAN USER INTERFACE 141

COMMON DIALOG BOXES 144

STEPS FOR CLEANING AND CONVERTING WEATHER DATA 147

CHAPTER THREE. INTRODUCTORY TUTORIAL 149

BROWSE THE MENU AND ONLINE HELP 149

SELECT A NEW STATION 149

IMPORT DAILY WEATHER FILES 150

CALCULATE WEATHER GENERATOR PARAMETERS 152

GENERATE WEATHER DATA 152

CALCULATE STATISTICS 153

CALCULATE STATISTICS FOR THE GENERATED DATA 153

GRAPH OBSERVED DAILY TEMPERATURE 153

GRAPH STATISTICS FOR OBSERVED AND GENERATED DATA 154

EXPORT DAILY WEATHER FILES 155

CHAPTER FOUR. WEATHERMAN REFERENCE GUIDE 157

VARIABLES 157

FILE MENU 157

STATION MENU 160

IMPORT/EXPORT MENU 164

GENERATE MENU 173

ANALYZE MENU 179

OPTIONS MENU 186

QUIT MENU 192

References 193
Appendix A. Abbreviations Used in WeatherMan 195
Daily Weather Variables 195
Summary Files 195
Appendix B. Climate File Format 197
Tables
Table 1. User Interface Items and their Functions in WeatherMan 142
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 148
Table 3. WeatherMan Variables and Associated Units 158
Table 4. Weather Station Information Required for a New Station 162
Table 5. Explanation of Error Codes Used to Flag Suspect or Erroneous Data 170
Table 6. Explanation of Import Options 171
Table 7. Explanation of Export Options 175
Table 8. Explanation of Data Fill Options 176
Table 9. Explanation of Statistics Time Groupings 182

Volume 3-4. Genotype Coefficient Calculator 201

Chapter One. Introduction 203

Program Components 203

System Requirements 207

Chapter Two. Getting Started 209

Chapter Three. Running GenCalc 211

Determine Genetic Coefficients 211

Discussion 221

References 223

Appendix A. GenCalc Model Requirements 225

Appendix B. Configuration File (DSSATPRO.FLE) 231

Appendix C. Abbreviations 233

Figure

Figure 1. GenCalc Components 204

Tables

Table 1. Requirements for Crop Models to Work Under GenCalc 225

Table 2. Example of a Cultivar (Genotype) Coefficient File 227

Table 3. Example of the Required Section of the OVERVIEW.OUT File 228

Table 4. Example of an Experiment Details File 229

Table 5. Example Contents of the DSSATPRO.FLE File 232

Volume 3-1

SEASONAL ANALYSIS

P.K. Thornton,
G. Hoogenboom,
P.W. Wilkens,
J.W. Jones

International Fertilizer Development Center
University of Georgia, University of Florida
International Benchmark Sites Network for Agrotechnology Transfer

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.

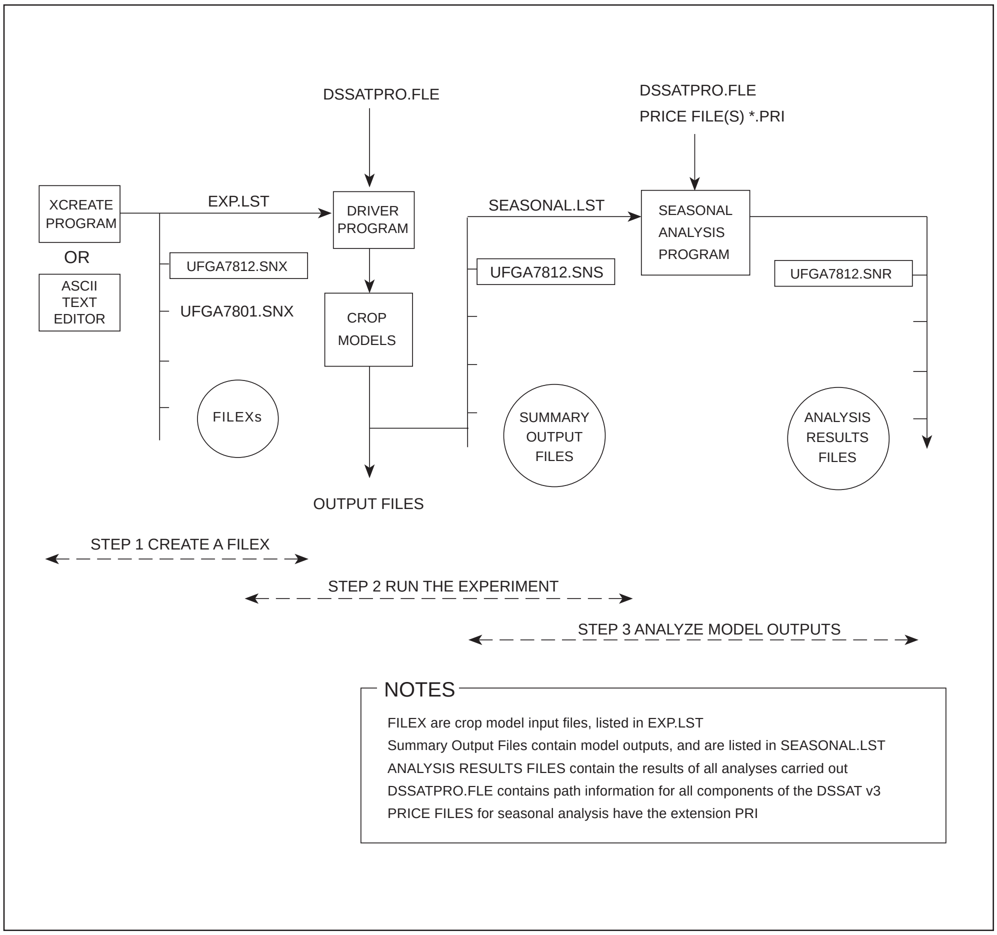


FIGURE 1. STEPS IN SEASONAL ANALYSIS.

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 [redacted]  0  1  0  0  0  0  1
 2 1 0 0 AUTOMATIC 90%              1  1  0  1  1 [redacted]  0  1  0  0  0  0  2
 3 1 0 0 AUTOMATIC 70%              1  1  0  1  1 [redacted]  0  1  0  0  0  0  3
 4 1 0 0 AUTOMATIC 50%              1  1  0  1  1 [redacted]  0  1  0  0  0  0  4
 5 1 0 0 AUTOMATIC 30%              1  1  0  1  1 [redacted]  0  1  0  0  0  0  5
 6 1 0 0 AUTOMATIC 10%              1  1  0  1  1 [redacted]  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     R    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).

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
```

It is important 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	MAT	TOPWT	SEEDW	TRAIN	TIRR	CET	PESW	TNUP	TNLC	TNLF	TSON	TSOC
		dap	dap	kg/ha	kg/ha	mm	mm	mm	mm	----kg/ha-----			kg/ha	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	117	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	117	7030	3457	803	0	481	101	24	18	26	3835	39
16	SB 1	46	117	6900	3388	534	0	473	89	28	7	31	3836	39
17	SB 1	46	117	4905	2287	493	0	423	157	29	3	31	3839	39
18	SB 1	46	117	7110	3521	828	0	517	144	23	17	29	3833	39
19	SB 1	46	117	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.

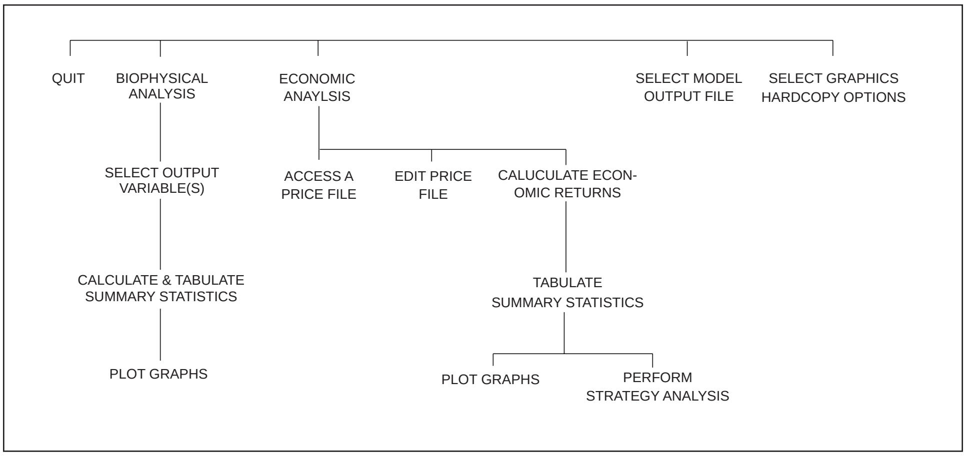


FIGURE 2. MENU OPTIONS FOR THE SEASONAL ANALYSIS PROGRAM.

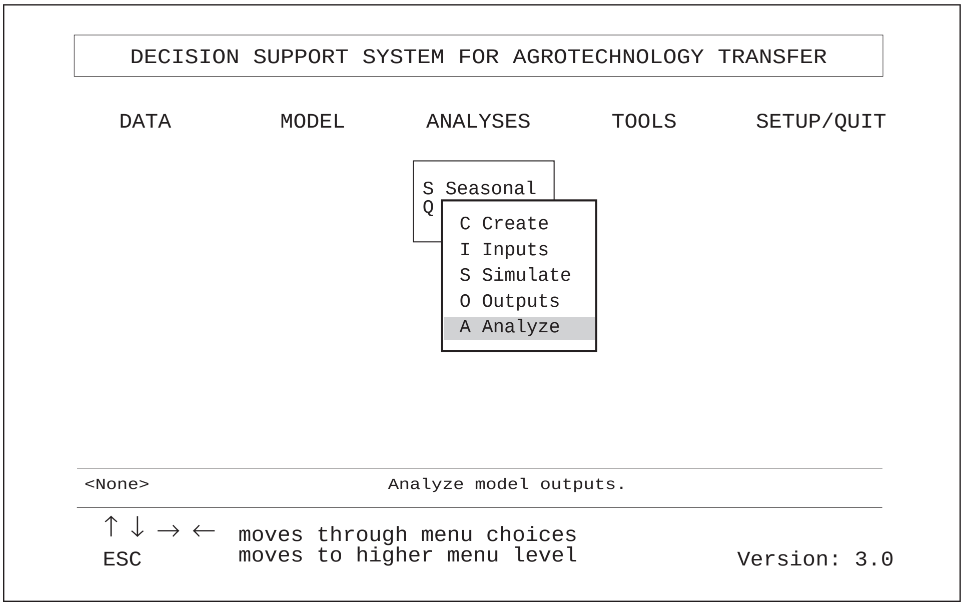
Formal strategy evaluation of all treatments, if required, is carried out using mean-Gini stochastic dominance (see Appendix B herein).
Any number of summary output files can be analyzed during one session with the program. The user can also control the type and format of hardcopy outputs from the graphics 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



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 hardopy options
 About VARAN2....

 Exit

F1 (Help)                                214240 Mem
```

Screen 5.

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.

As for the driver program, if the colors on the screen are difficult to see (such as when the program is being run on a monochrome laptop comput-

```
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.

er), 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 <Ø> 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
   1  START SIM day    [ ]     le for analysis
   2  PLANTING day     [ ]
   3  ANTHESIS day     [ ]     s
   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.

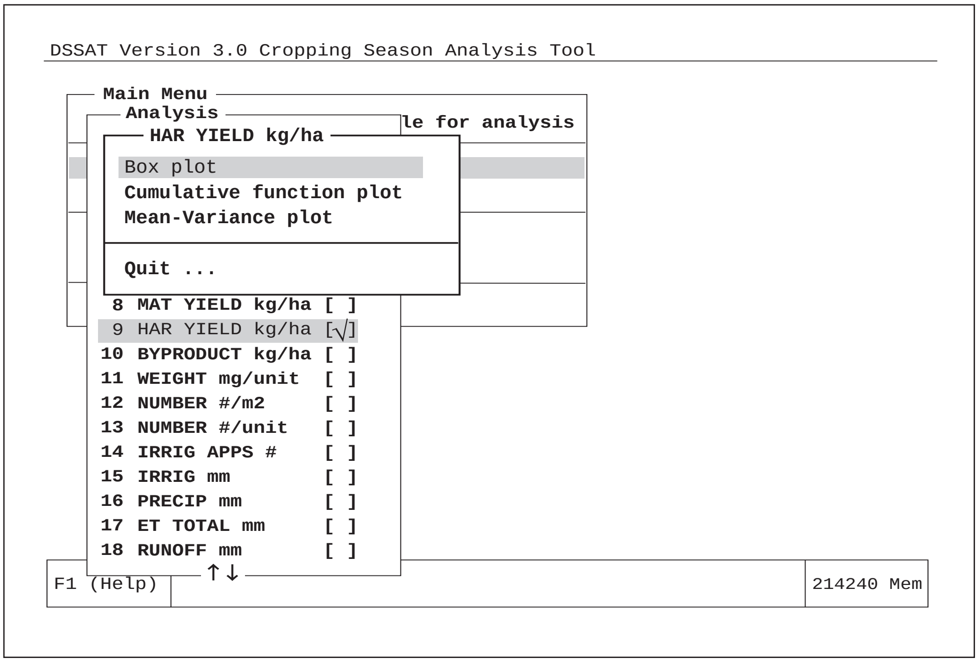
The program calculates various statistics and presents them on screen (see Screen 9, above). These values show, by treatment, the mean, standard deviation, minimum, and maximum harvest yield obtained from running the soybean simulation model. Screen 9 shows the results obtained from the simulation of 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 the distri-



SCREEN 10.

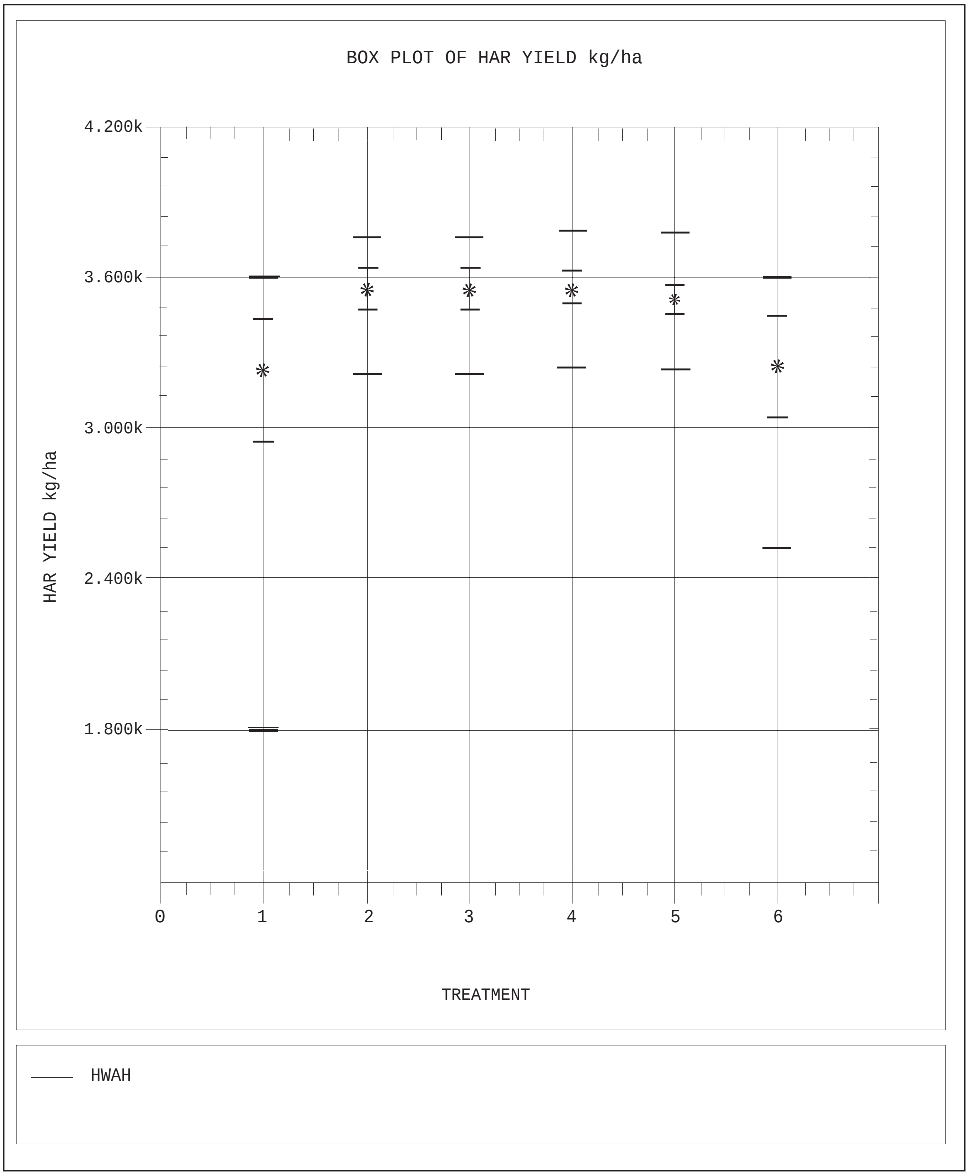
bution of the variable for each treatment selected, the 0th (the lowest single short line), 25th (the lower of the short lines connected by the vertical bar), 50th (the star), 75th (the upper of the short lines connected by the vertical bar), and 100th (the upper single short line) percentiles are plotted. 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 plot-



SCREEN 11.

ted 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 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 fol-

```
DSSAT Version 3.0 Cropping Season Analysis Tool

  Main Menu
   Analysis                          le 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.

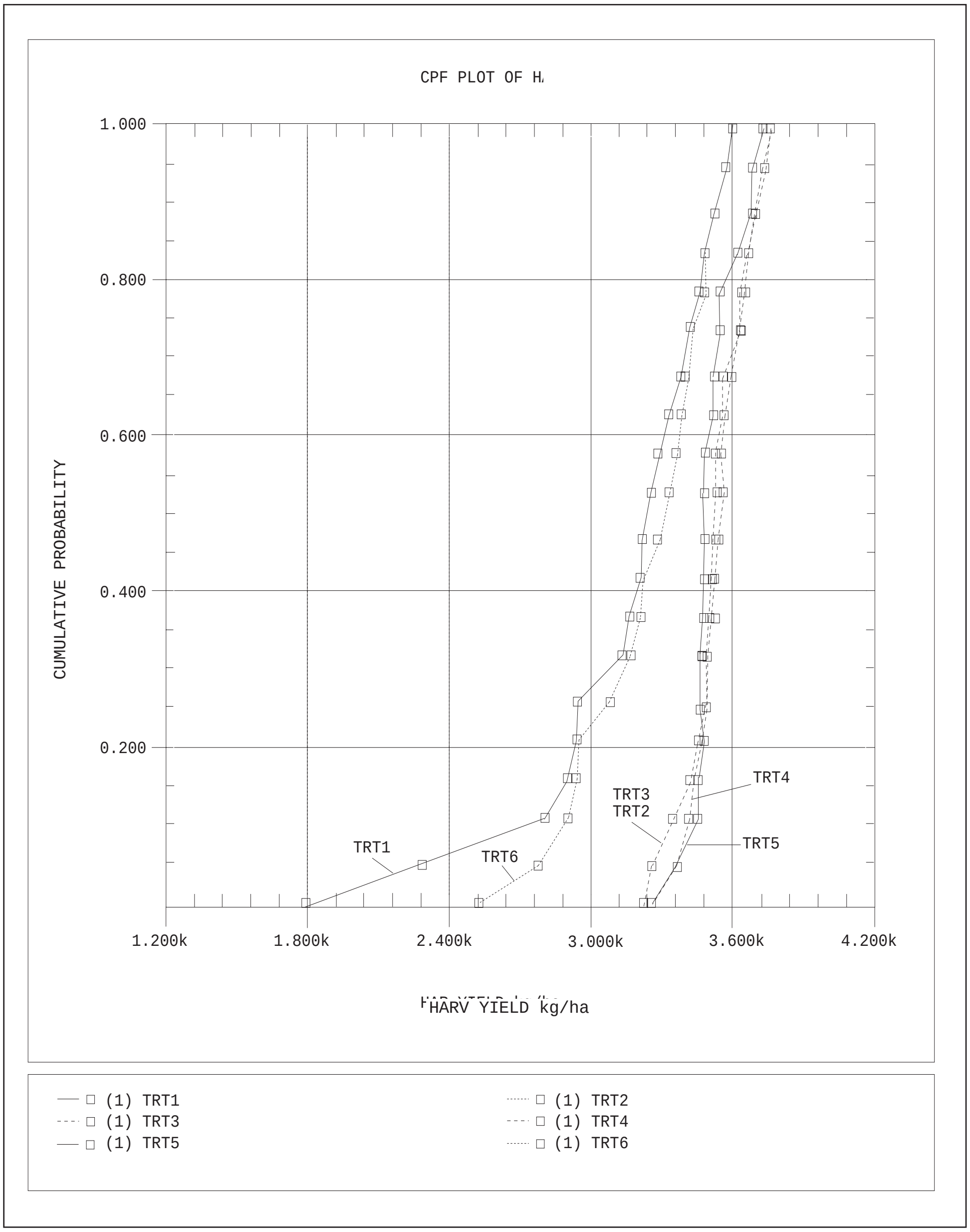
lowing page). A maximum of six cumulative function plots may be graphed at any time, and you can select or deselect all the treatments at once with the <+> or <-> key (as described before under Screen 8), or individual treatments with the space bar. If more than six treatments are selected, the program 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

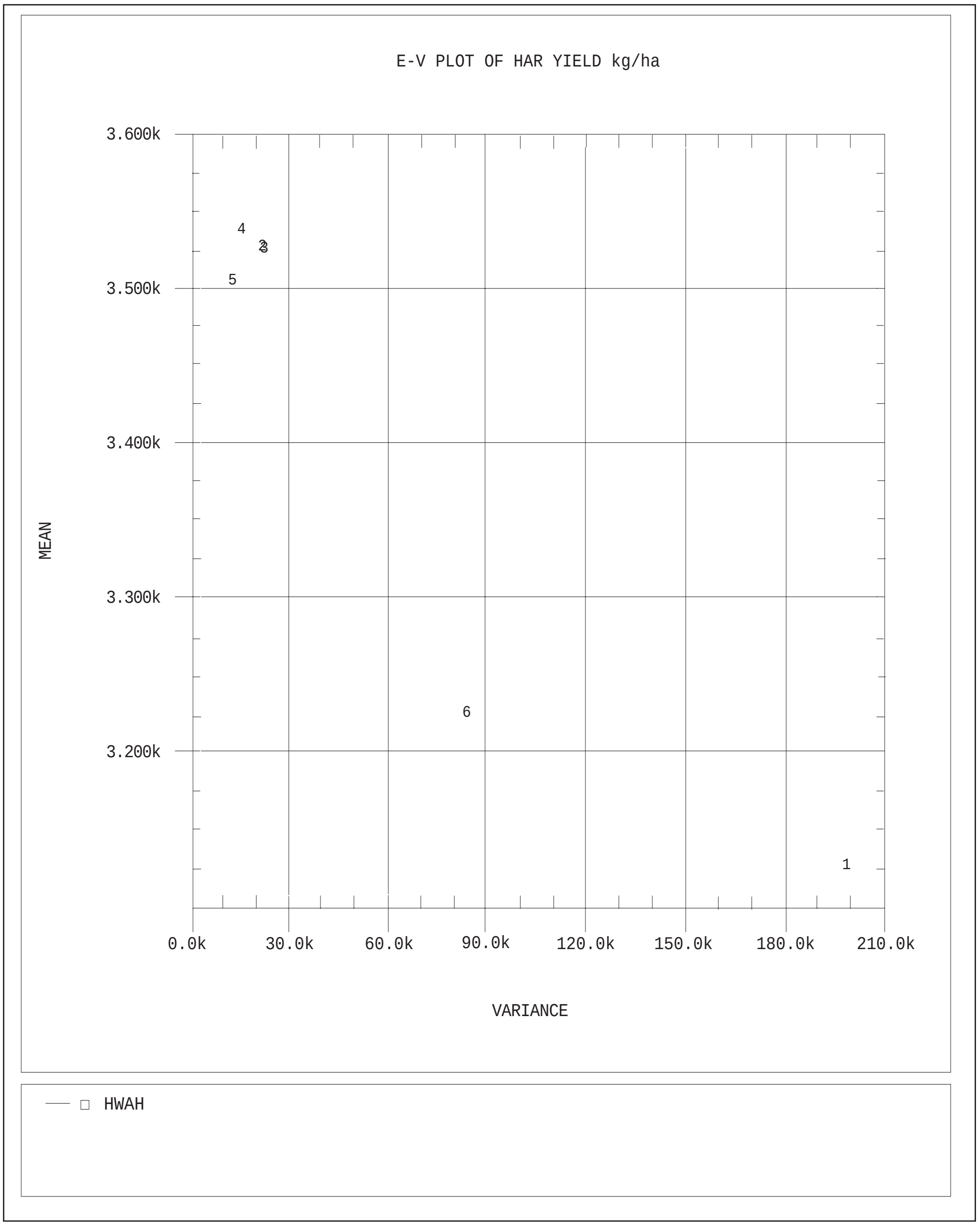
When this option in Screen 10 is selected, output variables may be plotted in mean-variance space. The calculated mean is plotted against the variance for the output variable of interest, and the treatment numbers themselves are drawn on the graph. A maximum of 20 treatments may be plotted in this way. 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



SCREEN 13.

rainfed treatment, 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 speci-

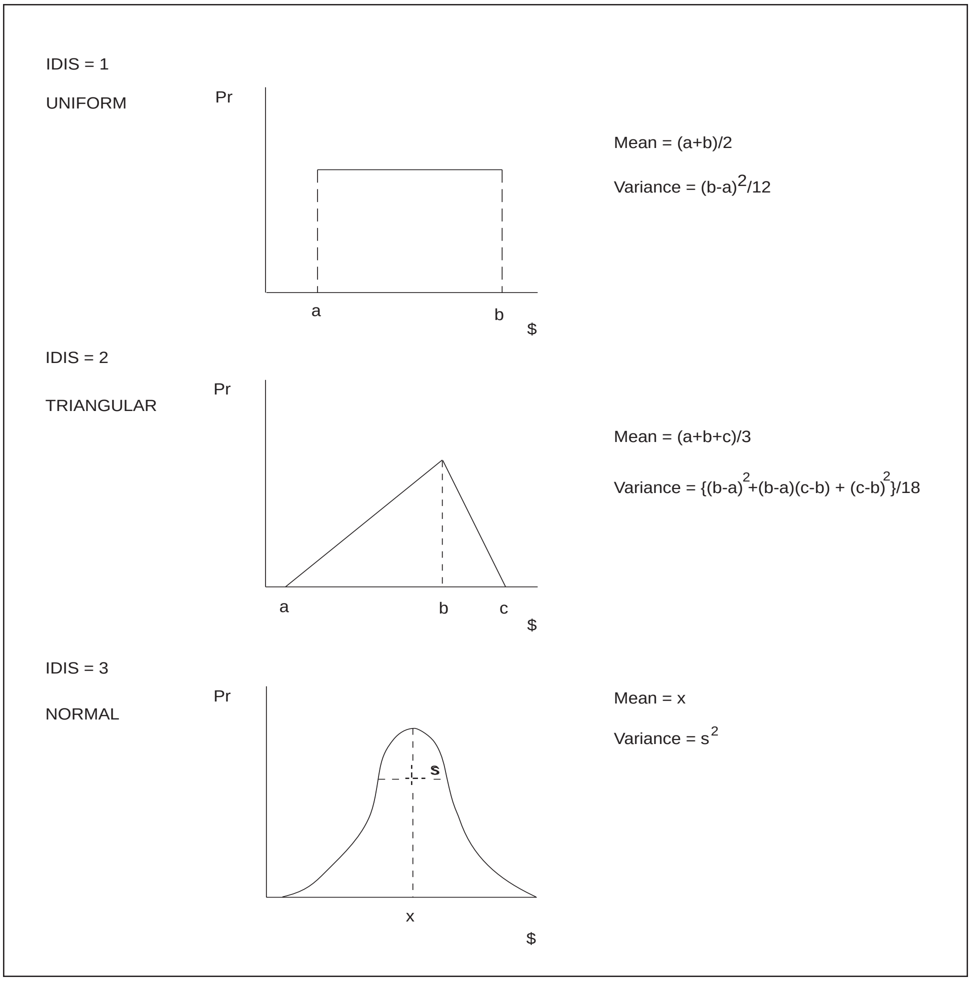


FIGURE 3. STOCHASTIC PRICE-COST DISTRIBUTIONS.

fy more than one 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,

```
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.

standard deviation, maximum and minimum value of net return or gross margin per hectare for each treatment (see Screen 19, on following page), using the costs and prices specified. Note that for the example, returns per hectare are highly

```
DSSAT Version 3.0 Cropping Season Analysis Tool

              Cost-Price Sensitivity Analysis: All Treatments


  No.   Cost-Price      Distribution ------------- Values -------------
  Edit?
   Grain price - -  $/t    Normal        av  320.00 sd   32.00
   Harvest byprod - $/t    Fixed                .00
   Base prod cost  $/ha    Fixed             345.00
   N fert cost - - $/kg    Fixed                .45
   N cost per appl -  $    Fixed              12.00
   Irrig cost - -  $/mm    Fixed                .50
   Irr cost per appl  $    Fixed              12.50
   Seed cost - - - $/kg    Fixed                .46
   Organic amends - $/t    Ignored
   P fert cost - - $/kg    Ignored
   P cost per appl -  $    Ignored

   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.

variable; note also that returns per 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).

```
DSSAT Version 3.0 Cropping Season Analysis Tool

  Main Menu
    Options
      Graphics/Strategy        file UFGA7812.PRI
                               ty analysis
      Box plot
      Cumulative function plot
      Mean-Variance plot
      Strategy analysis
  Ex
      Quit

F1 (Help)                                        214240 Mem
```

SCREEN 20.

```
DSSAT Version 3.0 Cropping Season Analysis Tool

                     Strategy Analysis

                    Mean-Gini Dominance
                    Dominant Treatment

              5   SB  AUTOMATIC 30%...... UFGA0001

              Do you want more details (Y/N?)
                          [Yes]

F1 (Help)                                        214240 Mem
```

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!

```
DSSAT Version 3.0 Cropping Season Analysis Tool

                         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         Y
   6  SB AUTOMATIC 10%...... UFGA0001    637.7        526.2         N

F1 (Help)          Press any key to continue          214240 Mem
```

SCREEN 22.

You should also exercise caution when interpreting the economic benefits to fertilizer use in terms of a 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.

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, however, 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:

$$E(A) >= E(B) \text{ and } E(A) - G(A) >= E(B) - G(B)$$

with strict inequality for one of these expressions, where E(.) is the mean, and G(.) 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).

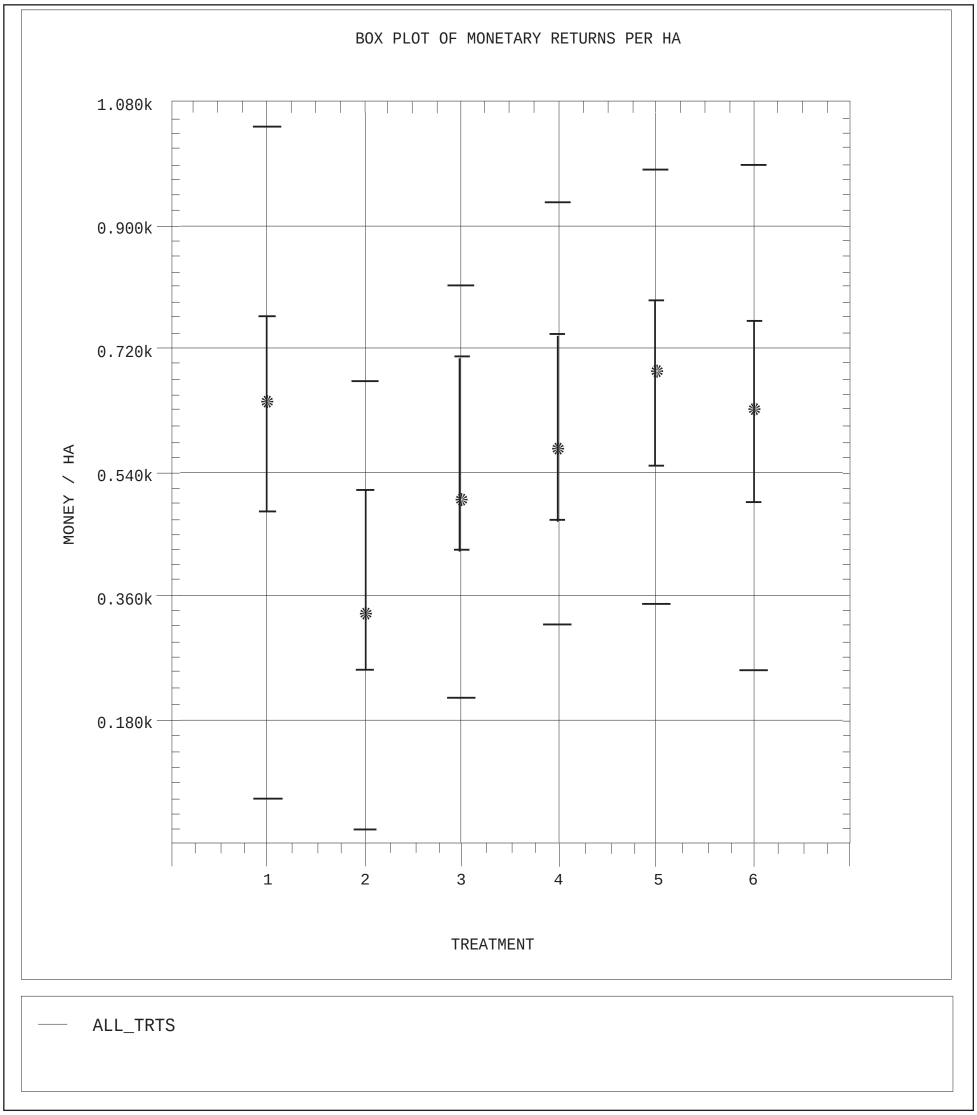
MGD, like SSD, assumes that the decision maker is averse to risk, but unlike SSD, the extremely risk-averse are excluded from the analysis. It is thus a more discriminating decision rule than SSD (since the MGD efficient set is usually smaller), and computationally, MGD is generally much easier to establish 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



Screen 24.

water applied in Treatments 2, 3, 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

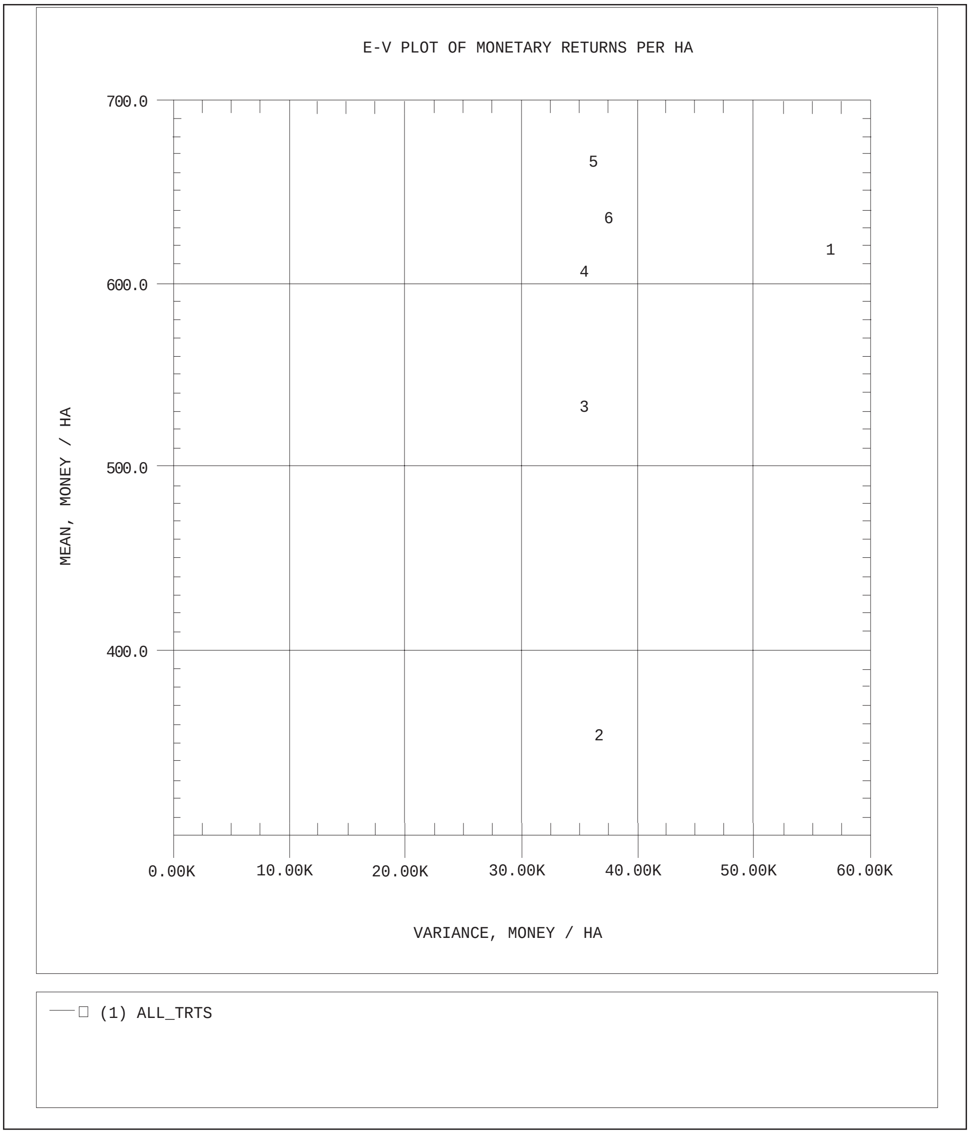
Variable : IRRIG APPS #

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.. 214240 MEM

SCREEN 26.



Screen 27.

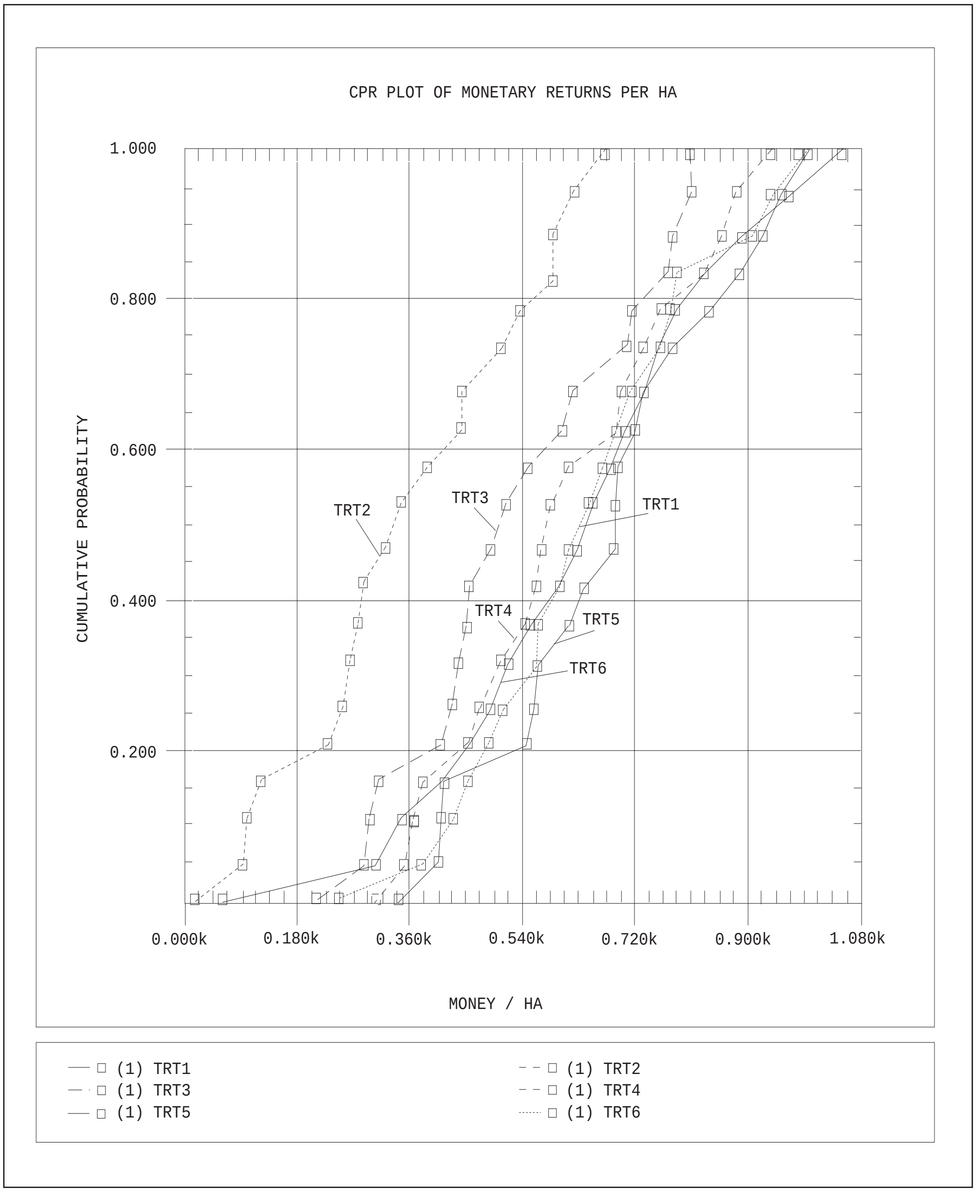
In terms of strategy analysis, the mean-Gini dominance calculations are shown in Screen 22 of the main text. As noted above, the dominant strategy also has the highest mean monetary return. In mean-Gini dominance, this will always be the case, but it will sometimes happen that the variability associated 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 4 and 5 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
CUMULATIVE PROBABILITY
1.000
0.800
0.600
0.400
0.200
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

P.K. THORNTON,
P.W. WILKENS,
G. HOOGENBOOM,
J.W. JONES

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER
UNIVERSITY OF FLORIDA, UNIVERSITY OF GEORGIA
INTERNATIONAL BENCHMARK SITES NETWORK FOR AGROTECHNOLOGY TRANSFER

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.

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 associated 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.

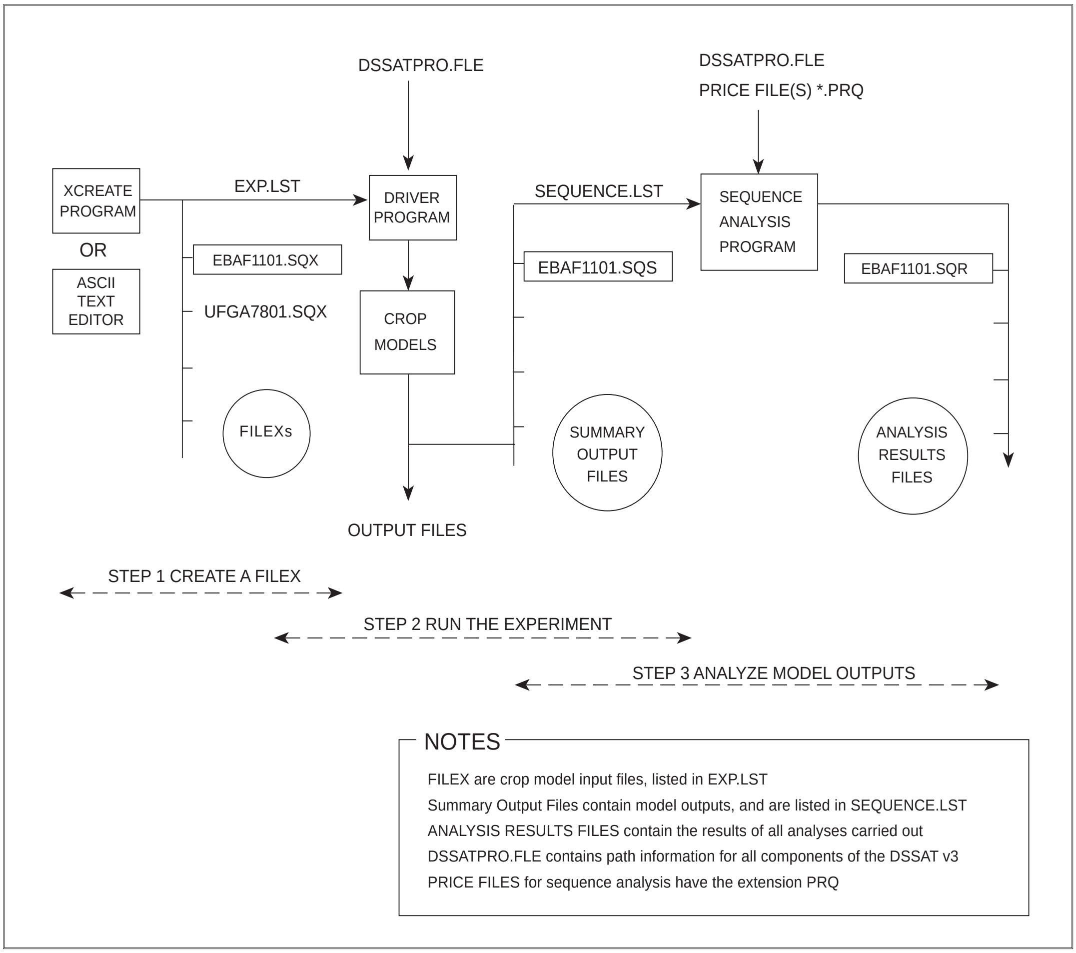


FIGURE 1. STEPS IN SEQUENCE ANALYSIS.

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 number

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
```

(@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           2  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″). Simulation control is specified (SM= ″2,″ see above). One further factor level is needed: a *HARVEST DETAILS section (MH = "1") is REQUIRED for any fallow component. 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 *SIMULATION CONTROLS section 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
```

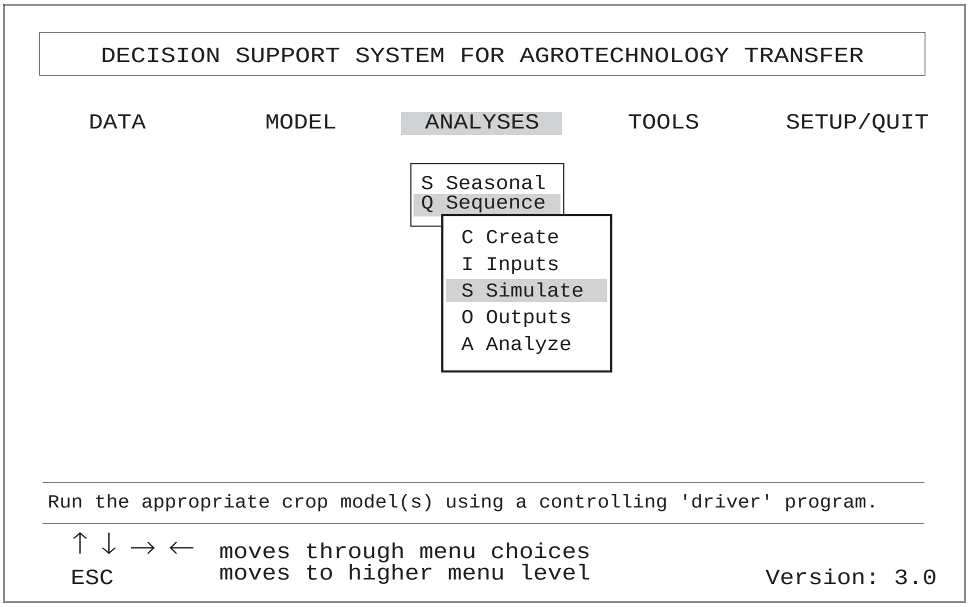
From within DSSAT v3, the current directory for sequence runs will usually be C:\DSSAT3\SEQUENCE, where such files as EXP.LST, SEQUENCE.LST and appropriate FILEXs are stored.

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



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.

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.

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.

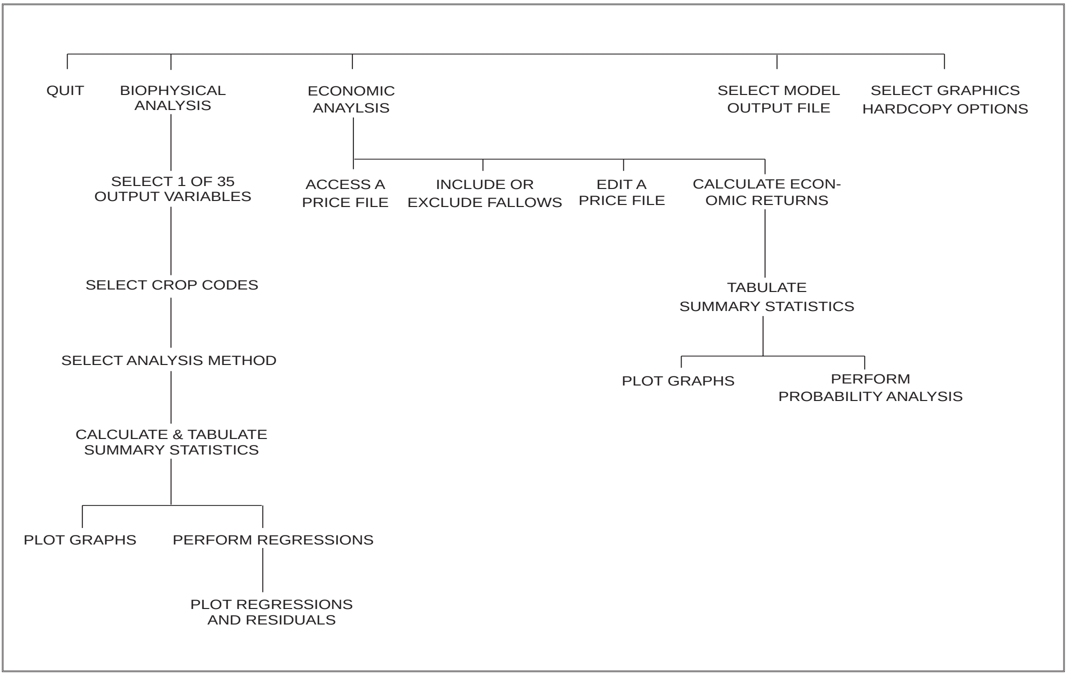


FIGURE 2. MENU OPTIONS FOR THE SEQUENCE ANALYSIS PROGRAM.

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

```
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.

EBAF1101.SQX, then simulation 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

```
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.

extension; this is added automatically, and cannot be 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 experi-

```
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.

ment. In some rotations, 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 <Ø> 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
  START SIM day          ason file for analysis
  PLANTING day
  ANTHESIS day           ariables
  MATURITY day           iables
  HARVEST day
  SOWING WT kg/ha        ns
  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
```

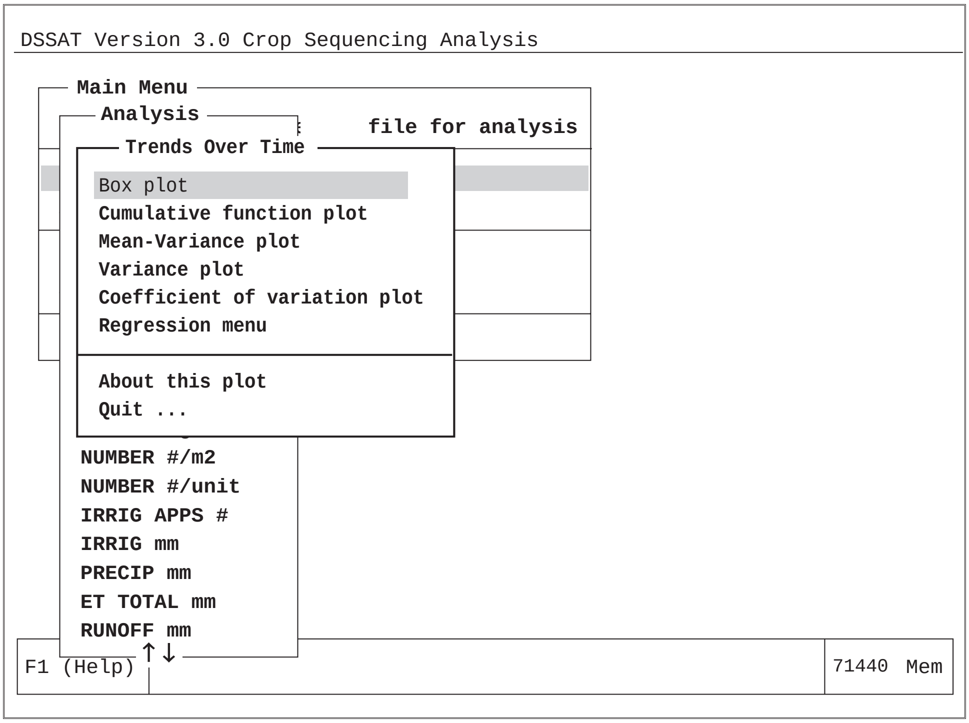
SCREEN 8.

```
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.



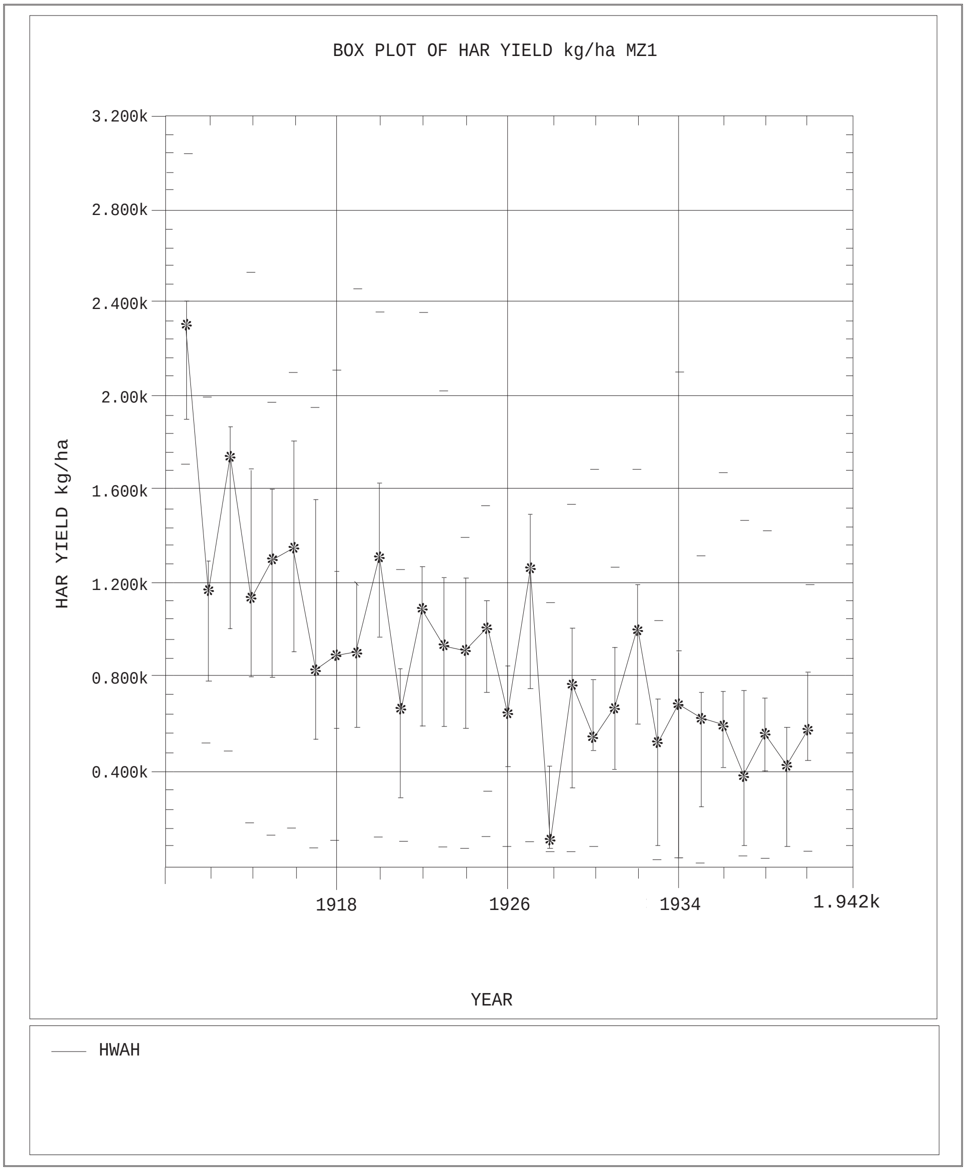
Screen 10.

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 hard-copy 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.

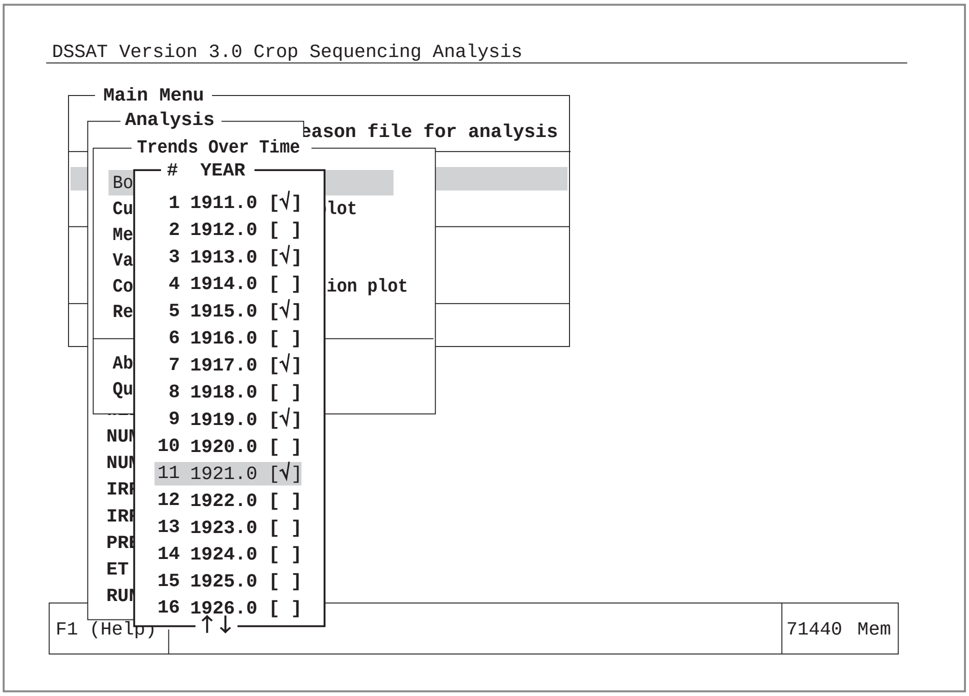
***NOTE:** To return to the analysis program from any graph, press any key.*

Option 2. Cumulative Function Plot

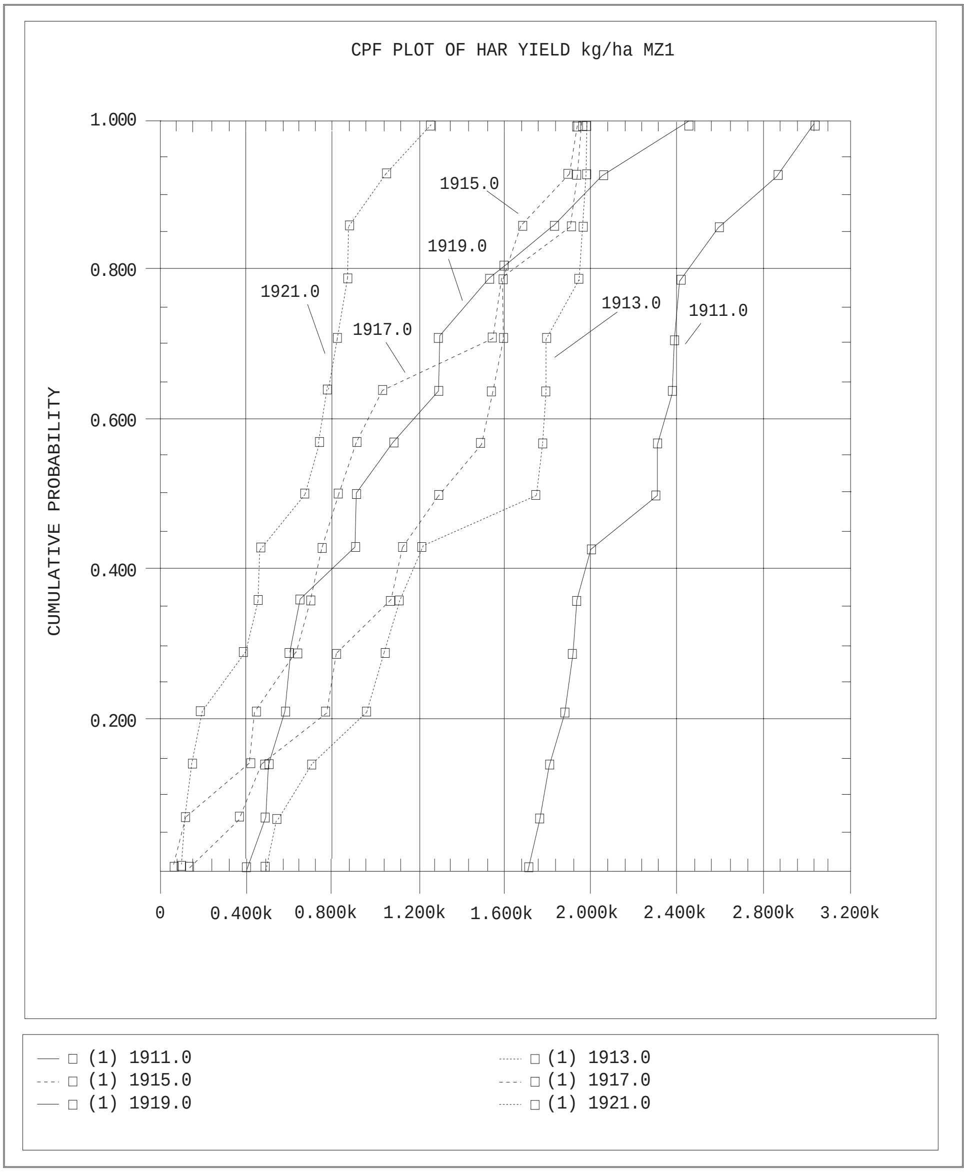
When this option is selected in Screen 10, output variables by year or season may also be plotted as cumulative function plots. (Cumulative function plots are sometimes called cumulative probability function (CPF) plots or cumulative distribution function plots – these are the same.) Here, the distribution 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.

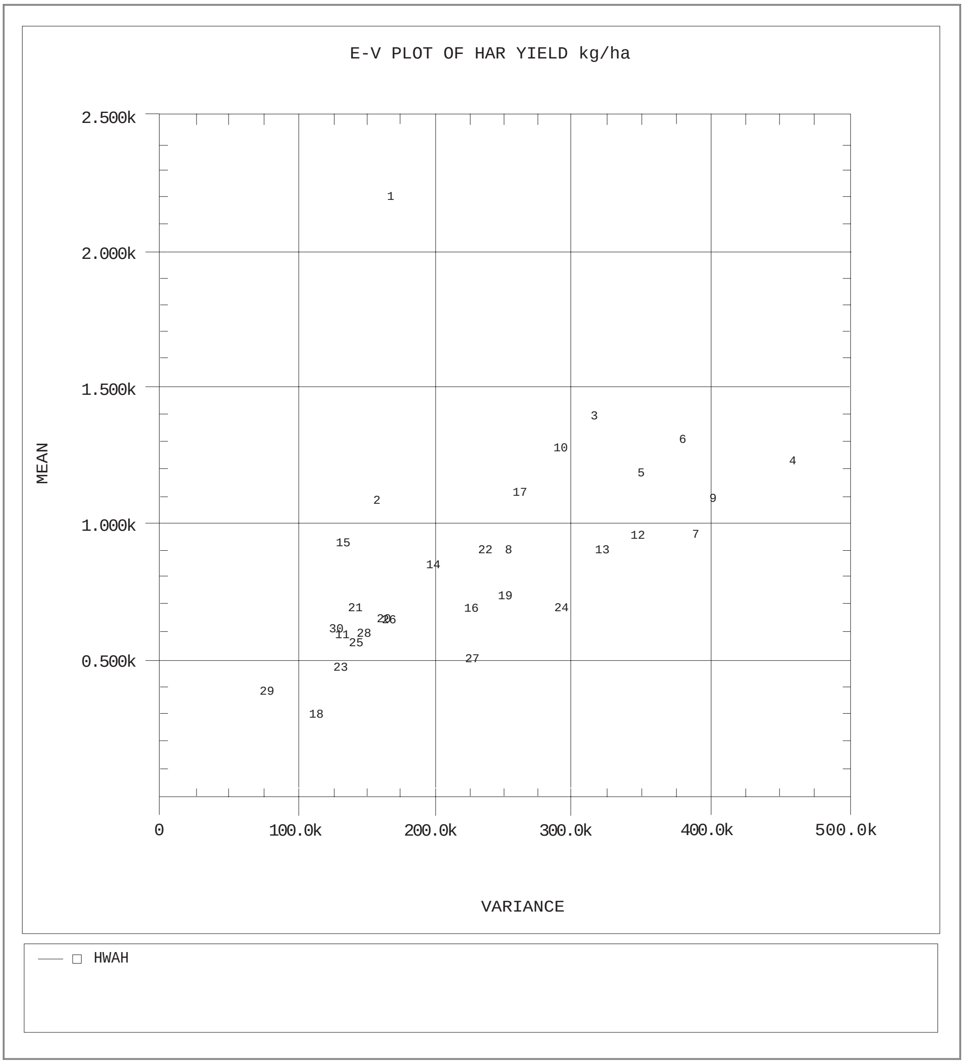


SCREEN 13.

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 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, 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).

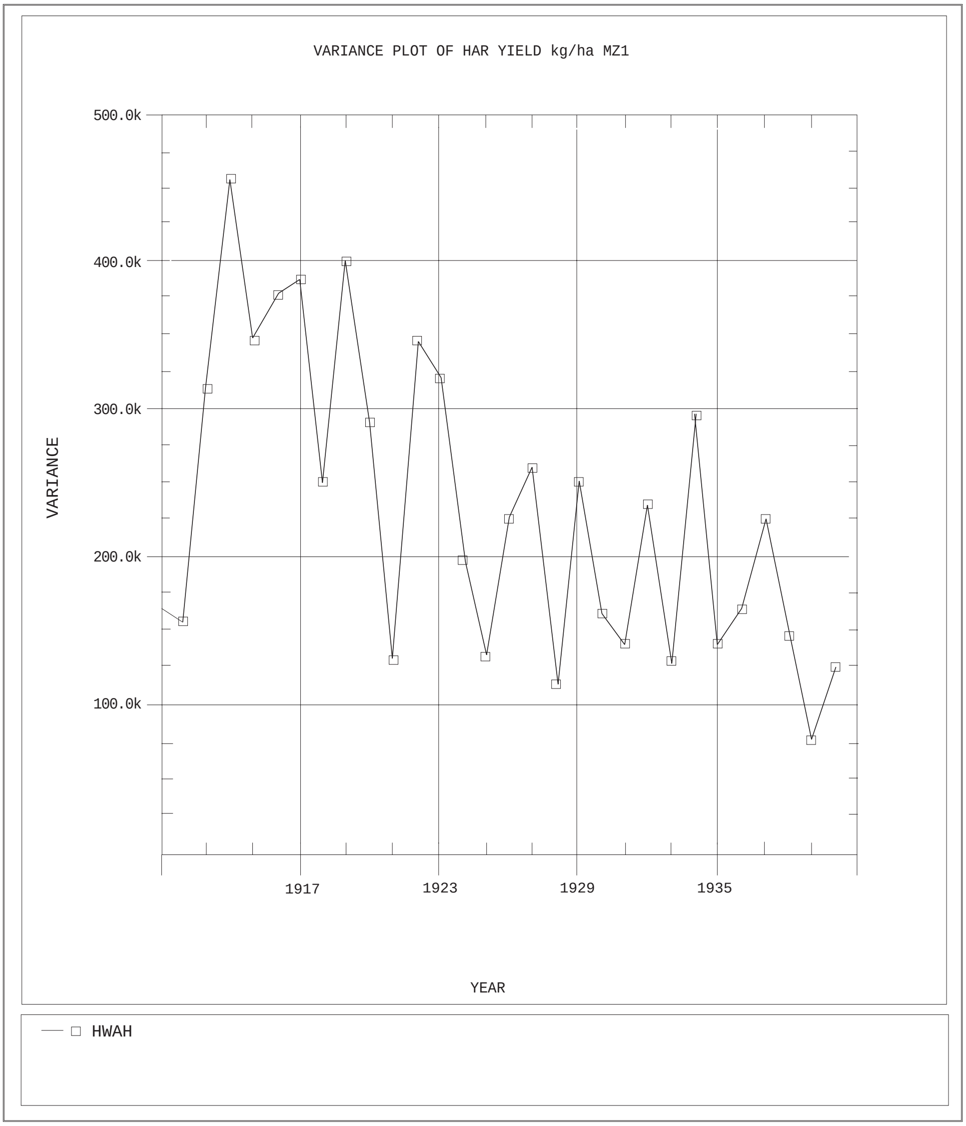


SCREEN 14.

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

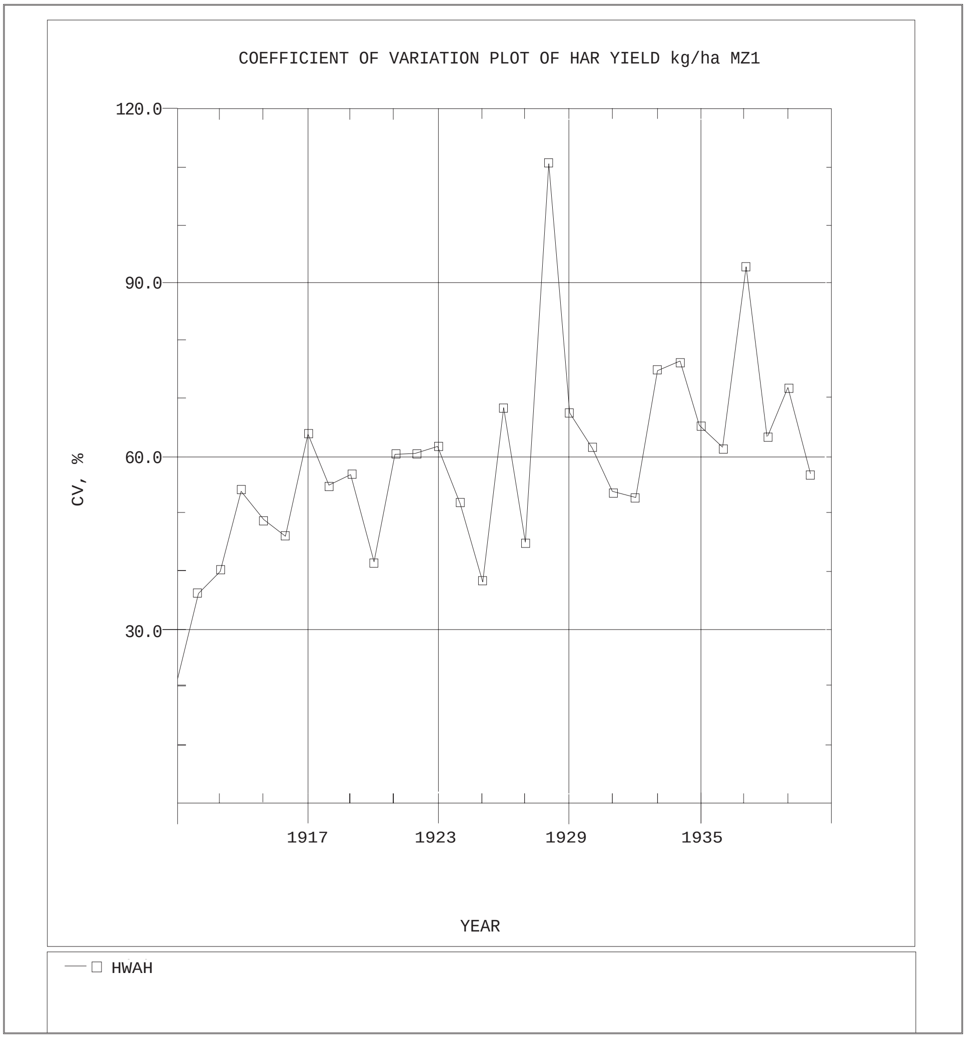


Screen 15.

time, 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



Screen 16.

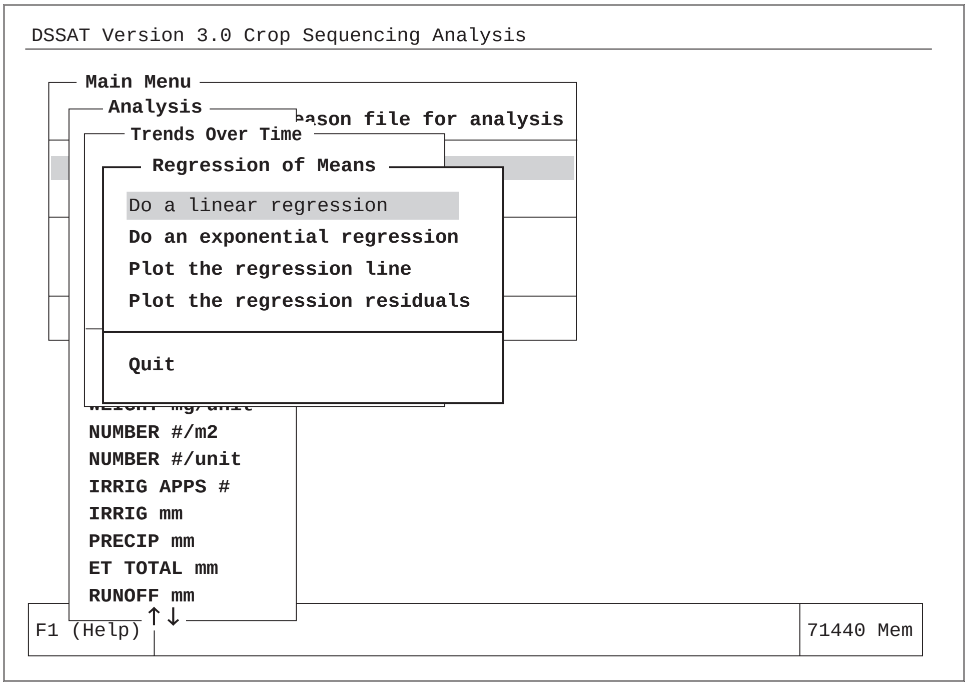
indication of changes in relative variability through time. Screen 16 (on previous page) shows an example for maize yield. Note that although mean yield decreased through time, relative variability, as measured by the coefficient of variation, increased markedly.

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 nAppendix, 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 Appendix A, 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 gradient is significantly different from zero (i.e., a

```
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.

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,

$$y = a + ßx + e$$

where e is a random variable drawn from $N(0,s_{x.y}^2)$, 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 $s_{x.y}^2$.

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

$$\ln(y) = \ln(c) + mx$$

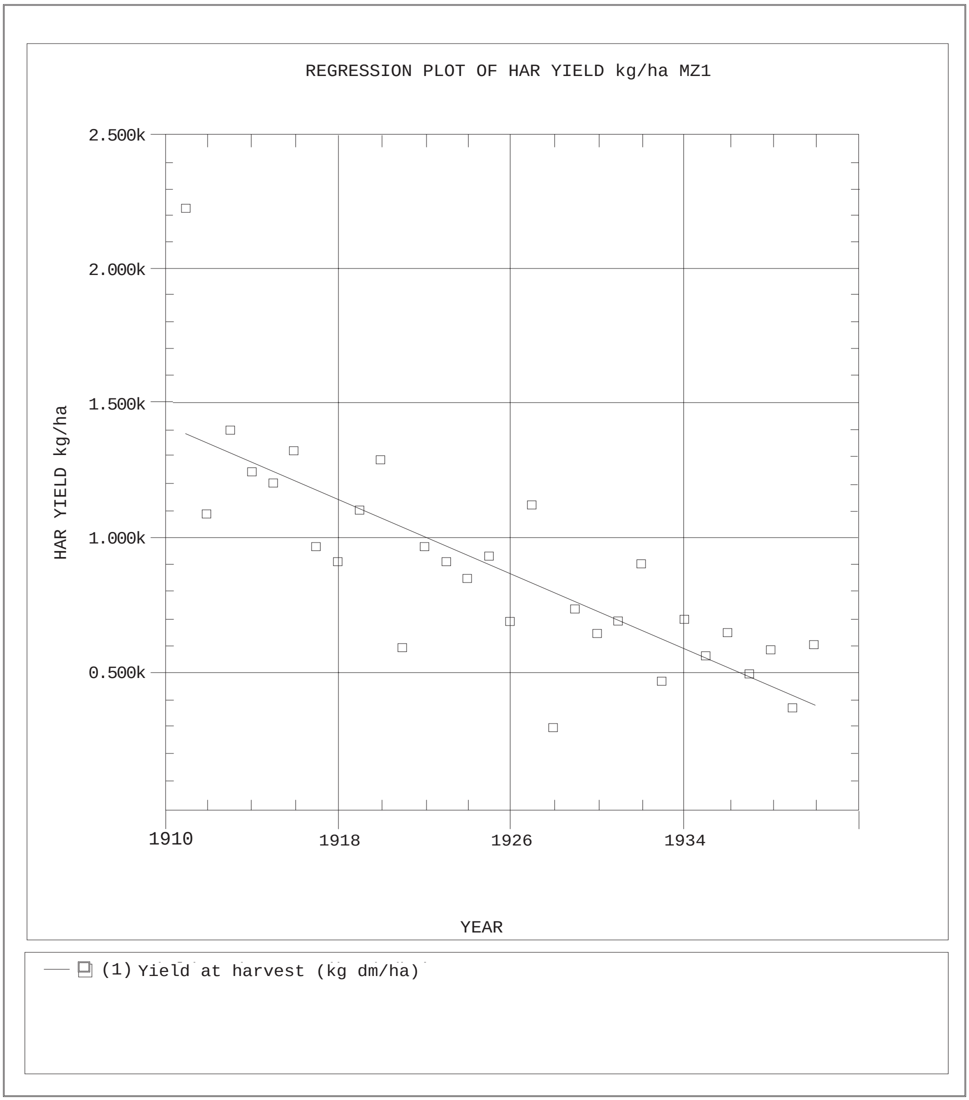
of the exponential function

$$y = c * \exp(mx),$$

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,

$$d_{y.x} = Y - Y = y - mx$$

where Y is the regressed value of output and 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.)

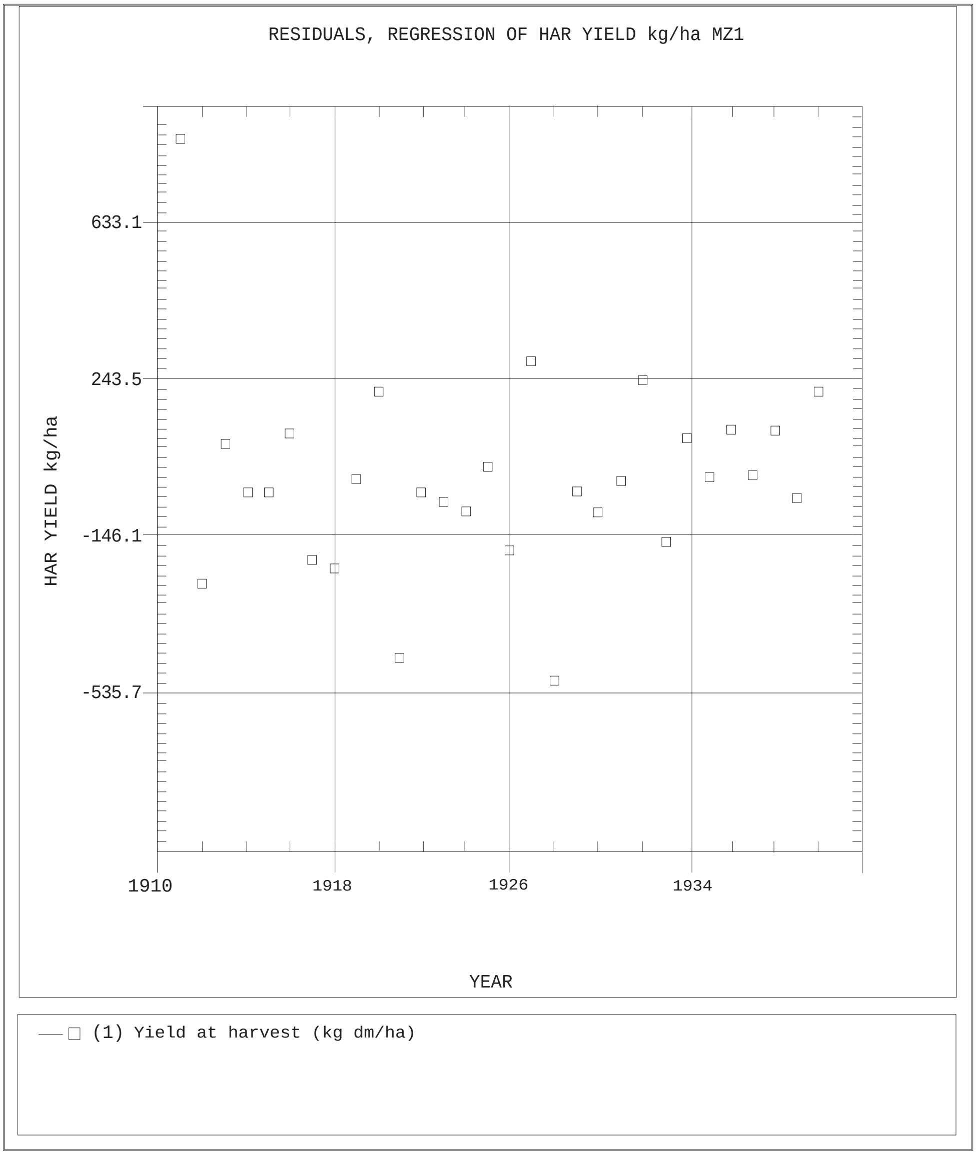
The resulting screen warns you that you have picked multiple crop codes. In the subsequent screen (Screen 22, on second following page), you have to make a choice as to how the program will analyze these multiple crops. There are three options, described as follows.

`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 day 55.8 (you can check this by analyzing the maize harvest date). Thus the sequence year

```
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.

number is calculated as 1912+(55.8/365), or 1912.2 to one decimal place (Screen 23).

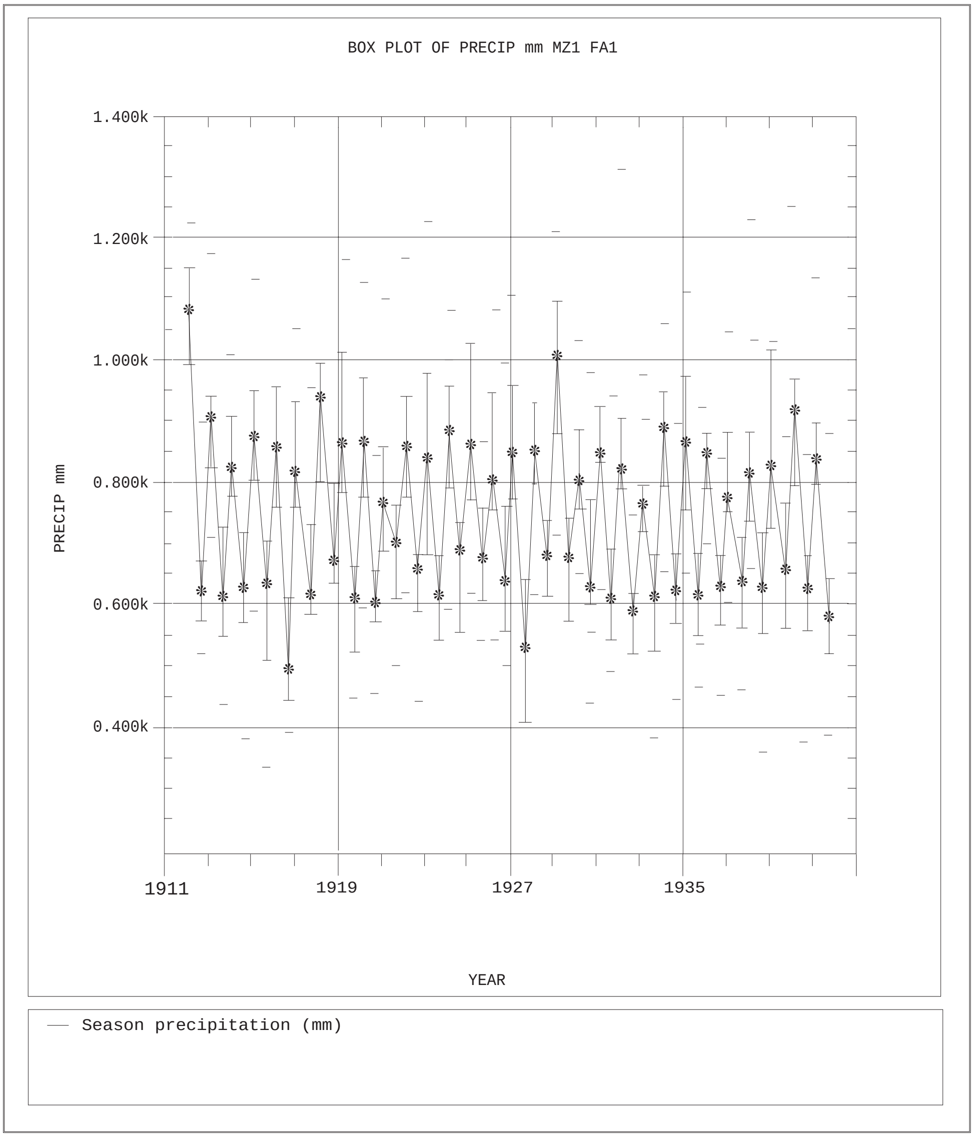
The first fallow period of the first replicate stopped on day 304 in 1912, as it did for each year subsequently (Table 4): remember that planting of maize took place on day 305 each year. The mean sequence year number for the fallow rainfall total is thus calculated as 1912+(304/365), or 1912.8 to one 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,

```
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.

but this 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 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 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.

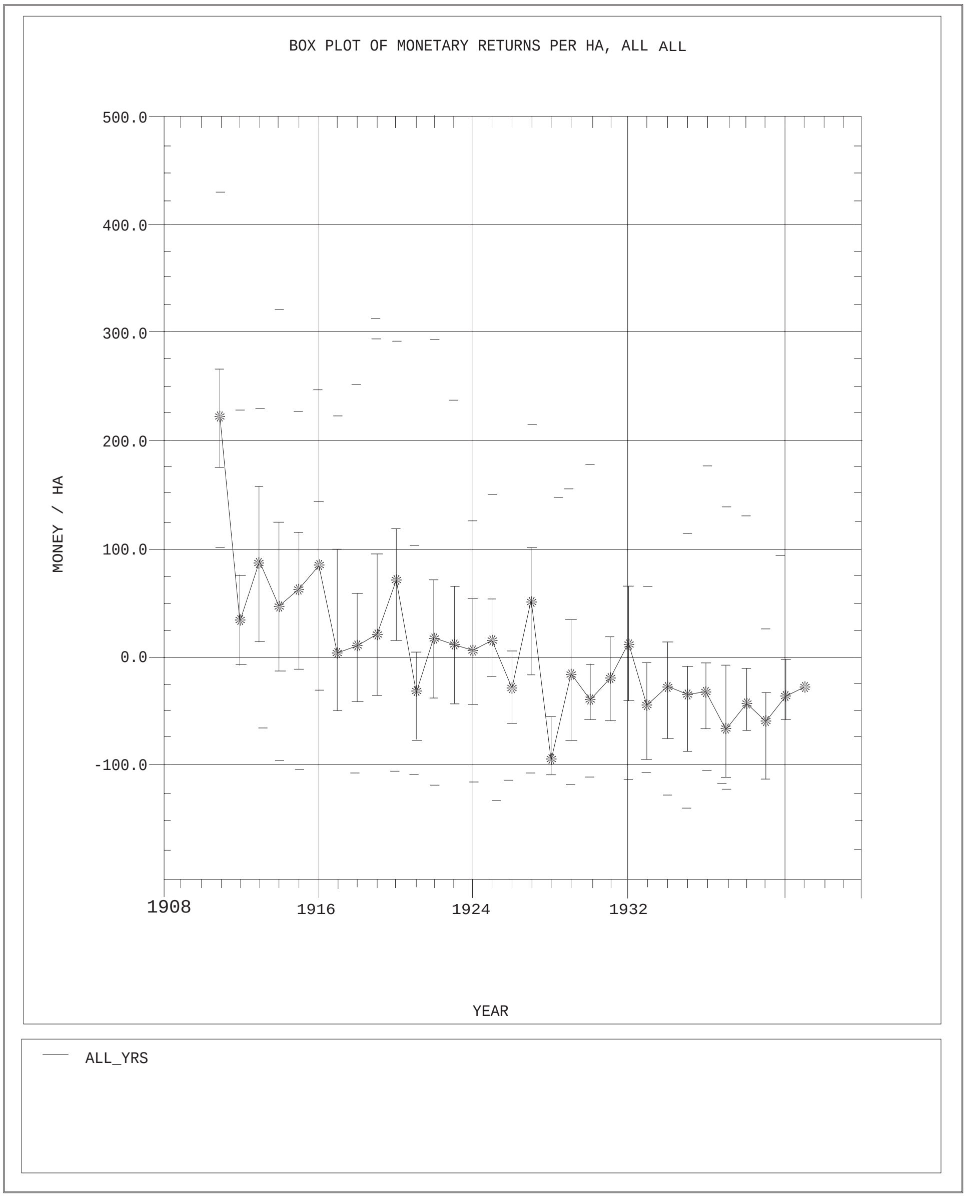
You then have the option to plot some results. The plot menu (Screen 28, below) allows you to do box plots of economic returns by crop component or total returns (all crop components included in the analysis). Select the option, "Box

```
DSSAT Version 3.0 Crop Sequencing Analysis

Main Menu
 Economic Evaluation
  Plot Menu                    file EBAF1101.PRQ)
  Box Plot of Returns - MZ1    ods in analysis
  Box Plot of Returns - FA1    ty analysis
M
A Box Plot of Total Returns
  Probability Analysis
Ex Review results

  Exit economic analysis

F1 (Help) |                      | 71440  Mem
```

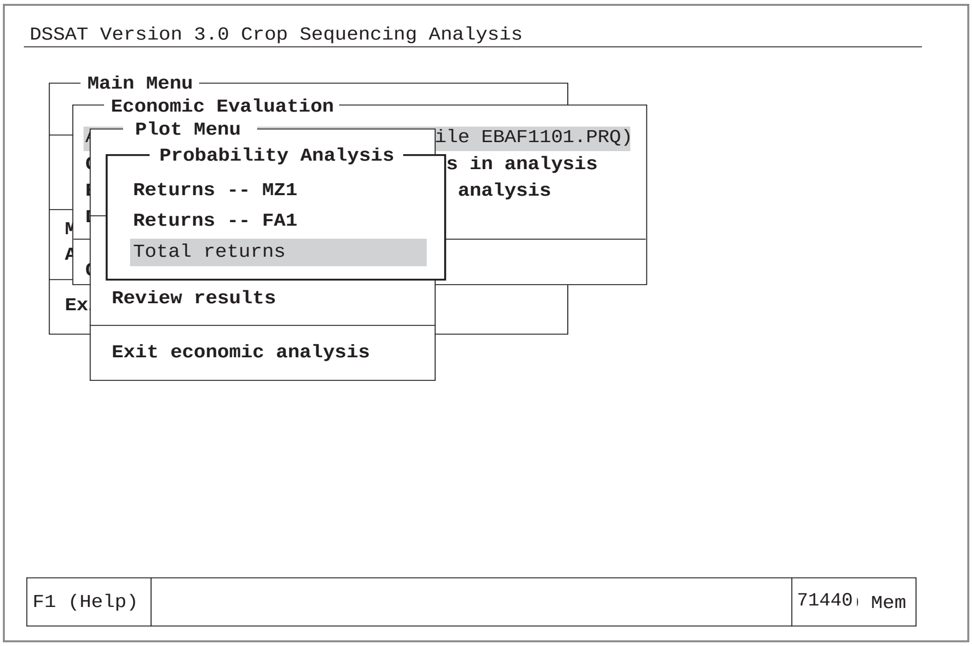
Screen 28.

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 analysis by crop component or for total returns (all components

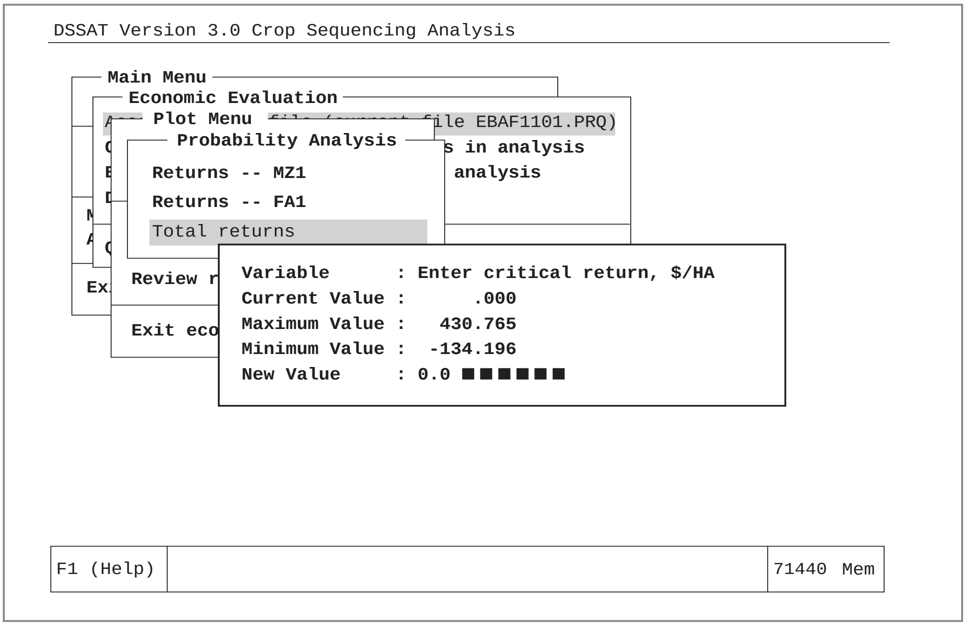


SCREEN 29.



Screen 30.

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 generate. In some situations, the probability of



Screen 31.

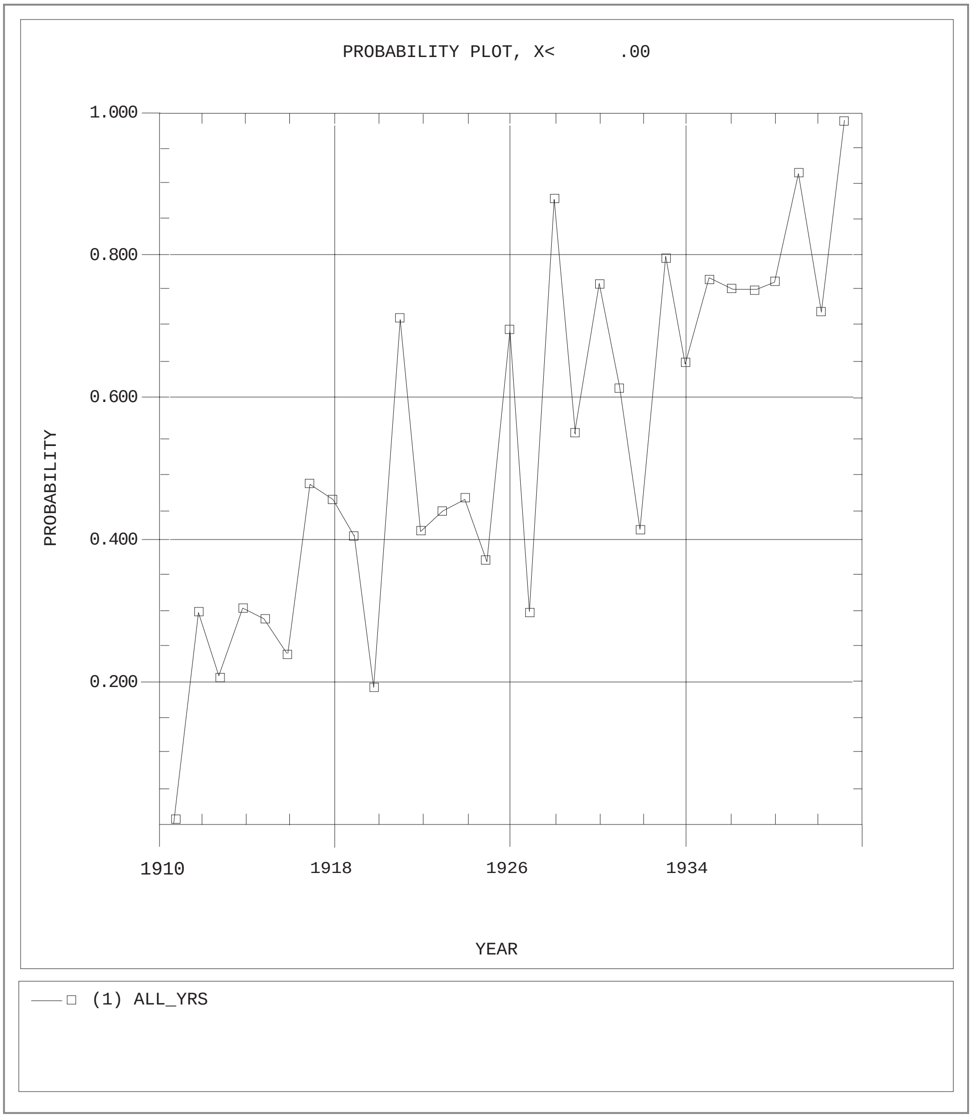
failing to generate a certain level of returns from an enterprise is an important criterion of viability; if this probability of failure increases through time, then this raises serious questions concerning the long-term viability of the crop sequence or rotation. The probability analysis performed is 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)   Press any key to continue....                 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 are stored in an ASCII file called GRAPH.INI (see Table 6).

```
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.

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	1571.6	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.	508.3333	-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:

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.

Thornton, P.K., G. Hoogenboom, P.W. Wilkens and J.W. Jones. 1994a. Seasonal analysis. *In:* Tsuji, G.Y., G. Uehara and S. Balas (eds.). DSSAT v3. Vol. 3-1. University of Hawaii, Honolulu, HI.

APPENDIX A.
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

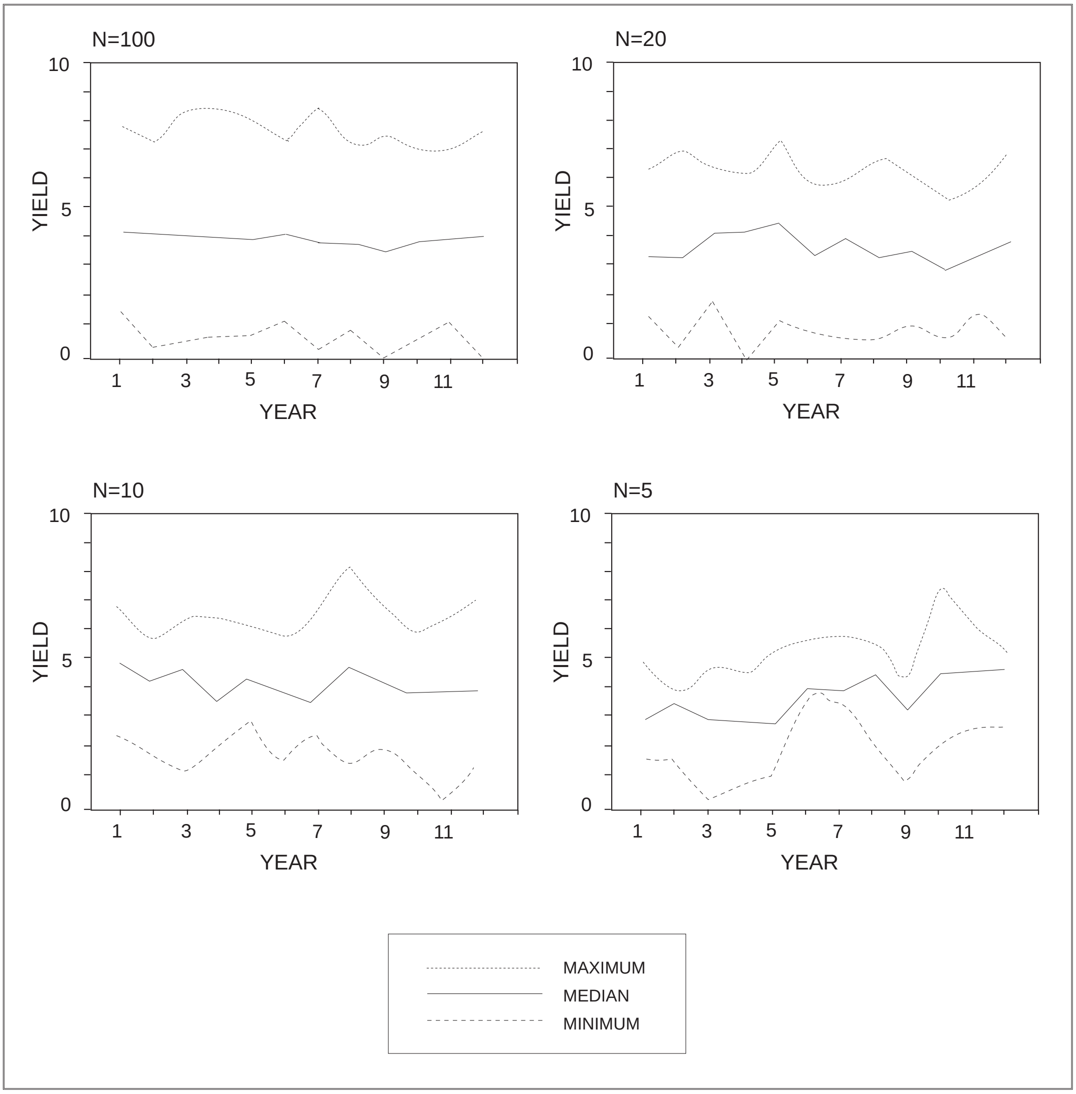


Figure 3. "Simulated" Sequence Outputs Showing Increasingly Erratic Plots as Replicates Fall Below 100 (N = 20, 10 and 5, Respectively).

over time is sufficient to say with certainty, this is not a viable sequence. Other situations may not be so cut and dried.

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

J.W. Hansen,
N.B. Pickering,
J.W. Jones,
C. Wells,
H. Chan,
D.C. Godwin

University of Florida
Massey University, University of Hawaii
International Fertilizer Development Center
International Benchmark Sites Network for Agrotechnology Transfer

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 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.

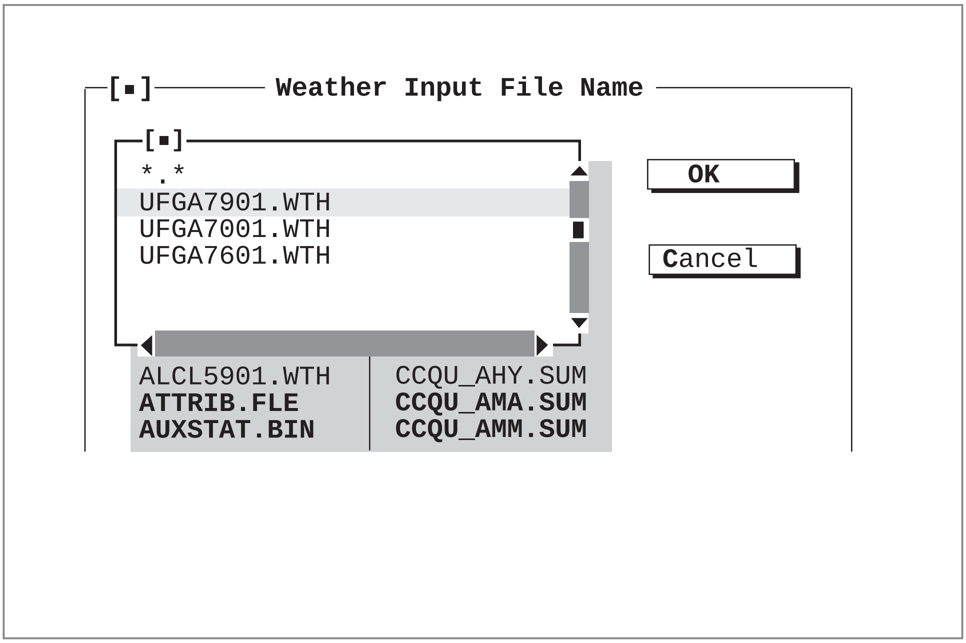
<ENTER>	Accepts highlighted choice and performs function. For most dialog boxes the default option is OK. For data entry dialog boxes, pressing the <ENTER> key is equivalent to pressing the <TAB> key.
L mouse button	Left button on the computer mouse. A single click highlights an item. Double click is 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 (Ø) 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. For a format file, any legal



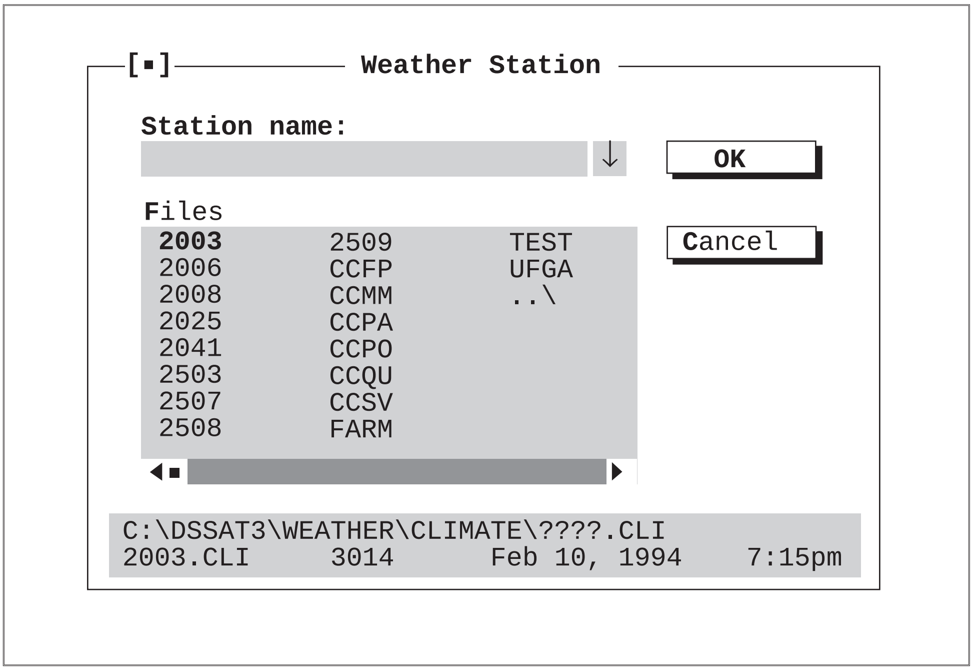
Screen 2.

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).

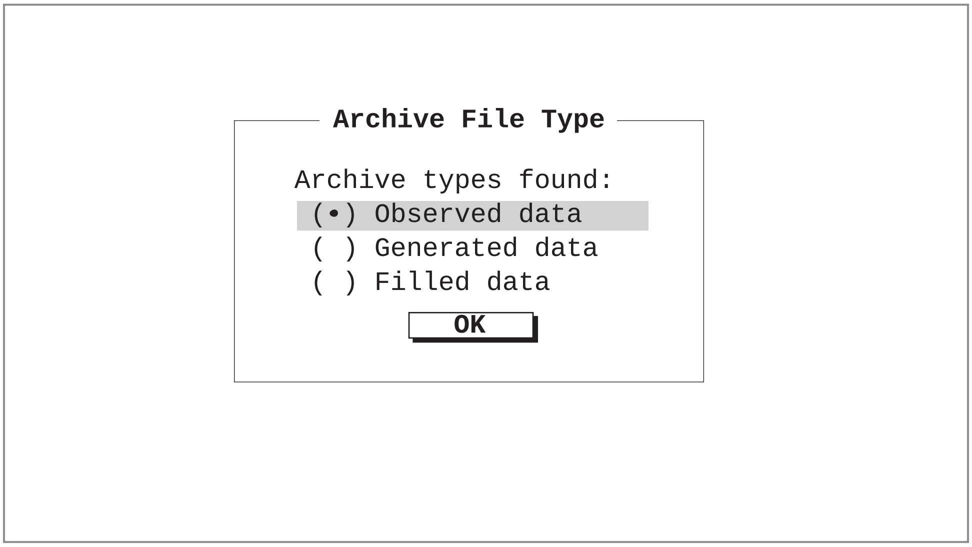
Three kinds of archive files for a single station can exist: Raw (or observed), Filled, and Generated. The raw archive file is generally retained, while filled and generated archive files may be automatically deleted upon exiting the WeatherMan, depending on the options selected under the OPTIONS main 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

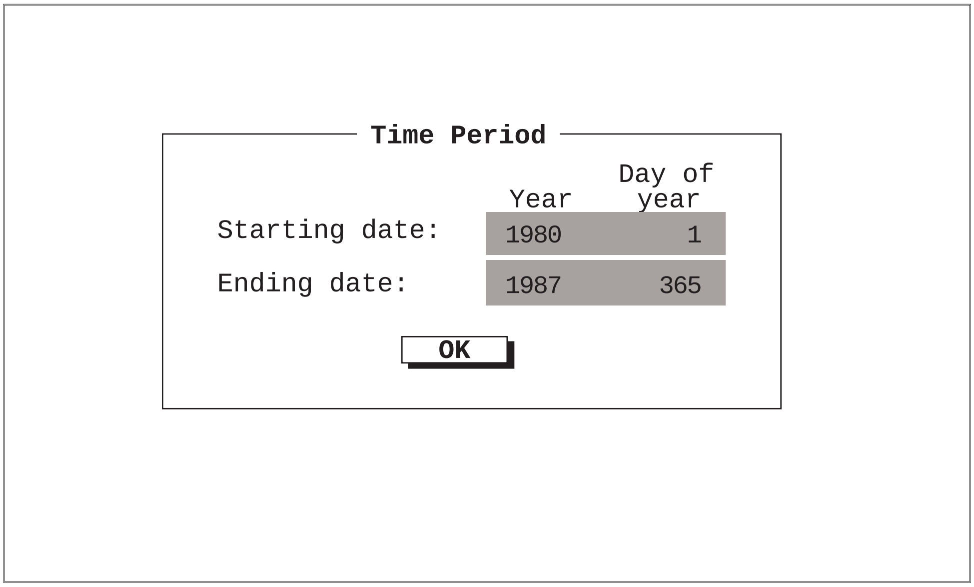


SCREEN 3.



SCREEN 4.

dates 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).



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
```

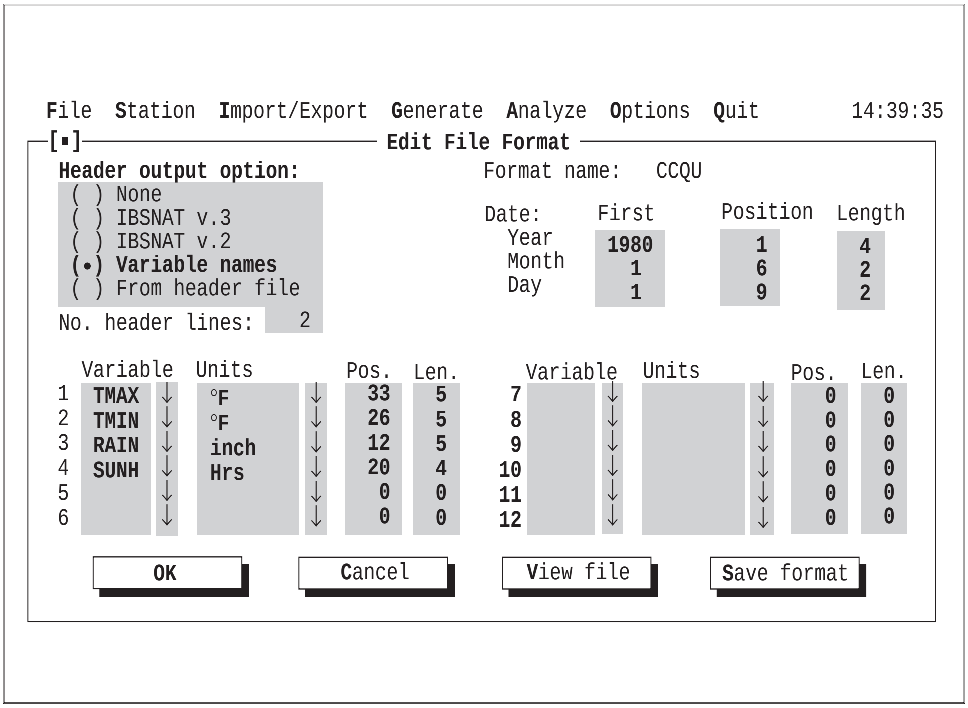
SCREEN 6.

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



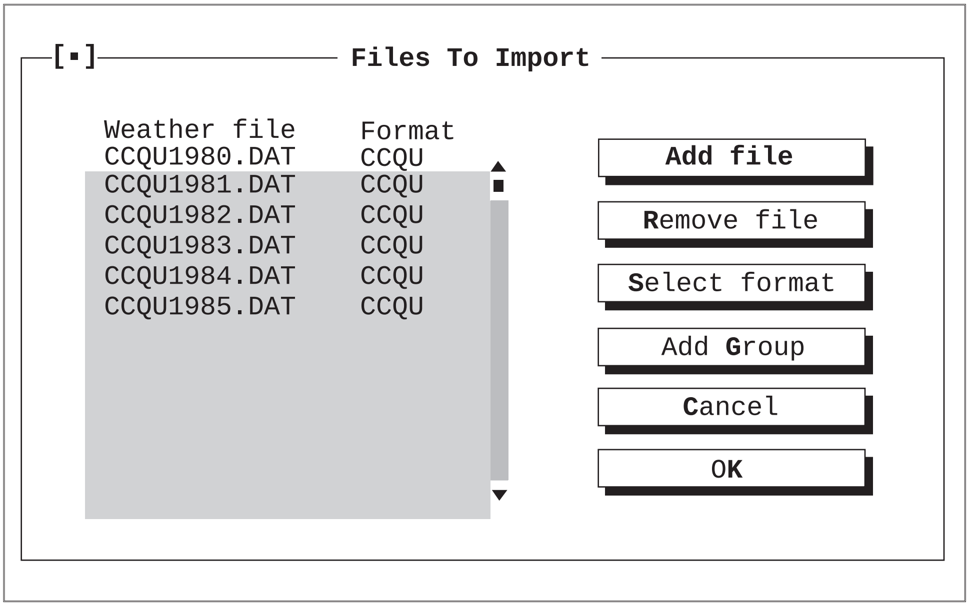
SCREEN 7.

Formats" option 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

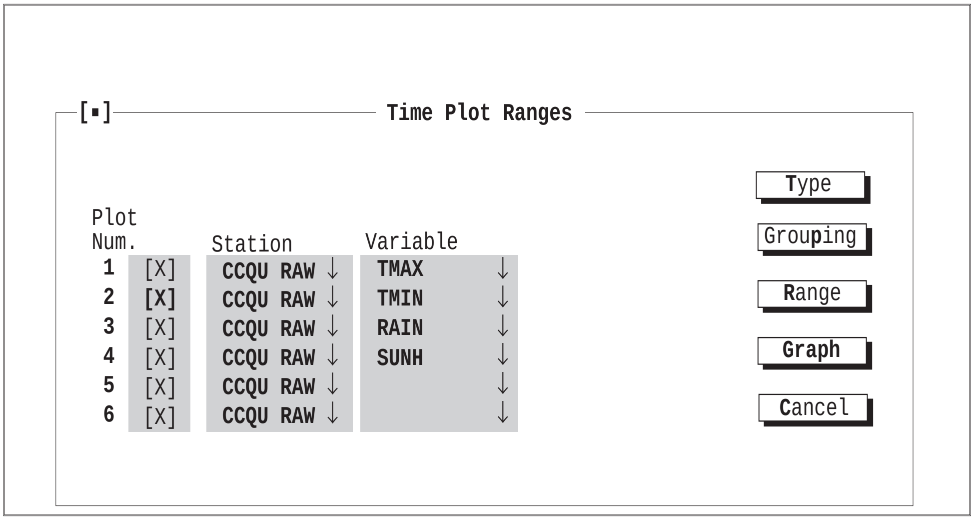
Go to ANALYZE|"Statistics." Select all statistics types and time groupings by checking all of the boxes, using a mouse or cursor keys and press the <SPACE> bar. Then, select the OK button to calculate statistics. Go to ANALYZE|"Report" to view the statistics files. Print only the monthly summary moments 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.



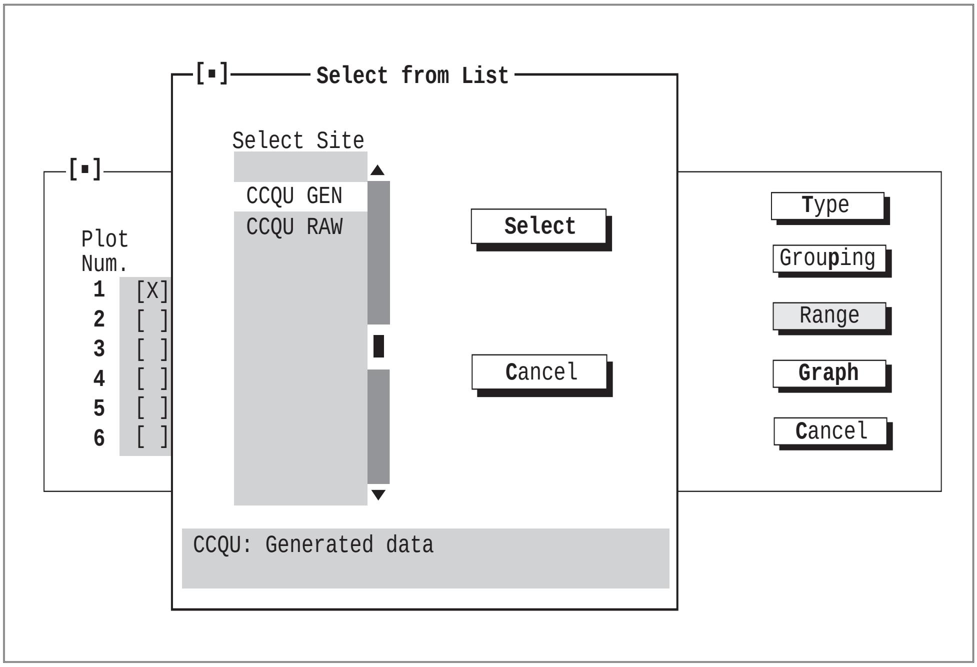
Screen 9.

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.

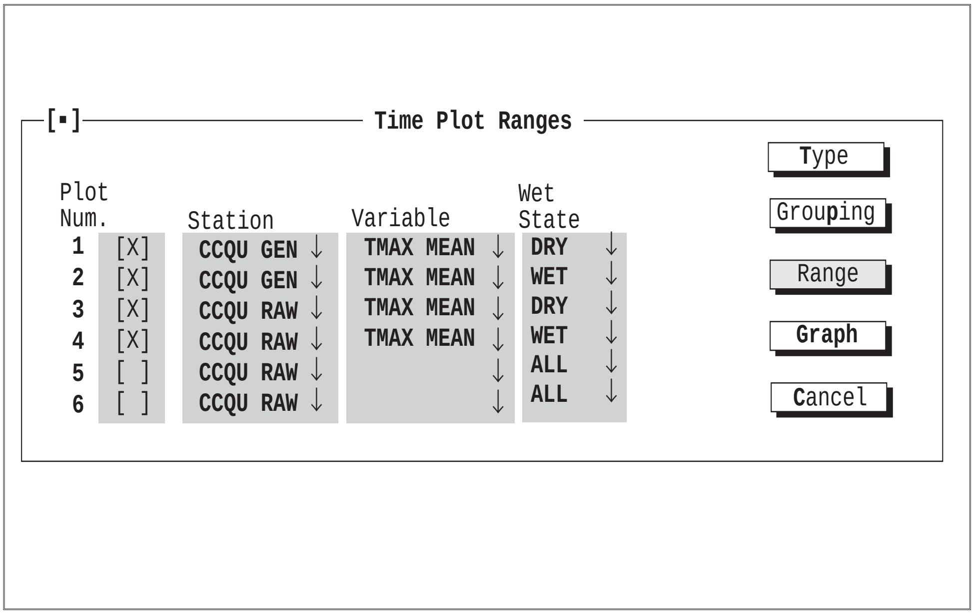
Graph Statistics for Observed and Generated Data

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 Plot Num. 2, specify TMAX Mean on WET days



Screen 10.



SCREEN 11.

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.

Table 3. WeatherMan Variables and Associated Units.

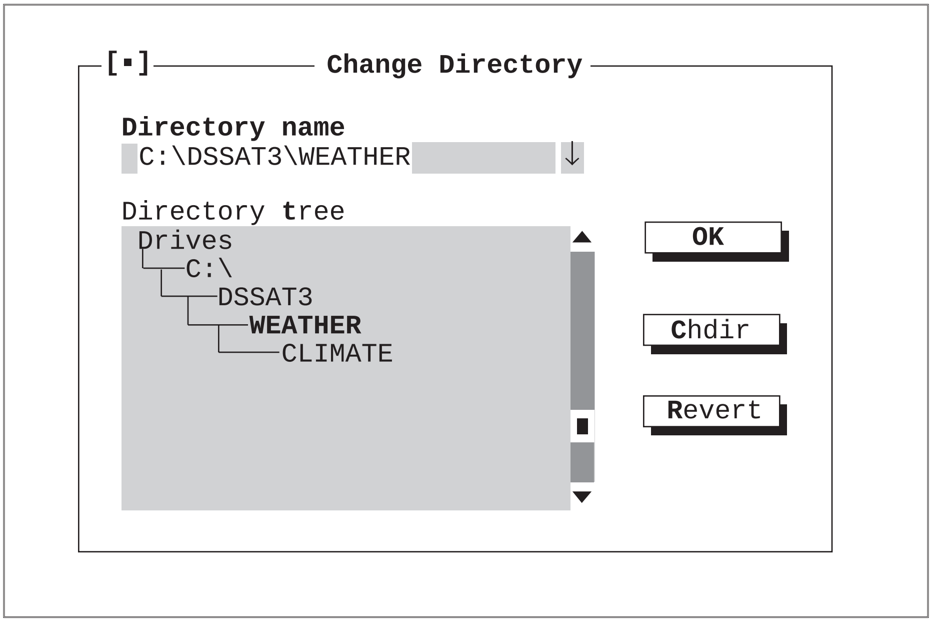
Variable	Description	Default unit	Other units
SRAD	Total daily solar radiation	MJ/m^2	cal/cm^2, $W\text{-}h/m^2$
TMAX	Maximum daily air temperature	°C	°F, °K
TMIN	Minimum daily air temperature	°C	°F, °K
RAIN	Total daily precipitation	mm	cm, inch
DEWP	Dew point temperature or vapor pressure	°C	°F, °K, 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 useful 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

```
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.

only allows a 4-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

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.

Export will be dis-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

File Station Import/Export Generate Analyze Options Quit 12:51:39

[▪] Monthly Means and Rainfall

	--mean monthly values--			Total	Number	Mean	Angstrom coef.	
	SPRAD	TMAX	TMIN	rain	of wet	SUNH	A	B
Mon	(MJ/m2)	(°C)	(°C)	(mm)	days	(%)	(Y-int)	(slope)
1	10.9	19.3	5.7	94.2	8.7	-99.0	0.250	0.500
2	13.4	21.2	7.2	118.3	8.3	-99.0	0.250	0.500
3	17.2	24.3	10.0	109.8	8.3	-99.0	0.250	0.500
4	21.4	28.0	13.5	78.7	5.8	-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.

where daily hours of 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 files specify columns of data, units

```
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
```

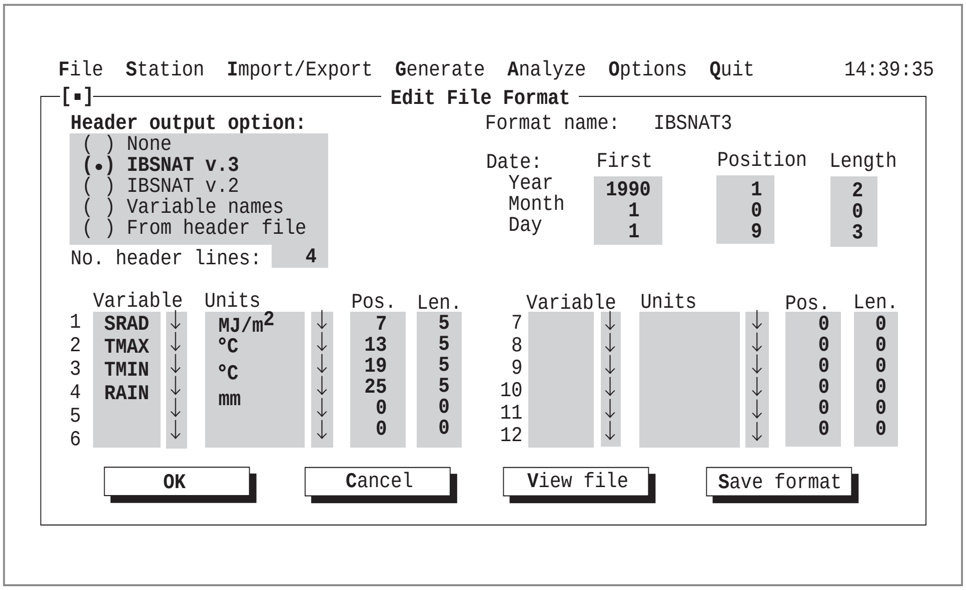
Screen 17.

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



SCREEN 18.

explicitly 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, so when you quit the operation, any changes you have made to the format will be lost.

```
  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 ------------------[↑]-
          1         2          3          4         5         6         7
  *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.

The VIEW FILE button displays the file in conjunction with a ruler as shown in Screen 19.

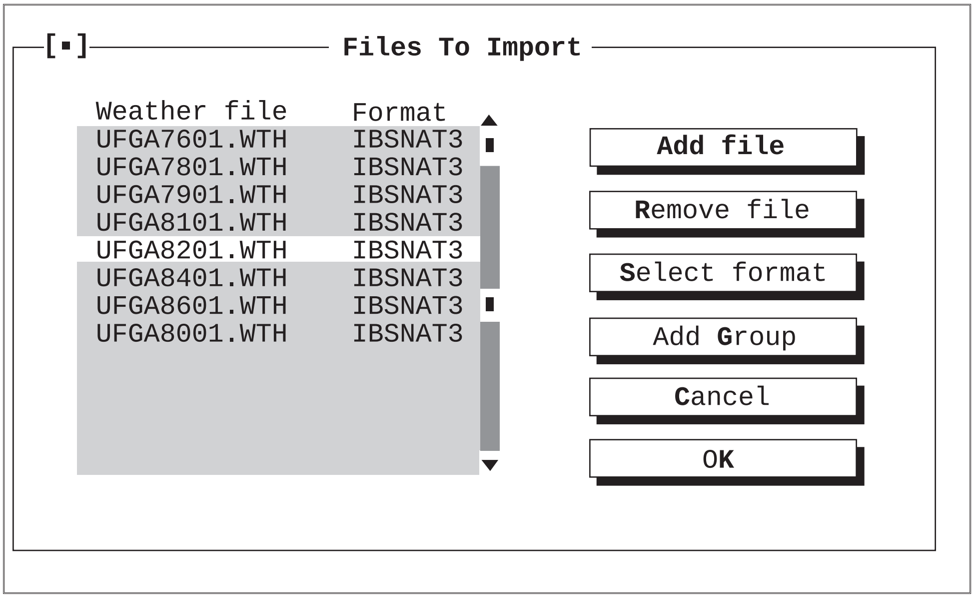
If a format is being edited during an Import operation and the "Preview formats" option is enabled (with a tick mark) in the "Import Options" dialog box (see Screen 24), then a "Preview Format" dialog box (Screen 20, below) will be presented when either the OK or the SAVE button is pressed. The "Preview 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).

```
[▪]                        Preview Format

  The highlighted text shows how WeatherMan will parse the first 50
  records in UFGA8001.WTH based on the current format.   Continue?

                C:\DSSAT3\WEATHER\UFGA8001.WTH
  Yr Dy  SRAD  TMAX  TMIN  RAIN
  80001   8.7  14.4   2.8   0.0                      18.5
  80002  13.9  17.2  -1.1   0.0                      28.7
  80003  13.0  18.9  -1.1   0.0                      27.6
  80004   2.0  18.9   5.0  27.9                       5.4
  80005  13.6  16.1   5.0   0.0                      27.8
  80006  14.2  12.2  -2.2   0.0                      28.9
  80007  13.6  20.0  -1.1   0.0                       7.3
  80008   9.1  22.8   5.0   0.0                      20.1
  80009   6.8  23.9  10.6   0.0                      15.6

              Yes                               No
```

Screen 20.

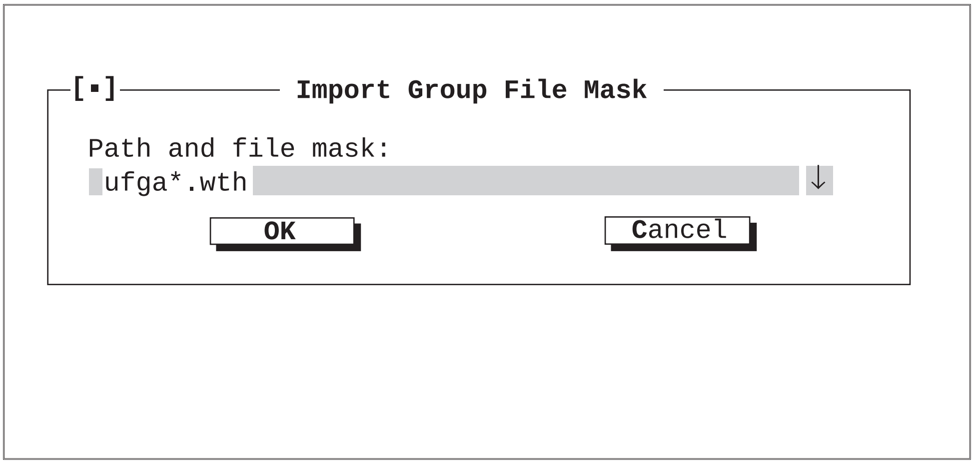


SCREEN 21.

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.

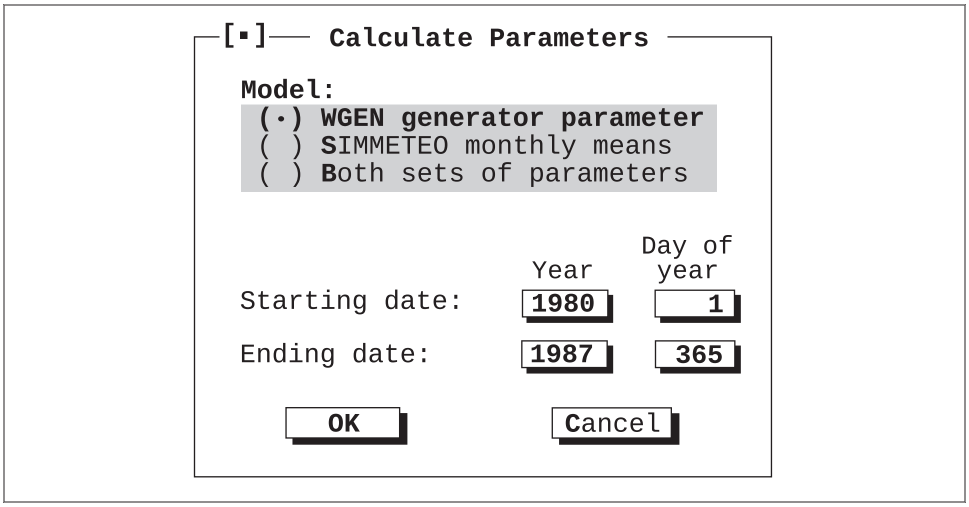
CALCULATE PARAMETERS

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 menu (see Screen 14)—both

```
File  Station  Import/Export  Generate  Analyze  Options  Quit      14:55:44
                              Calculate parameters
                              Generate data
```

SCREEN 28.



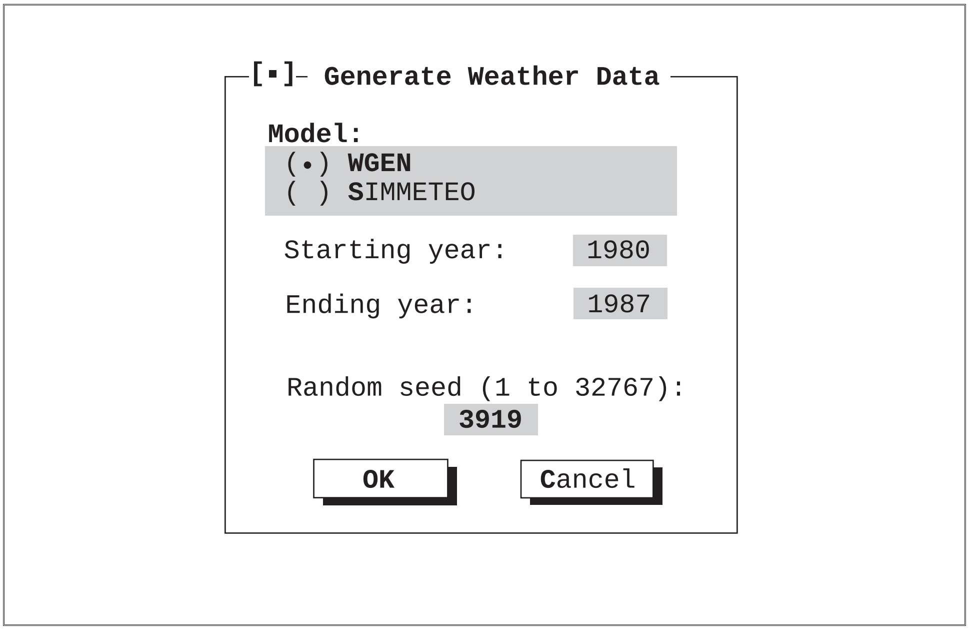
SCREEN 29.

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.



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.

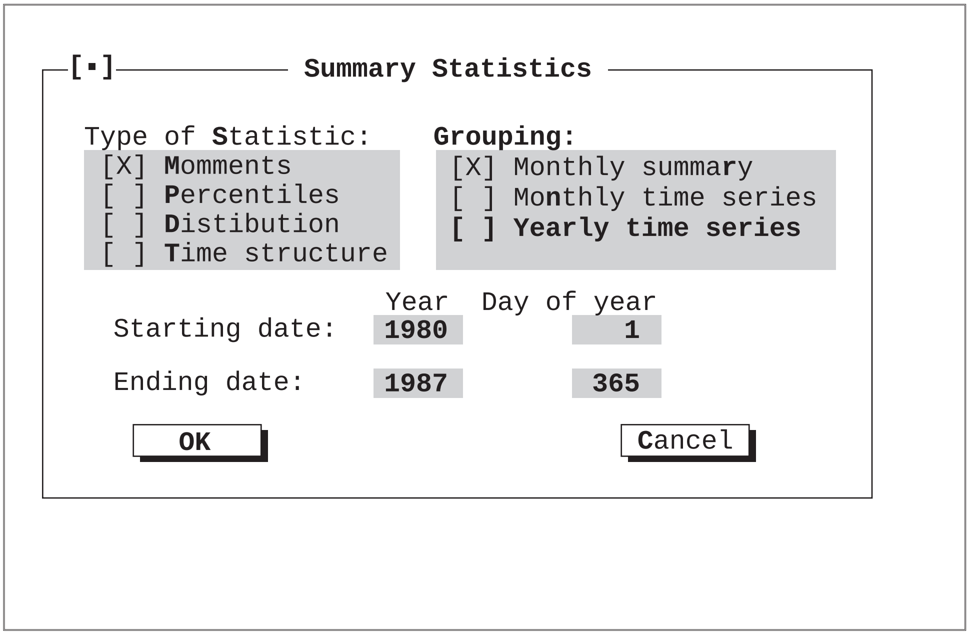
`Data fill.` The "Data fill" option creates a filled archive file called Station_FIL.WTD. This file is usually treated as a temporary file for the duration of the WeatherMan session (see the following section entitled, "Options Menu" and the subsection "Temporary Files" for a description of how to change 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



Screen 32.

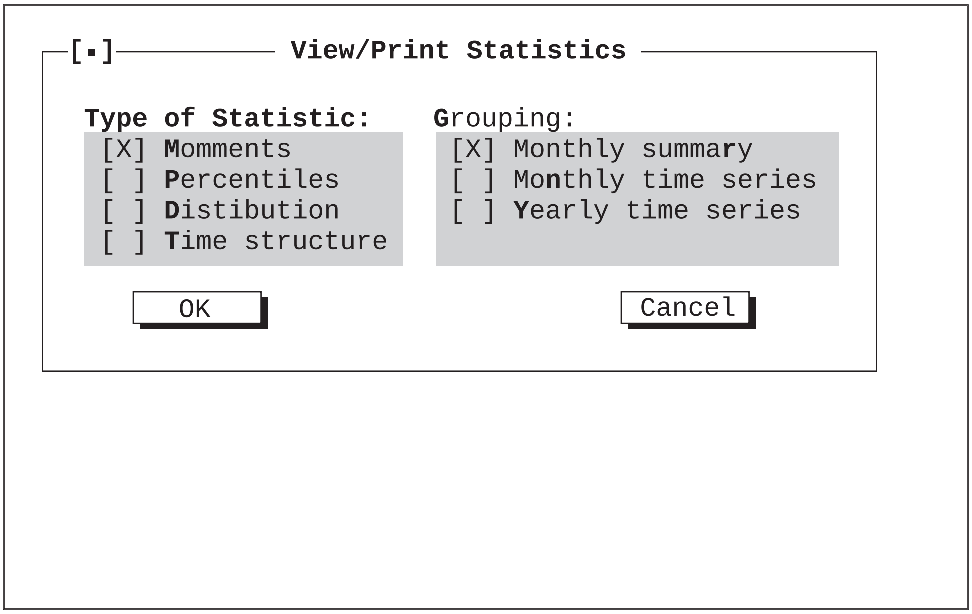
skewness coefficient. "Percentiles" are the 0, 25, 50, 75, and 100 percentiles. "Distribution" includes both histograms and cumulative probabilities. "Time structure" includes autocorrelograms for all variables except rainfall, and has conditional probabilities for rainfall. All statistics are automatically 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



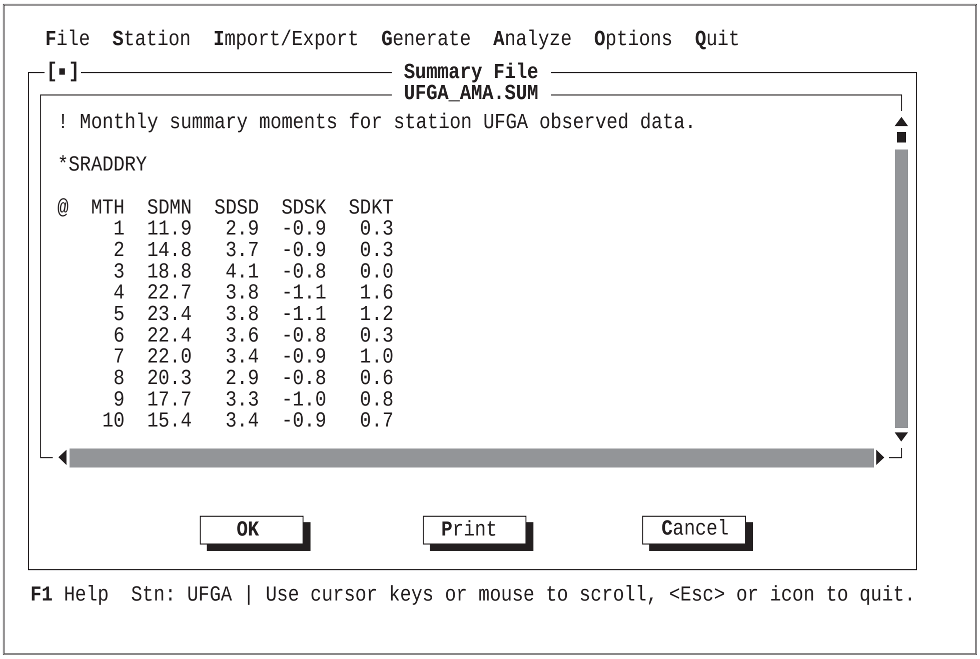
SCREEN 33.

sequentially. Up to 12 summary files 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.



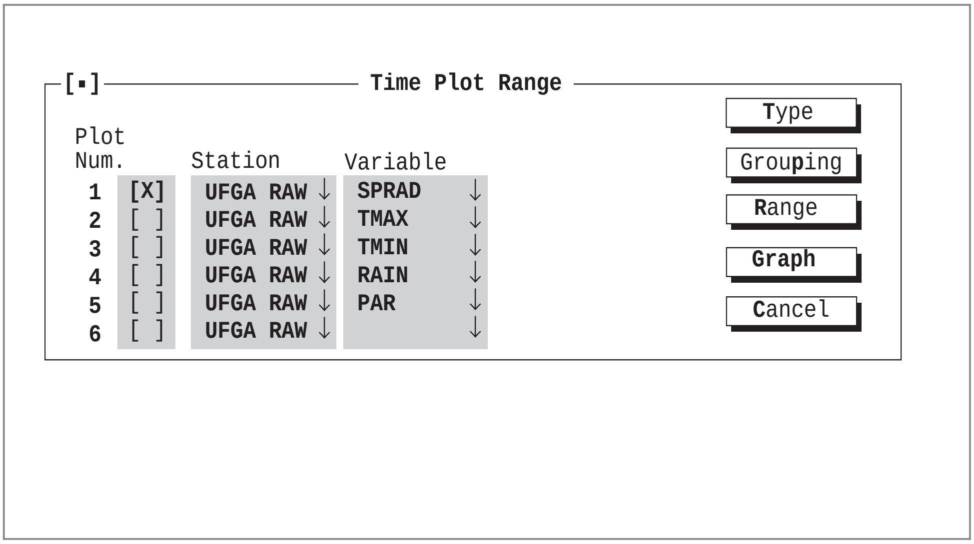
SCREEN 34.

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.

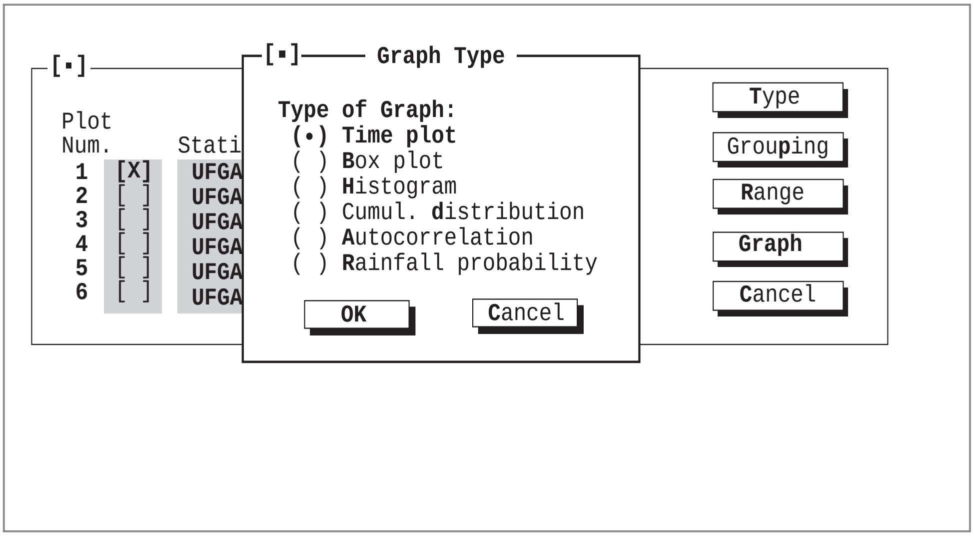
An example of a plot definition dialog box is given in Screen 35 (on following page) for a “Time Plot Range” where six plots are defined and two (TMAX and TMIN) are checked for plotting.



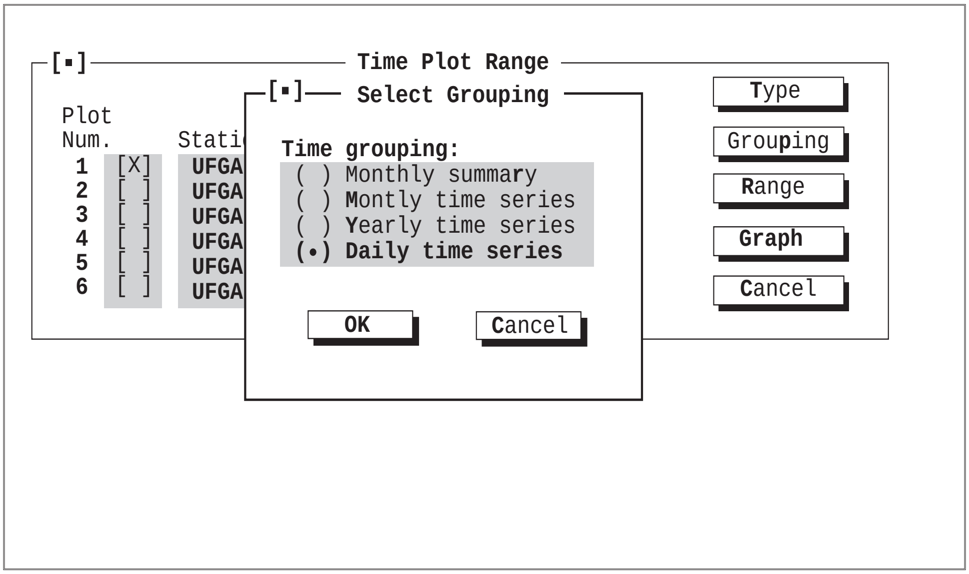
SCREEN 35.

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 36.



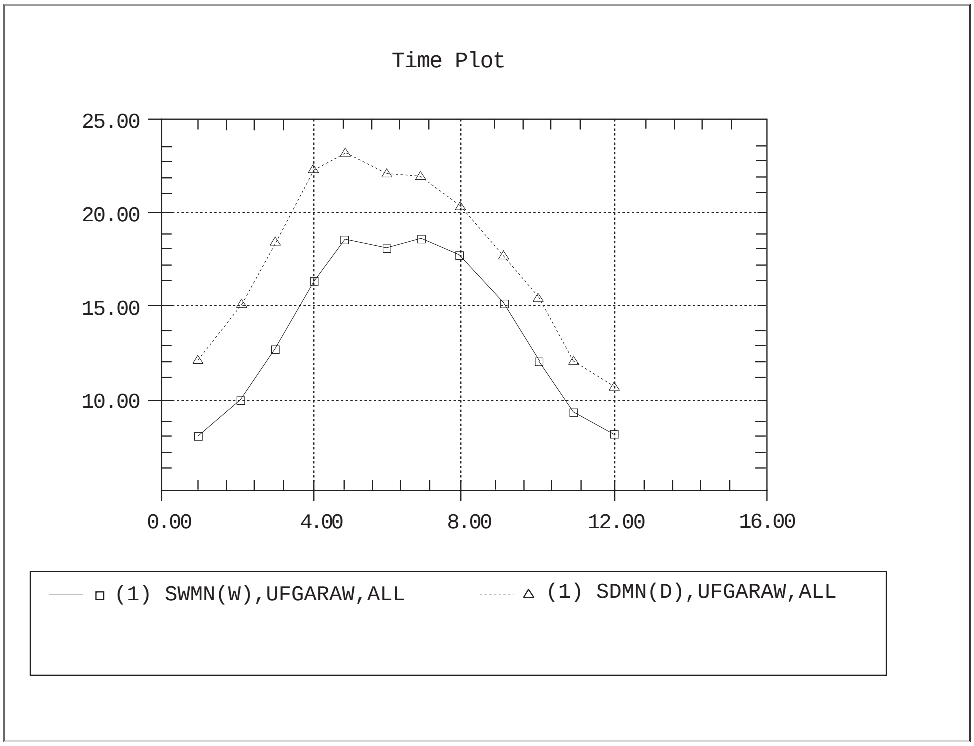
SCREEN 37.

(Screen 33) 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 wetdays, 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,"



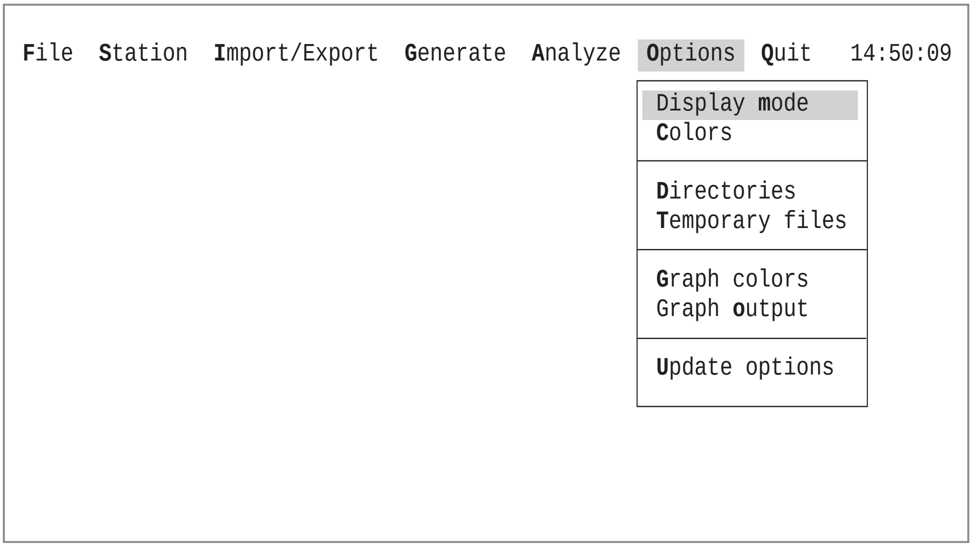
Screen 38.

"D," or "A" appears in parentheses, it 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.*

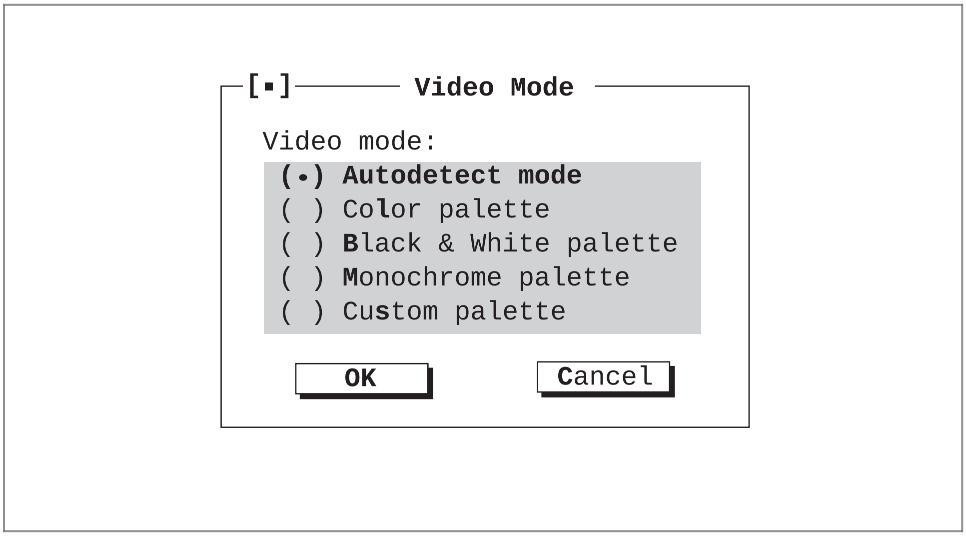


Screen 39.

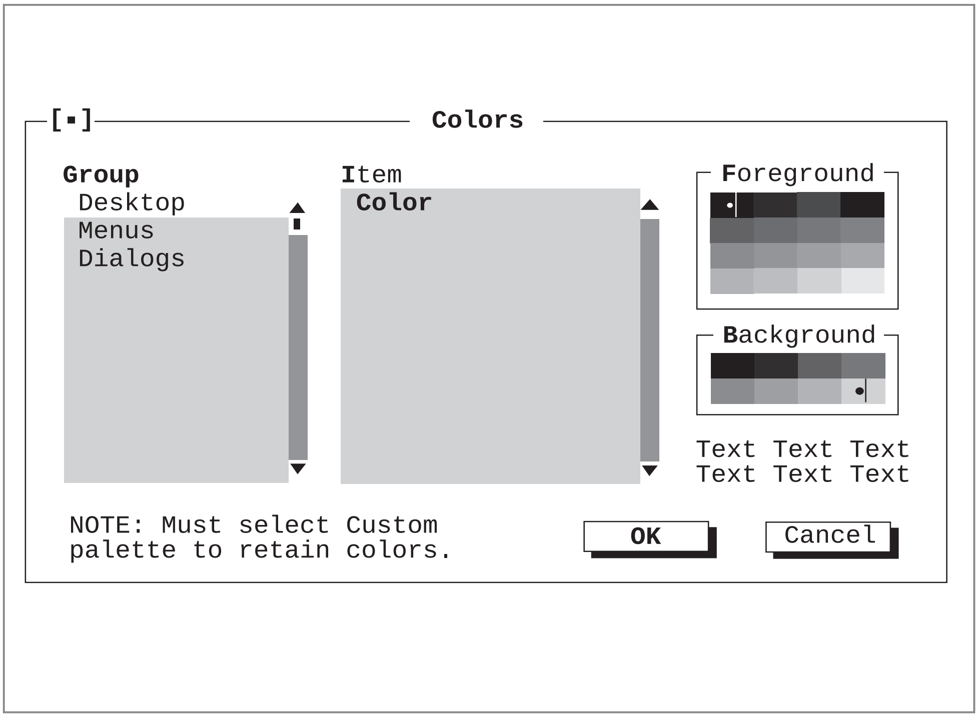
Display Mode

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 alter-



Screen 40.

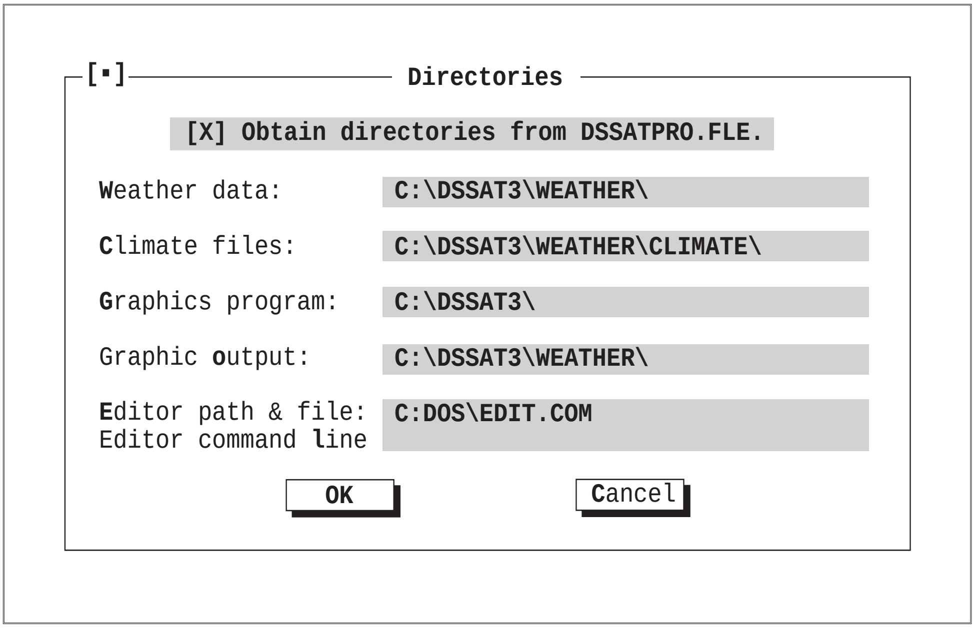


SCREEN 41.

native mode or 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).



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 sta-

```
[▪]— 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.

tistics (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.

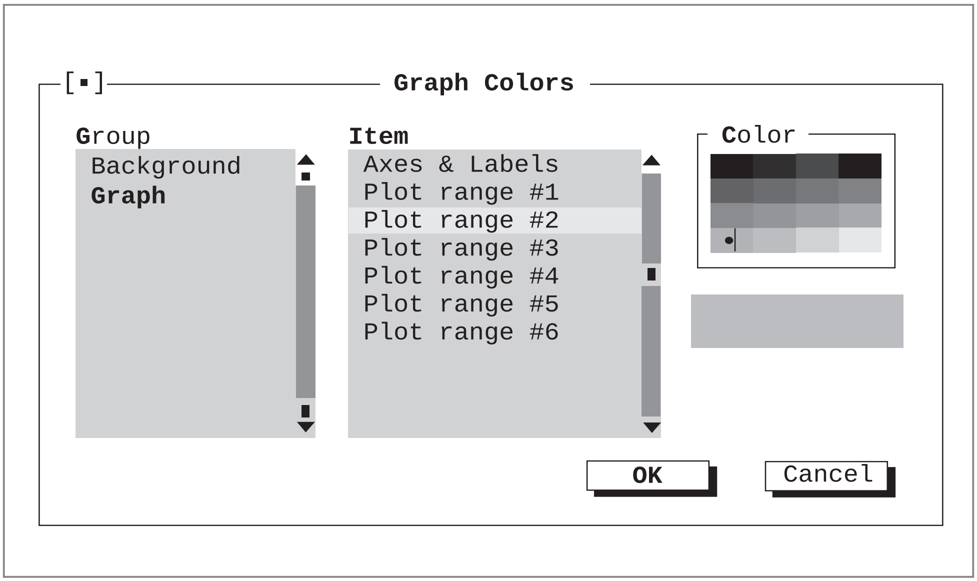
Graph Colors and Graph Options

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.

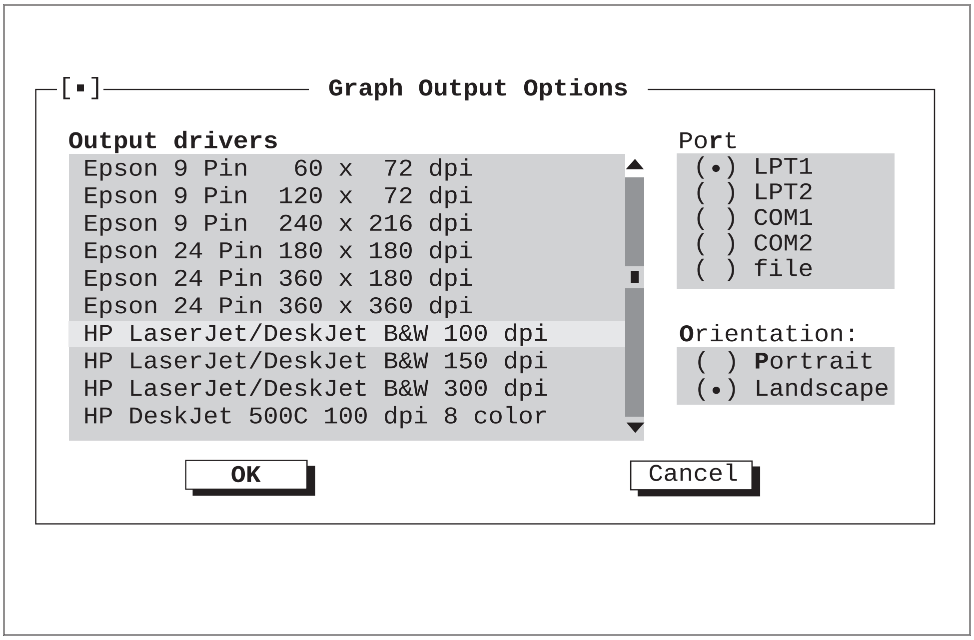
In Screen 45, you can select an output device type/resolution/paper size combination from the scrolling list. If a “file” is selected as the output port (see the options under the “Port” window), the user is prompted for a file name using a standard “File List” dialog box prior to entering the graphics 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



Screen 45.

WM.CFG while Graphics 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 shortcut 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.

REFERENCES

Borland. 1993. Borland Pascal Version 7. Borland International, Scotts Valley, California.

Conway, H.M. Jr, S.L. May Jr., and E. Armstrong, Jr. 1963. The Weather Handbook. Conway Publications, Atlanta, GA.

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.

Geng, S. and J.S. Auburn. 1986. Weather simulation models based on summaries of long-term data. In Intl. Symp. on Impact of Weather Parameters on the Growth and Yield of Rice, April 7-10. International Rice Research Institute, Los Banos, Philippines.

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.

NOAA. 1974. Climate of the States. Water Information Center, National Oceanographic and Atmospheric Administration, United States Department of Commerce, Asheville, NC.

Pickering, N.B., J.W. Hansen, J.W. Jones, H. Chan, and D. Godwin. 1994. WeatherMan: A utility for managing and generating daily weather data. Agron. J. 86(2):332-337.

Pickering, N.B., J.R. Stedinger, and D.A. Haith. 1988. Weather input for nonpoint-source pollution models. J. Irrig. Drain. Eng. 114(4):674-690.

Prescott, J.A. 1940. Evaporation from a water surface in relation to solar radiation. Trans. R. Soc. S. Austr. 64: 114-118.

Richardson, C.W. and D.A. Wright. 1984. WGEN: a model for generating daily weather variables. United States Department of Agriculture, Agricultural Research Service, ARS-8, Washington, DC.

Rietveld, M.R. 1978. A new method for estimating the regression coefficients in the formula relating solar radiation to sunshine. Agricul. Meterol. 19:243-252.

Rudloff, W. 1981. World-Climate. Wissenschaftliche Verlagsgesellschaft, mbH Stuttgart, Germany.

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, ºC.
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, ºC.
TMNY	Mean annual daily minimum temperature, ºC.
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, ºC.
NAMN	Mean daily minimum temperature for month, ºC.
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, ºC.
XDSD	Standard deviation of maximum temperature on dry days.
XWMN	Mean daily maximum temperature on wet days, ºC.
XWSD	Standard deviation of maximum temperature on wet days.
NAMN	Mean daily minimum temperature, ºC.
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

L.A. HUNT,
S. PARARAJASINGHAM

UNIVERSITY OF GUELPH
INTERNATIONAL BENCHMARK SITES NETWORK FOR AGROTECHNOLOGY TRANSFER

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).

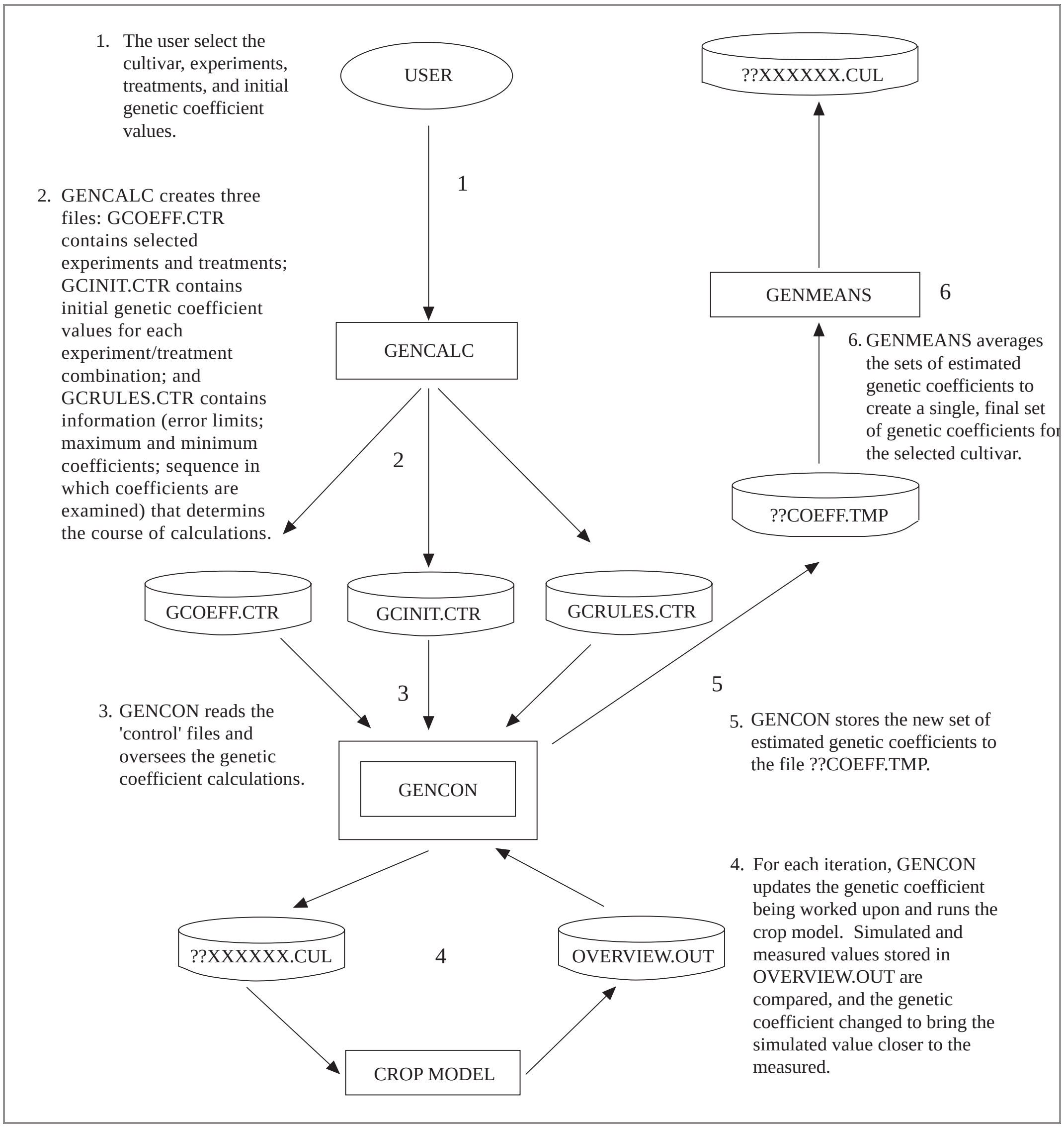


FIGURE 1. GENCALC COMPONENTS.

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.

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.

```
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 (??COEFF.TMP) 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 GENCOEFF.ABV 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

```
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.

include 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 will have a “U” immediately following the numerical value. This indicates that the particular coefficient was not

```
*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
```

SCREEN 10.

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 12.

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

```
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.

with values currently in the cultivar 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 haveboth 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.

REFERENCES

Hunt, L.A. 1988. IBSNAT's genetic coefficients: coping with germplasm diversity. Agrotechnology Transfer No. 7 p. 1-5.

Hunt, L.A. and S. Pararajasingham. 1993. GenCalc: Genotype coefficient calculator, user's guide, version 2.0. Crop Science Publication No. LAH-01-93, University of Guelph.

Hunt, L.A., S. Pararajasingham, J.W. Jones, G. Hoogenboom, D.T. Imamura and R.M. Ogoshi. 1993. GENCALC - Software to facilitate the use of crop models for analyzing field experiments. Agron. J. 85:1090-1094.

Hunt, L.A., J.W. Jones, G. Hoogenboom, D.C. Godwin, U. Singh, N. Pickering, P.K. Thornton, K.J. Boote and J.T. Ritchie. 1994a. General input and output file structures for crop simulation models. *In:* Uhlir, P.F. and G.C. Carter (eds.) Crop Modeling and Related Environmental Data, A Focus on Applications for Arid and Semiarid REgions in Developing Countries. CODATA Monograph Series, Volume 1. CODATA, Paris, France, pp. 35-72.

Hunt, L.A., J.W. Jones, P.K. Thornton, G. Hoogenboom, D.T. Imamura, G.Y. Tsuji and U. Singh. 1994b. 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.

IBSNAT. 1989. Decision support system for agrotechnology transfer V. 2.1: user's guide. Department of Agronomy and Soil Science, College of Tropical Agricultural and Human Resources. University of Hawaii, Honolulu, HI.

IBSNAT. 1990. Documentation for IBSNAT crop model input and output files, V. 2.1 for the decision support system for agrotechnology transfer (DSSAT V. 2.1). Technical Report 5. Department of Agronomy and Soil Science, College of Tropical Agriculture 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.

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 treatment to be

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).

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 num-

ber), a blank, 17 spaces for the cultivar 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)

NOTES:

NOTES:

NOTES:

NOTES:

NOTES:

NOTES:

NOTES:

NOTES:

NOTES:

NOTES: