Volume 2

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.

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Department of Agronomy and Soil Science
College of the Tropical Agriculture and Human Resources
University of Hawaii
Honolulu, Hawaii 96822

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J.W. JONES, L.A. HUNT,
G. HOOGENBOOM,
D.C. GODWIN, U. SINGH,
G.Y. TSUJI, N.B. PICKERING,
P.K. THORNTON,
W.T. BOWEN, K.J. BOOTE,
J.T. RITCHIE,

UNIVERSITY OF FLORIDA, UNIVERSITY OF GUELPH
UNIVERSITY OF GEORGIA, INTERNATIONAL FERTILIZER DEVELOPMENT CENTER
UNIVERSITY OF HAWAII, MICHIGAN STATE UNIVERSITY
INTERNATIONAL BENCHMARK SITES NETWORK FOR AGROTECHNOLOGY TRANSFER

CHAPTER ONE.

INTRODUCTION

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

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

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

In recent years, the International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT) has published documentation for a set of crop model inputs and outputs (IBSNAT, 1986, 1990). This system of files and data formats was used for the models integrated into the Decision Support System for Agrotechnology Transfer (DSSAT v2.1) (IBSNAT, 1989), in which corn, wheat, soybean, and peanut crop models all used the same database software and strategy evaluation program. This system was useful for running and validating the models, for conducting sensitivity analysis, and for evaluating the variability and risks of different management strategies for a range of locations specified by soil and weather data. The attempt to develop and use general files and formats provided a good start and demonstrated the utility of the endeavor. However, the introduction of other crops (such as rice), the introduction of other models of the same crops, and the introduction of other processes into the existing models revealed several deficiencies. Further, the large number of files presented difficulties to many users. Work was initiated, therefore, to develop a more universal set of files.

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

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

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

CHAPTER TWO.

FILE STRUCTURE

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

FILE ANNOTATION

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

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

FILE NAMING CONVENTIONS

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

EXTENSIONS

.WTH	Weather data file
.SOL	Soil profile data file

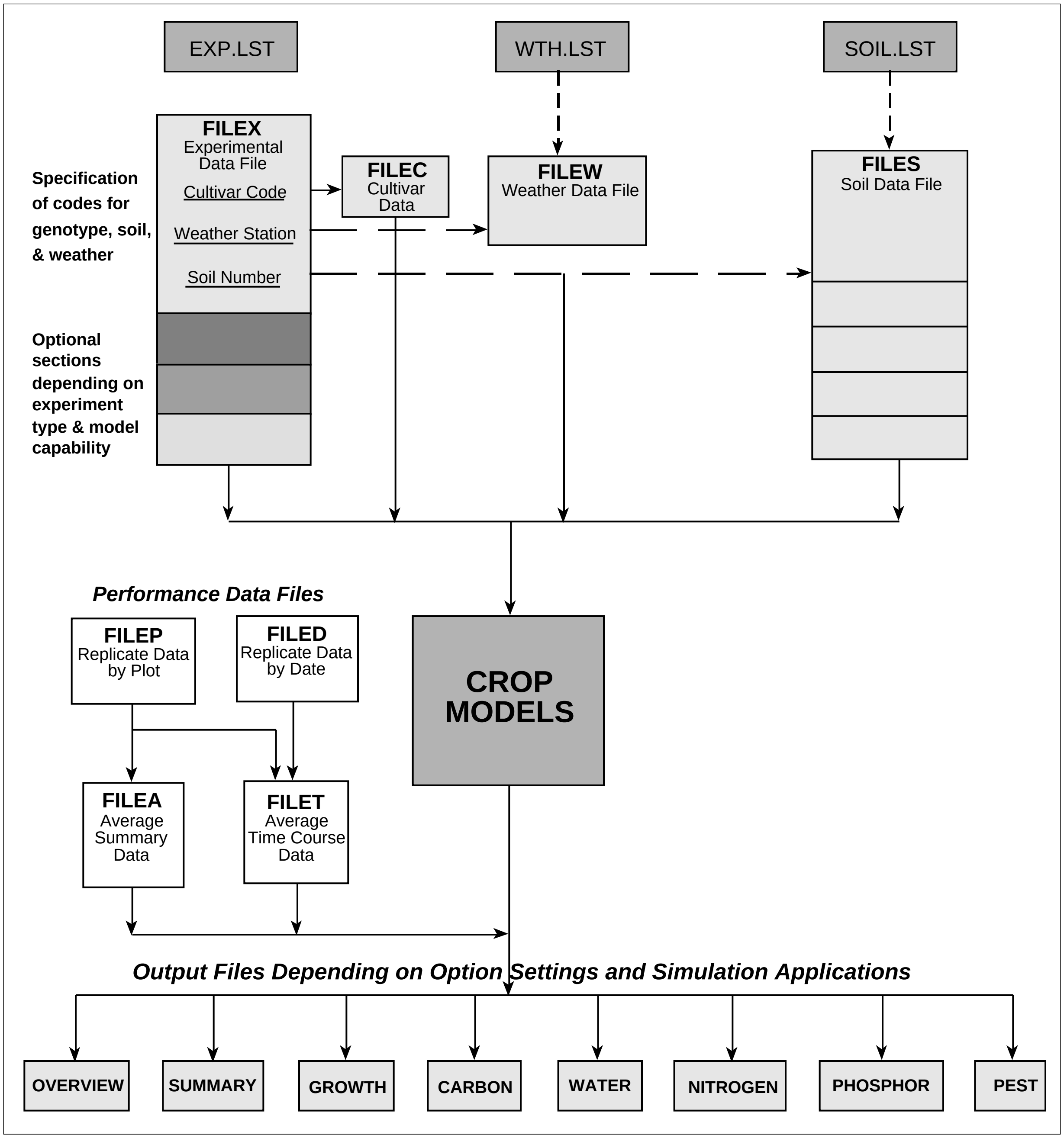

FIGURE 1. OVERVIEW OF INPUT AND OUTPUT FILES USED BY CROP MODELS.

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

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

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

PREFIXES

For most model input files and experiment observation files, the prefix is constructed from an institute code (2 characters), a site code (2 characters), the year of the experiment (2 characters) and an experiment number (2 characters). For example, an experiment conducted by the University of Florida (UF) at Gainesville (GA) in 1988 (88) would yield a file prefix of UFGA8801. The file prefix conventions used for output files and genotype coefficient files are shown in Table 1.

Missing Data

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

CHAPTER THREE.
INPUTS

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

Experiment List File

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

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

TABLE 1. CROP MODEL INPUT AND OUTPUT FILES.

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

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

Experiment Data Files

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

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

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

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

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

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

STRUCTURE

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

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

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

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

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

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

EXAMPLE

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

Experiment Details File

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

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

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

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

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

The various sections of FILEX are summarized below.

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

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

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

TABLE 3. EXPERIMENT DETAILS FILE. (FILEX)

STRUCTURE

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

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

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

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

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

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

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

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

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

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

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

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

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

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

TREATMENT LEVEL INDICATORS

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

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

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

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

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

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

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

Simulation Control Information

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

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

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

TABLE 4. SIMULATION CONTROLS.

STRUCTURE

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

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

Line 4: Management

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

Line 5: Outputs

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

Other lines

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

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

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

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

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

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

Examples of FILEX for Various Experiments

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

Experiment 1 (Potential Yield)

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

TABLE 5. EXAMPLE FILEX FOR A POTENTIAL YIELD EXPERIMENT IN WHICH THERE ARE TWO VARIETIES OF SOYBEAN GROWN IN TWO LOCATIONS. THE FILE NAME FOR STORING THIS EXPERIMENT INFORMATION WOULD BE UFGA9101.SBX.

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

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

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

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

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

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

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

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

Experiment 2 (Climate Change Study)

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

TABLE 6. EXAMPLE FILEX FOR A CLIMATE CHANGE EXPERIMENT IN WHICH MAXIMUM AND MINIMUM DAILY TEMPERATURE ARE RAISED 4 °C, AND THERE ARE 2 VARIETIES OF SOYBEAN GROWN IN TWO LOCATIONS. THE FILE NAME FOR STORING THIS EXPERIMENT INFORMATION WOULD BE UFGA9102.SBX.

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

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

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

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

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

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

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

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

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

Experiment 3 (Irrigation Studies)

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

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

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

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

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

*CULTIVARS
@C CR INGENO CNAME
 1 MZ UF0001 PI304C

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

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

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

*PLANTING DETAILS
@P PDATE EDATE  PPOP  PPOE  PLME  PLDS  PLRS  PLRD  PLDP  PLWT  PAGE  PENV  PLPH
 1 81177          9.5   9.5 S     R      100     0   4.0   -99   -99 -99.0 -99.0
 2 81195          9.5   9.5 S     R      100     0   4.0   -99   -99 -99.0 -99.0

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

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

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

Experiment 4 (Fertilizer and Irrigation Studies)

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

Table 8. Example FILEX for a Maize Irrigation and Nitrogen Level Experiment. The File Name for Storing this Experiment Information Would Be UFGA8102.MZX.

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

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

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

*CULTIVARS
@C CR INGENO CNAME
 1 MZ UF0001 PI304C

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

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

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

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

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

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

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

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

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

Weather Data File

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

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

TABLE 9. WEATHER DATA FILE. (FILEW)

STRUCTURE

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

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

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

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

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

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

Example Weather Data File. (FILEW = “UFGA7801.WTH”)

```
*WEATHER : GAINESVILLE,FLORIDA,U.S.A
@ INSI      LAT     LONG  ELEV   TAV   AMP REFHT WNDHT
  UFGA   29.630  -82.370    40  20.9   7.4   1.5   2.0
@DATE  SRAD  TMAX  TMIN  RAIN
78001   5.3  18.3  13.3   4.8
78002  11.1  18.3   8.3   0.0
78003  14.7  13.9   3.3   0.0
78004  14.4  19.4   0.0   0.0
78005  10.9  23.9   6.7   0.0
78006  10.8  25.6  11.1   0.0
78007   9.5  25.0   9.4   0.0
78008   3.1  23.9  15.6  10.4
78009  16.3  18.3   1.1  25.1
78010  15.7   8.9  -3.9   0.0
78011  15.4  11.7  -2.8   0.0
78012   7.2  19.4   1.7   0.0
78013  10.9  20.0  13.3  27.9
78014  11.4  14.4   3.3   0.0
78015  14.2   7.8  -3.3   0.0
78016  13.2  16.1  -3.9   0.0
78017  10.4  21.7   9.4   4.8
78018  15.0  21.7   6.7   0.0
78019   0.6  19.4   8.9  71.9
78020   4.3  16.7   7.2   6.9
78021  10.4  10.0   1.1   0.0
78022  13.4  16.7   1.1   0.0
78023   6.6  16.7   7.8   0.0
78024  10.7  23.3   5.6   0.0
78025   7.4  26.1  16.7   0.0
78026  17.1  25.6   6.1   5.6
78027   7.4  12.2   0.0   0.0
78028  15.9  11.1  -1.1   0.0
78029  17.4  10.6  -4.4   0.0
78030  16.2  12.2  -3.3   0.0
78031   3.8  12.2   4.4   0.0
```

Soil Data File

The soil file (FILES) contains data on the soil profile properties. These data are used in the soil water, nitrogen, phosphorus and root growth sections of the crop models. The file generally contains information that is available for the soil at a particular experimental site, and supplementary information extracted from a soil survey database for a soil of the same taxonomic classification as the soil at the experimental site. Occasionally, when a detailed soil analysis has been performed at the experimental site, the file will contain no information from a survey database.

In FILES, the first line of data contains the soil identifiers, information on soil texture and depth, a description that could equate to the soil classification according to a specified, locally used system (such as the Canadian soil classification system), and the country. The second line contains geographic data together with taxonomic information presented according to Soil Taxonomy (Soil Survey Staff, 1975). The third line contains information on soil properties that do not vary with depth, such as surface albedo, and on measurement techniques. The fourth line contains data on the first layer; the fifth line on the second layer, and so on for each succeeding layer in the soil profile. The second tier of information for the soil layers is optional and contains variables related to the soil phosphorus balance, and other nutrients. Soil organic carbon is included in this file because it is frequently used to compute other soil properties. The percentage of sand is assumed to be 100 minus the percentages of clay and silt, and thus is not included as an input. The number of layers, and the thickness of each layer should be the same as those in the soil analysis and initial conditions sections of the experiment file whenever possible. The file may contain properties for several soils of the same classification, providing each soil has its own code number. The data for each soil are simply appended to the file. The structure of the file and a truncated example are shown in Table 10.

The data in the soils file are arranged so that entries need be made only for the aspects simulated. For example, if only water aspects are to be simulated, only those variables described as physical characteristics need be supplied. If only water and nitrogen aspects are to be simulated, then the physical, N and pH variables need to be entered. If phosphorus is to be considered, then all these latter variables plus all P variables must be entered.

TABLE 10. SOIL DATA FILE. (FILES)

STRUCTURE

Variable	Variable Name[1]	Header[2]	Format[3]
Line 1			
*SOILS:			0 C 10
Institute + country name			1 C 70
Subsequent lines relate to sections, as follows:			
Line 1			
Identifier (Institute + Site + Year + Soil)	PEDON	ID_SOIL	1 C 10
Source	SLSOUR	SLSOURCE	2 C 11
Texture, code[4]	SLTX	SLTX	1 C 5
Depth, cm	SLDP	SLDP	1 R 5 0
Description or local classification	SLDESC	SLDESCRIP	1 C 50
Line 2			
Site name	SSITE	SITE	1 C 11
Country name	SCOUNT	COUNTRY	1 C 11
Latitude	SLAT	LAT	1 R 8 3
Longitude	SLONG	LONG	1 R 8 3
Family, SCS system	TACON	SCSFAMILY	1 C 50
Line 3			
Color, moist, Munsell hue	SCOM	SCOM	1 C 5
Albedo, fraction	SALB	SALB	1 R 5 2
Evaporation limit, cm	U	SLU1	1 R 5 0
Drainage rate, fraction day^{-1}	SWCON	SLDR	1 R 5 2
Runoff curve number (Soil Conservation Service)	CN2	SLRO	1 R 5 0
Mineralization factor, 0 to 1 scale	SLNF	SLNF	1 R 5 2
Photosynthesis factor, 0 to 1 scale	SLPF	SLPF	1 R 5 2
pH in buffer determination method, code[4]	SMHB	SMHB	1 C 5
Phosphorus, extractable, determination code[4]	SMPX	SMPX	1 C 5
Potassium determination method, code[4]	SMKE	SMKE	1 C 5
Line 4 + (NL-1), where NL = number of layers. (L = Layer number)			
Depth, base of layer, cm	ZLYR(L)	SLB	1 R 5 0
Master horizon	MH(L)	SLMH	1 C 5
Lower limit, cm^3 cm^{-3}	LL(L)	SLLL	1 R 5 3
Upper limit, drained, cm^3 cm^{-3}	DUL(L)	SDUL	1 R 5 3

Upper limit, saturated, cm^3 cm^{-3}	SAT(L)	SSAT	1 R 5 3
Root growth factor, 0.0 to 1.0	SHF(L)	SRGF	1 R 5 2
Sat. hydraulic conductivity, macropore, cm h^{-1}	SWCN(L)	SSKS	1 R 5 1
Bulk density, moist, g cm^{-3}	BD(L)	SBDM	1 R 5 2
Organic carbon, %	OC(L)	SLOC	1 R 5 2
Clay (<0.002 mm), %	CLAY(L)	SLCL	1 R 5 1
Silt (0.05 to 0.002 mm), %	SILT(L)	SLSI	1 R 5 1
Coarse fraction (>2 mm), %	STONES(L)	SLCF	1 R 5 1
Total nitrogen, %	TOTN(L)	SLNI	1 R 5 2
pH in water	PH(L)	SLHW	1 R 5 1
pH in buffer	PHKCL(L)	SLHB	1 R 5 1
Cation exchange capacity, cmol kg^{-1}	CEC(L)	SCEC	1 R 5 1

Line 4 + NL to (4 + NL + (NL - 1)), where NL = number of layers.
(L = Layer number)

Depth, base of layer, cm	ZZLYR(L)	SLB	1 R 5 0
Phosphorus, extractable, mg kg^{-1}	EXTP(L)	SLPX	1 R 5 1
Phosphorus, total, mg kg^{-1}	TOTP(L)	SLPT	1 R 5 1
Phosphorus, organic, mg kg^{-1}	ORGP(L)	SLPO	1 R 5 1
$CaCO_3$ content, g kg^{-1}	CACO(L)	SLCA	1 R 5 1
Aluminum	EXTAL(L)	SLAL	1 R 5 1
Iron	EXTFE(L)	SLFE	1 R 5 1
Manganese	EXTMN(L)	SLMN	1 R 5 1
Base saturation, cmol kg^{-1}	TOTBAS(L)	SLBS	1 R 5 1
Phosphorus isotherm A, mmol kg^{-1}	PTERMA(L)	SLPA	1 R 5 1
Phosphorus iostherm B, mmol kg^{-1}	PTERMB(L)	SLPB	1 R 5 1
Potassium, exchangeable, cmol kg^{-1}	EXK(L)	SLKE	1 R 5 1
Magnesium, cmol kg^{-1}	EXMG(L)	SLMG	1 R 5 1
Sodium, cmol kg^{-1}	EXNA(L)	SLNA	1 R 5 1
Sulfur	EXTS(L)	SLSU	1 R 5 1
Electric conductivity, seimen	SLEC(L)	SLEC	1 R 5 1

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

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

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

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

EXAMPLE SOIL DATA FILE. (FILES = "SOIL.SOL")

```
*SOIL INPUT FILE

*IBMZ910014  SCS         FSA     180 Millhopper Fine Sand
@SITE        COUNTRY          LAT     LONG SCS FAMILY
 Gainesville USA            29.63   -82.37 Loamy,silic,hyperth Arenic Paleudult ( 14)
@ SCOM  SALB  SLU1  SLDR  SLRO  SLNF  SLPF  SMHB  SMPX  SMKE
    99  0.18   2.0  0.65  60.0  1.00  0.80 SA001 SA001 SA001
@  SLB  SLMH  SLLL  SDUL  SSAT  SRGF  SSKS  SBDM  SLOC  SLCL  SLSI  SLCF  SLNI  SLHW  SLHB  SCEC
     5   -99 0.026 0.096 0.230 1.000   -99  1.30  2.00   -99   -99   -99   -99   -99   -99   -99
    15   -99 0.025 0.086 0.230 1.000   -99  1.30  1.00   -99   -99   -99   -99   -99   -99   -99
    30   -99 0.025 0.086 0.230 0.800   -99  1.40  1.00   -99   -99   -99   -99   -99   -99   -99
    60   -99 0.025 0.086 0.230 0.200   -99  1.40  0.50   -99   -99   -99   -99   -99   -99   -99
    90   -99 0.028 0.090 0.230 0.100   -99  1.45  0.10   -99   -99   -99   -99   -99   -99   -99
   120   -99 0.028 0.090 0.230 0.050   -99  1.45  0.10   -99   -99   -99   -99   -99   -99   -99
   150   -99 0.029 0.130 0.230 0.002   -99  1.45  0.04   -99   -99   -99   -99   -99   -99   -99
   180   -99 0.070 0.258 0.360 0.000   -99  1.20  0.24   -99   -99   -99   -99   -99   -99   -99
```

GENOTYPE

Three files are suggested for dealing with the morphological and physiological characteristics of a particular genotype: one for the specific species (crop) characteristics (FILEG), one for the “ecotype” characteristics within a species (FILEE), and one for the specific cultivar characteristics within an ecotype grouping (FILEC).

These files would contain all genotype specific inputs required for simulation. Their content and organization, and indeed their usage, currently vary greatly among crop models and crops. No attempt has been made, therefore, to document contents. The use of at least one genotype file, specifically FILEC, is highly recommended. For such a file, a standard format is recommended with each line beginning with 6 spaces for a cultivar identification code (the first two items should be the code for the Institute that assigned the number), a blank, 16 spaces for the cultivar name, a blank, 6 spaces for a type identifier (e.g., an identifier for highland or lowland bean ecotypes), and then data in a (1X, F5.?) format (i.e., 1 blank, followed by 5 spaces for a real variable with the required number of decimals).

CHAPTER FOUR.
OUTPUTS

A number of output files for each simulation run, which may encompass several experiments, are described in Table 1. The first output file, OVERVIEW.OUT (Table 11), provides an overview of input conditions and crop performance, and a comparison with actual data if available. The first section in this file presents information that uniquely describes the simulated data set, as described below.

Line 1:	Run number and description; default to experiment code and name plus treatment number and name
Line 2:	Model name and version
Line 3:	Experiment name, Institute code, Site code, Experiment no., Crop (group) code
Line 4:	Treatment number and specifications
Line 5:	Crop, cultivar, ecotype
Line 6:	Simulation starting date
Line 7:	Planting date, population, and row spacing
Line 8:	Weather location, site and year
Line 9:	Soil number, texture and family
Line 10:	Soil initial conditions
Line 11:	Water balance
Line 12:	Irrigation
Line 13:	Nitrogen balance
Line 14:	Fertilizer N applications
Line 15:	Residue applications
Line 16:	Environmental options
Line 17:	Simulation options
Line 18:	Management options

The second section contains a summary of soil characteristics and cultivar coefficients. The next section deals with the crop and soil status at the main developmental stages, followed by a comparison of simulated and measured data for major variables. This in turn is followed by information on simulated stress factors and weather data summary during the different developmental phases (as

appropriate to the crop). An example of the file is shown in Table 11.
The second output file, SUMMARY.OUT (Table 12), provides a summary of outputs for use in applications programs with one line of data for each crop season. The third to last files contain detailed simulation results, including simulated seasonal (at daily or less frequent intervals) growth and development (Table 13), carbon balance (Table 14), water balance (Table 15), nitrogen balance (Table 16), phosphorus balance and pest (Table 17) aspects. These files are included for detailed graphic and numerical comparisons of simulated results with data collected periodically during a growing season. They can be saved in files named according to the code of the first experiment in the simulation session, but with a final letter to indicate the aspect dealt with in the file.

All of the above output files are set up so that successive simulated results in one session are appended to the respective files. The output files are temporary information transfer files, created during simulation, and they are overwritten when a new simulation session is started. The output files can include additional information such as may relate to parameter changes for sensitivity analysis. However, the symbol "!" should be put in column 1 when such additional information is included in the output files. The "!" symbol designates a comment and graphics and other analysis programs must be designed to ignore these lines.

TABLE 11. EXAMPLE OF THE SIMULATION OVERVIEW FILE. (OUT0)

```
*SIMULATION OVERVIEW FILE

*RUN   1        : IRRIGATED, COBB
 MODEL          : CRGRO940 - SOYBEAN
 EXPERIMENT     : UFGA8101 SB    COBB, IRRIGATED, VEG. & REPROD. STRESS
 TREATMENT  1   : IRRIGATED, COBB

 CROP           : SOYBEAN        CULTIVAR : COBB             -  MATURITY GROUP 8
 STARTING DATE  : JUN 26 1981
 PLANTING DATE  : JUN 26 1981    PLANTS/m2 : 35.9     ROW SPACING :  76.cm
 WEATHER        : UFGA   1981
 SOIL           : IBSB910015     TEXTURE :       - Millhopper Fine Sand
 SOIL INITIAL C : DEPTH:180cm EXTR. H2O:158.4mm  NO3:   .0kg/ha  NH4:   .0kg/ha
 WATER BALANCE  : IRRIGATE ACCORDING TO FIELD SCHEDULE
 IRRIGATION     :      315 mm IN    19 APPLICATIONS
 NITROGEN BAL.  : SOIL-N, N-UPTAKE & DYNAMIC N-FIXATION SIMULATION
 N FERTILIZER   :        0 kg/ha IN     0 APPLICATIONS
 RESIDUE/MANURE :        0 kg/ha IN     0 APPLICATIONS
 ENVIRONM. OPT. : DAYL=      .0  SRAD=      .0  TMAX=      .0  TMIN=      .0
                  RAIN=      .0  CO2 = R 330.0  DEW =      .0  WIND=      .0
 SIMULATION OPT : WATER   :Y  NITROGEN:Y  N-FIX:Y  PESTS  :N  PHOTO  :C  ET :R
 MANAGEMENT OPT : PLANTING:R  IRRIG   :R  FERT :R  RESIDUE:R  HARVEST:M  WTH:M

*SUMMARY OF SOIL AND GENETIC INPUT PARAMETERS

   SOIL LOWER UPPER   SAT  EXTR  INIT   ROOT   BULK     pH    NO3    NH4    ORG
  DEPTH LIMIT LIMIT    SW    SW    SW   DIST   DENS                          C
   cm   cm3/cm3    cm3/cm3    cm3/cm3        g/cm3         ugN/g  ugN/g     %
--------------------------------------------------------------------------------
  0-  5  .023  .086  .230  .063  .086   1.00   1.36   5.30    .00    .00    .90
  5- 15  .023  .086  .230  .063  .086   1.00   1.40   5.40    .00    .00    .69
 15- 30  .023  .086  .230  .063  .086    .50   1.46   5.70    .00    .00    .28
 30- 45  .023  .086  .230  .063  .086    .29   1.47   5.80    .00    .00    .20
 45- 60  .023  .086  .230  .063  .086    .29   1.47   5.80    .00    .00    .20
 60- 90  .021  .076  .230  .055  .076    .38   1.43   5.90    .00    .00    .09
 90-120  .020  .076  .230  .056  .076    .13   1.48   5.90    .00    .00    .03
120-150  .027  .130  .230  .103  .130    .06   1.57   5.90    .00    .00    .03
150-180  .070  .258  .360  .188  .258    .03   1.79   5.90    .00    .00    .03

 TOT-180   5.5  21.4  45.3  15.8  21.4  <--cm   -  kg/ha-->     .0     .0  38949
 SOIL ALBEDO    :  .18       EVAPORATION LIMIT : 5.00        MIN. FACTOR  : 1.00
 RUNOFF CURVE # :66.00       DRAINAGE RATE     :  .50        FERT. FACTOR :  .84
```

```
 SOYBEAN CULTIVAR :IB0002-COBB                ECOTYPE :SB0801-MATURITY GROUP 8
 CSDVAR :12.25  PPSEN  :  .33  EMG-FLW:21.00  FLW-FSD:16.00  FSD-PHM :37.00
 WTPSD  : .180  SDPDVR : 2.05  SDFDUR :23.00  PODDUR :15.00  XFRUIT  : 1.00

*SIMULATED CROP AND SOIL STATUS AT MAIN DEVELOPMENT STAGES

 RUN NO.  1    IRRIGATED, COBB

   DATE CROP GROWTH   BIOMASS  LAI  LEAF   ET  RAIN IRRIG SWATER CROP  N  STRESS
         AGE  STAGE     kg/ha        NUM.  mm   mm    mm    mm   kg/ha %  H2O  N
--------------------------------------------------------------------------------
 26 JUN    0 START SIM      0   .00   .0    4    18     0   172    0  .0 .00 .00
 26 JUN    0 SOWING         0   .00   .0    4    18     0   172    0  .0 .00 .00
 29 JUN    3 EMERGENCE     25   .04   .0    5    19     0   162    1 5.1 .00 .00
 29 JUN    3 END JUVEN.    25   .04   .0    5    19     0   162    1 5.1 .00 .00
  7 JUL   11 UNIFOLIATE    81   .13  1.3   13    19     8   158    3 3.4 .00 .00
 11 JUL   15 FLOWER IND   143   .25  2.3   25    41     8   161    4 3.0 .07 .00
 11 AUG   46 FIRST FLWR  2630  4.45 11.1  165   141    85   157   96 3.7 .02 .00
 27 AUG   62 FIRST POD   4320  5.41 15.5  230   165   142   157  153 3.6 .00 .00
 27 AUG   62 FIRST POD   4320  5.41 15.5  230   165   142   157  153 3.6 .00 .00
 29 AUG   64 END MSNODE  4337  5.20 16.1  235   192   142   180  155 3.6 .00 .00
  5 SEP   71 END LEAF    5163  5.06 16.1  265   219   142   147  175 3.4 .00 .00
  7 SEP   73 FIRST SEED  5355  4.96 16.1  272   221   157   153  179 3.3 .00 .00
  8 OCT  104 END POD     7978  3.30 16.1  397   248   272   142  269 3.4 .00 .00
 18 OCT  114 PHYS. MAT   8658  3.03 16.1  429   250   287   124  302 3.5 .00 .04
 30 OCT  126 HARV. MAT   7340   .20 16.1  456   268   315   134  264 3.6 .00 .16
 30 OCT  126 HARVEST     7340   .20 16.1  456   268   315   134  264 3.6 .00 .16


*MAIN GROWTH AND DEVELOPMENT VARIABLES

@     VARIABLE                                PREDICTED    MEASURED
      --------                                ---------    --------
      ANTHESIS DATE (DAP)                          46          47
      FIRST PEG / POD (DAP)                        62          66
      FIRST SEED (DAP)                             73          66
      PHYSIOLOGICAL MATURITY (DAP)                114         118
      POD YIELD (kg/ha)                          4545        4526.
      SEED YIELD (kg/ha)                         3575        3502.
      SHELLING PERCENTAGE (%)                   78.65         -99
      WEIGHT PER SEED (g)                        .165       .1476
      SEED NUMBER (SEED/m2)                      2166        2374.
      SEEDS/POD                                  2.05        1.88
      MAXIMUM LAI (m2/m2)                        5.41        6.25
      BIOMASS (kg/ha) AT ANTHESIS                2630         -99
      BIOMASS N (kg N/ha) AT ANTHESIS              96         -99
```

```
      BIOMASS (kg/ha) AT HARVEST MAT.          7340       6851.
      STALK (kg/ha) AT HARVEST MAT.            2712       2137.
      HARVEST INDEX (kg/kg)                    .487         -99
      FINAL LEAF NUMBER (MAIN STEM)           16.10         -99
      SEED N (kg N/ha                           228         -99
      BIOMASS N (kg N/ha)                       264         -99
      STALK N (kg N/ha)                          21         -99
      SEED N (%)                               6.37         -99


*ENVIRONMENTAL AND STRESS FACTORS

 -----------------------------ENVIRONMENT—----------------------STRESS----------
 |--DEVELOPMENT PHASE--|-TIME-|-------WEATHER--------| |---WATER--| |-NITROGEN-|
                         DURA TEMP  TEMP  SOLAR PHOTOP PHOTO GROWTH PHOTO GROWTH
                         TION  MAX   MIN    RAD  [day] SYNTH        SYNTH
                         days   oC    oC   MJ/m2   hr
 -------------------------------------------------------------------------------
 Emergence -First Flower  43  34.07  22.26 20.01  13.60  .000  .019  .000  .000
 First Flower-First Seed  27  32.41  21.98 16.30  12.80  .000  .000  .000  .000
 First Seed - Phys. Mat.  41  30.87  17.54 16.38  11.78  .000  .000  .049  .009
 Emergence  - Phys. Mat. 111  32.48  20.45 17.77  12.73  .000  .007  .018  .003

                                                       (0.0 = Minimum Stress
                                                        1.0 = Maximum Stress)


 SOYBEAN    YIELD :     3575 kg/ha    [DRY WEIGHT]
```

TABLE 12. DETAILED SIMULATION SUMMARY OUTPUT FILE. (OUTS)

STRUCTURE

Variable	Variable Name[1]	Header[2]	Format[3]
Line 1			
*SUMMARY :			0 C 10
Institute code	INSTE		1 C 2
Site code	SITEE		0 C 2
Experiment code	EXPTNO		0 C 4
Crop group code	CROP		1 C 2
Experiment name	ENAME		1 C 60
Line 2 to number runs made. Details of each simulation run, as follows:			
Run number	RUNO	RP	0 I 2
Treatment number	TRTNO	TN	1 I 2
Rotation component	ROTNO	R	1 I 1
Rotation option	ROTOPT	O	0 I 1
Crop component	CRPNO	C	0 I 1
Crop code	CROP	CR	1 C 2
Title	TITLET	TNAM	1 C 19
Field identifier	FLDNAM	FNAM	1 C 8
Simulation start date, year + day of year	YRSIM	SDAT	1 I 5
Planting date, year + day of year	YRPLT	PDAT	1 I 5
Anthesis date, start, year + day of year	YRNR1	ADAT	1 I 5
Maturity (physiological) date, year+day of year	YRNR7	MDAT	1 I 5
Harvest date, year + day of year	YRDOY	HDAT	1 I 5
Planting material dry weight, kg ha^{-1}	SDRATE	DWAP	1 I 5
Canopy dry weight at maturity, kg ha^{-1}	TOPWT	CWAM	1 I 5
Yield at maturity, kg ha^{-1}	SDWT	HWAM	1 I 5
Yield at harvest, kg ha^{-1}	SDWTAM	HWAH	1 I 5
Harvested byproduct dry weight, kg ha^{-1}	BWAH	BWAH	1 I 5
Harvest product individual dry wt., mg or g	HWUM	HWUM	1 I 5
Harvest product number per m^2 at maturity	SEEDNO	H#AM	1 I 5
Harvest product number per unit at maturity	PSPP	H#UM	1 R 5 2
Irrigation applications, number	NAP	IR#M	1 I 5
Irrigation applied, cumulative, mm	TOTIR	IRCM	1 I 5
Precipitation cumulative, mm	CRAIN	PRCM	1 I 5
Evapotranspiration in season, cumulative, mm	CET	ETCM	1 I 5
Runoff, cumulative, mm	TRUNOF	ROCM	1 I 5
Cumulative drainage from profile, mm	TDRAIN	DRCM	1 I 5
Water remaining in soil, available, mm	PESW	SWXM	1 I 5
Nitrogen applications, number	NAPNIT	NI#M	1 I 5
Nitrogen applied, cumulative, kg ha^{-1}	AMTNIT	NICM	1 I 5

Nitrogen fixed, cumulative, kg ha^{-1}	WTNFX	NFXM	1 I 5
Total N uptake during season, kg/ha	WTNUP	NUCM	1 I 5
Nitrogen leached, cumulative, kg ha^{-1}	TLCH	NLCM	1 I 5
Inorganic N in soil at maturity, kg/ha	TSIN	NIAM	1 I 5
Tops N at maturity, kg ha^{-1}	WTNCAN	CNAM	1 I 5
Nitrogen in harvest product (seed), kg ha^{-1}	WTNSD	GNAM	1 I 5
Residue, etc. applied, cumulative, kg ha^{-1}	CRESAP	RECM	1 I 5
Soil organic N at end of season, kg ha^{-1}	TSON	ONAM	1 I 5
Soil C at end of season, t ha^{-1}	TSOC	OCAM	1 I 5
Number of phosphorus applications	NNAPHO	PO#M	1 I 5
Total P applied during season, kg/ha	TOTPH	POCM	1 I 5
Cumulative plant P uptake, kg/ha	TOTPUP	CPAM	1 I 5
Soil P at end of season, kg/ha	TPLEFT	SPAM	1 I 5

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

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

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

EXAMPLE SUMMARY OUTPUT FILE

```
*SUMMARY : UFGA8101 SB COBB, IRRIGATED, VEG. & REPROD. STRESS

!IDENTIFIERS............................. DATES.........................
@RP TN ROC CR TNAM                 FNAM      SDAT  PDAT  ADAT  MDAT  HDAT
  1  1 110 SB IRRIGATED, COBB     UFGA0001 81177 81177 81223 81291 81303
  2  2 110 SB IRRIGATED, WITH VEG UFGA0001 81177 81177 81224 81293 81305
  3  3 110 SB IRRIGATED, WITH REP UFGA0001 81177 81177 81223 81291 81303
  1  1 110 SB IRRIGATED           UFGA0001 78166 78166 78211 78282 78294
  2  2 110 SB NON - IRRIGATED     UFGA0001 78166 78166 78211 78278 78290



DRY WEIGHTS...................................
DWAP  CWAM  HWAM  HWAH  BWAH  HWUM  H#AM  H#UM
  81  7340  3575  3575  3765   165  2166  2.05
  81  6178  3174  3174  3004   157  2021  2.05
  81  7038  3389  3389  3649   159  2126  2.05
  75  6116  2962  2962  3153   134  2208  2.05
  75  3056  1139  1139  1917   145   784  2.05



WATER...................................
IR#M  IRCM  PRCM  ETCM  ROCM  DRCM  SWXM
  19   315   268   456     0    72   134
  13   206   269   424     0    36   121
  15   264   268   448     0    72   104
  19   190   534   440    31   290    74
   0     0   534   319    31   284    59



NITROGEN......................................
NI#M  NICM  NFXM  NUCM  NLCM  NIAM  CNAM  GNAM
   0     0   352     2     0    32   264   228
   0     0   322     1     0    29   234   202
   0     0   342     1     0    31   252   216
   0     0   314     4    20    39   222   189
   0     0   204     2    20    37    96    73
```

```
ORGANIC MATTER... PHOSPHORUS............
RECM  ONAM  OCAM  PO#M  POCM  CPAM  SPAM
   0  3870    39     0     0     0     0
   0  3873    39     0     0     0     0
   0  3873    39     0     0     0     0
1000  3838    39     0     0     0     0
1000  3842    39     0     0     0     0
```

TABLE 13. DETAILED SIMULATION GROWTH OUTPUT FILE. (OUTG)

STRUCTURE

Variable	Variable Name[1]	Header[2]	Format[3]
Line 1			
Run number[4]	NREP		5 I 3
Run identifier	TITLER		1 0 C 25
Line 2			
Model name	MODEL		18 C 8
Crop name	CROPD		3 C 10
Line 3			
Experiment identifier, made up of:			
Institute code	INSTE		18 C 2
Site code	SITEE		0 C 2
Experiment number/abbreviation	EXPTNO		0 C 4
Crop group code	CROP		1 C 2
Experiment name (Treatment set and experimental condition names, separated by a semi-colon)	ENAME		18 C 60
Line 4			
Treatment number	TRTNO		11 I 2
Treatment name	TITLET		5 C 25
Line 5[5]			
Variable abbreviations			1 C 77+
Line 6 on			
Date (Year + days from Jan. 1)	YRDOY	DATE	1 I 5
Crop age (days from planting)	DAP	CDAY	1 I 5
Leaf number	VSTAGE	L#SD	1 R 5 1
Growth stage	RSTAGE	GSTD	1 I 5
Leaf area index	XLAI	LAID	1 R 5 2
Leaf dry weight, kg ha^{-1}	WTLF	LWAD	1 I 5
Stem dry weight, kg ha^{-1}	STMWT	SWAD	1 I 5
Grain dry weight, kg ha^{-1}	SDWT	GWAD	1 I 5
Root dry weight in layer L, kg ha^{-1}	RTWT	RWAD	1 I 5
Crop dry weight, kg ha^{-1}	TOPWT	CWAD	1 I 5
Grain number, #/m^2	SEEDNO	G#AD	1 I 5
Grain dry weight, mg/grain	SDSIZE	GWGD	1 R 5 1
Harvest index	HI	HIAD	1 R 5 3

---

1 Abbreviations used as variable names in the IBSNAT models.

2 Abbreviations suggested for use in header lines (those designated with '@') within the file. They correspond to the variable names used in the associated database.

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

*4 Each new run should be demarcated with '*RUN' at the beginning of this line in each file.*

5 Additional information can be placed between lines 4 and 5, as required by a user, as illustrated in the example, and as documented for the Overview file in the text.

EXAMPLE GROWTH OUTPUT FILE

```
*GROWTH ASPECTS OUTPUT FILE

*RUN   1         : IRRIGATED, COBB
 MODEL           : CRGRO940 - SOYBEAN
 EXPERIMENT      : UFGA8101 SB    COBB, IRRIGATED, VEG. & REPROD. STRESS
 TREATMENT  1    : IRRIGATED, COBB

 CROP            : SOYBEAN        CULTIVAR : COBB             -  MATURITY GROUP 8
 STARTING DATE   : JUN 26 1981
 PLANTING DATE   : JUN 26 1981    PLANTS/m2 : 35.9     ROW SPACING :  76.cm
 WEATHER         : UFGA   1981
 SOIL            : IBSB910015     TEXTURE :       - Millhopper Fine Sand
 SOIL INITIAL C  : DEPTH:180cm EXTR. H2O:158.4mm  NO3:   .0kg/ha  NH4:   .0kg/ha
 WATER BALANCE   : IRRIGATE ACCORDING TO FIELD SCHEDULE
 IRRIGATION      :      315 mm IN    19 APPLICATIONS
 NITROGEN BAL.   : SOIL-N, N-UPTAKE & DYNAMIC N-FIXATION SIMULATION
 N FERTILIZER    :        0 kg/ha IN     0 APPLICATIONS
 RESIDUE/MANURE  :        0 kg/ha IN     0 APPLICATIONS
 ENVIRONM. OPT.  : DAYL=      .0  SRAD=      .0  TMAX=      .0  TMIN=      .0
                   RAIN=      .0  CO2 = R 330.0  DEW =      .0  WIND=      .0
 SIMULATION OPT  : WATER   :Y  NITROGEN:Y  N-FIX:Y  PESTS  :N  PHOTO  :C  ET :R
 MANAGEMENT OPT  : PLANTING:R  IRRIG   :R  FERT :R  RESIDUE:R  HARVEST:M  WTH:M

@DATE   CDAY  L#SD  GSTD  LAID  LWAD  SWAD  GWAD  RWAD  CWAD  G#AD  GWGD  HIAD
 81177     0    .0     0   .00     0     0     0     0     0     0    .0  .000
 81183     6    .4     0   .07    35     6     0    23    41     0    .0  .000
 81189    12   1.6     0   .16    77    15     0    44    92     0    .0  .000
 81195    18   3.1     0   .40   173    46     0    98   219     0    .0  .000
 81201    24   4.9     0   .95   313   134     0   192   447     0    .0  .000
 81207    30   6.5     0  1.75   533   324     0   381   858     0    .0  .000
 81213    36   8.2     0  2.82   801   613     0   567  1414     0    .0  .000
 81219    42   9.9     0  3.84  1080  1047     0   753  2127     0    .0  .000
 81225    48  11.7     1  4.73  1325  1560     0   905  2885     0    .0  .000
 81231    54  13.4     1  5.32  1540  2078     0  1051  3619     0    .0  .000
 81237    60  15.0     1  5.39  1618  2473     0  1161  4091     0    .0  .000
 81243    66  16.1     3  5.15  1658  2859     0  1264  4533     0    .0  .000
 81249    72  16.1     3  4.99  1760  3303     0  1366  5232     0    .0  .000
 81255    78  16.1     5  4.71  1799  3625    34  1437  5897   403   8.4  .006
 81261    84  16.1     5  4.31  1699  3648   298  1429  6425   950  31.4  .046
 81267    90  16.1     5  3.97  1578  3523   777  1402  6901  1453  53.5  .113
 81273    96  16.1     5  3.63  1425  3315  1544  1333  7364  2106  73.3  .210
 81279   102  16.1     5  3.37  1318  3182  2331  1280  7868  2166 107.6  .296
```

TABLE 14. DETAILED SIMULATION CARBON BALANCE OUTPUT FILE. (OUTC)

STRUCTURE

Variable	Variable Name[1]	Header[2]	Format[3]
Line 1			
Run number[4]	NREP		5 I 3
Run identifier	TITLER		10 C 25
Line 2			
Model name	MODEL		18 C 8
Crop name	CROPD		3 C 10
Line 3			
Experiment identifier, made up of:			
Institute code	INSTE		18 C 2
Site code	SITEE		0 C 2
Experiment number/abbreviation	EXPTNO		0 C 4
Crop group code	CROP		1 C 2
Experiment name (Treatment set and experimental condition names, separated by a semi-colon)	ENAME		18 C 60
Line 4			
Treatment number	TRTNO		11 I 2
Treatment name	TITLET		5 C 25
Line 5[5]			
Variable abbreviations			1 C 77+
Line 6 on			
Date (Year + days from Jan. 1)	YRDOY	DATE	1 I 5
Days from planting	DAP	CDAY	1 I 5
Soil organic carbon, kg ha^{-1}	TSOC	SOCD	1 I 5
Total plant weight, kg ha^{-1}	TOTWT	TWAD	1 I 5
Canopy interception of PAR, %	PCINP	LI%D	1 R 5 2
Canopy gross photosynthesis, g $CH_2O/m^2/d$	PG	PHAD	1 R 5 2
Carbon mobilized for growth, g $CH_2O/m^2/d$	CMINEA	CMAD	1 R 5 2
Canopy growth rate, g tissue/m^2/d	GROWTH	CGRD	1 R 5 2
Canopy growth resp, g $CH_2O/m^2/d$	GRWRES	GRAD	1 R 5 2
Canopy maint resp, g $CH_2O/m^2/d$	MAINR	MRAD	1 R 5 2
C stored in a day, g $CH_2O/m^2/d$	CAD	CHAD	1 R 5 2
Percent C in leaf, %	RHOL	CL%D	1 R 5 2
Percent C in stem, %	RHOS	CS%D	1 R 5 2

---

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

2 *Abbreviations suggested for use in header lines (those designated with '@') within the file. They correspond to the variable names used in the associated database.*

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

4 *Each new run should be demarcated with '*RUN' at the beginning of this line in each file.*

5 *Additional information can be placed between lines 4 and 5, as required by a user, as illustrated in the example, and as documented for the Overview file in the text.*

Example Carbon Output File

```
*CARBON BALANCE OUTPUT FILE

*RUN   1        : IRRIGATED, COBB
 MODEL          : CRGRO930 - SOYBEAN
 EXPERIMENT     : UFGA8101 SB    COBB, IRRIGATED, VEG. & REPROD. STRESS
 TREATMENT  1   : IRRIGATED, COBB

 CROP           : SOYBEAN        CULTIVAR : COBB             -  MATURITY GROUP 8
 STARTING DATE  : JUN 26 1981
 PLANTING DATE  : JUN 26 1981    PLANTS/m2 : 35.9     ROW SPACING :  76.cm
 WEATHER        : FGA   1981
 SOIL           : IBSB910015     TEXTURE :       - Millhopper Fine Sand
 SOIL INITIAL C : DEPTH:180cm EXTR. H2O:158.4mm  NO3:   .0kg/ha  NH4:   .0kg/ha
 WATER BALANCE  : IRRIGATE ACCORDING TO FIELD SCHEDULE
 IRRIGATION     :      315 mm IN    19 APPLICATIONS
 NITROGEN BAL.  : SOIL-N, N-UPTAKE & DYNAMIC N-FIXATION SIMULATION
 N FERTILIZER   :        0 kg/ha IN     0 APPLICATIONS
 RESIDUE/MANURE :        0 kg/ha IN     0 APPLICATIONS
 ENVIRONM. OPT. : DAYL=      .0  SRAD=      .0  TMAX=      .0  TMIN=      .0
                  RAIN=      .0  CO2 = R 330.0  DEW =      .0  WIND=      .0
 SIMULATION OPT : WATER   :Y  NITROGEN:Y  N-FIX:Y  PESTS  :N  PHOTO  :C  ET :R
 MANAGEMENT OPT : PLANTING:R  IRRIG   :R  FERT :R  RESIDUE:R  HARVEST:M  WTH:M

@DATE   CDAY  SOCD  TWAD  LI%D  PHAD  CMAD  CGRD  GRAD  MRAD  CHAD  CL%D  CS%D
 81177     0    39     0   .00   .00   .00   .00   .00   .00   .00   .00   .00
 81183     6    39    64   .00  1.25   .00   .57   .34   .13   .21 20.39 21.35
 81189    12    39   136   .00  2.81   .00  1.34   .79   .32   .35 29.76 27.58
 81195    18    39   317   .00  6.96   .00  3.29  1.96   .80   .91 34.23 26.99
 81201    24    39   638   .00 12.21   .28  7.40  3.75  1.34   .00 21.66 15.14
 81207    30    39  1238   .00 21.69   .32 12.36  6.77  2.88   .00 12.12  9.59
 81213    36    39  1981   .00 24.45   .37 14.46  6.91  3.44   .00  7.96  7.74
 81219    42    39  2880   .00 29.19   .45 17.39  7.99  4.26   .00  5.88  6.86
 81225    48    39  3789   .00 28.61   .55 16.32  7.60  4.77   .47  4.84  6.75
 81231    54    39  4670   .00 28.54   .76 15.15  7.17  5.58  1.40  4.78  8.30
 81237    60    39  5252   .00 31.56  1.00 16.14  8.17  5.44  2.81  5.16 10.40
 81243    66    39  5797   .00 28.12  1.38 13.45  6.64  5.90  3.52  5.87 12.99
 81249    72    39  6598   .00 24.16  1.99 11.82  4.98  6.27  3.08  6.79 16.00
 81255    78    39  7334   .00 32.67  2.70 17.69  6.55  7.48  3.66  7.26 17.61
 81261    84    39  7854   .00 31.39  3.11 19.23  8.03  5.14  2.10  7.11 17.31
 81267    90    39  8304   .00 28.86  2.99 16.24  8.33  7.29   .00  6.10 14.90
 81273    96    39  8697   .00 29.56  2.18 14.43  9.89  7.26   .15  5.02 12.28
 81279   102    39  9148   .00 27.81  1.84 13.59 10.00  5.58   .49  4.12 10.21
 81285   108    39  9393   .00 23.47  1.34 11.40  8.67  4.41   .34  3.04  7.65
 81291   114    39  9860   .00 20.92   .00  2.93  2.05  5.48 10.46  3.56  9.62
 81297   120    39  8922   .00  5.92  1.97  2.33  1.05  3.88   .63  1.12 18.71
```

TABLE 15. DETAILED SIMULATION WATER BALANCE OUTPUTFILE. (OUTW)

STRUCTURE

Variable	Variable Name[1]	Header[2]	Format[3]			
Line 1						
Run number[4]	NREP		5	I	3	
Run identifier	TITLER		10	C	25	
Line 2						
Model name	MODEL		18	C	8	
Crop name	CROPD		3	C	10	
Line 3						
Experiment identifier, made up of:						
Institute code	INSTE		18	C	2	
Site code	SITEE		0	C	2	
Experiment number/abbreviation	EXPTNO		0	C	4	
Crop group code	CROP		1	C	2	
Experiment name (Treatment set and experimental condition names, separated by a semi-colon)	ENAME		18	C	60	
Line 4						
Treatment number	TRTNO		11	I	2	
Treatment name	TITLET		5	C	25	
Line 5[5]						
Variable abbreviations			1	C	77+	
Line 6 on						
Date (Year + days from Jan. 1)	YRDOY	DATE	1	I	5	
Days from planting	DAP	CDAY	1	I	5	
Plant Transpiration, mm d^{-1}	AVEP	EPAA	1	R	5	2
Evapotranspiration, mm day^{-1}	AVET	ETAA	1	R	5	2
Potential evaporation, mm day^{-1}	AVEO	EOAA	1	R	5	2
Potentially extractable water, cm	PESW	SWXD	1	R	5	1
Cumulative runoff	TRUNOF	ROFC	1	R	5	1
Cumulative drainage	TDRAIN	DRNC	1	I	5	
Cumulative precipitation, mm	CRAIN	PREC	1	I	5	
Cummulative irrigation, mm	TOTIR	IRRC	1	I	5	
Average solar radiation, MJ m^{-2}	AVSRAD	SRAA	1	R	5	1
Average maximum temperature, °C	AVTMX	TMXA	1	R	5	1
Average minimum temperature, °C	AVTMN	TMNA	1	R	5	1

---

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

2 *Abbreviations suggested for use in header lines (thoses designated with '@') within the file. They correspond to the variable names used in the associated database.*

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

4 *Each new run should be demarcated with '*RUN' at the beginning of this line in each file.*

5 *Additional information can be placed between lines 4 and 5, as required by a user, as illustrated in the example, and as documented for the Overview file in the text.*

EXAMPLE WATER OUTPUT FILE

```
*WATER BALANCE OUTPUT FILE

*RUN   1        : IRRIGATED, COBB
 MODEL          : CRGRO940 - SOYBEAN
 EXPERIMENT     : UFGA8101 SB    COBB, IRRIGATED, VEG. & REPROD. STRESS
 TREATMENT  1   : IRRIGATED, COBB

 CROP           : SOYBEAN        CULTIVAR : COBB             -  MATURITY GROUP 8
 STARTING DATE  : JUN 26 1981
 PLANTING DATE  : JUN 26 1981    PLANTS/m2 : 35.9     ROW SPACING :  76.cm
 WEATHER        : UFGA   1981
 SOIL           : IBSB910015     TEXTURE :       - Millhopper Fine Sand
 SOIL INITIAL C : DEPTH:180cm EXTR. H2O:158.4mm  NO3:   .0kg/ha  NH4:   .0kg/ha
 WATER BALANCE  : IRRIGATE ACCORDING TO FIELD SCHEDULE
 IRRIGATION     :      315 mm IN    19 APPLICATIONS
 NITROGEN BAL.  : SOIL-N, N-UPTAKE & DYNAMIC N-FIXATION SIMULATION
 N FERTILIZER   :        0 kg/ha IN     0 APPLICATIONS
 RESIDUE/MANURE :        0 kg/ha IN     0 APPLICATIONS
 ENVIRONM. OPT. : DAYL=      .0  SRAD=      .0  TMAX=      .0  TMIN=      .0
                  RAIN=      .0  CO2 = R 330.0  DEW =      .0  WIND=      .0
 SIMULATION OPT : WATER   :Y  NITROGEN:Y  N-FIX:Y  PESTS  :N  PHOTO  :C  ET :R
 MANAGEMENT OPT : PLANTING:R  IRRIG   :R  FERT :R  RESIDUE:R  HARVEST:M  WTH:M

@DATE   CDAY  EPAA  ETAA  EOAA  SWXD  ROFC  DRNC  PREC  IRRC  SRAA  TMXA  TMNA
 81177     0   .00  3.92  7.37 172.3    .0    .0    18     0  25.2  36.1  21.7
 81183     6   .27  1.44  5.61 161.1    .0  12.5    19     8  22.2  32.8  19.2
 81189    12   .53  2.05  5.35 166.7    .0  13.2    33     8  19.6  34.8  21.7
 81195    18  1.47  3.88  5.83 169.7    .0  20.5    63     8  21.5  34.8  22.2
 81201    24  1.97  2.62  3.73 156.2    .0  29.6    73     8  14.5  33.7  21.9
 81207    30  5.20  5.55  6.62 143.9    .0  29.6    74    27  23.6  35.9  22.2
 81213    36  2.60  3.93  3.93 161.6    .0  29.6    94    66  15.6  33.9  21.9
 81219    42  4.05  5.20  5.20 163.5    .0  40.1   137    66  21.0  33.3  22.0
 81225    48  4.45  5.26  5.26 151.2    .0  41.6   145    85  21.1  33.3  22.2
 81231    54  3.93  4.25  4.25 139.8    .0  41.6   146   104  17.1  33.3  23.1
 81237    60  4.00  4.44  4.44 151.6    .0  42.1   165   123  18.2  32.6  21.9
 81243    66  3.18  3.59  3.59 197.7    .1  44.2   219   142  14.8  31.7  21.9
 81249    72  3.44  3.76  3.76 156.2    .1  71.5   220   157  15.4  32.6  21.9
 81255    78  4.00  4.56  4.56 148.9    .1  71.5   230   170  18.6  33.1  21.7
 81261    84  2.52  2.99  2.99 152.2    .1  71.5   247   183  12.9  30.0  20.2
 81267    90  3.69  4.25  4.25 143.1    .1  71.5   247   202  17.8  32.0  19.4
 81273    96  3.78  4.51  4.51 139.5    .1  71.5   247   230  18.9  32.2  18.3
 81279   102  3.45  3.76  3.76 129.6    .1  71.5   247   249  16.3  30.9  15.9
 81285   108  2.46  2.78  2.78 133.5    .1  71.5   250   272  12.0  29.8  18.9
 81291   114  3.22  3.76  3.76 123.6    .1  71.5   250   287  16.9  30.7  11.9
 81297   120  1.63  2.77  2.89 129.2    .1  71.5   254   315  12.3  30.6  17.1
```

TABLE 16. DETAILED SIMULATION NITROGEN OUTPUT FILE. (OUTN)

STRUCTURE

Variable	Variable Name[1]	Header[2]	Format[3]
Line 1			
Run number[4]	NREP		5 I 3
Run identifier	TITLER		10 C 25
Line 2			
Model name	MODEL		18 C 8
Crop name	CROPD		3 C 10
Line 3			
Experiment identifier, made up of:			
Institute code	INSTE		18 C 2
Site code	SITEE		0 C 2
Experiment number/abbreviation	EXPTNO		0 C 4
Crop group code	CROP		1 C 2
Experiment name (Treatment set and experimental condition names, separated by a semi-colon)	ENAME		18 C 60
Line 4			
Treatment number	TRTNO		11 I 2
Treatment name	TITLET		5 C 25
Line 5[5]			
Variable abbreviations			1 C 77+
Line 6 on			
Date (Year + days from Jan. 1)	YRDOY	DATE	1 I 5
Days from planting	DAP	CDAY	1 I 5
Crop nitrogen	WTNCAN	CNAD	1 R 5 1
Grain nitrogen, kg ha^{-1}	WTNSD	GNAD	1 R 5 1
Veg. (stem + leaf) nitrogen, kg ha^{-1}	WTNVEG	VNAD	1 R 5 1
Percent nitrogen in grain, %	PCNGRN	HN%D	1 R 5 2
Percent veg(stem+leaf) nitrogen, %	PCNVEG	VN%D	1 R 5 2
Cumulative inorganic N applied, kg ha^{-1}	TANFGR	NAPC	1 R 5 I
Cumulative N fixation, kg ha^{-1}	WTNFX	NFXC	1 R 5 1
Cumulative N uptake, kg ha^{-1}	WTNUP	NUPC	1 R 5 1
Cumulative N leached, kg ha^{-1}	TLCH	NLCC	1 R 5 1
Inorganic N in soil, kg ha^{-1}	TSIN	NIAD	1 R 5 1
Organic N in soil, kg ha^{-1}	TSON	NOAD	1 I 5

---

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

2 *Abbreviations suggested for use in header lines (those designated with '@') within the file. They correspond to the variable names used in the associated database.*

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

4 *Each new run should be demarcated with '*RUN' at the beginning of this line in each file.*

5 *Additional information can be placed between lines 4 and 5, as required by a user, as illustrated in the example, and as documented for the Overview file in the text.*

EXAMPLE NITROGEN OUTPUT FILE

```
*NITROGEN BALANCE OUTPUT FILE

*RUN   1        : IRRIGATED, COBB
 MODEL          : CRGRO940 - SOYBEAN
 EXPERIMENT     : UFGA8101 SB    COBB, IRRIGATED, VEG. & REPROD. STRESS
 TREATMENT  1   : IRRIGATED, COBB

 CROP           : SOYBEAN        CULTIVAR : COBB             -  MATURITY GROUP 8
 STARTING DATE  : JUN 26 1981
 PLANTING DATE  : JUN 26 1981    PLANTS/m2 : 35.9     ROW SPACING :  76.cm
 WEATHER        : UFGA   1981
 SOIL           : IBSB910015     TEXTURE :       - Millhopper Fine Sand
 SOIL INITIAL C : DEPTH:180cm EXTR. H2O:158.4mm  NO3:   .0kg/ha  NH4:   .0kg/ha
 WATER BALANCE  : IRRIGATE ACCORDING TO FIELD SCHEDULE
 IRRIGATION     :      315 mm IN    19 APPLICATIONS
 NITROGEN BAL.  : SOIL-N, N-UPTAKE & DYNAMIC N-FIXATION SIMULATION
 N FERTILIZER   :        0 kg/ha IN     0 APPLICATIONS
 RESIDUE/MANURE :        0 kg/ha IN     0 APPLICATIONS
 ENVIRONM. OPT. : DAYL=      .0  SRAD=      .0  TMAX=      .0  TMIN=      .0
                  RAIN=      .0  CO2 = R 330.0  DEW =      .0  WIND=      .0
 SIMULATION OPT : WATER   :Y  NITROGEN:Y  N-FIX:Y  PESTS  :N  PHOTO  :C  ET :R
 MANAGEMENT OPT : PLANTING:R  IRRIG   :R  FERT :R  RESIDUE:R  HARVEST:M  WTH:M

@DATE   CDAY  CNAD  GNAD  VNAD  GN%D  VN%D  NAPC  NFXC  NUPC  NLCC  NIAD  NOAD
 81177     0    .0    .0    .0   .00   .00     0    .0    .0    .0    .2  3895
 81183     6   1.6    .0   1.6   .00  4.03     0    .6    .0   -.7   2.3  3893
 81189    12   3.0    .0   3.0   .00  3.28     0   2.5    .0   -.7   3.6  3892
 81195    18   6.3    .0   6.3   .00  2.89     0   7.2    .0  -1.2   5.4  3891
 81201    24  14.3    .0  14.3   .00  3.21     0  17.9    .0  -1.8   7.3  3889
 81207    30  30.4    .0  30.4   .00  3.54     0  38.9    .0  -1.8   8.4  3888
 81213    36  52.5    .0  52.5   .00  3.72     0  64.7    .0  -1.8   9.6  3887
 81219    42  78.8    .0  78.8   .00  3.70     0  94.8    .0  -2.5  11.6  3886
 81225    48 105.3    .0 105.3   .00  3.65     0 124.4    .0  -2.6  13.0  3885
 81231    54 130.2    .0 130.2   .00  3.60     0 152.9    .0  -2.6  14.2  3883
 81237    60 146.3    .0 146.3   .00  3.58     0 174.1    .0  -2.7  15.5  3882
 81243    66 160.2    .0 159.7   .00  3.53     0 193.4    .0  -2.8  16.8  3881
 81249    72 176.7    .0 171.5   .00  3.39     0 213.6    .0  -4.7  19.9  3880
 81255    78 186.2   2.1 170.9  6.37  3.15     0 227.5    .0  -4.7  21.1  3879
 81261    84 193.2  19.0 152.1  6.37  2.84     0 237.6    .0  -4.7  22.3  3877
 81267    90 210.3  49.5 133.5  6.37  2.62     0 257.4    .0  -4.7  23.3  3876
 81273    96 233.4  98.4 109.4  6.37  2.31     0 282.1    .0  -4.7  24.4  3875
 81279   102 262.4 148.5  92.4  6.37  2.05     0 312.1    .0  -4.7  25.5  3874
 81285   108 281.1 184.6  78.2  6.37  1.83     0 330.7    .5  -4.7  31.0  3873
 81291   114 301.8 213.7  71.7  6.37  1.66     0 352.2    .6  -4.7  31.8  3872
 81297   120 270.5 222.2  33.7  6.37  1.02     0 352.2   1.3  -4.7  32.0  3871
```

TABLE 17. DETAILED SIMULATION PEST OUTPUT FILE. (OUTD)

STRUCTURE

Variable	Variable Name[1]	Header[2]	Format[3]
Line 1			
Run number[4]	NREP		5 I 3
Run identifier	TITLER		10 C 25
Line 2			
Model name	MODEL		18 C 8
Crop name	CROPD		3 C 10
Line 3			
Experiment identifier, made up of:			
Institute code	INSTE		18 C 2
Site code	SITEE		0 C 2
Experiment number/abbreviation	EXPTNO		0 C 4
Crop group code	CROP		1 C 2
Experiment name (Treatment set and experimental condition names, separated by a semi-colon)	ENAME		18 C 60
Line 4			
Treatment number	TRTNO		11 I 2
Treatment name	TITLET		5 C 25
Line 5[5]			
Variable abbreviations			1 C 77+
Line 6 on			
Date (Year and days from Jan. 1)	YRDOY	DATE	1 I 5
Crop age (days from planting)	DAP	CDAY	1 I 5
Daily diseased leaf area increase, $cm^2/m^2/d$	DISLA	DL	1 I 5
Daily % diseased leaf area increase, $g/m^2/d$	DISLAP	%DL%	1 R 5 1
Daily leaf area consumed, $m^2/m^2/d$	LAIDT	DLAI	1 R 5 2
Daily leaf mass consumed, $g/m^2/d$	WLIDOT	DLFM	1 R 5 2
Daily stem mass consumed, $g/m^2/d$	WSIDOT	DSTM	1 R 5 2
Daily seed mass consumed, $g/m^2/d$	SWIDOT	DSDM	1 R 5 2
Daily seed number consumed, $\#/m^2/d$	SDIDOT	DSD#	1 R 5 2
Daily shell mass consumed, $g/m^2/d$	WSHIDT	DSHM	1 R 5 2
Daily shell number consumed, $\#/m^2/d$	SHIDOT	DSH#	1 R 5 2
Daily root mass consumed, $g/m^2/d$	WRIDOT	DRTM	1 R 5 2
Daily root length density consumed, $cm/cm^3/d$	RLVDOT	DRLV	1 R 5 2

---

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

2 *Abbreviations suggested for use in header lines (those designated with '@') within the file. They correspond to the variable names used in the associated database.*

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

4 *Each new run should be demarcated with '*RUN' at the beginning of this line in each file.*

5 *Additional information can be placed between lines 4 and 5, as required by a user, as illustrated in the example, and as documented for the Overview file in the text.*

EXAMPLE PEST OUTPUT FILE

```
*PEST ASPECTS OUTPUT FILE

*RUN   1         : Pest and Diseases
 MODEL           : CRGRO940 - PEANUT
 EXPERIMENT      : UFGA7602 PN    PEANUT PEST TEST 1
 TREATMENT  8    : LEAF,STEM,SEED,SHELL MASS

 CROP            : PEANUT         CULTIVAR : FLORUNNER        -  FLORUNNER VARS
 STARTING DATE   : MAY  5 1976
 PLANTING DATE   : MAY  5 1976    PLANTS/m2 : 12.9     ROW SPACING :  31.cm
 WEATHER         : UFGA   1976
 SOIL            : IBPN910015     TEXTURE :       - Millhopper Fine Sand
 SOIL INITIAL C  : DEPTH:180cm EXTR. H2O:158.4mm  NO3:   .0kg/ha  NH4:   0kg/ha
 WATER BALANCE   : IRRIGATE ACCORDING TO FIELD SCHEDULE
 IRRIGATION      :       75 mm IN     4 APPLICATIONS
 NITROGEN BAL.   : NOT SIMULATED ; NO N-STRESS
 N FERTILIZER    :
 RESIDUE/MANURE  :
 ENVIRONM. OPT.  : DAYL=      .0  SRAD=      .0  TMAX=      .0  TMIN=      .0
                   RAIN=      .0  CO2 = R 330.0  DEW =      .0  WIND=      .0
 SIMULATION OPT  : WATER   :Y  NITROGEN:N  N-FIX:Y  PESTS  :Y  PHOTO  :C  ET :R
 MANAGEMENT OPT  : PLANTING:R  IRRIG   :R  FERT :R  RESIDUE:R  HARVEST:R  WTH:M

@DATE   CDAY  DLA   %DL%  DLAI  DLFM  DSTM  DSDM  DSD#  DSHM  DSH#  DRTM  DRLV
 76126     0     0    .0   .00   .00   .00   .00   .00   .00   .00   .00   .00
 76129     3     0    .0   .00   .00   .00   .00   .00   .00   .00   .00   .00
 76132     6     0    .0   .00   .00   .00   .00   .00   .00   .00   .00   .00
 76135     9     0    .0   .00   .00   .00   .00   .00   .00   .00   .00   .00
 76138    12     0    .0   .00   .00   .00   .00   .00   .00   .00   .00   .00
 76141    15     0    .0   .00   .00   .00   .00   .00   .00   .00   .00   .00
 76144    18     0    .0   .00   .00   .00   .00   .00   .00   .00   .00   .00
 76147    21     0    .0   .00   .00   .00   .00   .00   .00   .00   .00   .00
 76150    24     0    .0   .00   .00   .00   .00   .00   .00   .00   .00   .00
 76153    27    39   1.3   .00   .00   .08   .00   .00   .00   .00   .18   .01
 76156    30   100   2.5   .00   .00   .12   .00   .00   .00   .00   .42   .03
 76159    33   235   3.8   .00   .00   .23   .00   .00   .00   .00   .68   .05
 76162    36   459   5.0   .00   .00   .32   .00   .00   .00   .00  1.02   .08
 76165    39   648   6.2   .00   .00   .35   .00   .00   .00   .00  1.87   .13
 76168    42   794   7.5   .00   .00   .45   .00   .00   .00   .00  2.75   .17
 76171    45  1031   8.7   .00   .00   .69   .00   .00   .00   .00  3.46   .22
 76174    48  1543  10.0   .00   .00   .81   .00   .00   .00   .00  3.32   .21
 76177    51  2313  11.3   .01   .60  1.33   .00   .00   .00   .00  3.31   .20
 76180    54  3200  12.5   .02   .75  1.54   .00   .76   .06   .39  3.36   .20
 76183    57  4118  13.8   .02   .93  1.79   .07  2.89   .26  1.47  3.16   .19
 76186    60  4953  15.0   .02   .87  1.93   .17  5.21   .51  2.61  3.28   .19
 76189    63  5869  16.3   .02   .97  2.22   .23  6.53   .67  3.22  3.54   .20
 76192    66  6722  17.5   .03  1.13  2.41   .29  8.00   .83  3.88  3.33   .18
 76195    69  7412  18.8   .02   .96  2.48   .34  9.66   .99  4.62  4.05   .21
 76198    72  7761  20.0   .01   .58  1.81   .35 12.32  1.19  5.80  5.29   .26
```

CHAPTER FIVE.

EXPERIMENT PERFORMANCE DATA FILES

Experiment performance data are contained in FILEP, FILED, FILEA and FILET, which the user generates using the formats shown in Tables 18 and 19. The correct formatting of FILEA and FILET is critical because these files link directly to the model(s). The purpose of these files is to present measured performance data for direct comparison with simulated results. FILEP is the basic performance data file, with information detailed at the replicate level for each treatment, arranged by plots. FILED would contain replicate performance data arranged by date of observations. In other words, FILEP and FILED are the basic performance data files, with information detailed at the replicate level for each treatment, arranged by plots in FILEP and by date of measurement in FILED. FILEA and FILET contain average values derived from the data in FILEP or FILED. FILEA uses one line of information per treatment and this one line is a summary of information of the entire treatment. The dates included on each line are of the main phenological events and the yield and yield components at final harvest, as well as other related variables. FILET contains one line of data for each observation date for each treatment. Averages are arranged in columns in order of treatment in FILEA, in order of date in the time-course file, FILET. The files will have a variable number of columns, depending on the data available. Each could have as few as one measured variable, or as many variables as measured. Each experimental data file, however, will always have an initial section with the institute and site codes and experiment number, the crop group code, and the experiment name. All columns have one leading blank and five spaces for data, and are headed by standard variable abbreviations (see Appendix C for a listing of abbreviations). Each data column, if appropriate, could also have header lines containing information on the date measurements were made, and on the factor by which data need to be multiplied to convert them to standard units. Examples are shown in Tables 18 and 19.

TABLE 18. EXAMPLE OF AN EXPERIMENT PERFORMANCE DATA AVERAGES FILE (FILEA), STORED IN THE DATA FILE, UFGA8101.SBA.

*EXP.DATA (A): UFGA8101SB COBB, IRRIGATED, VEG. & REPROD. STRESS

@ TRNO	HWAM	HWUM	H#AM	H#UM	LAIX	CWAM	BWAH	ADAT	MDAT	PD1T	PDFT	PWAM
1	3502.	.1476	2374.	1.88	6.25	6851.	2137.	224	295	243	243	4526.
2	3355.	.1529	2195.	1.84	4.48	6109.	1587.	225	295	245	245	4403.
3	2738.	.1292	2119.	1.77	6.25	5881.	2064.	224	295	243	243	3690.

TABLE 19. EXAMPLE OF AN EXPERIMENT TIME-COURSE DATA FILE (FILET), SHOWING TIME SERIES FOR TREATMENT 1, STORED IN THE DATA FILE, UFGA8101.SBT.

*EXP.DATA (T): UFGA8101SB COBB, IRRIGATED, VEG. & REPROD. STRESS

@TRNO	DATE	L#SD	LAID	P#AD	SWAD	GWAD	LWAD	CWAD	PWAD	SHAD	G#AD	SH%D	SLAD
1	81188	.8	.11	0.	18	0.	40	58	0.	0.	0.	00.00	272
1	81190	1.4	.15	0.	20	0.	53	74	0.	0.	0.	00.00	277
1	81196	2.5	.37	0.	70	0.	144	214	0.	0.	0.	00.00	254
1	81204	6.3	1.27	0.	254	0.	350	604	0.	0.	0.	00.00	360
1	81208	6.8	1.75	0.	404	0.	497	901	0.	0.	0.	00.00	351
1	81210	7.1	1.75	0.	437	0.	499	936	0.	0.	0.	00.00	350
1	81212	7.4	1.74	0.	462	0.	525	987	0.	0.	0.	00.00	332
1	81215	7.9	2.48	0.	678	0.	722	1400	0.	0.	0.	00.00	344
1	81219	8.6	3.11	0.	1005	0.	864	1869	0.	0.	0.	00.00	359
1	81223	10.3	3.47	0.	1260	0.	980	2240	0.	0.	0.	00.00	354
1	81225	10.4	4.20	0.	1384	0.	1102	2486	0.	0.	0.	00.00	380
1	81229	10.6	4.57	0.	1758	0.	1317	3075	0.	0.	0.	00.00	348
1	81233	-99	4.33	0.	1896	0.	1206	3102	0.	0.	0.	00.00	357
1	81237	14.1	5.00	50.	2163	0.	1469	3636	4	4	0.	00.00	341
1	81245	14.4	5.87	757.	2704	0.	1717	4510	89	89	0.	00.00	342
1	81246	-99	6.25	-99	2897	0.	1750	4849	202	202	0.	00.00	359
1	81251	11.8	5.34	992.	2639	0.	1657	4657	361	361	0.	00.00	322
1	81252	-99	4.85	-99	2727	0.	1472	4621	421	421	0.	00.00	330
1	81257	15.3	4.49	1467	2940	0.	1704	5504	860	860	0.	00.00	264
1	81259	-99	5.06	-99	3674	0.	1651	6624	1299	1299	0.	00.00	306
1	81261	15.3	4.74	1505	2928	557	1694	5992	1370	813	2918	40.66	280
1	81266	-99	4.50	-99	3270	919	1612	6794	1912	993	3470	48.06	281
1	81267	15.0	4.10	1442	2566	1037	1409	5957	1983	946	2439	52.29	291
1	81271	16.5	3.85	1184	2419	1294	1549	6154	2185	891	2142	59.22	249
1	81273	-99	4.10	-99	2876	1643	1572	6998	2550	907	2511	64.43	261
1	81274	17.3	4.33	1552	3287	2437	1730	8578	3561	1124	3063	68.44	250
1	81278	16.0	3.17	1193	2603	1804	1398	6732	2732	928	2109	66.03	227
1	81280	-99	3.96	-99	2962	2387	1532	7913	3419	1032	2434	69.82	259
1	81287	-99	3.83	-99	3024	3278	1525	8858	4310	1032	2690	76.06	251
1	81294	-99	2.18	-99	2483	3548	810	7869	4576	1028	2469	77.53	268
1	81301	-99	.61	-99	1966	3208	215	6323	4142	934	2223	77.45	287
1	81308	-99	.44	-99	2307	3796	163	7378	4909	1113	2524	77.33	276

CHAPTER SIX. DISCUSSION

These proposed file structures resulted from the interest in an earlier set of crop model inputs and outputs published by IBSNAT (1986, 1990). The earlier standards have been used for a number of crop models in the integrated software package called DSSAT (Decision Support System for Agrotechnology Transfer). This earlier attempt demonstrated the value of such standards in facilitating the organization and exchange of crop weather, soil, and plot data among modeling and model user groups at various institutions. The inputs and outputs described in this document represent a wider range of crop, weather, and soil conditions, and should be nonspecific to a crop model. By expanding the list of inputs, however, it is more likely that some of the inputs will not be available for all experiments or for all intended applications. This creates a dilemma for modelers, who must decide which of the defined variables are to be a minimum set required to run their models, or must include capabilities in their models to recognize and estimate missing variables. The same is true for outputs. However, this does not create the same difficulty as the lack of inputs; it means that only parts of the models can be validated in any one experiment. Nonetheless, a basic minimum data set is needed for effective interpretation of all experiments, regardless of model validation applications. Such a minimum data set has been defined (IBSNAT, 1988), and vigorous efforts should be made to obtain such information in all experiments. The files described here reflect this minimum data set, and thus form part of an overall system that encompasses forms for data collection in the field, files for data storage, and files for use by various analysis programs. Further changes in the model input component of this system will inevitably have an impact on the other components. The design of the system as an entity makes it easier to accommodate such changes than would be the case if each part was considered separately. It is hoped that such an advantage can be

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maintained and strengthened in the future.

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APPENDIX A.

WEATHER LIST AND SOIL PROFILE LIST FILES

WEATHER LIST FILE

This file contains a list of weather data files which are available for use by the simulation models. It has one line of information (see Table 20, below) for each weather data set which gives the file name, site name, latitude, longitude, and elevation. The actual weather file used for a particular experiment is specified in the experiment file (FILEX). The weather list file typically would be used in sensitivity analysis where a user may wish to examine crop performance under alternate weather conditions.

TABLE 20. EXAMPLE WEATHER LIST FILE. (WTH.LST)

```
*WEATHER LIST

@# FILENAME EXT SITE NAME................. LAT..... LONG.... ELEV. TAV.. TAMP.
 1 CCPA8601 WTH CIAT,PALMIRA,COLOMBIA           3.5    -76.4   -99 -99.0 -99.0
 2 CCPA8701 WTH CIAT,PALMIRA,COLOMBIA           3.5    -76.4   -99 -99.0 -99.0
 3 DTSP8501 WTH SUPHAN_BURI,THAILAND           14.5    100.1   -99 -99.0 -99.0
 4 EBGO8701 WTH CNPAF,GOIANIA,BRAZIL          -16.3    -49.1   -99 -99.0 -99.0
 5 IGQU8901 WTH ICTA,QUEZADA,GUATEMALA         14.3    -90.0   -99 -99.0 -99.0
 6 IRMZ8501 WTH IRRI,MUNOZ,PHILIPPINES         15.7    120.9   -99 -99.0 -99.0
 7 IRMZ8601 WTH IRRI,MUNOZ,PHILIPPINES         15.7    120.9   -99 -99.0 -99.0
 8 IRPI8001 WTH IRRI,PILA,PHILIPPINES          14.2    121.3    50  27.0   3.8
 9 IRPI8501 WTH IRRI,PILA,PHILIPPINES          14.2    121.3    50  27.0   3.8
10 IRPI8601 WTH IRRI,PILA,PHILIPPINES          14.2    121.3    50  27.0   3.8
11 IUCA7901 WTH CASTANA,IOWA,USA               42.2    -93.7   -99 -99.0 -99.0
12 KSAS8101 WTH ASHLAND,KANSAS,USA             39.0    -97.0   -99 -99.0 -99.0
13 UBKA8601 WTH KAJONDI_FARM,BURUNDI           -3.3     30.0   -99 -99.0 -99.0
14 UFGA7601 WTH GAINESVILLE,FLORIDA,USA        29.6    -82.4    10  20.9   7.4
15 UFGA7801 WTH GAINESVILLE,FLORIDA,USA        29.6    -82.4    10  20.9   7.4
16 UFGA7901 WTH GAINESVILLE,FLORIDA,USA        29.6    -82.4    10  20.9   7.4
17 UFGA8001 WTH GAINESVILLE,FLORIDA,USA        29.6    -82.4    10  20.9   7.4
18 UFGA8101 WTH GAINESVILLE,FLORIDA,USA        29.6    -82.4    10  20.9   7.4
19 UFGA8201 WTH GAINESVILLE,FLORIDA,USA        29.6    -82.4    10  20.9   7.4
20 UFGA8401 WTH GAINESVILLE,FLORIDA,USA        29.6    -82.4    10  20.9   7.4
21 UFGA8501 WTH GAINESVILLE,FLORIDA,USA        29.6    -82.4    10  20.9   7.4
22 UFGA8601 WTH GAINESVILLE,FLORIDA,USA        29.6    -82.4    10  20.9   7.4
23 UFQU7901 WTH QUINCY,FLORIDA,USA             30.6    -86.4   -99 -99.0 -99.0
```

SOIL PROFILE LIST FILE

This file contains a list of soil profiles which are available for use by the simulation models. It has one line of information (see Table 21, below) for each soil profile which gives the file name, soil code, texture, depth and description. The actual soil profile used for a particular experiment is specified in the experiment file (FILEX).

TABLE 21. EXAMPLE SOIL PROFILE LIST FILE. (SOL.LST)

```
*SOIL LIST

@# FILENAME EXT SOIL CODE  TEXTURE DEPTH  DESCRIPTION
 1 SOIL     SOL GAPN930001 SALO    178    FACEVILLE
 2 SOIL     SOL IBBN910015 FSA     180    MILLHOPPER FINE SAND
 3 SOIL     SOL IBBN910030 -99     209    M3
 4 SOIL     SOL IBBN910038 -99     150    SAN_FERNANDO,QUEZADA
 5 SOIL     SOL IBMZ910014 FSA     180    MILLHOPPER FINE SAND
 6 SOIL     SOL IBPN910015 FSA     180    MILLHOPPER FINE SAND
 7 SOIL     SOL IBRI910001 -99     50     ANDAQUEPTIC HAPLAQUOLL
 8 SOIL     SOL IBRI910002 -99     50     VERTIC TROPAQUEPT
 9 SOIL     SOL IBRI910063 -99     135    UPLAND
10 SOIL     SOL IBRI910071 -99     51     SUPHAN LOWLAND
11 SOIL     SOL IBSB910015 FSA     180    MILLHOPPER FINE SAND
12 SOIL     SOL IBSB910017 SALO    203    ORANGEBURG SANDY LOAM
13 SOIL     SOL IBSB910026 SILO    180    IDA SILT LOAM
14 SOIL     SOL IBWH910018 CSI     180    HAYNIE
```

APPENDIX B.

EXPERIMENT DETAILS CODES

Headers used in the @ line to identify variables are listed first, codes to identify methods, chemicals, etc. are listed next in sections that relate to specific aspects (Chemicals;Crop and weed species;Diseases and pests;Drainage; Environment modification factors; Fertilizers, inoculants and amendments; Harvest components;Harvest size categories;Methods-fertilizer and chemical applications; Methods-irrigation and water management;Methods-soil analysis; Planting materials; Plant distribution; Residues and organic fertilizers; Rotations;Soil texture;and Tillage implements).

The fields in the file are as follows:

CDE The ‘universal’ code used to facilitate data interchange.

DESCRIPTION A description of the code, with units.

SO The source of the codes (IB=IBSNAT). Codes added by a user should be referenced in this field and the name and address of the person adding the code should be entered as a comment (ie.with a ‘!’ in column 1) below this note. This is important to ensure that information from different workers can be easily integrated. Users adding codes should also ensure that those constructed by adding a number to section code (eg.FE001,CH001) are clearly identified with a letter in the this position (eg.FEK01 for a fertilizer code added by someone with a family name beginning with K).

```
*Headers
@CDE     DESCRIPTION                                                         SO
ADDRESS  Contact address of principal scientist                              IB
C        Crop component number (default = 1)                                IB
CDATE    Application date, year + day or days from planting                  IB
CHAMT    Chemical application amount, kg ha-1                                IB
CHCOD    Chemical material, code                                             IB
CHDEP    Chemical application depth, cm                                      IB
CHME     Chemical application method, code                                   IB
CHNOTES  Chemical notes (Targets, chemical name, etc.)                       IB
CNAME    Cultivar name                                                       IB
CNOTES   Cultivar details (Type, pedigree, etc.)                             IB
CR       Crop code                                                           IB
CU       Cultivar level                                                      IB
ECO2     CO2 adjustment, A,S,M,R + vpm                                       IB
EDATE    Emergence date, earliest treatment                                  IB
EDAY     Daylength adjustment, A,S,M,R + h                                   IB
EDEW     Humidity adjustment, A,S,M,R + oC                                   IB
EMAX     Temperature (maximum) adjustment, A,S,M,R + oC                      IB
EMIN     Temperature (minimum) adjustment, A,S,M,R + oC                      IB
ERAD     Radiation adjustment, A,S,M,R + MJ m-2day-1                         IB
ERAIN    Precipitation adjustment, A,S,M,R + mm                              IB
EWIND    Wind adjustment, A,S,M,R + km day-1                                 IB
FACD     Fertilizer application/placement, code                              IB
FAMC     Ca in applied fertilizer, kg ha-1                                   IB
FAMK     K in applied fertilizer, kg ha-1                                    IB
FAMN     N in applied fertilizer, kg ha-1                                    IB
FAMO     Other elements in applied fertilizer, kg ha-1                       IB
FAMP     P in applied fertilizer, kg ha-1                                    IB
FDATE    Fertilization date, year + day or days from planting                IB
FDEP     Fertilizer incorporation/application depth, cm                      IB
FL       Field level                                                         IB
FLDD     Drain depth, cm                                                     IB
FLDS     Drain spacing, m                                                    IB
FLDT     Drainage type, code                                                 IB
FLOB     Obstruction to sun, degrees                                         IB
FLSA     Slope and aspect, degrees from horizontal plus direction (W, NW, etc. IB
FLST     Surface stones (Abundance, % + Size, S,M,L)                         IB
FMCD     Fertilizer material, code                                           IB
FOCD     Other element code, e.g.,. MG                                       IB
HAREA    Harvest area, m-2                                                   IB
HARM     Harvest method                                                      IB
HCOM     Harvest component, code                                             IB
HDATE    Harvest date, year + day or days from planting                      IB
HL       Harvest level                                                       IB
```

HLEN	Harvest row length, m	IB
HPC	Harvest percentage, %	IB
HRNO	Harvest row number	IB
HSIZ	Harvest size group, code	IB
HSTG	Harvest stage	IB
IAME	Method for automatic applications, code	IB
IAMT	Amount per automatic irrigation if fixed, mm	IB
IC	Initial conditions level	IB
ICBL	Depth, base of layer, cm	IB
ICDAT	Initial conditions measurement date, year + days	IB
ICND	Nodule weight from previous crop, kg ha-1	IB
ICRE	Rhizobia effectiveness, 0 to 1 scale	IB
ICRN	Rhizobia number, 0 to 1 scale	IB
ICRT	Root weight from previous crop, kg ha-1	IB
IDATE	Irrigation date, year + day or days from planting	IB
IDEP	Management depth for automatic application, cm	IB
ID_FIELD	Field ID (Institute + Site + Field)	IB
ID_SOIL	Soil ID (Institute + Site + Year + Soil)	IB
IEFF	Irrigation application efficiency, fraction	IB
IEPT	End point for automatic appl., % of max. available	IB
INGENO	Cultivar identifier	IB
IOFF	End of automatic applications, growth stage	IB
IROP	Irrigation operation, code	IB
IRVAL	Irrigation amount, depth of water/watertable, etc., mm	IB
ITHR	Threshold for automatic appl., % of max. available	IB
MC	Chemical applications level	IB
ME	Environment modifications level	IB
MF	Fertilizer applications level	IB
MH	Harvest level	IB
MI	Irrigation level	IB
MP	Planting level	IB
MR	Residue level	IB
MT	Tillage level	IB
NOTES	Notes	IB
O	Rotation component - option (default = 1)	IB
ODATE	Environmental modification date, year + day or days from planting	IB
PAGE	Transplant age, days	IB
PAREA	Gross plot area per rep, m-2	IB
PCR	Previous crop code	IB
PDATE	Planting date, year + days from Jan. 1	IB
PENV	Transplant environment, ~C	IB
PEOPLE	Names of scientists	IB
PLAY	Plot layout	IB
PLDP	Planting depth, cm	IB
PLDR	Plots relative to drains, degrees	IB
PLDS	Planting distribution, row R, broadcast B, hill H	IB
PLEN	Plot length, m	IB
PLME	Planting method, code	IB
PLOR	Plot orientation, degrees from N	IB
PLPH	Plants per hill (if appropriate)	IB
PLRD	Row direction, degrees from N	IB
PLRS	Row spacing, cm	IB
PLSP	Plot spacing, cm	IB
PLWT	Planting material dry weight, kg ha-1	IB
PPOE	Plant population at emergence, m-2	IB
PPOP	Plant population at seeding, m-2	IB
PRNO	Rows per plot	IB
R	Rotation component - number (default = 1)	IB
RACD	Residue application/placement, code	IB
RAMT	Residue amount, kg ha-1	IB
RCOD	Residue material, code	IB
RDATE	Incorporation date, year + days	IB
RDEP	Residue incorporation depth, cm	IB
RDMC	Residue dry matter content, %	IB
RESK	Residue potassium concentration, %	IB
RESN	Residue nitrogen concentration, %	IB
RESP	Residue phosphorus concentration, %	IB
RINP	Residue incorporation percentage, %	IB
SA	Soil analysis level	IB
SABD	Bulk density, moist, g cm-3	IB
SABL	Depth, base of layer, cm	IB

SADAT	Analysis date, year + days from Jan. 1	IB
SAHB	pH in buffer	IB
SAHW	pH in water	IB
SAKE	Potassium, exchangeable, cmol kg-1	IB
SANI	Total nitrogen, g kg-1	IB
SAOC	Organic carbon, g kg-1	IB
SAPX	Phosphorus, extractable, mg kg-1	IB
SH20	Water, cm3 cm-3	IB
SITE(S)	Name and location of experimental site(s)	IB
SLDP	Soil depth, cm	IB
SLTX	Soil texture	IB
SM	Simulation control level	IB
SMHB	pH in buffer determination method, code	IB
SMKE	Potassium determination method, code	IB
SMPX	Phosphorus determination method, code	IB
SNH4	Ammonium, KCl, g elemental N Mg-1 soil	IB
SNO3	Nitrate, KCl, g elemental N Mg-1 soil	IB
TDATE	Tillage date, year + day	IB
TDEP	Tillage depth, cm	IB
TIMPL	Tillage implement, code	IB
TL	Tillage level	IB
TN	Treatment number	IB
TNAME	Treatment name	IB
WSTA	Weather station code (Institute + Site)	IB

*Chemicals (Herbicides, Insecticides, Fungicides, etc.)

@CDE	DESCRIPTION	SO
CH001	Alachlor (Lasso), Metolachlor (Dual) [Herbicide]	IB
CH002	Propanil [Herbicide]	IB
CH003	Trifluralin [Herbicide]	IB
CH004	Dalapon [Herbicide]	IB
CH005	MCPA [Herbicide]	IB
CH006	2,4-D [Herbicide]	IB
CH007	2,4,5-T [Herbicide]	IB
CH008	Pendimethalin [Herbicide]	IB
CH009	Atrazine [Herbicide]	IB
CH010	Diquat [Herbicide]	IB
CH011	Paraquat [Herbicide]	IB
CH021	Carbaryl, Sevin, Septene [Insecticide]	IB
CH022	Malathion, Mercaptothion [Insecticide]	IB
CH023	Naled [Insecticide]	IB
CH024	Dimethoate [Insecticide]	IB
CH025	Fention [Insecticide]	IB
CH026	Diazinon, Basudin [Insecticide]	IB
CH027	Ethion, Diethion [Insecticide]	IB
CH028	Oxydemeton-Methyl [Insecticide]	IB
CH029	Azinphos-Methyl [Insecticide]	IB
CH030	Phosphamidon [Insecticide]	IB
CH031	Mevinphosl [Insecticide]	IB
CH032	Methyl Parathion [Insecticide]	IB
CH033	Parathion [Insecticide]	IB
CH034	DDT [Insecticide]	IB
CH035	BHC, HCH [Insecticide]	IB
CH036	Chlordane [Insecticide]	IB
CH037	Heptachlor [Insecticide]	IB
CH038	Toxaphene [Insecticide]	IB
CH039	Aldrin [Insecticide]	IB
CH040	Dieldrin [Insecticide]	IB
CH041	Endrin, Nendrin [Insecticide]	IB
CH042	Methomyl, Lannat [Insecticide]	IB
CH043	Thiotex [Insecticide]	IB
CH044	Furadan [Insecticide]	IB
CH045	Endosulfan [Insecticide]	IB
CH051	Captan [Fungicide]	IB
CH052	Benomyl [Fungicide]	IB
CH053	Zineb [Fungicide]	IB
CH054	Maneb [Fungicide]	IB
CH055	Mancozeb [Fungicide]	IB
CH056	Tilt [Fungicide]	IB
CH057	Rhizobium (for legume crops)	IB

*Crop and Weed Species

```
@CDE   DESCRIPTION                                                         SO
AR     Aroid                                                               IB
AL     Alfalfa/Lucerne                                                     IB
BA     Barley                                                              IB
BN     Dry bean                                                            IB
BS     Beet sugar                                                          IB
BW     Broad leaf weeds                                                    IB
CO     Cotton                                                              IB
CS     Cassava                                                             IB
FA     Fallow                                                              IB
GW     Grass weeds                                                         IB
ML     Pearl Millet                                                        IB
MZ     Maize                                                               IB
OA     Oats                                                                IB
PN     Peanut                                                              IB
PT     Potato                                                              IB
RI     Rice                                                                IB
SB     Soybean                                                             IB
SC     Sugar Cane                                                          IB
SG     Grain sorghum                                                       IB
ST     Shrubs/trees                                                        IB
WH     Wheat                                                               IB

*Disease and Pest Organisms
@CDE   DESCRIPTION                                                         SO
!Examples of codes that have been used are given below.                    IB
CEW    Corn earworm (Heliothis zea), no. m-2                               IB
VBC    Velvetbean caterpillar (Anticarsia gemmatalis), no. m-2             IB
SBL    Soybean looper (Pseudoplusia includens), no. m-2                    IB
SKB    Southern green stinkbug (Mezara viridula), no. m-2                  IB
RKN    Root-knot nematode (Meloidogyne spp.), no. cm-3 soil                IB
CUT    Cutworm, no. m-2                                                    IB

*Drainage
@CDE   DESCRIPTION                                                         SO
DR000  No drainage                                                         IB
DR001  Ditches                                                             IB
DR002  Sub-surface tiles                                                   IB
DR003  Surface furrows                                                     IB

*Environment Modification Factors
@CDE   DESCRIPTION                                                         SO
A      Add                                                                 IB
S      Subtract                                                            IB
M      Multiply                                                            IB
R      Replace                                                             IB

*Fertilizers, Inoculants and Amendments
@CDE   DESCRIPTION                                                         SO
FE001  Ammonium nitrate                                                    IB
FE002  Ammonium sulfate                                                    IB
FE003  Ammonium-nitrate-sulfate                                            IB
FE004  Anhydrous ammonia                                                   IB
FE005  Urea                                                                IB
FE006  Diammnoium phosphate                                                IB
FE007  Monoammonium phosphate                                              IB
FE008  Calcium nitrate                                                     IB
FE009  Aqua ammonia                                                        IB
FE010  Urea ammonium nitrate solution                                      IB
FE011  Calcium ammonium nitrate solution                                   IB
FE012  Ammonium polyphosphate                                              IB
FE013  Single superphosphate                                               IB
FE014  Triple superphosphate                                               IB
FE015  Liquid phosphoric acid                                              IB
FE016  Potassium chloride                                                  IB
FE017  Potassium nitrate                                                   IB
FE018  Potassium sulfate                                                   IB
FE019  Urea super granules                                                 IB
FE020  Dolomitic limestone                                                 IB
FE021  Rock phosphate                                                      IB
FE022  Calcitic limestone                                                  IB
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FE024  Rhizobium                                                                IB
FE026  Calcium hydroxide                                                        IB

*Harvest components
@CDE   DESCRIPTION                                                              SO
C      Canopy                                                                   IB
L      Leaves                                                                   IB
H      Harvest product                                                          IB

*Harvest size categories
@CDE   DESCRIPTION                                                              SO
A      All                                                                      IB
S      Small - less than 1/3 full size                                          IB
M      Medium - from 1/3 to 2/3 full size                                       IB
L      Large - greater than 2/3 full size                                       IB

*Methods - Fertilizer and Chemical Applications
@CDE   DESCRIPTION                                                              SO
AP000  Applied when required - no shortage                                      IB
AP001  Broadcast, not incorporated                                              IB
AP002  Broadcast, incorporated                                                  IB
AP003  Banded on surface                                                        IB
AP004  Banded beneath surface                                                   IB
AP005  Applied in irrigation water                                              IB
AP006  Foliar spray                                                             IB
AP007  Bottom of hole                                                           IB
AP008  On the seed                                                              IB
AP009  Injected                                                                 IB
AP011  Brodcast on flooded/saturated soil, none in soil                         IB
AP012  Brodcast on flooded/saturated soil, 15% in soil                          IB
AP013  Brodcast on flooded/saturated soil, 30% in soil                          IB
AP014  Brodcast on flooded/saturated soil, 45% in soil                          IB
AP015  Brodcast on flooded/saturated soil, 60% in soil                          IB
AP016  Brodcast on flooded/saturated soil, 75% in soil                          IB
AP017  Brodcast on flooded/saturated soil, 90% in soil                          IB
AP018  Band on saturated soil,2cm flood, 92% in soil                            IB
AP019  Deeply placed urea super granules/pellets, 95% in soil                   IB
AP020  Deeply placed urea super granules/pellets, 100% in soil                  IB

*Methods - Irrigation and Water Management (Units for associated data)
@CDE   DESCRIPTION                                                              SO
IR001  Furrow, mm                                                               IB
IR002  Alternating furrows, mm                                                  IB
IR003  Flood, mm                                                                IB
IR004  Sprinkler, mm                                                            IB
IR005  Drip or trickle, mm                                                      IB
IR006  Flood depth, mm                                                          IB
IR007  Water table depth, mm                                                    IB
IR008  Percolation rate, mm day-1                                               IB
IR009  Bund height, mm                                                          IB

*Methods - Soil Analysis
@CDE   DESCRIPTION                                                              SO
SA001  Olsen                                                                    IB
SA002  Bray No. 1                                                               IB
SA003  Bray No. 2                                                               IB
SA004  Mehlich                                                                  IB
SA005  Anion exchange resin                                                     IB
SA006  Truog                                                                    IB
SA007  Double acid                                                              IB
SA008  Colwell                                                                  IB
SA009  Water                                                                    IB
SA010  IFDC Pi strip                                                            IB

*Planting Material/Method
@CDE   DESCRIPTION                                                              SO
PM001  Dry seed                                                                 IB
PM002  Transplants                                                              IB
PM003  Vegetative cuttings                                                      IB
PM004  Pregerminated seed                                                       IB
```

```
*Plant Distribution
@CDE   DESCRIPTION                                                                                SO
R      Rows                                                                                       IB
H      Hills                                                                                      IB
U      Uniform                                                                                    IB

*Residues and Organic Fertilizer
@CDE   DESCRIPTION                                                                                SO
RE001  Crop residue                                                                               IB
RE002  Green Manure                                                                               IB
RE003  Barnyard Manure                                                                            IB
RE004  Liquid Manure                                                                              IB

*Rotation
@CDE   DESCRIPTION                                                                                SO
RO001  Continuous arable crops                                                                    IB
RO002  Rotation with forages                                                                      IB

*Soil Texture
@CDE   DESCRIPTION                                                                                SO
CLOSA  Coarse loamy sand                                                                          IB
CSA    Coarse sand                                                                                IB
CSI    Coarse silt                                                                                IB
CSALO  Coarse sandy loam                                                                          IB
CL     Clay                                                                                       IB
CLLO   Clay loam                                                                                  IB
FLO    Fine loam                                                                                  IB
FLOSA  Fine loamy sand                                                                            IB
FSA    Fine sand                                                                                  IB
FSALO  Fine sandy loam                                                                            IB
SICLL  Silty clay loam                                                                            IB
LO     Loam                                                                                       IB
LOSA   Loamy sand                                                                                 IB
SA     Sand                                                                                       IB
SACL   Sandy clay                                                                                 IB
SACLL  Sandy clay loam                                                                            IB
SI     Silt                                                                                       IB
SICL   Silty clay                                                                                 IB
SILO   Silty loam                                                                                 IB
SALO   Sandy loam                                                                                 IB
VFLOS  Very fine loamy sand                                                                       IB
VFSA   Very fine sand                                                                             IB
VFSAL  Very fine sandy loam                                                                       IB

*Tillage Implements
@CDE   DESCRIPTION                                                                                SO
TI002  Tandem disk                                                                                IB
TI003  Offset disk                                                                                IB
TI004  Oneway disk                                                                                IB
TI005  Moldboard plow                                                                             IB
TI006  Chisel plow                                                                                IB
TI007  Disk plow                                                                                  IB
TI008  Subsoiler                                                                                  IB
TI009  Beeder/lister                                                                              IB
TI010  Field cultivator                                                                           IB
TI011  Row crop cultivator                                                                        IB
TI012  Harrow-springtooth                                                                         IB
TI013  Harrow-spike                                                                               IB
TI014  Rotary hoe                                                                                 IB
TI015  Roto-tiller                                                                                IB
TI016  Row crop planter                                                                           IB
TI017  Drill                                                                                      IB
TI018  Shredder                                                                                   IB
TI019  Hoe                                                                                        IB
TI020  Planting stick                                                                             IB
TI021  Animal-drawn implement                                                                     IB
TI022  Hand                                                                                       IB
TI023  Manual hoeing                                                                              IB
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APPENDIX C.

SIMULATED AND FIELD DATA CODES

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Codes currently used for both simulated and field data are listed in sections relating to
specific model output files. Codes currently only used for field data are listed in a section
headed Expdata. Codes are assigned as far as possible in accord with the following convention:
   1st letter: Plant component (eg. C for canopy; H for harvest product)
   2nd letter: Measurement aspect (eg. W for dry weight; N for nitrogen weight)
   3rd letter: Basis of measurement (eg. A for unit area; P for plant)
   4th letter: Time or stage of measurement (eg. D for specific day)
For complex aspects (eg. ear plus grain) this convention has been modified by dropping the
usual 4th letter and using the first 2 letter for component(s). Codes for dates have letters
for the stage first and then a D or DAT.

The fields in the file are as follows:
   CDE  The ‘universal’ code used to facilitate data interchange.
   LABEL  A short description used when labelling graphs.
   DESCRIPTION  A 35 character description of the aspect.
   OTHER CODE(S)  Additional codes that may be used locally (eg. YILD for HWAM)
   SO  The source of the codes (IB=IBSNAT). Codes added by a user should be referenced in this
       field and the name and address of the person adding the code should be entered as a
       comment (ie.with a ‘!’ in column 1) below this note. This is important to ensure that
       information from different workers can be easily integrated.
       [ SE  The section to which the code belongs. Used for sorting.]

*SUMMARY
@CDE LABEL           DESCRIPTION                        OTHER CODE(S)                SO SE
ADAT ANTHESIS day    Anthesis date (YrDoy)              ANTH                         IB SU
BWAH BYPRODUCT kg/ha By-product harvest (kg dm/ha)                                   IB SU
CNAA TOPS N,ANTHESIS Tops N at anthesis (kg/ha)                                      IB SU
CNAM TOPS N kg/ha    Tops N at maturity (kg/ha)                                      IB SU
CPAM TOPS P kg/ha    Tops P at maturity (kg/ha)                                      IB SU
CWAA TOPS WT,ANTHSIS Tops weight at anthesis (kg dm/ha)                              IB SU
CWAM TOPS WT kg/ha   Tops weight at maturity (kg dm/ha)                              IB SU
DRCM DRAINAGE mm     Season water drainage (mm)                                      IB SU
DWAP SOWING WT kg/ha Planting material weight (kg dm/ha)                             IB SU
ETCM ET TOTAL mm     Season evapotranspiration (mm)                                  IB SU
FNAM FIELD NAME      Field name                                                      IB SU
GN%M GRAIN N%,MATURE Grain N at maturity (%)                                         IB SU
GNAM GRAIN N kg/ha   Grain N at maturity (kg/ha)                                     IB SU
H#AM NUMBER #/m2     Number at maturity (no/m2)                                      IB SU
H#UM NUMBER #/unit   Number at maturity (no/unit)                                    IB SU
HDAT HARVEST day     Harvest date (YRDOY)                                            IB SU
HIAM HARVEST INDEX   Harvest index at maturity                                       IB SU
HWAH HAR YIELD kg/ha Yield at harvest (kg dm/ha)                                     IB SU
HWAM MAT YIELD kg/ha Yield at maturity (kg dm/ha)                                    IB SU
HWUM WEIGHT mg/unit  Unit wt at maturity (mg dm/unit)                                IB SU
IR#M IRRIG APPS #    Irrigation applications (no)                                    IB SU
IRCM IRRIG mm        Season irrigation  (mm)                                         IB SU
L#SM LEAF NUMBER #   Leaf number per stem,maturity                                   IB SU
L#SX LEAF NUMBER #   Leaf number per stem,maximum                                    IB SU
LAIX LAI MAXIMUM     Leaf area index, maximum                                        IB SU
MDAT MATURITY day    Physiological maturity date (YrDoy)                             IB SU
NFXM N FIXED kg/h    N fixed during season (kg/ha)                                   IB SU
NI#M N APPLICATION # N applications (no)                                             IB SU
NIAM SOIL N kg/ha    Inorganic N at maturity (kg N/ha)                               IB SU
NICM TOT N APP kg/ha Inorganic N applied (kg N/ha)                                   IB SU
NLCM N LEACHED kg/ha N leached during season (kg N/ha)                               IB SU
NUCM N UPTAKE kg/ha  N uptake during season (kg N/ha)                                IB SU
OCAM ORGANIC C t/ha  Organic soil C at maturity (t/ha)                               IB SU
ONAM ORGANIC N kg/ha Organic soil N at maturity (kg/ha)                              IB SU
PD1T POD 1 DATE yd   Pod 1 date (YrDoy)                                              IB SU
PDAT PLANTING DATE   Planting date (YrDoy)                                           IB SU
PDFT FULL POD DATE   Full pod date (YrDoy)                                           IB SU
PO#M P APPLICATION # Number of P applications (no)                                   IB SU
POCM P APPLIED kg/ha P applied (kg/ha)                                               IB SU
PRCM PRECIP mm       Season precipitation (mm)                                       IB SU
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PWAM POD WT kg/ha    Pod weight at maturity (kg dm/ha)                         IB SU
RECM RESIDUE kg/ha   Residue applied (kg/ha)                                   IB SU
ROCM RUNOFF mm       Season surface runoff (mm)                                IB SU
R1AT FIRST BLOOM     Beginning Bloom Stage                                     IB SU
R2AT FIRST PEG       Beginning Peg Stage                                       IB SU
R3AT FIRST POD       Beginning Pod Stage                                       IB SU
R4AT FULL POD        Full Pod Stage                                            IB SU
R5AT FIRST SEED      Beginning Seed Stage                                      IB SU
R6AT FULL SEED       Full Seed Stage                                           IB SU
R7AT FIRST MATURITY  Beginning Maturity Stage                                  IB SU
R8AT HARV MATURITY   Harvest Maturity Stage                                    IB SU
R9AT OVER-MATURE     Over-Mature Pod Stage                                     IB SU
SDAT SIMULATION DATE Simulation start date (YrDoy)                             IB SU
SNAM STEM N,MATURITY Stem N at maturity (kg/ha)                                IB SU
SPAM SOIL P kg/ha    Soil P at maturity (kg/ha)                                IB SU
SWXM EXTR WATER cm   Extractable water at maturity (cm)                        IB SU
THAM THRESHING %     Threshing % at maturity                                   IB SU
TNAM TREATMENT NAME  Treatment title                                           IB SU

*GROWTH
@CDE LABEL           DESCRIPTION                           LOCAL CODE          SO SE
CDAY CROP AGE days   Crop age (days from planting)                             IB GR
CHTD CANOPY HEIGHT m Canopy height (m)                                         IB GR
CWAD TOPS WT kg/ha   Tops weight (kg dm/ha)                                    IB GR
CWID CANOPY WIDTH m  Canopy width (m;for 1 row)                                IB GR
E#AD EAR NO./m2      Ear number (no/m2)                                        IB GR
EWAD EAR WT. kg/ha   Ear (no grain) weight (kg dm/ha)                          IB GR
G#AD GRAIN NO #/m2   Grain number (no/m2)                                      IB GR
GSTD GROWTH STAGE    Growth stage                                              IB GR
GWAD GRAIN WT kg/ha  Grain weight (kg dm/ha)                                   IB GR
GWGD GRAIN WT mg     Unit grain weight (mg dm/grain)                           IB GR
HIAD HARVEST INDEX   Harvest index (grain/top)                                 IB GR
HIPD POD INDEX       Pod harvest index (pod/top)                               IB GR
L#SD LEAF NUMBER     Leaf number per stem                                      IB GR
LAID LAI             Leaf area index                                           IB GR
LAWD SLA cm2/g       Specific leaf area (cm2/g)                                IB GR
LN%D LEAF N %        Leaf nitrogen concentration (%)                           IB GR
LWAD LEAF WT kg/ha   Leaf weight (kg dm/ha)                                    IB GR
NSTD N STRESS FACTOR Nitrogen stress factor (0-1)                              IB GR
NWAD NODULE WT kg/ha Nodule weight (kg dm/ha)                                  IB GR
P#AD POD NO #/m2     Pod number (no/m2)                                        IB GR
PRSD SHOOT FRACTION  Partitioning of wt to shoot (ratio)                       IB GR
PWAD POD WT kg/ha    Pod weight (kg dm/ha)                                     IB GR
PWDD DETACHED POD WT Detached pod weight (kg dm/ha)                            IB GR
PWTD POD WT kg/ha    Total pod weight (kg dm/ha)                               IB GR
RDPD ROOT DEPTH m    Root depth (m)                                            IB GR
RL10 RLD 180-210cm   Root density,180-210cm (cm/cm3)                           IB GR
RL1D RLD    0-5 cm   Root density,   0-5 cm (cm/cm3)                           IB GR
RL2D RLD   5-15 cm   Root density,  5-15 cm (cm/cm3)                           IB GR
RL3D RLD  15-30 cm   Root density, 15-30 cm (cm/cm3)                           IB GR
RL4D RLD  30-45 cm   Root density, 30-45 cm (cm/cm3)                           IB GR
RL5D RLD  45-60 cm   Root density, 45-60 cm (cm/cm3)                           IB GR
RL6D RLD  60-90 cm   Root density, 60-90 cm (cm/cm3)                           IB GR
RL7D RLD  90-120cm   Root density, 90-120cm (cm/cm3)                           IB GR
RL8D RLD 120-150cm   Root density,120-150cm (cm/cm3)                           IB GR
RL9D RLD 150-180cm   Root density,150-180cm (cm/cm3)                           IB GR
RN%D ROOT N %        Root N concentration (%)                                  IB GR
RWAD ROOT WT kg/ha   Root weight (kg dm/ha)                                    IB GR
SH%D SHELLING %      Shelling % (seed wt/pod wt*100)                           IB GR
SHAD SHELL WT kg/ha  Shell weight (kg dm/ha)                                   IB GR
SHND SHELL N %       Shell N concentration (%)                                 IB GR
SLAD SLA cm2/g       Specific leaf area (cm2/g)                                IB GR
SN%D STEM N %        Stem (stover) N concentration %)                          IB GR
SWAD STEM WT kg/ha   Stem weight (kg dm/ha)                                    IB GR
T#AD TILLER NO #/m2  Tiller number (no/m2)                                     IB GR
WSGD H20 STRESS,GR   Water stress - growth (0-1)                               IB GR
WSPD H20 STRESS,PHS  Water stress - photosynthesis (0-1)                       IB GR
```

```
*NITROGEN
@CDE LABEL           DESCRIPTION                             LOCAL CODE                  SO SU
AMLS NH3VOL kgN/ha/d Ammonia Vol. (kg N/ha/day)                                          IB NI
CNAD CROP N kg/ha    Tops N (kg/ha)                                                      IB NI
FALG ALGAL ACTIVITY  Floodwater Phot.Act.Index (0 to 1)                                  IB NI
FALI FLOOD LT INDX   Floodwater Light Index (0 to 1)                                     IB NI
FDEN DNITRF kgN/ha/d Floodwater Denitrif Rt (kg N/ha/d)                                  IB NI
FL3C FLD NH3 mg N/l  Floodwater Aqueous NH3 (mg N/l)                                     IB NI
FL3N FLD NO3 mg N/l  Floodwater NO3-N (mg N/l)                                           IB NI
FL4C FLD NH4 mg N/l  Floodwater NH4-N Conc. (mg N/l)                                     IB NI
FL4N FLD NH4  kgN/ha Floodwater Ammoniacal N (kg N/ha)                                   IB NI
FLBD Puddle BD g/cc  Puddled Soil Surface L BD (g/cc)                                    IB NI
FLEF Flood Evap mm   Floodwater Evaporation Rate (mm/d)                                  IB NI
FLNI FLOOD NIT INDX  Floodwater Nitrogen Index (0 to 1)                                  IB NI
FLPH FLOOD pH        Maximum Daytime Floodwater pH                                       IB NI
FLTI FLOOD TMP INDX  Floodwater Temp. Index (0 to 1)                                     IB NI
FLUR FLD UREA kgN/ha Floodwater Urea N (kg N/ha)                                         IB NI
FUHY UREA HYD kgN/ha Urea Hydrol Floodwater (kg N/ha/d)                                  IB NI
GN%D GRAIN N %       Grain N concentration (%)                                           IB NI
GNAD GRAIN N kg/ha   Grain N (kg/ha)                                                     IB NI
LN%D LEAF N %        Leaf N concentration (%)                                            IB NI
LNAD LEAF N kg/ha    Leaf N (kg/ha)                                                      IB NI
NAPC N APPLIED kg/ha Inorganic N applied (kg/ha)                                         IB NI
NFXC N FIXED kg/ha   N fixed (kg/ha)                                                     IB NI
NFXD N FIXED kg/ha.d N fixation rate (kg/ha.day)                                         IB NI
NH10 NH4 ug/g180-210 NH4 in 180-210cm (ug N/g soil)                                      IB NI
NH1D NH4 ug/g  0-5cm NH4 in    0-5 cm (ug N/g soil)                                      IB NI
NH2D NH4 ug/g 5-15cm NH4 in   5-15 cm (ug N/g soil)                                      IB NI
NH3D NH4 ug/g15-30cm NH4 in  15-30 cm (ug N/g soil)                                      IB NI
NH4D NH4 ug/g30-45cm NH4 in  30-45 cm (ug N/g soil)                                      IB NI
NH5D NH4 ug/g45-60cm NH4 in  45-60 cm (ug N/g soil)                                      IB NI
NH6D NH4 ug/g60-90cm NH4 in  60-90 cm (ug N/g soil)                                      IB NI
NH7D NH4 ug/g 90-120 NH4 in  90-120cm (ug N/g soil)                                      IB NI
NH8D NH4 ug/g120-150 NH4 in 120-150cm (ug N/g soil)                                      IB NI
NH9D NH4 ug/g150-180 NH4 in 150-180cm (ug N/g soil)                                      IB NI
NHTD TOTAL NH4 kg/ha Total soil NH4 (kg N/ha)                                            IB NI
NI10 NO3 ug/g180-210 NO3 in 180-210cm (ug N/g soil)                                      IB NI
NI1D NO3 ug/g  0-5cm NO3 in    0-5 cm (ug N/g soil)                                      IB NI
NI2D NO3 ug/g 5-15cm NO3 in   5-15 cm (ug N/g soil)                                      IB NI
NI3D NO3 ug/g15-30cm NO3 in  15-30 cm (ug N/g soil)                                      IB NI
NI4D NO3 ug/g30-45cm NO3 in  30-45 cm (ug N/g soil)                                      IB NI
NI5D NO3 ug/g45-60cm NO3 in  45-60 cm (ug N/g soil)                                      IB NI
NI6D NO3 ug/g60-90cm NO3 in  60-90 cm (ug N/g soil)                                      IB NI
NI7D NO3 ug/g 90-120 NO3 in  90-120cm (ug N/g soil)                                      IB NI
NI8D NO3 ug/g120-150 NO3 in 120-150cm (ug N/g soil)                                      IB NI
NI9D NO3 ug/g150-180 NO3 in 150-180cm (ug N/g soil)                                      IB NI
NIAD TOTAL N kg/ha   Total soil NO3+NH4 (kg N/ha)                                        IB NI
NITD TOTAL NO3 kg/ha Total soil NO3 (kg N/ha)                                            IB NI
NLCC N LEACHED kg/ha N leached (kg N/ha)                                                 IB NI
NOAD ORGANIC N kg/ha Organic N in soil (kg N/ha)                                         IB NI
NUPC N UPTAKE kg/ha  N uptake (kg N/ha)                                                  IB NI
OXRN OXNITR kgN/ha/d Ox Layer Nitrif Rt (kg N/ha/d)                                      IB NI
RN%D ROOT N %        Root N concentration (%)                                            IB NI
SHND SHELL N %       Shell N concentration (%)                                           IB NI
SN%D STEM N %        Stem (stover) N concentration (%)                                   IB NI
SNAD STEM N kg/ha    Stem N (kg/ha)                                                      IB NI
VN%D VEG N %         Veg (stem+leaf) N concentration (%)                                 IB NI
VNAD VEGE N kg/ha    Veg (stem+leaf) N (kg/ha)                                           IB NI

*WATER
@CDE LABEL           DESCRIPTION                             LOCAL CODE                  SO SE
DA3D DAYLENGTH h     Daylength (h;3 deg basis)                                           IB WA
DAYD DAYLENGTH h     Daylength (h;sunrise to sunset)                                     IB WA
DRNC DRAINGE mm      Cumulative drainage (mm)                                            IB WA
EOAA POT EVAP mm/d   Av pot.evapotranspiration (mm/d)                                    IB WA
EOAD POT EVAP mm/d   Potential evapotranspiration (mm/d)                                 IB WA
EPAA PLANT EVAP mm/d Av plant transpiration (mm/d)                                       IB WA
EPAC TRANSPIRATION   Cumulative transpiration (mm)                                       IB WA
EPAD PLANT EVAP mm/d Plant transpiration (mm/d)                                          IB WA
ESAA SOIL EVAP mm/d  Av soil evaporation (mm/d)                                          IB WA
ESAC SOIL EVAP mm    Cumulative soil evaporation (mm)                                    IB WA
```

```
ESAD SOIL EVAP mm/d  Soil evaporation (mm/d)                                    IB WA
ETAA EVAPOTRANS mm/d Av evapotranspiration (mm/d)                               IB WA
ETAC EVAPOTRANS mm   Cumulative evapotranspiration (mm)                         IB WA
ETAD EVAPOTRANS mm/d Evapotranspiration (mm/d)                                  IB WA
IR#C IRRIGATION #    Irrigation applications (no)                               IB WA
IRRC IRRIGATION mm   Cumulative irrigation  (mm)                                IB WA
PREC PRECIPITATION   Cumulative precipitation (mm)                              IB WA
ROFC RUNOFF mm       Cumulative runoff (mm)                                     IB WA
SRAA SRAD MJ/m2.day  Av solar radiation (MJ/m2.day)                             IB WA
SW10 SWC 180-210cm   Soil water 180-210cm(cm3/cm3)                              IB WA
SW1D SWC    0-5 cm   Soil water    0-5 cm(cm3/cm3)                              IB WA
SW2D SWC   5-15 cm   Soil water   5-15 cm(cm3/cm3)                              IB WA
SW3D SWC  15-30 cm   Soil water  15-30 cm(cm3/cm3)                              IB WA
SW4D SWC  30-45 cm   Soil water  30-45 cm(cm3/cm3)                              IB WA
SW5D SWC  45-60 cm   Soil water  45-60 cm(cm3/cm3)                              IB WA
SW6D SWC  60-90 cm   Soil water  60-90 cm(cm3/cm3)                              IB WA
SW7D SWC  90-120cm   Soil water  90-120cm(cm3/cm3)                              IB WA
SW8D SWC 120-150cm   Soil water 120-150cm(cm3/cm3)                              IB WA
SW9D SWC 150-180cm   Soil water 150-180cm(cm3/cm3)                              IB WA
SWXD EXTR WATER cm   Extractable water (cm)                                     IB WA
TMNA MINIMUM TEMP C  Av minimum temperature (C)                                 IB WA
TMXA MAXIMUM TEMP C  Av maximum temperature (C)                                 IB WA
TS10 S-TMP 80-210cm  Soil temperature 180-210cm (C)                             IB WA
TS1D S-TMP   0-5 cm  Soil temperature    0-5 cm (C)                             IB WA
TS2D S-TMP  5-15 cm  Soil temperature   5-15 cm (C)                             IB WA
TS3D S-TMP 15-30 cm  Soil temperature  15-30 cm (C)                             IB WA
TS4D S-TMP 30-45 cm  Soil temperature  30-45 cm (C)                             IB WA
TS5D S-TMP 45-60 cm  Soil temperature  45-60 cm (C)                             IB WA
TS6D S-TMP 60-90 cm  Soil temperature  60-90 cm (C)                             IB WA
TS7D S-TMP 90-120cm  Soil temperature  90-120cm (C)                             IB WA
TS8D S-TMP 20-150cm  Soil temperature 120-150cm (C)                             IB WA
TS9D S-TMP 50-180cm  Soil temperature 150-180cm (C)                             IB WA

*CARBON
@CDE LABEL           DESCRIPTION                           LOCAL CODE           SO SE
CGRD CGR g/m2.d      Crop growth rate (g top+store/m2.d)                        IB CA
CHAD CH2O g/m2.d     CH20 accumulation (g CH2O/m2.d)                            IB CA
CL%D LEAF C %        C in leaf (%)                                              IB CA
CMAD CH MOB g/m2.d   C mobilization (g CH2O/m2.d)                               IB CA
CS%D STEM C %        C in stem (%)                                              IB CA
GRAD GR RESP g/m2.d  Growth respiration (g CH2O/m2.d)                           IB CA
LI%D LIGHT INTER %   Light (PAR) interception (%)                               IB CA
LI%N NOON LIGHT IN % Noon light (PAR) interception (%)                          IB CA
LMHN NOON PMAX,SHADE Noon Pmax shaded leaves (mg/m2.s)                          IB CA
LMLN NOON PMAX,LIGHT Noon Pmax sunlit leaves (mg/m2.s)                          IB CA
MRAD M RESP g/m2.d   Maintenance resp (g CH2O/m2.d)                             IB CA
N%HN NOON N,SHADE %  Noon N shaded leaves (%)                                   IB CA
N%LN NOON N,LIGHT %  Noon N sunlit leaves (%)                                   IB CA
OMAC OM APPL kg/ha   Cumulative OM applied (kg dm/ha)                           IB CA
PHAD P GROSS g/m2.d  Gross photosynthesis (g CH2O/m2.d)                         IB CA
PHAN PG,NOON mg/m2.s Gross photosyn.,noon (mg CO2/m2.s)                         IB CA
SLHN NOON SLW,SHADE  SLW in shaded lves,noon (mg dm/cm2)                        IB CA
SLLN NOON SLW,Light  SLW in sunlit lves,noon (mg dm/cm2)                        IB CA
SOCD SOIL OC t/ha    Soil organic carbon (t/ha)                                 IB CA
TGAV AVG CAN TMP, C  Daily average canopy temp (C)                              IB CA
TGNN NOON CAN TMP, C Noon canopy temperature (C)                                IB CA
TWAD TOTAL WT kg/ha  Tops+roots+storage wt (kg dm/ha)                           IB CA

*PESTS
@CDE LABEL           DESCRIPTION                           LOCAL CODE           SO SE
CASM ASSIM g CH2O    Cumulative assimilate reduction                            IB PE
CEW  CEW #/row-m     Corn Earworm                                               IB PE
CLAI LAI m2/m2       Cumulative leaf area consumed                              IB PE
CLFM LEAF g/m2       Cumulative leaf mass consumed                              IB PE
CPO% PLTPOP %        Cumulative pl population reduction                         IB PE
CRLF ROOT cm/cm2     Cumulative root length consumed                            IB PE
CRLV ROOT cm/cm2     Cumulative root ln density consumed                        IB PE
CRTM ROOT g/m2       Cumulative root mass consumed                              IB PE
CSD# SEED #/m2       Cumulative seed number consumed                            IB PE
CSDM SEED g/m2       Cumulative seed mass consumed                              IB PE
CSH# SHELL #/m2      Cumulative shell number consumed                           IB PE
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CSHM SHELL g/m2      Cumulative shell mass consumed                                     IB PE
CSTM STEM g/m2       Cumulative stem mass consumed                                      IB PE
DASM ASSIM g CH2O/d  Daily carbohydrate pool reduction                                  IB PE
DLA  DIS. LAI cm2/m2 Daily diseased leaf area increase                                  IB PE
DLA% DIS. LAI %/d    Daily % diseased leaf area increase                                IB PE
DLAI LAI m2/m2.d     Daily leaf area consumed                                           IB PE
DLFM LEAF g/m2.d     Daily leaf mass consumed                                           IB PE
DPO% PLTPOP %/day    Daily plant population reduction                                   IB PE
DRLF ROOT cm/cm2.d   Daily total root length consumed                                   IB PE
DRLV ROOT cm/cm3.d   Daily root length density consumed                                 IB PE
DRTM ROOT g/m2.d     Daily root mass consumed                                           IB PE
DSD# SEED #/m2.d     Daily seed number consumed                                         IB PE
DSDM SEED g/m2.d     Daily seed mass consumed                                           IB PE
DSH# SHELL #/m2.d    Daily shell number consumed                                        IB PE
DSHM SHELL g/m2.d    Daily shell mass consumed                                          IB PE
DSTM STEM g/m2.d     Daily stem mass consumed                                           IB PE
FAW  FAW #/m         Fall armyworm                                                      IB PE
RTWM RTWM #/m        Root worm                                                          IB PE
SGSB SGSB #/m        Southern green stinkbug                                            IB PE
SL   SB LOOPER #/m   Soybean looper                                                     IB PE
VBC5 VBC5 #/m        5 instar velvetbean caterpillar                                    IB PE
VBC6 VBC6 #/m        6 instar velvetbean caterpillar                                    IB PE

*EXPERIMENTAL DATA
@CDE LABEL           DESCRIPTION                                  LOCAL CODE            SO SE
AP1D APEX 1cm day    Apex 1cm date (YrDoy)                                              IB EX
CHN% CHAFF N %       Chaff N (%)                                                        IB EX
CHWA CHAFF WT kg/ha  Chaff weight (kg dm/ha)                                            IB EX
DRID DOUBLE RIDGES d Double ridges date (YrDoy)                                         IB EX
DWAD DEAD WT kg/ha   Dead material weight (kg dm/ha)                                    IB EX
EDAT EMERGENCE day   Emergence date (YrDoy)                                             IB EX
EEMD EAR EMERGENCE d Ear emergence date (YrDoy)                                         IB EX
EGWA EAR+GRAIN kg/ha Ear plus grain weight (kg dm/ha)                                   IB EX
EGWS EAR+GRAIN g/s   Ear+grain weight (g dm/shoot)                                      IB EX
G#PD GRAIN NO #/pl   Grain number (no/plant)                                            IB EX
G#SD GRAIN NO #shoot Grain number (no/shoot)                                            IB EX
GW%M GRAIN H20 %     Grain moisture at maturity (%)                                     IB EX
GWAM GRAIN WT kg/ha  Grain wt at maturity (kg dm/ha)                                    IB EX
GWGM GRAIN WT mg     Unit wt at maturity (mg dm/grain)                                  IB EX
GWPM GRAIN WT g/pl   Grain wt at maturity (g dm/plant)                                  IB EX
GYAM GRAIN YLD kg/ha Grain yield at maturity (kg fm/ha)                                 IB EX
GYPM GRAIN YLD g/pl  Grain yld at maturity (g fm/plant)                                 IB EX
GYVM TEST WT kg/hl   Test weight at maturity (kg fm/hl)                                 IB EX
HWAC COR YIELD kg/ha Corrected yield (kg dm/ha)                                         IB EX
HYAM HARVEST kg/ha   Harvest yld at maturity (kg fm/ha)                                 IB EX
LAFD FLAG AREA cm2   Flag leaf area (cm2/leaf)                                          IB EX
LALD LEAF AREA cm2   Leaf area (cm2/leaf)                                               IB EX
LAPD LEAF AREA cm2/p Leaf area (cm2/plant)                                              IB EX
LARD LEAF APPEARANCE Leaf appearance rate (#/day)                                       IB EX
L#IR LEAF # INCREASE Leaf number increase rate (#/day)                                  IB EX
LDAD DEAD LEAF kg/ha Dead leaf weight (kg dm/ha)                                        IB EX
LF3D LEAF 3 FULL day Full expansion, leaf 3 (Yrdoy)                                     IB EX
LF5D LEAF 5 FULL day Full expansion, leaf 5 (Yrdoy)                                     IB EX
LLFD LAST LEAF day   Last leaf date (YrDoy)                                             IB EX
LWAM LEAF WT kg/ha   Leaf weight (kg/ha)                                                IB EX
LWPD LEAF WT g/plant Leaf weight (g/plant)                                              IB EX
PARI PAR INTERCEPT % PAR interception (%)                                               IB EX
RLAD ROOT LN cm/cm2  Root length (cm/cm2)                                               IB EX
RLWD ROOT L/W cm/g   Root length/weight (cm/g)                                          IB EX
RWLD ROOT W/L g/cm   Root weight/length (g/cm)                                          IB EX
S#PD SHOOT NO #/pl   Shoot (apex) number (no/plant)                                     IB EX
S#AD SHOOT NO #/m2   Shoot (apex) number (no/m2)                                        IB EX
SCWA STM+CHAFF kg/ha Stem plus chaff (kg/ha)                                            IB EX
SP#P SPIKELETS #/pl  Spikelet number (no/plant)                                         IB EX
SWPD STEM WT g/plant Stem weight (g dm/plant)                                           IB EX
T#PD TILLER NO.#/pl  Tiller number (no/plant)                                           IB EX
T#AD TILLER NO.#/m2  Tiller number (no/m2)                                              IB EX
TNAM TOTAL N kg/ha   Total N at maturity (kg N/ha)                                      IB EX
TSPD TERMINAL SPKL d Terminal spikelet date (YrDoy)                                     IB EX
TWAM TOTAL WT kg/ha  Total wt, maturity (kg dm/ha)                                      IB EX
VWAM VEG WT kg/ha    Veg (lf+st) wt,maturity (kg dm/ha)                                 IB EX
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Z21D ZADOKS 21 day   Zadoks 21 date (YrDoy)                                     IB EX
Z30D ZADOKS 30 day   Zadoks 30 date (YrDoy)                                     IB EX
Z31D ZADOKS 31 day   Zadoks 31 date (YrDoy)                                     IB EX
Z37D ZADOKS 37 day   Zadoks 37 date (YrDoy)                                     IB EX
Z39D ZADOKS 39 day   Zadoks 39 date (YrDoy)                                     IB EX
TDWA TOTAL+D  kg/ha  Tops+roots+storage+dead (kg dm/ha)                         IB EX
CDWA CANOPY+D kg/ha  Tops+dead wt (kg dm/ha)                                    IB EX
LALN LEAF AREA,NEW   Leaf area,new leaves (cm2 lf-1)                            IB EX
BR1D BRANCH 1 YrDoy  Branch 1 date (YrDoy)                                      IB EX
BR2D BRANCH 2 YrDoy  Branch 1 date (YrDoy)                                      IB EX
BR3D BRANCH 3 YrDoy  Branch 1 date (YrDoy)                                      IB EX
BR4D BRANCH 4 YrDoy  Branch 1 date (YrDoy)                                      IB EX
SDWT SEED WT g/pl    Seed weight (g pl-1)                                       IB EX
HWAD YIELD  kg/ha    Yield on specified day (kg dm/ha)                          IB EX
```

APPENDIX D.

WEATHER DATA CODES

Headers used in the @ line to identify variables are listed first; codes ('flags') used to designate data types are listed next.

The fields in the file are as follows:
CDE The 'universal' code used to facilitate data interchange.
DESCRIPTION A description of the code, with units.
SO The source of the codes (IB=IBSNAT). Codes added by a user should be referenced in this field and the name and address of the person adding the code should be entered as a comment (ie.with a '!' in column 1) below this note. This is important to ensure that information from different workers can be easily integrated.

*Headers

@CDE	DESCRIPTION	SO
ALPHA	WGEN parameter	IB
ANGA	Angstrom 'a' coefficient	IB
ANGB	Angstrom 'b' coefficient	IB
DATE	Date, year + days from Jan. 1	IB
DEWP	Dewpoint temperature, ~C	IB
DURN	Duration of summarization period for climate files, Yr	IB
ELEV	Elevation, m	IB
GSDU	Growing season duration, Day	IB
GSST	Growing season start day, Doy	IB
IN	Institute code	IB
LAT	Latitude, degrees (decimals)	IB
LONG	Longitude, degrees (decimals)	IB
MONTH	Month, #	IB
NAMN	Temperature minimum,monthly average, C	IB
NASD	WGEN parameter	IB
PAR	Photosynthetic radiation, moles m-2 day-1	IB
PDW	WGEN parameter	IB
RAIN	Rainfall (incl.snow), mm day-1	IB
RAIY	Rainfall,yearly total, mm	IB
REFHT	Reference height for weather measurements, m	IB
RHUMM	Relative humidity average over whole day for month, %	IB
RNUM	Rainy days, # month-1	IB
RTOT	Rainfall total, mm month-1	IB
SAMN	Solar radiation,monthly average, MJ m-2 d-1	IB
SDMN	WGEN parameter	IB
SDSD	WGEN parameter	IB
SI	Site code	IB
SRAD	Solar radiation, MJ m-2 day-1	IB
SRAY	Solar radiation,yearly average, MJ m-2 day-1	IB
START	Start of summary period for climate (CLI) files, Year	IB
SWMN	WGEN parameter	IB
SWSD	WGEN parameter	IB
TAMP	Temperature amplitude, monthly averages, ~C	IB
TAV	Temperature average for whole year, ~C	IB
TMAX	Temperature maximum, ~C	IB
TMIN	Temperature minimum, ~C	IB
WIND	Wind speed average, m sec-1	IB
WINDM	Windspeed average over whole day for month, m s-1	IB
WNDHT	Reference height for windspeed measurements, m	IB
WRUN	Wind run, km day-1	IB
XAMN	Temperature maximum,monthly average, C	IB
XDMN	WGEN parameter	IB
XDSD	WGEN parameter	IB
XWMN	WGEN parameter	IB
XWSD	WGEN parameter	IB

*Flags
Flags attached to data to indicate the nature of the original data. Upper case flags = original data replaced; lower-case flags = original data.

@CDE	DESCRIPTION	SO
A	Above maximum - data replaced	IB
a	Above maximum - but original data left	IB
B	Below minimum - data replaced	IB
b	Below minimum - - but original data left	IB
D	Decadal averages only in original file - data replaced	IB
d	Decadal averages only in original file - but original data left	IB
E	Format error in original file - data replaced	IB
e	Format error in original file - but original data left	IB
H	Solar radiation as sunshine hours - data replaced	IB
h	Solar radiation as sunshine hours - but original data left	IB
M	Monthly averages only in original file - data replaced	IB
m	Monthly averages only in original file - but original data left	IB
N	No data in original file - data replaced	IB
n	No data in original file - but original data left	IB
R	Rate of change exceeded - data replaced	IB
r	Rate of change exceeded - but original data left	IB

VOLUME 2-2

CROP MODELS

G. HOOGENBOOM,
J.W. JONES, P.W. WILKENS,
W.D. BATCHELOR,
W.T. BOWEN, L.A. HUNT,
N.B. PICKERING, U. SINGH,
D.C. GODWIN, B. BAER,
K.J. BOOTE, J.T. RITCHIE,
J.W. WHITE

UNIVERSITY OF GEORGIA, UNIVERSITY OF FLORIDA
INTERNATIONAL FERTILIZER DEVELOPMENT CENTER
UNIVERSITY OF GUELPH, MICHIGAN STATE UNIVERSITY
CENTRO INTERNACIONAL de AGRICULTURA TROPICAL, UNIVERSITY OF HAWAI
INTERNATIONAL BENCHMARK SITES NETWORK FOR AGROTECHNOLOGY TRANSFER

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The generic models, CERES, CROPGRO and CROPSIM, used in DSSAT v3, were developed by groups of modelers working on a specific model within the generic ones. In order to give due credit to these scientists and their contributions to a model or models, the following listing of authors by model name is provided.

CERES–Barley

S. Otter-Nacke, J.T. Ritchie, D.C. Godwin and U. Singh
Michigan State University and International Fertilizer Development Center

CERES–Maize

J.T. Ritchie, U. Singh, D.C. Godwin, W.T. Bowen
Michigan State University and International Fertilizer Development Center

CERES–Millet

U. Singh, J.T. Ritchie and W.T. Bowen
International Fertilizer Development Center and Michigan State University

CERES–Sorghum

J.T. Ritchie, D.C. Godwin and U. Singh
Michigan State University and International Fertilizer Development Center

CERES–Wheat

D.C. Godwin, J.T. Ritchie and U. Singh
International Fertilizer Development Center and Michigan State University

CERES–Rice

U. Singh, D.C. Godwin and J.T. Ritchie
International Fertilizer Development Center and Michigan State University

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N.B. *The following individuals contributed to the development of one or more of the CERES models: L.A. Hunt, P.W. Wilkens, G. Smallwood, B. Baer and G. Alargarswamy.*

CROPGRO–Dry Bean

G.Hoogenboom, J.W. White, J.W. Jones, K.J. Boote, W.T. Bowen, N.B. Pickering and W.D. Batchelor
University of Georgia, Centro International de Agricultura Tropical, University of Florida and International Fertilizer Development Center

CROPGRO–Peanut

K.J. Boote, J.W. Jones, G. Hoogenboom, N.B. Pickering, W.D. Batchelor and W.T. Bowen
University of Florida, University of Georgia and International Fertilizer Development Center

CROPGRO–Soybean

J.W. Jones, K.J. Boote, G. Hoogenboom, W.T. Bowen, N.B. Pickering and W.D. Batchelor
University of Florida, University of Georgia and International Fertilizer Development Center

CROPSIM–Cassava

R.B. Matthews, L. A. Hunt, P. W. Wilkens, G. Hoogenboom and W.T. Bowen
University of Guelph, International Fertilizer Development Center and University of Georgia

PREFACE

The information presented in the example and output sections of this Part is representative of the results you can produce from your copy of the DSSAT v3 crop models. These are examples only, however, and your results may vary slightly from the results you receive, due to the evolutionary nature of the crop models. Incremental improvements, many suggested by users as they calibrate and validate the models with their own data sets, are constantly being evaluated and implemented. Therefore, post-press changes to the models may reflect improvements implemented after printing of this Volume.

CHAPTER ONE.
INTRODUCTION

The crop models developed under the auspices of the International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT) Project are process oriented computer models which simulate growth, development, and yield as a function of plant genetics, weather and soil conditions, and crop management selections. These include models for the following crops: aroids (*Colocasia esculenta L.* [taro] & *Xanthosoma sagittifolium L.*[tannier]), barley (*Hordeum vulgare L.*), cassava (*Manihot esculenta L.*), corn (*Zea mays L.*), dry bean (*Phaseolus vulgaris L.*), millet (*Pennisetum americanum L.*), peanut (*Arachis hypogea L.*), potato (*Solanum tuberosum L.*), rice (*Oryza sativa L.*), sorghum (*Sorghum bicolor L.*), soybean (*Glycine max [L.] Merr*.) and wheat (*Triticum eastivum L.*). In the Decision Support System for Agrotechnology Transfer (DSSAT) v2.1 (IBSNAT 1989; Jones et al. 1990) individual models existed for each crop (Table 1). As part of the move to DSSAT v3, crop models were combined to avoid coding duplication and other problems associated with model improvement. For the family of grain legume crops a generic model was developed called CROPGRO, which is being extended to include other crops, such as tomato. The grain cereals, except for CERES-Rice, were combined into a generic grain cereal model called CERES. Development of the root crop models will continue as separate models.

Previously, individual user's guides were developed for the crop models SOYGRO (Jones et al., 1989), PNUTGRO (Boote et al., 1989), BEANGRO (Hoogenboom et al., 1991), CERES-Wheat (Godwin et al., 1989), CERES-Maize (Ritchie et al., 1989), CERES-Barley (Otter-Nacke et al., 1991), and CERES-Rice (Singh et al., 1993). In DSSAT v3, one model user-interface was developed for use by all crop models, and thus, one user's guide.

Since, however, these crop models can also be run as stand-alone models, there is some flexibility as to how the executables, input and output files are organized on a computer disk. The organization of these files for running under both the DSSAT v3 Shell (Volume 1-3, Hunt et al. 1994) and as stand alones is described in Appendix C of this Part.

The operation of the crop models in DSSAT v3 using the DSSAT v3 Shell (Volume 1-3, Hunt et al. 1994) interface is described herein.

TABLE 1. OLD AND NEW GENERATION CROP SIMULATION MODELS.

Crop	DSSAT v2.1 Model	DSSAT v3 Model	Reference
Cereals			
Barley	CERES-Barley	Generic CERES	Otter-Nacke et al. (1991)
Corn (Maize)	CERES-Maize	Generic CERES	Ritchie et al.(1989)
Millet	CERES-Millet	Generic CERES	Singh et al. (1991)
Rice	CERES-Rice	CERES-Rice	Singh et al. (1993)
Sorghum	CERES-Sorghum	Generic CERES	Alargarswamy and Ritchie (1991)
Wheat	CERES-Wheat	Generic CERES	Godwin et al. (1989)
Grain Legumes			
Dry bean	BEANGRO	CROPGRO	Hoogenboom et al (1994)
Peanut	PNUTGRO	CROPGRO	Boote et al. (1989)
Soybean	SOYGRO	CROPGRO	Jones et al. (1989)
Roots and Tubers			
Aroids	SUBSTOR-Aroids	N/A	Prasad et al. (1991)
Cassava	N/A	CROPSIM-Cassava	Matthews and Hunt (1994)
Potato	SUBSTOR-Potato	N/A	Griffin et al. (1993)

CHAPTER TWO.
INPUTS AND OUTPUTS

The DSSAT v3 crop models incorporate the input and output ASCII file structures fully described in Volume 2-1 (Jones et al. 1994) of this book. This I/O system is considerably different than the crop model inputs and outputs structures found in DSSAT v2.1 (IBSNAT 1989, 1990).

WEATHER

Though daily weather formats are similar to those in DSSAT v2.1, additional features have been added to accommodate improved quality control of weather data. A space has been designated next to each data field for characters to document when data were filled from other sources and the reason for filling. The quality control options for weather data in DSSAT v3 are handled by WeatherMan, described in Volume 3-3 (Hansen et al. 1994) of this book. In the DSSAT v3 crop models, including CROPGRO and CERES, the name of the weather file is constructed internally from the weather file information contained in the experiment input file. The code for the weather file includes eight characters, such as UFGA8101, and the file UFGA8101.WTH would be constructed in the model code if observed weather data would be used as input, or the file UFGA8101.WTG would be constructed in the model code if externally generated weather data would be used as input. The model will look first in the current directory for this file. If the model is unable to locate the weather file in the current crop model data directory, the model will check the path specified by the DSSAT v3 path-declaration file (DSSATPRO.FLE). For a complete description of the weather file (FILEW) formats and structures, see Volume 2-1 (Jones et al. 1994) of this book.

SOIL

The soil file has also been changed in DSSAT v3. First, more information was added in an attempt to make the soil inputs more generally applicable by other crop models. For example, clay and silt percentages are now included, and new inputs were defined to allow for simulation of soil phosphorus dynamics. The first release of the DSSAT v3 models will not include the phosphorus module in any of the crop models. Secondly, all new models use the same soil file, whereas models in DSSAT V2.1 required a separate soil file for each crop. The new soil file is usually named SOIL.SOL, but the models will accept soil profile data in input files specific for each institute, e.g. UF.SOL would contain soil profile information defined by the University of Florida. The models will first look for the SOIL.SOL file in the "current" path, and if the model is unable to locate the SOIL.SOL file, the model will try to locate the UF.SOL file. The file name UF.SOL is constructed by the models based on the institute code of the institute at which the experiment was performed. For a complete description of the soil file (FILES) formats and structures, see Volume 2-1 (Jones et al. 1994) of this book.

Crop Management

In DSSAT v3, details of a crop experiment, such as field information, treatments, planting information, initial conditions, irrigation, residue and fertilizer management, and harvest information are contained in one single file. This single file is referred to as experiment details file or FILEX. A user can name FILEX based on institute id, site id, year, experiment number, and crop code; the naming convention is similar to the one of DSSAT V2.1 (IBSNAT, 1989; 1990). For example, the file UFGA8101.SBX is the file name for a soybean experiment conducted in 1981 at the University of Florida in Gainesville (UFGA). The experiment details file FILEX is divided into sections; a "*" designates each section, and the file uses the symbol "@ "in column 1 of lines that contain codes or headers for variables defined in the section following this header line. The file uses "!" to define comment lines; blank lines can also be used in the file to delineate data input blocks and these lines are ignored by the model when reading the experiment details file. For a complete description of the experiment details file (FILEX) formats and structures, see Volume 2-1 (Jones et al. 1994) of this book.

Simulation Control

Each DSSAT v3 experiment details file FILEX contains a *SIMULATION CONTROL section that fully specifies all options for a simulation run. This section also defines automatic management characteristics for planting, irrigation, fertilizer, residue, and harvest. These automatic management options allow the user to define management conditions for hypothetical "experiments." For a complete description of the Simulation Controls section of FILEX, see Volume 2-1(Jones et al. 1994) of this book.

Average Final Field Data

The DSSAT v3 models use two files for field observed data and other related information. The first file contains averages of field observations, and this information is used for comparison between model simulated data and field observed

TABLE 2. AVERAGE FINAL FIELD DATA FILE. (FILEA = "UFGA7801.SBA")

*EXP.DATA (A): UFGA7801SB BRAGG, IRRIGATED & NON-IRRIGATED

@TRNO	HWAM	HWUM	H#AM	H#UM	LAIX	CWAM	BWAH	ADAT	MDAT	PD1T	PDFT	PWAM	HIAM	THAM
1	3041.	.1440	2223.	1.96	4.67	6068.	1958.	211	282	233	233	4009.	.501	75.85
2	1178.	.1230	969.	1.85	4.50	3491.	1756.	211	282	233	233	1602.	.337	73.53

data to calibrate, validate and test the models. The field average observational data file is called FILEA. For the example used in the Crop Management section above, this file would be called UFGA8101.SBA. The format for FILEA in DSSAT v3 is different from the format of FILEA in DSSAT v2.1. Generally, the data in FILEA are in stored in columns, which are each 6 characters in width, with a header above each column indicating the type of data in that column. The crop model uses the same header information for its outputs, so that corresponding simulated and observed data can be matched regardless of the location of these columns in the input files. An abbreviation file (DATA.CDE) defines these headers, including appropriate units of the variables and values associated with those headers. These abbreviations are also used by the data handling components of DSSAT v3, graphics, and seasonal and sequence analysis programs. An example of a FILEA is shown in Table 2. For a description of FILEA formats and structures, see Volume 2-1 (Jones et al. 1994) of this book.

TIME-COURSE FIELD DATA

In addition to FILEA, a second file is used to store field data for within-season measurements. This time-course data file, FILET, can contain an unlimited number of 6-character columns. Data that were measured in the field can be stored in this file, and these can include both measured soil, plant, and pest information as a function of day of year. For example FILET, e.g. UFGA8101.SBT, is the time course file for an experiment conducted the University of Florida in Gainesville in 1981. An example of a FILET is shown in Table 3. For a description of FILET formats and structures, see Volume 2-1 (Jones et al. 1994) of this book.

OUTPUT FILES

Outputs from the models are written to the following files:

OVERVIEW.OUT which contains a copy of the output as shown on the computer screen during the simulation;

SUMMARY.OUT which contains a one line summary of the main developmental events, water and nitrogen variables, and yield and yield components;

GROWTH.OUT, which contains a summary of the growth balance variables over time;

WATER.OUT, which contains a summary of the soil and plant water variables over time;

NITROGEN.OUT, which contains a summary of the soil and plant nitrogen variables over time;

CARBON.OUT, which contains a summary of some of the main soil and plant carbon variables; and

PEST.OUT, which contains a summary of the pest variables as a function of time.

FILES GROWTH.OUT, WATER.OUT, NITROGEN.OUT, CARBON.OUT, and PEST.OUT contain time-series outputs at steps as small as one day or as large as specified by the user. Each file can be switched on or off, and the frequency of daily outputs can be specified in the Simulation Control section of FILEX. These output files are temporary and are erased and overwritten at the start of each new simulation run. Users, however, can select an option to save these files with experiment specific file names. This option can be fixed permanently through one variable in FILEX or interactively through the Sensitivity Analysis option. For example, the above described 1981 University of Florida experiment output files could be saved as UFGA8101.SBO, UFGA8191.SBS, UFGA8191.SBG, UFGA8101.SBW, UFGA8101.SBN, UFGA8101.SBC, and UFGA8101.SBD, respectively. For a description of these file formats and structures, see Volume 2-1 (Jones et al. 1994) of this book

TABLE 3. TIME-COURSE FIELD DATA FILE. (FILET = "UFGA7801.SBT")

*EXP.DATA (T): UFGA7801SB BRAGG, IRRIGATED & NON-IRRIGATED

@TRNO	DATE	LAID	SWAD	GWAD	LWAD	CWAD	PWAD	SHAD	SH%D	SLAD	HIAD
1	78194	.89	178	0.	266	444	0.	0.	0.00	334.6	0.000
1	78201	1.28	300	0.	366	667	0.	0.	0.00	349.7	0.000
1	78208	1.91	551	0.	656	1207	0.	0.	0.00	291.2	0.000
1	78215	2.86	943	0.	843	1786	0.	0.	0.00	339.3	0.000
1	78222	4.17	1561	0.	1187	2748	0.	0.	0.00	351.3	0.000
1	78229	3.90	1956	0.	1204	3160	0.	0.	0.00	323.9	0.000
1	78236	4.66	2947	0.	1723	4792	123	123	0.00	270.5	0.000
1	78243	4.47	3144	0.	1772	5224	308	308	0.00	252.3	0.000
1	78250	4.44	3303	182	1631	5740	805	623	22.60	272.2	0.030
1	78257	3.99	3326	754	1568	6507	1613	859	46.75	254.5	0.116
1	78264	4.67	3657	1912	1769	8586	3161	1249	60.49	264.0	0.222
1	78271	2.83	2732	2223	1180	7144	3232	1009	68.78	239.8	0.311
1	78278	2.09	2515	2730	858	7136	3763	1033	72.55	243.6	0.383
1	78285	.47	1851	2913	170	5866	3845	932	75.76	276.5	0.497
1	78292	.09	2064	3169	34	6270	4172	1003	75.96	264.7	0.505
2	78194	.75	160	0.	244	405	0.	0.	0.00	307.4	0.000
2	78201	1.08	251	0.	311	563	0.	0.	0.00	347.3	0.000
2	78208	1.81	535	0.	626	1161	0.	0.	0.00	289.1	0.000
2	78215	3.29	1080	0.	974	2054	0.	0.	0.00	337.8	0.000
2	78222	4.38	1663	0.	1261	2923	0.	0.	0.00	347.3	0.000
2	78229	4.30	2083	0.	1392	3475	0.	0.	0.00	308.9	0.000
2	78236	4.21	2556	0.	1517	4184	112	112	0.00	277.5	0.000
2	78243	4.50	2673	0.	1439	4431	319	319	0.00	312.7	0.000
2	78250	2.09	1998	42	838	3104	268	226	15.67	249.4	0.014
2	78257	3.24	2650	253	1220	4530	661	408	38.28	265.6	0.056
2	78264	2.30	2609	471	931	4440	901	430	52.28	247.0	0.106
2	78271	1.14	2113	775	498	3812	1200	425	64.58	228.9	0.203
2	78278	.85	1905	782	371	3398	1122	340	69.70	229.1	0.230
2	78285	.53	1922	1149	236	3732	1574	425	73.00	224.5	0.308
2	78292	.07	1590	1206	30	3250	1630	424	73.99	233.3	0.371

CHAPTER THREE. SYSTEM OVERVIEW

FLOW OF INFORMATION

The DSSAT v3 crop simulation models consist of three modules: model driver, input module and crop simulation module. Figure 1 presents a schematic overview of these modules. The main difference with the DSSAT v2.1 models is that the input and sensitivity analysis section of each model is now separated from its model simulation section. In DSSAT v3, one input and sensitivity module is used by all crop simulation models. When a user starts a DSSAT v3 model,

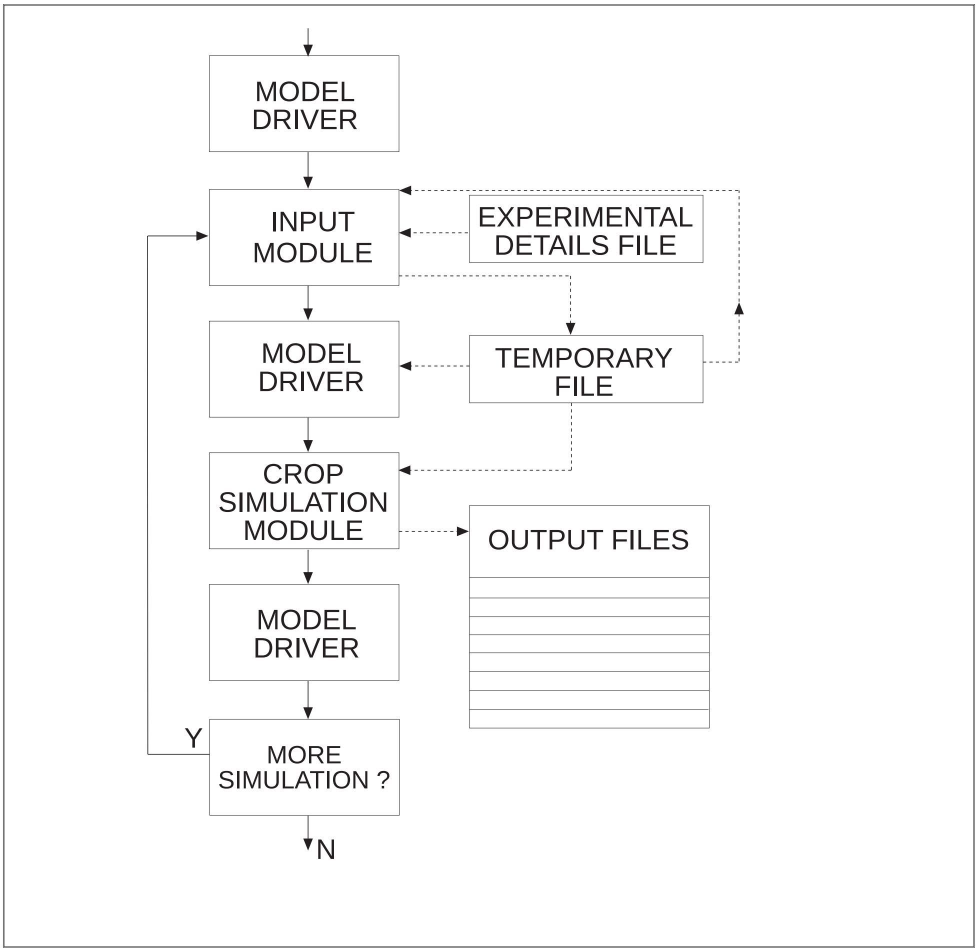


FIGURE 1. FLOW OF INFORMATION FOR THE CURRENT DSSAT V3 CROP SIMULATION MODELS.

the model driver program, MDRIV940.EXE, is executed. The driver program calls the model input module, MINPT940.EXE, which reads the experiment list file (EXP.LST) and experiment data file (FILEX). While reading these files, the input module displays various screens, including those for experiment and treatment selection options. When a user has selected and/or modified the options available in the sensitivity analysis section, a temporary file is written. Control is given back to the model driver and the simulation module is called (IBSNAT30.INP). The simulation module does not provide any interaction with the user; instead it reads the temporary input file, simulates growth over a season and outputs simulation results on the screen. Upon completion of a simulation, control is returned to the model driver, and a user can then choose to run another simulation run or terminate the simulation. The format of the temporary file (IBSNAT30.INP) is discussed later in this chapter.

Component Structure

Crop Model Driver

Because the crop model driver was developed to control the calling of the input and the crop simulation modules, all EXE files need to be located in the same directory for the system to work properly (Figure 2). Typically, this would be the C:\DSSAT3 directory. The models, however, can be run from any data directory, as long as the path where the EXE files are located is specified. To run a model, the driver is executed from the directory containing input data, and the names of the input module and the crop module are specified as command-line arguments. The default syntax is the following (see next page):

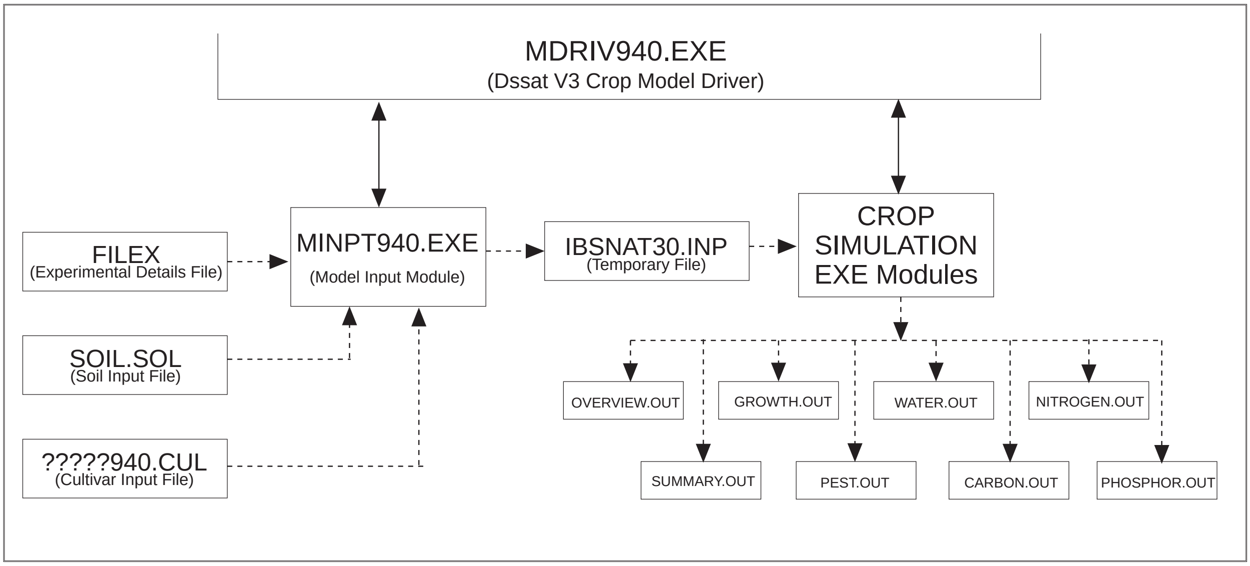


Figure 2. DSSAT v3 Crop Simulation Modules and Input/Output File Handling.

\PATH\MDRIV940.EXE MINPT940.EXE CRGRO940.EXE

where PATH is the path for all EXE files (e.g. C:\DSSAT3);
MDRIV940.EXE is the name of the model driver;
MINPT940.EXE is the name of the input module; and
CRGRO940.EXE is the name of the crop simulation module.
Current crop simulation modules available include :

GECER940.EXE	-	Generic CERES module for barley, maize, millet, sorghum, and wheat
RICER940.EXE	-	CERES -Rice module for rice
CRGRO940.EXE	-	Generic CROPGRO module for dry bean, peanut and soybean,
CSSIM940.EXE	-	CROPSIM-Cassava module for cassava.

Additional options can be included on the command line:

\PATH\MDRIV940.EXE MINPT940.EXE CRGRO940.EXE TYPEIO RNMODE

where TYPEIO is a one-character variable, used as a file type for transfer of information between the input module and crop simulation module. Options include :

I - A single treatment input file using FILEX format with no headers, blank lines or comment lines. TYPEIO = "I" is used by the GECER940.EXE, RICER940.EXE, and CRGRO940.EXE crop simulation modules.
X - FILEX single treatment format with headers and blank lines. TYPEIO = "X" is used by the CSSIM940.EXE crop simulation module.

RNMODE is a one-character variable, used to define the execution or operational mode of the model. Options include :

I - Interactive simulation, allowing for sensitivity analysis screen selections;
A - Run all treatments defined for one particular experiment;
G - Run in the genetic coefficient estimator mode, used with GenCalc only (see Volume 3-4, Hunt et al. 1994, of this book);
N - Run in the seasonal analysis mode, used with the seasonal analysis program only (see Volume 3-1, Thornton et al. 1994a, of this book);
Q - Run in the sequence analysis mode, used with the sequence analysis program only (see Volume 3-2, Thornton et al. 1994b, of this book);
S - Run in the spatial analysis mode with Geographic Information Systems (GIS) only;
F - Run in the farming systems analysis mode.

General users should not be concerned about these options, as they are controlled by individual driver programs.

For all RNMODE options, except "I," the experiment and treatment number can also be specified :

\PATH\MDRIV940.EXE MINPT940.EXE CRGRO940.EXE TYPEIO RNMODE EXPARG TRNARG

where EXPARG is the experiment number and TRNARG is the treatment number. Both EXPARG and TRNARG are integers.

The model driver program described here is normally used only for interactive simulations. Other components within DSSAT v3, such as the genetic coefficient calculator and seasonal analysis, sequence analysis and GIS programs, use their own driver programs to interface both with the model input module and crop simulation modules.

Model Input Module

The current DSSAT v3 input module was designed to handle both the reading of FILEX and error checking, as well as to make available options by which the user can modify specific inputs in the Sensitivity Analysis section. An example of this option will be presented later in this chapter. The function of the model input module is to read the experiment details file (FILEX), extract the required information to run one treatment, and to create a temporary input file to be read by the crop simulation module. This allows for the addition of other crop simulation models to the system, since only a temporary output file needs to be created in the prescribed format for use by the DSSAT v3 crop simulation models.

Without the model driver program, the following syntax is required to run the input module :

\PATH\MINPT940.EXE CRGRO940.EXE FILEIO TYPEIO RNMODE EXPARG TRNARG

where CRGRO940.EXE is the crop simulation module, with options as specified earlier; FILEIO is the name of the temporary input file used to transfer information between the input module and the crop simulation module – this name is usually controlled by the driver program which runs the entire system.

Crop Simulation Module

When the crop simulation module is executed, it reads the temporary input file, IBSNAT30.INP. This single treatment input file was created by the input module and runs a single season simulation. The syntax to run a crop simulation module, without the model driver program, is the following :

\PATH\CRGRO940.EXE FILEIO TYPEIO RNMODE REPARG

The options specified on the command line are the same as those discussed for the input module, except for REPARG, which is the run number of the current simulation. It is critical that the correct file type be specified for the temporary file, since it contains the reduced input information for the crop model. Normally, FILEIO will be "IBSNAT30.INP" and TYPEIO will be "I." TYPEIO can be set to "X" to create a single treatment version of FILEX, but only the CSSIM940.EXE crop simulation module will work with this option. The system's flexibility is such that when a new crop simulation module is added, only the input module needs to be modified to specify the input file type of the new crop simulation module and a subroutine added to write the new format.

Crop Model Execution

In the above section, "Component Structure," of this Chapter, detailed information for the various command line arguments is included. In general, however, model users can ignore these individual options, since they are handled internally by the DSSAT v3 Shell, batch programs, or driver programs. Under the SETUP menu in the DSSAT v3 Shell (see Volume 1-3, Hunt et al. 1994, of this book), the user defines each individual module; that is, the crop model driver program (MDDRIV940.EXE), the crop model inputs module (MINPT940.EXE) and one of the crop simulation modules (e.g., GECER940.EXE, RICER940.EXE, CRGRO940.EXE or CSSIM940.EXE). In addition the user defines the file type of the intermediate file, which is set to "I" by default. The remainder of the controls are then handled by the DSSAT v3 Shell.

If a user wants to run each module individually, all command line arguments need to be used correctly and input files need to be available, as some of the individual modules do not handle error checking.

Hardware And Software

The DSSAT v3 crop simulation models were developed on personal computers, using Microsoft DOS™ Versions 5 and 6, and the Microsoft Fortran Compiler™ Version 5.1. The modules are coded in Fortran 77 to remain compatible with other platforms. The crop models have also been successfully implemented on VAX and SUN computers.

The crop models perform best on computers with 80386 or 80486 processor and math-coprocessors. Minimum memory requirements are 512 KByte of Random Access Memory. Harddisk requirements are at least 1 MByte for all executable and data files.

CHAPTER FOUR.
CREATING INPUT FILES

Under the DSSAT v3 Shell main menu item, MODELS (see Volume 1-3, Hunt et al. 1994, of this book), there is a menu of crop models available, separated into grain cereals, grain legumes, root crops, and other crops (see Screen 1). A menu belonging to each group contains a listing of various crops or species for the group selected (see Screen 1 for those crops found under "Legumes"). Although in the DSSAT v3 system all three grain legume crops (dry bean, peanut, and soybean) are simulated with the same model (CROPGRO), users have the option to change the selected crop model through the SETUP menu in the DSSAT v3 Shell and replace it with their own model. Instructions for modifying the SETUP options are presented in Volume 1-3 (Hunt et al. 1994) of this book. If the soybean model is selected, for example, a menu appears (Screen 1), showing a list of available options in the logical sequence a user needs to follow in order to simulate a particular experiment.

Five options are available under each crop model selection :

1. Creating a model input file.
2. Listing and managing crop model input files.
3. Running the crop model.
4. Listing and managing crop model output files.
5. Graphing simulated results and experimental data.

```
            DECISION SUPPORT SYSTEM FOR AGROTECHNOLOGY TRANSFER

   DATA        MODELS        ANALYSES        TOOLS        SETUP/QUIT

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

 Choose experiments, change inputs if required, and then simulate.

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

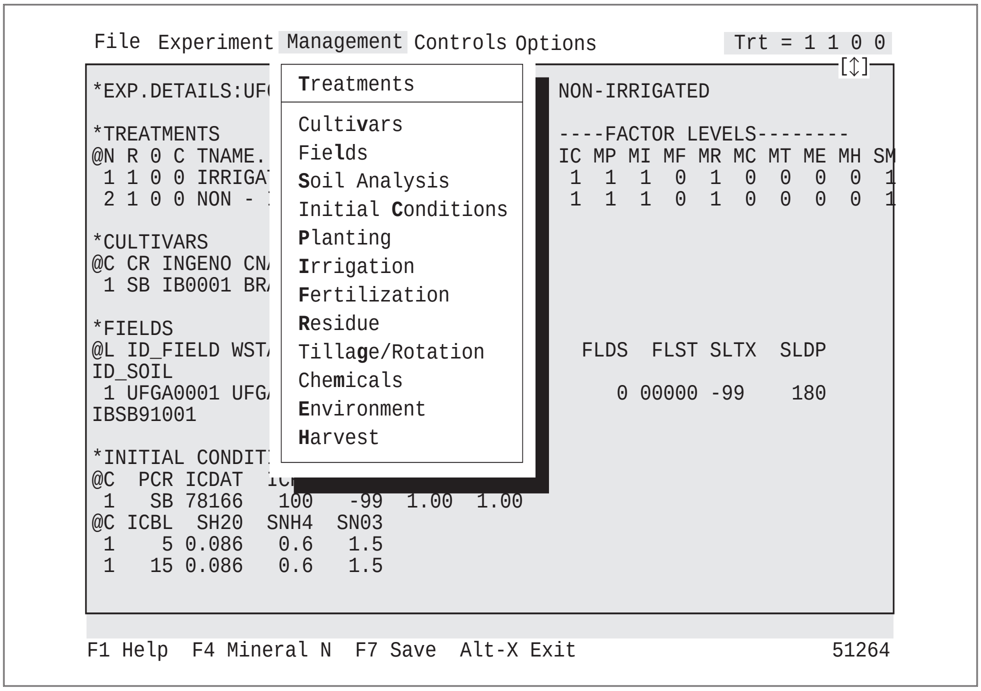
SCREEN 1.

Model Input File For Crop Management

The DSSAT v3 crop model input file (or the experiment details input file, FILEX) can be created through an interactive menu-driven program, XCreate, or through an ASCII text editor. It is important that the input file format be identical to that described in Volume 2-1 (Jones et al. 1994) of this book, including the use of "*" for header sections, "@" for header lines and "!" for comments. The input module uses these characters while reading FILEX for particular sections. It is strongly advised that the XCreate program be used to create FILEX (Screen 2) if a user is unfamiliar or uncomfortable with the strict formats of the input/output documentation (see Volume 2-1, Jones et al. 1994, of this book). Information on the XCreate program can be found in Volume 1-4 (Imamura 1994) of this book. An example of a model input file is found in Table 4.

Critical sections of FILEX include the following :

*TREATMENTS
This defines the treatments of an experiment and the associated treatment factor levels.



Screen 2.

TABLE 4. CROP MODEL INPUT FILE. (FILEX = "UFGA7801.SBX")

```
*EXP.DETAILS: UFGA7801SB BRAGG, IRRIGATED & NON-IRRIGATED

*TREATMENTS                        -------------FACTOR LEVELS------------
@N R O C TNAME.................... CU FL SA IC MP MI MF MR MC MT ME MH SM
01 1 1 0 IRRIGATED                  1  1  0  1  1  1  0  1  0  0  0  0  1
02 1 1 0 NON - IRRIGATED            1  1  0  1  1  0  0  1  0  0  0  0  1

*CULTIVARS
@C CR INGENO CNAME
 1 SB IB0001 BRAGG

*FIELDS
@L ID_FIELD WSTA....  FLSA  FLOB  FLDT  FLDD  FLDS  FLST SLTX   SLDP ID_SOIL
 1 UFGA0001 UFGA7801 -99       0 DR000     0     0 00000 -99     180 IBSB910015

*INITIAL CONDITIONS
@C   PCR ICDAT  ICRT  ICND  ICRN  ICRE
 1    SB 78166   100   -99  1.00  1.00
@C  ICBL  SH2O  SNH4  SNO3
 1     5 0.086   0.6   1.5
 1    15 0.086   0.6   1.5
 1    30 0.086   0.6   1.5
 1    45 0.086   0.6   1.5
 1    60 0.086   0.6   1.5
 1    90 0.076   0.6   0.6
 1   120 0.076   0.6   0.5
 1   150 0.130   0.6   0.5
 1   180 0.258   0.6   0.5

*PLANTING DETAILS
@P PDATE EDATE  PPOP  PPOE  PLME  PLDS  PLRS  PLRD  PLDP  PLWT  PAGE  PENV  PLPH
 1 78166   -99  29.9  29.9     S     R    91     0   4.0   -99   -99 -99.0 -99.0

*IRRIGATION AND WATER MANAGEMENT
@I  EFIR  IDEP  ITHR  IEPT  IOFF  IAME  IAMT
 1  0.75   -99   -99   -99   -99   -99   -99
@I IDATE  IROP  IRVAL
 1 78181 IR001    13
 1 78230 IR001    13
 1 78235 IR001    13
 1 78237 IR001    13
 1 78240 IR001    11
 1 78242 IR001    11
 1 78244 IR001    11
 1 78246 IR001    11
 1 78250 IR001    11
 1 78253 IR001    11
 1 78256 IR001     8
 1 78259 IR001     8
```

```
 1 78262 IR001     8
 1 78265 IR001     8
 1 78269 IR001     7
 1 78272 IR001     8
 1 78279 IR001     7
 1 78283 IR001     8
 1 78294 IR001    10

*RESIDUES AND OTHER ORGANIC MATERIALS
@R RDATE  RCOD  RAMT  RESN  RESP  RESK  RINP  RDEP
 1 78166 RE001  1000   0.8    -9  -9           15

*SIMULATION CONTROLS
@N GENERAL     NYERS NREPS START YRDAY RSEED SNAME....................
 1 GE              1     1     S 78166  2150 BRAGG, IRRIGATED & NON-IR
@N OPTIONS     WATER NITRO SYMBI PHOSP POTAS DISES
 1 OP              Y     Y     Y     N     N     N
@N METHODS     WTHER INCON LIGHT EVAPO INFIL PHOTO
 1 ME              M     M     E     R     S     C
@N MANAGEMENT  PLANT IRRIG FERTI RESID HARVS
 1 MA              R     R     R     R     M
@N OUTPUTS     FNAME OVVEW SUMRY FROPT GROTH CARBN WATER NITRO MINER DISES  LONG
 1 OU              N     Y     Y     3     Y     Y     Y     Y     N     N     Y

@  AUTOMATIC MANAGEMENT
@N PLANTING   PFIRST PLAST PH2OL PH2OU PH2OD PSTMX PSTMN
 1 PL            155   200    40   100    30    40    10
@N IRRIGATION  IMDEP ITHRL ITHRU IROFF IMETH IRAMT IREFF
 1 IR             30    50   100 GS000 IR001    10  0.75
@N NITROGEN    NMDEP NMTHR NAMNT NCODE NAOFF
 1 NI             30    50    25 FE001 GS000
@N RESIDUES    RIPCN RTIME RIDEP
 1 RE            100     1    20
@N HARVEST    HFIRST HLAST HPCNP HPCNR
 1 HA              0   365   100     0
```

*CULTIVARS
This defines the crop (CR) and cultivar (INGENO) which will be simulated.

*FIELDS
This defines the weather station (WSTA) and soil profile (ID_SOIL) which will be used as inputs.

*INITIAL CONDITIONS
This defines the initial soil water (SH_2O) and nitrogen conditions at the start of simulation (SNH_4 + SNO_3).

*PLANTING DETAILS
This defines the planting date (PDATE), plant density (PPOP), row spacing (PLRS) and planting depth (PLDP) at planting.

*IRRIGATION AND WATER MANAGEMENT
This defines the dates (IDATE) and amounts (IRVAL) of irrigation applications.

*FERTILIZERS
This defines the dates (FDATE), amount (FAMN) and types (FMDC) of fertilizer applications.

*ENVIRONMENT MODIFICATIONS
This defines environmental modifications related to weather conditions.

*HARVEST DETAILS
This defines final harvest date ((HDATE) and other harvest parameters.

*RESIDUES AND OTHER ORGANIC MATERIALS
This defines initial residue from the previous crop present at the start of simulation.

The importance of the above sections depends on the treatment factor levels selected in the *TREATMENT section.

*SIMULATION CONTROLS
This section is critical, since it defines the various options available for simulation, such as water balance and nitrogen balance simulation, crop management options, and defines the output files and output frequency.

Volume 2-1 (Jones et al. 1994) of this book presents additional details about the specifics of each input section and the headers and header abbreviations for FILEX and various examples.

Experiment List File

The models require an experiment list file (FILEL) to display the various experiments available for simulation (Table 5). The XCreate program updates the experiment list after each new FILEX is created by a user. In addition, DSSAT v3 has an experiment File Manager utility that is accessed by selecting the "I Inputs" option under the MODELS menu of the DSSAT v3 Shell (Screen 1). The File Manager utility allows the user to either include or exclude a particular experiment from the experiment list file, and also includes options to edit a particular experiment data file and search and sort. For a description of this utility, see Volume 1-3 (Hunt et al. 1994) of this book.

Table 5. Experiment List File. (FILEL = "EXP.LST")

```
*EXPERIMENT LIST

@# FILENAME EXT ENAME
 1 IUCA7901 SBX WAYNE, IRRIGATED & NON-IRRIGATED
 2 UFGA7801 SBX BRAGG, IRRIGATED & NON-IRRIGATED
 3 UFGA7802 SBX BRAGG, IRR*INSECT DAMAGE
 4 UFGA7901 SBX IRRIGATION 3I
 5 UFGA8101 SBX COBB, IRRIGATED, VEG. & REPROD. STRESS
 6 UFQU7901 SBX BRAGG, WELL IRRIGATED
 7 UFQU7902 SBX BRAGG, DEFOLIATION STUDY
```

CHAPTER FIVE.
RUNNING THE CROP MODELS

Once a user has created a FILEX and the experiment list file (FILEL) has been updated, a crop model can be run, by selecting the "Simulate" option as shown in Screen 1. A screen displaying the name of the model, the model developers and the institutions which have been involved in model development will be presented. Screen 3 below, for CROPGRO, is an example of the screen which will be presented.

```
IBSNAT 3.0 Generic Input

CROPGRO 3.00 (93.0)

G. Hoogenboom, J.W. Jones, K.J. Boote, W.T. Bowen,
N.B. Pickering, W.D. Batchelor, and J.W. White

The University of Georgia & University of Florida

CROPGRO simulates crop growth and development, soil water dynamics and
soil nitrogen dynamics in response to weather, soil characteristics,
cultivar characteristics, and crop management. This version simulates
soybean, peanut and drybean crops. It uses the IBSNAT standard data
formats and files for DSSAT v3.

September 1994

Please press < ENTER > key (↵) to continue
```

Screen 3.

Pressing the <ENTER> or <RETURN> key in this screen will present Screen 4 (on following page), which displays a list of experiment case studies that can be used for simulation.

```
                                                    INST.  SITE  YEAR  EXPT.
     CROP EXPERIMENTAL CASE STUDIES                  ID     ID          NO
     ---- ------------------------                  ----   ----  ----  ----
  1.  SB  WAYNE, IRRIGATED & NON-IRRIGATED           IU     CA   1979   01
  2.  SB  BRAGG, IRRIGATED & NON-IRRIGATED           UF     GA   1978   01
  3.  SB  BRAGG, IRR*INSECT DAMAGE                   UF     GA   1978   02
  4.  SB  IRRIGATION 3I                              UF     GA   1979   01
  5.  SB  COBB, IRRIGATED, VEG. & REPROD. STRESS     UF     GA   1981   01
  6.  SB  BRAGG, WELL IRRIGATED                      UF     QU   1979   01
  7.  SB  BRAGG, DEFOLIATION STUDY                   UF     QU   1979   02

     EXPERIMENT SELECTED ===>   1
     NEW SELECTION ?     --->   2
```

Screen 4.

What is displayed on Screen 4 is actually a listing of FILEL (see Table 5). Any one of these experiments can be selected for simulation. Each item in the list may represent an actual experiment or a hypothetical one created to predict how a crop would perform under specified conditions. For the example shown, Experiment "2" was selected, which was a soybean experiment, conducted in 1978 at the University of Florida in Gainesville

When this experiment is selected, Screen 5 (shown below) is presented.

```
                                             INST.  SITE  YEAR  EXPT.  TRT.
   BRAGG, IRRIGATED & NON-IRRIGATED           ID     ID          NO     NO
   --------------------------------          ----   ----  ----  ----   ----
1. IRRIGATED                                  UF     GA   1978   01     1
2. NON - IRRIGATED                            UF     GA   1978   01     2
3. RUN ALL TREATMENTS                         UF     GA   1978   01

   TREATMENT SELECTED ====>   1
   NEW SELECTION ?    ====>   1
```

Screen 5.

Screen 5 displays the treatments of Experiment "2" selected in Screen 4. For this experiment, there are two treatments, irrigated (Option 1) and non-irrigated (Option 2). In addition, in Screen 5, a user can choose to have the model simulate all treatments of the particular experiment (Option 3). For this example experiment, Option 1 was selected.

When the experiment and the treatment have been selected, Screen 6 (below) is presented.

```
   What Would You Like To Do?

0. Run Simulation
1. Select Sensitivity Analysis Options.

   CHOICE ?   [ Default = 0 ] ===> 0

   Please enter Run  1 name : ===> Example
```

SCREEN 6.

In Screen 6, the user can choose to run either a simulation (Option 0) or a sensitivity analysis (Option 1). Option 1 is discussed in some detail in Chapter 7, "Management and Sensitivity Analysis Options." For this example, Option 0, "Run Simulation," was selected.

Following the selection of Option 0, a prompt, as shown in Screen 6, is displayed, and the user is asked to enter a run identifier. This identifier can be any combination of words or characters up to a maximum of 25. For this example, "Example" was entered.

```
SIMULATION OVERVIEW

RUN   1        : Example
MODEL          : CRGRO940 - SOYBEAN
EXPERMIMENT    : UFGA7801 SB    BRAGG, IRRIGATED & NON-IRRGATED
TREATMENT   1  : IRRIGATED

CROP           : SOYBEAN        CULTIVAR : BRAGG           -  MATURITY GROUP7
STARTING DATE  : JUN 15 1978
PLANTING DATE  : JUN 15 1978    PLANTS/m2 : 29.9    ROW SPACING :  91.cm
WEATHER        : UFGA   1978
SOIL           : IBSB910015     TEXTURE :      - Millhopper Fine Sand
SOIL INITIAL C : DEPTH:180cm EXTR. H20:158.4mm N03: 22.9kg/ha  NH4: 16.5kg/ha
WATER BALANCE  : IRRIGATE ACCORDING TO FIELD SCHEDULE
IRRIGATION     :      190 mm IN    19 APPLICATIONS
NITROGEN BAL.  : SOIL-N, N-UPTAKE & DYNAMIC N-FIXATION SIMULATION
N FERTILIZER   :  NO FERTILIZER APPLIED
RESIDUE/MANURE :     1000 kg/ha IN     1 APPLICATIONS
ENVIRONM. OPT. : DAYL=      .0  SRAD=      .0  TMAX=      .0  TMIN=     .0
               : RAIN=      .0  C02 = R 330.0  DEW =      .0  WIND=     .0
SIMULATION OPT : WATER   :Y  NITROGEN:Y  N-FIX:Y  PESTS  :N  PHOTO  :C ET :R
MANAGEMENT OPT : PLANTING:R  IRRIG   :R  FERT :N  RESIDUE:R  HARVEST:M WTH:M

Please press < ENTER > key to continue
```

SCREEN 7.

Screen 7 (above) displays an overview of the inputs and simulation data for the experiment selected in Screen 4. These data include crop, cultivar and maturity group information; start of simulation and planting dates; row and plant spacing; weather site and year; general soil profile information and initial conditions at the start of simulation; water balance simulation option and irrigation management; nitrogen balance simulation, nitrogen fertilizer management and organic residue; environmental or weather variable modifications; and a summary of simulation and management options.

```
SUMMARY OF SOIL AND GENETIC INPUT PARAMETERS

   SOIL  LOWER UPPER   SAT  EXTR  INIT   ROOT   BULK     pH    NO3    NH4    ORG
  DEPTH  LIMIT LIMIT    SW    SW    SW   DIST   DENS                           C
   cm    cm3/cm3   cm3/cm3     cm3/cm3          g/cm3         ugN/g  ugN/g     %
--------------------------------------------------------------------------------
   0-  5  .023  .086  .230  .063  .086   1.00   1.36   5.30   1.50    .60    .90
   5- 15  .023  .086  .230  .063  .086   1.00   1.40   5.40   1.50    .60    .69
  15- 30  .023  .086  .230  .063  .086    .50   1.46   5.70   1.50    .60    .28
  30- 45  .023  .086  .230  .063  .086    .29   1.47   5.80   1.50    .60    .20
  45- 60  .023  .086  .230  .063  .086    .29   1.47   5.80   1.50    .60    .20
  60- 90  .021  .076  .230  .055  .076    .38   1.43   5.90    .60    .60    .09
  90-120  .020  .076  .230  .056  .076    .13   1.48   5.90    .50    .60    .03
 120-150  .027  .130  .230  .103  .130    .06   1.57   5.90    .50    .60    .03
 150-180  .070  .258  .360  .188  .258    .03   1.79   5.90    .50    .60    .03

 TOT-180   5.5  21.4  45.3  15.8  21.4  <--cm   -  kg/ha-->   22.9   16.5  38949
 SOIL ALBEDO    :  .18      EVAPORATION LIMIT : 5.00       MIN. FACTOR  : 1.00
 RUNOFF CURVE # :66.00      DRAINAGE RATE     :  .50       FERT. FACTOR :  .84

 SOYBEAN CULTIVAR :IB0001-BRAGG               ECOTYPE :SB0701-MATURITY GROUP 7
 CSDVAR :12.33  PPSEN  :  .32  EMG-FLW:19.50  FLW-FSD:17.00  FSD-PHM :36.00
 WTPSD  : .200  SDPDVR : 2.05  SDFDUR :26.00  PODDUR :15.00  XFRUIT  : 1.00

 Please press < ENTER> key to continue
```

Screen 8.

Screen 8 displays more detailed information about the selected experiment's soil profile characteristics and cultivar characteristics. These include the lower limit, drained upper limit and saturated water content, extractable soil water, initial soil water content, relative root distribution, bulk density, pH, initial NO_3 and NH_4, and organic carbon for each soil layer, and total amount in the profile. Also shown are some of the soil surface characteristics such as soil albedo, first stage evaporation limit, soil nitrogen mineralization factor, SCS runoff curve number, and a drainage rate. The fertility factor is currently used only in the grain legume models to account for mineral deficiencies not simulated in the current version of the model or unknown factors that limit growth in a particular soil.

The cultivar characteristics are crop specific and are discussed in Appendix A, "Genetic Coefficients." As shown in this example for soybean, cultivar coefficients include the critical short day for photoperiod sensitivity (CSDVAR); relative sensitivity to photoperiod (PPSEN); optimum number of days from emergence to flowering (EMG-FLW); optimum number of days from flowering to first seed (FLW-FSD); optimum number of days from first seed to physiological maturity (FSD-PHM), individual seed weight (WTPSD); number of seeds per pod (SDPDVR); seed filling duration (SDFDUR) and pod filling duration (PODDUR); and relative biomass partitioning between vegetative and reproductive structures (XFRUIT).

Screens 7 and 8 are displayed during the initialization of the model. Following these initialization screens, Screen 9 (shown on following page) is presented, which is displayed during the actual model simulation. All the variables shown in this screen are predicted variables.

SIMULATED CROP AND SOIL STATUS AT MAIN DEVELOPMENT STAGES

RUN NO. 1 Example

DATE	CROP AGE	GROWTH STAGE	BIOMASS kg/ha	LAI	LEAF NUM.	ET mm	RAIN mm	IRRIG mm	SWATER mm	CROP kg/ha	N %	STRESS H2O	N
15 JUN	0	START SIM	0	.00	.0	0	0	0	158	0	.0	.00	.00
15 JUN	0	SOWING	0	.00	.0	0	0	0	158	0	.0	.00	.00
21 JUN	6	EMERGENCE	21	.03	.1	3	2	0	157	1	5.1	.00	.06
21 JUN	6	END JUVEN.	21	.03	.1	3	2	0	157	1	5.1	.00	.06
28 JUN	13	UNIFOLIATE	60	.11	1.2	11	10	0	157	3	5.1	.00	.26
2 JUL	17	FLOWER IND	116	.20	2.1	20	10	13	157	5	4.3	.03	.32
31 JUL	46	FIRST FLWR	1854	3.25	8.8	128	274	13	186	61	3.3	.00	.27
22 AUG	68	FIRST POD	4340	5.22	13.9	230	518	26	149	156	3.6	.00	.01
22 AUG	68	FIRST POD	4340	5.22	13.9	230	518	26	149	156	3.6	.00	.01
29 AUG	75	END MSNODE	5304	5.19	15.4	268	518	63	139	185	3.5	.00	.00
29 AUG	75	END LEAF	5304	5.19	15.4	268	518	63	139	185	3.5	.00	.00
1 SEP	78	FIRST SEEND	5710	5.13	15.4	285	518	85	138	196	3.4	.00	.00
1 OCT	108	END POD	7469	3.36	15.4	401	534	165	98	245	3.3	.13	.01
11 OCT	118	PHYS. MAT	7747	2.89	15.4	431	534	180	78	263	3.4	.32	.07
23 OCT	130	HARV. MAT	6107	.19	15.4	448	534	190	69	224	3.7	.47	.10
23 OCT	130	HARVEST	6107	.19	15.4	448	534	190	69	224	3.7	.47	.10

Please press < ENTER > key to continue

Screen 9.

Each model is initialized at the start of simulation date, as specified in the input file. All models operate at daily time steps; thus, growth, development and other variables are incremented daily. Each crop model predicts the critical growth stages for that particular crop as shown in Screen 9 (above) for soybean. At each stage, total biomass, leaf area index (LAI), total number of leaves on the main stem and total nitrogen (CROP) and nitrogen concentration (N) are shown. These variables relate mainly to the carbon and nitrogen balance of the models. In addition, some soil and plant water variables are shown, such as total evapotranspiration (ET), total rainfall received and irrigation applied, and plant extractable soil water. The last two columns in Screen 9 show plant water and nitrogen stress averages calculated from the time of the previous stage until the current stage.

When the last stage, e.g., “HARVEST” for this example, appears, the simulation has ended. The actual time it will take from the start of simulation, “START SIM,” until final harvest, can vary from a few seconds to a few minutes, depending on computer hardware and the crop management options selected.

```
     VARIABLE                                       PREDICTED        MEASURED
     ------                                         -------          ------
     ANTHESIS DATE (dap)                               46               45
     FIRST PEG / POD (dap)                             68               67
     FIRST SEED (dap)                                  78               67
     PHYSIOLOGICAL MATURITY (dap)                     118              116
     POD YIELD (kg/ha)                               3941             4009.
     SEED YIELD (Kg/ha)                              2932             3041.
     SHELLING PERCENTAGE (%)                        74.41            75.85
     WEIGHT PER SEED (g)                             .133            .1440
     SEED NUMBER (SEED/m2)                           2202             2223.
     SEEDS/POD                                       2.05             1.96
     MAXIMUM LAI (m2/m2)                             5.25             4.67
     BIOMASS (kg/ha) AT ANTHESIS                     1854              -99
     BIOMASS N (kg N/ha) AT ANTHESIS                   61              -99
     BIOMASS (kg/ha) AT HARVEST MAT.                 6107             6068.
     STALK (kg/ha) AT HARVEST MAT.                   2087             1958.
     HARVEST INDEX (kg/ha)                           .480             .501
     FINAL LEAF NUMBER (MAIN STEM)                  15.41              -99
     SEED N (kg N/ha)                                 187              -99
     BIOMASS N (kg N/ha)                              224              -99
     STALK N (kg N/ha)                                 20              -99
     SEED N (%)                                      6.37              -99


Please press < ENTER> key to continue
```

SCREEN 10.

After the seasonal results are presented in Screen 9, model predicted data can be compared with experimental data for the main development stages, yield and yield components, and some of the nitrogen variables (Screen 10, above). When no experiment data are available for a particular stage, a “-99” is displayed for that item.

```
ENVIRONMENTAL AND STRESS FACTORS

----------------------------------ENVIRONMENT----------------STRESS----------
|--DEVELOPMENT PHASE--|-TIME-|-------WEATHER--------| |---WATER--| |-NITROGEN-|
                        DURA TEMP   TEMP  SOLAR PHOTOP PHOTO GROWTH PHOTO GROWTH
                        TION  MAX    MIN    RAD  [day] SYNTH        SYNTH
                        days   oC     oC   MJ/m2   hr
------------------------------------------------------------------------------
Emergence -First Flower    40  33.04  22.20  19.34  13.74  .000  .004  .000  .273
First Flower-First Seed    32  33.33  21.71  19.55  13.03  .000  .000  .000  .006
First Seed - Phys. Mat.    40  31.95  19.39  16.82  11.98  .099  .179  .098  .022
Emergence  - Phys. Mat.   112  32.73  21.06  18.50  12.91  .035  .066  .035  .107

                                                      (0.0 = Minimum Stress
                                                       1.0 = Maximum Stress)


SOYBEAN     YIELD :      2932 kg/ha      [DRY WEIGHT]

Do you want to run more simulations?
Y or N ? [Default = "N"] ===> N
```

SCREEN 11.

Screen 11 (above), the final screen in this series, displays a summary of environmental variables derived during the main developmental stages, which include the vegetative growth phase until flowering, the vegetative and reproductive development growth phase from flowering until the start of seed growth, and the reproductive growth phase from beginning seed growth until physiological maturity. To simulate another treatment or another experiment, a user needs to enter a ‘Y’ at the prompt. An ‘N’ entry ends the crop model simulation and the user can then print out or graph the simulated results. For a description of the graphing and printing options, see Chapter 7, “Displaying Results.”

Screens 7 through 11, which appear on the monitor during an interactive simulation, are stored in a model output file, OVERVIEW.OUT. This file, in ASCII text format, is 80 characters wide, making it easy to either edit this file or print it to a dot matrix or laser printer.

Example listings of the OVERVIEW.OUT file is shown in Table 6A for CERES-Maize and Table 6B for CROPGRO-Soybean.

TABLE 6A. CROP MODEL OUTPUT OVERVIEW FILE FOR CERES-MAIZE. (OUTO = "OVERVIEW.OUT")

```
*SIMULATION OVERVIEW FILE

*RUN   1        : Example CERES-Maize
 MODEL          : GECER940 - MAIZE
 EXPERIMENT     : UFGA8201 MZ    N X IRRIGATION, GAINESVILLE
 TREATMENT  4   : IRRIGATED HIGH NITROGEN

 CROP           : MAIZE          CULTIVAR : McCurdy 84aa     -
 STARTING DATE  : FEB 25 1982
 PLANTING DATE  : FEB 26 1982    PLANTS/m2 :  7.2     ROW SPACING :  61.cm
 WEATHER        : UFGA   1982
 SOIL           : IBMZ910014     TEXTURE : FSA   - Millhopper Fine Sand
 SOIL INITIAL C : DEPTH:180cm EXTR. H2O:160.9mm  NO3: 14.9kg/ha  NH4: 21.1kg/ha
 WATER BALANCE  : IRRIGATE ACCORDING TO FIELD SCHEDULE
 IRRIGATION     :      264 mm IN    16 APPLICATIONS
 NITROGEN BAL.  : SOIL-N & N-UPTAKE SIMULATION; NO N-FIXATION
 N FERTILIZER   :      401 kg/ha IN     7 APPLICATIONS
 RESIDUE/MANURE :     1000 kg/ha IN     1 APPLICATIONS
 ENVIRONM. OPT. : DAYL=      .0  SRAD=      .0  TMAX=      .0  TMIN=      .0
                  RAIN=      .0  CO2 = R 330.0  DEW =      .0  WIND=      .0
 SIMULATION OPT : WATER   :Y  NITROGEN:Y  N-FIX:N  PESTS  :N  PHOTO  :C  ET :R
 MANAGEMENT OPT : PLANTING:R  IRRIG   :R  FERT :R  RESIDUE:R  HARVEST:M  WTH:M

*SUMMARY OF SOIL AND GENETIC INPUT PARAMETERS

    SOIL LOWER UPPER   SAT  EXTR  INIT   ROOT   BULK     pH    NO3    NH4    ORG
   DEPTH LIMIT LIMIT    SW    SW    SW   DIST   DENS                           C
    cm   cm3/cm3    cm3/cm3    cm3/cm3        g/cm3         ugN/g  ugN/g     %
-------------------------------------------------------------------------------
   0-  5  .026  .096  .230  .070  .086   1.00   1.30   7.00    .60   1.50   2.00
   5- 15  .025  .086  .230  .061  .086   1.00   1.30   7.00    .60   1.50   1.00
  15- 30  .025  .086  .230  .061  .086    .80   1.40   7.00    .60   1.50   1.00
  30- 45  .025  .086  .230  .061  .086    .20   1.40   7.00    .60   1.50    .50
  45- 60  .025  .086  .230  .061  .086    .20   1.40   7.00    .60   1.50    .50
  60- 90  .028  .090  .230  .062  .076    .10   1.45   7.00    .60    .60    .10
  90-120  .028  .090  .230  .062  .076    .05   1.45   7.00    .60    .50    .10
 120-150  .029  .130  .230  .101  .130    .00   1.45   7.00    .60    .50    .04
 150-180  .070  .258  .360  .188  .258    .00   1.20   7.00    .60    .50    .24

 TOT-180   6.2  22.3  45.3  16.1  21.4  <--cm   -  kg/ha-->   14.9   21.1  87080
 SOIL ALBEDO    :  .18       EVAPORATION LIMIT : 2.00       MIN. FACTOR  : 1.00
 RUNOFF CURVE # :60.00       DRAINAGE RATE     :  .65       FERT. FACTOR :  .80
 MAIZE   CULTIVAR :IB0035-McCurdy 84aa       ECOTYPE :     -
 P1     : 200.00  P2     :  .3000  P5     : 940.00
 G2     : 700.00  G3     :  8.000  PHINT  : 75.000
```

```
*SIMULATED CROP AND SOIL STATUS AT MAIN DEVELOPMENT STAGES

 RUN NO.  1    Example CERES-Maize

   DATE CROP GROWTH   BIOMASS  LAI  LEAF   ET  RAIN IRRIG SWATER CROP  N  STRESS
        AGE  STAGE     kg/ha         NUM.  mm   mm    mm    mm   kg/ha %  H2O  N
--------------------------------------------------------------------------------
 25 FEB    0 Start Sim      0   .00   .0    0     0     0   152    0  .0 .00 .00
 26 FEB    0 Sowing         0   .00   .0    1     0     0   151    0  .0 .00 .00
 27 FEB    1 Germinate      0   .00   .0    1     0     0   151    0  .0 .00 .00
  7 MAR    9 Emergence     29   .00  1.9   11    58    13   205    1 4.4 .00 .00
 22 MAR   24 End Juveni   141   .30  7.5   23    60    23   161    5 3.9 .02 .00
 27 MAR   29 Floral Ini   275   .52  9.0   35   103    23   179   11 3.9 .00 .01
 12 MAY   75 75% Silkin  9251  4.64 23.7  214   361   142   165  194 2.1 .00 .03
 22 MAY   85 Beg Gr Fil 11940  4.36 23.7  267   363   201   166  193 1.6 .00 .02
  3 JUL  127 Maturity   23149  2.02 23.7  456   661   264   156  245 1.1 .00 .05
  3 JUL  127 Harvest    23149  2.02 23.7  456   661   264   156  245 1.1 .00 .05


*MAIN GROWTH AND DEVELOPMENT VARIABLES

@     VARIABLE                        PREDICTED     MEASURED
      --------                        ---------     --------
      FLOWERING DATE (dap)                  75            75
      PHYSIOL. MATURITY (dap)              127           128
      GRAIN YIELD (kg/ha)                13769         14060
      WT. PER GRAIN (g)                  .2971         0.309
      GRAIN NUMBER (GRAIN/m2)             3916         3847.
      GRAINS/EAR                        543.90          496.
      MAXIMUM LAI (m2/m2)                 4.71           -99
      BIOMASS (kg/ha) AT ANTHESIS         9251           -99
      BIOMASS N (kg N/ha) AT ANTHESIS      194           -99
      BIOMASS (kg/ha) AT HARVEST MAT.    23149         22001
      STALK (kg/ha) AT HARVEST MAT.      11515         10120
      HARVEST INDEX (kg/kg)               .595           -99
      FINAL LEAF NUMBER                  23.75           -99
      GRAIN N (kg N/ha)                    190         192.9
      BIOMASS N (kg N/ha)                  245         267.7
      STALK N (kg N/ha)                     55          74.8
      SEED N (%)                          1.64          1.60
```

```
*ENVIRONMENTAL AND STRESS FACTORS

-----------------------------------ENVIRONMENT-----------------STRESS----------
 |--DEVELOPMENT PHASE--|-TIME-|-------WEATHER--------| |---WATER--| |-NITROGEN-|
                         DURA TEMP  TEMP  SOLAR PHOTOP PHOTO  LEAF  PHOTO  LEAF
                         TION  MAX   MIN    RAD  [day] SYNTH EXPAN. SYNTH  EXPAN.
                         days   oC    oC   MJ/m2   hr
-------------------------------------------------------------------------------
 Emergence-End Juvenile   15  28.06  13.01 17.17  11.75  .002  .023  .004  .009
 End Juvenil-Floral Init   5  27.00  15.98 12.66  12.05  .000  .000  .003  .006
 Floral Init-End Lf Grow  46  27.23  13.93 18.66  12.80  .000  .000  .026  .064
 End Lf Grth-Beg Grn Fil  10  31.67  15.18 23.28  13.51  .000  .000  .022  .055
 Grain Filling Phase      39  32.57  20.52 20.06  13.82  .000  .000  .031  .076

                                                       (0.0 = Minimum Stress
                                                        1.0 = Maximum Stress)

       MAIZE     YIELD :   13769 kg/ha [  219.3 bu/acre ]
```

Table 6B. Crop Model Output Overview File for CROPGRO-Soybean. (OUTO = "OVERVIEW.OUT")

```
*SIMULATION OVERVIEW FILE

*RUN   1         : Example CROPGRO - Soybean
 MODEL           : CRGRO940 - SOYBEAN
 EXPERIMENT      : UFGA7801 SB    BRAGG, IRRIGATED & NON-IRRIGATED
 TREATMENT  1    : IRRIGATED

 CROP            : SOYBEAN        CULTIVAR : BRAGG            -  MATURITY GROUP 7
 STARTING DATE   : JUN 15 1978
 PLANTING DATE   : JUN 15 1978    PLANTS/m2 : 29.9     ROW SPACING :  91.cm
 WEATHER         : UFGA   1978
 SOIL            : IBSB910015     TEXTURE : FSA   - Millhopper Fine Sand
 SOIL INITIAL C  : DEPTH:180cm EXTR. H2O:158.4mm  NO3: 22.9kg/ha  NH4: 16.5kg/ha
 WATER BALANCE   : IRRIGATE ACCORDING TO FIELD SCHEDULE
 IRRIGATION      :      190 mm IN    19 APPLICATIONS
 NITROGEN BAL.   : SOIL-N, N-UPTAKE & DYNAMIC N-FIXATION SIMULATION
 N FERTILIZER    :  NO FERTILIZER APPLIED
 RESIDUE/MANURE  :     1000 kg/ha IN     1 APPLICATIONS
 ENVIRONM. OPT.  : DAYL=      .0  SRAD=      .0  TMAX=      .0  TMIN=      .0
                   RAIN=      .0  CO2 = R 330.0  DEW =      .0  WIND=      .0
 SIMULATION OPT  : WATER   :Y  NITROGEN:Y  N-FIX:Y  PESTS  :N  PHOTO  :C  ET :R
 MANAGEMENT OPT  : PLANTING:R  IRRIG   :R  FERT :N  RESIDUE:R  HARVEST:M  WTH:M

*SUMMARY OF SOIL AND GENETIC INPUT PARAMETERS

    SOIL LOWER UPPER   SAT  EXTR  INIT   ROOT   BULK     pH    NO3    NH4    ORG
   DEPTH LIMIT LIMIT    SW    SW    SW   DIST   DENS                          C
    cm   cm3/cm3    cm3/cm3    cm3/cm3        g/cm3         ugN/g  ugN/g     %
--------------------------------------------------------------------------------
   0-  5  .023  .086  .230  .063  .086   1.00   1.36   5.30   1.50    .60    .90
   5- 15  .023  .086  .230  .063  .086   1.00   1.40   5.40   1.50    .60    .69
  15- 30  .023  .086  .230  .063  .086    .50   1.46   5.70   1.50    .60    .28
  30- 45  .023  .086  .230  .063  .086    .29   1.47   5.80   1.50    .60    .20
  45- 60  .023  .086  .230  .063  .086    .29   1.47   5.80   1.50    .60    .20
  60- 90  .021  .076  .230  .055  .076    .38   1.43   5.90    .60    .60    .09
  90-120  .020  .076  .230  .056  .076    .13   1.48   5.90    .50    .60    .03
 120-150  .027  .130  .230  .103  .130    .06   1.57   5.90    .50    .60    .03
 150-180  .070  .258  .360  .188  .258    .03   1.79   5.90    .50    .60    .03

 TOT-180   5.5  21.4  45.3  15.8  21.4  <--cm   -  kg/ha-->   22.9   16.5  38949
 SOIL ALBEDO    :  .18       EVAPORATION LIMIT : 5.00        MIN. FACTOR  : 1.00
 RUNOFF CURVE # :66.00       DRAINAGE RATE     :  .50        FERT. FACTOR :  .84
 SOYBEAN CULTIVAR :IB0001-BRAGG              ECOTYPE :SB0701-MATURITY GROUP 7
 CSDVAR :12.33  PPSEN  :  .32  EMG-FLW:19.50  FLW-FSD:17.00  FSD-PHM :36.00
 WTPSD  : .200  SDPDVR : 2.05  SDFDUR :26.00  PODDUR :15.00  XFRUIT  : 1.00
```

```
*SIMULATED CROP AND SOIL STATUS AT MAIN DEVELOPMENT STAGES

 RUN NO.  1    Example CROPGRO - Soybean

   DATE CROP GROWTH   BIOMASS  LAI  LEAF   ET  RAIN IRRIG SWATER CROP  N  STRESS
        AGE  STAGE     kg/ha        NUM.  mm    mm    mm    mm   kg/ha %  H2O  N
--------------------------------------------------------------------------------
 15 JUN    0 START SIM      0   .00   .0    0     0     0   158    0  .0 .00 .00
 15 JUN    0 SOWING         0   .00   .0    0     0     0   158    0  .0 .00 .00
 21 JUN    6 EMERGENCE     21   .03   .1    3     2     0   157    1 5.1 .00 .06
 21 JUN    6 END JUVEN.    21   .03   .1    3     2     0   157    1 5.1 .00 .06
 28 JUN   13 UNIFOLIATE    60   .11  1.2   11    10     0   157    3 5.1 .00 .26
  2 JUL   17 FLOWER IND   116   .20  2.1   20    10    13   157    5 4.3 .03 .32
 31 JUL   46 FIRST FLWR  1854  3.25  8.8  128   274    13   186   61 3.3 .00 .27
 22 AUG   68 FIRST POD   4340  5.22 13.9  230   518    26   149  156 3.6 .00 .01
 22 AUG   68 FIRST POD   4340  5.22 13.9  230   518    26   149  156 3.6 .00 .01
 29 AUG   75 END MSNODE  5304  5.19 15.4  268   518    63   139  185 3.5 .00 .00
 29 AUG   75 END LEAF    5304  5.19 15.4  268   518    63   139  185 3.5 .00 .00
  1 SEP   78 FIRST SEED  5710  5.13 15.4  285   518    85   138  196 3.4 .00 .00
  1 OCT  108 END POD     7469  3.36 15.4  401   534   165    98  245 3.3 .13 .01
 11 OCT  118 PHYS. MAT   7747  2.89 15.4  431   534   180    78  263 3.4 .32 .07
 23 OCT  130 HARV. MAT   6107   .19 15.4  448   534   190    69  224 3.7 .47 .10
 23 OCT  130 HARVEST     6107   .19 15.4  448   534   190    69  224 3.7 .47 .10


*MAIN GROWTH AND DEVELOPMENT VARIABLES

@     VARIABLE                        PREDICTED     MEASURED
      --------                        ---------     --------
      ANTHESIS DATE (dap)                46           45
      FIRST PEG / POD (dap)              68           67
      FIRST SEED (dap)                   78           67
      PHYSIOLOGICAL MATURITY (dap)      118          116
      POD YIELD (kg/ha)                3941         4009.
      SEED YIELD (kg/ha)               2932         3041.
      SHELLING PERCENTAGE (%)         74.41        75.85
      WEIGHT PER SEED (g)              .133        .1440
      SEED NUMBER (SEED/m2)            2202         2223.
      SEEDS/POD                        2.05         1.96
      MAXIMUM LAI (m2/m2)              5.25         4.67
      BIOMASS (kg/ha) AT ANTHESIS      1854          -99
      BIOMASS N (kg N/ha) AT ANTHESIS    61          -99
      BIOMASS (kg/ha) AT HARVEST MAT.  6107         6068.
      STALK (kg/ha) AT HARVEST MAT.    2087         1958.
      HARVEST INDEX (kg/kg)            .480         .501
      FINAL LEAF NUMBER (MAIN STEM)   15.41          -99
      SEED N (kg N/ha)                  187          -99
      BIOMASS N (kg N/ha)               224          -99
      STALK N (kg N/ha)                  20          -99
      SEED N (%)                       6.37          -99
```

```
*ENVIRONMENTAL AND STRESS FACTORS

------------------------------------ENVIRONMENT----------------STRESS----------
 |--DEVELOPMENT PHASE--|-TIME-|-------WEATHER-------| |---WATER--| |-NITROGEN-|
                         DURA TEMP  TEMP  SOLAR PHOTOP PHOTO GROWTH PHOTO GROWTH
                         TION  MAX   MIN    RAD  [day] SYNTH        SYNTH
                         days   oC    oC   MJ/m2   hr
-------------------------------------------------------------------------------
 Emergence -First Flower  40  33.04  22.20 19.34  13.74  .000  .004  .000  .273
 First Flower-First Seed  32  33.33  21.71 19.55  13.03  .000  .000  .000  .006
 First Seed - Phys. Mat.  40  31.95  19.39 16.82  11.98  .099  .179  .098  .022
 Emergence  - Phys. Mat. 112  32.73  21.06 18.50  12.91  .035  .066  .035  .107

                                                       (0.0 = Minimum Stress
                                                        1.0 = Maximum Stress)


 SOYBEAN    YIELD :     2932 kg/ha    [DRY WEIGHT]
```

CHAPTER SIX.
DISPLAYING RESULTS

General File Manager

After finishing one or more simulation runs, a user can display simulated results in various formats using the DSSAT v3 General File Manager. In Screen 1, the option following "Simulate" is "Outputs." When this option is chosen, Screen 12 (shown below) is presented, which displays the General File Manager menu for handling the various simulation output files.

```
General File Manager - MODEL OUTPUTS                                Version 1.0

                  - Files in Directory: C:\DSSAT3\SOYBEAN -

  L      FILE NAME      FILE HEADING

  √      CARBON.OUT     *CARBON BALANCE OUTPUT FILE
  √      GROWTH.OUT     *GROWTH ASPECTS OUTPUT FILE
  √      NITROGEN.OUT   *NITROGEN BALANCE OUTPUT FILE
  √      OVERVIEW.OUT   *SIMULATION OVERVIEW FILE
  √      SUMMARY.OUT    UFGA7801SB BRAGG, IRRIGATED & NON-IRRIGATED
  √      WATER.OUT      *WATER BALANCE OUTPUT FILE

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

Screen 12.

In Screen 12, the simulation output files are listed. The OVERVIEW.OUT file was discussed in Chapter 5. The file, SUMMARY.OUT, contains a one line summary for each simulation and is mainly used for applications, such as the seasonal and sequence analysis programs discussed in Volumes 3-1 (Thornton et al. 1994 a) and 3-2 (Thornton et al. 1994 b), respectively, of this book. Files GROWTH.OUT, WATER.OUT, NITROGEN.OUT, and CARBON.OUT contain time-dependent variables as simulated by the crop models. Although these files can be edited, they are normally wider than 80 characters and fairly long, depending upon the number of simulations made by the user. The first 13 variables of each of the listed output files are identical for all crop models, with the first two variables being year-day of year and days after planting. Additional variables can be added as a function of each individual model. For more detailed information, see Volume 2-1 (Jones et al., 1994) of this book.

One of the features of the General File Manager allows the installation of a user's editor. By selecting the Edit option (key < F8>) and positioning the highlight bar over the file name, this output file can be edited. An option for a printout of this output file can also be selected from the editor. The General File Manager includes other options, which are discussed in Volume 1-3 (Hunt et al. 1994) of this book.

The crop models automatically overwrite existing output files. Thus, when a new crop model run is initiated, the old output files are erased and new output files are opened. To keep and save output files, a user can rename the generically-named model output files, or select an option under the Sensitivity Analysis section to store the output files, using a naming convention with Institute and Site code IDs similar to those used for the experiment input file.

Graphic Display

DSSAT v3 contains a Graphics option, shown in Screen 1. When this option is selected, the graphics display program, Wingraf is run. See Part 3 of this Volume (Volume 2-3, Chan et al. 1994) for a description of this program. Screen 13 (on the following page) displays the first Wingraf screen.

Wingraf allows the user to display the simulated data as a function of day of year or planting date. In addition, field-measured data are included in the graph, when available.

A user can graphically display growth and development variables: (GROWTH.OUT), soil and plant water and weather variables (WATER.OUT), soil and plant nitrogen variables (NITROGEN.OUT), pest and disease variables (PEST.OUT) and carbon balance and photosynthesis variables (CARBON.OUT). By selecting the menu option "User-Selected Variables" displayed in Screen 13, a user can also design a new list of variables by combining variables from previously listed options (see Screens 14 and 15).

```
 Select Graph  Options  Exit
  Growth...
  Water...
  Nitrogen...
  Disease & Pests...
  Carbon...

  User-Selected Variables  ▶

  Summary Validation       ▶

  Summary Response...

F1 Help   Esc Escape          X-Var.:            Simulation:
```

Screen 13.

For our example, the “Growth” option was selected in Screen 13, which produces a screen with a list of available variables for graphing (see Screen 14).

Also in Screen 13, the “Options” menu item can be selected. From the “Options” submenu, a user can set the colors for graph plotting, such as graph background, item and line colors; change the label of the x-axis; choose type of x-y plotting; choose whether or not to have experimental and simulated data plotted; select the number of graph intervals; and the number of tics. More details about setting graph options can be found in Part 3 of this Volume (Volume 2-3, Chan et al. 1994).

```
▌≡  Select Graph   Options  Exit
[■]                              GROWTH

 Variables                              Run Numbers
 [ ] Leaf number per stem               [X] Example
 [ ] Growth stage
 [ ] Leaf area index
 [X] Leaf dry weight (kg/ha)
 [X] Stem dry weight (kg/ha)
 [X] Grain dry weight (kg/ha)
 [X] Root dry weight (kg/ha)
 [X] Crop dry weight (kg/ha)
 [ ] Grain number (no/m2)
 [ ] Grain dry weight (mg/grain)
 [ ] Harvest index (grain/top)
 [ ] Pod dry weight (kg/ha)
 [ ] Pod number (no/m2)
 [ ] Photo water stress factor (0-1)
 [ ] Growth water stress factor (0-1)

 Previous   Next   X Variable   Graph   Reset   Option
```

SCREEN 14.

In Screen 14 (above), a user can choose to have displayed up to 6 variable-run combinations. Press the NEXT button on this screen to present another screen (Screen 15, below) displaying additional variables available for graphing.

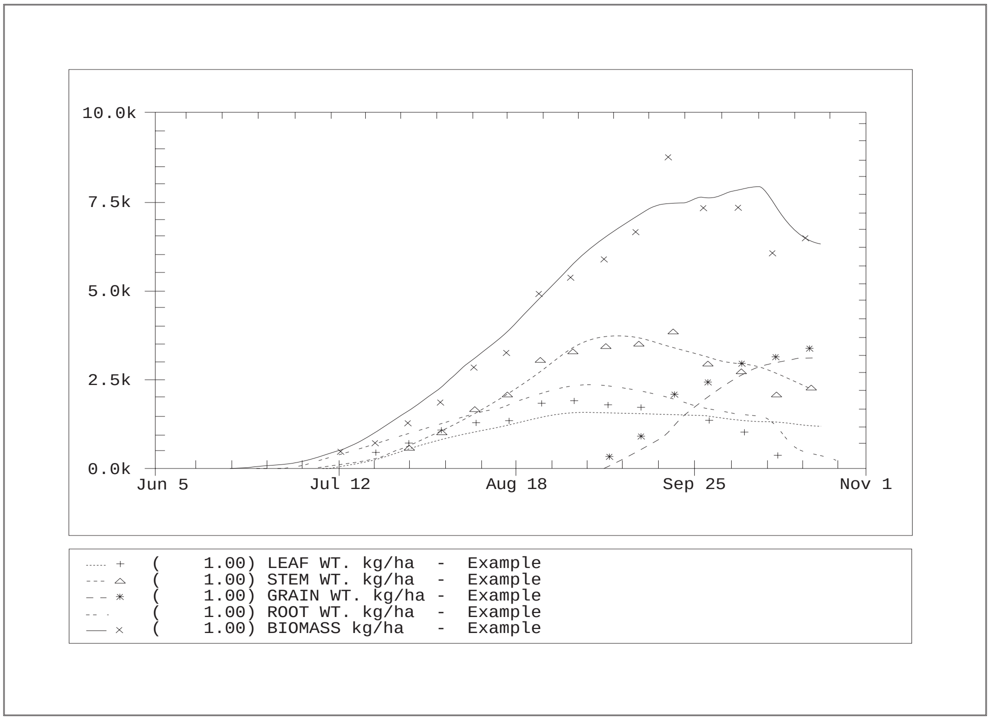
```
▌≡  Select Graph   Options  Exit
[■]                              GROWTH

 Variables                              Run Numbers
 [ ] Nitrogen stress factor (0-1)
 [ ] Leaf N concentration (%)
 [ ] Shelling % (seed wt/pod st*100
 [ ] Pod harvest index (pod/top)
 [ ] Detached pod dry weight (kg/ha)
 [ ] Total pod dry weight (kg/ha)
 [ ] Specific leaf area Cm2/g)
 [ ] Canopy height (m)
 [ ] Canopy breadth (m;for 1 row)
 [ ] Nodule dry weight (kg/ha)
 [ ] Root depth (m)
 [ ] Root density,   0-5 cm (cm/cm3)
 [ ] Root density,  5-15 cm (cm/cm3)
 [ ] Root density, 15-30 cm (cm/cm3)
 [ ] Root density, 30-45 cm (cm/cm3)

 Previous   Next   X Variable   Graph   Reset   Option

F1 Help  Esc Escape         X Var.: Time         Simulation: Default
```

SCREEN 15.

To select variables for display, click the mouse on a variable or hit the space bar. When all variables have been selected, use either the mouse or the <TAB> key to select the "Run Numbers" option. The default X-Variable is "day of year," but a user can change this to "days after planting" or to another variable with the X-VARIABLE button in Screen 16.

The OPTION button in Screens 14 and 15 is **only** available once a graph has been plotted. Then it can be used to make necessary modifications to the current graph, such as changing the x, y coordinates, modifying the multiplier for each plot, changing the min/max values, turning the graph grid line "On" or "Off" and printing the graph to a hard copy.

Use the <TAB> key or GRAPH button or the <SHIFT><G> keys to display the graph.



Screen 16.

Screen 16 shows an example graph with model predicted data depicted as lines and field-measured data as symbols. A detailed description of the Wingraf program can be found in Part 3 of this Volume (Volume 2-3, Chan et al. 1994).

CHAPTER SEVEN.
MANAGEMENT AND SENSITIVITY ANALYSIS OPTIONS

So far only options to simulate either a field or hypothetical experiment have been discussed. In these two cases, the model uses the information provided in the experiment details file, FILEX (Table 4). A user can also interactively modify many of the input variables defined in the input files, including those in the experiment data file, weather file, soil file and genetics file. To do this, select Option 1, "Select Sensitivity Analysis Options," shown in Screen 6 (in Chapter 5). Screen 17, shown below, will be presented.

```
                MANAGEMENT / SENSITIVITY ANALYSIS
                =================================

     The questions which follow relate to the initial
     experiment and treatment you selected.  These
     default values allow you to validate the simulation
     results. To evaluate alternative management strategies
     or make tactical or strategical decisions, you can
     modify or change the default values.

     If you choose not to change any of the default values,
     press the ENTER key in response to the questions

     Please press < ENTER > to continue  ===>
```

SCREEN 17.

The user needs to keep in mind that any changes made in the inputs in the screen which follows this one (Screen 18) might cause the model to give different simulation results compared to those derived from field measured data.

```
   MANAGEMENT / SENSITIVITY ANALYSIS OPTIONS
   =========================================

 0. RETURN TO THE MAIN MENU

 1. Simulation Timing .......  JUN 15 1978
 2. Crop ....................  SOYBEAN             SBGRO930.SPE SBGRO930.CUL
 3. Cultivar ................  BRAGG               MAT : 7     MATURITY GROUP 7
 4. Weather .................  UFGA                OBSERVED    WMOD:N
 5. Soil ....................  IBSB910015
 6. Initial Conditions ......  AS REPORTED
 7. Planting ................  JUN 15 1978         ROW SP: 91. PLANTS/m2: 29.90
 8. Harvest .................  AT HARVEST MATURITY
 9. Water and Irrigation ....  ACCORDING TO FIELD SCHEDULE
10. Nitrogen ................  NOT FERTILIZED      N-FIX SIMULAT.
11. Phosphorus ..............  N/A
12. Residue .................
13. Pest and Diseases .......  PEST & DISEASE INTERACTION NOT SIMULATED
14. Crop Process Options ....  H20:Y NIT:Y N-FIX:Y PEST:N PHOTO:C WTM:M ET:R
15. Output Control ..........  FREQ: 3 OVV:Y SUM:Y GROWTH:Y H20:Y NIT:Y PEST:N

   SELECTION ?  [Default = 0] ===>
```

SCREEN 18.

Screen 18 shows the various categories of variables which can be modified.

Simulation Timing

The “Simulation Timing and Control” menu (Screen 19 on the next page) allows the user to define when a simulation begins. In all cases, the start of simulation date and year (Options 1 and 2) has to be earlier than the planting date, since all model variables are initiated at the start of simulation date. During the period between start of simulation and the planting date only the soil water and nitrogen balances are simulated.

Option 3, “End of Simulation Date,” allows the user to determine the last day of simulation, and although this normally should be set in the “Harvest” section, it could be set to “-99” in this menu.

Option 4, “Number of Years to be Simulated,” allows the user to specify how many years will be simulated. This is normally set to “1.” If, in the example screen shown, the “Number of Years” was set to “2,” the model would conduct two simulations, one for 1978, and one for 1979. The user needs to be sure that weather data are available for the years for which the simulations are to be run.

```
   SIMULATION TIMING AND CONTROL
   =============================

0. Return to Main Menu

1. Start of Simulation Date ...........] JUN 15
2. Year of Simulation .................]   1978
3. End of Simulation Date .............]     -9
4. Number of Years to Be Simulated ....]      1
5. Initial Conditions .................] AS REPORTED


   SELECTION (#) ? [ Default = 0 ] --->
```

Screen 19.

When Option 5, "Initial Conditions," is selected, Screen 20 (below) is presented.

```
   INITIAL SOIL CONDITIONS
   ==========================

0. Return to Previous Menu

1. As Reported from Input Files .....................|
2. Simulated Output Conditions from Previous Run ....|


   CURRENT INITIAL SOIL CONDITIONS ===> AS REPORTED
   SELECTION (#) ? [ Default = 0 ] --->
```

Screen 20.

In Screen 20, a user can define whether the model initiates the variables at the start of each succeeding simulation (Option 1) or if the final conditions from a previous model run are to be used (Option 2). Selecting Option 2 in this screen is useful when simulating crop rotation studies.

CROP

The "Crop Selection and Modification" menu shown in Screen 21 (below) can currently be used only with the grain legume models.

```
          CROP SELECTIONS AND MODIFICATION
          ================================

0.  Return to Previous Menu

1.  Crop Selection ....................[ SOYBEAN
2.  Crop Parameter File ...............[ SBGRO930.SPE


    SELECTION ? [ Default = 0 ] --->
```

SCREEN 21.

When Option 1, "Crop Selection," is selected is Screen 21, the system checks which crop species files are present and then displays Screen 22 (below).

When Option 2, "Crop Parameter File," is selected in Screen 21, the user can choose a different crop species or parameter file as input. The default crop

```
                IBSNAT 3.0 CROPS
                ================
                 1)      DRY BEANS
                 2)      PEANUT
                 3)      SOYBEAN

                SELECT CROP (#) ====> 1
```

SCREEN 22.

species file is "??GRO940.SPE," where ?? is either SB for soybean, PN for peanut, or BN for dry bean.

In Screen 22, the user can choose to change the crop to one of those listed.

CULTIVAR

The "Cultivar Selection and Modification" menu shown in Screen 23 (below) allows the user to modify inputs related to the cultivar.

```
   CULTIVAR SELECTION AND MODIFICATION
   ===================================

0. Return to Previous Menu

1. Cultivar Selection ................[ IB0001 - BRAGG
2. Cultivar Parameter ................[ SBGRO930.CUL
3. Cultivar Parameter Modification ...|
4. Ecotype Selection .................[ SB701 - MATURITY GROUP 7



   SELECTION ? [ Default = 0 ] ---> 1
```

SCREEN 23.

When Option 1, "Cultivar Selection," is selected, Screen 24 (on following page) is presented.

Option 2, "Cultivar Parameter File," allows the user to choose an alternate parameter file as input.

When Option 3, "Cultivar Parameter Modification" is selected, Screen 25 (on following page) is presented.

Option 4, "Ecotype Selection," is applicable only for the grain legume models, which use an ecotype file to represent the variables that are used to define a group of cultivars with the same growth and development characteristics. In Chapter 5, "New Crop Model Features," more information on the ecotype file is presented.

```
                          VARIETY SELECTION
                          =================

                                                   ECOTYPE   MATURITY
NO.  ENTRY    VARIETY                               GROUP      GROUP
---  ------   --------------------                -------   --------
 1)  990001   M GROUP   1                           SB0101       01
 2)  990002   M GROUP   2                           SB0201       02
 3)  990003   M GROUP   3                           SB0301       03
 4)  IB0003   WAYNE                                 SB0301       03
 5)  990004   M GROUP   4                           SB0401       04
 6)  990005   M GROUP   5                           SB0501       05
 7)  990006   M GROUP   6                           SB0601       06
 8)  990007   M GROUP   7                           SB0701       07
 9)  990008   M GROUP   8                           SB0801       08
10)  990009   M GROUP   9                           SB0901       09
11)  990010   M GROUP  10                           SB1001       10
12)  990011   M GROUP 000                           SB0001       00
13)  990012   M GROUP  00                           SB0001       00
14)  990013   M GROUP   0                           SB0001       00
15)  UC0001   ALTONA                                SB0001       00

 More.... press < ENTER > key

16)  IB0001   BRAGG                                 SB0701       07
17)  IB0043   CLARK                                 SB0502       05
18)  IB0002   COBB                                  SB0801       08
19)  IB0060   CUMBERLAND                            INDETE       DE
20)  UC0002   MAPLE ARROW                           SB0001       00
21)  UC0003   MCCALL                                SB0001       00
22)  IB0003   WAYNE                                 OB0301       03

     VARIETY SELECTED ===>    16
     NEW SELECTION ?  --->
```

SCREEN 24.

In Screen 24, the user can choose an alternate cultivar from the one defined in FILEX. For this example, variety number 16, "Bragg," is the default cultivar. A user can select any variety or cultivar by entering one of the numbers from the first column.

```
             CULTIVAR SPECIFIC COEFFICIENTS
             ==============================

CULTIVAR :     BRAGG
-------------------------------

Please Check the User's Guide For Definitions,
Units, and Ranges of Coefficients.

  1) CSDVAR:  12.330           2) PPSEN :    .320
  3) PH2T5 :  19.500           4) FL-SH :  11.000
  5) FL-SD :  17.000           6) SD-PM :  36.000
  7) FL-LF :  15.000           8) LFMAX :   1.022
  9) SLAVR : 350.000          10) XFRT  :   1.000
 11) WTPSD :    .200          12) SFDUR :  26.000
 13) SDPDV :   2.050          14) PODUR :  15.000


Please Enter Parameter # You Would Like To Modify [Default = 0]
(Enter -1 to Save Values in File SBGRO930.CUL).
```

SCREEN 25.

In Screen 25, the user can modify all parameters which are defined in the cultivar file. This example screen displays the coefficients for the soybean cultivar "Bragg."

WEATHER

The "Weather Data Selection and Modification" menu allows the user to select and modify input variables related to the weather conditions (Screen 26, below).

```
          WEATHER DATA SELECTION AND MODIFICATION
          =======================================

0.  Return to Previous Menu

1.  Recorded/Simulated Data ............[ OBSERVED DATA
2.  Weather Data Selection .............[ UFGA7801.WTH
3.  Weather Data Path ..................[ C:\DSSAT3\WEATHER\
4.  Enter Weather File Name Interactive.[ UFGA7801.WTH
5.  Weather Data Modification ..........[ N


    SELECTION ? [ Default = 0 ] ---> 1
```

SCREEN 26.

In Screen 26, Option 1, "Recorded/Simulated Data," allows the user to define if either measured/observed weather data or generated weather data are to be used. In the case of generated data, the model generates these data internally through one of two weather generators that are part of the models, or by reading data from files which contain generated weather data (see Screen 27, on following page).

When Option 2, "Weather Data Selection," is selected, Screen 28 (on following page) is presented.

Option 3, "Weather Data Path," allows the user to define an alternate path where weather data files are located.

Option 4, "Enter Weather File Name Interactive," allows the user to enter an alternate file name. A user must be certain that this file exists; otherwise the model will not be able to simulate the selected management conditions. If a different weather year is selected, the system will modify all date-related inputs to the year selected.

Option 5, "Weather Data Modification," allows the user to interactively modify the weather variables by either adding or subtracting a constant number, multiplying one or more weather variables by a constant number, or setting one or more variables as constant. If 'Y' is selected for this Option, Screen 29 (on following page) is presented.

```
   WEATHER INPUT METHODS
   =====================

0. Return to Previous Menu

1. Field Observed Data .............................|
2. Externally Simulated Data .......................|
3. Internally Generated Data .......................|


   CURRENT WEATHER INPUT CONDITIONS ===> OBSERVED DATA
   SELECTION (#) ? [ Default = 0 ]  --->
```

Screen 27.

```
    WEATHER LOCATIONS              LAT.     LONG   ELEV  YEAR   DATA SET
    ------------------------------------------------------------------
 1) CIAT, PALMIRA, COLOMBIA       3.500  -76.400   -99.  1986   CCPA8601.WTH
 2) CIAT, PALMIRA, COLOMBIA       3.500  -76.400   -99.  1987   CCPA8701.WTH
 3) SUPHEN_BURI, THAILAND        14.500  100.100   -99.  1985   DTSP8501.WTH
 4) CNPAF, GOIANIA, BRAZIL      -16.300  -49.100   -99.  1987   EBGO8701.WTH
 5) ICTA, QUEZADA, GUATEMALA     14.300  -90.000   -99.  1989   IGQU8901.WTH
 6) IRRI, MUNOZ, PHILIPPINES     15.700  120.900   -99.  1985   IRMZ8501.WTH
 7) IRRI, MUNOZ, PHILIPPINES     15.700  120.900    50.  1986   IRMZ8601.WTH
 8) IRRI, PILA, PHILIPPINES      14.200  121.300    50.  1980   IPPI8001.WTH
 9) IRRI, PILA, PHILIPPINES      14.200  121.300    50.  1985   IPPI8501.WTH
10) IRRI, PILA, PHILIPPINES      14.200  121.300   -99.  1986   IPPI8601.WTH
11) CASTANA, IOWA, USA           42.200  -93.700   -99.  1979   IUCH7901.WTH
12) ASHLAND, KANSAS, USA         39.000  -97.000   -99.  1981   KSAS8101.WTH
13) KAJONDI_FARM, BURUNDI        -3.300   30.000    10.  1986   UBKA8601.WTH
14) GAINESVILLE, FLORIDA, USA    29.600  -82.400    10.  1976   UFGA7601.WTH
15) GAINESVILLE, FLORIDA, USA    29.600  -82.400         1978   UFGA7801.WTH


    More... PRESS ENTER KEY

16) GAINESVILLE, FLORIDA, USA    29.600  -82.400    10.  1979   UFGA7901.WTH
17) GAINESVILLE, FLORIDA, USA    29.600  -82.400    10.  1980   UFGA8001.WTH
18) GAINESVILLE, FLORIDA, USA    29.600  -82.400    10.  1981   UFGA8101.WTH
19) GAINESVILLE, FLORIDA, USA    29.600  -82.400    10.  1982   UFGA8201.WTH
20) GAINESVILLE, FLORIDA, USA    29.600  -82.400    10.  1984   UFGA8401.WTH
21) GAINESVILLE, FLORIDA, USA    29.600  -82.400    10.  1985   UFGA8501.WTH
22) GAINESVILLE, FLORIDA, USA    29.600  -82.400    10.  1986   UFGA8601.WTH
23) QUINCY, FLORIDA, USA         30.600  -86.400   -99.  1979   UFQU7901.WTH

    WEATHER DATA SELECTED ===>  15
    ALTERNATE SELECTION ? --->
```

Screen 28.

Screen 28 (on preceding page) allows the user to select an alternate weather file as input. The screen displays a listing of the weather data locations available for this example's disk path. For this example, weather data from Gainesville, Florida, collected during 1978 (UFGA7801.WTH) are used (i.e., the number "15" was selected in Screen 28 and is presented next to Option 2 in Screen 26).

```
SELECT/REVISE WEATHER VARIABLES:
================================

0)   RETURN                      OFFSET  MULT.  VALUE
1)   Photoperiod (Day length)      .00   1.00
2)   Solar Radiation               .00   1.00
3)   Maximum Temperature           .00   1.00
4)   Minimum Temperature           .00   1.00
5)   Rainfall                      .00   1.00
6)   Carbon Dioxide                .00   1.00  330.00
7)   Humidity (dew point)          .00   1.00
8)   Wind speed                    .00   1.00

 Relative adjustments of CO2 from a base value of    330. ppm.

 PFD and Solar Radiation automatically changed together.


 CHOICE ? < Default = 0 > ===>
```

Screen 29.

Screen 29 shows an overview of the weather variables which can be modified. In this example screen, the CO_2 concentration is set to 330 ppm, while none of the other variables are modified. When one of the variables is selected by its corresponding option number, Screen 30 (on following page) is presented.

```
Select modification option, then enter amount:

0)  NO CHANGE               ( ambient conditions )
1)  Additive Change         ( 3.0 = 3 higher )
2)  Subtractive Change      ( 3.0 = 3 lower )
3)  Multiplicative Change   ( 1.2 = 20% higher )
4)  Constant Value          ( 100 = constant of 100 )

<=== CHOICE? < Default = 0 >
```

SCREEN 30.

Screen 30 allows the user to choose one of the modification options listed in order to revise or alter the weather variable selected in Screen 29 (on preceding page).

SOIL

The "Soil Profile Selection and Modification" menu allows the user to modify input variables related to the soil profile characteristics (Screen 31, below).

```
   SOIL PROFILE SELECTION AND MODIFICATION
   =======================================

0. Return to Main Menu

1. Soil Profile Selection ............[ IBSB910015 - FSH
2. Soil Profile File .................[ SOIL.SOL
3. Soil Profile Path .................[ C:\DSSAT3\SOIL\
4. Soil Profile Layer Thickness ......|
5. Soil Profile Parameters ...........|
6. Soil Surface Parameters ...........|


   SELECTION ? [ Default = 0 ] ---> 1
```

SCREEN 31.

In Screen 31, Option 1, "Soil Profile Selection," allows the user to select an alternate soil profile as input. If this option is selected, Screen 32 (on following page) is presented. As can be seen in Screen 31, pedon number IBSB910015 "Millhopper Fine Sand" was selected from Screen 32. When an alternate soil profile is selected as input from that first presented in Screen 31, the user will be requested to redefine the initial soil conditions, because for many soils the initial conditions are soil profile specific (see Screen 34).

Option 2, "Soil Profile File" in Screen 31, allows the user to define an institute soil file as an alternate soil input file. For this example experiment, the institute is the University of Florida. Therefore the alternate soil file would be UF.SOL.

Option 3, "Soil Profile Path," allows the user to define an alternate directory path for the soil file.

Option 4, "Soil Profile Layer Thickness," allows the user to modify the thickness of each soil profile layer. If this option is selected, Screen 33 (on following page) is presented.

Option 5, "Soil Profile Parameters," allows the user to modify the input values for the most important soil profile parameters. These include the drained upper limit, lower limit of plant extractable soil water, saturated water content, initial soil water content, bulk density, pH, soil organic carbon content, and rooting characteristics. If this option is selected, Screen 34 is presented.

Option 6, "Soil Surface Parameters," allows the user to modify the input values for the most important soil surface characteristics. These include soil albedo, first stage evaporation limit, runoff curve number, drainage rate, nitrogen mineralization factor, and growth reduction or fertility factor, which is only implemented in the grain legume models. If this option is selected, Screen 35 is presented.

```
                    SOILS IN THE DATA BASE
                    ======================
REF
NO. TAXONOMY NAME                                                     SOIL NUMBER
--- ---------------------------------------------                     -----------
 1) Millhopper Fine Sand                                              IBSB910015
 2) Orangeburg Sandy Loam                                             IBSB910017
 3) Ida Silt Loam                                                     IBSB910026
 4) Millhopper Fine Sand                                              IBPN910015
 5) Millhopper Fine Sand                                              IBMZ910014
 6) Haynie                                                            IBWH910018
 7) M3                                                                IBBN910030
 8) San-Fernando                                                      IBBN910038
 9) Millhopper Fine Sand                                              IBBN910015
10) UNKNOWN                                                           GAPN930001
11) ANDAQUEPTIC HAPLAQUOLL                                            IBRI910001
12) VERTIC TROPAQUEPT                                                 IBRI910002
13)                                                                   IBRI910063
14)                                                                   IBRI910071

     SELECTED SOIL TYPE ===>  1
     NEW SELECTION ?    --->
```

Screen 32.

Screen 32 shows a listing of some of the soil profiles available. More information on how to modify the initial conditions is described in the next section, "Initial Conditions," in this Chapter.

```
      LAYER DEPTH MODIFICATION
      ========================

   0)   RETURN TO THE MAIN MENU

   1)      .00 -    5.00........]   5.00 cm
   2)     5.00 -   15.00........]  10.00 cm
   3)    15.00 -   30.00........]  15.00 cm
   4)    30.00 -   45.00........]  15.00 cm
   5)    45.00 -   60.00........]  15.00 cm
   6)    60.00 -   90.00........]  30.00 cm
   7)    90.00 -  120.00........]  30.00 cm
   8)   120.00 -  150.00........]  30.00 cm
   9)   150.00 -  180.00........]  30.00 cm


       SELECTION ? [ Default = 0 ] ===>
```

Screen 33.

```
   SOIL PROFILE MODIFICATION
   =========================

0. Return to Main Menu

1. Drained Upper Limit ..............|
2. Lower Limit ......................|
3. Saturated Water Content ..........|
4. Initial Soil Water Content .......|
5. Bulk Density .....................|
6. pH ...............................|
7. Soil Organic Carbon ..............|
8. Rooting Characteristics ..........|


   SELECTION ? [ Default = 0 ] ===>
```

Screen 34.

```
   SOIL SURFACE PARAMETERS
   =======================

0. Return to Previous Menu

1. Soil Albedo ...................]   .180
2. Evaporation Limit .............]  5.000
3. Runoff Curve Number ...........] 66.000
4. Drainage Rate .................]   .500
5. Mineralization Factor .........]  1.000
6. Growth Reduction/Fertility Fac.]   .840


   SELECTION (#) ? [ Default = 0 ] --->
```

Screen 35.

Initial Conditions

The "Initial Conditions at Start of Simulation" menu allows the user to modify the input variables used to initialize the crop model when a simulation is started (Screen 36, below).

```
        INITIAL CONDITIONS AT START OF SIMULATION
        =========================================

 0. Return to Previous Menu

 1. Initial Soil Water Content ..........................0
 2. Initial Soil N03 ....................................0
 3. Initial Soil NH4 ....................................0
 4. Growth Reduction Factor Due to Poor Soil Fertility ..]      .840
 5. Root Weight from Previous Crop ......................]    100.00
 6. Nodule Weight from Previous Crop ....................]       .00
 7. Previous Crop .......................................]        SB


   SELECTION ? [ Default = 0 ] --->
```

Screen 36.

In Screen 36, Options 1, 2 and 3, "Initial Soil Water Content," "Initial Soil NO3" and "Initial Soil NH4," respectively, allow the user to modify these variables for each layer. If Option 1 is selected, Screen 37 (on following page) is presented.

Option 4, "Growth Reduction Factor Due to Poor Soil Fertility," is used only in the grain legume models to adjust biomass growth for conditions which are currently not included in the crop process simulations.

Options 5, 6 and 7, "Root Weight from Previous Crop," "Nodule Weight from Previous Crop" and "Previous Crop," respectively, relate to crop residues remaining from previous crop and which are present at planting of the current crop. This information is needed when the soil nitrogen balance is simulated.

```
    INITIAL SOIL WATER CONTENT
    ==========================

  0) RETURN TO THE MAIN MENU

  1)   0. -    5. cm ........]        .0860  cm3/cm3
  2)   5. -   15. cm ........]        .0860  cm3/cm3
  3)  15. -   30. cm ........]        .0860  cm3/cm3
  4)  30. -   45. cm ........]        .0860  cm3/cm3
  5)  45. -   60. cm ........]        .0860  cm3/cm3
  6)  60. -   90. cm ........]        .0760  cm3/cm3
  7)  90. -  120. cm ........]        .0760  cm3/cm3
  8) 120. -  150. cm ........]        .1300  cm3/cm3
  9) 150. -  180. cm ........]        .2580  cm3/cm3


    SELECTION ? [ Default = 0 ] --->
```

Screen 37.

Screen 37 displays the variables which can be changed if Option 1, “Initial Soil Water Content” in Screen 36, is selected.

Planting

The "Planting Timing and Control" menu allows the user to define the conditions at planting (Screen 38, below).

```
   PLANTING TIMING AND CONTROL
   ===========================

 0. Return to Main Menu

 1. Planting Date ......................]      JUN 15
 2. Year of Planting ...................]        1978
 3. Plant Population ...................]      29.900
 4. Row Spacing ........................]      91.000
 5. Row Direction ......................]        .000
 6. Planting Depth .....................]       4.000
 7. Planting Material Dry Weight .......]     -99.000
 8. Planting Method ....................]   SEED
 9. Planting Management ................]   ON REPORTED DATE
10. Automatic Planting Options .........|

   SELECTION (#) ? [ Default = 0 ] --->
```

Screen 38.

In Screen 38, Options 1 and 2, "Planting Date" and "Planting Year," respectively, allow the user to modify the planting date and year.

Options 3 and 4, "Plant Population" and "Row Spacing," respectively, allow the user to define plant density, row spacing and plant spacing.

Option 5, "Row Direction," is used only in the grain legume models to define light interception for the simulated leaf level photosynthesis processes.

Option 6, "Planting Depth," affects germination and emergence.

Option 7, "Planting Material Dry Weight," allows the user to define the initial weight of the root crops at planting.

Option 8, "Planting Method," allows the user to define planting method, strategy (e.g., seed, transplant, etc.)

Option 9, "Planting Management," allows the user to define when planting occurs; either at the specified date in Option 1 or 2 or through an automatic planting routine (Option 10).

Option 10, "Automatic Planting Options," allows the user to define a window for soil water and temperature which determine when soil conditions in the top of the profile are optimum for germination (see Screen 39, below). Delineation of soil water and temperature, within which planting can occur, can also be specified in Screen 39. It is important that the earliest planting date, defined in Screen 39, be a date after the start of simulation date, as defined in Screen 19.

```
   AUTOMATIC PLANTING MANAGEMENT
   =============================

0. Return to Previous Menu

1. Earliest Planting Date ......................] JUN  4 1978
2. Latest Planting Date ........................] JUL 19 1978
3. Lowermost Soil Water Content ................]     40.
4. Uppermost Soil Water Content ................]    100.
5. Management Depth For Soil Water .............]     30.
6. Maximum Soil Temperature (Top 10 cm Avg).(°C)]     40.
7. Minimum Soil Temperature (Top 10 cm Avg).(°C)]     10.


   START OF SIMULATION DATE IS AFTER THE START OF
   THE AUTOMATIC PLANTING WINDOW.
   PLEASE MODIFY PLANTING DATE OR SIMULATION WILL TERMINATE !


   SELECTION (#) ? [ Default = 0 ] --->
```

SCREEN 39.

Harvest

The “Harvest Timing and Control” menu allows the user to define the conditions for crop harvesting. The default for harvest is when the crop reaches harvest maturity, as shown in Screen 40 (below).

```
   HARVEST TIMING AND CONTROL
   ==========================

0. Return to Main Menu                        AT HARVEST MATURITY
                                                  -9    -9
1. Harvest Management .................]
2. Harvest Date .......................]
3. Harvest Days after Planting ........]   -9
4. Harvest Stage ......................]   Harvest
5. Harvest Component ..................]
6. Harvest Size Group .................]
7. Harvest Percentage .................]   100.
8. Automatic Harvest Options ..........|



   SELECTION (#) ? [ Default = 0 ] --->
```

Screen 40.

In Screen 40, Option 1, “Harvest Management,” allows the user to define various management options. If this option is selected, Screen 41 (on following page) is presented.

Option 2, “Harvest Date,” is active only when, in Screen 41, the user selects Option 2, “On Reported Date(s).” Then, Screen 40 is presented again and the user can select Option 2 and enter the harvest date.

Option 3, “Harvest Date After Planting,” is active only when, in Screen 41, the user selects Option 3, “On Reported Days After Planting.” Then, Screen 40 is presented again and the user can select Option 3 and enter the number of days after planting for the harvest date.

Option 4, “Harvest Stage,” allows the user to select the phenological or development stage at which to harvest the crop and terminate the simulation.

Options 5, 6 and 7, “Harvest Component,” “Harvest Size Group” and Harvest

Percentage," respectively, presented in this screen, are in the process of being developed. An option for "Multiple Harvests" is also under development.

When Option 8, "Automatic Harvest Options," is selected, Screen 42 (on following page) is presented, which allows the user to select conditions for harvest.

```
   HARVEST MANAGEMENT STRATEGY
   ===========================

0. Return to Previous Menu

1. At Harvest Maturity ..........................
2. On Reported Date(s) ..........................
3. On Reported Days After Planting ...............
4. At Reported Growth Stage(s) ...................
5. Automatic When Conditions are Satisfactory .....

   CURRENT HARVEST MANAGEMENT      ===> AT HARVEST MATURITY
   SELECTION (#) ? [ Default = 0 ] --->
```

Screen 41.

Screen 41 allows the user to define various harvest management options. These include harvest at crop harvest maturity (Option 1 and the default for Option 1 in Screen 40); harvest on reported date (Option 2) or fixed day (Option 3); harvest at a particular developmental stage (Option 4); and an automatic harvest as a function of a set of crop and environmental conditions (Option 5).

```
   AUTOMATIC PLANTING MANAGEMENT
   =============================

0. Return to Previous Menu

1. Earliest Harvest Date (Days after Maturity) .]      0
2. Latest Harvest Date   (Days of Year ) .......] DEC 31 1978
3. Product Harvested .......................(%)]    100.
4. Residue Harvested .......................(%)]      0.


   SELECTION (#) ? [ Default = 0 ] --->
```

SCREEN 42.

Screen 42 shows the various conditions which can be set when the automatic harvest management option is selected in Screen 40.

WATER AND IRRIGATION

The "Water and Irrigation Management and Modification" menu allows the user to modify the various options and variables associated with the water balance simulation and irrigation applications (Screen 43, below).

```
   WATER AND IRRIGATION MANAGEMENT AND MODIFICATION
   ================================================

0. Return to Main Menu

1. Water Balance Simulation ..........] Y
2. Irrigation Management .............] ACCORDING TO FIELD SCHEDULE
3. Automatic Irrigation Control ......] -9.000  -9.0
4. Automatic Irrigation-Fixed Amount..] -9.000 mm
5. Irrigation Efficiency .............]  .75
6. Enter Irrigation Interactive ......|
7. Water Output File .................] Y


   SELECTION ? [ Default = 0 ] ===>
```

SCREEN 43.

Option 1, "Water Balance Simulation" in Screen 43 (on preceding page), allows the user to turn the water balance simulation on or off.

Option 2, "Irrigation Management," allows the user to define the various irrigation management options, and when selected, Screen 44 (below) is presented.

Options 3 and 4, "Automatic Irrigation Control" and "Automatic Irrigation - Fixed Amount," respectively, allow the user to define the automatic irrigation controls explained earlier. These two options can be modified only when an automatic irrigation strategy has been selected under Option 2.

Option 5, "Irrigation Efficiency," allows the user to determine how much water is actually applied. For example, for furrow irrigation or sprinkler irrigation not all water measured in the supplying pipes is actually applied to the field or plot.

Option 6, "Enter Irrigation Interactive," can only be accessed when, under Option 2, "Irrigation Management," the user selects "According to Field Schedule" (see example in Screen 43). When Option 6 is selected, Screen 45 is presented.

Option 7, "Water Output File," allows the user to either switch the soil and plant water output file on or off.

```
   IRRIGATION MANAGEMENT STRATEGY
   ==============================

0. Return to Main Menu

1. Rainfed / Not Irrigated ........................
2. Irrigated According To Field Schedule ..........
3. Automatic Irrigation / Refill Profile ..........
4. Automatic Irrigation / Apply Fixed Amount ......
5. No Water Stress / No Water Balance Simulation ..


   CURRENT IRRIGATION MANAGEMENT   ---> ACCORDING TO FIELD SCHEDULE
   SELECTION (#) ? [ Default = 0 ] ===>
```

SCREEN 44.

In Screen 44, the user can select either rainfed with no supplemental irrigation (Option 1) or irrigate according to the field schedule (Option 2). In the latter case, the irrigation data must be in FILEX. There are also two automatic irrigation options: Options 3 and 4.

Option 3 selects to refill the selected profile depth to the drained upper limit or field capacity.

Option 4 applies a fixed amount each time the system calls for an irrigation event. Both automatic irrigation events are controlled by a soil depth and a threshold value for extractable water, which can both be defined by the user.

Option 5, "No Water Stress/No Water Balance Simulation," allows the user to choose not to simulate the soil water balance, which is the same as setting the water balance simulation to 'N' in Screen 43.

```
INTERACTIVE DATA ENTRY FOR IRRIGATION
=======================================
```

#	Date	Amount (mm)	Irrigation Type
16	78272	8.0	Furrow, mm
17	78279	8.0	Furrow, mm
18	78283	8.0	Furrow, mm
19	78294	10.0	Furrow, mm

```
(E)dit, (A)dd and event, (D)elete, (Q)uit (↵ = Done)
```

SCREEN 45.

Screen 45 is an example screen listing the options available for adding irrigation interactively. In this screen, a user can either edit, add, or delete an irrigation event.

Nitrogen

The “Nitrogen Management and Modification” menu allows the user to modify variables and options associated with the soil nitrogen simulation (Screen 46, below).

```
   NITROGEN MANAGEMENT AND MODIFICATION
   ====================================

0. Return to Main Menu

1. Nitrogen Balance Simulation .......] Y
2. N-Fertilizer Management ...........] NOT FERTILIZED
3. Automatic Fertilizer Management ...]
4. Enter N-Fertilizer Interactive ....|
5. Nitrogen Fixation .................] N-FIX SIMULAT.
6. Nitrogen Fixation Characteristics..|
7. Nitrogen Output File ..............] Y


   SELECTION ? [ Default = 0 ] ===>
```

Screen 46.

Option 1, “Nitrogen Balance Simulation,” allows the user to turn the soil nitrogen balance simulation on or off. Note that the water balance simulation must be set to ‘Y’ to simulate the soil nitrogen balance.

Option 2, “N-Fertilizer Management,” allows the user to define the various nitrogen fertilizer management options. When this option is selected, Screen 47 (on following page) is presented.

Option 3 in Screen 48, “Automatic Fertilizer Management,” can only be accessed if Option 3, “Automatic N-Fertilizer Application” in Screen 47, is selected. When Option 3 in Screen 47 is selected, Screen 48 is presented. The user makes his selection(s) in Screen 48 and a ‘Y’ is placed next to Option 3 in Screen 46.

Option 4, “Enter N-Fertilizer Interactive,” can only be accessed if Option 2, “Apply N-Fertilizer According to Field Schedule” in Screen 47, is selected. The screen which defines interactive N-fertilizer applications is not shown, but is similar to the screen for irrigation management (Screen 45, on preceding page).

Options 5 and 6, "Nitrogen Fixation" and "Nitrogen Fixation Characteristics,", respectively, are only applicable for the grain legume models. When Option 5 is selected, Screen 49 is presented. When Option 6 is selected, Screen 50 is presented.

Option 7, "Nitrogen Output File," allows the user to either switch the soil and plant nitrogen output file on or off.

```
   NITROGEN FERTILIZER MANAGEMENT STRATEGY
   =======================================

0. Return to Main Menu

1. Not Fertilized ..................................
2. Apply N-Fertilizer According to Field Schedule ...
3. Automatic N-Fertilizer Application ..............
4. No Nitrogen Stress / No N-Balance Simulation .....


   CURRENT IRRIGATION MANAGEMENT   ---> NOT FERTILIZED
   SELECTION (#) ? [ Default = 0 ] ===>
```

Screen 47.

In Screen 47 (above), the user can select Option 1, "Not Fertilized," with no supplemental nitrogen fertilizer applied, or Option 2, "Fertilize According to the Field Schedule."

In the latter case, the nitrogen fertilizer data must be in FILEX. Please note that Option 4 in Screen 46, "Enter N-Fertilizer Interactive" can only be accessed if Option 2 in Screen 47 is selected. (See Option 4 for screen 46.)

Option 3 allows "Automatic Nitrogen Fertilizer Application" as a function of pre-set conditions. Please note that Option 3 in screen 46, "Automatic Fertilizer Management," can only be accessed if Option 3 in this screen is selected. (See Option 3 for Screen 46.) When Option 3 in Screen 46 is selected, Screen 48 (on following page) is presented.

Option 4 in Screen 47 allows the user to choose not to simulate the soil nitrogen balance, which is the same as setting Option 1 to 'N' in Screen 46.

```
   AUTOMATIC NITROGEN FERTILIZER APPLICATION
   =========================================

0. Return to Previous Menu

1. Threshold - Nitrogen Stree Factor ........(%)]   50.000
2. Amount of N-Fertilizer Per Application .kg/ha]   25.000
3. Application Depth .......................(cm)]   30.000
4. Material Code ............................(#)] Ammonium nitrate



   SELECTION (#) ? [ Default = 0 ] --->
```

Screen 48.

Screen 48 shows the various threshold levels which can be set for automatic nitrogen fertilizer applications. In this screen, the threshold value (Option 1) uses a nitrogen factor expressed on a relative basis between 0 and 100 percent, where “0” means that the plants are under complete nitrogen stress and “100” means that the plants are under no nitrogen stress.

Options 2, 3 and 4 allow the user to define the amount of nitrogen fertilizer to be applied, the application depth, and the type of nitrogen fertilizer, respectively, when the crop model calls for a nitrogen fertilizer application, as selected under the threshold level of Option 1.

```
   NITROGEN FIXATION STRATEGY
   ==========================

0. Return to Previous Menu

1. No Nitrogen Fixation Simulation ..................
2. Dynamic Nitrogen Fixation Simulation .............
3. Unlimited Nitrogen Fixation Simulation ...........


   CURRENT NITROGEN FIXATION SELECTION ===> N-FIX SIMULAT.
   SELECTION (#) ? [ Default = 0 ]     --->
```

Screen 49.

Screen 49 (above) shows the nitrogen fixation variables available when Option 5 in Screen 46 is selected. Please note that Option 5 in Screen 46 is available only for the grain legume models (soybean, peanut and drybean).

In Screen 49, Option 1, “No Nitrogen Fixation Simulation,” allows the user to simulate a complete soil and plant nitrogen balance. However, plants will not fix nitrogen, which is similar to non-nodulating cultivars.

Option 2, “Dynamic Nitrogen Fixation Simulation,” allows the user to simulate both a dynamic nitrogen uptake and nitrogen fixation as a function of soil and weather conditions.

Option 3, “Unlimited Nitrogen Fixation Simulation,” allows the user to simulate a dynamic nitrogen uptake and assumes that the remainder of the nitrogen required for growth is available via N fixation.

```
   NITROGEN FIXATION CHARACTERISTICS
   =================================

0.  Return to Previous Menu

1.  Rhizobia Effectiveness ........]  1.000
2.  Rhizobia Number (Relative .....]  1.000


   SELECTION (#) ? [ Default = 0 ] --->
```

SCREEN 50.

Screen 50 shows the nitrogen fixation characteristics which can be modified when Option 6 in Screen 46 is selected.

In Screen 50, Option 1, "Rhizobia Effectiveness," is a relative number between 0 and 1. An effectiveness of "1" means that the rhizobia are completely active with respect to nitrogen fixation.

Option 2, "Rhizobia Number," is also a relative number (0 to 1) which allows the user to determine the initial amount of rhizobia present at the start of simulation.

PHOSPHORUS

The "Phosphorus Management and Modification" menu is under development and is not available for the current DSSAT v3 crop models.

Residue

The "Crop Residue Management at Start of Simulation" menu allows the user to modify variables related to crop residue at the start of simulation (Screen 51, below).

```
      CROP RESIDUE MANAGEMENT AT START OF SIMULATION
      ==============================================

  0.  Return to Main Menu

  1.  Residue Application Date .............................]    78166
  2.  Residue Applied at Start of Simulation ..............]   1000.0 kg/ha
  3.  Residue Nitrogen Concentration .......................]      .80 %
  4.  Residue Phosphorus Concentration .....................]      .00 %
  5.  Residue Incorporation ................................]   100.00 %
  6.  Residue Incorporation Depth ..........................]     15.0 cm
  7.  Residue Material Code ................................]    IB001
  8.  Root Weight from Previous Crop .......................]   100.00 kg/ha
  9.  Nodule Weight from Previous Crop .....................]      .00 kg/ha
 10.  Previous Crop ........................................]       SB


    SELECTION (#) ? [ Default = 0 ] --->
```

Screen 51.

In Screen 51, Option 1, "Residue Application Date," uses the same date as the start of simulation date.

Options 2, 3, 4, 5 and 6 allow the user to define, respectively, the amount of residue applied, its nitrogen and phosphorus concentration, the amount of residue incorporated into the soil, and the incorporation depth.

Options 8 and 9, "Root Weight from Previous Crop" and "Nodule Weight from Previous Crop," respectively, allows the user to enter these values. Please note that the program assumes that all below ground material from a previous crop remains in the soil.

Option 10 allows the user to define the crop grown previously (e.g., the crop grown before the current crop).

Pest And Disease

The "Pest and Disease Selection and Modification" menu is currently available only in the grain legume models (Screen 52, below).

```
          PEST AND DISEASE SELECTION AND MODIFICATION
          ===========================================

 0.  Return to Main Menu

 1.  Pest & Disease Simulation .........] N
 2.  Enter Pest Population or Damage ...]
 3.  Pest Output File ..................] N



     SELECTION ? [ Default = 0 ] ===>
```

Screen 52.

In Screen 52, Option 1, "Pest & Disease Simulation," allows the user to turn the pest and disease simulation on or off.

Option 2, "Enter Pest Population or Damage," is not currently available. Information on how to manually edit or create a pest population or crop damage can be found in Appendix C herein.

Option 3, "Pest Output File," allows the user to switch the pest output file on or off.

Crop Process Options

The “Simulation Control and Modification” menu allows the user to control various internal process simulations of the models (Screen 53, below).

```
   SIMULATION CONTROL AND MODIFICATION
   ===================================

0. Return to Main Menu

1. Water Balance Simulation .................] Y
2. Nitrogen Balance Simulation ..............] Y
3. Nitrogen Fixation Simulation .............] N-FIX SIMULAT.
4. Phosphorus Balance Simulation ............] N
5. Pest and Disease Interaction Simulation ..] Y
6. Weather Input Method .....................] OBSERVED DATA
7. Initial Conditions .......................] AS REPORTED
8. Photosynthesis Simulation Method .........] CANOPY PHOT
9. Evaporation Simulation Method ............] PRIESTLEY-TAYLOR



   SELECTION ? [ Default = 0 ] ===>
```

Screen 53.

In Screen 53, Options 1, 2, 3, 4, 5, 6 and 7 can be modified in their respective menus. For example, the options for the Water Balance simulation (Option 1) and Nitrogen Balance simulation (Option 2), can be found in the “Water and Irrigation” and “Nitrogen” sections, respectively, of this Chapter. Please note that Options 3, 5 and 8 are crop model or species specific.

OUTPUT CONTROL

The “Output File Options and Controls” menu allows the user to switch each output file (Options 2-9 in Screen 54, below) on or off.

```
          OUTPUT FILE OPTIONS AND CONTROLS
          ================================

 0.  Return to Main Menu

 1.  Video Output ...............................   I
 2.  Overview Output File .......................   Y
 3.  Summary Output File ........................   Y
 4.  Growth Output File .........................   Y
 5.  Carbon Balance Output File .................   Y
 6.  Water Balance Output File ..................   Y
 7.  Nitrogen Balance Output File ...............   Y
 8.  Mineral Nutrients Output File ..............   N
 9.  Pest Output File ...........................   Y
10.  Frequency of Simulation Output (in days)....   3
11.  Save Output Files with Experiment Code .....   N
12.  Write Output Files with Long Format ........   Y


   SELECTION ? [ Default = 0 ] ===>
```

SCREEN 54.

In Screen 54, Option 1, “Video Output,” allows the user to control the model output to the computer screen or monitor. Only the “I”, “Interactive Option,” will actually display output on the computer screen. “I” is the default for Option 1.

When a “1” is entered (that is, the <1> key and then the <ENTER> key are pressed), indicating that NO video output is required, this menu screen will immediately go blank and all screen writes will be eliminated. If the user wishes to select this option (i.e., have no screen display), but also wishes to select any of the other options, it is recommended that the user first enter those options and then select Option 1. Otherwise, although other options in this screen can be selected after entering “1,” the user will not see the menu and will have to work from memory.

Once a “1” is entered, press the <ENTER> key twice. A dialog box will be presented in which the user can enter a “run name” for the simulation. Press the <ENTER> key again. Simulation will begin, but nothing will be seen on the screen during the simulation. When simulation is completed, a message will be displayed on the screen informing the user of this.

NOTE: *If you select Option 1 and enter an "1," but wish to see this menu screen again, simply press "1" again. However, enter the second "1" BEFORE pressing the <ENTER> key twice, because after that is done, this screen cannot be refreshed.*

Option 2, "Overview Output File," allows the user to control the output file, OVERVIEW.OUT.

Option 3, "Summary Output File," allows the user to control the output file, SUMMARY.OUT. A 'Y' selection for this file will erase the file from the previous run and will create a new output file; an 'A' selection for this file will append the outputs of the current simulation to the already existing SUMMARY.OUT file and no headers will be written. A 'N' will cause this file not to be created.

Option 4, "Growth Output File," allows the user to control the output file, GROWTH.OUT.

Option 5, "Carbon Balance Output File," allows the user to control the output file, CARBON.OUT.

Option 6, "Water Balance Output File," controls the output file, WATER.OUT.

Option 7, "Nitrogen Balance Output File," allows the user to control the output file, NITROGEN.OUT.

Option 8, "Mineral Nutrients Output File," is not yet operational and will be implemented later to control the output file, PHOSPHOR.OUT.

Option 9, "Pest Output File," allows the user to control the output file, PEST.OUT. Please note that this option is available only in the grain legume models.

Option 10, "Frequency of Simulation Output," allows the user to control the output interval, in days, for those output files which contain time-series data, such as GROWTH.OUT, WATER.OUT, CARBON.OUT, NITROGEN.OUT, PHOSPHOR.OUT and PEST.OUT.

Option 11, "Save Output Files with Experiment Code," allows the user to save the files using the same file name as FILEX for that experiment, except for its last character, which must be a G, W, N, C, P or D, for growth, water, nitrogen, carbon, phosphorus, and pests and diseases, respectively. The default setting for Option 11 is 'N'.

Option 12, "Write Output Files with Long Format," writes the output file with additional variables besides the standard variables used for each model. Screens 14 and 15 in the "Graphic Display" section of Chapter 6 give an indication of some of the additional variables which are stored in file GROWTH.OUT if the long format is selected for the output files.

CHAPTER EIGHT.
PROBLEMS AND ERROR MESSAGES

Many types of personal micro-computers are available and it has not been possible to test the DSSAT v3 simulation models on all possible systems, hardware configurations or operating systems. System requirements to run DSSAT v3 and its crop models can be found in Chapter 2 of Volume 1-1 (Tsuji et al. 1994) of this book. A listing of important error messages is given in Table 7.

Some common problems which may occur:

1. One of the three required executable files, MDRIV940.EXE, MINPT940.EXE and one of the crop simulation modules, is missing.
2. The three required executable files are not located in the same directory.
3. The model is being run from a data directory rather than from the crop model data directory.
4. One of the input files is missing. Required files are :
   - EXP.LST – use the file manager in DSSAT v3 to recreate this file;
   - The experiment selected during the model run. Look for a file with an X extension, i.e., ????????.CRX, where ???????? includes the Institute code, Site code, year and experiment number and CR is the crop code, e.g., UFGA7801.SBX. The ????????.CRX should also be included in the EXP.LST file. This file can be created or edited with the XCreate program (see Volume 1-4, Imamura 1994, of this book) or added to the EXP.LST with the General File Manager (see Chapter 6 herein).
   - The cultivar file. This file is normally located either in the crop data directory or in the genotype directory of DSSAT v3 (C:\DSSAT3\GENOTYPE). The file name has the CUL extension, using the file name convention ????????.CUL, where ???????? is the crop model name and version, e.g., SBGRO940.CUL.
   - The ecotype file. This file is normally located either in the crop data directory or in the genotype directory of DSSAT v3 (C:\DSSAT3\GENOTYPE). The file name has the ECO extension, using the file name convention ????????.ECO, where ???????? is the crop model name and version e.g., SBGRO940.ECO.
   - The crop species file. This file is normally located either in the crop data directory or the genotype directory of DSSAT v3 (C:\DSSAT3\GENOTYPE). The file name has the SPE extension, using the file naming convention ????????.SPE, where ???????? is the crop model name and version, e.g., SBGRO940.SPE.
   - The soil file. This file is normally located either in the crop data directory or in the soil data directory of DSSAT v3 (C:\DSSAT3\SOIL). Look for a file with the SOL extension. The general soil file name used in the crop models is SOIL.SOL.

- The weather file. This file is normally located either in the crop data directo ry or in the weather data directory of DSSAT v3 (C:\DSSAT3\WEATHER). Look for a file with the WTH extension, using the file name convention ????????.WTH, where ???????? includes the institute code, site code, and year, e.g., UFGA7801.WTH.
- The crop species in the *CULTIVAR section of FILEX is wrong. Check the code under "CR" in the *CULTIVAR section.
- The cultivar specified in the *CULTIVAR section is wrong or not included in the genotype file of the model. Check the code under INGENO in the *CULTIVAR sec tion of FILEX. Also check the genotype file ???????.CUL. If thecultivar is currently not included in this file, use the genotype calculator program to add this cultivar to the cultivar list and to estimate the initial values for all genetic coefficients.
- The weather station specified in the *FIELDS section is wrong or the file is not included in either the model data directory or weather data directory. Check the code under WSTA in the *FIELDS section of FILEX.
- The soil profile identified in the *FIELDS section is wrong or the soil profile is not part of the soil file SOIL.SOL. Check the section under ID_SOIL in the *FIELDS section of FILEX.

Required model input data are explained in detail in Volume 2-1 (Jones et al., 1994) of this book, and example files are included with the required variables highlighted for the various options available for simulation.

The input section of the model includes detailed error checking routines. The most common error messages are listed in Table 7. These messages include the subroutine and the input file in which the error occurred, and in some cases also the line number of the input file. These messages also give you some information about the type of error which occurred. In many cases these errors can be corrected by editing FILEX using either the XCreate program (see Volume 1-4, Imamura 1994, of this book) or any other ASCII text editor.

There might be cases where the model gives a runtime error. These errors could either be due to a problem with the input file, such as a "0" where the model expects a number > 0, or other problems. However, in some cases, these errors can be caused by a combination of inputs which we have been unable to test during model development. If this happens, please make sure that your error is reproducible; that is, you can recreate the same error and error message using the same combination of input conditions. Please carefully document the problem, error message, combination of inputs and input files, and model version number and contact one of the model developers, a listing of whom can be found in Appendix D.

Table 7. Important Error messages.

AUTFER 1
Error in Fertilizer Sensitivity Analysis Selection. Fix entry or batch file.

AUTIRR 1
Error in Irrigation Sensitivity Analysis Selection. Fix entry or batch file.

CROPGR 1
Incompatible input file format.

CROPGR 2
Planting date is before start of simulation date. Please fix input file.

MRUN 1
Specified weather data files not available. Please create files.

IDWTH 1
Error in Weather Sensitivity Selection entry. Fix entry or batch file.

IDWTH 2
End of File in Weather Sensitivity Selection entry. Fix entry or batch file.

INPUT 1
Error in Selection entry. Fix entry or batch file.

INPUT 2
Planting Date is Before Start of Simulation. Please Fix Input File.

IPCROP 1
Error in Crop Parameter Input File. End of File Reached.

IPECO 1
Error in Ecotype entry. Fix entry or batch file.

IPECO 2
Error in Ecotype entry. Fix ecotype input file.

IPECO 3
DEFAULT Ecotype not found. Fix ecotype input file.

IPECO 21
Ecotype input section not found. Please correct file.

IPENV 1
Incorrect format in environmental section. Check format.

IPEXP 1
Treatment input section not found. Please add to input file.

IPEXP 2
Error in Experiment Selection entry. Fix entry or batch file.

IPEXP 3
Error in Treatment Selection entry. Fix entry or batch file.

IPEXP 4
Simulation must begin on or before the planting date. Correct dates.

IPEXP 10
Error in crop input. Correct input file.

IPEXP 11
Error in cultivar input. Correct input file.

IPEXP 20
You selected a crop which can not be simulated by this model. Please ReExecute.

IPEXP 21
Experiment list input section not found. Please correct file.

IPEXP 22
Incorrect weather method option selected. Please correct file.

IPFERT 1
Fertilizer input section not found. Please add to input file.

IPFERT 2
Error in fertilizer inputs. Check format.

IPFERT 10
Error in date of fertilizer application input. Correct input file.

IPFERT 11
Error in depth of fertilizer application input. Correct input file.

IPFERT 12
Error in amount of N-fertilizer input. Correct input file.

IPFERT 13
Error in amount of P-fertilizer input. Correct input file.

IPFERT 14
Error in fertilizer code. Correct input file.

IPFLD 1
Field input section not found. Please add to input file.

IPFLD 2
Error in field inputs. Check format.

IPFLD 10
Error in weather station input. Correct input file.

IPFLD 11
Error in soil identification input. Correct input file.

IPHAR 1
Harvest input section not found. Please add to input file.

IPHAR 2
Error in harvest inputs. Check format.

IPHAR 3
Harvest growth stage not found. Please add to input file.

IPHAR 4
Reported harvest date not found. Please add to input file.

IPHAR 5
Reported harvest date after planting not found. Please add to input file.

IPHAR 10
Error in date of harvest input. Correct input file.

IPHAR 11
Error in harvest input. Correct input file.

IPHAR 12
Error in harvest stage code. Correct input file.

IPIRR 1
Irrigation input section not found. Please add to input file.

IPIRR 2
Error in irrigation inputs. Check format.

IPIRR 10
Error in date of irrigation input. Correct input file.

IPIRR 11
Error in amount of irrigation input. Correct input file.

IPIRR 12
Error in irrigation code. Correct input file.

IPPARM 21
Pest parameter input section not found. Please correct file.

IPPLNT 1
Planting input section not found. Please add to input file.

IPPLNT 2
Error in planting inputs. Check format.

IPPLNT 10
Error in planting date input. Check format.

IPPLNT 11
Error in plant population input. Check format.

IPPLNT 12
Error in row spacing input. Check format.

IPPLNT 13
Error in row orientation input. Check format.

IPRES 1
Residue input section not found. Please add to input file.

IPRES 2
Error in residue inputs. Check format.

IPRES 10
Error in date of residue application input. Correct input file.

IPRES 11
Error in amount of residue input. Correct input file.

IPRES 12
Error in amount of residue N input. Correct input file.

IPRES 13
Error in amount of residue P input. Correct input file.

IPRES 14
Error in amount of residue K input. Correct input file.

```
IPSLAN     1
Initial soil analysis section not found.  Please add to input file.

IPSLAN     2
Error in initial soil analysis inputs.  Check format.

IPSLAN    10
Error in initial bulk density inputs.  Please check data.

IPSLAN    11
Error in initial organic carbon inputs.  Please check data.

IPSLAN    12
Error in initial nitrogen inputs.  Please check data.

IPSLIN     1
Initial soil input section not found.  Please add to input file.

IPSLIN     2
Error in initial soil inputs.  Check format.

IPSLIN    10
Error in initial soil water inputs.  Please check data.

IPSLIN    11
Error in initial NH4 inputs.  Please check data.

IPSLIN    12
Error in initial NO3 inputs.  Please check data.

IPSLIN    13
Error in initial residue weight inputs.  Please check data.

IPSLIN    14
Error in initial residue nodule weight inputs.  Please check data.

IPSLIN    15
Error in inoculation efficiency data.  Please check data.

IPSLIN    16
Error in fixation efficiency data.  Please check data.

IPSIM      1
Simulation control section not found.  Please add to input file.

IPSIM      2
Incorrect number of lines in simulation control section.  Check format.

IPSIM      3
Impossible combination--for MEEVP='Z', MEPHO must be 'L'.

IPSOIL     1
Error in Soil Selection entry.  Fix entry or batch file.

IPSOIL     2
More than 19 layers in the soil profile.  Correct input file.

IPSOIL     3
Error in Soil Selection entry.  Fix soil input file.

IPSOIL     4
End of soil file.  Please add missing information to input file.
```

IPSOIL 5
Depth of second tier does not match the one of the first tier. Fix input file.

IPSOIL 6
Number of layers in second tier does not match the number in the first tier.

IPSOIL 21
Soil input section not found. Please correct file.

IPVAR 1
Error in Cultivar entry. Fix entry or batch file.

IPVAR 2
Error in Cultivar entry. Fix cultivar input file.

IPVAR 21
Genetics input section not found. Please correct file.

IPVAR 22
LFMAX is less than or equal 0. Please correct file.

IPVAR 23
SLAVAR is less than or equal 0. Please correct file.

IPVAR 24
XFRUIT is less than or equal 0. Please correct file.

IPVAR 25
WTPSD is less than or equal 0. Please correct file.

IPVAR 26
SDPDVR is less than or equal 0. Please correct file.

IPVAR 27
SFDUR is less than or equal 0. Please correct file.

IPVAR 28
PODUR is less than or equal 0. Please correct file.

IPWTH 1
Simulation date must be AFTER first available weather day. Correct dates.

IPWTH 2
Missing day in weather data file.

IPWTH 3
Missing or negative data in weather data file.

PLANT 1
Error in photosynthesis process option. Please correct input file.

PATH 1
Code not found in profile file DSSATPRO.FLE. Please correct file.

READA 1
Error in experiment data (averages) file. Could not find @TRNO header line.

READA 2
Error in experiment data (averages) file.

SEDLYR 1
Error in Soil Sensitivity Analysis Selection entry. Fix entry or batch file.

SEWTH 1
Error in Weather Sensitivity Analysis Selection. Fix entry or batch file.

SWFIX 1
Error in Fertilizer Sensitivity Analysis Selection. Fix entry or batch file.

SWINSC 1
Error in Initial Soil Sensitivity Analysis Selection. Fix entry or batch file.

SWIRR 1
Error in Irrigation Sensitivity Analysis Selection. Fix entry or batch file.

WEATHR 1
Weather method selected not available. Please fix input file.

WTHMOD 1
Weather modification created negative data in minimum data set. Check changes.

MISC -1
End-of-file encountered in input file.

MISC 6100
Integer overflow in input file. Check format.

MISC 6101
Invalid integer in input file. Check format.

MISC 6103
Invalid real in input file. Check format.

MISC 6205
A Edit descriptor expected for Character. Check format.

MISC 6206
Invalid format in input file. Check format.

MISC 6416
File not found. Create input file.

CHAPTER NINE.
NEW CROP MODEL FEATURES

Nitrogen Balance And Nitrogen Fixation (grain legume models only)

The soil N-balance in DSSAT v3 CERES models is the same as the soil N-balance of the individual CERES models in DSSAT v2.1 (Godwin and Jones, 1991). CROPGRO now also has detailed soil and plant nitrogen balance components, which include simulation of nitrogen uptake, nitrogen fixation, and nitrogen mobilization. Hoogenboom et al. (1990) incorporated the CERES-Wheat soil-N balance into SOYGRO V5.42 and added a nitrogen fixation component. This version of SOYGRO, called SOYNIT, underwent testing with 14 different data sets from the NiFTAL Project (Hoogenboom et al. 1990). These components were incorporated into CROPGRO and therefore the soybean, peanut, and dry bean models are now sensitive to soil-N and N-fixing dynamics. Users can run the models without simulating the soil nitrogen balance, and in this case, nitrogen is assumed to be non-limiting as was the case in the individual grain legume models. Also, users can select the soil nitrogen balance without simulating nodule growth and nitrogen fixation. In this case, soil nitrogen is taken up first each day, and any remaining nitrogen demand in the plant is met by allocating sufficient carbon to fix the nitrogen without considering limitations in the nitrogen-fixing mechanisms. Usually, both the soil nitrogen-balance and dynamic nitrogen-fixation are turned on, so that plant carbohydrate status, soil temperature, aeration, and limiting nodule mass can limit nitrogen fixation and simulate non-nodulating legume lines, such as those used in many nitrogen fixation experiments.

Crop Rotations

An option exists which allows users to select whether to reinitialize the soil conditions after each run or to use the ending conditions from one simulation run as inputs to subsequent simulation runs. This feature allows for crop rotations to be studied, with carryover effects in the soil currently limited to crop residue, soil nitrogen, soil carbon, and soil water as a function of soil depth. Future additions will include phosphorus, other soil properties, and perhaps pest organisms. The Sequence Analysis program of DSSAT v3, described in Volume 3-2 (Thornton et al. 1994 b) of this book, allows users to specify crop rotations and to analyze results over long-term simulations.

Evapotranspiration Calculations

In the CERES and CROPGRO models, options exist for the Priestley-Taylor method (Priestley and Taylor, 1972) and the FAO-Penman method (Doorenbos and Pruitt 1975) for potential evapotranspiration calculation. The Priestley-Taylor method is the same as used in previous versions of the models and was described by Ritchie (1985). The use of the FAO-Penman method requires daily humidity and wind speed data, in addition to the minimum weather data set required previously (Penman, 1948). The DSSAT v3 weather file format includes columns for these data when they are available. However, when these additional inputs are not available or have not been measured, users should select the Priestley-Taylor method.

Photosynthesis Calculation Options (grain legume models only)

The CROPGRO model includes two options to compute daily canopy photosynthesis. The first option is based on a single calculation of daily light interception followed by a single calculation of daily canopy photosynthesis. The second option is based on hourly calculations of sunlit and shaded leaf light interception followed by hourly photosynthesis calculations. Using this option, the daily canopy calculation is based on a canopy light extinction coefficient, in contrast to table look-up values in the earlier GRO models. The same light response curve is still used in CROPGRO, but it was modified slightly. For the hourly calculations, the hedge-row photosynthesis model developed by Boote and Loomis (1991) was used, since it more accurately simulates the effects of row and plant spacing on light interception and growth, which is needed to simulate plant density studies. For the hedge-row model, relationships were needed to simulate height and width of canopies, and thus routines were added to crop species files relating to potential elongation of internodes to node position on the plants in order to compute canopy height and width growth.

Carbon Dioxide Effects

The CERES and CROPGRO models include the capability to simulate the effects of CO_2 on photosynthesis and water use. Internally in the models the daily potential transpiration calculations are being modified by the CO_2 concentration, based on the effects of CO_2 on stomatal conductivity (Peart et al., 1989). For the CERES and CROPGRO models, when the canopy photosynthesis model is used, a multiplicative modification is made to daily canopy photosynthesis as described by Curry et al. (1990). For the CROPGRO model, when the hedge-row photosynthesis model is selected, CO_2 is used to modify the leaf assimilation rate in a more mechanistic way, with an adaptation of the Farquhar et al. model by Pickering et al. (1993).

Climate Change Studies

The DSSAT v3 crop simulation models have the capability to modify daily weather data, read in from the weather file, as well as photoperiod (daylength). Each weather variable can be modified, by multiplying a constant times the input value and/or by adding a constant to it. This provides flexibility to change one or all weather variables, and includes the capability to set them to constant values similar to conditions as observed in growth chamber and other constant environment experiment studies. Users can specify the date that a given modification is to begin and can also define more than one entry if the experiment includes environment switching of any type. These options are included in a special environmental section of FILEX for any experiment and can also be changed interactively during any model run.

Weather Generators

The DSSAT v3 crop simulation models have built-in capabilities for simulating weather using either one of two weather generators. Coefficients for generating weather are stored in site-specific climate files, e.g. *.CLI, such as UFGA.CLI, where UFGA is the site of the weather station. One of the weather generators is SIMMETEO, as developed by Geng et al. (1986). SIMMETEO requires only monthly averages of solar radiation, maximum and minimum air temperatures, precipitation, and days with precipitation as inputs. SIMMETEO then computes coefficients and uses the WGEN weather generator to simulate daily data. The second weather generator is WGEN, as developed by Richardson (1985). WGEN requires more statistics as input than does SIMMETEO. Its monthly weather statistics can be computed from daily data for a number of years, preferably five or more complete historical weather years. The DSSAT v3 models' ability to simulate weather internally, using only monthly averages of variables, will greatly expand the application of these models to areas where the monthly data are all that will be available.

Species, Ecotype And Cultivar Inputs

The DSSAT v3 grain legume models have three files that quantify parameters for each grain legume crop. The earlier genetics file for each crop, e.g., GENETICS.SB9, used for soybean in SOYGRO V5.42 in DSSAT v2.1, was split into two files for DSSAT v3 and additional changes were made. One file is the CULtivar file; for example, SBGRO940.CUL. This file contains fewer genetic coefficients for soybean than SOYGRO V5.42. A second file is the ECOtype file; for example, SBGRO940.ECO, which contains coefficients that are thought to change among GROUPS of cultivars, but not for every cultivar. Thus the number of coefficients that have to be estimated for a new cultivar was reduced to 15. Since the coefficients in this file have to estimated for each cultivar that is to be simulated, they are discussed in more detail in Appendix A of this Part. A third file of parameters is the SPEcies file, designated by SPE, for example SBGRO940.SPE. This file is equivalent to the CROPPARM file in the earlier GRO models. In the naming convention for the cultivar file, ecotype file, and species file, the first two characters correspond to a particular species, and the following six characters represent the model used and its version number. For instance, the file, SBGRO940.*, designates the Soybean species, ecotype, and cultivar input files used in the GRO model (CROPGRO) released in 1994.

Both the generic CERES model and the CERES - Rice model use only the cultivar files and do not have either an ecotype file or a species file as input. The change in these models in DSSAT v3 from those of the older models is that the DSSAT v3 genetic files use the same file format as that of the new Input/Output file structures described in Volume 2-1 (Jones et.al 1994) of this book.

Pest Effects (grain legume models only)

A generalized method for incorporating pest damage in the crop models was developed (Batchelor et al., 1993) for DSSAT v3. Twenty-one coupling points were identified in the CROPGRO model, and damage can be simulated by reducing various state and/or rate variables. Damage can also be induced by input or field-observed damage or for field-measured pest populations. Pest and pest damage coefficients are defined in a special pest input file (e.g., for soybean, SBGRO940.PST). These pest coefficients are defined through the coupling points in the crop model and the damage rates associated with a unit of pest input.

Field-observed pest damage or pest densities are input into the time course observed data file (FILET), which may include plant and soil variables, as well as pest damage levels (for example, UFGA8101.SBT). This approach was taken in order to facilitate a common way of handling field data in DSSAT v3. Users can also input hypothetical values of pest levels or pest damage in the time course file (FILEA) for an experiment in order to study damage effects on crop growth and yield. A detailed description of the method for incorporating pest damage into the DSSAT v3 models can be found in Appendix B of this Part.

CHAPTER TEN.
TEMPORARY MODEL INPUT FILE

In Figure 3 some of the crop simulation model interface options are shown. The model driver program distributed with DSSAT v3, i.e. MDRIV940.EXE, calls the model input module, i.e. MINPT940.EXE. The model input module reads the experiment details file FILEX and creates a temporary output file, called "IBSNAT30.INP." The input module has the option to create a temporary output file, using different formats. In Figure 3 three options are shown. Filetype is "I" for the CEGER940.EXE, CRGRO940.EXE, RICER940.EXE and CSSIM940.EXE models. Filetype "X" is also used by the CSSIM940.EXE model and could be used by other crop models if installed in DSSAT v3. A user-defined filetype could also be used for a new crop simulation module to link it to DSSAT v3. However, the input module would have to be modified to add this particular filetype to the system.

Filetype "X" is identical to the current Input/Output file format of FILEX, except that it includes only information for one treatment, rather than an entire experiment. Filetype "I" is similar to the current Input/Output file format of FILEX,

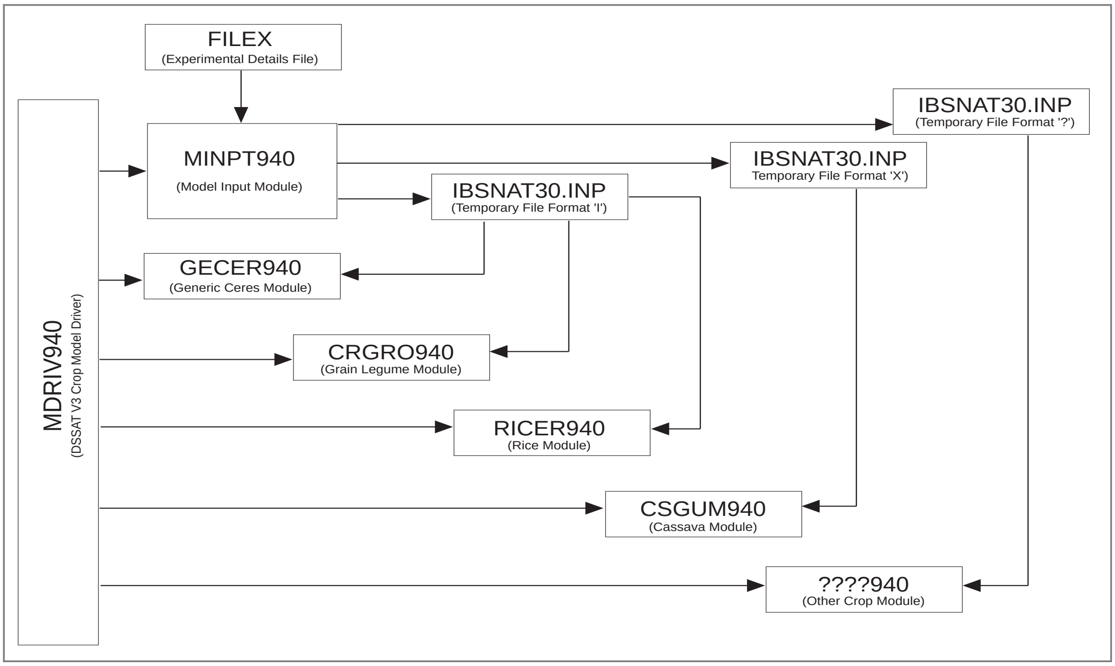


FIGURE 3. RELATIONSHIP BETWEEN THE TEMPORARY MODEL INPUT FILE AND THE VARIOUS CROP SIMULATION MODULES.

except that it contains additional information with respect to location and names of input files, and all headers, comment lines, and blank lines have been deleted. An example of a typical temporary file is shown in Table 8. This file was generated using the same experimental and treatment selections discussed earlier in Chapter 5, "Running the Crop Model," herein. The example FILEX for this experiment is shown in Table 4.

All information shown in this file is required; if lines or headers are deleted the crop simulation models will not run.

The section "*MODEL INPUT FILE includes the run mode, i.e. interactive etc., run number, experiment number, i.e. entry number in the experiment list file EXP.LST, treatment number, and number of treatments in the selected experiment.

The section "*FILES" includes the name and path for respectively the crop simulation module, FILEX, FILEA, FILET, species file, ecotype file, cultivar file, pest file, soils file, weather file, and output files.

The section "*SIMULATION CONTROL" is identical to the simulation control section of FILEX, except that the headers have been deleted. Note that it also includes the automatic management section.

The section "*EXP.DETAILS" is identical to the experiment details section of FILEX, except for no header information.

The section "*TREATMENTS" only shows information for the actual treatment which is being simulated, while all level information has been deleted.

The sections "*CULTIVARS", "*FIELDS", "*INITIAL CONDITIONS", "*PLANTING DETAILS", "*IRRIGATION", "*FERTILIZERS", "*RESIDUES", "*ENVIRONMENT" and "*HARVEST" all only include the information for the actual treatment level which is simulated. The information for the other levels has been eliminated, and all headers have been deleted. If a particular section does not have any levels, such as "*HARVEST" shown in the example, the actual section header still needs to be included.

The "*SOIL" section includes the detailed soil profile description, including location, names, soil surface and soil layer information for the soil selected under the "*FIELDS" section. A blank line delineates the information for the first and second tier. The format is the same as the format of the data stored in the actual soil profile file, except for the headers.

The "*CULTIVAR" section includes all the values of the variables for the particular cultivar selected under the "*CULTIVAR" section discussed earlier. The format is the same as the format of the data stored in the actual cultivar file, except for the headers.

The user needs to be aware that the crop simulation modules do not include error checking procedures. If the user decides to modify the format of this temporary file, or creates his own temporary file through different procedures, we can not guarantee that the crop simulation module will work properly.

TABLE 8. Example of a Temporary Crop Model Input File, Using File Format = "I" ("IBSNAT30.INP").

```
*MODEL INPUT FILE            I     1     2     1     2
*FILES
MODEL          CRGRO940.EXE
FILEX          UFGA7801.SBX
FILEA          UFGA7801.SBA
FILET          UFGA7801.SBT
SPECIES        SBGRO940.SPE C:\DSSAT3\GENOTYPE\
ECOTYPE        SBGRO940.ECO C:\DSSAT3\GENOTYPE\
CULTIVAR       SBGRO940.CUL C:\DSSAT3\GENOTYPE\
PESTS          SBGRO940.PST C:\DSSAT3\PEST\
SOILS          SOIL.SOL     C:\DSSAT3\SOIL\
WEATHER        UFGA7801.WTH C:\DSSAT3\WEATHER\
OUTPUT         OVERVIEW
*SIMULATION CONTROL
                   1     1     S 78166  2150 BRAGG, IRRIGATED & NON-IR
                   Y     Y     Y     N     N     N
                   M     M     E     R     S     C
                   R     R     N     R     M
                   N     Y     Y     3     Y     Y     Y     Y     N     N     Y
!AUTOMATIC MANAGEM
               78155 78200   40.  100.   30.   40.   10.
                 30.   50.  100. GS000 IR001  10.0  .750
                 30.   50.   25. FE001 GS000
                100.     1   20.
                   0 78365  100.    0.
*EXP.DETAILS
  2UFGA7801 SB BRAGG, IRRIGATED & NON-IRRIGATED
*TREATMENTS
  11 0 0 IRRIGATED
*CULTIVARS
   SB IB0001 BRAGG (7)
*FIELDS
   UFGA0001 UFGA7801 -99      0. DR000    0.    0. 00000 FSA    180. IBSB910015
*INITIAL CONDITIONS
      SB 78166  100.    0.  1.00  1.00           1
      5.  .086    .6   1.5
     15.  .086    .6   1.5
     30.  .086    .6   1.5
     45.  .086    .6   1.5
     60.  .086    .6   1.5
     90.  .076    .6    .6
    120.  .076    .6    .5
    150.  .130    .6    .5
    180.  .258    .6    .5
*PLANTING DETAILS
   78166   -99  29.9  29.9     S     R   91.    0.   4.0  -99.  -99. -99.0 -99.0
```

```
*IRRIGATION
    .750  -99.  -99.  -99.   -99   -99    .0
   78181 IR001   13.     0
   78230 IR001   13.     0
   78235 IR001   13.     0
   78237 IR001   13.     0
   78240 IR001   11.     0
   78242 IR001   11.     0
   78244 IR001   11.     0
   78246 IR001   11.     0
   78250 IR001   11.     0
   78253 IR001   11.     0
   78256 IR001    8.     0
   78259 IR001    8.     0
   78262 IR001    8.     0
   78265 IR001    8.     0
   78269 IR001    7.     0
   78272 IR001    8.     0
   78279 IR001    7.     0
   78283 IR001    8.     0
   78294 IR001   10.     0
*FERTILIZERS
*RESIDUES
   78166 RE001  1000   .80   .00   .00  100.   15.
*ENVIRONMENT
*HARVEST
*SOIL
 IBSB910015  SCS         FSA    180. Millhopper Fine Sand
 Gainesville USA          29.630 -82.370 Loamy,silic,hyperth Gross. Paleudults ( 15)
.18   5.0   .50   66.  1.00   .84 IB001 IB001 IB001
    5.        .023  .086  .230 1.000   7.4  1.36   .90 -99.0 -99.0 -99.0   .00   5.3 -99.0 -99.0
   15.        .023  .086  .230 1.000   7.4  1.40   .69 -99.0 -99.0 -99.0   .00   5.4 -99.0 -99.0
   30.        .023  .086  .230  .498  15.8  1.46   .28 -99.0 -99.0 -99.0   .00   5.7 -99.0 -99.0
   45.        .023  .086  .230  .294  28.0  1.47   .20 -99.0 -99.0 -99.0   .00   5.8 -99.0 -99.0
   60.        .023  .086  .230  .294  27.6  1.47   .20 -99.0 -99.0 -99.0   .00   5.8 -99.0 -99.0
   90.        .021  .076  .230  .380  17.5  1.43   .09 -99.0 -99.0 -99.0   .00   5.9 -99.0 -99.0
  120.        .020  .076  .230  .133    .3  1.48   .03 -99.0 -99.0 -99.0   .00   5.9 -99.0 -99.0
  150.        .027  .130  .230  .062    .1  1.57   .03 -99.0 -99.0 -99.0   .00   5.9 -99.0 -99.0
  180.        .070  .258  .360  .031    .0  1.79   .03 -99.0 -99.0 -99.0   .00   5.9 -99.0    .0

    5.    .0    .0    .0    .0    .0    .0    .0    .0
   15.    .0    .0    .0    .0    .0    .0    .0    .0
   30.    .0    .0    .0    .0    .0    .0    .0    .0
   45.    .0    .0    .0    .0    .0    .0    .0    .0
   60.    .0    .0    .0    .0    .0    .0    .0    .0
   90.    .0    .0    .0    .0    .0    .0    .0    .0
  120.    .0    .0    .0    .0    .0    .0    .0    .0
  150.    .0    .0    .0    .0    .0    .0    .0    .0
  180.    .0    .0    .0    .0    .0    .0    .0    .0
*CULTIVAR
IB0001 BRAGG (7)       SB0701 12.33  .320 19.50 10.00 15.00 35.50 15.00 1.022 350.0 170.0  1.00  .180
```

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APPENDIX A.
GENETIC COEFFICIENTS

Information on differences among crop genotypes are input to the model through genotype coefficient files. These files include BACER940.CUL for barley, MZCER940.CUL for maize, MLCER940.CUL for millet, SGCER940.CUL for sorghum, WHCER940.CUL for wheat, BNGRO940.CUL for dry bean, PNGRO940.CUL for peanut, SBGRO940.CUL for soybean, RICER940.CUL for rice, and CSSIM940.CUL for cassava. The coefficients stored in these files allow a single crop growth model to predict differences in development, growth and yield among cultivars when planted in the same environment. These genetic coefficients can be divided into those that relate to vegetative and reproductive development, to vegetative growth, and to reproductive growth.

DSSAT v3 contains a program called Generating Genetic Coeffiecients, or GenCalc (see Hunt et al., 1993; and Volume 3-4, Hunt et al., 1994, of this book), which can be used to estimate the genetic coefficients for each species and new (or old) cultivars. The model user is therefore referred to this document for further detail about estimating these coefficients. Here, only the coefficients required for each species are defined, and an example for each species is given. Cultivar coefficients available for each species in DSSAT v3 are listed in this appendix.

CERES-Barley

Table 9 shows an example of the current cultivars defined for barley. Required genetic coefficients include :

VAR#	Identification code or number for a specific cultivar.
VAR-NAME	Name of cultivar.
ECO#	Ecotype code for this cultivar, points to the Ecotype in the ECO file (currently not used).
P1V	Relative amount that development is slowed for each day of unfulfilled vernalization, assuming that 50 days of vernalization is sufficient for all cultivars (0-9).

P1D	Relative amount that development is slowed when plant are grown in a photoperiod 1 hour shorter that the optimum (which is considered to be 20 hours) (1-5).
P5	Relative grain filling duration based on thermal time (degree days above a base temperature of 1^{O}C), where each unit increase above zero adds 40 degree days to an initial value of 300 degree days..
G1	Kernel number per unit weight of stem (less leaf blades and sheaths) plus spike at anthesis (1/g) (1-5).
G2	Kernel filling rate under optimum conditions (mg/day) (1-5).
G3	Non-stressed dry weight of a single stem (excluding leaf blades and sheaths) and spike when elongation ceases (g) (1-5).
PHINT	Phylochron interval; the interval in thermal time (degree days) between successive leaf tip appearances.

TABLE 9. GENETIC COEFFICIENTS FILE FOR CERES-BARLEY. (BACER940.CUL)

```
*BARLEY GENOTYPE COEFFICIENTS - GECER940 MODEL
!
@VAR#  VRNAME           ECO#    P1V   P1D    P5    G1    G2    G3 PHINT
!                                 1     2     3     4     5     6     7
!
IB0001 generic (2)      IB0001    .5   4.0   2.0   5.0   3.0   1.0 95.00
IB0002 generic (6)      IB0001    .5   4.0   2.0   5.0   3.0   4.0 95.00
IB0003 Golden Promise ( IB0001    .5   4.0   2.0   5.0   3.0   2.0 95.00
IB0004 Maris Mink (2)   IB0001    .5   3.0   2.0   5.0   3.0   2.0 95.00
IB0005 Aramir           IB0001    .5   3.4   2.0   3.0   3.0   3.0 95.00
IB0006 Georgie (2)      IB0001    .5   3.0   2.0   3.0   4.0   2.0 95.00
IB0007 Julia            IB0001    .5   7.0   5.0   3.5   3.0   2.0 95.00
IB0008 Union  (2)       IB0001    .5   3.6   2.0   3.0   3.0   2.0 95.00
IB0009 Tellus           IB0001    .5   3.5   2.0   3.0   3.0   3.0 95.00
IB0010 Mona             IB0001    .5   1.5   2.0   3.0   3.0   3.0 95.00
IB0011 Lise             IB0001    .5   1.5   2.0   3.0   3.0   3.0 95.00
IB0012 Igri (2)         IB0001   6.0   3.0   2.0   2.0   4.0   3.0 95.00
IB0013 Video (2)        IB0001   6.0   3.0   2.0   4.0   5.0   2.5 95.00
IB0014 Maris Otter (2)  IB0001   3.0   4.5   2.0   5.0   3.0   2.0 95.00
IB0015 Proctor (2)      IB0001    .5   4.5   5.0   5.2   1.1    .7 95.00
IB0016 Berolina (2)     IB0001    .5   4.0   4.0   3.0   3.0   2.0 95.00
IB0017 Arena (2)        IB0001    .5   4.5   4.0   3.0   3.0   2.0 95.00
IB0018 Deba Abed        IB0001    .5   3.0   3.0   2.5   3.0   3.0 95.00
IB0019 Philip (6)       IB0001    .5   3.0   1.5   4.0   3.0   4.0 95.00
IB0020 Yokozuna (6)     IB0001    .5   3.0   2.0   3.0   5.0   4.0 95.00
IB0021 Andrea (6)       IB0001   6.0   3.0   3.0   3.0   3.0   4.0 95.00
IB0022 Marinka (2)      IB0001   6.0   3.0   3.0   3.0   3.0   2.0 95.00
IB0023 Catinka (6)      IB0001   6.0   3.0   3.0   3.0   3.0   4.0 95.00
IB0024 Sonate (2)       IB0001   6.0   3.0   3.0   3.0   3.0   2.0 95.00
IB0025 Tapir (6)        IB0001   6.0   3.0   3.0   3.0   3.0   4.0 95.00
IB0026 Franka (6)       IB0001   6.0   3.5   3.0   3.0   3.0   4.0 95.00
IB0027 Mammut (6)       IB0001   6.0   3.0   3.0   3.0   3.0   3.0 95.00
IB0028 Maris Puma       IB0001   6.0   3.0   3.0   3.0   3.0   3.0 95.00
IB0029 Optima (6)       IB0001   6.0   3.0   4.0   3.0   2.5   3.0 95.00
IB0030 Maris Badger     IB0001    .5   7.0   5.0   4.0   5.0   3.0 95.00
IB0040 Shabet           IB0001   3.0   1.0   5.0   4.0   3.0   2.0 95.00
IB0042 Ord Early        IB0001   3.0   3.0   1.0   2.2   3.5   4.0 95.00
IB0043 Ord Mid-Early    IB0001   3.0   3.0   1.0   2.2   3.5   4.0 95.00
IB0044 Ord Mid-Late     IB0001   3.0   3.0   1.0   2.2   3.5   4.0 95.00
IB0045 Ord Late         IB0001   3.0   3.0   1.0   2.2   3.5   4.0 95.00
IB0051 Azure (6)        IB0001    .5   1.0   3.5   4.0   3.0   4.0 95.00
IB0052 Bedford (2)      IB0001    .5   1.0   3.5   5.0   3.0   2.0 95.00
IB0053 Bumper (6)       IB0001    .5   1.0   3.5   4.0   3.0   4.0 95.00
IB0054 Hector (2)       IB0001    .5   1.0   3.5   4.0   3.0   2.0 95.00
```

```
IB0055 Larker (6)       IB0001    .5   1.0   3.5   4.0   3.0   4.0 95.00
IB0056 Robust (6)       IB0001    .5   1.0   3.5   4.0   3.0   4.0 95.00
IB0057 Summit (2)       IB0001    .5   1.0   3.5   4.0   3.0   2.0 95.00
IB0058 Bowman (6)       IB0001    .5   1.0   3.5   4.0   3.0   4.0 95.00
IB0059 Hazen  (6)       IB0001    .5   1.0   3.5   4.0   3.0   4.0 95.00
IB0101 A. Abiad (2)     IB0001    .5   3.0   4.0   3.5   4.0   2.0 95.00
IB0102 Beecher (6)      IB0001    .5   2.5   4.0   2.2   3.5   4.0 95.00
IB0103 Algerie (2)      IB0001    .5   3.0   3.0   2.0   2.0   2.0 95.00
```

CERES-Maize

Table 10 shows an example of the current cultivars defined for corn. Required genetic coefficients include :

VAR#	Identification code or number for a specific cultivar
VAR-NAME	Name of cultivar
ECO#	Ecotype code for this cultivar, points to the Ecotype in the ECO file (currently not used).
P1	Thermal time from seedling emergence to the end of the juvenile phase (expressed in degree days above a base temperature of 8°C) during which the plant is not responsive to changes in photoperiod.
P2	Extent to which development (expressed as days) is delayed for each hour increase in photoperiod above the longest photoperiod at which development proceeds at a maximum rate (which is considered to be 12.5 hours).
P5	Thermal time from silking to physiological maturity (expressed in degree days above a base temperature of 8°C).
G2	Maximum possible number of kernels per plant.
G3	Kernel filling rate during the linear grain filling stage and under optimum conditions (mg/day).
PHINT	Phylochron interval; the interval in thermal time (degree days) between successive leaf tip appearances.

TABLE 10. GENETIC COEFFICIENTS FILE FOR CERES-MAIZE. (MZCER940.CUL)

```
*MAIZE GENOTYPE COEFFICIENTS - GECER940 MODEL
!
@VAR#  VRNAME           ECO#    P1    P2    P5    G2    G3 PHINT
!                                1     2     3     4     5     6
IB0001 CORNL281        IB0001 110.0 0.300 685.0 825.4  6.60 75.00
IB0002 CP170           IB0001 120.0 0.000 685.0 825.4 10.00 75.00
IB0003 LG11            IB0001 125.0 0.000 685.0 825.4 10.00 75.00
IB0004 F7 X F2         IB0001 125.0 0.000 685.0 825.4 10.00 75.00
IB0005 PIO 3995        IB0001 130.0 0.300 685.0 825.4  8.60 75.00
IB0006 INRA            IB0001 135.0 0.000 685.0 825.4 10.00 75.00
IB0007 EDO             IB0001 135.0 0.300 685.0 825.4 10.40 75.00
IB0008 A654 X F2       IB0001 135.0 0.000 685.0 825.4 10.00 75.00
IB0009 DEKALB XL71     IB0001 140.0 0.300 685.0 825.4 10.50 75.00
IB0010 F478 X W705A    IB0001 140.0 0.000 685.0 825.4 10.00 75.00
IB0011 DEKALBXL45      IB0001 150.0 0.400 685.0 825.4 10.15 75.00
IB0012 PIO 3382        IB0001 160.0 0.700 890.0 750.0  8.50 75.00
IB0013 B59*OH43        IB0001 162.0 0.800 685.0 784.0  6.90 75.00
IB0014 F16 X F19       IB0001 165.0 0.000 685.0 825.4 10.00 75.00
IB0015 WASHINGTON      IB0001 165.0 0.400 715.0 750.0 11.00 75.00
IB0016 B14XOH43        IB0001 172.0 0.300 685.0 825.4  8.50 75.00
IB0017 R1*(N32*B14)    IB0001 172.0 0.800 685.0 825.4 10.15 75.00
IB0018 B60*R71         IB0001 172.0 0.800 685.0 710.4  7.70 75.00
IB0019 WF9*B37         IB0001 172.0 0.800 685.0 825.4 10.15 75.00
IB0020 B59*C103        IB0001 172.0 0.800 685.0 825.4 10.15 75.00
IB0021 Garst 8702      IB0001 175.0 0.200 960.0 778.0  6.00 75.00
IB0022 B14*C103        IB0001 180.0 0.500 685.0 825.4 10.15 75.00
IB0023 B14*C131A       IB0001 180.0 0.500 685.0 825.4 10.15 75.00
IB0024 PIO 3720        IB0001 180.0 0.800 685.0 825.4 10.00 75.00
IB0025 WASH/GRAIN-1    IB0001 185.0 0.400 775.0 760.0 12.00 75.00
IB0026 A632 X W117     IB0001 187.0 0.000 685.0 825.4 10.00 75.00
IB0027 Garst 8750      IB0001 190.0 0.200 930.0 810.0  6.30 75.00
IB0028 TAINAN-11       IB0001 200.0 0.800 670.0 730.0  6.80 75.00
IB0029 PIO 3541        IB0001 200.0 0.300 800.0 700.0  8.50 75.00
IB0030 PIO 3707        IB0001 200.0 0.700 800.0 590.0  6.30 75.00
IB0031 PIO 3475        IB0001 200.0 0.700 800.0 725.0  8.60 75.00
IB0032 PIO 3382        IB0001 200.0 0.700 800.0 650.0  8.50 75.00
IB0033 PIO 3780        IB0001 200.0 0.760 685.0 600.0  9.60 75.00
IB0034 PIO 3780*       IB0001 200.0 0.760 685.0 725.0  9.60 75.00
IB0035 McCurdy 84aa    IB0001 200.0 0.300 940.0 700.0  8.00 75.00
IB0036 C281            IB0001 202.0 0.300 685.0 825.4  5.80 75.00
IB0037 SWEET CORN      IB0001 210.0 0.520 625.0 825.0 10.00 75.00
IB0038 Garst 8555      IB0001 215.0 0.400 890.0 800.0  9.00 75.00
IB0039 PIO 3901        IB0001 215.0 0.760 600.0 560.0  9.00 75.00
IB0040 B8*153R         IB0001 218.0 0.300 760.0 575.0  8.80 75.00
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IB0041 Garst 8808        IB0001 220.0 0.400 780.0 780.0  8.50 75.00
IB0042 B73 X MO17        IB0001 220.0 0.520 880.0 730.0 10.00 75.00
IB0043 PIO 511A          IB0001 220.0 0.300 685.0 645.0 10.50 75.00
IB0044 W69A X F546       IB0001 240.0 0.300 685.0 825.4 10.00 75.00
IB0045 A632 X VA26       IB0001 240.0 0.300 685.0 825.4 10.00 75.00
IB0046 W64A X W117       IB0001 245.0 0.000 685.0 825.4  8.00 75.00
IB0047 PIO 3147          IB0001 255.0 0.760 685.0 834.0 10.00 75.00
IB0048 WF9*B37           IB0001 260.0 0.800 710.0 825.4  6.50 75.00
IB0049 NEB 611           IB0001 260.0 0.300 720.0 825.0  9.00 75.00
IB0050 PV82S             IB0001 260.0 0.500 750.0 600.0  8.50 75.00
IB0051 PV76S             IB0001 260.0 0.500 750.0 600.0  8.50 75.00
IB0052 PIO 3183          IB0001 260.0 0.500 750.0 600.0  8.50 75.00
IB0053 CESDA-28          IB0001 260.0 0.500 669.0 780.0  7.10 75.00
IB0054 B14*OH43          IB0001 265.0 0.800 665.0 780.0  6.90 75.00
IB0055 MCCURDY 6714      IB0001 265.0 0.300 825.0 825.4  9.80 75.00
IB0056 FM 6              IB0001 276.0 0.520 867.0 616.0 10.70 75.00
IB0057 TOCORON-3         IB0001 276.0 0.520 867.0 600.0  8.12 75.00
IB0058 NC+59             IB0001 280.0 0.300 750.0 825.0 10.00 75.00
IB0059 H6                IB0001 310.0 0.300 685.0 825.4 10.00 75.00
IB0060 H610(UH)          IB0001 300.0 0.520 920.0 580.0  6.40 75.00
IB0061 PB 8              IB0001 300.0 0.520 990.0 400.0  7.00 75.00
IB0062 B56*C131A         IB0001 318.0 0.500 700.0 805.0  6.40 75.00
IB0063 PIO X 304C        IB0001 320.0 0.520 940.0 625.0  6.00 75.00
IB0064 H.OBREGON         IB0001 360.0 0.800 685.0 825.4 10.15 75.00
IB0065 SUWAN-1           IB0001 380.0 0.600 780.0 750.0  7.00 75.00
```

CERES-Millet

Table 11 shows an example of the current cultivars defined for millet. Required genetic coefficients include :

VAR#	Identification code xor number for a specific cultivar
VAR-NAME	Name of cultivar
ECO#	Ecotype code for this cultivar, points to the Ecotype in the ECO file (currently not used).
P1	Thermal time from seedling emergence to the end of the juvenile phase (expressed in degree days above a base temperature of 10^{o}C) during which the plant is not responsive to changes in photoperiod.
P2O	Critical photoperiod or the longest day length (in hours) at which development occurs at a maximum rate. At values greater than P2O, the rate of development is reduced.
P2R	Extent to which phasic development leading to panicle initiation (expressed in degree days) is delayed for each hour increase in photoperiod above P2O.
P5	Thermal time (degree days above a base temperature of 10^{o}C) from beginning of grain filling (3-4 days after flowering) to physiological maturity.
G1	Scaler for relative leaf size.
G4	Scaler for partitioning of assimilates to the panicle (head).
PHINT	Phylochron interval; the interval in thermal time (degree days) between successive leaf tip appearances.

TABLE 11. GENETIC COEFFICIENTS FILE FOR CERES-MILLET. (MLCER940.CUL)

```
*MILLET GENOTYPE COEFFICIENTS - GECER940 MODEL
!
!
@VAR#  VRNAME           ECO#    P1   P20   P2R    P5    G1    G4 PHINT
!                                1     2     3     4     5     6     7
IB0033 BJ104           IB0001 120.0 13.40 145.0 340.0  1.50  1.00 95.00
IB0034 CZH-859         IB0001 170.0 12.10 138.0 420.0  2.13  0.50 95.0
IB0035 CZP-87          IB0001 136.0 12.40 130.0 370.0  2.10  0.50 95.00
IB0036 CZMP-2          IB0001 135.0 12.60 140.0 370.0  2.00  0.50 95.00
IB0037 MBH-110         IB0001 140.0 12.50 148.0 365.0  2.12  0.50 95.00
IB0038 RCB-2           IB0001 136.0 12.10 135.0 365.0  2.14  0.50 95.00
IB0039 CZP-78          IB0001 136.0 12.10 125.0 362.0  2.00  0.50 95.00
IB0040 CZP-85          IB0001 142.0 12.30 130.0 380.0  2.15  0.50 95.00
IB0041 WCC-75          IB0001 160.0 12.00 142.0 422.0  2.10  0.50 95.00
IB0042 CZP-84          IB0001 138.0 12.20 128.0 360.0  2.30  0.50 95.00
IB0043 CZH-83-J1       IB0001 136.0 12.60 130.0 350.0  2.30  0.50 95.00
IB0044 CIVT            IB0001 120.0 12.00 142.0 590.0  1.00  0.50 95.00
```

CERES-Sorghum

Table 12 shows an example of the current cultivars defined for sorghum. Required genetic coefficients include :

VAR#	Identification code or number for a specific cultivar.
VAR-NAME	Name of cultivar.
ECO#	Ecotype code for this cultivar, points to the Ecotype in the ECO file (currently not used).
P1	Thermal time from seedling emergence to the end of the juvenile phase(expressed in degree days above a base temperature of 8^oC) during which the plant is not responsive to changes in photoperiod.
P2O	Critical photoperiod or the longest day length (in hours) at which development occurs at a maximum rate. At values higher than P2O, the rate of development is reduced.
P2R	Extent to which phasic development leading to panicle initiation (expressed in degree days) is delayed for each hour increase in photoperiod above P2O.
P5	Thermal time (degree days above a base temperature of 8^oC) from beginning of grain filling (3-4 days after flowering) to physiological maturity.
G1	Scaler for relative leaf size.
G2	Scaler for partitioning of assimilates to the panicle (head).
PHINT	Phylochron interval; the interval in thermal time (degree days) between successive leaf tip appearances.

Table 12. Genetic Coefficients File for CERES-Sorghum. (SGCER940.CUL)

```
*SORGHUM GENOTYPE COEFFICIENTS - GECER940 MODEL
!
@VAR#  VRNAME          ECO#    P1   P2O   P2R    P5    G1    G2 PHINT
!                               1     2     3     4     5     6     7
IB0001 RIO             IB0001 430.0 11.60  24.0 540.0    .0   6.0 49.00
IB0002 9188            IB0001 393.0 13.00  23.0 540.0    .0   6.0 49.00
IB0003 BRANDES         IB0001 374.0 11.00 116.0 540.0    .0   6.0 49.00
IB0004 MN1500          IB0001 495.0 11.80 139.0 540.0    .0   6.0 49.00
IB0005 HEGARI          IB0001 273.0 11.50 136.0 540.0    .0   6.0 49.00
IB0006 100M            IB0001 291.0 11.00 127.0 540.0    .0   6.0 49.00
IB0007 80M             IB0001 337.0 12.60 262.0 540.0    .0   6.0 49.00
IB0008 60M             IB0001 337.0 12.80 290.0 540.0    .0   6.0 49.00
IB0009 SM100           IB0001 365.0 13.00  45.0 540.0    .0   6.0 49.00
IB0010 SM80            IB0001 356.0 12.00  74.0 540.0    .0   6.0 49.00
IB0011 SM60            IB0001 365.0 12.20  74.0 540.0    .0   6.0 49.00
IB0012 REDLON          IB0001 393.0 12.50  30.0 540.0    .0   6.0 49.00
IB0013 CAPROCK         IB0001 393.0 12.80  84.0 540.0    .0   6.0 49.00
IB0014 ATx378XRTx7000  IB0001 384.0 11.30  24.0 540.0    .0   6.0 49.00
IB0015 ATx623          IB0001 380.0 13.00  35.0 540.0    .0   6.0 49.00
IB0016 RTx430          IB0001 400.0 13.00 123.0 540.0    .0   6.0 49.00
IB0017 ATx623XRTx430   IB0001 390.0 13.00  35.0 540.0    .0   6.0 49.00
IB0018 BTx3197         IB0001 411.0 13.00 108.0 540.0    .0   6.0 49.00
IB0019 RTx7078         IB0001 421.0 14.40 221.0 540.0    .0   6.0 49.00
IB0020 TX 610          IB0001 180.0 16.50   1.0 580.0  22.0   6.0 49.00
IB0021 WHEATLAND       IB0001 365.0 12.50  30.0 540.0    .0   6.0 49.00
IB0022 ATx399XRTx430   IB0001 393.0 12.80  40.0 540.0    .0   6.0 49.00
IB0023 ATx378XRTx430   IB0001 411.0 12.50  20.0 540.0    .0   6.0 49.00
IB0024 ATx623XRTx7000  IB0001 374.0 13.00  14.0 540.0    .0   6.0 49.00
IB0025 38M             IB0001 291.0 13.00  12.0 540.0    .0   6.0 49.00
IB0026 CSH-1           IB0001 410.0 13.60  40.0 540.0   3.0   5.5 49.00
IB0027 DE KALB 46      IB0001 325.0 15.50  30.0 540.0   9.0   6.0 49.00
IB0028 PIONEER 8333    IB0001 325.0 15.50  30.0 540.0  11.0   6.0 49.00
IB0029 DK              IB0001 200.0 15.50  12.0 540.0    .0   6.0 49.00
IB0030 PIONEER 8515    IB0001 275.0 15.50  30.0 500.0    .0   6.0 49.00
IB0031 RS 626          IB0001 300.0 15.50  30.0 400.0    .0   6.0 49.00
IB0032 DK- E57         IB0001 325.0 15.50  30.0 450.0  13.0   6.0 49.00
IB0040 RS610           IB0001 460.0 12.50  90.0 600.0   5.0   6.0 49.00
IB0041 NK212           IB0001 420.0 15.50  30.0 500.0  13.0   6.0 49.00
IB0042 PIONEER 846     IB0001 480.0 12.50 190.0 650.0   5.0   5.0 49.00
IB0043 CSH-6           IB0001 410.0 13.60  40.0 510.0   7.0   4.5 49.00
IB0044 CSH-6           IB0001 320.0 13.50 180.0 540.0   7.0   5.5 49.00
IB0046 M-35-1          IB0001 320.0 14.00  45.6 556.0  15.0   4.5 49.00
IB0047 SPV-504         IB0001 310.0 13.00  35.0 554.0  15.0   4.5 49.00
IB0048 CSH-5           IB0001 255.0 13.50  40.5 490.0  10.0   5.5 49.00
IB0049 CSH-9           IB0001 225.0 13.50  45.1 573.0  10.0   5.5 49.00
IB0050 SPH-388         IB0001 232.0 12.50  43.7 590.0  10.0   4.5 49.00
```

CERES-Wheat

Table 13 shows an example of the current cultivars defined for wheat. Required genetic coefficients include :

VAR#	Identification code or number for a specific cultivar.
VAR-NAME	Name of cultivar.
ECO#	Ecotype code for this cultivar, points to the Ecotype in the ECO file (currently not used).
P1V	Relative amount that development is slowed for each day of unfulfilled vernalization, assuming that 50 days of vernalization is sufficient for all cultivars.
P1D	Relative amount that development is slowed when plants are grown in a photoperiod 1 hour shorter than the optimum (which is considered to be 20 hours).
P5	Relative grain filling duration based on thermal time (degree days above a base temperature of 1^{o}C), where each unit increase above zero adds 20 degree days to an initial value of 430 degree days.
G1	Kernel number per unit weight of stem (less leaf blades and sheaths) plus spike at anthesis (1/g).
G2	Kernel filling rate under optimum conditions (md/dy).
G3	Non-stressed dry weight of a single stem (excluding leaf blades and sheaths) and spike when elongation ceases (g).
PHINT	Phylochron interval; the interval in thermal time (degree days) between successive leaf tip appearances.

TABLE 13. GENETIC COEFFICIENTS FILE FOR CERES-WHEAT. (WHCER940.CUL)

```
*WHEAT GENOTYPE COEFFICIENTS - GECER940 MODEL
!
@VAR#  VRNAME           ECO#    P1V   P1D    P5    G1    G2    G3 PHINT
!                                 1     2     3     4     5     6     7
IB0001 CONDO (DURUM)    IB0001   .5   1.5   2.0   5.3   1.9   1.9 95.00
IB0002 WARED            IB0001   .5   2.7   2.0   5.0   1.8   1.9 95.00
IB0003 WALDRON          IB0001   .5   2.7   2.0   5.0   1.7   1.9 95.00
IB0004 ELLAR            IB0001   .5   2.7   2.0   4.7   1.8   1.9 95.00
IB0005 BUTTE            IB0001   .5   2.7   2.0   2.8   2.4   1.9 95.00
IB0006 WARD (DURUM)     IB0001   .5   1.5   2.0   3.6   1.6   1.9 95.00
IB0030 RONGOTEA         IB0001   .5   2.7   2.0   1.6   3.9   1.7 95.00
IB0031 KOPARA           IB0001   .5   2.7   2.0   1.6   3.9   1.7 95.00
IB0032 BOUNTY           IB0001  6.0   3.7   2.1   3.2   2.5   1.7 95.00
IB0033 MOULIN           IB0001  6.0   3.9   2.1   3.8   2.1   1.8 95.00
IB0034 AVALON           IB0001  6.0   4.0   2.0   3.0   2.7   1.7 95.00
IB0178 CENTURK          IB0001  6.0   2.5   2.0   4.3   1.7   1.2 95.00
IB0221 HERON            IB0001   .5   2.3   2.0   2.0   2.0   4.0 95.00
IB0222 SHERPA           IB0001   .5   3.1   1.0   3.5   2.5   5.0 95.00
IB0223 GABO             IB0001   .5   3.1   2.5   1.8   3.0   5.0 95.00
IB0224 BENCUBBIN        IB0001   .5   4.5   2.5   1.2   3.0   4.9 95.00
IB0326 GAMENYA          IB0001   .5   3.3   6.0   4.6   2.7   4.9 95.00
IB0333 SST              IB0001  3.0   3.0   4.0   4.4   4.9   1.7 95.00
IB0368 TRIUMPH          IB0001  6.0   1.9   2.0   2.8   1.6   1.9 95.00
IB0411 CARIBO           IB0001  6.0   4.4   2.0   4.0   3.1   2.6 95.00
IB0446 IMPROVED TRIUMPH IB0001  6.0   1.3   2.0   2.8   4.1   1.9 95.00
IB0459 LANCER           IB0001  6.0   1.7   2.0   2.8   1.6   1.9 95.00
IB0460 LEEDS            IB0001  6.0   2.7   2.0   2.8   1.6   1.9 95.00
IB0469 STURDY           IB0001  6.0   1.0   2.0   3.9   2.3   1.5 95.00
IB0470 NOR.KING #812    IB0001  6.0   1.0   2.0   3.9   2.3   1.9 95.00
IB0487 SCOUT 66         IB0001  6.0   2.4   2.0   3.8   2.4   1.3 95.00
IB0488 NEWTON           IB0001  6.0   2.5   3.5   3.4   2.6   1.4 95.00
IB0489 NEWANA           IB0001   .5   4.5   3.0   4.8   3.3   1.7 95.00
IB0494 GAGE             IB0001  6.0   2.2   2.0   2.8   1.6   1.9 95.00
IB0495 KOLIBRI          IB0001   .5   3.3   2.5   4.0   3.1   2.1 95.00
IB0496 KLEIBER          IB0001   .5   3.0   3.0   3.6   3.1   2.1 95.00
IB0500 TAM 105          IB0001  6.0   3.3   2.5   2.8   3.0   1.8 95.00
IB0501 IMIA 66          IB0001  6.0   2.7   2.0   2.8   1.6   1.9 95.00
IB0510 PAHA             IB0001  6.0   2.7   2.0   2.8   1.6   1.9 95.00
IB0515 ROLETTE          IB0001  6.0   2.7   2.0   2.8   1.6   1.9 95.00
IB0519 WANSER           IB0001  6.0   2.7   2.0   3.0   3.1   1.9 95.00
IB0536 COULEE           IB0001  6.0   2.7   2.0   2.8   1.6   1.9 95.00
IB0541 TAM W 101        IB0001  3.0   3.0   2.5   4.1   3.0   1.8 95.00
IB0542 NUGAINES         IB0001  6.0   2.7   3.0   5.5   3.6   2.3 95.00
IB0543 PAWNEE           IB0001  6.0   2.6   2.0   2.8   1.6   1.9 95.00
IB0547 CLOUD            IB0001  6.0   2.0   2.0   2.8   1.6   1.9 95.00
```

IB0548	TRISON	IB0001	6.0	2.7	2.0	2.8	1.6	1.9 95.00
IB0551	ARTHUR	IB0001	6.0	2.7	2.0	4.2	2.1	1.9 95.00
IB0552	TITAN	IB0001	3.0	2.0	4.5	4.3	3.1	1.9 95.00
IB0553	FRANKENMUTH	IB0001	6.0	2.7	2.0	3.8	1.6	1.9 95.00
IB0555	ISRAEL SW	IB0001	.5	3.0	4.5	2.9	4.7	2.6 95.00
IB0563	EAGLE	IB0001	6.0	3.5	2.0	3.2	3.0	1.9 95.00
IB0599	VONA	IB0001	6.0	3.1	2.5	3.9	1.6	1.7 95.00
IB0610	SAGE	IB0001	6.0	2.7	2.0	2.8	1.6	1.9 95.00
IB0700	BEZOSTAYA	IB0001	6.0	2.9	5.0	4.3	3.1	1.9 95.00
IB0701	MIRONOVSKAYA	IB0001	6.0	2.9	5.0	4.8	3.1	1.9 95.00
IB0702	ROUGHRIDER	IB0001	6.0	2.9	5.0	4.8	3.1	1.9 95.00
IB0777	ESTANZ. DORADO	IB0001	1.0	4.0	2.0	3.0	3.0	3.0 95.00
IB1001	ATLE	IB0001	6.0	2.7	2.0	1.3	1.6	1.9 95.00
IB1002	CAPELLE DESPREZ	IB0001	6.0	4.2	2.0	1.7	2.9	3.7 95.00
IB1003	JUFY 2	IB0001	6.0	2.7	2.0	2.8	1.6	1.9 95.00
IB1004	LELY	IB0001	6.0	3.5	2.0	4.8	2.8	4.4 95.00
IB1005	DONATA	IB0001	6.0	3.5	2.0	4.4	3.0	1.7 95.00
IB1006	MARIS HOBBIT	IB0001	6.0	2.7	2.0	3.6	3.1	3.6 95.00
IB1007	MARIS HUNTSMAN2	IB0001	6.0	2.9	2.0	3.9	3.9	2.2 95.00
IB1008	TALENT	IB0001	6.0	3.3	3.5	3.5	3.8	1.9 95.00
IB1009	HYSLOP	IB0001	6.0	2.7	2.0	3.0	1.6	1.9 95.00
IB1010	LUKE	IB0001	6.0	2.7	2.0	2.8	1.3	1.9 95.00
IB1011	ARMINDA	IB0001	6.0	2.7	2.0	4.3	4.6	1.9 95.00
IB1012	CAPITOLE	IB0001	6.0	3.2	2.5	3.1	3.6	1.0 95.00
IB1013	TOP	IB0001	6.0	3.5	3.5	3.2	3.3	1.9 95.00
IB1014	COURTOT	IB0001	6.0	3.3	2.5	3.4	3.1	1.0 95.00
IB1015	MARIS FUNDEN	IB0001	6.0	3.5	4.0	2.8	2.7	1.9 95.00
IB1015	STEPHENS	IB0001	6.0	3.3	2.5	3.5	6.8	2.7 95.00
IB1016	YAMHILL	IB0001	6.0	3.3	2.5	3.9	5.5	2.8 95.00
IB1017	MARIS HUNTSMAN	IB0001	6.0	3.5	4.0	3.9	3.0	2.2 95.00
IB1018	HD2160(INDIA)	IB0001	.5	3.3	2.5	4.0	2.9	2.4 95.00
IB1019	FARO	IB0001	6.0	3.3	2.5	4.3	4.9	2.6 95.00
IB1020	NIMBUS	IB0001	6.0	3.3	2.5	4.6	4.0	2.1 95.00
IB1021	SCHIROKKO	IB0001	.5	3.3	2.5	4.7	3.4	2.0 95.00
IB1022	ARKAS	IB0001	.5	3.3	2.5	4.0	3.1	2.1 95.00
IB1023	TURBO	IB0001	.5	3.3	2.5	4.8	3.3	2.1 95.00
IB1024	MARIS MARDLER	IB0001	6.0	3.3	2.5	4.8	3.3	2.1 95.00
IB1025	STARKEII	IB0001	6.0	3.3	1.0	4.0	2.4	2.1 95.00
IB1500	MANITOU	IB0001	.5	3.2	.0	4.9	1.8	1.7 95.00
IB1907	MEXIPAK	IB0001	.5	3.0	2.0	2.9	3.0	1.7 95.00
IB1908	SONALIKA	IB0001	.5	1.8	3.5	4.0	1.9	1.7 95.00
IB1909	NOVI SAD	IB0001	.5	3.5	2.0	4.0	1.3	1.7 95.00
IB2001	ANZA	IB0001	.5	3.4	2.0	3.5	2.7	4.4 95.00
IB2004	COKER 6815	IB0001	6.0	1.0	2.0	4.1	3.1	1.9 95.00
IB2006	NADADORES	IB0001	.5	2.7	2.0	2.8	1.6	1.9 95.00
IB2008	PENJAMO	IB0001	.5	2.7	2.0	2.8	1.6	1.9 95.00
IB2011	PLAINSMAN	IB0001	6.0	2.7	2.0	2.8	1.6	1.9 95.00

IB2012	PRODURA	IB0001	.5	3.1	2.5	3.3	3.3	5.3	95.00
IB2013	TAMU	IB0001	6.0	2.7	2.0	2.8	1.6	1.9	95.00
IB2014	WALDRON	IB0001	.5	1.5	2.0	2.8	1.6	1.9	95.00
IB2123	EGRET	IB0001	.5	3.0	2.0	2.6	3.3	2.7	95.00
IB2124	WW33G	IB0001	.5	3.0	2.0	3.7	1.8	2.4	95.00
IB4000	SQUAREHD MASTER	IB0001	6.0	4.7	2.0	1.1	2.2	1.9	95.00
IB4001	JUFY1	IB0001	.5	3.0	2.0	1.8	2.5	3.9	95.00
IB9800	FREDERICK	IB0001	6.0	2.7	2.0	3.8	1.6	1.9	95.00

CROPGRO-Dry Bean

Table 14 shows an example of the current cultivars defined for dry bean. Required genetic coefficients include :

VARTY	Also VAR#; the identification code or number for a specific cultivar.
VRNAME	Name of cultivar.
ECONO	Also ECO#; the ecotype code for this cultivar, points to the Ecotype in the ECO (BNGRO940.ECO) file.
CSDVAR	Also CSDL; critical daylength below which reproductive development proceeds unaffected by daylength, and above which development rate is reduced in proportion to hours above CSDVAR (h).
PPSEN	Slope of relative rate of development for daylengths above CSDVAR, or sensitivity to photoperiod (1/h).
PH2T5	Also EM-FL; the time from end of juvenile phase to first flower in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).
PHTHRS(6)	Also FL-SH; the time from first flower to first pod greater than 0.5 cm in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).
PHTHRS(8)	Also FL-SD the time from first flower to first seed in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).
PHTHRS(10)	Also SD-PM the time from first seed to physiological maturity in photo-thermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).
PHTHRS(13)	Also FL-LF the time from first flower to end of leaf growth in photo-thermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).

LFMAX	Maximum leaf photosynthesis rate at saturated light level, optimal temperature (micromol (CO_2 /m^2s))

SLAVAR	Specific leaf area (SLA) for new leaves during peak vegetative growth for cultivar I, modified by environmental factors (cm^2/g).

SIZLF	Maximum size of fully expanded leaf on the plant under standard growing conditions (3 leaflets), cm^2

XFRUIT	Maximum fraction of daily available gross photosynthesis (PG) which is allowed to go to seeds plus shells for cultivar I, varies from 0 - 1.

WTPSD	Maximum weight per seed under non-limiting substrate (g).

SFDUR	Seed filling duration for a cohort of seed (photothermal days).

SDPDVR	Also SDPDV; average seed per pod under stnadard growing conditions.

PODUR	Photothermal days for cultivar to add full pod load under optimal conditions, used to compute rate of pod and flower addition.

Table 14. Genetic Coefficients File for CROPGRO-Dry Bean. (BNGRO940.CUL)

*DRYBEAN GENOTYPE COEFFICIENTS - CRGRO94 MODEL

@VAR#	VRNAME	ECO#	CSDL	PPSEN	EM-FL	FL-SH	FL-SD	SD-PM	FL-LF	LFMAX	SLAVR	SIZLF	XFRT	WTPSD	SFDUR	SDPDV	PODUR
!			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
990006	MesoAm Hab 2 & 3	MESIND	12.17	0.000	32.0	2.0	9.0	24.00	18.00	1.00	320.	133.0	1.00	0.230	14.0	5.20	8.0
990001	Andean Habit 1	ANDDET	12.17	0.050	24.5	2.0	11.0	25.50	16.00	1.00	295.	133.0	1.00	0.550	11.0	3.50	3.5
990002	Andean Habit 2	ANDIND	12.17	0.050	26.0	4.0	11.0	26.50	18.00	1.00	350.	133.0	1.00	0.600	11.0	3.50	3.5
990003	Andean Habit 3	ANDIND	12.17	0.050	30.0	4.5	9.5	28.00	22.00	1.00	350.	133.0	1.00	0.650	20.0	4.20	5.0
990004	Andean Habit 4	ANDIND	12.17	0.050	34.0	5.0	9.0	34.00	34.00	1.00	350.	133.0	1.00	0.650	22.0	5.20	6.0
990005	Meso Amer. Hab.1	MESDET	12.17	0.000	27.0	4.0	9.0	22.00	16.00	1.00	350.	133.0	1.00	0.230	16.0	5.20	5.0
990007	Mex Highland H 3	MEXHIL	12.17	0.050	27.0	4.0	8.0	26.00	20.00	1.00	350.	133.0	1.00	0.440	17.0	3.20	5.0
IB0001	Porillo Sintet	MESIND	13.17	0.008	32.0	2.0	9.0	23.00	18.00	1.00	320.	133.0	1.00	0.210	15.0	5.20	10.0
IB0002	BAT 477+	MESIND	12.17	0.000	32.0	2.0	9.0	24.00	18.00	1.00	320.	133.0	1.00	0.230	14.0	5.20	8.0
IB0003	Seafarer	MESDET	12.17	0.000	25.0	5.0	09.0	23.00	22.00	1.00	350.	133.0	1.00	0.180	17.0	5.00	8.0
IB0004	C-20	MESIND	12.17	0.000	32.0	5.0	09.0	24.00	22.00	1.00	350.	133.0	1.00	0.170	17.0	5.00	8.0
IB0005	BAT 881	MESIND	12.17	0.000	33.0	2.0	9.0	24.00	18.00	1.00	300.	133.0	1.00	0.230	14.0	5.20	8.0
IB0006	ICTA-Ostua	MESIND	12.17	0.000	27.0	3.0	8.0	23.00	22.00	1.00	295.	133.0	1.00	0.200	17.0	5.40	5.0
IB0007	Rabia de Gato	MESIND	12.17	0.040	24.0	3.0	8.0	21.00	22.00	1.00	295.	133.0	1.00	0.180	17.0	5.40	5.0
IB0008	TURBO-III	MESIND	12.17	0.050	30.0	4.0	9.0	23.00	22.00	1.00	295.	133.0	1.00	0.180	17.0	4.00	5.0
IB0010	Carioca (G4017)	MESIND	12.17	0.000	33.5	3.0	11.0	24.00	18.00	0.90	270.	133.0	1.00	0.250	15.0	5.00	6.5
IB0011	Isabella	ANDDET	12.17	0.000	25.0	3.0	8.0	20.00	9.00	1.00	295.	133.0	1.00	0.290	15.0	3.50	10.0
IB0012	Manitou	ANDDET	12.17	0.000	28.0	3.0	8.0	23.00	9.00	1.00	295.	133.0	1.00	0.550	15.0	3.50	10.0
IB0013	Redkloud	ANDDET	12.17	0.000	24.5	2.0	11.0	25.50	7.00	1.00	305.	133.0	1.00	0.550	11.0	3.50	3.5
IB0014	Canadian Wonder	ANDDET	12.17	0.000	24.5	2.0	11.0	25.50	7.00	1.00	295.	133.0	1.00	0.550	11.0	3.50	3.5

CROPGRO-Peanut

Table 15 shows an example of the current cultivars defined for peanut. Required genetic coefficients include :

VARTY	Also VAR#; the identification code or number for a specific cultivar.
VRNAME	Name of cultivar.
ECONO	Also ECO#; the ecotype code for this cultivar, points to the Ecotype in the ECO (PNGRO940.ECO) file.
CSDVAR	Also CSDL; critical daylength below which reproductive development proceeds unaffected by daylength, and above which development rate is reduced in proportion to hours above CSDVAR (h).
PPSEN	Slope of relative rate of development for daylengths above CSDVAR, or sensitivity to photoperiod (1/h).
PH2T5	Also EM-FL; the time from end of juvenile phase to first flower in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).
PHTHRS(6)	Also FL-SH; the time from first flower to first peg, in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).
PHTHRS(8)	Also FL-SD the time from first flower to first seed in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).
PHTHRS(10)	Also SD-PM the time from first seed to physiological maturity in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).
PHTHRS(13)	Also FL-LF the time from first flower to end of leaf growth in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).

LFMAX	Maximum leaf photosynthesis rate at saturated light level, optimal temperature (micromol (CO_2 /m^2s))
SLAVAR	Specific leaf area (SLA) for new leaves during peak vegetative growth for cultivar I, modi-fied by environmental factors (cm^2/g).
SIZLF	Maximum size of fully expanded leaf on the plant under standard growing conditions (3 leaflets), cm^2
XFRUIT	Maximum fraction of daily available gross photosynthesis (PG) which is allowed to go to seeds plus shells for cultivar I, varies from 0 - 1.
WTPSD	Maximum weight per seed under non-limiting substrate (g).
SFDUR	Seed filling duration for a cohort of seed (photothermal days).
SDPDVR	Also SDPDV; average seed per pod under stnadard growing conditions.
PODUR	Photothermal days for cultivar to add full pod load under optimal conditions, used to compute rate of pod and flower addition.

Table 15. Genetic Coefficients File for CROPGRO-Peanut. (PNGR094.CUL)

```
*PEANUT GENOTYPE COEFFICIENTS - CRGRO940 MODEL

@VAR#  VRNAME            ECO#  CSDL PPSEN EM-FL FL-PG FL-SD SD-PM FL-LF LFMAX SLAVR SIZLF  XFRT WTPSD SFDUR SDPDV PODUR
!                                 1     2     3     4     5     6     7     8     9    10    11    12    13    14    15
990001 V EARLY SPANISH  PN0006 11.84  0.00  18.4   6.5  17.0 83.70 73.20  1.30  230.  20.0  0.95 0.575  37.0  1.70  35.0
990002 EARLY VALENCIA   PN0007 11.84  0.00  18.4   6.5  17.0 83.70 73.20  1.30  230.  20.0  0.95 0.575  37.0  1.70  35.0
990003 MEDIUM VIRGINIA  PN0005 11.84  0.00  18.4   6.5  17.0 83.70 73.20  1.30  230.  20.0  0.95 0.575  37.0  1.70  35.0
```

CROPGRO-Soybean

Table 16 shows an example of the current cultivars defined for soybean. Required genetic coefficients include :

VARTY	Also VAR#; the identification code or number for a specific cultivar.
VRNAME	Name of cultivar.
ECONO	Also ECO#; the ecotype code for this cultivar, points to the Ecotype in the ECO (SBGRO940.ECO) file.
CSDVAR	Also CSDL; critical daylength below which reproductive development proceeds unaffected by daylength, and above which development rate is reduced in proportion to hours above CSDVAR (h).
PPSEN	Slope of relative rate of development for daylengths above CSDVAR, or sensitivity to photoperiod (1/h).
PH2T5	Also EM-FL; the time from end of juvenile phase to first flower in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).
PHTHRS(6)	Also FL-SH; the time from first flower to first pod greater than 0.5 cm in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).
PHTHRS(8)	Also FL-SD the time from first flower to first seed in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).
PHTHRS(10)	Also SD-PM the time from first seed to physiological maturity in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).
PHTHRS(13)	Also FL-LF the time from first flower to end of leaf growth in photothermal days, which is equal to the minimum duration under optimal temperature and photoperiod (photothermal days).

LFMAX	Maximum leaf photosynthesis rate at saturated light level, optimal temperature (micromol (CO_2 /m^2s))
SLAVAR	Specific leaf area (SLA) for new leaves during peak vegetative growth for cultivar I, modified by environmental factors (cm^2/g).
SIZLF	Maximum size of fully expanded leaf on the plant under standard growing conditions (3 leaflets), cm^2
XFRUIT	Maximum fraction of daily available gross photosynthesis (PG) which is allowed to go to seeds plus shells for cultivar I, varies from 0 - 1.
WTPSD	Maximum weight per seed under non-limiting substrate (g).
SFDUR	Seed filling duration for a cohort of seed (photothermal days).
SDPDVR	Also SDPDV; average seed per pod under stnadard growing conditions.
PODUR	Photothermal days for cultivar to add full pod load under optimal conditions, used to compute rate of pod and flower addition.

Table 16. Genetic Coefficients File for CROPGRO-Soybean. (SBGRO940.CUL)

```
*SOYBEAN GENOTYPE COEFFICIENTS - CRGRO940 MODEL

@VAR#  VRNAME          ECO#  CSDL PPSEN EM-FL FL-SH FL-SD SD-PM FL-LF LFMAX SLAVR SIZLF  XFRT WTPSD SFDUR SDPDV PODUR
!                               1     2     3     4     5     6     7     8     9    10    11    12    13    14    15
990001 M GROUP   1      SB0101 13.84 0.203  17.0   6.0  13.0 32.00 30.00 1.022  350. 180.0  1.00  0.18  22.0  2.05  10.0
990002 M GROUP   2      SB0201 13.59 0.249  17.4   6.0  13.5 33.00 30.00 1.022  350. 180.0  1.00  0.18  22.0  2.05  10.0
990003 M GROUP   3      SB0301 13.40 0.285  19.0   6.0  14.0 34.00 30.00 1.022  350. 180.0  1.00  0.18  22.0  2.05  10.0
990004 M GROUP   4      SB0401 13.09 0.294  19.4   7.0  15.0 34.50 30.00 1.022  350. 180.0  1.00  0.18  22.0  2.05  10.0
990005 M GROUP   5      SB0501 12.83 0.303  19.8   8.0  15.5 35.00 15.00 1.022  350. 180.0  1.00  0.18  22.0  2.05  10.0
990006 M GROUP   6      SB0601 12.58 0.311  20.2   9.0  16.0 35.50 15.00 1.022  350. 180.0  1.00  0.18  22.0  2.05  10.0
990007 M GROUP   7      SB0701 12.33 0.320  20.8  10.0  16.0 36.00 15.00 1.022  350. 180.0  1.00  0.18  22.0  2.05  10.0
990008 M GROUP   8      SB0801 12.07 0.330  21.5  10.0  16.0 36.00 15.00 1.022  350. 180.0  1.00  0.18  22.0  2.05  10.0
990009 M GROUP   9      SB0901 11.88 0.340  23.0  10.0  16.0 36.50 15.00 1.022  350. 180.0  1.00  0.18  22.0  2.05  10.0
990010 M GROUP  10      SB1001 11.78 0.349  23.5  10.0  16.0 37.00 15.00 1.022  350. 180.0  1.00  0.18  22.0  2.05  10.0
990011 M GROUP 000      SB0001 14.60 0.129  15.5   5.0  12.0 29.50 30.00 1.022  350. 180.0  1.00  0.18  22.0  2.05  10.0
990012 M GROUP  00      SB0001 14.35 0.148  16.0   5.0  12.0 30.00 30.00 1.022  350. 180.0  1.00  0.18  22.0  2.05  10.0
990013 M GROUP   0      SB0001 14.10 0.171  16.8   6.0  13.0 31.00 30.00 1.022  350. 180.0  1.00  0.18  22.0  2.05  10.0

UC0001 ALTONA (00)      SB0001 14.42 0.148  17.5   7.5  14.0 33.00 33.00 1.022  350. 180.0  1.00  0.18  16.0  2.05  12.0
UC0002 MAPLE ARROW (00) SB0001 14.42 0.148  17.8   7.0  13.0 33.50 33.00 1.022  350. 180.0  1.00  0.18  16.0  2.05  10.5
UC0003 MCCALL (00)      SB0001 14.42 0.148  17.0   5.5  12.0 34.00 33.00 1.022  350. 180.0  1.00  0.18  16.0  2.05   9.0
IB0011 EVANS (0)        SB0001 14.00 0.171  16.8   6.5  12.4 33.00 31.00 1.022  360. 180.0  1.00  0.18  24.0  2.05  12.0
IB0037 ELGIN-87 (2)     SB0201 13.65 0.240  17.4   6.0  10.7 33.00 31.50 1.022  380. 150.0  1.00  0.18  20.0  2.05  10.0
IB0003 WAYNE (3)        SB0302 13.50 0.226  21.0   8.0  15.5 30.00 25.00 1.022  380. 135.0  1.00  0.16  20.0  2.20  21.0
IB0009 WILLIAMS (3)     SB0301 13.45 0.285  20.5   9.0  16.0 30.00 30.00 1.022  350. 120.0  1.00  0.18  24.0  2.50  15.0
IB0010 WILLIAMS-82 (3)  SB0301 13.45 0.285  19.5   8.0  15.0 31.50 30.00 1.022  350. 120.0  1.00  0.18  24.0  2.50  10.0
IB0043 CLARK (4)        SB0502 12.83 0.303  18.0   9.0  15.0 32.00 30.00 1.022  390. 200.0  1.00  0.18  20.0  2.10  12.0
IB0008 FORREST (5)      SB0501 12.83 0.303  22.6   7.0  14.5 33.00 15.00 1.022  350. 140.0  1.00  0.18  23.0  2.05   9.0
IB0001 BRAGG (7)        SB0701 12.33 0.320  19.5  10.0  15.0 35.50 15.00 1.022  350. 170.0  1.00  0.18  22.0  2.05  10.0
IB0006 RANSOM (7)       SB0701 12.37 0.320  18.0  10.0  16.0 32.00 15.00 1.022  350. 170.0  1.00  0.18  22.0  2.05  10.0
IB0002 COBB (8)         SB0801 12.25 0.330  21.0   9.0  16.0 37.00 15.00 1.022  380. 180.0  1.00  0.15  22.0  1.90  10.0
IB0033 PAPILLON (9)     SB0901 11.88 0.340  28.0   6.0  11.0 30.00 15.00 1.022  350. 180.0  1.00  0.18  22.0  2.05  20.0
IB0012 JUPITER (10)     SB0901 11.88 0.340  28.9   7.0  13.5 31.50 15.00 1.022  350. 180.0  1.00  0.18  22.0  2.05  20.0
```

CERES-Rice

Table 17 shows an example of the current cultivars defined for rice. Required genetic coefficients include :

VAR#	Identification code or number for a specific cultivar.
VAR-NAME	Name of cultivar.
ECO#	Ecotype code for this cultivar, points to the Ecotype in the ECO file (currently not used).
P1	Time period (expressed as growing degree days [GDD] in ^{o}C above a base temperature of 9^{o}C) from seedling emergence during which the rice plant is not responsive to changes in photoperiod. This period is also referred to as the basic vegetative phase of the plant.
P2O	Critical photoperiod or the longest day length (in hours) at which the development occurs at a maximum rate. At values higher than P2O developmental rate is slowed, hence there is delay due to longer day lengths.
P2R	Extent to which phasic development leading to panicle initiation is delayed (expressed as GDD in ^{o}C) for each hour increase in photoperiod above P2O
P5	Time period in GDD (^{o}C) from beginning of grain filling (3 to 4 days after flowering) to physiological maturity with a base temperature of 9^{o}C.
G1	Potential spikelet number coefficient as estimated from the number of spikelets per g of main culm dry weight (less lead blades and sheaths plus spikes) at anthesis). A typical value is 55.
G2	Single grain weight (g) under ideal growing conditions, i.e. nonlimiting light, water, nutrients, and absence of pests and diseases.
G3	Tillering coefficient (scaler value) relative to IR64 cultivar under ideal conditions. A higher tillering cultivar would have coefficient greater than 1.0.
G4	Temperature tolerance coefficient. Usually 1.0 for varieties grown in normal environments. G4 for japonica type rice growing in a warmer environment would be 1.0 or greater. Likewise, the G4 value for indica type rice in very cool environments or season would be less than 1.0.

Table 17. Genetic Coefficients File for CERES-Rice. (RICER940.CUL)

```
*RICE GENOTYPE COEFFICIENTS - RICER940 MODEL
!
@VAR#  VAR-NAME........   ECO#    P1   P2R    P5   P2O    G1    G2    G3    G4
!                                  1     2     3     4     5     6     7     8
!
IB0001 IR 8             IB0001 880.0  52.0 550.0  12.1  65.0 .0280  1.00  1.00
IB0002 IR 20            IB0001 500.0 166.0 500.0  11.2  65.0 .0280  1.00  1.00
IB0003 IR 36            IB0001 450.0 149.0 350.0  11.7  68.0 .0230  1.00  1.00
IB0004 IR 43            IB0001 720.0 120.0 580.0  10.5  65.0 .0280  1.00  1.00
IB0005 LABELLE          IB0001 318.0 189.0 550.0  12.8  65.0 .0280  1.00  1.00
IB0006 MARS             IB0001 698.0 134.0 550.0  13.0  65.0 .0280  1.00  1.00
IB0007 NOVA 66          IB0001 389.0 155.0 550.0  11.0  65.0 .0280  1.00  1.00
IB0008 PETA             IB0001 420.0 240.0 550.0  11.3  65.0 .0280  1.00  1.00
IB0009 STARBONNETT      IB0001 880.0 164.0 550.0  13.0  65.0 .0280  1.00  1.00
IB0010 UPLRI5           IB0001 620.0 160.0 380.0  11.5  50.0 .0220  0.60  1.00
IB0011 UPLRI7           IB0001 760.0 150.0 450.0  11.7  65.0 .0280  1.00  1.00
IB0012 IR 58            IB0001 460.0   5.0 420.0  13.5  60.0 .0250  1.00  1.00
IB0013 SenTaNi (???)    IB0001 320.0  50.0 550.0  10.0  70.0 .0300  1.00  1.00
IB0014 IR 54            IB0001 350.0 125.0 520.0  11.5  60.0 .0280  1.00  1.00
IB0015 IR 64            IB0001 500.0 160.0 450.0  12.0  60.0 .0250  1.00  1.00
IB0016 IR 60(Est)       IB0001 490.0 100.0 320.0  11.5  75.0 .0275  1.00  1.00
IB0017 IR 66            IB0001 500.0  50.0 490.0  12.5  62.0 .0265  1.00  1.00
IB0018 IR 72x           IB0001 400.0 100.0 580.0  12.0  76.0 .0230  1.00  1.00
IB0019 RD 7 (cal.)      IB0001 603.3 150.0 452.5  11.2  65.0 .0230  1.00  1.00
IB0020 RD 23 (cal.)     IB0001 310.3 140.0 370.0  11.2  53.0 .0230  1.00  1.00
IB0021 CICA8            IB0001 700.0 120.0 360.0  11.7  60.0 .0270  1.00  1.00
IB0022 LOW TEMP.SEN     IB0001 400.0 120.0 420.0  12.0  60.0 .0250  1.00  0.80
IB0023 LOW TEMP.TOL     IB0001 400.0 120.0 420.0  12.0  60.0 .0250  1.00  1.25
IB0024 17 BR11,T.AMAN   IB0001 740.0 180.0 400.0  10.5  55.0 .0250  1.00  0.90
IB0025 18 BR22,T.AMAN   IB0001 650.0 110.0 400.0  12.0  60.0 .0250  1.00  1.00
IB0026 19 BR 3,T.AMAN   IB0001 650.0 110.0 420.0  12.0  65.0 .0250  1.00  1.00
IB0027 20 BR 3,BORO     IB0001 650.0  90.0 400.0  13.0  65.0 .0250  1.00  1.00
IB0029 CPIC8            IB0001 380.0 150.0 300.0  12.8  38.0 .0210  1.00  1.00
IB0030 LEMONT           IB0001 500.0  50.0 300.0  12.8  60.0 .0207  1.00  1.00
IB0031 RN12             IB0001 380.0  50.0 300.0  12.8  40.0 .0199  1.00  1.15
IB0032 TW               IB0001 360.0  50.0 290.0  12.8  55.0 .0210  1.00  1.00
IB0115 IR 64            IB0001 540.0 160.0 490.0  12.0  50.0 .0250  1.10  1.00
IB0116 HEAT SENSITIVE   IB0001 460.0   5.0 390.0  13.5  62.0 .0250  1.00  1.15
IB0118 IR 72            IB0001 560.0  20.0 390.0  13.5  60.0 .0250  1.00  1.00
```

CROPSIM-CASSAVA

Table 18 shows an example of the current cultivars defined for cassava. Required genetic coefficients include :

DUB1 Duration of branch 1 phase (Biological day* from germination to first branch)

DUBR Duration of branch 2 and greater phases (Biological day* between branches)

DESP Development, sensitivity to photoperiod (h^{-1}) (0=insensitive)

PHCX Photosynthesis, canopy, maximum rate (g dm/m^2 d^{-1})

S#PE Stem number per plant at emergence (#)

S#FX Shoot number per fork, maximum (#)

S#PX Shoot number per plant, maximum (#)

SWNX Stem weight to node weight ration (fr)

L#IS Leaf number, increase rate, standard (leaves (shoot-1) Biological day*-1)

L#IP Leaf number, increase period (Biological day* after emergence)

LALX Leaf area, maximum, (cm^2/leaf)

LAXA Leaf area, maximum, age at which reached (Biological day* after emergence)

LAL3 Leaf area, 300 days after emergence (cm^2/leaf)

LAWS Leaf area to weight ration, standard (cm^2/g)

LFLI Leaf life (Day)

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* Biological days are equivalent to chronological days at the optimum temperature and daylength, and with no water or nutrient limitations.

Table 18. Genetic Coefficients File for CROPSIM-Cassava. (CSSIM940.CUL)

```
*CASSAVA GENOTYPE COEFFICIENTS -CSSIM940 MODEL
!
@VAR# VRNAME........... TYPE  DUB1  DUBR  DESP  PHCX  S#PE  S#FX  S#PX  SWNX  L#IS  L#IP  LALX  LAXA  LAL3  LAWS  LFLI
!                              1     2     3     4     5     6     7     8     9    10    11    12    13    14    15
990001 Default             1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0001 MCol-1120           1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0002 MCol-22             1  44.4  58.8     0  20.0   1.2  3.60    28  .650  0.85   330   300    60    50   180   130
UC0003 MCl-113             1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0004 MMex-59             1  41.3  29.4     0  24.0   1.0  2.80    35  .750  1.21   212   450    60    50   250    65
UC0005 Popayan             1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0006 MCol-1684           1  14.7  24.8     0  27.5   1.0  2.61    27  .590  0.94   370   220    55    40   270    45
UC0007 MVen-77             1  49.4  42.9     0  27.5   1.0  2.95    25  .760  1.13   353   450    70    35   270    75
UC0008 MPtr-26             1  64.7  50.0     0  27.5   1.0  3.00    20  .708  1.45   294   450    70    50   220    75
UC0009 MCol-638            1  44.4  28.2     0  23.5   1.0  2.95    52  .700  1.10   235   350    60    35   220    80
UC0010 Ceiba               1  32.4  35.3     0  26.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0011 JD2                 1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0012 MAus-1              1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0013 MAus-10             1  14.7  41.2  0.25  25.0   3.0  3.09    50  0.76  1.21   235   240    45    70   350   161
UC0014 MAus-13             1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0014 MAus-15             1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0016 MAus-19             1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0017 MAus-22             1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0018 MAus-7              1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0019 MAus-8              1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0020 MCol-1438           1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0021 MCol-1468           1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0022 MCol-1501           1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0023 MCol-1505           1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0024 MCol-1513           1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0025 MCol-72             1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0026 MMex-11             1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0027 TMS-30572           1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0028 Nina                1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0029 Pata                1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0030 SM1-150             1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0031 Betawi              1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
UC0032 CM-507-37           1  44.1  35.3     0  27.5   1.0  3.00    30  .650  1.21   235   300    60    50   240    70
 ! Notes:
! Palta (1984): MMex59,MVen218,MCol1684 are vigorous cultivars;
!               MCol72,MCol22,MCol638 are less vigorous.
! CM507-37: hybrid; see El-Sharkaway & Cock (1987).
! TMS 30572 in Gutierrez et al (1987).
```

APPENDIX B.
IMPLEMENTING PEST DAMAGE

In DSSAT v3, the pest damage routines have been implemented only in the CROPGRO models (Batchelor et al., 1993). In order to use the damage routines, the type of damage, as well as the amount of damage, must be input by the user. The damage routines were structured to provide flexibility in collecting damage data. Two different methods can be used to describe damage. In typical farm operations, pest population data can be collected through field scouting, and damage can be computed if pest feeding rates are known. In other instances, the actual amount of damage can be measured. This latter approach is useful when pest populations are difficult to measure, or when the source of damage is unknown. Predefined pest definitions can be used to convert scouting report data on pest populations, or observed damage, into daily damage, which is subsequently applied to the crop model. Predefined damage definitions can be used to convert observed levels of damage into daily damage that is subsequently applied to the crop model. New pest or damage definitions can be developed for a wide range of damage types. Currently, damage can be applied to 21 different plant components in CROPGRO.

Pest Damage Methodology

Twenty one state and/or rate variables, called coupling point (see Table 19), were identified as targets for pest damage. Damage is applied to each coupling point by the coupling point damage variable (or PCPID, described in the following section). There is a unique coupling point damage variable for each coupling point. The user supplies information that is used by the crop model to compute daily damage, which is then applied to the desired coupling point through the coupling point damage variable.

Four different types (or variable PCTID, described in the following section) can be defined to describe observed damage data:

1. Daily Absolute Damage rate,
2. Percent Observed Damage,
3. Daily Percent Damage rate, and
4. Daily Absolute Damage rate with pest competition and food preference effects.

Table 19 shows the allowable damage types available for each coupling point. The coupling point damage variable (PCPID) contains the amount of damage

TABLE 19. COUPLING POINTS AND DAMAGE TYPES USED TO APPLY DAMAGE IN THE CROPGRO CROP MODELS.

Coupling point	Units[1]	Available damage types[2]	Coupling point damage variable
leaf area index	m^2 m^{-2}	1,2,3,4	LAD
leaf mass	g m^{-2}	1,2,3,4	LMD
stem mass	g m^{-2}	1,2,3,4	SMD
root mass	g m^{-2}	1,3,4	RMD
root length	cm cm^{-2}	1,3,4	RLF
root length volume	cm cm^{-3}	1,3,4	RLV
small seed number	no. m^{-2}	1,3,4	SDNS
large seed number	no. m^{-2}	1,3,4	SDNL
mature seed number	no. m-2	1,3,4	SDNM
small seed mass	g m^{-2}	1,3,4	SDMS
large seed mass	g m^{-2}	1,3,4	SDML
mature seed mass	g m^{-2}	1,3,4	SDMM
small shell number	no. m^{-2}	1,3,4	SHNS
large shell number	no. m^{-2}	1,3,4	SHNL
mature shell number	no. m^{-2}	1,3,4	SHNM
small shell mass	g m^{-2}	1,3,4	SHMS
large shell mass	g m^{-2}	1,3,4	SHML
mature shell mass	g m^{-2}	1,3,4	SHMM
whole plant	no m^{-2}	1,3	WPD
assimilate	g m^{-2}	1,3	ASM
necrotic leaf area index	cm^2 cm^{-2}	1,3	PDLA

1 *Per unit ground area*
2 *Where damage type are: (1) Daily Absolute Damage rate, (2) Percent Observed Damage, (3) Daily Percent Damage rate, and (4) Daily Absolute Damage rate with pest competition and food preference effects*

(PDCF1) and the damage type descriptor (PCTID) tells CROPGRO how to apply the damage to the coupling point.

The type of damage selected depends upon the type of damage data that can be collected. Number 1, “Absolute Daily Damage,” is useful when pest population data can be collected. If pest populations and feeding rates are known, daily damage to coupling points can be computed in units of mass per unit area. Number 2, “Percent Observed Damage,” typically occurs when observations of plant components are compared between some scientific treatment and control. For example, defoliation can occur in one treatment, resulting in a percent difference in leaf mass between a treatment and control. In this case, the source of damage may not be known; while time series measurements describing the percent reduction between treatment and control is known. Number 3, "Daily Percent Damage," rate is useful when damage can be measured as percent on a daily basis. For instance, in a manual defoliation study, 33 percent and 66 percent defoliation may be applied on a particular day during the season. In this case, damage is applied as a percent daily damage. Another example would be the application of a shade cloth that blocks 80 percent of incoming light, resulting in an 80 percent reduction in daily assimilate production during the period of shading. Number 4, "Daily Absolute Damage" rate is intended to be used for insects that compete for feeding sites. If insect demand for the primary food source is high relative to supply, some damage is partitioned to secondary food sources.

Pest Damage Data Files

Two data files are used to define the pest linkage. A field-specific record of observed pest or pest damage levels is contained in the time series file (FILET) associated with each experiment. A typical FILET with recorded pest populations is shown in Table 20. Each column has a 4 character header that is unique for each pest (the PID variable, described below). The first two columns in this file contain the treatment number and observation date. The measured level of pest and/or damage is input in a column containing a 4 character header abbreviation for the pest or damage. This approach for recording observed pest and damage levels follows a typical field scouting record format. The steps required to define a pest progress file are as follows.

1. Put a header in the header column of FILET that matches the pest identifier (PID; see Tables 21-23 for dry bean, peanut and soybean, respectively) for the pest defined in the pest coefficient file.
2. Input the year and day of year in the first two columns of FILET for pest observation dates.
3. Input population level or damage level in FILET in the pest column corresponding to the observation date.

Observed pest and damage reported in the pest progress file (FILET) must have a corresponding definition in the pest coefficient file (*.PST). This crop-specific pest coefficient file defines individual pests or damage in terms of coupling points and feeding rates. Feeding rate coefficients, which have designated units, provide a means of converting from pest population to damage to coupling points. The pest coefficient files, distributed with the CROPGRO model for dry bean, peanut, and soybean are shown in Tables 21-23.

The following columns are included in these pest coefficient files.
1st column: pest number (LN);
2nd column: pest identifier (PID);
3rd column: pest name (PNAME);
4th column: damage characterization type (PCTID);
5th column: coupling point identifier (PCPID), defined in Table 19;
6th column: feeding rate coefficient (PDCF1);
7th column: additional coefficient (PDCF2, currently not implemented.
8th column: units of the feeding rate coefficient (Units); and
9th column: source for damage rates (Source).

To add a new pest or damage type to the pest coefficient file, the user must contact the model developer (see Appendix D of this Part).

Table 20. Typical Time Series File (FILET) Containing Examples of Pest Progress Data for Six Pest and Damage Types[1] for Soybean.

```
*EXP.DATA (T): UFBI9101SB Drew field drought study

@TRNO  DATE   CEW6   SL6   VC5   VC6   SHAD   GC5
     1 91147   0.0   1.5  0.25   0.4   30.0   0.0
     1 91154   0.5   2.8  0.25   0.6   30.0   0.6
     1 91161   0.9   3.3  0.1    1.2    0.0   0.1
     1 91168   1.5   6.4  0.0    1.6    -99   0.0
     1 91175   0.2   0.5  0.0    1.8    -99   0.0
     1 91181   0.0   1.2  0.0    1.0    -99   0.0
     1 91188   -99   1.5  -99    0.2    -99   0.0
     1 91195   -99   3.3  -99    0.0    -99   0.0
```

1 *The pest names defined by these pest header are: CEW6 - 6th instar corn earworm; SL6 - 6th instar soybean looper; VC5- 5th instar velvetbean caterpillar; VC6 - 6th instar velvetbean caterpillar; SHAD - percent canopy shading by shade cloth; and GC5 - 5th instar green cloverworm. Each pest and damage is defined in the pest coefficient file.*

TABLE 21. A TYPICAL PEST COEFFICIENT FILE FOR DRY BEAN. (BNGRO940.PST)

LN	PID	PNAME	PCTID	PCPID	PDCF1	PFCF2	Units	Source
01	EMP	Empoasca kramerii	4	SDNS	10.0000000	0.0000	no./larva/d	estimated
				SDNL	2.50000000	0.0000	no./larva/d	estimated
				LAD	0.00505000	0.0000	m2/larva/d	estimated
02	APN2	4 Instar Apion	1	SDNS	10.0000000	0.0000	no./larva/d	estimated
			1	SDNL	2.50000000	0.0000	no./larva/d	estimated
03	APN4	4 Instar Apion	1	SDNS	10.0000000	0.0000	no./larva/d	estimated
			1	SDNL	2.50000000	0.0000	no./larva/d	estimated
04	HL2	Heliothis	1	SDNS	10.0000000	0.0000	no./larva/d	estimated
05	HL4	Heliothis	1	SDNS	10.0000000	0.0000	no./larva/d	estimated
06	HL6	Heliothis	1	SDNS	10.0000000	0.0000	no./larva/d	estimated
07	EPN	Epinotia	4	SDNS	15.0000000	0.0000	no./m2/d	estimated
				SDNM	5.00000000	0.0000	no./m2/d	estimated
08	WFL	Bemisia (white fly)	1	LMD	2.00000000	0.0000	g/larva/day	estimated
09	BSM	Bean stem maggot	1	RLV	1.00000000	0.0000	cm/cm2/lar/d	estimated
10	PCLA	Obs.% defoliation	2	LAD	1.00000000	0.0000	%	estimated
11	PSTM	Obs.% Stem damage	2	SMD	1.00000000	0.0000	%	estimated
12	PDLA	% Diseased Leaf Area	3	PDLA	1.00000000	0.0000	%/day	estimated
13	PRP	% Reduction in Photo	3	ASM	1.00000000	0.0000	%/day	estimated
14	PLAI	% daily LAI dest.	3	LAD	1.00000000	0.0000	%/day	estimated
15	PLM	% daily Leaf Mass	3	LMD	1.00000000	0.0000	%/day	estimated
16	PWP	% Whole Plants	3	WPD	1.00000000	0.0000	%/day	estimated
17	PSDN	% All Seed Dest.	3	SDNL	1.00000000	0.0000	%/day	estimated
				SDNS	1.00000000	0.0000	%/day	estimated
				SDNM	1.00000000	0.0000	%/day	estimated
18	PSHN	% All Shell Dest.	3	SHNL	1.00000000	0.0000	%/day	estimated
				SHNS	1.00000000	0.0000	%/day	estimated
				SHNM	1.00000000	0.0000	%/day	estimated
19	PPDN	% All Pod Dest.	3	PPDN	1.00000000	0.0000	%/day	estimated
20	PRTM	% Root mass dest.	3	RMD	1.00000000	0.0000	%/day	estimated

TABLE 22. A TYPICAL PEST COEFFICIENT FILE FOR PEANUT. (PNGRO940.PST)

LN	PID[1]	PNAME	PCTID	PCPID	PDCF1	PFCF2	Units	Source
01	CEW6	Corn Earworm[2]	1	LAD	0.00505000	0.0000	m2/larva/d	Szmedra et al. 1988
02	VBC5	5 Instar Velvetbean[3]	1	LAD	0.00081000	0.0000	m2/larva/d	Reid, 1975
03	VBC6	6 Instar Velvetbean	1	LAD	0.00144000	0.0000	m2/larva/d	Reid, 1975
04	SL4	Soybean Looper[4]	1	LAD	0.00044000	0.0000	m2/larva/d	Reid and Green 1975
05	SL5	Soybean Looper	1	LAD	0.00071000	0.0000	m2/larva/d	Reid and Green 1975
06	SL6	Soybean Looper	1	LAD	0.00124000	0.0000	m2/larva/d	Reid and Green 1975
07	FAW	Fall Armyworm	1	LMD	2.00000000	0.0000	g/larva/d	estimated
08	RTWM	rootworm	1	RLV	1.00000000	0.0000	cm/cm2/lar/d	estimated
09	PCLA	Obs.% defoliation	2	LAD	1.00000000	0.0000	%	estimated
10	PSTM	Obs.% Stem damage	2	SMD	1.00000000	0.0000	%	estimated
11	PDLA	% Diseased Leaf Area	3	PDLA	1.00000000	0.0000	%/day	estimated
12	PRP	% Reduction in Photo	3	ASM	1.00000000	0.0000	%/day	estimated
13	PLAI	% daily LAI dest.	3	LAD	1.00000000	0.0000	%/day	estimated
14	PLM	% daily Leaf Mass	3	LMD	1.00000000	0.0000	%/day	estimated
15	PWP	% Whole Plants	3	WPD	1.00000000	0.0000	%/day	estimated
16	PSDN	% All Seed Dest.	3	SDNL	1.00000000	0.0000	%/day	estimated
				SDNS	1.00000000	0.0000	%/day	estimated
				SDNM	1.00000000	0.0000	%/day	estimated
17	PSHN	% All Shell Dest.	3	SHNL	1.00000000	0.0000	%/day	estimated
				SHNS	1.00000000	0.0000	%/day	estimated
				SHNM	1.00000000	0.0000	%/day	estimated
18	PPDN	% All Pod Dest.	3	PPDN	1.00000000	0.0000	%/day	estimated
19	PRTM	% Root mass dest.	3	RMD	1.00000000	0.0000	%/day	estimated

[1] *Pest identifier or abbreviation for the pest or damage type.*
[2] *Corn Earworm (Heliothis Zea.)*
[3] *Velvetbean Caterpillar (Anticarsia gemmatalis)*
[4] *Soybean Looper (Pseudoplusia includens)*

TABLE 23. A TYPICAL PEST COEFFICIENT FILE FOR SOYBEAN. (SBGRO940.PST)

LN	PID[1]	PNAME	PCTID	PCPID	PDCF1	PFCF2	Units	Source
01	CEW6	Corn Earworm[2]	4	SDNS	10.0000000	0.0000	no./larva/d	Batchelor et al.1989
				SDNL	2.50000000	0.0000	no./larva/d	Szmedra et al. 1988
				LAD	0.00505000	0.0000	m2/larva/d	Szmedra et al. 1988
02	VBC5	5 Instar Velvetbean[3]	1	LAD	0.00081000	0.0000	m2/larva/d	Reid, 1975
03	VBC6	6 Instar Velvetbean	1	LAD	0.00144000	0.0000	m2/larva/d	Reid, 1975
04	SL4	Soybean Looper[4]	1	LAD	0.00044000	0.0000	m2/larva/d	Reid and Green 1975
05	SL5	Soybean Looper	1	LAD	0.00071000	0.0000	m2/larva/d	Reid and Green 1975
06	SL6	Soybean Looper	1	LAD	0.00124000	0.0000	m2/larva/d	Reid and Green 1975
07	SGSB	Stinkbug[5]	4	SDNS	15.0000000	0.0000	no./m2/d	Batchelor et al. 1989
				SDNM	5.00000000	0.0000	no./m2/d	Batchelor et al. 1989
08	FAW	Fall Armyworm	1	LMD	2.00000000	0.0000	g/larva/day	estimated
09	RTWM	rootworm	1	RLV	1.00000000	0.0000	cm/cm2/lar/d	estimated
10	PCLA	Obs.% defoliation	2	LAD	1.00000000	0.0000	%	estimated
11	PSTM	Obs.% Stem damage	2	SMD	1.00000000	0.0000	%	estimated
12	PDLA	% Diseased Leaf Area	3	PDLA	1.00000000	0.0000	%/day	estimated
13	PRP	% Reduction in Photo	3	ASM	1.00000000	0.0000	%/day	estimated
14	PLAI	% daily LAI dest.	3	LAD	1.00000000	0.0000	%/day	estimated
15	PLM	% daily Leaf Mass	3	LMD	1.00000000	0.0000	%/day	estimated
16	PWP	% Whole Plants	3	WPD	1.00000000	0.0000	%/day	estimated
17	PSDN	% All Seed Dest.	3	SDNL	1.00000000	0.0000	%/day	estimated
				SDNS	1.00000000	0.0000	%/day	estimated
				SDNM	1.00000000	0.0000	%/day	estimated
18	PSHN	% All Shell Dest.	3	SHNL	1.00000000	0.0000	%/day	estimated
				SHNS	1.00000000	0.0000	%/day	estimated
				SHNM	1.00000000	0.0000	%/day	estimated
19	PPDN	% All Pod Dest.	3	PPDN	1.00000000	0.0000	%/day	estimated
20	PRTM	% Root mass dest.	3	RMD	1.00000000	0.0000	%/day	estimated

[1] *Pest identifier or abbreviation for the pest or damage type.*
[2] *Corn Earworm (Heliothis Zea.)*
[3] *Velvetbean Caterpillar (Anticarsia gemmatalis)*
[4] *Soybean Looper (Pseudoplusia includens)*
[5] *Southern Green Stinkbug (Nezara virdula L.)*

Examples of Pest Data Files for Various Experiments

Example 1 (Corn Earworm Damage in Soybean)

In this example, damage resulting from 6th instar corn earworm (PID = CEW6) was applied to both irrigated and non-irrigated treatments in the soybean experiment UFGA7802.SBX. In the experiment, treatments 1 and 2 contained irrigated and non-irrigated Bragg soybean without pest damage. In treatments 3 and 4, pest damage due to observed levels of corn earworm was applied to the irrigated and non-irrigated treatments. It was assumed that the CEW6 population was measured through periodic field scouting, which resulted in the scouting report shown in Table 24.

In order to apply the pest damage in the model, the following steps were followed:

1. Checked to ensure that the pest was defined in the pest coefficient file (SBGRO940.PST) (see Table 23);
2. Entered the observed population levels in FILET (UFGA7802.SBT); and
3. Set the PEST damage option to 'Y' in FILEX (UFGA7802.SBX).

The steps described in the preceding section, "Pest Damage Data Files" were followed to add the pest population observations to FILET. As part of Step 2, a column was added in FILET, UFGA7802.SBT, using a text editor, containing the CEW6 header for corn earworm (or the PID) (see Table 25). The CEW6 header in

Table 24. Corn Earworm Population Data Collected from Field Scouting for the Soybean Experiment UFGA7802.

Day of year	Corn earworm population, no. m^{-2}
222	0.0
229	0.5
236	1.0
243	2.5
250	5.5
257	11.1
264	14.1
271	13.1
278	0.5
285	0.8
292	0.9

Table 25. Time Series File for the Soybean Experiment UFGA7802 Showing 6th Instar Corn Earworm Population Levels (CEW6).

*EXP.DATA (T): UFGA7802SB BRAGG, IRR*INSECT DAMAGE

@TRNO	DATE	LAID	SWAD	GWAD	LWAD	CWAD	PWAD	SHAD	SH%D	SLAD	HIAD	CEW6
1	78194	.89	178	0.	266	444	0.	0.	0.00	334.6	0.0	0.0
1	78201	1.28	300	0.	366	667	0.	0.	0.00	349.7	0.0	0.0
1	78208	1.91	551	0.	656	1207	0.	0.	0.00	291.2	0.0	0.0
1	78215	2.86	943	0.	843	1786	0.	0.	0.00	339.3	0.0	0.0
1	78222	4.17	1561	0.	1187	2748	0.	0.	0.00	351.3	0.0	0.0
1	78229	3.90	1956	0.	1204	3160	0.	0.	0.00	323.9	0.0	0.0
1	78236	4.66	2947	0.	1723	4792	123	123	0.00	270.5	0.0	0.0
1	78243	4.47	3144	0.	1772	5224	308	308	0.00	252.3	0.0	0.0
1	78250	4.44	3303	182	1631	5740	805	623	22.60	272.2	0.030	0.0
1	78257	3.99	3326	754	1568	6507	1613	859	46.75	254.5	0.116	0.0
1	78264	4.67	3657	1912	1769	8586	3161	1249	60.49	264.0	0.222	0.0
1	78271	2.83	2732	2223	1180	7144	3232	1009	68.78	239.8	0.311	0.0
1	78278	2.09	2515	2730	858.0	7136	3763	1033	72.55	243.6	0.383	0.0
1	78285	.47	1851	2913	170.0	5866	3845	932	75.76	276.5	0.497	0.0
1	78292	.09	2064	3169	34.0	6270	4172	1003	75.96	264.7	0.505	0.0
2	78194	.75	160	0.	244	405	0.	0.	0.00	307.4	0.0	0.0
2	78201	1.08	251	0.	311	563	0.	0.	0.00	347.3	0.0	0.0
2	78208	1.81	535	0.	626	1161	0.	0.	0.00	289.1	0.0	0.0
2	78215	3.29	1080	0.	974	2054	0.	0.	0.00	337.8	0.0	0.0
2	78222	4.38	1663	0.	1261	2923	0.	0.	0.00	347.3	0.0	0.0
2	78229	4.30	2083	0.	1392	3475	0.	0.	0.00	308.9	0.0	0.0
2	78236	4.21	2556	0.	1517	4184	112	112	0.00	277.5	0.0	0.0
2	78243	4.50	2673	0.	1439	4431	319	319	0.00	312.7	0.0	0.0
2	78250	2.09	1998	42	838	3104	268	226	15.67	249.4	0.014	0.0
2	78257	3.24	2650	253	1220	4530	661	408	38.28	265.6	0.056	0.0
2	78264	2.30	2609	471	931	4440	901	430	52.28	247.0	0.106	0.0
2	78271	1.14	2113	775	498	3812	1200	425	64.58	228.9	0.203	0.0
2	78278	.85	1905	782	371	3398	1122	340	69.70	229.1	0.230	0.0
2	78285	.53	1922	1149	236	3732	1574	425	73.00	224.5	0.308	0.0
2	78292	.07	1590	1206	30	3250	1630	424	73.99	233.3	0.371	0.0
3	78194	.89	178	0.	266	444	0.	0.	0.00	334.6	0.0	0.0
3	78201	1.28	300	0.	366	667	0.	0.	0.00	349.7	0.0	0.0
3	78208	1.91	551	0.	656	1207	0.	0.	0.00	291.2	0.0	0.0
3	78215	2.86	943	0.	843	1786	0.	0.	0.00	339.3	0.0	0.0
3	78222	4.17	1561	0.	1187	2748	0.	0.	0.00	351.3	0.0	0.0
3	78229	3.90	1956	0.	1204	3160	0.	0.	0.00	323.9	0.0	0.5
3	78236	4.66	2947	0.	1723	4792	123	123	0.00	270.5	0.0	1.0
3	78243	4.47	3144	0.	1772	5224	308	308	0.00	252.3	0.0	2.5
3	78250	4.44	3303	182	1631	5740	805	623	22.60	272.2	0.030	5.5
3	78257	3.99	3326	754	1568	6507	1613	859	46.75	254.5	0.116	11.1
3	78264	4.67	3657	1912	1769	8586	3161	1249	60.49	264.0	0.222	14.1
3	78271	2.83	2732	2223	1180	7144	3232	1009	68.78	239.8	0.311	13.1
3	78278	2.09	2515	2730	858	7136	3763	1033	72.55	243.6	0.383	0.5
3	78285	.47	1851	2913	170	5866	3845	932	75.76	276.5	0.497	0.8
3	78292	.09	2064	3169	34	6270	4172	1003	75.96	264.7	0.505	0.9

FILET must match the unique 4 character pest identifier (PID) for corn earworm in the pest coefficient file, SBGRO940.PST (see Table 23). This file is in used by the model to match the pest population with the pest coefficients. The header must be left-justified in the columns in FILET as described in Volume 2-1 (Jones et al. 1994) of this book for FILET formats. Next, the observed population levels were placed in UFGA7802.SBT (Table 25). (Note that the populations were entered in treatments 3 and 4. During the simulation, daily populations are linearly interpolated between observations entered in this file.) Finally, the DISES option was set to 'Y' and the pest output was turned on ((DIOUT = 'Y') in the Simulation Controls section of UFGA7802.SBX, as shown in Table 26.

Table 26. Simulation Control Section of File UFGA7802.SBX Showing the Disease Simulation Option (DISES) Set to 'Y' to Enable Pest Damage Simulation.

```
*SIMULATION CONTROLS
@N GENERAL     NYERS NREPS START YRDAY RSEED SNAME....................
 1 GE              1     1     S  78166  2150 BRAGG, IRRIGATED & NON-IR
@N OPTIONS     WATER NITRO SYMBI PHOSP POTAS DISES
 1 OP              Y     Y     Y     N     N     Y
@N METHODS     WTHER INCON LIGHT EVAPO INFIL PHOTO
 1 ME              M     M     E     R     S     C
@N MANAGEMENT  PLANT IRRIG FERTI RESID HARVS
 1 MA              R     R     R     R     M
@N OUTPUTS     FNAME OVVEW SUMRY FROPT GROUT CAOUT WAOUT NIOUT MIOUT DIOUT  LONG
 1 OU              N     Y     Y     3     Y     Y     Y     Y     N     Y     Y
```

Example 2 (Velvetbean Caterpillar Defoliation Damage in Soybean)

The experiment UFQU7902 contained two soybean treatments. An insecticide was used in the control treatment and a second treatment was not sprayed. Periodic measurements of leaf area index showed severe defoliation due to velvetbean caterpillar larva occurred in the untreated treatment. In this experiment, pest population data were not collected; however, percent defoliation measured for the damaged treatment is shown in Table 27. In this experiment, defoliation can be simulated by specifying the percent observed defoliation over time.

To simulate damage, the following steps were taken:

1. Checked to ensure that the pest was defined in the pest coefficient file (SBGRO940.PST) (see Table 23);
2. Entered the observed defoliation in FILET (UFQU7902.SBT); and
3. Set the PEST damage option to 'Y' in FILEX (UFQU7902.SBX).

The steps described in the section, "Pest Damage Data Files," were followed to add the pest observations to FILET. The PID for percent cumulative leaf area damage is PCLA. The PCPID was leaf area index, indicated by the CROPGRO leaf area index damage variable, LAD (Table 19). The PCTID selected was "2," which indicates that damage will be entered in FILET as observed defoliation. The crop model will compute the daily damage required to obtain this level of defoliation on the observation dates. The damage coefficient is 1.0, so that the

Table 27. Percent Defoliation Measured at Different Observation Dates for the Soybean Experiment UFQU7902. Defoliation Occurred Due to Velvetbean Caterpillar Population; However, the Population Level Was Unknown.

Day of year	Observed defoliation,
241	0.0
248	22.6
255	56.1
262	50.0
271	52.5
276	57.1
283	57.9
288	61.7
292	53.3
295	71.4
303	100.0

damage recorded in FILET will be directly applied to one or more variables in the model. This means that these variables in the model are proportionally reduced by the same percent as entered for these coefficients in FILET. When a damage type, such as this one, is defined, direct measures of damage are typically recorded in the time series file and the damage coefficient is set to 1.0.

A column with the header PCLA was entered in the time series file UFQU7902.SBT. Percent damage on each observation date was entered for treatment 2 as shown in Table 28. The crop model linearly interpolates between observations to obtain daily levels of observed damage. An entry of "-99" indicates that data were not available. Thus, CROPGRO skips that entry for linear interpolation of daily damage. Finally, the DISES variable in the Simulation Controls section of UFQU7902.SBX was set to 'Y' as shown in Table 26.

TABLE 28. TIME SERIES DATA FILE FOR THE SOYBEAN EXPERIMENT UFQU7902 SHOWING OBSERVED DEFOLIATION LEVELS (PCLA) RESULTING FROM VELVETBEAN CATERPILLAR DAMAGE.

*EXP.DATA (T): UFQU7902SB BRAGG, WELL IRRIGATED (defoliation)

@TRNO	DATE	LAID	SWAD	GWAD	LWAD	CWAD	PWAD	SHAD	SH%D	SLAD	PCLA
1	79234	4.15	1945	0	1214	3228	0	0	0.00	323.5	-99
1	79241	5.48	2650	0	1659	4455	132	132	0.00	327.6	-99
1	79248	5.53	3075	60	1925	5491	566	506	10.60	298.8	-99
1	79255	5.54	3509	303	1718	6755	1357	1054	15.24	293.4	-99
1	79262	5.32	3435	777	1866	7395	1988	1211	39.08	269.8	-99
1	79271	4.04	3362	1319	1481	7351	2509	1190	48.59	272.4	-99
1	79276	4.25	3103	1943	1540	7635	3013	1070	64.49	279.8	-99
1	79283	3.92	3754	2635	1659	9372	4039	1404	65.24	248.3	-99
1	79288	3.85	3601	3313	1600	9957	4883	1570	67.85	261.2	-99
1	79292	1.36	2633	3039	592	7578	4267	1228	71.22	200.6	-99
1	79295	0.54	2084	3896	148	7666	5406	1510	72.07	243.2	-99
1	79303	0.47	2388	3541	140	7345	4763	1222	74.34	241.0	-99
2	79234	5.00	-99	0	1540	-99	0.	-99	-99	-99	0.0
2	79241	5.20	-99	0	1540	-99	100	-99	-99	-99	0.0
2	79248	4.10	-99	0	1600	-99	600	-99	-99	-99	22.6
2	79255	2.50	-99	300	1096	-99	1200	-99	-99	-99	56.1
2	79262	2.70	-99	700	1185	-99	1800	-99	-99	-99	50.0
2	79271	1.90	-99	1000	859	-99	1950	-99	-99	-99	52.5
2	79276	1.80	-99	1600	948	-99	2500	-99	-99	-99	57.1
2	79283	1.50	-99	2100	740	-99	3200	-99	-99	-99	57.9
2	79288	1.30	-99	2300	592	-99	3600	-99	-99	-99	65.7
2	79292	0.70	-99	2400	266	-99	3400	-99	-99	-99	75.3
2	79295	0.20	-99	3000	88	-99	4200	-99	-99	-99	85.4
2	79303	0.00	-99	-99	0.	-99	-99	-99	-99	-99	100.0
2	79304	0.00	-99	-99	0.	-99	-99	-99	-99	-99	100.0
2	79305	0.00	-99	-99	0.	-99	-99	-99	-99	-99	100.0

Example 3 (Leafspot Disease in Peanut)

In this third example, an experiment was conducted to determine the effect of late leafspot on peanut pod yield. In the control treatment, a fungicide was sprayed following extension guidelines to obtain good control of leafspot disease throughout the growing season. In the second treatment, no leafspot control measures were taken. Observed defoliation between the control and disease treatments were taken periodically throughout the growing season. Percent diseased leaf area was also measured on each treatment. Defoliation and percent diseased leaf area for the disease treatment were recorded as shown in Table 29.

As in the previous examples, the following steps were taken to link this damage to the crop model:

1. Checked to ensure that the pest was defined in the pest coefficient file (PNGRO940.PST) (see Table 22);
2. Entered observed defoliation and percent diseased leaf area in FILET (UFGA8602.PNT); and
3. Set PEST damage option to 'Y' in FILEX (UFGA8602.PNX).

Table 29. Observed Percent Defoliation and Percent Diseased Leaf Area Collected from Field Scouting for the Peanut Experiment UFGA8602.

Days after planting(DAP)	Percent observed defoliation (PCLA)	Percent diseased leaf area (PDLA)
218	0.0	0.0
230	0.0	0.25
232	4.8	0.28
238	17.3	1.49
246	25.5	41.3
254	26.0	58.8
260	28.0	56.5
266	29.5	75.7
274	31.2	90.1
280	32.0	88.5
288	30.5	99.1
294	29.0	98.6
302	-99	100.0

The steps described in the section, "Pest Damage Data Files," were followed to add the pest observations to FILET. The PID for this damage is PDLA (see Table 22). The associated coupling point damage variable (PCPID) is also PDLA, which reduces healthy leaf area in the crop model (Table 19), and subsequently photosynthetic capacity. The damage characterization type (PCTID) is "3" since diseased leaf area is described as a percent per day.

After the two damage types were confirmed defined in the pest coefficient file (PNGRO940.PST; Table 22), the observed levels of damage were input in the time series file, UFGA8602.PNT, in columns corresponding to the four character pest identification codes PCLA and PDLA (Table 30). Daily values of damage will be generated by the model through linearly interpolating between observations. Finally, the DISES variable in the Simulation Controls section of UFGA8602.PNX was set to 'Y' to simulate pest damage in the same manner as shown in Table 26.

Table 30. Time Series File for the Peanut Experiment UFGA8602 Showing Observed Levels of Defoliation (PCLA) and Diseased Leaf Area (PDLA) Due to Leafspot Disease.

*EXP.DATA (T): UFGA8602PN RAINFED, FLORUNNER,GOOD DISEASE CONTROL

@TRNO	DATE	L#SD	PCLA	PDLA	LAID	P#AD	SWAD	GWAD	LWAD	CWAD	PWAD	ATPW	DTPW	SHAD	G#AD	HIPD	SH%D	SLAD	GWGD
1	86176	7.4	0.0	0.0	0.29	0.	85.	0.	137.	222.	0.	0.	0.	0.	0.0	0.000	0.0	215.	0.0
1	86190	10.6	0.0	0.0	1.14	0.	397.	0.	492.	889.	0.	0.	0.	0.	0.0	0.000	0.0	231.	0.0
1	86204	14.8	0.0	0.0	2.48	19.	1332.	0.	1164.	2509.	13.	13.	0.	13.	0.0	0.005	0.0	213.	0.0
1	86211	15.6	0.0	0.0	3.16	32.	1714.	0.	1526.	3306.	67.	67.	0.	67.	0.0	0.020	0.0	209.	0.0
1	86218	17.1	0.0	0.0	5.52	226.	3049.	56.	2248.	5545.	248.	248.	0.	192.	67.5	0.045	20.7	246.	83.0
1	86230	21.0	0.0	0.0	5.64	273.	3411.	264.	2440.	6528.	678.	678.	0.	414.	197.1	0.104	36.1	231.	133.9
1	86232	21.8	0.0	0.0	6.50	461.	4052.	486.	2640.	7683.	990.	990.	0.	504.	331.6	0.129	48.8	246.	146.6
1	86238	23.3	0.0	0.0	7.34	468.	4696.	900.	3153.	9322.	1474.	1474.	0.	574.	400.8	0.158	60.6	232.	224.6
1	86246	25.0	0.0	0.02	7.55	630.	4572.	1449.	3078.	9812.	2162.	2162.	0.	713.	519.3	0.220	67.0	246.	279.0
1	86254	26.5	0.0	0.0	7.75	797.	5073.	2375.	3457.	11958	3429.	3429.	0.	1054.	684.2	0.287	69.3	225.	347.1
1	86260	28.8	0.0	0.08	6.85	583.	4548.	2477.	2966.	10896	3381.	3381.	0.	904.	724.2	0.310	73.0	231.	342.0
1	86266	27.0	0.0	0.01	8.06	860.	5568.	3492.	3640.	13850	4642.	4642.	0.	1150.	868.8	0.335	75.6	221.	401.9
1	86274	29.0	0.0	0.06	6.75	694.	4764.	3343.	2903.	12108	4450.	4440.	10.	1097.	760.0	0.367	75.2	232.	439.9
1	86280	28.0	0.0	0.07	4.53	602.	5076.	4168.	2030.	12512	5416.	5405.	11.	1237.	833.8	0.432	77.1	223.	499.9
1	86288	29.8	0.0	0.13	4.67	794.	5438.	4413.	2223.	13189	5687.	5528.	159.	1115.	869.9	0.419	79.6	210.	507.3
1	86294	31.5	0.0	0.57	4.85	640.	5330.	4289.	2644.	13477	5683.	5503.	180.	1214.	808.4	0.408	77.9	183.	530.6
1	86302	30.5	0.0	0.15	4.57	604.	5667.	4638.	2342.	13748	6190.	5739.	451.	1101.	881.0	0.417	80.8	196.	526.4
2	86176	7.6	0.0	0.0	0.29	0.	85.	0.	137.	222.	0.	0.	0.	0.	0.0	0.000	0.0	215.	0.0
2	86190	10.8	0.0	0.0	1.14	0.	397.	0.	492.	889.	0.	0.	0.	0.	0.0	0.000	0.0	231.	0.0
2	86204	14.3	0.0	0.0	2.45	12.	1366.	0.	1165.	2538.	7.	7.	0.	7.	0.0	0.003	0.0	211.	0.0
2	86211	15.6	0.0	0.0	4.03	247.	1940.	0.	1662.	3692.	90.	90.	0.	90.	0.0	0.024	0.0	243.	0.0
2	86218	16.8	0.0	0.0	5.28	224.	2933.	33.	2253.	5421.	235.	235.	0.	232.	37.0	0.043	12.8	235.	89.2
2	86230	21.7	0.0	0.25	6.18	378.	3767.	436.	2513.	7217.	937.	937.	0.	501.	281.0	0.130	45.0	245.	155.2
2	86232	21.8	4.8	0.28	6.02	365.	3832.	419.	2503.	7229.	895.	895.	0.	475.	293.6	0.124	46.4	241.	142.7
2	86238	23.7	17.3	1.49	5.94	549.	4106.	915.	2608.	8269.	1554.	1554.	0.	639.	431.8	0.188	59.0	228.	211.9
2	86246	25.5	41.3	4.22	4.24	552.	4616.	1438.	1807.	8438.	2015.	2015.	0.	577.	487.3	0.239	71.0	235.	295.1
2	86254	26.0	58.8	5.05	2.34	627.	4872.	1933.	1076.	8486.	2538.	2538.	0.	605.	523.2	0.299	76.2	218.	369.4
2	86260	28.0	56.5	4.77	2.10	564.	4161.	2588.	995.	8568.	3412.	3412.	0.	824.	646.7	0.398	75.8	211.	400.2
2	86266	29.5	75.7	4.15	1.75	786.	5448.	2973.	886.	10224	3890.	3890.	0.	917.	705.4	0.380	76.5	197.	421.5
2	86274	31.2	90.1	4.88	0.52	454.	3732.	2921.	270.	7664.	3718.	3662.	56.	741.	588.1	0.478	79.6	190.	496.7
2	86280	32.0	88.5	9.17	0.40	706.	3804.	3477.	234.	8355.	4409.	4316.	93.	839.	741.2	0.516	80.7	173.	469.1
2	86288	30.5	99.1	7.89	0.04	394.	3473.	2300.	19.	6258.	3876.	2766.	1110.	466.	441.0	0.442	83.2	188.	521.5
2	86294	29.0	98.6	0.0	0.04	342.	3241.	2195.	36.	5926.	4439.	2649.	1790.	454.	404.5	0.447	82.8	94.	542.6
2	86302	0.0	100.0	0.0	0.00	17.	3087.	111.	0.	3223.	2538.	136.	2402.	25.	22.9	0.042	62.0	0.	484.7

APPENDIX C.
RUNNING MODELS UNDER THE DSSAT V3 SHELL AND AS STAND-ALONE EXECUTABLES

RUNNING UNDER THE DSSAT V3 SHELL

When running the models under the DSSAT v3 Shell (see Volume 1-3, Hunt et al. 1994, of this book, for a description of the Shell), the location of the various files are obtained from a file-locator file in the DSSAT v3 directory named DSSAT-PRO.FLE (see the Appendix to Volume 1 for a listing of this file). Each crop model is designed to first check the local directory (from where the model is run) for input files. If it does not find them in the local path, the model modules will open the DSSATPRO.FLE file to find the path of soil, weather, and crop coefficient files. Table 31 lists the various modules and files required for running the crop models and the default paths for running them under DSSAT the DSSAT v3 Shell. Note, however, that DSSAT v3 users can change these paths through the SETUP menu found under the DSSATv3 Shell (Volume 1-3, Hunt et al. 1994).

TABLE 31. SUGGESTED ORGANIZATION OF FILES FOR EXECUTION OF CROP MODELS UNDER THE DSSAT V3 SHELL, USING CROPGRO-SOYBEAN AS AN EXAMPLE.

Path	Module or File Type	File Name
C:\DSSAT3	Model Driver Module	MDRIV940.EXE
C:\DSSAT3	Model Input Module	MINPT940.EXE
C:\DSSAT3	Model Executable Module	CRGRO940.EXE
C:\DSSAT3	Graphic Program	WINGRAF.EXE
C:\DSSAT3	Variable Definition File	DATA.CDE
C:\DSSAT3	File Containing Paths	DSSATPRO.FLE
C:\DSSAT3\GENOTYPE	Crop Cultivar Coefficient File	SBGRO940.CUL
C:\DSSAT3\GENOTYPE	Crop Species Coefficient File	SBGRO940.SPE
C:\DSSAT3\GENOTYPE	Crop Ecotype Coefficient File	SBGRO940.ECO
C:\DSSAT3\SOIL	Soil Data File	SOIL.SOL
C:\DSSAT3\WEATHER	Weather Data Files	UFGA7801.WTH
C:\DSSAT3\SOYBEAN	Management Inputs (FILEXs)	UFGA7801.SBX
C:\DSSAT3\SOYBEAN	Observed Field Data (Averages)	UFGA7801.SBA
C:\DSSAT3\SOYBEAN	Observed Field Data (Seasonal)	UFGA7801.SBT
C:\DSSAT3\SOYBEAN	List of Experiments	EXP.LST
C:\DSSAT3\SOYBEAN	List of Available Weather Data	WTH.LST
C:\DSSAT3\SOYBEAN	Model Output Files	GROWTH.OUT, etc.

Running as Stand-alone Executables

When running the DSSAT v3 crop models in stand-alone mode, all input and output data files are stored in one directory on a disk, and the executable modules are stored in a separate disk directory. One could also combine all executables with the input and output data. Table 32 lists the different files needed to run the crop models in a stand-alone mode and a suggested path structure. The example files are listed for soybean using the CROPGRO module, however a similar structure could be used for other models.

Table 32. Suggested Organization of Files for Stand-alone Execution of Crop Models, Using CROPGRO-Soybean as an Example.

Path	Module or File Type	File Name
C:\CROPGRO	Model Driver Module	MDRIV940.EXE
C:\CROPGRO	Model Input Module	MINPT940.EXE
C:\CROPGRO	Model Executable Module	CRGRO940.EXE
C:\CROPGRO	Graphic Program	WINGRAF.EXE
C:\CROPGRO	Variable Definition File	DATA.CDE
C:\CROPGRO	Batch File to Run Crop Model	GRO.BAT
C:\CROPGRO	Batch File to Run Graphics	GRAPH.BAT
C:\CROPGRO\SOYBEAN	Soil Data File	SOIL.SOL
C:\CROPGRO\SOYBEAN	Weather Data Files	UFGA7801.WTH
C:\CROPGRO\SOYBEAN	Management Inputs (FILEXs)	UFGA7801.SBX
C:\CROPGRO\SOYBEAN	Observed Field Data (Averages)	UFGA7801.SBA
C:\CROPGRO\SOYBEAN	Observed Field Data (Seasonal)	UFGA7801.SBT
C:\CROPGRO\SOYBEAN	List of Experiments	EXP.LST
C:\CROPGRO\SOYBEAN	List of Available Weather Data	WTH.LST
C:\CROPGRO\SOYBEAN	Crop Cultivar Coefficient File	SBGRO940.CUL
C:\CROPGRO\SOYBEAN	Crop Species Coefficient File	SBGRO940.SPE
C:\CROPGRO\SOYBEAN	Crop Ecotype Coefficient File	SBGRO940.ECO
C:\CROPGRO\SOYBEAN	Model Output Files	GROWTH.OUT, etc.

APPENDIX D.
CONTACTS FOR CROP MODEL INFORMATION

Crop Model Driver and Crop Model Inputs Program

Dr. G. Hoogenboom
Dept. of Biological and Agricultural Engineering
Georgia Station
University of Georgia
Griffin, GA 30223-1797, USA
Phone: 1-404-228-7216
Fax: 1-404-228-7218
E-mail: ghoogen@gaes.griffin.peachnet.edu

CERES–Barley, Maize, Millet, Wheat, Sorghum

Dr. P.W. Wilkens
Research and Development Division
International Fertilizer Development Center
P.O. Box 2040
Muscle Shoals, AL. 35662, USA
Phone: 1-205-381-6600
Fax: 1-205-381-7408
E-mail: p.wilkens@cgnet.com

CERES–Rice

Dr. U. Singh
Research and Development Division
International Fertilizer Development Center
P.O. Box 2070
Muscle Shoals, AL. 35662, USA
Phone: 1-205-381-6600
Fax: 1-205-381-7408

CROPGRO–Dry Bean

Dr. G. Hoogenboom or
Dr. J.W. White
Centro Internacional de Agricultura Tropical
Apartado Aereo 6713
Cali,COLOMBIA
E-mail: j.white@cgnet.com

CROPGRO–Peanut

Dr. K.J. Boote
Department of Agronomy
University of Florida
Gainesville, FL 32611, USA
Phone: 1-904-392-8535
Fax: 1-904-392-4092
or Dr. G. Hoogenboom

CROPGRO–Soybean

Dr. J.W. Jones
Department of Agricultural Engineering
University of Florida
Gainesville, FL 32611, USA
Phone: 1-904-392-8694
Fax: 1-904-392-4092
E-mail: jwj@water.agen.ufl.edu
or Drs. G. Hoogenboom and K. J. Boote

CROPSIM–Cassava

Dr. L.A. Hunt or
Dr. R. Matthews
Department of Crop Science
University of Guelph
Guelph, Ontario, NIG 2W1, CANADA
Phone: 1-519-824-4120
Fax: 1-519-763-8933
E-mail: thunt@crop.uoguelph.ca

VOLUME 2-3

GRAPHING SIMULATED & EXPERIMENT DATA

H. CHAN,
P.W. WILKENS,
G. HOOGENBOOM,
J.W. JONES,
D.C. GODWIN

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

CHAPTER ONE.
INTRODUCTION

A graphics program was written for DSSAT v3 to provide users with the capability to easily plot graphs that are routinely used during the development and validation of crop models. This program, called Graphing Simulated and Experiment Data, or Wingraf, adheres to the file definitions and data formats of DSSAT v3 described in Volume 2-1 (Jones et.al 1994) of this book. It is similar in operation to the graphics package in DSSAT v2.1 (IBSNAT 1989), but with notable functional and operational differences. Functionally, it allows users to plot time series graphs, Y versus X graphs, (such as grain weight vs. biomass), end of season responses (such a as yield vs. irrigation amount), and observed vs. simulation crop performance relationships for validation purposes. Operationally, users can use a mouse or keyboard commands to select variables. They can print the graph or save it to a file, change screen colors and graph scales, and create combinations of graphs that were not possible in v2.1.

The basic design of Wingraf is based on a set of codes that are used as headers over each column of data. For example, a simulated results data file may have a column of data with a header LAID, which refers to time-course values of leaf area index (LAI). If there is a corresponding field observation data file, the Wingraf program will search that file for a column of data with LAID as a header. It will then display a plot of LAI vs. time, with simulated data graphed by connecting points and observed data plotted by symbols. If the program does not find LAID in the observed data file, it will just plot simulated results. It can also be used to plot experimental data only.

A set of codes for crop, soil, and weather data are included with DSSAT v3 (see Appendix C of Volume 2-1, Jones et al. 1994, of this book for a listing of these codes). Note that these codes (left column) are followed by a short description which is used to label graphs, and a longer description with units. These codes are not rigid. Users may add their own codes and definitions to the file named DATA.CDE (see Appendix C of Volume 2-1, Jones et al. 1994, of this book), and Wingraf will correctly label any data that has this new code as a header. Note, however, that the DSSAT v3 crop models use the codes as defined in Appendix C of Volume 2-1 (Jones et al. 1994) of this book. If other crop models use other codes, this file could be changed accordingly.

CHAPTER TWO.
PROGRAM OVERVIEW

GUIDELINES

GENERAL

Wingraf was developed to run under the DSSAT v3 Shell (see Volume 1-3, Hunt et al. 1994, of this book) or as a stand-alone program (see note below). It uses TurboVision[1] for the user interface routines. The user interfaces with the program via menus and dialog boxes and the program displays information via windows. Wingraf supports the use of a mouse, provided a mouse driver has been loaded prior to the execution of this program. Both mouse and keyboard commands can be used in Wingraf, but the user interface is most easily exploited by the use of the mouse, and as such, examples cited in this Part refer to mouse actions. If using a keyboard, however, nearly all menu choices may be selected by use of the <ALT> key as well as with the highlighted letter of the menu option. The <TAB> and <SHIFT><TAB> keys can be used for moving through choices in dialog boxes.

NOTE: *When running Wingraf as a stand-alone program, the options to execute the program are as follows:*

1. *If running Wingraf under the Wingraf program directory, type "WINGRAF".*
2. *If running Wingraf under the data file directory, type "\DSSAT3\WINGRAF" at the DOS System C> prompt.*
3. *If the Wingraf program directory is included in the system's PATH, type "WINGRAF" at the DOS System C> prompt.*

SCREEN "BUTTONS"

In all Wingraf screens, where multiple buttons are available (e.g., the OK button in Screen 1, on following page, or the PREVIOUS, NEXT, X VARIABLE, GRAPH, RESET, OPTION buttons in Screen 3 in Chapter 3), you may "press" these by one of two methods:

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

---

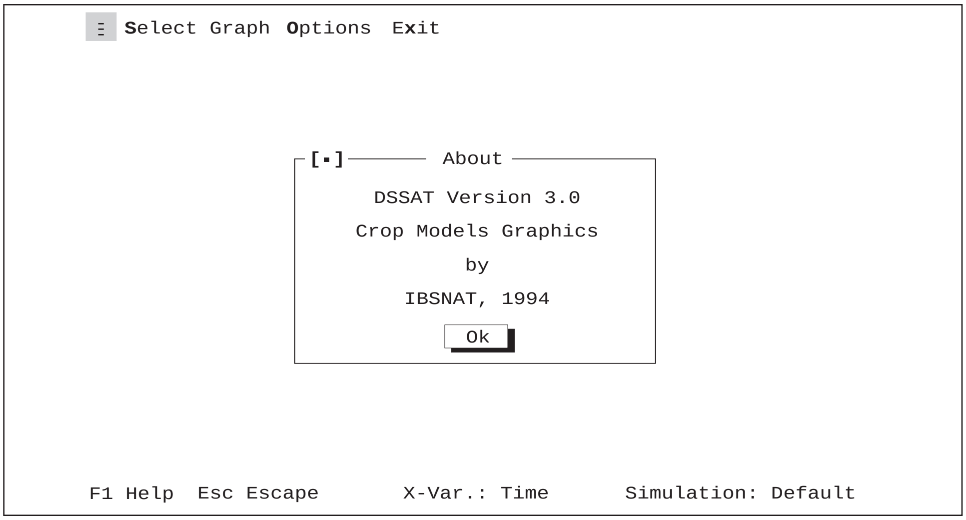
[1] TurboVision is a registered trademark of Borland International, Inc.

MENU STRUCTURE

The Wingraf main menu options are selected by a single click with a mouse on a menu choice, which will either execute an action, present a submenu, or display a dialog box requiring further user input. From the keyboard, use the arrow keys to move through and highlight the main menu items. Press the <ENTER> key when the menu item you wish to open is highlighted.

Selecting the "∫" symbol in the upper left corner of the Wingraf main menu display, allows you to exit Wingraf, or alternatively, to display the "About" screen (Screen 1, below).

A context-sensitive help function is provided throughout the entire program. The <F1> key invokes the help system.



SCREEN1

HARDWARE

Wingraf requires a minimum configuration of a 286SX or better processor running EMM386 with expanded memory with a math-coprocessor. DOS version 5.0 or higher is recommended. Wingraf requires 640K of random access memory (RAM), with a minimum of 420K free RAM running under the DSSAT v3 Shell. Wingraf supports most text and graphics display modes, but VGA color is recommended for clarity. In addition, if hardcopy output is needed, a supported printer is required.

CHAPTER THREE.
EXECUTE PROGRAM

Wingraf can be accessed through the DSSAT v3 Shell under three different entry points. To display graphs of measurements made within the growing season (time series graphs) and summary responses, open the Wingraf program under the Shell's DATA main menu item. To do this, highlight DATA and then select the "X Experiment" option by using the mouse, pressing the <X> key or by moving the highlight bar with the arrow keys to the"X Experiment" option and pressing the <ENTER> key. From the "X Experiment" menu, select the "Utilities" option. A list of three menu options will be presented. Select the "G Graph" menu option and then select a crop from the window that is presented. The Wingraf main menu screen will be presented (see Screen 2 in Chapter 4).

To plot simulated and experimental data, open Wingraf under the Shell's MODEL main menu item. Please note that you must first run one of the DSSAT v3 crop models listed under the MODEL menu item before using the Wingraf program or no simulated data will be available for graphing.

Wingraf is found in two places under the MODEL main menu item. The first can be found by selecting the "O Other" item from the list of options in the pull-down MODEL menu. Select this item and a submenu of various options is presented, including "G Graph." Select "G Graph" to open Wingraf. Alternatively, after selecting one of the crop models in the MODEL pull-down menu, a third tier menu is presented, which includes "G Graph." Again, select "G Graph" to open Wingraf.

When "G Graph" is selected from these selection points, the Wingraf main menu screen is presented (see Screen 2 in Chapter 4). The top line of this screen, with SELECT GRAPH, OPTIONS and EXIT, is the menu bar. Each item in this menu bar has a related pull-down menu. To access these menus, click on the menu item with the mouse and the pull-down menus will be presented. With the keyboard, use the arrow keys to move through the menu bar and the pull-down menus under each will be presented. To select items in these menus, either click on one with the mouse, use the arrow keys to highlight an item in the pull-down menu and press the <ENTER> key or press the first letter of the item. For example, press <G> to open "Growth" under the Select Graph menu bar item.

CHAPTER FOUR.
GRAPH MENU

Under the SELECT GRAPH menu item are displayed the primary plotting functions in Wingraf (Screen 2, below). Growth, water, nitrogen, diseases and pests, and carbon output files are directly supported and use the DSSAT v3 standard output files, GROWTH.OUT, WATER.OUT, NITROGEN.OUT, PEST.OUT, and CARBON.OUT, respectively. The phosphorus option is included for compatibility with future model outputs.

```
   Select Graph  Options  Exit
  ┌────────────────────────────┐
  │ Growth...                  │
  │ Water...                   │
  │ Nitrogen...                │
  │ Diseases & Pests...        │
  │ Carbon...                  │
  ├────────────────────────────┤
  │ User Selected Variables  ▶ │
  ├────────────────────────────┤
  │ Summary Validation       ▶ │
  ├────────────────────────────┤
  │ Summary Response...        │
  └────────────────────────────┘

 F1 Help  Esc Escape       X-Var.: Time      Simulation: Default
```

SCREEN 2.

GROWTH, WATER, NITROGEN, PHOSPHORUS, DISEASES & PESTS, CARBON OPTIONS

Selecting one of these options enables the user to plot a graph for the selected function. The screens presented when any one of these options is selected are similar. Thus, the screens for "Growth" will be used for illustration. When the "Growth"option is selected, Screen 3, on the following page, is presented.

```
 Select Graph  Options  Exit
[▪]─────────────────────────── GROWTH ──────────────────────────────
 Variables                          Run Numbers
 [ ] Leaf number per stem           [X] IRRIGATED
 [ ] Growth stage                   [X] NON - IRRIGATED
 [ ] Leaf area index
 [X] Leaf dry weight (kg/ha)
 [ ] Stem dry weight (kg/ha)
 [ ] Grain dry weight (kg/ha)
 [ ] Root dry weight (kg/ha)
 [X] Crop dry weight (kg/ha)
 [ ] Grain number (no/m2)
 [ ] Grain dry weight (mg/grain)
 [ ] Harvest index (grain/top)
 [ ] Pod dry weight (kg/ha)
 [ ] Pod number (no/m2)
 [ ] Photo water stress factor (0-1)
 [ ] Growth Water stress factor (0-1)
 [ ] Nitrogen stress factor (0-1)

 Previous   Next   X Variable   Graph   Reset   Option

F1 Help  Esc Escape       X-Var.: Time      Simulation: Default
```

Screen 3.

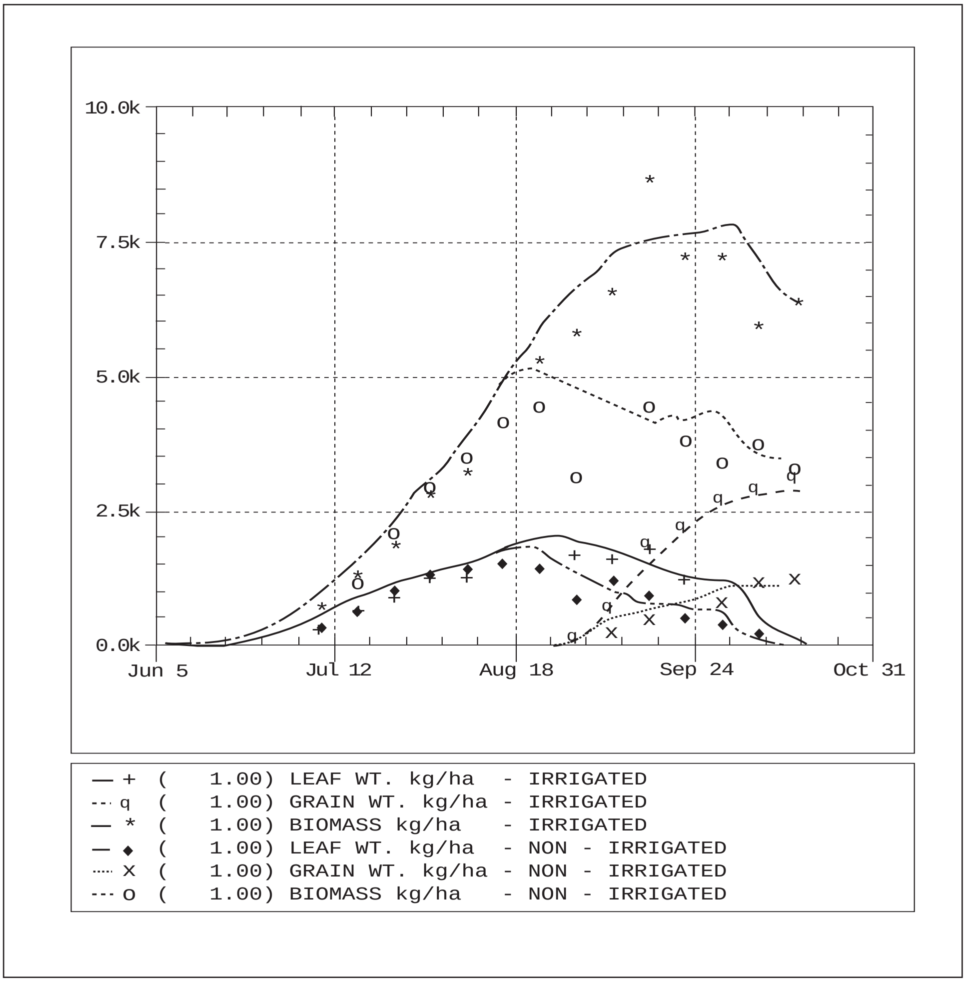
Selecting Plots

In Screen 3, users may select up to 6 plots for each graph. These six plots may be one variable with six runs, six variables with one run, or any combination of variables and runs up to 6. Selecting the RESET button will reset all current selections.

In example Screen 3, two variables, "Leaf dry weight (kg/ha)" and "Crop dry weight (kg/ha)," have been selected and two runs, "IRRIGATED" and "NON-IRRIGATED."

Pressing the GRAPH button displays the graph of these variables and runs (see Screen 4, on following page).

NOTE: *The OPTION button on the status line in Screen 3 is grayed out and will not be selectable until the first graph has been plotted.*



Screen 4.

X-Variable

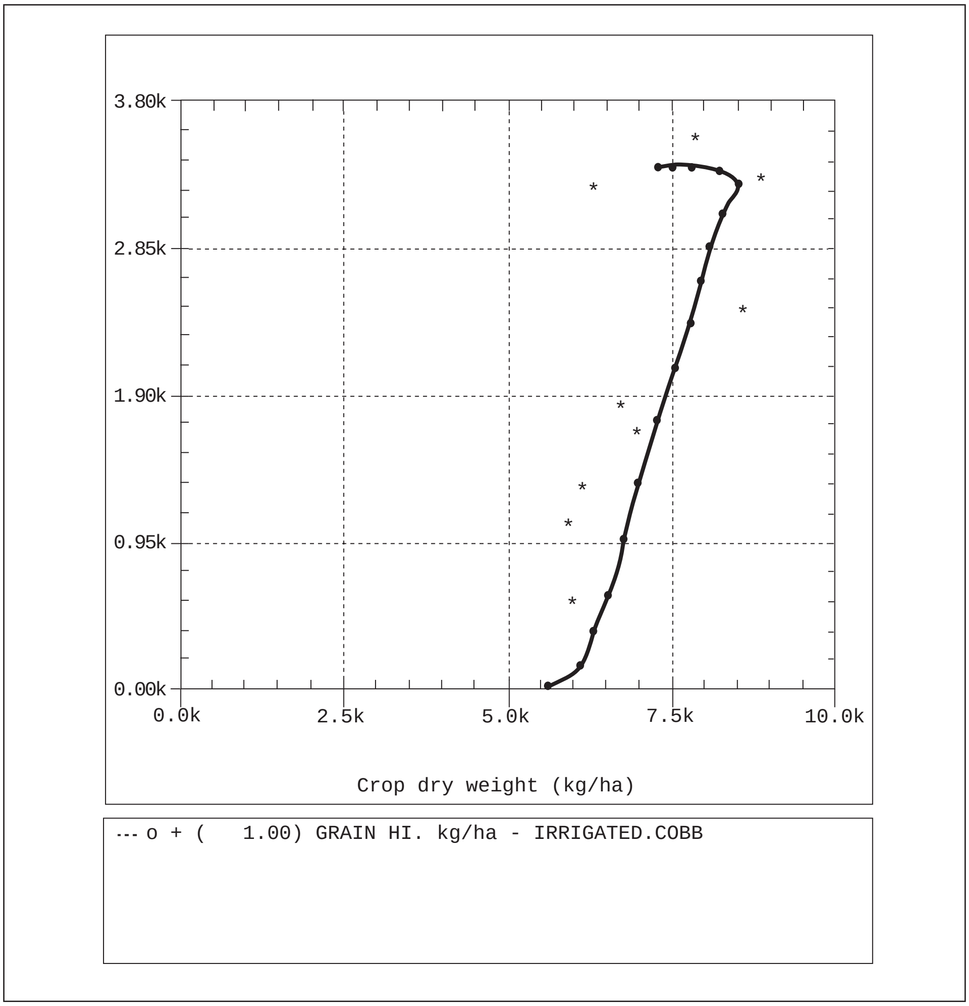
The default setting for graph plotting is the variables selected (for example, those selected in Screen 3) versus time. Users can specify an X-variable other than "time" by pressing the X VARIABLE button (see Screen 3). Screen 5, on the following page, will be presented.

```
 ≡ Select Graph Options Exit
┌[▪]──────────────────────── Growth ──────────────────────────────┐
│ Variab┌[▪]──────── Select X Variables ──────────┐               │
│[ ] Lea│                                          │               │
│[ ] Gro│     ( ) Leaf number per stem             │               │
│[ ] Lea│     ( ) Growth stage                     │               │
│[ ] Lea│     ( ) Leaf area index                  │               │
│[ ] Ste│     ( ) Leaf dry weight (kg/ha)          │               │
│[ ] Gra│     ( ) Stem dry weight (kg/ha)          │               │
│[ ] Roo│     ( ) Grain dry weight (kg/ha)         │               │
│[ ] Cro│     ( ) Root dry weight (kg/ha)          │               │
│[ ] Gra│     (•) Crop dry weight (kg/ha)          │               │
│[ ] Gra│     ( ) Grain number (no/m2)             │               │
│[ ] Har│     ( ) Grain dry weight (mg/grain)      │               │
│[ ] Poc│     ( ) Harvest index (grain/top)        │               │
│[ ] Poc│     ( ) Pod dry weight (kg/ha)           │               │
│[ ] Pho│     ( ) Pod number (no/m2)               │               │
│[ ] Gro│     ( ) Photo water stress factor (0-1)  │               │
│       │     ( ) Growth water stress factor (0-1) │               │
│       │                                          │               │
│ Previ │ Previous     Next    Ok    Esc           │ption          │
└───────┴──────────────────────────────────────────┘───────────────┘
 F1 Help  Esc Escape      X-Var.: Time      Simulation: Default
```

SCREEN 5.

In Screen 5, the X-variable, "Crop dry weight," has been selected. Pressing the OK button in this screen, will display this variable next to "X-Var:" on the status line in Screen 3. Pressing the GRAPH button in Screen 3 will display this case of Y vs X, as shown in Screen 6, on the following page.

To reset the X variable back to time, select the X VARIABLE button again and press the <ESC> key.



SCREEN 6.

OPTION "BUTTON"

Once a graph has been plotted for selected variables, the OPTION button on the status line (see Screen 3) will no longer be grayed out and will be selectable.

Functions under the OPTION button (see Screen 7, on following page) allow a user to make necessary modifications to the current graph.

"Display Graph Again" will display the modified graph again.

"Change Min/Max" allows the parameters for the X and Y axes to be changed (see Screen 8, on following page).

```
 Select Graph  Options  Exit
[▪]──────────────────────────── GROWTH ──────────────────────────
 Variables                             Run Numbers
 [X] Leaf number per stem              [X] IRRIGATED
 [X] Growth stage                      [X] NON-IRRIGATED
 [X] Leaf area index
 [ ] Leaf dry weight (kg/ha)
 [ ] Stem dry weight (kg/ha)
 [ ] Grain dry weight (kg/ha)
 [ ] Root dry weight (kg/ha)
 [ ] Crop dry weight (kg/ha)
 [ ] Grain number (no/m2)
 [ ] Grain dry weight (mg/grain)
 [ ] Harvest index (grain/top)
 [ ] Pod dry weight (kg/ha)              Display Graph Again   F7
 [ ] Pod number (no/m2)                  Change Min/Max...
 [ ] Photo water stress factor (0-1)     Modify Multipliers...
 [ ] Growth Water stress factor (0-1)    Grid ON               F4
                                         Output Graph          F8
 Previous   Next   X Variable   Grap     Print Graph Data      F9

F1 Help  Esc Escape       X-Var.: Time      Simulation: Default
```

SCREEN 7.

"Modify Multipliers" allows the user to modify the default multiplication factor for each plot (see Screen 9, on following page). Altering multipliers allows variables of widely disparate scaling to be shown on the same graph.

"Grid ON" toggles the plotting of grid lines On/Off.

```
 Select Graph  Options  Exit
[▪]──────────────────────────── GROWTH ──────────────────────────
 Variables                             Run Numbers
 [X] Leaf number per stem              [X] IRRIGATED
 [X] Grow[▪]──────────── Change Min. & Max. ─────────────
 [X] Leaf
 [ ] Leaf
 [ ] Stem  Min X:      160.0000     Max X:      309.0000
 [ ] Grai
 [ ] Root
 [ ] Crop  Min Y:        0.0000     Max Y:       16.0000
 [ ] Grai
 [ ] Grai
 [ ] Harv
 [ ] Pod
 [ ] Pod                 Ok             Esc
 [ ] Phot
 [ ] Grow

 Previous   Next   X Variable   Graph   Reset   Option

F1 Help  Esc Escape       X-Var.: Time      Simulation: Default
```

SCREEN 8.

```
 Select Graph  Options  Exit
[▪]                                  GROWTH
 Variabl[▪]          Change Multipliers
[X] Leaf
[X] Grow
[X] Leaf      Multiplier #1:                  1.00
[ ] Leaf
[ ] Stem      Multiplier #2:                  1.00
[ ] Grai
[ ] Root      Multiplier #3:                  1.00
[ ] Crop
[ ] Grai      Multiplier #4:                  1.00
[ ] Grai
[ ] Harv      Multiplier #5:                  1.00
[ ] Pod
[ ] Pod       Multiplier #6:                  1.00
[ ] Phot
[ ] Grow                 Ok          Esc

 Previous   Next   X Variable   Graph   Reset   Option
F1 Help  Esc Escape        X-Var.: Time      Simulation: Default
```

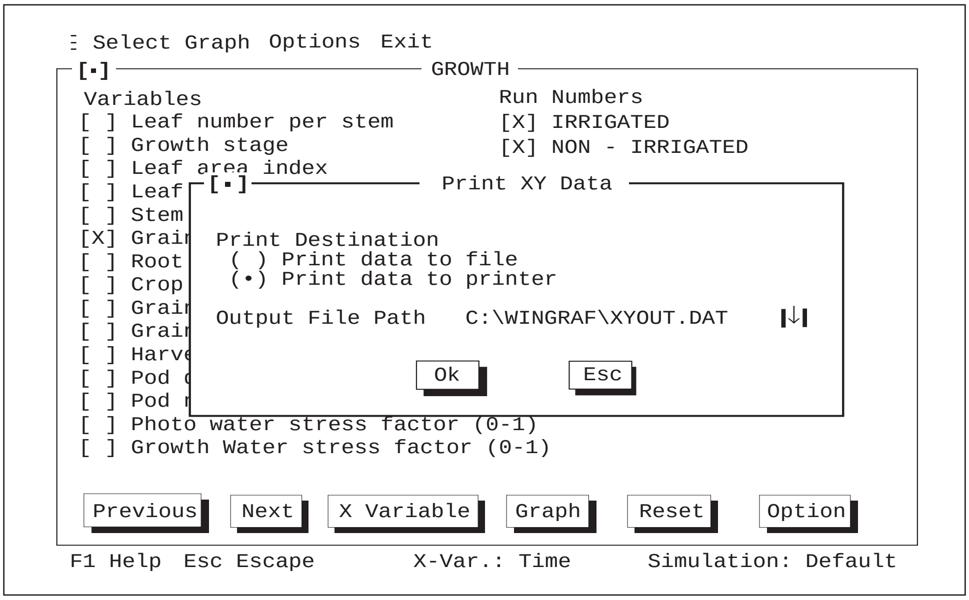
SCREEN 9.

"Output Graph" allows the user to output the current graph to either a printer or a disk file (see Screen 10, below).

```
 Select Graph  Options  Exit
[▪]                                  GROWTH
 Variables                               Run Numbers
[X] Leaf number per stem                 [X] IRRIGATED
[X] Growth stage                         [X] NON - IRRIGATED
[X] Leaf area index
[ ] Leaf dry weight (kg/ha)
[ ] Stem dry wei[▪]          Confirm
[ ] Grain dry we
[ ] Root dry wei        Output: Screen Dump
[ ] Crop dry wei       Device: HP Laser Jet
[ ] Grain number            Port: LPT1
[ ] Grain dry we
[ ] Harvest inde
[ ] Pod dry weig          Ok        Cancel
[ ] Pod number (
[ ] Photo water
[ ] Growth Water stress factor (0-1)

 Previous   Next   X Variable   Graph   Reset   Option
F1 Help  Esc Escape        X-Var.: Time      Simulation: Default
```

SCREEN 10.

"Print Graph Data" allows the user to send the current plot data (and observed data, if present) to the printer or a disk file (see Screen 11, below) in an X-Y format (see Table 1 for an example file of the plot data).



SCREEN 11.

TABLE 1. EXAMPLE FILE OF SIMULATED AND OBSERVED DATA USED TO PLOT THE GRAPH FOR THE GROWTH VARIABLE, "GRAIN DRY WEIGHT" (GWAD).

-------SIMULATED DATA--------				--------OBSERVED DATA--------			
@Day	GWAD	Day	GWAD	Day	GWAD	Day	GWAD
@ X1	Y1	X2	Y2	OX1	OY1	OX2	OY2
166	0.000	166	0.000	194	0.000	194	0.000
169	0.000	169	0.000	201	0.000	201	0.000
172	0.000	172	0.000	208	0.000	208	0.000
175	0.000	175	0.000	215	0.000	215	0.000
178	0.000	178	0.000	222	0.000	222	0.000
181	0.000	181	0.000	229	0.000	229	0.000
184	0.000	184	0.000	236	0.000	236	0.000
187	0.000	187	0.000	243	0.000	243	0.000
190	0.000	190	0.000	250	182.000	250	42.000
193	0.000	193	0.000	257	754.000	257	253.000
196	0.000	196	0.000	264	1912.000	264	471.000
199	0.000	199	0.000	271	2223.000	271	775.000
202	0.000	202	0.000	278	2730.000	278	782.000
205	0.000	205	0.000	285	2913.000	285	1149.000
208	0.000	208	0.000	292	3169.000	292	1206.000
211	0.000	211	0.000				
214	0.000	214	0.000				
217	0.000	217	0.000				
220	0.000	220	0.000				
223	0.000	223	0.000				
226	0.000	226	0.000				
229	0.000	229	0.000				
232	0.000	232	0.000				
235	0.000	235	0.000				
238	0.000	238	0.000				
241	0.000	241	0.000				
244	0.000	244	0.000				
247	29.000	247	29.000				
250	142.000	250	128.000				
253	323.000	253	261.000				
256	580.000	256	418.000				
259	938.000	259	556.000				
262	1290.000	262	634.000				
265	1589.000	265	689.000				
268	1870.000	268	779.000				
271	2127.000	271	836.000				
274	2314.000	274	940.000				
277	2549.000	277	1031.000				
280	2695.000	280	1070.000				
283	2764.000	283	1098.000				
286	2836.000	286	1118.000				
289	2872.000	289	1129.000				
292	2891.000						
294	2899.000						

User-Selected Variables Option

When this option is selected, a submenu with two menu items is presented. These allow you to create a file for graph plotting and to define your own list of variables for graphing.

Define

With this menu item, users can create a file for graph plotting provided the file format follows the output file format specified in Part 1 of this Volume (Volume 2-1, Jones et al. 1994). A user-defined file may contain many of the predefined variables in DATA.CDE (see Appendix C of Volume 2-1, Jones et al. 1994). If additional variables are to be plotted, the user may append variable codes and definitions to the DATA.CDE file.

User-Selected

With this menu item, users can select their own variables from those found in the GROWTH, WATER, NITROGEN, DISEASES, PESTS, and CARBON output files. When this item is selected, a window similar to Screen 12, below, is presented. Screen 12 is an example screen showing the list of variables for the GROWTH output file. The right-hand lists presents the Wingraf default GROWTH vari-

```
 ≡ Select Graph  Options  Exit
┌[▪]──────────────── User-Selected - (GROWTH) ─────────────────────┐
│ Variables                            User-Selected               │
│ [ ] Leaf number per stem             [ ] Leaf area index         │
│ [ ] Growth stage                     [ ] Leaf dry weight (kg/ha) │
│ [X] Leaf area index                  [ ] Avg plant transpiriation (mm/d)
│ [X] Leaf dry weight (kg/ha)          [ ] Avg evapotranspiriation (mm/d)
│ [ ] Stem dry weight (kg/ha)          [ ] Avg potential evapotr (mm/d)
│ [ ] Grain dry weight (kg/ha)         [ ] P in grain (%)          │
│ [ ] Root dry weight (kg/ha)          [ ] Lable P Pool (kg/ha)    │
│ [ ] Crop dry weight (kg/ha)          [ ] Active P Pool (kg/ha)   │
│ [ ] Grain number (no/m2)             [ ] Stable P Pool (kg/ha)   │
│ [ ] Grain dry weight (mg/grain)      [ ] Percent C in leaf (%)   │
│ [ ] Harvest index (grain/top)        [ ] Percent C in stem (%)   │
│ [ ] Pod dry weight (kg/ha)                                       │
│ [ ] Pod number (no/m2)                                           │
│ [ ] Photo water stress factor (0-1)                              │
│ [ ] Growth Water stress factor (0-1)                             │
│                                                                  │
│       Previous      Next     Ok      Esc      Reset              │
└──────────────────────────────────────────────────────────────────┘
 F1 Help  Esc Escape       X-Var.: Time      Simulation: Default
```

Screen 12.

ables. The list on the left presents GROWTH output variables which the user may select. After defining the variable list, by putting an "x" beside those variables to be used, users may plot graphs of variables from different variable groups. In this way, key variables from different output files can be displayed simultaneously.

Summary Validation Option

This option allows you to visually compare simulated and measured results for a given experiment. Two options are available for summary validations (Screen 13. below). In each case, the model output file, OVERVIEW.OUT, is used.

```
  Select Graph  Options  Exit
   Growth...
   Water...
   Nitrogen...
   Phosphorus...
   Diseases & Pests...
   Carbon...

   User Selected Variables  ►

   Summary Validation       ►
      Single plotting...
      Double plotting...

F1 Help  Esc Escape      X-Var.: Time      Simulation: Default
```

Screen 13.

Single Plotting

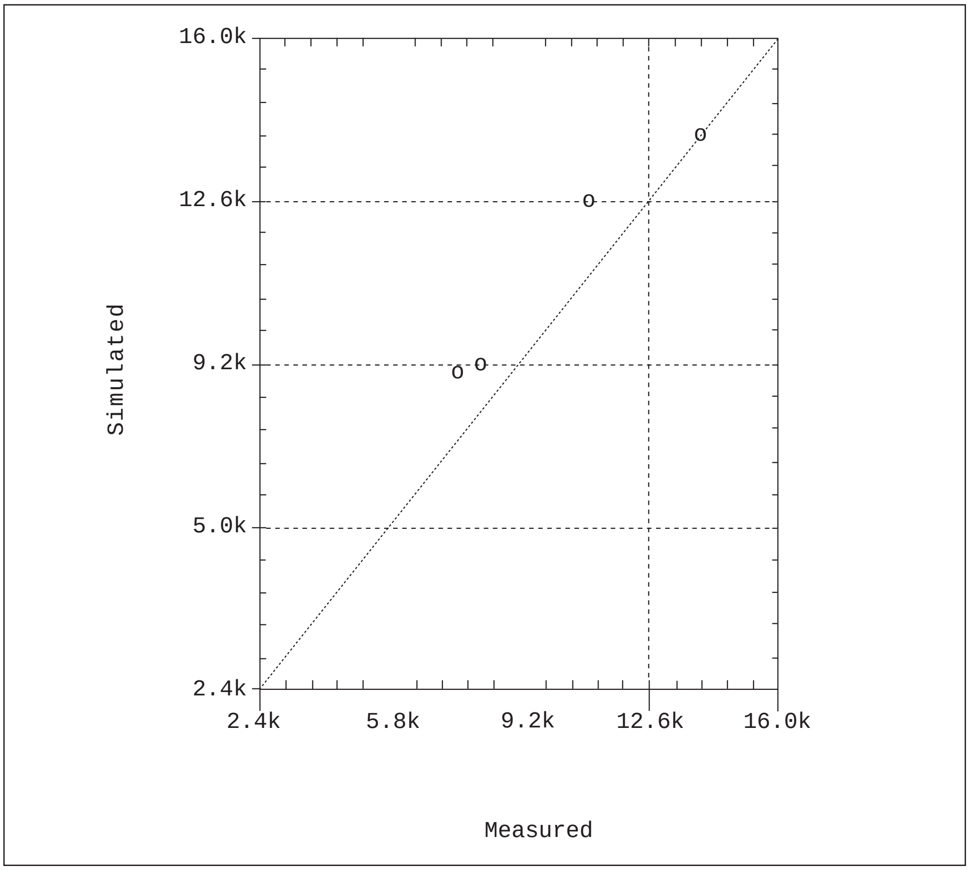
Use "Single Plotting" to select one, and only one, of the variables listed when this menu item is selected (see Screen 14, on following page) for simulated versus observed data plotting. Observed data would be those found in FILEA (see Volume 2-1, Jones et al. 1994, for a description of this file) for a particular experiment. For example, FILEA for experiment UFGA8601.SBX, would be file, UFGA8601.SBA.

When "Single Plotting" is selected, Screen 14 (on following page) is presented.

```
 Select Graph  Options  Exit
[▪]─────────────────────── OVERVIEW ──────────────────────────
 Variables
( ) ANTHESIS DATE (dap)
( ) FIRST PEG / POD (dap)
( ) FIRST SEED (dap)
( ) PHYSIOLOGICAL MATURITY (dap)
( ) POD YIELD (kg/ha)
(•) SEED YIELD (kg/ha)
( ) SHELLING PERCENTAGE (%)
( ) WEIGHT PER SEED (g)
( ) SEED NUMBER (SEED/m2)
( ) SEEDS/POD
( ) MAXIMUM LAI (m2/m2)
( ) BIOMASS (kg/ha) AT ANTHESIS
( ) BIOMASS N (kg N/ha) AT ANTHESIS
( ) BIOMASS (kg/ha) AT HARVEST MAT.
( ) STALK (kg/ha) AT HARVEST MAT.

  Previous      Next      Graph      Reset      Option

F1 Help  Esc Escape                    Simulation: Default
```

SCREEN 14.

In Screen 14, "Seed Yield," has been selected as the variable to be plotted for simulated vs. observed (or measured). Pressing the GRAPH button will display this graph, as shown in Screen 15, on following page.



Screen 15.

Double Plotting

Use "Double Plotting" to select only one X and only one Y variable of the variables listed when this menu item is selected (see Screen 16, on following page) for X vs. Y plotting.

```
 Select Graph  Options  Exit
-[▪]-------------------- SUMMARY ---------------------------------

 X Variables                             Y Variables
 [ ] Simulation start date (YRDOY)       [ ] Simulation start date (YRDOY)
 [ ] Planting date (YRDOY)               [ ] Planting date (YRDOY)
 [ ] Anthesis date (YRDOY)               [ ] Anthesis date (YRDOY)
 [ ] Physical maturity date (YRDOY)      [ ] Physical maturity date (YRDOY)
 [ ] Harvest date (YRDOY)                [ ] Harvest date (YRDOY)
 [ ] Planting material wt (kg dm/ha      [ ] Planting material wt (kg dm/ha
 [ ] Tops wt at maturity (kg dm/ha)      [ ] Tops wt at maturity (kg dm/ha)
 [ ] Yield at maturity (kg dm/ha)        [X] Yield at maturity (kg dm/ha)
 [ ] Yield at harvest (kg/dm/ha)         [ ] Yield at harvest (kg/dm/ha)
 [ ] By-product harvest (kg dm/ha)       [ ] By-product harvest (kg dm/ha)
 [ ] Wt at maturity (mg dm/unit)         [ ] Wt at maturity (mg dm/unit)
 [ ] Number at maturity (no/m2)          [ ] Number at maturity (no/m2)
 [ ] Number at maturity (no/unit)        [ ] Number at maturity (no/unit)
 [ ] Irrigation applications (no)        [ ] Irrigation applications (no)
 [X] Season irrigation (mm)              [ ] Season irrigation (mm)

   Previous       Next       Graph       Reset       Option

 F1 Help  Esc Escape       X-Var.: Time      Simulation: Default
```

SCREEN 16.

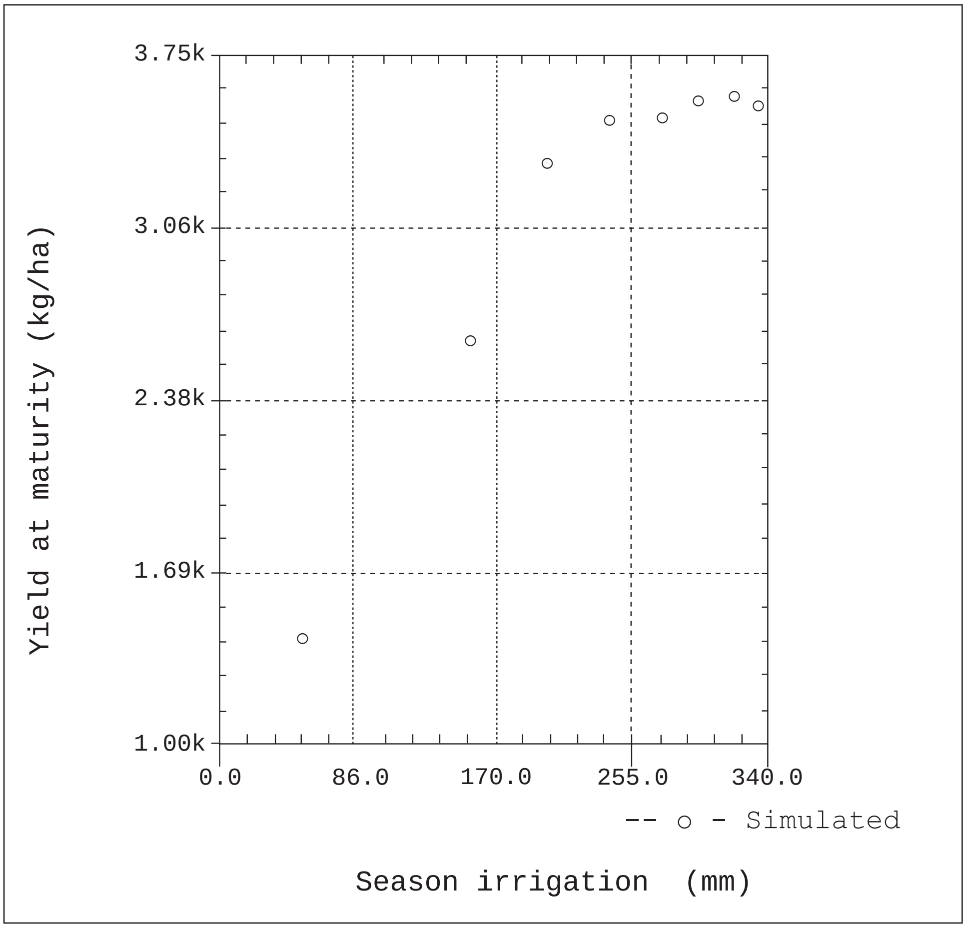
SUMMARY RESPONSE OPTION

This option is used for summary graph plotting. Only one X and one Y variable can be selected for graph plotting. When this option is selected, Screen 17 (on following page) is presented.

```
 Select Graph  Options  Exit
[▪]                       SUMMARY

X Variables                          Y Variables
[ ] Simulation start date (YRDOY)    [ ] Simulation start date (YRDOY)
[ ] Planting date (YRDOY)            [ ] Planting date (YRDOY)
[ ] Anthesis date (YRDOY)            [ ] Anthesis date (YRDOY)
[ ] Physical maturity date (YRDOY)   [ ] Physical maturity date (YRDOY)
[ ] Harvest date (YRDOY)             [ ] Harvest date (YRDOY)
[ ] Planting material wt (kg dm/ha   [ ] Planting material wt (kg dm/ha
[ ] Tops wt at maturity (kg dm/ha)   [ ] Tops wt at maturity (kg dm/ha)
[ ] Yield at maturity (kg dm/ha)     [X] Yield at maturity (kg dm/ha)
[ ] Yield at harvest (kg/dm/ha)      [ ] Yield at harvest (kg/dm/ha)
[ ] By-product harvest (kg dm/ha)    [ ] By-product harvest (kg dm/ha)
[ ] Wt at maturity (mg dm/unit)      [ ] Wt at maturity (mg dm/unit)
[ ] Number at maturity (no/m2)       [ ] Number at maturity (no/m2)
[ ] Number at maturity (no/unit)     [ ] Number at maturity (no/unit)
[ ] Irrigation applications (no)     [ ] Irrigation applications (no)
[X] Season irrigation (mm)           [ ] Season irrigation (mm)

  Previous      Next       Graph       Reset      Option

F1 Help  Esc Escape       X-Var.: Time       Simulation: Default
```

Screen 17.

In Screen 17, "Season irrigation" has been selected as the X-variable and "Yield at maturity" as the Y-variable. Pressing the GRAPH button will display this graph, as shown in Screen 18, on following page.



SCREEN 18.

In Screen 18, the example graph displays "Yield at harvest" plotted against "Season irrigation."

CHAPTER FIVE.
OPTIONS MENU

The OPTIONS menu item allows the user to select previously run simulations and to modify the operation, look and feel of Wingraf. The user may define most of the operational parameters, configure Wingraf, and select previous simulations (Screen 15).

When the OPTIONS menu item is selected, the pull-down menu shown in Screen 19 (below) is displayed.

```
  Ξ Select Graph  Options  Exit
                 Select Simulation...
                 Colors                    ▶
                 Directories...
                 Set Graph Options...
                 Select Field Data File...
                 Output Device Options     ▶
                 Save Options...           F2

  F1 Help  Esc Escape       X-Var.: Time      Simulation: Default
```

SCREEN 19.

SELECT SIMULATION OPTION

With this option, users can select previously simulated results provided the default output file names have been changed. Selecting this option opens the crop dialog box shown in Screen 20 (on following page).

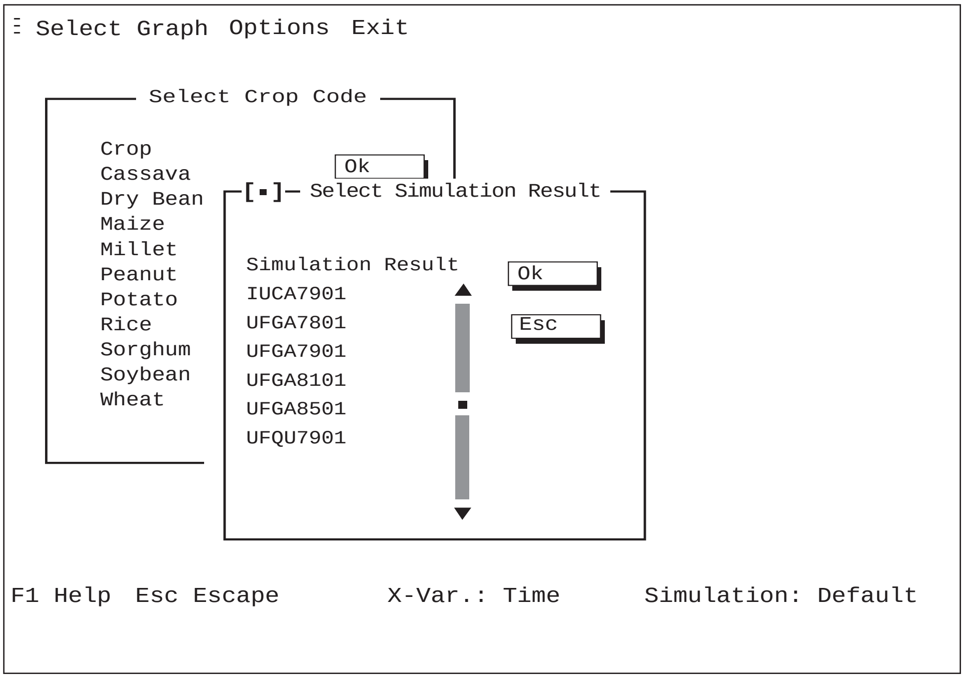
```
  ≡ Select Graph  Options  Exit

   [■]── Select Crop Code ──────────────

      Crop
      Cassava                 [ Ok  ]
      Dry Bean         ▲
      Maize                   [ Esc ]
      Millet
      Peanut
      Potato
      Rice
      Sorghum          ■
      Soybean
      Wheat            ▼
```

SCREEN 20.

If simulations have been run for any of the crops listed in this box and the output file names have been changed from the default names (e.g., from GROWTH.OUT), then selecting one will present a listing of output files. For example, if Soybean is selected from the crop code dialog box in Screen 20, and the output names have been changed, then those files will be displayed. For the UFGA7801-Soybean experiment, these might be, UFGA7801.SBG, UFGA7801.SBW, UFGA7801.SBN for GROWTH.OUT, WATER.OUT, NITROGEN.OUT, respectively.

When one of the crops listed is selected and simulations have been run with output names changed, then Screen 21 (on following page) will appear.

If no previous simulation results have been saved with the experiment-coded file names described above, a message will appear on the screen to inform the user of this.



SCREEN 21.

In Screen 21, a listing of available simulation results is presented. Any listed simulation may be chosen and then plotted.

Colors Option

Colors for both graphics and the desktop may be selected by choosing the Colors menu option (Screen 22, below).

```
Ξ Select Graph Options Exit
               Select Simulation...
               Colors                ▶
                 Graph Color...
                 Desktop Color...   ..
                                     ▶
               Sa Auto Detect Scheme   F2
                  Color Scheme
                  Monochrome Scheme
                  Black/White Scheme
                  Color Setting...

F1 Help  Esc Escape       X-Var.: Time      Simulation: Default
```

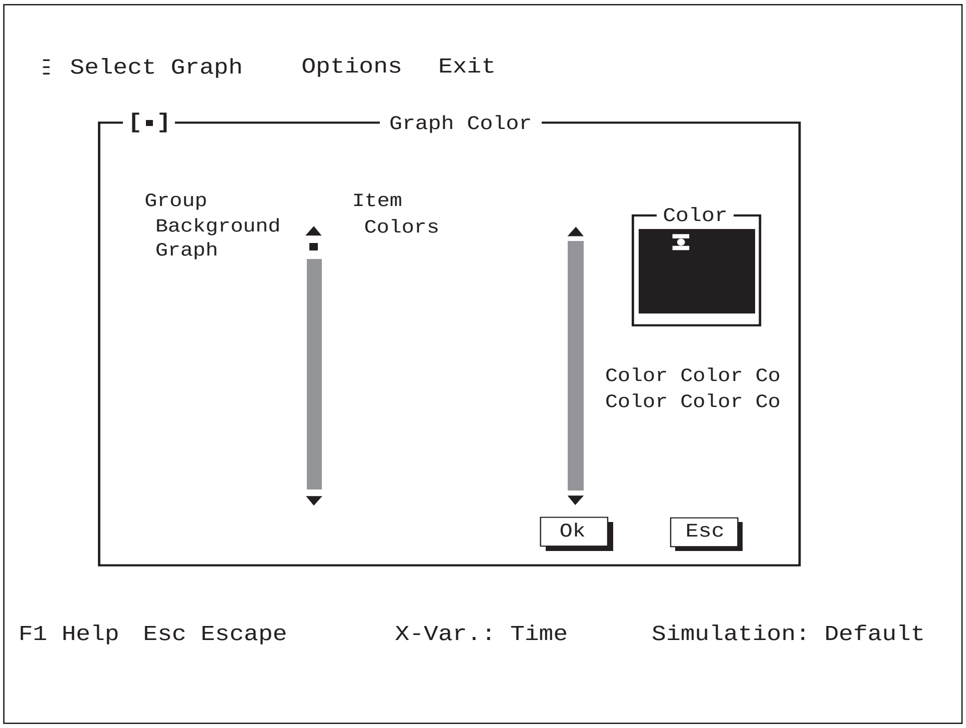
Screen 22.

Graph Color

Select "Graph Color" to define the colors used for graph plotting, such as graph background and line color. When "Graph Color" is selected, a listing of color schemes is presented (see Screen 22, above).

Select one of the first four items listed and the graph background and line color will be adjusted to that described in each listing. For example, if "Auto Detect Scheme" is selected, the program will use its default colors. Or, if "Black/White Scheme" is selected, the program will convert colors to black and white.

If "Color Setting" is selected, the user may customize the colors used according to his/her individual preference. When this menu item is selected, Screen 23 (on following page) will be presented.



SCREEN 23.

DESKTOP COLOR

Use "Desktop Color" to customize the desktop color scheme as well as the color setting for individual desktop displays. When "Desktop Color" is selected, a screen similar to the one shown in Screen 23 (above) will be presented, in which a user can select colors for background color of the desktop, dialog boxes, menus, the viewer and so on.

Directories Option

This option allows the user to change the default path for graph plotting. When this option is selected, Screen 24, below, is presented. The Graphics Program Path, which can also be changed in Screen 24, will not normally need to be changed.

```
 ☰  Select Graph    Options  Exit

      [▪]─────────── Change Default Data Path ──────────────

         Default Data Path:       C:\DSSAT3\SOYBEAN\

         Graphics Program Path:   C:\DSSAT3\SOYBEAN\

                          Ok           Esc

 F1 Help  Esc Escape       X-Var.: Time      Simulation: Default
```

Screen 24.

Set Graph Options

This option allows the user to specify various graph options as shown in Screen 25, below.

```
 Ξ  Select Graph    Options  Exit

        [▪]─────────── Graph Options ──────────────

          X-Axis Label              Experimental data
           (•) Day of Year           (•) Plot
           ( ) Days after planting   ( ) Don't plot
                                     ( ) Prompt if available

          X vs Y Plotting           Simulated Data
           ( ) Connect points        (•) Plot
           ( ) Symbols               ( ) Don't plot
           (•) Both symbols & points

          Num of Intervals:   4   Tics/Interval:   5

                      [ Ok ]      [ Esc ]

 F1 Help  Esc Escape      X-Var.: Time     Simulation: Default
```

Screen 25.

Make selections in Screen 25 and then press the OK button to save them. Press the ESC button if you do not wish to save your selections.

NOTE: *If under the Simulated Data option, "Don't plot" has been selected, then the pull-down menu under the SELECT GRAPH menu item of the Wingraf main menu screen will change as shown in Screen 26, on following page.*

```
≡  Select Graph    Options  Exit
   Field Data...
   Summary Response...

F1 Help  Esc Escape       X-Var.: Time      Simulation: Default
```

Screen 26.

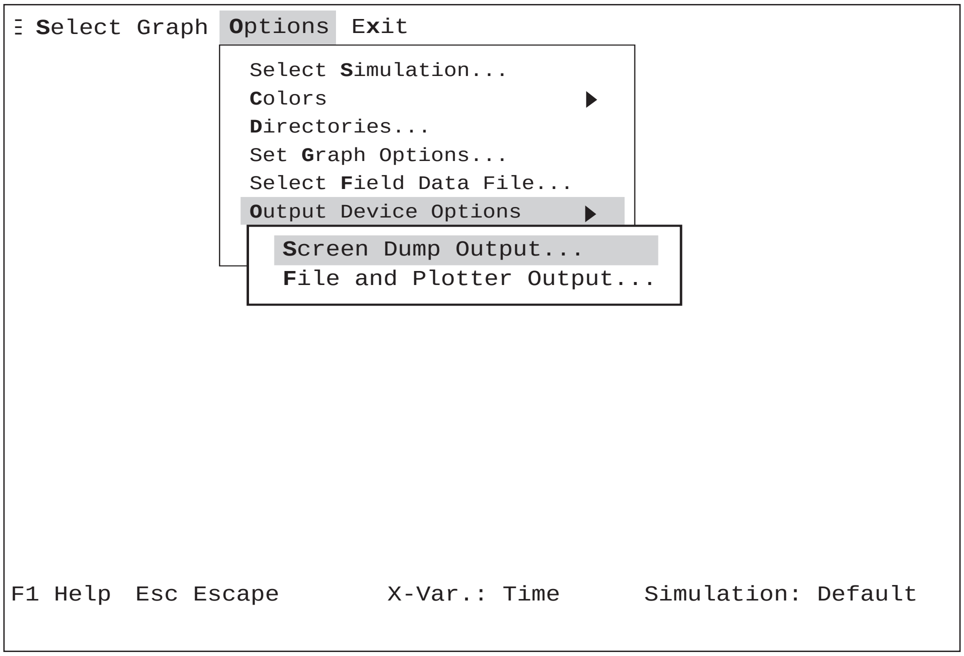
When "Don't plot" is selected from the Simulated Data options in Screen 25, you must open the "Field Data" menu item under SELECT GRAPH and select a field data file for graph plotting. When "Field Data" is selected, Screen 27 (below) is presented with a listing of data files available.

```
≡  Select Graph    Options  Exit

        [▪] ── Select Experimental Data File
        Data File Name
         IUCA7901.SBT                    Ok

        Files
         IUCA7901.SBT                    Cancel
         UFGA7801.SBT
         UFGA7901.SBT
         UFGA8101.SBT
         UFGA8501.SBT
         UFQU7901.SBT
        ..\

        C:\DSSAT3\EXPER\SOYBEAN\????????.SBT
        IUCA7901.SBT 14389    Apr 13, 1994 10:00am

F1 Help  Esc Escape       X-Var.: Time      Simulation: Defa
```

Screen 27.

Output Device Options

This option allows the user to configure both screen dump output and plotter/file output When this option is selected, Screen 28 (below) is presented..



Screen 28.

Screen Dump Output

Use "Screen Dump Output" to set up the graph output option as a screen-dump and to select a printer device, printer port, orientation, and other options shown in Screen 29 (on following page).

```
  Select Graph   Options  Exit

      [▪] ──────── Screen Dump Options ────────

      Printer Driver              Printer I/O Plot
       ( ) Epson MX                (•) LPT 1
       ( ) Epson LQ                ( ) LPT 2
       ( ) Epson Fx                ( ) COM 1
       ( ) Toshiba P               ( ) COM 2
       (•) HP Laser Jet
       ( ) HP Ink Jet              Orientation
                                   (•) Portrait
                                   ( ) Landscape
      Resolution (0-3):  1.00


      X Multi. ( >=1 ): 1.00      Y Multi. ( >=1 ): 1.00

                       Ok          Esc

 F1 Help  Esc Escape       X-Var.: Time      Simulation: Default
```

SCREEN 29.

FILE AND PLOTTER OUTPUT

Use “File and Plotter Output” to select the graph output option to file output or to both plotter output and file output (see Screen 30, below). The output file can be in either HPGL or Postscript format. The graph file can be imported into other graphic editors, word processing program or drawing programs for further modification.

```
  Select Graph   Options  Exit

    [▪] ──────── Plotter/File Output Options ────────

     Plotter Type                 Orientation
      (•) HPGL                     (•) Portrait
      ( ) Postscript               ( ) Landscape


     Plotter Com Port             Plotter Output Option
      (•) COM1                     ( ) Both Plotter & File
      ( ) COM2                     (•) File Output Only


     File Name:
     C:\DSSAT3\SOYBEAN\OUTPUT00.GRA


                    Ok          Esc
```

SCREEN 30.

SAVE GRAPH OPTIONS

Changes made with the "Set Graph Options" or "Save Options" menu items under OPTIONS in the Wingraf main menu saves selected configurations to the file called GRAPH.INI. Normally, Wingraf configuration data will be handled and updated through the Wingraf menu structure. You may wish, however, to edit GRAPH.INI with a text editor. Thus, a listing of the contents of GRAPH.INI which pertains to Wingraf is shown in Table 2.

Two sections of GRAPH.INI hold configuration data for Wingraf and for the default output device. Under the [WINGRAF] section of the GRAPH.INI file, defaults for plotting in Wingraf are defined. Specifically, they are:

gcolor0 to gcolor7:	Refer to the default color palette for plotting.
interval:	Number of major divisions on the X and Y axis.
tics:	Number of tic marks between the major divisions.
days:	'D' for day after planting date; 'Y' for day of year.
symbols:	'C' for connect symbols with lines; 'S' for plotting. symbols alone; or "B" for both symbols and lines.
thickness:	'T' for thick lines; 'N' for normal width lines
plot:	'P' for plot simulated data; 'D' for don't plot simulated data.
exp:	'A' for always plot experimental data; 'N' for never plot; or
'P' for	prompt when data are available.

Under the [Device] section of the INI file, defaults for the selected output device in Wingraf are defined. Specifically, they are:

output:	'S' for screen Dump; 'P' for plotter and file output; or 'F' for
file	alone.
driver:	"0" for Epson MX; "1" for Epson LQ; "2" for Epson FX; "3"
for	Toshiba P; "4" for HP Laser Jet; or "5" for HP Ink
Jet.	
plotter:	"0" for HPGL or "1" for Postscript.
port:	"0" for LPT1; "1" for LPT2; "2" for COM1; or "3" for COM2.
orientation:	"0" for Portrait or "1" for Landscape.
resolution:	Resolution.
xmult:	X-multiplier.
ymult:	Y-multiplier.
file:	Name for file output.

TABLE 2. EXAMPLE OF A WINGRAF GRAPH.INI FILE.

```
[WINGRAF]
gcolor0=1
gcolor1=15
gcolor2=14
gcolor3=12
gcolor4=15
gcolor5=10
gcolor6=11
gcolor7=13
interval=4
tics=5
days=Y
symbols=B
thickness=T
plot=P
exp=N
[Device]
output=F
driver=1
plotter=1
port=2
orientation=0
resolution=1.00
xmult=1.00
ymult=1.00
file=C:\WINGRAF\OUTPUT00.GRA
```

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International Benchmark Sites Network for Agrotechnology Transfer Project. 1989. Decision Support System for Agrotechnology Transfer Version 2.1 (DSSAT V2.1). Dept. Agronomy and Soil Sci.; College of Trop. Agr. and Human Resources; University of Hawaii; Honolulu, HI.

Jones, J.W., L.A. Hunt, G. Hoogenboom, D.C. Godwin, U. Singh, G.Y. Tsuji, N. Pickering, P.K. Thornton, W.T. Bowen, K.J. Boote and J.T. Ritchie. 1994. Input and output files. *In:* Tsuji, G.Y., G. Uehara and S. Balas (eds). DSSAT v3. Vol. 2-1. University of Hawaii, Honolulu, HI.

NOTES: