A User's Guide to CERES Wheat - V2.10

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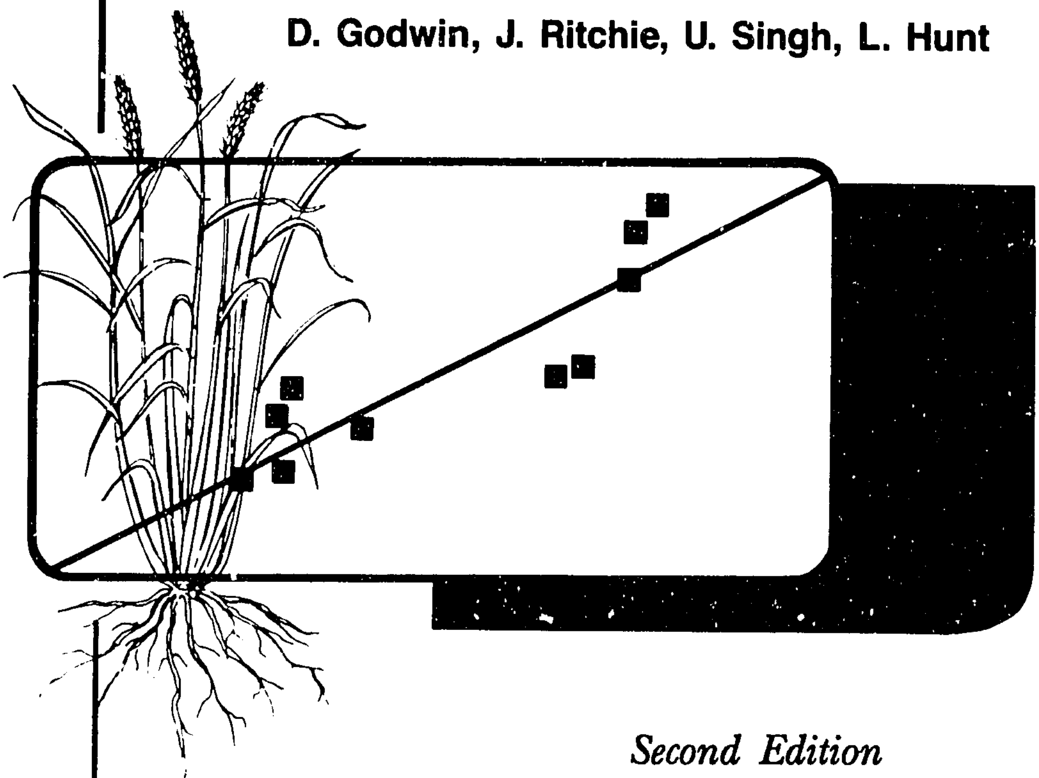

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CHAPTER 1
Model Overview

CERES WHEAT V2.10 is a process-oriented, management-level model of wheat (*Triticum aestivum* L.) crop growth and development that also simulates soil water balance and nitrogen balance associated with the growth of wheat. It is a daily-incrementing, user-friendly, menu-driven model written and compiled in Microsoft FORTRAN V4.01 and Quick BASIC V4.0. It may be run on an IBM or IBM-compatible microcomputer with either a floppy-disk or a hard-disk system. It has been developed by an international and interdisciplinary team of scientists over a period of several years. Dr. Joe Ritchie of Michigan State University, and formerly of the United States Department of Agriculture-Agricultural Research Service (USDA-ARS), Temple, Texas, has coordinated development of the model. The nitrogen sub-model was primarily developed by modelers at the International Fertilizer Development Center (IFDC), Muscle Shoals, Alabama with collaboration from Dr. C. A. Jones of USDA-ARS, Temple, Texas. Model development has been an ongoing process for many years. An earlier version of the model is described in Ritchie and Otter (1985). A more complete documentation of the current version of the model together with procedures for estimating inputs and a description of some of the applications in which the model has been used has been recently completed (Ritchie, Godwin, and Otter-Nacke, 1990). The model has also been the subject of extensive testing (Otter-Nacke, Godwin, and Ritchie, 1986).

The model uses a minimum of readily available weather, soil, and variety-specific genetic inputs. To simulate wheat growth, development, and yield the model takes into account the following processes:

- Phenological development, especially as it is affected by genotype and weather;
- Extension growth of leaves, stems, and roots;
- Biomass accumulation and partitioning, especially as phenological development affects the development and growth of vegetative and reproductive organs;
- Soil water balance and water use by the crop; and
- Soil nitrogen transformations, uptake by the crop, and partitioning among plant parts.

In recent years, the International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT)[1] project has incorporated crop models into its program for international agrotechnology transfer. This project uses models of several different crops, which has required the adoption of a standard format for inputs and outputs from the models. CERES WHEAT V2.10 is a member of a family of models that use the minimum data set as specified by IBSNAT (1988) and

1. IBSNAT is a program of the U.S. Agency for International Fertilizer Development implemented by the University of Hawaii, under Contract No. AID/DAN-4054-A-00-70-81-00.

the input and output structures described in Technical Report 5 (IBSNAT, 1986a). Other members of the CERES family are MAIZE, SORGHUM, PEARL MILLET, BARLEY, and RICE. The adoption of standardized model inputs and outputs has also led to the incorporation of a graphics package developed at the University of Florida (Jones et al., 1988). This graphics package facilitates interpretation of model outputs.

CERES WHEAT V2.10 differs from previously documented versions of the model in the following areas:

1. The structure of model input files and output files has been modified.
2. Modifications have been made to the procedures for calculation of runoff.
3. Additional procedures for simulating the transformation of urea fertilizer have been included.
4. The soil nitrification calculations have been modified.
5. The calculations of N remobilization associated with grain filling include a pool of labile N within the plant.
6. The menus for modification of model inputs or selected parameters have been incorporated.
7. The capacity to simulate multiple-year or multiple-treatment scenarios without requiring additional keyboard inputs has been added.
8. Facilities for trapping and interactively handling missing observations have been added.
9. Facilities for interactive display of summary or detailed crop, soil water, and nitrogen outputs have been added.
10. The model now uses solar radiation data in units of MJ m^{-2} day^{-1} rather than cal cm^{-2} day^{-1}.
11. Modifications to the genetics file inputs to accommodate a wider range of sensitivities to vernalization. The coefficient range has been reversed compared to the earlier versions of the model. Currently zero is the value used for a true spring wheat, and six for a winter wheat requiring maximum vernalization.

CHAPTER 2
System Components

The CERES WHEAT package consists of three main components.

Simulation Model

Program and Data diskettes provide the following options (see Chapters 5, 6 and 10):

1. Single-year simulation.
2. Multiple-year simulation.
3. Sensitivity analysis (see Chapter 11).
4. Display of detailed model output on the screen.

Graphics Program

The Graphics diskette allows the following model outputs to be plotted on the screen and thus facilitates interpretation of these outputs (see Chapters 7 and 10).

1. Crop variables.
2. Weather and soil variables.
3. Soil and plant nitrogen variables.
4. Harvest variables.

Inputs Program

The Input Editor may be used to create input files for the model (see Chapter 9).

CERES WHEAT V2.10 can be run in either a stand-alone mode or as a component of the Decision Support System for Agrotechnology Transfer (DSSAT). The DSSAT can be obtained from the IBSNAT Project, University of Hawaii.

CHAPTER 3
System Requirements

CERES WHEAT V2.10 was developed using an IBM AT microcomputer, DOS 3.2, Microsoft[2] FORTRAN V4.01, and Microsoft Quick BASIC V4.0. The model runs fastest on AT-equivalent machines with an 80287 or 80387 coprocessor and a clock speed of 8 MHz or faster, and with all input and output files and executable code located on a hard-disk drive. The model also runs on an IBM or IBM-compatible personal computer that uses a dual floppy disk drive and has a minimum memory capacity of 256K. However, this configuration has some limitations.

Both the FORTRAN and BASIC section of the CERES WHEAT model require DOS version 2.0 or higher. The graphics display component requires a personal computer (PC) with a graphics adapter (IBM Color Graphics Adapter [CGA] or Enhanced Graphics Adapter [EGA] or equivalent) and color or monochrome graphics monitor with either a CGA or EGA screen resolution. The graphics section of the model will not operate with a Hercules graphics card. If the graphics display option is not required, the model will operate effectively on PC's that do not have graphics adapters.

A 256K system has enough memory for approximately five runs per session. If the user exceeds this capacity, the system will come to a halt in the graphics portion while reading the output files generated by the model. If the system aborts because of insufficient memory, the user must reboot the system.

When a dual floppy disk system is used, the amount of storage on the diskettes is limited. The user must allow room on drive B: (Data Disk) for the output files created by the model and a work file for graphics display. The size of the files depends upon the number of runs and the total number of days simulated in the output files. Options exist in the model to reduce output frequency, which will in turn reduce the size of output files created by the model. A dual-floppy system can accommodate about ten simulation runs in each session when output frequency is to 7 days. This is a default setting; with more frequent output, fewer runs can be accommodated. If the user exceeds the amount of space available on the diskette, the graphics program will give an error "NOT ENOUGH SPACE FOR RANDOM WORK FILE."

The CERES WHEAT model will run on all IBM PC's, XT's, AT's, and true compatibles. We have successfully run CERES WHEAT on the IBM PC, IBM XT, IBM AT, IBM PS/2, COMPAQ, Toshiba, Multitech, Zenith, Cordata PC 400, and Bentley microcomputers that meet the minimum requirements described above.

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2. Microsoft Corporation, 10700 Northup Way, Bellevue, WA 98004.

CHAPTER 4

Getting Started

CERES WHEAT V2.10 is supplied on four floppy diskettes: (1) Program (and source code), (2) Data, (3) Input Editor, and (4) Graphics. A directory of each of these diskettes is provided in Tables 1, 2, 3, 4, and 5, respectively. Before proceeding further, insert the diskettes, one by one, into drive A: to obtain the directories. If all the directories match the ones in Tables 1-5, you may proceed. If there are differences, such as missing files, please contact the suppliers of the model before continuing.

An install program is included to help you install CERES WHEAT V2.10 on your computer. If you are using a dual-floppy disk drive, the install program will require you to copy the four floppy diskettes: 1. CERES WHEAT V2.10 PROGRAM, 2. CERES WHEAT V2.10 DATA, 3. CERES WHEAT V2.10 INPUT, and 4. CERES WHEAT V2.10 GRAPHICS diskettes onto **five** formatted diskettes. All diskettes are supplied with write-protect tabs so the model will not run with the disks you received. This is to protect your original diskettes in case your execution copies are lost or damaged in some way. Please label your copied diskettes the same as the original diskettes. If you plan to run CERES WHEAT from the diskettes, then the Program, Input, and Graphics diskettes must contain the system file COMMAND.COM. If you run CERES WHEAT from your hard disk, you will not have to create these system diskettes. The step-by-step procedures for installing CERES WHEAT to run on floppy diskettes and on hard-disk systems are given in Chapters 5 and 6, respectively.

When your microcomputer is booted (first turned on or when DOS is loaded), a file called CONFIG.SYS is used to establish the characteristics of the computer.

The file CONFIG.SYS should have the following three lines:

```
DEVICE = ANSI.SYS
FILES = 20 (or more)
BREAK = ON
```

This is an important file, and the model will not run unless it is on your system disk (floppy or hard disk). The install program will create this file for you or, if it already exists, modify it to include the above statements. If these changes to your CONFIG.SYS file will conflict with other application programs, you can enter these statements at the DOS level before running the model. An unmodified version of your CONFIG.SYS file will be in CONFIG.OLD.

In summary, if you plan to use a two-diskette system to run CERES WHEAT, you should follow the steps in Chapter 5 and your copy of floppy diskettes No. 1, 3, and 4 (Program, Input, and Graphics) should contain the following files in addition to the ones supplied to you: COMMAND.COM and ANSI.SYS and, for the Graphics diskette, GRAPHICS.COM. If you use a hard-disk system to run CERES WHEAT, these files should be on your hard disk with your operating system.

CHAPTER 5

Running CERES WHEAT on a Two-Diskette System

To run CERES WHEAT on a two-diskette system, three of the five diskettes must be system diskettes; that is, they must first be formatted with the /S option (see below). Then, you must copy ANSI.SYS from your DOS diskette to each of these three diskettes (Nos. 1, 3, and 4). You must also copy GRAPHICS.COM from your DOS diskette, to the fourth diskette (labeled "4. CERES WHEAT V2.10 GRAPHICS").

You need a total of five blank diskettes. Follow this step-by-step procedure for formatting your diskettes and installing the CERES WHEAT model:

1. Insert your DOS system diskette (Version 2.0 or higher) into drive A:. Turn on the power to start the system.
2. Insert a blank diskette (No. 1) into drive B:.
3. Enter:

   FORMAT B:/S
   N (In response to "Format another (Y/N)?")
   COPY A:ANSI.SYS B:

4. Remove the diskette from drive B: after formatting is complete.
5. Label the new diskette from drive B: "**1. CERES WHEAT V2.10 PROGRAM.**"
6. Insert a blank diskette (No. 2) into drive B:.
7. Enter:

   FORMAT B:
   Y (In response to "Format another (Y/N)?")

8. Remove the diskette from drive B: after formatting is complete and label it "**2. CERES WHEAT V2.10 DATA.**"
9. Insert a blank diskette (No. 3) into drive B: and press <ENTER> key. In response to "Format another diskette (Y/N)?" when formatting is complete, enter "N."
10. Remove the diskette from drive B: after formatting is complete and label it "**5. CERES WHEAT V2.10 SOURCE CODE.**"
11. Insert a blank diskette (No. 4) into drive B:.
12. Enter:

    FORMAT B:/S
    N (In response to "Format another (Y/N)?")
    COPY A:ANSI.SYS B:

13. Remove the diskette from drive B: after formatting is complete.
14. Label the diskette from drive B: "**3. CERES WHEAT V2.10 INPUT.**"
15. Insert a blank diskette (No. 5) into drive B:.
16. Enter:

    FORMAT B:/S
    N (In response to "Format another (Y/N)?")
    COPY A:GRAPHICS.COM B:
    COPY A:ANSI.SYS B:

17. Remove the diskette from drive B: after formatting is complete.
18. Label the diskette from drive B: "**4. CERES WHEAT V2.10 GRAPHICS .**"

To install CERES WHEAT, complete the following steps:

1. Insert the provided "**1. CERES WHEAT V2.10 PROGRAM**" diskette (No. 1) into drive A:.
2. Enter:

   A:WHINS

3. Follow the autoinstall procedure on the screen.

To run CERES WHEAT V2.10 using the copies you have created:

1. Insert "**1. CERES WHEAT V2.10 PROGRAM** " diskette into drive A: and "**2. CERES WHEAT V2.10 DATA**" diskette into drive B:.
2. Turn on the power to the computer or reboot the system by pressing and holding the <CTRL> and <ALT> keys and then pressing the <DEL> key and releasing them all.
3. To start the CERES WHEAT program, enter:

   HELPWH
   or
   WHEAT

4. After the simulation is finished, you will be prompted to replace the Program disk (No. 1) with the Graphics disk (No. 4) to run the graphics section of the model. Press any key to continue.

You will be prompted to select items from screen menus to simulate wheat growth and yield. An example run is included in Chapter 10.

CHAPTER 6

Running CERES WHEAT on a Hard-Disk System

If you plan to use the CERES WHEAT model as part of IBSNAT's DSSAT package, please refer to the install procedure in the DSSAT User's Guide (IBSNAT, 1989). The step-by-step procedure for setting up the stand-alone version of the model on your hard disk is as follows:

1. Start the system. If the system power is off, turn on the power. If the system is on, press and hold the <CTRL> and <ALT> keys, then press <DEL> key, and then release them all to reboot the system.
2. Insert the provided "**1. CERES WHEAT V2.10 PROGRAM**" diskette (No. 1) into drive A:.
3. Enter:

   A:WHINS

4. Follow the autoinstall procedure on the screen.
   Note: The install program will modify your CONFIG.SYS file. It will save the unmodified version in CONFIG.OLD.

After installing the model in subdirectory WHEAT, you are ready to run the model by simply entering HELPWH or WHEAT. After this, whenever you start the computer to run the model, use the following steps:

1. Turn on the computer.
2. Enter:

   HELPWH

You will be prompted to select items from screen menus to simulate wheat growth and yield. An example run is included in Chapter 10.

CHAPTER 7
System Setup for CERES WHEAT Graphics

The first time the WHEAT graphics are run, the system will prompt you to enter your system setup. The computer will ask the following questions:

1. **"The drive and path of graphics program?"**
   If you are on a two-floppy disk system, enter: "A:".
   If you are on a hard-disk drive system, enter "C:" or appropriate drive and pathname \WHEAT.

2. **"Which data drive contains the selected data?"**
   If you are on a two-disk drive system, enter: "B:".
   If you are on a hard-disk drive system, enter: "C:" or the appropriate drive.

3. **"Enter graphics option:"**
   Set your monitor type and graphics adapter card as follows. Note: The graphics section will not work on a system with a HERCULES graphics card.
   Graphics Options Available
   [1] - CGA-LOW - 320 x 200 pixels, 3-color graph
   [2] - CGA-HIGH - 640 x 200 pixels, monochrome graph (HERCULES NOT AVAILABLE)
   [3] - EGA-LOW - 640 x 200 pixels, 6-color graph, requires EGA
   [4] - EGA-MED - 640 x 350 pixels, 3-color graph, requires EGA
   [5] - EGA-HIGH - 640 x 350 pixels, 6-color graph, requires EGA & 128 video memory
   Enter the graphics option appropriate to your setup and preferences. The greater the number of pixels, the higher the resolution on the screen:
   CGA is Color Graphics Adapter or regular color graphics;
   EGA is Enhanced Graphics Adapter or higher resolution graphics.

   If you enter the wrong option for your graphics setup, the program will abort. You can reset your graphics definitions by deleting file "SETUP.FLE" from either the Graphics disk (No. 4) or your hard disk (see Chapter 8). This file will be recreated when you repeat steps 1 and 2.

4. **"Would you like to save disk drive and graphics option for future runs (Y/N)?"**
   If you answer "Y" to this question, you will not be asked the system setup questions again and a file "SETUP.FLE" will be created. If you answer "N" to this question, the program will repeat the system setup questions each time the graphics option is run. To change the system setup after you have answered "Y" to the setup question, delete the file "SETUP.FLE".

CHAPTER 8
Problems

Many types of microcomputers are available, and we have not been able to test the simulation model CERES WHEAT V2.10 on all systems. If the model does not work after you have created your floppies, please check the instructions given in Chapters 5 and 6. Most probably, the original disks will not run on your system because they do not include the required system files. Make sure that your "Program disk," "Input disk," and "Graphics disk" have a COMMAND.COM file. Make sure that you have at least 256K of memory available and that you do not have any resident programs which use additional memory. Go through the copying/install process once more to check that you followed all the instructions correctly. If your system is "IBM compatible," please inform the authors about your problems. Make a copy of your error message and clearly describe the type of system you have: brand name, model type, amount of memory, video display, graphics card, printer, type and version of operating system, and any other information that can help us determine your problems.

If the model executes but aborts during the real-time running process, reboot the system and start again. If the same error occurs, try to choose a different experiment and treatment for the next run. If the model continues to abort, please make a screen dump of the error message, follow the above instructions, and contact the authors.

If the model operates correctly but the graphics section does not work, check to see that you have a graphics board in your system. To be able to plot the results to the screen, a color graphics or monochrome (not HERCULES) graphics board is needed. Follow the instructions given above and if the same error continues, contact the authors.

Possible errors which could occur:

1. You are using the wrong operating system.
2. Your machine is not a true "IBM-compatible" microcomputer.
3. Not enough memory is available to execute the model section of CERES WHEAT.
4. No CONFIG.SYS file is defined in your system.
5. Not enough disk space is available on either your floppy disk or your hard disk to run the model.
6. Not enough memory is available to execute the graphics section of CERES WHEAT.
7. No graphics card is present in your microcomputer.
8. You have a HERCULES graphics card.
9. You used the wrong setup when you first defined your system in the graphics section of the model (see Chapter 7).
10. Your program disk is not placed in disk drive A:, and your data disk is not placed in disk drive B:.
11. Some files are missing on your disks; in this case, check your original disks or request another set of original disks from the authors.

If any of the errors mentioned above occur during the execution of the program, please reread the instructions in the user's manual. We would like to know of any problems or errors that might occur as you run the model.

CHAPTER 9
Procedures to Add New Experiments for Simulation

There are three ways that input data files can be created for running CERES WHEAT V2.10. The recommended procedure is to create the files directly from the IBSNAT minimum data set after the experimental data have been entered (IBSNAT, 1988, 1986b). (Contact IBSNAT[3] directly for software for minimum data set entry and data retrieval for the crop simulation models.) The files can also be created (a) by using a text editor (word processor) on the PC or (b) interactively by using the INPUT program supplied. The formats for all the files (Files 1-9 and Files A and B) are documented in Technical Report No. 5 (IBSNAT, 1990 VI.I). The IBSNAT Data Base Management system (DBMS) is a powerful system that provides the user with other applications in addition to the creation of files for these crop models. IBSNAT's DBMS program also provides the capacity for recording all experimental details (by plot), some statistical analysis, and plotting of experimental results.

Single-Year

Manual Creation of Files

In creating each of the files indicated below, refer to IBSNAT Technical Report 5 (IBSNAT, 1990 VI.I) for the formats. The new files must use these formats or they will not work correctly.

1. Add a 3-line entry to file WHEXP.DIR to indicate to CERES WHEAT that a new experiment is available for simulation (see Table 6 where an example is highlighted).
2. If the experiment was performed in a new weather year or site, create a new weather data file (i.e., KSAS1010.W81; see Table 7) and add one entry to file WTH.DIR to indicate its availability (see Table 8 where an example of a possible new entry is highlighted). For further details on naming your new weather data file, refer to IBSNAT (1990 VI.I). Make sure weather data are available for the whole range of days for which you want to run your simulation because the model requires daily weather data. It checks for missing and negative data entries (for solar radiation and rainfall, and temperature only if -99) and will give the user a warning if the data do not match the required input formats.
3. If a new soil type is used, add a new set of data to file SPROFILE.WH2 (see Table 9). If the data for the soil at the experimental site are already in SPROFILE.WH2, then there is no need to add the soil again. The soils should each have a unique number in the file. IBSNAT has developed a special soil data entry program (IBSNAT, 1989) to generate the parameters required for a particular soil type. The minimum characteristics needed are soil series name, soil family name, % sand, % silt, % clay, % organic carbon, % stoniness, wet bulk density, and pH for each horizon. These data can be obtained from the Soil Conservation Service (SCS) database in Lincoln, Nebraska (con-

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3. IBSNAT Project, Department of Agronomy and Soil Science, College of Tropical Agriculture and Human Resources, University of Hawaii, 2500 Dole Street, Krauss Hall 22, Honolulu, Hawaii 96822.

Conservation Service (SCS) database in Lincoln, Nebraska (contact the authors of the model or IBSNAT to check whether your particular soil type is available), your local or state SCS representative, or your local soil laboratory.

4. Create file _____.WH8 with a two-line entry for management variables for each treatment. If there are five treatments, then there are 10 lines in this file. The file name designated by __________ should have eight characters and be named according to IBSNAT (1990 VI.I). For example, KSAS8101.WH8 is FILE8 for institute "KS", site "AS", year "81", and experiment "01" (Table 10).
5. Create file _____.WH6 with all irrigation events for each treatment (Table 11). The last entry for each treatment is -1 for Julian day (IBSNAT, 1990 VI.I).
6. Create file _____.WH5 with initial soil water, nitrate, ammonium, and pH data for each treatment (Table 12). *Note: If a sensitivity analysis is run and soil type is changed during simulation, the initial condition values will need to come from the soil profile data, not from FILE5. The number of soil layers and their thicknesses must be exactly the same as those in the soil data file SPROFILE.WH2 for that soil; otherwise the model will abort and will give you an error message.*
7. Create file _____.WH7 with all nitrogen fertilizer application dates, amounts, depths of incorporation, and type of N fertilizer (IBSNAT, 1988) for each treatment (Table 13). The last entry for each treatment is -1 for Julian day (IBSNAT, 1990 VI.I).
8. Create file _____.WH4 with a one-line entry for amount of straw residue, depth of straw incorporation, C:N ratio of straw, and amount of root residue for each treatment (Table 14). The last entry for each treatment is -1 for Julian day (IBSNAT, 1990 VI.I).
9. If there is a new cultivar, create genetic coefficient data and input into GENETICS.WH9 (Table 15). The GENETICS.WH9 data file on diskette No. 2 contains coefficients for over sixty-five cultivars.
10. For field comparisons, put treatment final yield data (averages) in file _____.WHA, two lines per treatment (Table 16). The following field-measured variables are defined in file _____.WHA:
    a. grain yield with 15.5% moisture (kg/ha);
    b. kernel dry weight (g/seed);
    c. number of grains per m^2 (#/m^2);
    d. number of grains per ear (#/ear);
    e. maximum LAI measured during the growing season (m^2/m^2);
    f. total aboveground dry biomass at harvest (kg/ha);
    g. straw dry weight at harvest (kg/ha);
    h. silking date (day of the year);
    i. physiological maturity date (day of the year);
    j. grain nitrogen percent;
    k. total nitrogen uptake (kg N/ha);
    l. straw nitrogen uptake (kg N/ha); and
    m. grain nitrogen uptake (kg N/ha).

Follow the format of the example shown in Table 13 to enter data.

11. For graphical time-series analysis, put seasonal replicated growth and other measurements in file _____.WHB. An example of this file is on the Data disk, No. 2, in file KSAS8101.WHB (see Table 17). The order and the type of variables for file _____.WHB are given in the GLABEL.DAT file (Table 18). The first line defines the ID codes for institute, site, experiment number, year, and treatment. The explanation of these codes is given in IBSNAT Technical Report No. 5 (IBSNAT, 1990 VI.I).

    The second line of each entry defines the growth variables that are present in the file. The numbers used in file _____.WHB should correspond to the numbers of the variables as defined in file GLABEL.DAT (Table 18). The first number on this second line defines the total number of field-measured variables defined in file _____.WHB, excluding the first column which is the day of the year. This variable is fixed, whereas the others can vary depending upon the type of data collected during the growth analysis experiment.

    The following lines contain the experimental data, starting with the day of the year in the first column. Always keep at least two spaces between each column and align the data below the first input line.

    After you have entered all experimental data for a particular treatment, enter a "-1" on the next line. Repeat the same setup for the other treatments of your experiment. Likewise, to graph soil water or nitrogen-related observations create ___.WHC and ___.WHD, respectively. The order and type of variables for ___.WHC are given in GLABEL2.DAT (Table 19) and for ___.WHD in GLABEL3.DAT (Table 20). More information is given in IBSNAT Technical Report 5.

After the files have been created, you can run CERES WHEAT for your experiment. The titles of your experiment and treatments will appear in the appropriate experiment and treatment selection menus when you run the model. The weather, soil, management, and cultivar data pertinent to your experiment can also be accessed via various menus which appear as you run the model. It is important to check that the variety code and the soil code you have selected are appropriate for your experiment. Errors will result if you attempt to select non-existing varieties or soils.

Sometimes the simulation model will be unable to predict your field-measured data, and the graphics representation will show a poor fit to the data points. This lack of correspondence might result from several factors, including the use of a cultivar that is not defined in file GENETICS.WH9, a soil type that is not defined in file SPROFILE.WH2, or an experiment or set of treatments that cannot be simulated by the model because the options (e.g., some fertility effects) are not available.

Data Entry with INPUTS Program

The INPUTS program enables you to interactively enter data from the keyboard into the appropriate files. The program is menu-driven and has an online help facility. In addition, the program incorporates a procedure for estimating inputs when the input values are not directly attainable. This estimation facility is available only for variables related to soil water and soil fertility. The INPUTS program can be used to edit existing files as well as to create new files.

For a description of the structure and format of the inputs, refer to IBSNAT Technical Report 5 (IBSNAT, 1990 VI.I). All model inputs are described in some detail in the model documentation (Ritchie et al., 1988). The online help facility provides definitions of model inputs and guidelines for appropriate values to use.

1. Insert a blank formatted diskette into drive B: (dual floppy system) or drive A: (hard-disk system) and access the INPUTS program by either loading the appropriate diskette (disk No. 3) into drive A: or by running it directly from the hard disk.
2. Type INPUTS and follow the instructions provided by the program. At any point, if you supply an input value that is out of range, the program will make an audible "beep" and request new input values. You can get help on most variables by typing in any non-numeric character (A to Z, ? @ * & etc., with the exception of L and /). The program will respond by displaying a short help message and then prompt for new input values. If you mistype a character in a numeric field, the program will automatically display the help screen. When you have completed data entry for a file, the program will display the data you have entered on the screen and then allow you to edit these data, move to another section of data entry, or exit the program. If you make a mistake entering one data item, continue entering data until you reach the end of the file and then access the menus to change the erroneous values.
3. For weather data (FILE1) enter an appropriate file name, using the convention described in IBSNAT Technical Report 5 (IBSNAT, 1990 VI.I), and then follow the menus. Procedures are incorporated for converting some ASCII files containing daily weather data to the appropriate format. Facilities for unit conversion are also provided.
4. Enter the appropriate codes for identification of your institute, experiment site, treatment, and year of the experiment.
5. Follow the menus for entry of treatment-specific data into each of FILES 4 through 8.
6. If necessary, add additional soil profile data to FILE2. If you do not have all the data requested, procedures are provided within the program to estimate them from standard soil profile descriptions.
7. If necessary, add additional cultivars to FILE9 using the menu provided.
8. Update the experiment directory file.
9. Update the weather directory file.

10. Use the VALIDATE procedure to check that all inputs are present.
11. Exit the program and copy your data files to the appropriate diskettes or directories.

Multiple-Year

The data inputs and setup for the multiple-year runs are almost identical to those for the single-year runs.

1. First ensure that FILES 2 through 7 contain the data for the treatment(s) you wish to simulate. Follow the instructions for these files as above.
2. For FILE8 ---.WH8, you must add all the entries as described earlier plus a code number indicating the number of years to be simulated. This number (MULTYR) should be added at the end of the second line of data for each multiple-year treatment. The number of years can occupy a total of four spaces but must include at least one blank space before the number. An example with 5 years' (highlighted) simulation is shown for ICTH7902.WH8 in Table 21.
3. For multiple-year runs, there must be at least MULTYR years of daily weather present. All of these weather data can be contained in one large file with one corresponding entry in the weather directory file (WTH.DIR) and with the file name specified in the experiment directory file (WHEXP.DIR). Alternatively, smaller weather files, each with 1 year's data, can be used. In this case the name of the first weather file in the sequence must be entered into both WHEXP.DIR and WTH.DIR. When the model comes to the end of the first file, it will automatically look for the next year's weather data in your current disk directory. It is, however, a good practice to enter all the weather file names into the WTH.DIR file to provide a ready reference as to which weather data sets are available. If you wish to simulate crops for which planting dates are toward the end of the year, so that the crop growth period spans calendar years, you must ensure that there is sufficient weather data present for the last crop to reach the end of its growing period.

Suppose, for example, that a multiple-year simulation were to commence in 1959 and run for 20 years. You could set up either a large file with 20 years of weather data, e.g., ICTH0199.W59, or 20 smaller files, e.g.,

ICTH0112.W59
ICTH0112.W60
....
....
ICTH0112.W78.

In the latter case, only ICTH0112.W59 would need to be entered into the WHEXP.DIR and WTH.DIR files.

CHAPTER 10
Example Simulation

The examples that follow are designed to demonstrate the model operation for single-year simulation, multiple-treatment run, and multiple-year simulation. The users should compare their simulation results with the screen output results presented here. The single-year example run was made by selecting the first experiment (Ashland, N x Irrigation Experiment, 1981-82) and the last treatment in that experiment (Irrigated 180 kg N/ha split application). Remember that to have the graphs which are displayed on the screen printed to your printer you need to have the file GRAPHICS.COM on your disk and an IBM-compatible printer appropriately connected to your PC. To run the model, type **HELPWH** and follow the onscreen menu as illustrated below. The action required by the user is highlighted thus ░ in the following presentation. When you run the model, the highlighting will not appear.

Computer Sample Screen

```
CERES WHEAT MODEL VERSION 2.10

     OPTIONS:

1.    Run the wheat model.  Type "WHEAT".
2.    Input data to be used with the model.
       Type "INPUT".
3.    Graph the results of the model run.
       If you want a hard copy of the graphs,
       run GRAPHICS.COM before running the graph.
       To graph results, type "GRAPH".
```

Computer Sample Screen

```
Welcome to the C E R E S  W H E A T model
Version 2.10 incorporating new menu structure
and support for multi-year and multi-treatment runs.
Version 2.10 also provides output support for IBSNAT   graphics and DSSAT.
Please note that the genetic coefficients in the genetics file
have been rescaled to a 0 to 9 scale.  Spring wheat cultivars
have low values and winter wheats high values.

Press "Enter" to continue
```

Single-Year Simulation

The first screen presented is the main screen showing experiments available for simulation. In the example on diskette, the first three experiments are for single-year crop simulation and the fourth entry is a multiple-year experiment. The following references will provide more information on these experiments: Experiment No. 1 (Wagger, 1983); Experiment No. 2 (Campbell et al., 1977a, 1977b); and Experiment No. 3 (Pearman et al., 1977, 1978).

Select Experiment 1:

Type "1" and press the <ENTER> key.

Computer Sample Screen

```
 LIST OF EXPERIMENTS TO BE SIMULATED        INST.   SITE  EXPT.
 ----------------------------------          ID      ID    NO    YEAR
                                            ----    ----  ----   ----
 1) ASHLAND : WHEAT N X IRRIGATED            KS      AS    01    1981
 2) SWIFT CURRENT CANADA 1975                IF      SW    01    1975
 3) ROTHAMSTED ENGLAND 1975                  IF      RO    01    1975
 4) Tel Hadya Syria Multiple Year Run        IC      TH    01    1980

 1] <=== CURRENT EXPERIMENT SELECTION.
    <— NEW SELECTION?
 1
```

The next screen shows the treatments available for the selected experiment. In this example there are six treatments: 2 "irrigations" (rainfed and irrigated) x 3 N rates. If "treatment 7" is chosen, then all six treatments for the experiment will be simulated without any further keyboard input.

Select treatment No. 6:

Type "6" and press the <ENTER> key.

Computer Sample Screen

```
 TRT                                                 INST   SITE  EXPT.
 NO. ASHLAND : WHEAT N X IRRIGATED                    ID     ID    NO   YEAR
 ------------------------------------------          ----   ----  ----  ----
 1) DRYLAND - 0 KG N/HA                               KS     AS    01   1981
 2) DRYLAND - 60 KG N/HA                              KS     AS    01   1981
 3) DRYLAND - 180 KG N/HA SPLIT APPLICATION           KS     AS    01   1981
 4) IRRIGATED - 0 KG N/HA                             KS     AS    01   1981
 5) IRRIGATED - 60 KG N/HA                            KS     AS    01   1981
 6) IRRIGATED 180 KG N/HA SPLIT APPLICATION           KS     AS    01   1981
 7) Run all treatments without keyboard inputs

 1] <=== CURRENT TREATMENT SELECTION.
 <— NEW SELECTION?
 6
```

The third-level menu allows you to choose one of three options:

Option 0. Perform simulation in normal manner, i.e., using the input data.

Option 1. Alter the output frequency from weekly to user-specified interval, the shortest interval being daily.

Option 2. Perform sensitivity analysis of selected input variables.

Select "Run Simulation:"

Type "0" and press the <ENTER> key.

Next, you can type in a title or identifier for the current run and press the <ENTER> key. This identifier can be up to 18 characters long. On the other hand, you may skip typing in the run identifier by simply pressing the <ENTER> key.

To get a display of observed and simulated results:

Type "Y" (for yes) and press the <ENTER> key.

Computer Sample Screen

```
 RUN-TIME OPTIONS?

 0)  RUN SIMULATION
 1)  SELECT SIMULATION OUTPUT FREQUENCY
 2)  MODIFY SELECTED MODEL VARIABLES INTERACTIVELY.

 <=== CHOICE? [ DEFAULT = 0 ]
0

          <=== ENTER UP TO HERE RUN IDENTIFIER, <cr> FOR NONE.
demo
Do you want post harvest comparison with observed data
 displayed on the screen (Y/N) ?
y
```

The next two simulation screens echo the inputs. The first input screen presents brief descriptions of the experiment, treatment, weather station and year of weather data, soil type, and varietal characteristics are given. The varietal characteristics or genetic-specific constants provide a 1-6 scale to quantitatively describe: sensitivity to vernalization (P1V), photoperiod sensitivity (P1D), duration of grain filling phase (P5), and potential number of kernels per ear (G1), potential grain filling rate (G2), and tiller production (G3). For detailed description refer to Chapter 12 of the User's Guide, Ritchie et al. (1988), and ATNews 7 (1988).

Computer Sample Screen

```
RUN  1 OUTPUT SUMMARY

INST_ID   :KS  SITE_ID: AS  EXPT_NO: 01  YEAR : 1981  TRT_NO:  6
EXP.      :ASHLAND : WHEAT  N  X  IRRIGATED
TRT.      :IRRIGATED 180 KG N/HA SPLIT APPLICATION
WEATHER   :Ashland
SOIL      :Haynie (Coarse-silty, mixed,calcareous,mesic Typ Udifluvent)
VARIETY   :NEWTON
IRRIG.    :ACCORDING TO THE FIELD SCHEDULE.

LATITUDE= 39.0, SOWING DEPTH=  6. CM, PLANT POPULATION=162. PLANTS PER SQ METER

GENETIC SPECIFIC CONSTANTS  P1V = 6.0   P1D = 2.5    P5 = 3.5
                               G1 = 3.4   G2 = 2.6  G3 = 1.4

DAY OF YEAR   IRRIGATION(MM)
    96            65.
   110            78.
   117            70.
Please press RETURN to continue.
```

The input values for soil water and soil nitrogen variables are given on the second input screen.

The units for SOIL ALBEDO (reflectivity coefficient) are dimensionless, U (stage 1 soil evaporation) is in mm, SWCON (profile drainage coefficient) is in cm day^{-1}, and RUNOFF CURVE NO. is dimensionless.

The lower limit for plant-extractable soil water (LO LIM), the drained upper limit (UP LIM), saturated soil water content (SAT SW), initial soil water content (IN SW), and plant-extractable soil water content (EXT SW=UP LIM-LO LIM) are expressed in cm^3 soil water cm^{-3} soil for each layer and the total (T) soil water for the profile for each of the above variables is expressed in cm. WR (root preference factor) is dimensionless, and NO3 and NH4 (mg/kg or ppm) are KCl-extractable initial soil NO_3^--N and NH_4^+-N. The total for the profile is expressed as kg N/ha.

Computer Sample Screen

SOIL PROFILE DATA [LOCATION: Manhattan,KS]
SOIL ALBEDO= .14 U= 5.0 SWCON= .60 RUNOFF CURVE NO.= 60.0

DEPTH-CM	LO LIM	UP LIM	SAT SW	EXT SW	IN SW	WR	NO3	NH4
							- - mg/kg - -	
0.- 15.	.072	.225	.275	.153	.205	1.000	9.8	3.4
15.- 30.	.070	.240	.290	.170	.170	.700	7.3	3.2
30.- 60.	.040	.154	.194	.114	.092	.200	5.1	2.5
60.- 90.	.032	.091	.141	.059	.065	.050	4.7	2.2
90.- 120.	.032	.087	.137	.055	.066	.030	4.3	2.7
120.- 150.	.032	.087	.137	.055	.066	.010	4.3	2.7
150.- 180.	.032	.087	.137	.055	.065	.010	4.3	2.7
T 0.- 180.	7.2	22.2	30.9	15.0	16.3		116.*	60.*

* NOTE: Units are in kg / hectare.

FERTILIZER INPUTS

DAY OF YEAR	KG/HA	DEPTH	SOURCE
289	90.00	15.00	AMMONIUM NITRATE
56	90.00	1.00	AMMONIUM NITRATE

Please press RETURN to continue.

The last input echoed (from the second input screen) before the simulation begins includes fertilizer application date(s), amount applied (kg N/ha), depth of application (cm), and type(s) of fertilizer.

The computer screen below gives a summary of crop development, growth, N status of the plant, soil water status, and indices of water and nitrogen stresses at different stages of the crop's phasic development.

Computer Sample Screen

DATE	CDTT	PHENOLOGICAL STAGE	BIOM	LAI	NUPTK	N%	CET	RAIN	PESW
			g/m^2	kg/ha			---mm---		cm
16 Oct	0.	SOWING							
17 Oct	11.	GERMINATION							
29 Oct	105.	EMERGENCE					14.	21.	10.
14 Apr	987.	T SPKLT VE DAYS=50.					15.	4.	9.
5 May	1288.	END VEG BEGIN EAR GROWTH	215.	2.25	93.8	4.36	209.	381.	12.
15 May	1475.	END EAR GR. EARS=1144.	556.	3.59	127.1	2.28	281.	552.	13.
25 May	1667.	BEG GR FILL	739.	3.39	129.4	1.75	326.	629.	15.
21 Jun	2183.	MATURITY	923.	3.00	129.0	1.40	366.	679.	15.
			1202.	.00	33.3	.44	491.	812.	12.

YIELD (KG/HA)=4548. (BU/ACRE)= 67.9 FINAL GPSM=11011. KERNEL WT. (mg)= 41.3
Please press ENTER to continue

ISTAGE	CSD1	CSD2	CNSD1	CNSD2	STAGE OF GROWTH
1	.00	.00	.00	.00	EMERG - TERM SPIKLT
2	.00	.00	.00	.38	END VEG - BEGIN EAR GROWTH
3	.00	.00	.00	.35	BEGIN EAR - END EAR GROWTH
4	.00	.00	.00	.00	END EAR GRTH - BEGIN GRFIL
5	.00	.00	.00	.00	LINEAR GRAIN FILL PHASE

* NOTE: In the above table, 0.0 represents minimum stress and 1.0 represents maximum stress for water (CSD) and nitrogen (CNSD) respectively,
Press "ENTER" to continue

CDTT: daily thermal time accumulator for the growing season (C);

PHENOLOGICAL STAGE: various development stages of wheat crop;

BIOM, g m^{-2}: above ground biomass (dry weight);

LAI: leaf area index ($m^2 m^{-2}$)

NUPTAK, kg N/ha: total N uptake by vegetative (non-grain) organ;

N%: N concentration in vegetative tissue;

CET, mm: cumulative evapotranspiration during the growing season (soil evaporation + transpiration);

RAIN, mm: cumulative rainfall and irrigation for the growing season;

PESW, cm:	plant-available soil water in the profile (soil water content - lower limit);
CSD1:	cumulative water stress factor affecting photosynthesis at respective stages;
CSD2:	cumulative water stress factor affecting leaf expansion and growth (more sensitive to water stress);
CNSD1:	cumulative nitrogen stress factor affecting photosynthesis at respective stages; and
CNSD2:	cumulative nitrogen stress factor affecting leaf expansion and growth at respective stages.

The final simulation screen gives the irrigation scheduling and a table of predicted and observed results. Missing observed values are indicated by -9.0 or 0.0.

Computer Sample Screen

	PREDICTED	OBSERVED
ANTHESIS DATE	138	141
MATURITY DATE	172	174
GRAIN YIELD (KG/HA)	4548.	4695.
KERNEL WEIGHT (MG)	41.3	23.1
GRAINS PER SQ METRE	11011.	20325.
GRAINS PER EAR	9.62	24.00
MAX. LAI	3.59	2.88
BIOMASS (KG/HA)	12024.	13064.
STRAW (KG/HA)	7475.	8369.
GRAIN N%	2.04	2.04
TOT N UPTAKE (KG N/HA)	125.9	166.5
STRAW N UPTAKE	33.3	71.0
GRAIN N UPTAKE	92.6	95.5

Please press RETURN to continue.

Computer Sample Screen

```
Simulation complete for this treatment.
Do you want to :
1  Return to Experiment and Treatment Menu
2  Display Detailed Outputs on Screen
3  Quit

Input a number (default is 1)
2
Which File do you wish to display
1  No File Display - Return to Simulation Menu
2  Summary Output File
3  Crop Growth Output File
4  Weather and Water Balance File
5  Nitrogen Balance File

Input a number
3
```

Once simulation for a given treatment is completed, the following three options in the Simulation menu are available:

Option 1. Run another experiment and/or treatment by returning to Experiment and Treatment menu;
Option 2. Display detailed output for the run just completed;
Option 3. Quit crop simulation and graph the results.

Example: To display the crop growth output file, **type "2"** (Display Detailed Outputs on Screen) **and press the <ENTER> key**. Next select "3" from the File Display menu (**type "3" and press the <ENTER> key**).

Computer Sample Screen

RUN 1 demo
INST_ID :KS SITE_ID: AS EXPT_NO: 01 YEAR : 1981 TRT_NO: 6
EXP. :ASHLAND : WHEAT N X IRRIGATED
TRT. :IRRIGATED 180 KG N/HA SPLIT APPLICATION
WEATHER :Ashland
SOIL :Haynie (Coarse-silty, mixed,calcareous,mesic Typ Udifluvent)
VARIETY :NEWTON
IRRIG. :ACCORDING TO THE FIELD SCHEDULE.

DAY	SDTT	BIO	TPSM	LAI	ROOT	STEM	GRAIN	LEAF	RTD	PTF	L1	L3	L5
OYR		g/m2			------ Weight in g			------	(cm)		--- RLV		--
308	85.	2.	162.	.04	.007	.000	.000	.014	30.	.65	.0	.0	.0
315	143.	5.	162.	.07	.012	.000	.000	.029	43.	.58	.1	.0	.0
322	237.	12.	162.	.19	.027	.000	.000	.076	63.	.65	.2	.0	.0
329	285.	16.	176.	.25	.046	.000	.000	.098	74.	.31	.3	.0	.0
336	314.	18.	213.	.28	.063	.000	.000	.112	82.	.08	.4	.1	.0
343	359.	23.	295.	.35	.107	.000	.000	.140	92.	.14	.8	.1	.0

Press "Enter" to continue

Screen display of detailed crop growth output at weekly interval (default).

DAY OYR: day of year;
SDTT: sum of daily thermal time per growth stage (C);
BIO: aboveground biomass in g m^{-2}.
BIO= [STEM+GRAIN+LEAF+(EAR-GRAIN)]*PLANTS
where PLANTS is plant population (plants m^{-2});
TPSM: number of tillers per m^{-2};
LAI: leaf (blade) area index (m^2 m^{-2});
ROOT: root dry weight (g/plant);
STEM: stem and tassel dry weight (g/plant);
GRAIN: grain dry weight (g/plant);
LEAF: leaf blade and leaf sheath dry weight (g/plant);
RTD: rooting depth (cm);
PTF: daily assimilate partitioning factor for tops (shoot);
L1 L3 L5: root length density (RLV) for soil layers 1, 3, and 5 (cm^3cm^{-3}), respectively.

In addition to the crop growth output (OUT2.WH), the user may also display summary output (OUT1.WH), weather and water balance output (OUT3.WH), and nitrogen balance output (OUT4.WH) files. These files also may be viewed or printed using DOS commands at the end of a model session.

To graph results, exit from File Display menu (**type "1" and press the <ENTER> key**) and quit Simulation menu (**type "3" and press the <ENTER> key**) as shown in the screen example.

On a floppy diskette system, you will be prompted to replace the Program disk (No. 1) with the Graphics disk (No. 4). On a hard-disk system, the program will immediately proceed with the graphics section of the model.

Computer Sample Screen

```
End of File

Which File do you wish to display
1  No File Display - Return to Simulation Menu
2  Summary Output File
3  Crop Growth Output File
4  Weather and Water Balance File
5  Nitrogen Balance File

Input a number
1
Simulation complete for this treatment.
Do you want to :
1  Return to Experiment and Treatment Menu
2  Display Detailed Outputs on Screen
3  Quit

Input a number (default is 1)
3
```

On a floppy diskette system, the graphics program is on drive A: and the data is stored on drive B:. For hard-disk systems, **type the drive number (C, D, E, etc.)** corresponding to your system and pathname **\WHEAT** as shown in the example for graphics program and **C:** for data drive.

Choose the graphics option that fits your system. If you have monochrome graphics, for example, select 2 (**type "2" and press the <ENTER> key**).

If you wish to save the setup, **type "Y" and press the <ENTER> key**; otherwise, **type "N" and press the <ENTER> key**.

Computer Sample Screen

```
 Type Drive and path of graphics program ? d:\\wheat
Which data drive contains the selected data? d:\wheat
>
Graphics Options Available
[1] - CGA-LOW  - 320 x 200 pixels, 3 color graph
[2] - CGA-HIGH - 640 x 200 pixels, monochrome graph (HERCULES NOT AVAILABLE)
[3] - EGA-LOW  - 640 x 200 pixels, 6 color graph, requires EGA
[4] - EGA-MED  - 640 x 350 pixels, 3 color graph, requires EGA
[5] - EGA-HIGH - 640 x 350 pixels, 6 color graph, requires EGA
      & 128k video memory
>
Enter graphics option  ? 2
Would you like to save disk drive and graphics option for future runs? y
```

The Select Graph Type menu allows four types of graphs for the CERES models. To plot crop variables on the screen:

Type "1" and press the <ENTER> key.

Computer Sample Screen

```
SELECT GRAPH TYPE

1. Crop variables
2. Weather and soil variables
3. Nitrogen variables [CERES models only]
4. Harvest variables
5. Graphical display of plant [Soybean only]
0. Exit graph

Option (0,1,2,3,4 or 5)? 1
```

The graphics program reads the simulated crop growth output values from file OUT2.WH. To have the observed values (from FILE B, e.g., KSAS8101.WHB) plotted as well:

Type "Y" and press the <ENTER> key.

Computer Sample Screen

```
READING DATA ... PLEASE WAIT!

FILE          RUN  POINTS  DOY
d:OUT2.WH      1     33    167
Do you want to plot field sample data points (Y/N)?  y
```

Selection of Variables and Treatments

This screen menu allows you to choose the variable(s) and treatment(s) (Run No.). For example, to plot stem, leaf and grain weights (3 variables or 3 lines) for "RUN #1" (Irrigated 180 kg N/ha), **type "3" and press the <ENTER> key.**

Next type in the appropriate variable no. and run no.:

Type: "6,1"
"7,1"
"8,1".

Note: In the CERES models, leaf dry weight includes the leaf blade dry weight and leaf sheath dry weight.

"Do you want to change X-axis, Y-axis or graphics display (Y/N)?"

The x-axis, y-axis or graphics display will not be changed for this example.

Computer Sample Screen

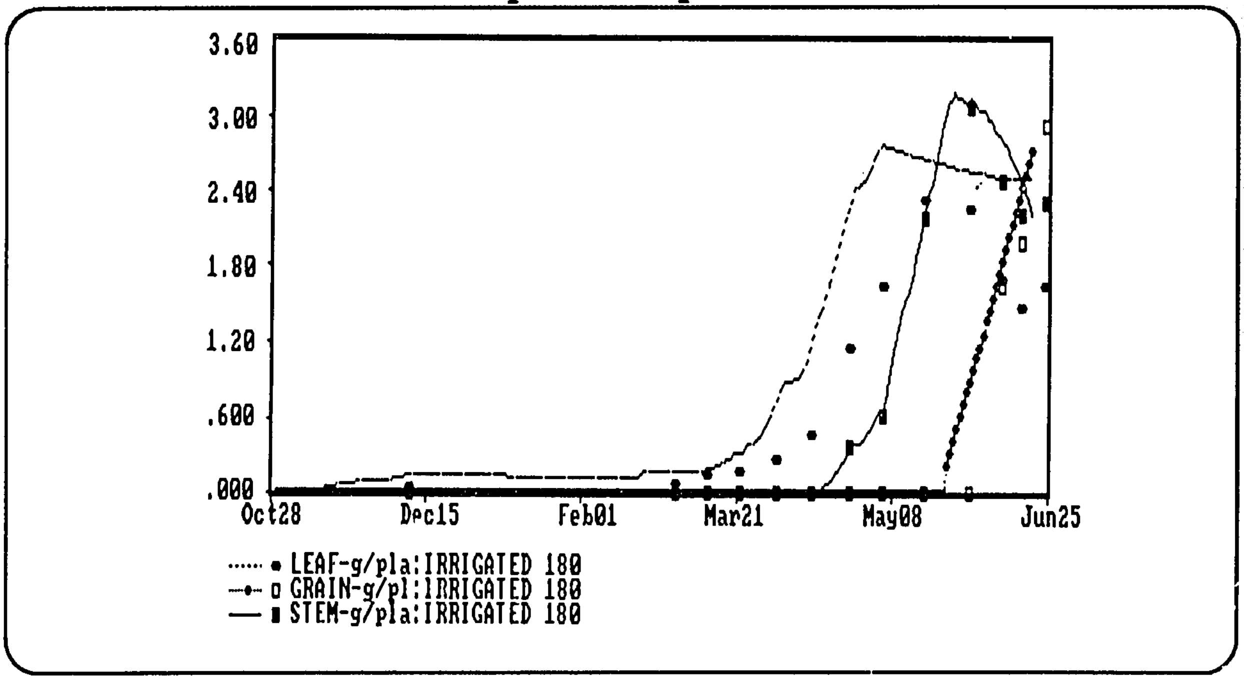
```
VARIABLES AVAILABLE FOR GRAPHING ARE:     RUN# AVAILABLE FOR SELECTION ARE:
 1. Growth Stage (C/day)                   1. demo
 2. Biomass (g/m^2)
 3. Number of Tillers
 4. Leaf Area Index
 5. Root Dry Weight (g/plant)
 6. Stem Dry Weight (g/plant)
 7. Grain Dry Weight (g/plant)
 8. Leaf Dry Weight (g/plant)
 9. Root depth cm
10. Daily Partitioning Factor for Shoot
11. Root Length Density Level 1 cm/cm3
12. Root Length Density Level 3 cm/cm3
13. Root Length Density Level 5 cm/cm3

You may plot 1 to 6 lines with any combination of variables and run#
How many lines do you want to plot ? 3
LINE# 1 : ENTER VARIABLE#,RUN# 6,1
LINE# 2 : ENTER VARIABLE#,RUN# 7,1
LINE# 3 : ENTER VARIABLE#,RUN# 8,1
Do you want to change X-axis, Y-axis or graphics display (Y/N)?     n
```

However, if you had typed "Y" in response to the above question, the program would allow the following options:

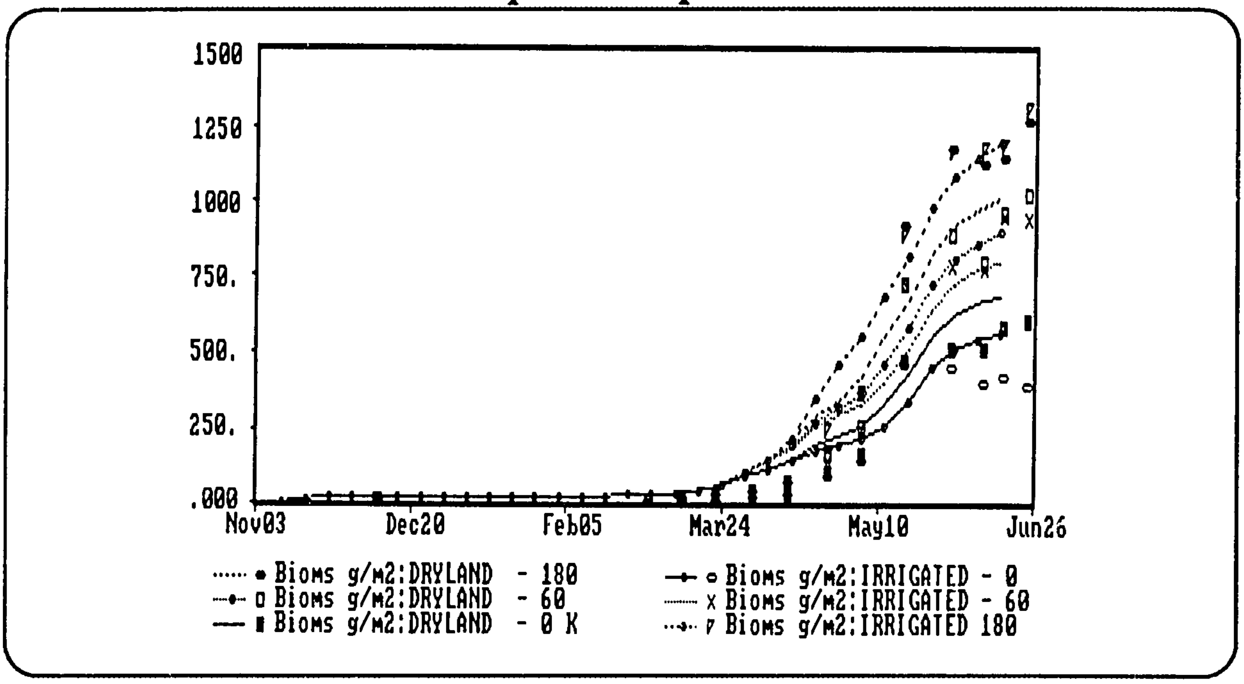
Option 1. Change screen type.
Option 2. Change X-axis scale from calendar dates to days after planting.
Option 3. Change X-axis scale.
Option 4. Change Y-axis scale.

Computer Sample Screen



Single-treatment, multiple-variable plot. The screen display on the top has Y-axis in g/plant for the variables (stem, leaf, and grain dry weights) chosen. When plotting more than one variable, please make certain that the variables have a comparable range of values.

Computer Sample Screen



Multiple-treatment, single-variable plot. The second graph was generated after running the CERES WHEAT model for all the treatments of experiment 1 (Ashland: wheat N x Irrigated). In the example shown, only one variable (biomass) is plotted for each of the runs.

The following graphs were generated following simulation of all the experiments and treatments that had corresponding observed data on the CERES WHEAT V2.10 Data Diskette (No. 2). Harvest variables were plotted (Option 4 in Select Graph Type menu).

There are 13 harvest variables available for graphing. Final harvest values are used for all the variables except maximum LAI. Maximum LAI is determined at anthesis. In the example that follows, observed vs. simulated results for variable 3 (grain yield) are given.

Computer Sample Screen

SELECT GRAPH TYPE

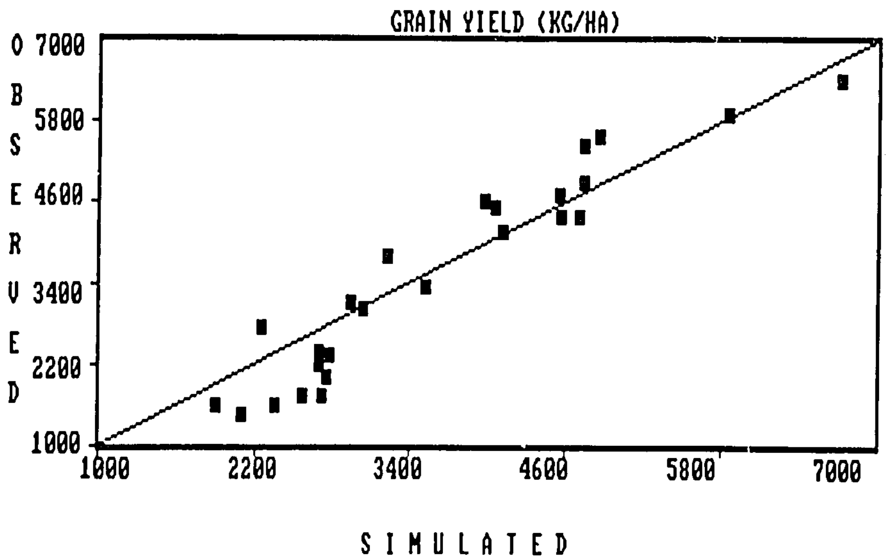
1. Crop variables
2. Weather and soil variables
3. Nitrogen variables [CERES models only]
4. Harvest variables
5. Graphical display of plant [Soybean only]
0. Exit graph

Option (0,1,2,3,4 or 5)? 4

Computer Sample Screen

```
THE VARIABLES AVAILABLE FOR GRAPHING ARE:
   1. ANTHESIS DATE
   2. MATURITY DATE
   3.  GRAIN YIELD (KG/HA)
   4. KERNEL WEIGHT (MG)
   5. GRAINS PER SQ METRE
   6. GRAINS PER EAR
   7. MAX. LAI
   8. BIOMASS (KG/HA)
   9. STRAW  (KG/HA)
  10. GRAIN N%
  11. TOT N UPTAKE (KG N/HA)
  12. STRAW N UPTAKE
  13. GRAIN N UPTAKE
ENTER OPTION (1 to  13 )? 3
Do you want to change X and Y scale or graphics display (y/n)? n
```

Computer Sample Screen



Multiple-Year Simulation

CERES WHEAT V2.10 offers a multiple-year simulation option using either real time or synthetic weather data. This option is started by selecting the appropriate experiment from the main-level menu, i.e., Main Experiment menu. In the example presented, Experiment No. 4 from Tel Hadya, Syria, was used for the multiple-year simulation.

Type "4" and press the <ENTER> key to run the multiple-year simulation.

Computer Sample Screen

LIST OF EXPERIMENTS TO BE SIMULATED	INST. ID	SITE ID	EXPT. NO	YEAR
1) ASHLAND : WHEAT N X IRRIGATED	KS	AS	01	1981
2) SWIFT CURRENT CANADA 1975	IF	SW	01	1975
3) ROTHAMSTED ENGLAND 1975	IF	RO	01	1975
4) Tel Hadya Syria Multiple Year Run	IC	TH	01	1980

1] <=== CURRENT EXPERIMENT SELECTION.
<— NEW SELECTION?
4

Treatment Selection

In the second-level menu, i.e., Treatment menu, a treatment that has the multiple-year run option is marked with an asterisk. In the given example, both the treatments have the multiple-year simulation capability. The user, therefore, may run either of the above treatments.

Type "1" and press the <ENTER> key to choose the treatment associated with nitrogen non-limiting soil 1.

Computer Sample Screen

```
 TRT                                                  INST.  SITE  EXPT.
 NO.  Tel Hadya Syria Multiple Year Run                ID     ID    NO   YEAR

1) Nitrogen Non-limiting soil 1                       IC     TH    01   1980 *
2) Nitrogen Non-Limiting soil 2                       IC     TH    01   1980 *
     * Indicates Multi-Year can be run for this treatment

1] <=== CURRENT TREATMENT SELECTION.
  <— NEW SELECTION?
1
Multiple Year Run    5 Years

 RUN-TIME OPTIONS?

 0)  RUN SIMULATION
 1)  SELECT SIMULATION OUTPUT FREQUENCY
 2)  MODIFY SELECTED MODEL VARIABLES INTERACTIVELY.
 3)  RUN MULTI-YEAR SIMULATION

 <=== CHOICE? [ DEFAULT = 0 ]
 3
```

"Run Time Options?"

The third-level menu (Run Time Options menu) has an additional fourth choice, the ability to run multiple-year simulation (Option 3). At this point, the user still has the option (Option 0) to run a single-year simulation for the above treatment.

Type "3" and press the <ENTER> key to run the multiple-year (5 years) simulation.

Display Options

The Multi-Year Output Selection menu has selections ranging from detailed output for growth, water balance, and nitrogen balance to one-line summary output for each year.

Type "3" and press the <ENTER> key to implement the one-line summary output.

The input echo display for multi-year simulation is identical to the single-year display as shown by sample screens below.

Computer Sample Screen

```
Multi-Year Output Selection Menu
Select an option from the list

1)  Full output with files for water balance, N balance and growth
2)  Summary output file with key variables output at growth stages
3)  One line summary output for each year

Default value is 3.
3

    <=== ENTER UP TO HERE RUN IDENTIFIER, <cr> FOR NONE.
multiyear syria
```

Computer Sample Screen

```
INST_ID :ic  SITE_ID; br  EXPT_NO: 01  YEAR : 1980  TRT_NO:  1
EXP.         :Tel Hadya Syria Multiple Year Run
TRT.         :Nitrogen Non-limiting soil 1
WEATHER  :Tel Hadya (Synthetic)
SOIL         :Tel Hadya (Palexerollic Chromoxerert; high AWC)
VARIETY   :MEXIPAK
IRRIG.       :NEVER IRRIGATED, RAINFED.

LATITUDE= 36.0, SOWING DEPTH=  5. CM, PLANT POPULATION=300. PLANTS PER SQ
METER

GENETIC SPECIFIC CONSTANTS  P1V =  .5  P1D = 3.0  P5 = 2.0
                            G1 = 2.9   G2 = 3.0  G3 = 1.7


DAY OF YEAR    IRRIGATION(MM)
Please press RETURN to continue.
```

Output Display

The simulated output as requested is a one-line summary for each year. The variables are:

- #: simulation number
- GRAIN YIELD: final grain yield (kg ha^{-1})
- MATURE BIOMASS: final aboveground biomass (kg ha^{-1})
- ANTHES BIOMASS: aboveground biomass at anthesis (kg/ha)
- N UPTAKE: total N uptake (kg N ha^{-1})
- N LOSS: N loss due to leaching from a layer 100 cm deep or to bottom of the profile if it is shallower plus any N loss due to denitrification (kg N ha^{-1})
- E-M DAYS: number of days from emergence to maturity
- E-M RAIN: amount of rain (mm) from emergence to maturity
- WAT STRS3: water stress factor at growth stage 3 (tassel initiation to silking)
- WAT STRS5: water stress factor at growth stage 5 (grain filling phase)
- NIT STRS3: nitrogen stress factor at growth stage 3 (tassel initiation to silking)
- NIT STRS5: nitrogen stress factor at growth stage 5 (grain filling phase)
- YR: year number.

On completion of the multiple-year (5 years) simulation, the output is sorted according to increasing grain yield. For example, the highest yield occurred in the fourth year.

"Do you want to:"

The user has the option to return to the Main Experiment menu, display detailed output on screen, or quit simulation. However, for the one-line summary output, it is not possible to choose Option 2 (Display Detailed Outputs on Screen).

Computer Sample Screen

DEPTH-CM	LO LIM	UP LIM	SAT SW	EXT SW	IN SW	WR	NO3	NH4
							— (mg/kg) —	
0.- 10.	.210	.340	.357	.130	.100	1.000	5.0	3.0
10.- 25.	.210	.350	.367	.140	.110	.700	5.0	3.0
25.- 50.	.230	.360	.380	.130	.260	.500	4.0	3.0
50.- 75.	.260	.380	.400	.120	.300	.150	3.5	2.0
75.- 100.	.270	.390	.410	.120	.300	.040	3.0	2.0
100.- 125.	.300	.380	.400	.080	.320	.020	2.0	2.0
125.- 150.	.300	.375	.390	.075	.320	.010	2.0	1.0
150.- 180.	.300	.375	.390	.075	.300	.020	1.5	1.0
180.- 200.	.300	.375	.390	.075	.300	.001	1.0	1.0
T 0.- 200.	54.3	74.5	78.1	20.3	55.1		0.*	0.*

WARNING Initial soil water content is below lower limit.
Please recheck input data.

* NOTE: Units are in kg / hectare.

NITROGEN NON-LIMITING

Please press RETURN to continue.

Computer Sample Screen

Simulation Outputs sorted according to yield

#	GRAIN YIELD	MATURE BIOMASS	ANTHES BIOMASS	N UPTAKE	N LOSS	E-M DAYS	E-M RAIN	WAT STRS1	WAT STRS5	NIT STRS1	NIT STRS5	YR
1	212.	4241.	4383.	0.	0.	158.	179.	.0	.9	.0	.0	3.
2	1757.	11241.	10755.	0.	0.	168.	295.	.0	.9	.0	.0	1.
3	1757.	11241.	10755.	0.	0.	168.	295.	.0	.9	.0	.0	4.
4	2379.	12051.	10457.	0.	0.	155.	241.	.0	.8	.0	.0	2.
5	2379.	12051.	10457.	0.	0.	155.	241.	.0	.8	.0	.0	5.

Press Enter to Continue

Simulation complete for this treatment.
Do you want to :
1 Return to Experiment and Treatment Menu
2 Display Detailed Outputs on Screen
3 Quit

Input a number (default is 1)
3

Simulation Output Frequency

At the third-level simulation menu (Run-time Options menu), in addition to carrying out simulation for the given input, a user has the option to change output frequency for water balance, crop growth, and nitrogen balance from a 7-day (default) interval to any other user-specified interval. The minimum interval is a daily time step.

To change output frequency select choice 1. **Type "1" and press the <ENTER> key.**

Computer Sample Screen

```
RUN-TIME OPTIONS?

0)  RUN  SIMULATION
1)  SELECT SIMULATION OUTPUT FREQUENCY
2)  MODIFY SELECTED MODEL VARIABLES INTERACTIVELY.

<=== CHOICE? [ DEFAULT = 0 ]
1
```

The screen example illustrates daily output for water balance, growth, and nitrogen components. After typing in the desired frequencies, run the model by choosing the "Run Simulation" option. **Type "0" and press the <ENTER> key.**

Computer Sample Screen

```
 7 Days  <=== OUTPUT FREQUENCY FOR WATER BALANCE  COMPONENTS.
      <— NEW VALUE?
1
 7 Days  <=== OUTPUT FREQUENCY FOR GROWTH COMPONENTS.
      <— NEW VALUE?
1
 7 Days  <=== OUTPUT FREQUENCY FOR NITROGEN COMPONENTS.
      <— NEW VALUE?
1

RUN-TIME OPTIONS?

0)  RUN SIMULATION
1)  SELECT SIMULATION OUTPUT FREQUENCY
2)  MODIFY SELECTED MODEL VARIABLES INTERACTIVELY.

<=== CHOICE? [ DEFAULT = 0 ]
0
```

CHAPTER 11
Sensitivity Analysis

The third-level menu also gives the option to run **sensitivity analysis studies** with the model. The sensitivity analysis menus are structured in a hierarchical manner and enable a user to modify almost all of the input parameters interactively. The user can very readily pose "what if" questions without using a text editor to modify any of the input data. This interactive option would be particularly suitable for use in training workshops as well as for developing new applications.

After selecting a particular experimental and treatment case study, you should select **Option 2** from the **Run-time Options menu.**

When Option 2 **Modify Selected Model Variables Interactively** is chosen, a primary-level interactive menu appears as shown (screen on bottom right). This menu identifies the general subject area of variables you may wish to examine. When any **option between 1 and 9** is selected, further instructions (sub-level menus) to help the user modify input data appear. Each of these menus features a terminator, enabling you to return to the main interactive menu.

Option 10 allows the display of key input data on the screen for checking of data prior to running the simulation. This is the "echo" which normally precedes all runs.

Option 11 allows you to run the model with interactively modified data.

Option 12 allows you to abandon all changes. With this option you may:

1. Return to experiment and treatment selection **(Option 0)**,
2. Redo the sensitivity analysis **(Option 2)**, or
3. Change output frequency.

Any time you change a particular parameter in the sensitivity analysis section, the model will inform you that the model prediction will not conform with the measured (observed) field data.

It should be noted that the changes you make are "volatile" in that they will only exist for the model run you are commencing. The original data are preserved and are never overwritten by any of your menu selections.

Computer Sample Screen

RUN-TIME OPTIONS?

0) RUN SIMULATION
1) SELECT SIMULATION OUTPUT FREQUENCY
2) MODIFY SELECTED MODEL VARIABLES INTERACTIVELY.

<=== CHOICE? [DEFAULT = 0]
2

Computer Sample Screen

MODIFICATION OF SELECTED MODEL VARIABLES INTERACTIVELY

VARIABLES TO BE MODIFIED

1. Planting Date, Simulation Date and Seeding Depth
2. Plant Population
3. Nitrogen Non-Limiting
4. Irrigation Inputs and Water Balance Switch
5 Fertilizer Inputs
6. Select New Variety
7. Soil Profile Inputs (Water Balance,Root Preference,DMOD)
8. Select Weather Data
9. Initial Soil Fertility and Water,
   and Crop Residue Parameters
10. Display Echo
11. End of Changes
12. Abandon all Changes and Return to Experiment Menu

ENTER NUMBER OF MODIFICATION : 1

Screen Examples

The following screen demonstrates the options provided in the various sub-menus when each of the nine options is in turn selected from the primary menu. For example, when **Option 1** (planting date and seeding depth) is chosen from the primary menu, the sub-menus come up with further choices.

All of the nine primary menu options are illustrated with some of their corresponding sub-menus in the screen examples that follow. Screen number 2 on page 55 illustrates the display **Option 10**, following additional fertilizer application. The final screen on page 65 again reminds the user of the changes that may have been made using the menus.

Computer Sample Screen

```
          Do you want to
    1. Change Planting Date ?
    2. Change Simulation Date ?
    3. Change Seeding Depth (cm) ?
    4. Return to main menu ?

    Enter number of choice : 1

  Existing Planting Date is 289 .

 Input New Planting Date : 320

      Do you want to
    1. Change Planting Date ?
    2. Change Simulation Date ?
    3. Change Seeding Depth (cm) ?
    4. Return to main menu ?

    Enter number of choice : 4
```

Computer Sample Screen

```
MODIFICATION OF SELECTED MODEL VARIABLES INTERACTIVELY

      VARIABLES TO BE MODIFIED

       1.  Planting Date, Simulation Date and Seeding Depth
       2.  Plant Population
       3.  Nitrogen Non-Limiting
       4.  Irrigation Inputs and Water Balance Switch
       5.  Fertilizer Inputs
       6.  Select New Variety
       7.  Soil Profile Inputs (Water Balance,Root Preference,DMOD)
       8.  Select Weather Data
       9.  Initial Soil Fertility and Water,
             and Crop Residue Parameters
      10.  Display Echo
      11.  End of Changes
      12.  Abandon all Changes and Return to Experiment Menu

    ENTER NUMBER OF MODIFICATION : 2

  Existing Plant Population is 162.00 /metre square.

  Input New Plant Population : 200.00
```

Computer Sample Screen

```
MODIFICATION OF SELECTED MODEL VARIABLES INTERACTIVELY

      VARIABLES TO BE MODIFIED

   1.  Planting Date, Simulation Date and Seeding Depth
   2.  Plant Population
   3.  Nitrogen Non-Limiting
   4.  Irrigation Inputs and Water Balance Switch
   5.  Fertilizer Inputs
   6.  Select New Variety
   7.  Soil Profile Inputs (Water Balance,Root Preference,DMOD)
   8.  Select Weather Data
   9.  Initial Soil Fertility and Water,
         and Crop Residue Parameters
  10.  Display Echo
  11.  End of Changss
  12.  Abandon all Changes and Return to Experiment Menu

   ENTER NUMBER OF MODIFICATION : 3

Nitrogen Effect is Simulated.
Do You Want to switch off Simulation of Nitrogen Balance?     (Y,N)  : y
```

Computer Sample Screen

```
MODIFICATION OF SELECTED MODEL VARIABLES INTERACTIVELY

        VARIABLES TO BE MODIFIED

         1.  Planting Date, Simulation Date and Seeding Depth
         2.  Plant Population
         3.  Nitrogen Non-Limiting
         4.  Irrigation Inputs and Water Balance Switch
         5.  Fertilizer Inputs
         6.  Select New Variety
         7.  Soil Profile Inputs (Water Balance,Root Preference,DMOD)
         8.  Select Weather Data
         9.  Initial Soil Fertility and Water,
                and Crop Residue Parameters
        10.  Display Echo
        11.  End of Changes
        12.  Abandon all Changes and Return to Experiment Menu

    ENTER NUMBER OF MODIFICATION : 3

Nitrogen is assumed non-limiting.
Do You Want To Simulate Nitrogen Balance ? (Y,N)  : y
```

Computer Sample Screen

```
MODIFICATION OF SELECTED MODEL VARIABLES INTERACTIVELY

        VARIABLES TO BE MODIFIED

  1.  Planting Date, Simulation Date and Seeding Depth
  2.  Plant Population
  3.  Nitrogen Non-Limiting
  4.  Irrigation Inputs and Water Balance Switch
  5.  Fertilizer Inputs
  6.  Select New Variety
  7.  Soil Profile Inputs (Water Balance,Root Preference,DMOD)
  8.  Select Weather Data
  9.  Initial Soil Fertility and Water,
        and Crop Residue Parameters
 10.  Display Echo
 11.  End of Changes
 12.  Abandon all Changes and Return to Experiment Menu

   ENTER NUMBER OF MODIFICATION : 4
```

Computer Sample Screen

FOLLOWS;

Event No.	DAY OF EVENT	AMOUNT ADDED (mm)
1	96	65.
2	110	78.
3	117	70.

To change the method of irrigation or to switch off irrigation, choose option 5.

Do you want to
1. Bypass Water & Nitrogen (assume both non-limiting) ?
2. Modify existing data ?
3. Add additional data ?
4. Apply irrigation ?
5. Change irrigation method or switch irrigation off ?
6. View irrigation data ?
7. Return to main menu ?

Enter number of choice : 5

Computer Sample Screen

This treatment is not irrigated. Choose option 4 to apply irrigation.

Do you want to
1. Bypass Water & Nitrogen (assume both non-limiting) ?
2. Modify existing data ?
3. Add additional data ?
4. Apply irrigation ?
5. Change irrigation method or switch irrigation off ?
6. View irrigation data ?
7. Return to main menu ?

Enter number of choice : 4

There is currently no irrigation applied.
Do you want to apply irrigation (Y or N) ?Y

Irrigation options are :
1. No irrigation
2. Irrigation applied using field schedule
3. Automatically irrigated at threshold soil water
4. Assume no water stress, water balance not used

The current option is : 1
Input new choice : 3

Computer Sample Screen

```
Irrigation options are :
  1. No irrigation
  2. Irrigation applied using field schedule
  3. Automatically irrigated at threshold soil water
  4. Assume no water stress, water balance not used

The current option is :  2
   Input new choice : 3
 Enter fractional value for irrigation system efficiency : 0.8
 Enter value for irrigation management depth (m)  : 1.0
 Enter value for available water triggering irrigation (%)  : 75
```

Computer Sample Screen

```
           Do you want to
   1. Bypass Water & Nitrogen (assume both non-limiting) ?
   2. Modify existing data ?
   3. Add additional data ?
   4. Apply irrigation ?
   5. Change irrigation method or switch irrigation off ?
   6. View irrigation data ?
   7. Return to main menu ?

   Enter number of choice : 1
WARNING : Can not run nitrogen balance with this option.
Do you want to choose another irrigation option (Y or N)? n
```

Computer Sample Screen

LIST OF EXPERIMENTS TO BE SIMULATED	INST. ID	SITE ID	EXPT. NO	YEAR
1) ASHLAND : WHEAT N X IRRIGATED	KS	AS	01	1981
2) SWIFT CURRENT CANADA 1975	IF	SW	01	1975
3) ROTHAMSTED ENGLAND 1975	IF	RO	01	1975
4) Tel Hadya Syria Multiple Year Run	IC	TH	01	1980

1] <=== CURRENT EXPERIMENT SELECTION.
<— NEW SELECTION?
1

Computer Sample Screen

TRT NO. ASHLAND : WHEAT N X IRRIGATED	INST. ID	SITE ID	EXPT. NO	YEAR
1) DRYLAND - 0 KG N/HA	KS	AS	01	1981
2) DRYLAND - 60 KG N/HA	KS	AS	01	1981
3) DRYLAND - 180 KG N/HA SPLIT APPLICATION	KS	AS	01	1981
4) IRRIGATED - 0 KG N/HA	KS	AS	01	1981
5) IRRIGATED - 60 KG N/HA	KS	AS	01	1981
6) IRRIGATED 180 KG N/HA SPLIT APPLICATION	KS	AS	01	1981
7) Run all treatments without keyboard inputs				

1] <=== CURRENT TREATMENT SELECTION.
<— NEW SELECTION?
3

Computer Sample Screen

MODIFICATION OF SELECTED MODEL VARIABLES INTERACTIVELY

VARIABLES TO BE MODIFIED

1. Planting Date, Simulation Date and Seeding Depth
2. Plant Population
3. Nitrogen Non-Limiting
4. Irrigation Inputs and Water Balance Switch
5. Fertilizer Inputs
6. Select New Variety
7. Soil Profile Inputs (Water Balance,Root Preference,DMOD)
8. Select Weather Data
9. Initial Soil Fertility and Water, and Crop Residue Parameters
10. Display Echo
11. End of Changes
12. Abandon all Changes and Return to Experiment Menu

ENTER NUMBER OF MODIFICATION : 5

Computer Sample Screen

FERTILIZER APPLICATION DATA FOR TREATMENT NO. 3.

Event No.	DAY OF EVENT	AMOUNT	DEPTH	TYPE
1	289	90.	15.	1
2	56	90.	1.	1

Do you want to

1. Modify existing data ?
2. Add another application ?
3. View fertilizer data again ?
4. Return to main menu ?

Enter number of choice : 2
Enter Additional Day : 1
Enter New Amount : 120
Enter New Depth : 5
Enter New Type : 6

Computer Sample Screen

MODIFICATION OF SELECTED MODEL VARIABLES INTERACTIVELY

VARIABLES TO BE MODIFIED

1. Planting Date, Simulation Date and Seeding Depth
2. Plant Population
3. Nitrogen Non-Limiting
4. Irrigation Inputs and Water Balance Switch
5. Fertilizer Inputs
6. Select New Variety
7. Soil Profile Inputs (Water Balance,Root Preference,DMOD)
8. Select Weather Data
9. Initial Soil Fertility and Water,
   and Crop Residue Parameters
10. Display Echo
11. End of Changes
12. Abandon all Changes and Return to Experiment Menu

ENTER NUMBER OF MODIFICATION : 10

Computer Sample Screen

SOIL ALBEDO= .14 U= 5.0 SWCON= .60 RUNOFF CURVE NO.= 60.0

DEPTH-CM	LO LIM	UP LIM	SAT SW	EXT SW	IN SW	WR	NO3	NH4
							- - (mg/kg)- - -	
0.- 15.	.072	.225	.275	.000	.205	1.000	9.8	3.4
15.- 30.	.070	.240	.290	.000	.170	.700	7.3	3.2
30.- 60.	.040	.154	.194	.000	.092	.200	5.1	2.5
60.- 90.	.032	.091	.141	.000	.065	.050	4.7	2.2
90.- 120.	.032	.087	.137	.000	.066	.030	4.3	2.7
120.- 150.	.032	.087	.137	.000	.066	.010	4.3	2.7
150.- 180.	.032	.087	.137	.000	.066	.010	4.3	2.7
T 0.- 180.	7.2	22.2	30.9	15.0	16.3		0.*	0.*

* NOTE: Units are in kg / hectare.

FERTILIZER INPUTS

DAY OF YEAR	KG/HA	DEPTH	SOURCE
289	90.00	15.00	AMMONIUM NITRATE
1	120.00	5.00	DIAMMONIUM PHOSPHATE
56	90.00	1.00	AMMONIUM NITRATE

Please press RETURN to continue.

Computer Sample Screen

MODIFICATION OF SELECTED MODEL VARIABLES INTERACTIVELY

VARIABLES TO BE MODIFIED

1. Planting Date, Simulation Date and Seeding Depth
2. Plant Population
3. Nitrogen Non-Limiting
4. Irrigation Inputs and Water Balance Switch
5. Fertilizer Inputs
6. Select New Variety
7. Soil Profile Inputs (Water Balance,Root Preference,DMOD)
8. Select Weather Data
9. Initial Soil Fertility and Water,
   and Crop Residue Parameters
10. Display Echo
11. End of Changes
12. Abandon all Changes and Return to Experiment Menu

ENTER NUMBER OF MODIFICATION : 6

Computer Sample Screen

================

VARIETIES IN THE DATA BASE

================

The current variety is 1907 .

NO.	VARIETY NAME	P1V	P1D	P5	G1	G2	G3
1	CONDO (DURUM)	.5	1.5	2.0	5.3	1.9	1.9
2	WARED	.5	2.7	2.0	5.0	1.8	1.9
3	WALDRON	.5	2.7	2.0	5.0	1.7	1.9
4	ELLAR	.5	2.7	2.0	4.7	1.8	1.9
5	BUTTE	.5	2.7	2.0	2.8	2.4	1.9
6	WARD (DURUM)	.5	1.5	2.0	3.6	1.6	1.9
30	RONGOTEA	.5	2.7	2.0	1.6	3.9	1.7
31	KOPARA	.5	2.7	2.0	1.6	3.9	1.7
32	BOUNTY	6.0	3.7	2.1	3.2	2.5	1.7
33	MOULIN	6.0	3.9	2.1	3.8	2.1	1.8
34	AVALON	6.0	4.0	2.0	3.0	2.7	1.7
178	CENTURK	6.0	2.5	2.0	4.3	1.7	1.2
221	HERON	.5	2.3	2.0	2.0	2.0	4.0
222	SHERPA	.5	3.1	1.0	3.5	2.5	5.0

Press <ENTER> to continue listing.

Computer Sample Screen

2008	PENJAMO	.5	2.7	2.0	2.8	1.6	1.9
2011	PLAINSMAN	6.0	2.7	2.0	2.8	1.6	1.9
2012	PRODURA	.5	3.1	2.5	3.3	3.3	5.3
2013	TAMU	6.0	2.7	2.0	2.8	1.6	1.9
2014	WALDRON	.5	1.5	2.0	2.8	1.6	1.9
2123	EGRET	.5	3.0	2.0	2.6	3.3	2.7
2124	WW33G	.5	3.0	2.0	3.7	1.8	2.4
4000	SQUAREHD MASTER	6.0	4.7	2.0	1.1	2.2	1.9
4001	JUFYI	.5	3.0	2.0	1.8	2.5	3.9
9800	FREDERICK	6.0	2.7	2.0	3.8	1.6	1.9

The current variety is 1907 .

Do you want to

1. Select a new variety ?
2. Create a new variety ?
3. Modify current genetic coefficients ?
4. View the varieties again ?
5. Return to the main menu ?

Enter number of choice : 1

New Variety : 2008

Computer Sample Screen

MODIFICATION OF SELECTED MODEL VARIABLES INTERACTIVELY

VARIABLES TO BE MODIFIED

1. Planting Date, Simulation Date and Seeding Depth
2. Plant Population
3. Nitrogen Non-Limiting
4. Irrigation Inputs and Water Balance Switch
5. Fertilizer Inputs
6. Select New Variety
7. Soil Profile Inputs (Water Balance,Root Preference,DMOD)
8. Select Weather Data
9. Initial Soil Fertility and Water,
   and Crop Residue Parameters
10. Display Echo
11. End of Changes
12. Abandon all Changes and Return to Experiment Menu

ENTER NUMBER OF MODIFICATION : 7

Computer Sample Screen

```
          SOILS IN THE DATA BASE.
REF       =====================
NO. TAXONOMY NAME                        LOCATION
-- -- -- -- -- -- -- -- -- --         -- -- -- -- -- -- --
  1)  DEEP SILTY CLAY
  2)  MEDIUM SILTY CLAY
  3)  SHALLOW SILTY CLAY
  4)  DEEP SILT LOAM
  5)  MEDIUM SILT LOAM
  6)  SHALLOW SILT LOAM
  7)  DEEP SANDY LOAM
  8)  MEDIUM SANDY LOAM
  9)  SHALLOW SANDY LOAM
 10)  DEEP SAND
 11)  MEDIUM SAND
 12)  SHALLOW SAND
 13)  Waipio (Clayey, kaolinitic, isohyperth, Tropeptic Eutrustox) Waipio, HI
 14)  Millhopper Fine Sand (Loamy,silic,hyperth Arenic Paleudult)  Gainesville

Press <Enter> to continue listing.
```

Computer Sample Screen

```
      Do you want to

  1.  Select a new soil ?
  2.  Modify or view parameters of current soil ?
  3.  View the soils again ?
  4.  Return to the main menu ?

  Enter number of choice : 1

  Input new soil selection : 3

  You have chosen a different profile which does not match the layers found in the
  file :  ICTH8001.WH5.

  Please change the profile or modify the layers in :   ICTH8001.WH5.
```

Computer Sample Screen

Do you want to

1. Select a new soil ?
2. Modify or view parameters of current soil ?
3. View the soils again ?
4. Return to the main menu ?

Enter number of choice : 2

Current Parameters to Modify or View

1. Swcon - Soil water drainage, fraction drained/day
2. CN2 - SCS curve number used to calculate daily runoff
3. DMOD - Mineralization rate modifier
4. LL - Lower limit of plant-extractable soil water
5. DUL - Drained upper limit soil water content
6. SAT - Saturated water content
7. WR - Weighting factor to determine new root growth
8. BD - Moist bulk density of soil
9. OC - Organic carbon concentration
10. End of changes

Parameter choice : 10

Computer Sample Screen

MODIFICATION OF SELECTED MODEL VARIABLES INTERACTIVEILY

VARIABLES TO BE MODIFIED

1. Planting Date, Simulation Date and Seeding Depth
2. Plant Population
3. Nitrogen Non-Limiting
4. Irrigation Inputs and Water Balance Switch
5. Fertilizer Inputs
6. Select New Variety
7. Soil Profile Inputs (Water Balance,Root Preference,DMOD)
8. Select Weather Data
9. Initial Soil Fertility and Water,
   and Crop Residue Parameters
10. Display Echo
11. End of Changes
12. Abandon all Changes and Return to Experiment Menu

ENTER NUMBER OF MODIFICATION : 8

Computer Sample Screen

WEATHER DATA SETS AVAILABLE	Dates From	Available Until	Inst ID	Weather Station ID
1) ASHLAND	10/01/81	07/31/82	KS	AS
2) SWIFT CURRENT CANADA 1975	05/12/75	09/07/75	IF	SW
3) ROTHAMSTED ENGLAND 1975	11/01/74	09/02/75	IF	RO
4) Tel Hadya (Synthetic)	01/01/79	12/31/81	IC	TH

1] <=== CURRENT EXPERIMENT SELECTION.
<— NEW SELECTION?
2

Computer Sample Screen

WARNING: Less than 60 days from planting date until end of weather data.
Would you like to change the planting date (Y or N)?

Y

Input New Planting Date: 145

Planting date specified may begin before the simulation, which begins on day 279. Is there enough time to grow the crop if it were planted on day 145 (Y or N)?
Y
Do you want to change the simulation date (Y or N)?
Y
Input New Date to Begin Simulation : 132

Computer Sample Screen

```
MODIFICATION OF SELECTED MODEL VARIABLES INTERACTIVELY

        VARIABLES TO BE MODIFIED

         1. Planting Date, Simulation Date and Seeding Depth
         2. Plant Population
         3. Nitrogen Non-Limiting
         4. Irrigation Inputs and Water Balance Switch
         5. Fertilizer Inputs
         6. Select New Variety
         7. Soil Profile Inputs (Water Balance,Root Preference,DMOD)
         8. Select Weather Data
         9. Initial Soil Fertility and Water,
              and Crop Residue Parameters
        10. Display Echo
        11. End of Changes
        12. Abandon all Changes and Return to Experiment Menu

  ENTER NUMBER OF MODIFICATION : 9
```

Computer Sample Screen

```
            Do you want to

         1.  Modify or view the soil profile parameters ?
         2.  Initialize soil moisture to a percentage
               of whole profile storage ?
         3.  Modify crop residue parameters ?
         4.  Return to the main menu ?

            Enter number of choice : 1

      Current Parameters to Modify or View

         1.  Dlayr - Depth of layer
         2.  SW - Soil water content of layer
         3.  NH4 - Soil ammonium in soil layer
         4.  NO3 - Soil nitrate in soil layer
         5.  PH - pH of soil in soil layer
         6.  End of changes

      Parameter choice : 3
```

Computer Sample Screen

```
Current values of NH4   by layers
 Layer          NH4
 -----        -------

  1            3.400
  2            3.200
  3            2.500
  4            2.200
  5            2.700
  6            2.700
  7            2.700

How many layers would you like to modify ?
  Input 0 to exit when finished

2
```

Computer Sample Screen

```
Input the layer number : 1
Input new value for NH4   :
10.4

Input the layer number : 2
Input new value for NH4   :
8.2

Current values of NH4   by layers
Layer           NH4
-----          -----

  1            10.400
  2             8.200
  3             2.500
  4             2.200
  5             2.700
  6             2.700
  7             2.700

How many layers would you like to modify ?
  Input 0 to exit when finished
0
```

Computer Sample Screen

Current Parameters to Modify or View
1. Dlayr - Depth of layer
2. SW - Soil water content of layer
3. NH4 - Soil ammonium in soil layer
4. NO3 - Soil nitrate in soil layer
5. PH - pH of soil in soil layer
6. End of changes

Parameter choice : 6

Do you want to

1. Modify or view the soil profile parameters ?
2. Initialize soil moisture to a percentage of whole profile storage ?
3. Modify crop residue parameters ?
4. Return to the main menu ?

Enter number of choice : 2

Computer Sample Screen

Layer	LL	DUL	SW
1	.072	.225	.205
2	.070	.240	.170
3	.040	.154	.092
4	.032	.091	.065
5	.032	.087	.066
6	.032	.087	.066
7	.032	.087	.066

Input a value to estimate how "full" the profile is at the beginning of the run.
A value of 1.0 indicates full to the dul.
Value chosen is : 0.5

Computer Sample Screen

Layer	LL	DUL	SW
1	.072	.225	.175
2	.070	.240	.205
3	.040	.154	.158
4	.032	.091	.107
5	.032	.087	.115
6	.032	.087	.128
7	.032	.087	.142

Do you want to

1. Modify or view the soil profile parameters ?
2. Initialize soil moisture to a percentage of whole profile storage ?
3. Modify crop residue parameters ?
4. Return to the main menu ?

Enter number of choice : 4

Computer Sample Screen

NOTE: Data modified by the user.
Therefore, the predicted and observed comparison data may not be valid.

	PREDICTED	OBSERVED
ANTHESIS DATE	138	141
MATURITY DATE	172	174
GRAIN YIELD (KG/HA)	2097.	1438.
KERNEL WEIGHT (MG)	41.3	28.1
GRAINS PER SQ METRE	5076.	5117.
GRAINS PER EAR	5.14	18.00
MAX. LAI	1.46	.81
BIOMASS (KG/HA)	5588.	3926.
STRAW (KG/HA)	3491.	2488.
GRAIN N%	1.34	1.86
TOT N UPTAKE (KG N/HA)	39.1	37.7
STRAW N UPTAKE	11.1	11.0
GRAIN N UPTAKE	28.0	26.7

Please press RETURN to continue.

CHAPTER 12
Genetic Coefficients

CERES WHEAT makes use of six genetic coefficients that summarize various aspects of the performance of a particular genotype. These coefficients are:

		Usual Range of Values
Development Aspects		
Vernalization coefficient	P1V	0-9
Photoperiodism coefficient	P1D	1-5
Grain filling duration coefficient	P5	1-5
Growth Aspects		
Kernel number coefficient	G1	1-5
Kernel weight coefficient	G2	1-5
Spike number coefficient	G3	1-5

The values for each coefficient range from zero or one to an uppermost value for a genotype which shows the maximum known expression of the trait. For example, the vernalization coefficient ranges from 0 for true spring wheats, through a value of 4 for many winter wheats from Western Europe and the Great Plains of North America, to values ranging upward from 7 for some wheats from Northern Europe. These "scale" values are converted to "biological" values within the model; these latter have the following meaning:

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: Degree days above a base of 1°C from 20°C days after anthesis to maturity.

G1: Kernel number per unit weight of stem (less leaf blades and sheaths) plus spike at anthesis (g^{-1}).

G2: Kernel filling rate under optimum conditions (mg day^{-1}).

G3: Non-stressed dry weight of a single stem (excluding leaf blades and sheaths) and spike when elongation ceases (g).

Approximate values of each of these genetic coefficients for a genotype that is not present in the genetics file (GENETICS.WH9), but for which experimental data are available, can be obtained by trial and error. The general sequence of steps in applying this method is as follows:

1. Select initial genetic coefficient values for the genotype in question. Do this by identifying in Table 22 a genotype which grows in an area of adaptation similar to that of the genotype in question.

2. Refine the initial value for the vernalization coefficient (P1V) by reference to local knowledge of the cultivar in question and information in footnote b of Table 22.
3. Enter the name of the genotype in question and the selected initial coefficient values in the genetics (GENETICS.WH9) file. There are several ways of doing this:
   a. Use any text editor, but be sure not to enter any tabs when the file is stored.
   b. Use the menu options within the CERES model to enter a new genotype, or modify an existing genotype (see example following).
   c. Use the INPUTS program, which is available from IBSNAT or IFDC.
4. For the experiment under consideration, check the value of PHINT (the eleventh variable on the second line of information for the particular experiment/treatment combination) in the treatment and management file (i.e., the file with extension .WH8). The variable is generally given a value of 95 degree days, but this should be changed to 75 degree days for experiments with spring sown wheats in upper latitudes where the mean daily temperature is below 5°C at the time of germination and emergence. Where data have been obtained on the number of degree days that elapse between the appearance of each successive leaf, these should be used for PHINT.
5. Run the model for one location/treatment combination for which data are available.
6. Examine and note the goodness-of-fit between the predicted and actual time of anthesis. If the predicted anthesis date was later (or earlier) than the actual, decrease (or increase) the values for P1D (the second variable) for the genotype in question in the genetics file.
7. Repeat steps 5 and 6 until a reasonable fit is obtained, or until P1D differs by 2.0 units or more from the initial guess. If the latter occurs, increase (or decrease) P1V (the first variable in the genetics file) until a reasonable fit is obtained, or until P1V is 2.0 units or more from the initial guess. Return to P1D if necessary.
8. Examine and note the goodness-of-fit between the predicted and actual days to maturity. If not satisfactory, increase (or decrease as appropriate) P5 (the third variable in the genetics file). Rerun and rechange the coefficient until a satisfactory fit is obtained.
9. Examine and note the goodness-of-fit between predicted and observed spike number per m^2. Adjust G3 (the sixth variable), rerun, and recompare until satisfied.
10. Examine and note the goodness-of-fit between predicted and actual kernel number per m^2. Change G1 (the fourth variable in the genetics file), rerun and recompare, as considered necessary.
11. Examine and note the goodness-of-fit between predicted and observed kernel weight. Adjust G2 (the fifth variable), rerun, and recompare until satisfied.

12. Determine whether the estimates of the various coefficients lie within the usual range of values. If outside the usual range, examine data dealing with the environmental conditions under which the crop was grown, and determine whether any exceptional stress was present during the growing cycle (e.g., very low soil phosphorus, very low pH, frost at anthesis). If so, note that the coefficients should not be used more widely than for the treatment/location from which they were derived, and should not be permanently entered into the genetic coefficient file.
13. If more treatments/location combinations are available, note the values estimated for the first treatment/location combination and then repeat for all other combinations. When all runs are complete, calculate means from those treatment/locations at which no extreme stresses were present, and enter these into the genetic coefficient file.

Computer Sample Screen

```
MODIFICATION OF SELECTED MODEL VARIABLES INTERACTIVELY

      VARIABLES TO BE MODIFIED

    1. Planting Date, Simulation Date and Seeding Depth
    2. Plant Population
    3. Nitrogen Non-Limiting
    4. Irrigation Inputs and Water Balance Switch
    5. Fertilizer Inputs
    6. Select New Variety
    7. Soil Profile Inputs (Water Balance,Root Preference,DMOD)
    8. Select Weather Data
    9. Initial Soil Fertility and Water,
           and Crop Residue Parameters
   10. Display Echo
   11. End of Changes
   12. Abandon all Changes and Return to Experiment Menu

  ENTER NUMBER OF MODIFICATION : 6
```

Computer Sample Screen

```
                    Do you want to

                 1. Select a new variety ?
                 2. Create a new variety ?
                 3. Modify current genetic coefficients ?
                 4. View the varieties again ?
                 5. Return to the main menu ?

               Enter number of choice : 3

            Current Values of Coefficients to Modify
              1.  P1V (Vernalization sensitivity) =  .5
              2.  P1D (Photoperiod sensitivity) = 3.0
              3.  P5 (Cumulative growing degree days from
                       anthesis to maturity) = 2.0
              4.  G1 (Kernel weight from stem weight) = 2.9
              5.  G2 (Genetic kernel growth rate constant) = 3.0
              6.  G3 (Potential dry weight for single
                       stem and ear at anthesis) = 1.7
              7.  End of changes

            Parameter choice : 3
            The current value of P5   is   2.00
            Input new value : 1.5
```

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Table 1. Files in " 1. CERES WHEAT V2.10 PROGRAM" diskette.

WHV2	EXE	
SOURCE		<DIR>
WHINS2	BAT	
HELPWH	BAT	
HELPFLOP	BAT	
FILES	40	
WHHARD	BAT	
GRAPH	BAT	
INPUT	BAT	
GRFLOPPY	BAT	
HELPHARD	BAT	
INFLOPPY	BAT	
WHFLOPPY	BAT	
WHINS	BAT	

Table 2. Files in subdirectory Source of " 1. CERES WHEAT V2.10 Program " diskete.

MWH4	FOR
MWH2	FOR
MDISOUT	FOR
MWH3	FOR
MMENU	FOR
MMENU2	FOR
MMENU3	FOR
MMENU4	FOR
MMENU5	FOR
MWH1	FOR
MWHSUB	FOR
COMIBS	BLK
NMOVE	BLK
NTRC1	BLK
NTRC2	BLK
PREDOB	BLK
WHEA1	BLK
WHEA2	BLK
WHEA3	BLK
WHEA4	BLK

Table 3. Files in " 2. CERES WHEAT V2.10 DATA " diskette.

```
WHV2     EXE
SOURCE       <DIR>
WHINS2   BAT
HELPWH   BAT
HELPFLOP BAT
FILES    40
WHHARD   BAT
GRAPH    BAT
INPUT    BAT
GRFLOPPY BAT
HELPHARD BAT
INFLOPPY BAT
WHFLOPPY BAT
WHINS    BAT
```

Table 4. Files in "3. CERES WHEAT V2.10 INPUT" diskette.

```
WHINS    BAT
INPUT    BAT
INFLOPPY BAT
INTRO    DAT
FILE2    HLP
FILE4    HLP
FILE5    HLP
FILE6    HLP
FILE7    HLP
FILE8    HLP
FILEA    HLP
FILEB    HLP
FILE9    HLP
GENETICS WH9
SPROFILE WH2
FILE1    HLP
MCREATE  EXE
WEATHER2 TXT
WHINS2   BAT
SOILS    SCR
NINIT    MEM
```

Table 5. Files in " 4. CERES WHEAT V2.00 GRAPHICS " diskette.

```
WHV2      EXE
SOURCE        <DIR>
WHINS2    BAT
HELPWH    BAT
HELPFLOP  BAT
FILES     40
WHHARD    BAT
GRAPH     BAT
INPUT     BAT
GRFLOPPY  BAT
HELPHARD  BAT
INFLOPPY  BAT
WHFLOPPY  BAT
WHINS     BAT
```

Table 6. File "WHEXP.DIR"

```
KSAS8101 ASHLAND : WHEAT  N  X  IRRIGATED         KSAS1010.W81 SPROFILE.WH2
KSAS8101.WH4 KSAS8101.WH5 KSAS8101.WH6 KSAS8101.WH7 KSAS8101.WH8 GENETICS.WH9
KSAS8101.WHA KSAS8101.WHB OUT1.WH OUT2.WH OUT3.WH OUT4.WH
IFSW7501 SWIFT CURRENT CANADA 1975                IFSW0504.W75 SPROFILE.WH2
IFSW7501.WH4 IFSW7501.WH5 IFSW7501.WH6 IFSW7501.WH7 IFSW7501.WH8 GENETICS.WH9
IFSW7501.WHA IFSW7501.WHB OUT1.WH OUT2.WH OUT3.WH OUT4.WH
IFRO7501 ROTHAMSTED ENGLAND 1975                  IFRO1110.W74 SPROFILE.WH2
IFRO7501.WH4 IFRO7501.WH5 IFRO7501.WH6 IFRO7501.WH7 IFRO7501.WH8 GENETICS.WH9
IFRO7501.WHA IFRO7501.WHB OUT1.WH OUT2.WH OUT3.WH OUT4.WH
ICTH8001 Tel Hadya Syria Multiple Year Run        ICTH0136.W79 SPROFILE.WH2
ICTH8001.WH4 ICTH8001.WH5 ICTH8001.WH6 ICTH8001.WH7 ICTH7902.WH8 GENETICS.WH9
ICTH8001.WHA ICTH8001.WHB OUT1.WH OUT2.WH OUT3.WH OUT4.WH OUT5.WH
```

Table 7. File "KSAS1010.W81" (for the first 30 days only).

KSAS	39.00	97.00	0.00	0.00			
KSAS	81	274	18.87	23.3	10.0	0.0	0.00
KSAS	81	275	18.20	22.2	5.6	0.0	0.00
KSAS	81	276	2.43	16.7	11.1	0.3	0.00
KSAS	81	277	13.77	26.1	12.8	34.0	0.00
KSAS	81	278	12.05	26.7	15.6	0.0	0.00
KSAS	81	279	16.53	18.9	9.4	0.0	0.00
KSAS	81	280	12.30	17.8	6.1	0.0	0.00
KSAS	81	281	13.72	18.9	2.8	0.0	0.00
KSAS	81	282	3.22	15.6	12.8	0.0	0.00
KSAS	81	283	11.63	18.3	7.2	0.0	0.00
KSAS	81	284	4.35	18.3	7.8	0.0	0.00
KSAS	81	285	1.67	18.3	13.9	6.3	0.00
KSAS	81	286	1.84	20.6	17.8	0.0	0.00
KSAS	81	287	6.78	20.6	13.3	1.8	0.00
KSAS	81	288	6.44	17.2	9.4	0.0	0.00
KSAS	81	289	3.43	16.7	8.9	0.0	0.00
KSAS	81	290	12.47	20.0	12.2	12.4	0.00
KSAS	81	291	12.22	12.8	6.1	0.0	0.00
KSAS	81	292	15.65	24.4	0.0	0.0	0.00
KSAS	81	293	15.06	23.3	11.7	0.0	0.00
KSAS	81	294	11.00	16.7	6.7	0.0	0.00
KSAS	81	295	13.85	10.6	1.7	0.0	0.00
KSAS	81	296	15.10	7.2	-3.3	0.0	0.00
KSAS	81	297	4.94	11.1	1.1	0.0	0.00
KSAS	81	298	5.82	11.1	5.6	3.0	0.00
KSAS	81	299	12.97	15.6	0.0	0.8	0.00
KSAS	81	300	13.14	21.7	5.6	0.0	0.00
KSAS	81	301	12.09	21.7	10.6	0.0	0.00
KSAS	81	302	12.34	25.0	10.0	0.0	0.00

Table 8. File "WTH.DIR".

```
KSAS Ashland                         10/01/81 07/31/82 KSAS1010.W81
IFSW Swift Current Canada 1975       05/12/75 09/07/75 IFSW0504.W75
IFRO Rothamsted England 1975         11/01/74 09/02/75 IFRO1110.W74
ICTH Tel Hadya (Synthetic)           01/01/79 12/31/81 ICTH0136.W79
```

Table 9. File "SPROFILE.WH2".

```
01              DEEP SILTY CLAY
  .11   6.00    .30  85.00    6.9  13.9 1.0  1.32E-03   32.5  6.67   .04 1.00
  10.   .513   .680   .760   .680  1.000  1.35  1.74  2.5  3.3  6.5  .00
  15.   .513   .679   .759   .679   .819  1.36  1.66  2.4  3.2  6.5  .00
  15.   .514   .679   .759   .679   .607  1.36  1.45  2.2  3.0  6.5  .00
  15.   .514   .679   .759   .679   .607  1.36  1.45  2.2  3.0  6.5  .00
  30.   .516   .677   .757   .677   .368  1.37  1.09  2.0  2.6  6.5  .00
  30.   .519   .675   .755   .675   .202  1.38   .65  1.7  2.2  6.5  .00
  30.   .521   .674   .754   .674   .111  1.38   .29  1.4  1.8  6.5  .00
  30.   .522   .673   .753   .673   .061  1.39   .09  1.1  1.3  6.5  .00
  30.   .522   .673   .753   .673   .033  1.39   .01   .8   .9  6.5  .00
  -1.   .00    .00    .00    .00    .00    .00   .00   .0   .0   .0  .00
02              MEDIUM SILTY CLAY
  .11   6.00    .20  87.00    6.9  13.9 1.0  1.32E-03   32.5  6.67   .04 1.00
  10.   .513   .680   .760   .680  1.000  1.35  1.74  2.5  3.3  6.5  .00
  15.   .513   .679   .759   .679   .819  1.36  1.66  2.4  3.2  6.5  .00
  15.   .514   .679   .759   .679   .607  1.36  1.45  2.2  3.0  6.5  .00
  15.   .516   .677   .757   .677   .407  1.37  1.12  2.0  2.7  6.5  .00
  15.   .516   .677   .757   .677   .407  1.37  1.12  2.0  2.7  6.5  .00
  30.   .518   .676   .756   .676   .247  1.37   .73  1.8  2.3  6.5  .00
  30.   .520   .674   .754   .674   .135  1.38   .37  1.5  1.9  6.5  .00
  -1.   .00    .00    .00    .00    .00    .00   .00   .0   .0   .0  .00
03              SHALLOW SILTY CLAY
  .11   6.00    .10  89.00    6.9  13.9 1.0  1.32E-03   32.5  6.67   .04 1.00
  10.   .513   .680   .760   .680  1.000  1.35  1.74  2.5  3.3  6.5  .00
  10.   .513   .679   .759   .679   .819  1.36  1.66  2.4  3.2  6.5  .00
  10.   .514   .679   .759   .679   .607  1.36  1.45  2.2  3.0  6.5  .00
  10.   .516   .677   .757   .677   .449  1.36  1.16  2.1  2.7  6.5  .00
  15.   .516   .677   .757   .677   .449  1.36  1.16  2.1  2.7  6.5  .00
  -1.   .00    .00    .00    .00    .00    .00   .00   .0   .0   .0  .00
04              DEEP SILT LOAM
  .12   6.00    .40  77.00    6.9  13.9 1.0  1.32E-03   93.1  6.67   .04 1.00
  10.   .106   .262   .362   .262  1.000  1.37  1.16  2.5  3.3  6.5  .00
  15.   .106   .262   .362   .262   .819  1.37  1.10  2.4  3.2  6.5  .00
  15.   .107   .262   .362   .262   .607  1.37   .97  2.2  3.0  6.5  .00
  15.   .107   .262   .362   .262   .607  1.37   .97  2.2  3.0  6.5  .00
  30.   .108   .261   .361   .261   .368  1.38   .72  2.0  2.6  6.5  .00
  30.   .110   .260   .360   .260   .202  1.38   .43  1.7  2.2  6.5  .00
  30.   .111   .259   .359   .259   .111  1.39   .20  1.1  1.8  6.5  .00
  30.   .112   .258   .358   .258   .061  1.39   .06  1.1  1.3  6.5  .00
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  30.    .112   .258   .358   .258    .033  1.39    .01    .8    .9  6.5   .00
  -1.    .00    .00    .00    .00     .00    .00    .00    .0    .0    .0   .00
05                 MEDIUM SILT LOAM
  .12  6.00     .30  79.00    6.9  13.9 1.0  1.32E-03    93.1  6.67    .04 1.00
  10.    .106   .262   .362   .262   1.000  1.37   1.16   2.5   3.3  6.5   .00
  15.    .106   .262   .362   .262    .819  1.37   1.10   2.4   3.2  6.5   .00
  15.    .107   .262   .362   .262    .607  1.37    .97   2.2   3.0  6.5   .00
  15.    .108   .261   .361   .261    .407  1.38    .75   2.0   2.7  6.5   .00
  15.    .108   .261   .361   .261    .407  1.38    .75   2.0   2.7  6.5   .00
  30.    .110   .260   .360   .260    .247  1.38    .49   1.8   2.3  6.5   .00
  30.    .111   .259   .359   .259    .135  1.39    .24   1.5   1.9  6.5   .00
  -1.    .00    .00    .00    .00     .00    .00    .00    .0    .0    .0   .00
06                 SHALLOW SILT LOAM
  .12  6.00     .20  81.00    6.9  13.9 1.0  1.32E-03    93.3  6.67    .04 1.00
  10.    .106   .262   .362   .262   1.000  1.37   1.16   2.5   3.3  6.5   .00
  10.    .106   .262   .362   .262    .819  1.37   1.10   2.4   3.2  6.5   .00
  10.    .107   .262   .362   .262    .607  1.37    .97   2.2   3.0  6.5   .00
  10.    .108   .261   .361   .261    .449  1.38    .77   2.1   2.7  6.5   .00
  15.    .108   .261   .361   .261    .449  1.38    .77   2.1   2.7  6.5   .00
  -1.    .00    .00    .00    .00     .00    .00    .00    .0    .0    .0   .00
07                 DEEP SANDY LOAM
  .13  6.00     .50  68.00    6.9  13.9 1.0  1.32E-03    98.3  6.67    .04 1.00
  10.    .086   .220   .320   .220   1.000  1.61    .70   2.5   3.3  6.5   .00
  15.    .086   .220   .320   .220    .819  1.61    .66   2.4   3.2  6.5   .00
  15.    .086   .220   .320   .220    .607  1.61    .58   2.2   3.0  6.5   .00
  15.    .086   .220   .320   .220    .607  1.61    .58   2.2   3.0  6.5   .00
  30.    .087   .219   .319   .219    .368  1.61    .43   2.0   2.6  6.5   .00
  30.    .088   .218   .318   .218    .202  1.62    .26   1.7   2.2  6.5   .00
  30.    .089   .218   .318   .218    .111  1.62    .12   1.4   1.8  6.5   .00
  30.    .089   .218   .318   .218    .061  1.62    .04   1.1   1.3  6.5   .00
  30.    .089   .217   .317   .217    .033  1.62    .01    .8    .9  6.5   .00
  -1.    .00    .00    .00    .00     .00    .00    .00    .0    .0    .0   .00
08                 MEDIUM SANDY LOAM
  .13  6.00     .50  70.00    6.9  13.9 1.0  1.32E-03    98.3  6.67    .04 1.00
  10.    .086   .220   .320   .220   1.000  1.61    .70   2.5   3.3  6.5   .00
  15.    .086   .220   .320   .220    .819  1.61    .66   2.4   3.2  6.5   .00
  15.    .086   .220   .320   .220    .607  1.61    .58   2.2   3.0  6.5   .00
  15.    .087   .219   .319   .219    .407  1.61    .45   2.0   2.7  6.5   .00
  15.    .087   .219   .319   .219    .407  1.61    .45   2.0   2.7  6.5   .00
  30.    .088   .219   .319   .219    .247  1.62    .29   1.8   2.3  6.5   .00
  30.    .089   .218   .318   .218    .135  1.62    .15   1.5   1.9  6.5   .00
  -1.    .00    .00    .00    .00     .00    .00    .00    .0    .0    .0   .00
09                 SHALLOW SANDY LOAM
  .13  6.00     .40  74.00    6.9  13.9 1.0  1.32E-03    98.4  6.67    .04 1.00
  10.    .086   .220   .320   .220   1.000  1.61    .70   2.5   3.3  6.5   .00
  10.    .086   .220   .320   .220    .819  1.61    .66   2.4   3.2  6.5   .00
  10.    .086   .220   .320   .220    .607  1.61    .58   2.2   3.0  6.5   .00
  10.    .087   .219   .319   .219    .449  1.61    .46   2.1   2.7  6.5   .00
  15.    .087   .219   .319   .219    .449  1.61    .46   2.1   2.7  6.5   .00
  -1.    .00    .00    .00    .00     .00    .00    .00    .0    .0    .0   .00
10                 DEEP SAND
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   .15  4.00    .60  65.00   6.9  13.9 1.0  1.32E-03  111.9  6.67   .04 1.00
   10.    .032   .107   .267   .107  1.000  1.66   .29  2.5  3.3  6.5  .00
   15.    .032   .107   .267   .107   .819  1.66   .28  2.4  3.2  6.5  .00
   15.    .032   .107   .267   .107   .607  1.66   .24  2.2  3.0  6.5  .00
   15.    .032   .107   .267   .107   .607  1.66   .24  2.2  3.0  6.5  .00
   30.    .032   .107   .267   .107   .368  1.66   .18  2.0  2.6  6.5  .00
   30.    .033   .106   .266   .106   .202  1.66   .11  1.7  2.2  6.5  .00
   30.    .033   .106   .266   .106   .111  1.66   .05  1.4  1.8  6.5  .00
   30.    .033   .106   .266   .106   .061  1.66   .01  1.1  1.3  6.5  .00
   30.    .033   .106   .266   .106   .033  1.66   .00   .8   .9  6.5  .00
   -1.    .00    .00    .00    .00    .00    .00   .00   .0   .0   .0  .00
 11                MEDIUM SAND
   .15  4.00    .50  70.00   6.9  13.9 1.0  1.32E-03  112.0  6.67   .04 1.00
   10.    .032   .107   .267   .107  1.000  1.66   .29  2.5  3.3  6.5  .00
   15.    .032   .107   .267   .107   .819  1.66   .28  2.4  3.2  6.5  .00
   15.    .032   .107   .267   .107   .607  1.66   .24  2.2  3.0  6.5  .00
   15.    .032   .107   .267   .107   .407  1.66   .19  2.0  2.7  6.5  .00
   15.    .032   .107   .267   .107   .407  1.66   .19  2.0  2.7  6.5  .00
   30.    .033   .106   .266   .106   .247  1.66   .12  1.8  2.3  6.5  .00
   30.    .034   .105   .265   .105   .135  1.66   .06  1.5  1.9  6.5  .00
   -1.    .00    .00    .00    .00    .00    .00   .00   .0   .0   .0  .00
 12                SHALLOW SAND
   .15  4.00    .40  75.00   6.9  13.9 1.0  1.32E-03  112.0  6.67   .04 1.00
   10.    .032   .107   .267   .107  1.000  1.66   .29  2.5  3.3  6.5  .00
   10.    .032   .107   .267   .107   .819  1.66   .28  2.4  3.2  6.5  .00
   10.    .032   .107   .267   .107   .607  1.66   .24  2.2  3.0  6.5  .00
   10.    .032   .107   .267   .107   .449  1.66   .19  2.1  2.7  6.5  .00
   15.    .032   .107   .267   .107   .449  1.66   .19  2.1  2.7  6.5  .00
   -1.    .00    .00    .00    .00    .00    .00   .00   .0   .0   .0  .00
 13 Waipio, HI   Waipio (Clayey, kaolinitic, isohyperth, Tropeptic Eutrustox)
  0.14  5.00   0.60  60.00  22.0   7.0 1.0  1.32E-03   60.1  6.67  0.04 1.00
   5.  0.220  0.350  0.550  0.350  1.000  1.00  2.27   .0   .0  6.3  0.0
  10.  0.230  0.350  0.550  0.350  1.000  1.00  2.27   .0   .0  6.3  0.0
  15.  0.240  0.350  0.550  0.350  0.800  1.05  1.10   .0   .0  5.8  0.0
  20.  0.250  0.370  0.480  0.370  0.400  1.17  1.41   .0   .0  5.8  0.0
  20.  0.260  0.380  0.460  0.380  0.200  1.22  0.59   .0   .0  6.0  0.0
  20.  0.250  0.380  0.460  0.380  0.050  1.22  0.36   .0   .0  6.0  0.0
  20.  0.260  0.400  0.480  0.400  0.020  1.17  0.27   .0   .0  6.0  0.0
  -1.  0.000  0.000  0.000  0.000  0.000  0.00  0.00   .0   .0  0.0  0.0
 14 Gainesville  Millhopper Fine Sand (Loamy,silic,hyperth Arenic Paleudult)
  0.18 02.00  00.650  60.00  21.0  29.9 1.0  1.32E-03  114.2  6.67  0.04 0.84
4.30E-05  287.5  7.01  0.04 0.84
   5.    .026   .096   .230   .096  1.000  1.30  2.00   .0   .0   .0  .00
  10.    .025   .086   .230   .086  1.000  1.30  1.00   .0   .0   .0  .00
  15.    .025   .086   .230   .086  0.800  1.40  1.00   .0   .0   .0  .00
  30.    .025   .086   .230   .086   .200  1.40  0.50   .0   .0   .0  .00
  30.    .028   .090   .230   .090   .100  1.45  0.10   .0   .0   .0  .00
  30.    .028   .090   .230   .090   .050  1.45  0.10   .0   .0   .0  .00
  30.    .029   .130   .230   .130   .002  1.45  0.04   .0   .0   .0  .00
  30.    .070   .258   .360   .258   .000  1.20  0.24   .0   .0   .0  .00
  -1.    .0     .0     .0     .0     .0     .0    0.0    .0   .0   .0  .00
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 15 Gainesville  Millhopper Fine Sand (Loamy,silic,hyperth Gross. Paleudults)
000.18 05.00  00.50  66.00  21.0  29.9 1.0  1.32E-03  114.2  6.67  0.04 0.84
    5.    .023   .086   .230   .086  1.000   .00   .00   .0   .0   .0   7.4
   10.    .023   .086   .230   .086  1.000   .00   .00   .0   .0   .0   7.4
   15.    .023   .086   .230   .086  0.498   .00   .00   .0   .0   .0  15.8
   15.    .023   .086   .230   .086   .294   .00   .00   .0   .0   .0  28.0
   15.    .023   .086   .230   .086   .294   .00   .00   .0   .0   .0  28.0
   30.    .021   .076   .230   .076   .380   .00   .00   .0   .0   .0  27.6
   30.    .020   .076   .230   .076   .133   .00   .00   .0   .0   .0  17.5
   30.    .027   .130   .230   .130   .062   .00   .00   .0   .0   .0   0.3
   30.    .070   .258   .360   .258   .031   .00   .00   .0   .0   .0   .10
   -1.    .0     .0     .0     .0     .0     .0    .0     .0   .0   .0   .0
 16 Gainesville  Lake Fine Sand (Hyperthermic, coated Typic Quartzipsamments)
000.18 00.00  00.50  66.00  21.0  29.9 1.0  1.32E-03  114.4  6.67  0.04 0.84
    5.    .020   .089   .230   .089  1.000   .00   .00   .0   .0   .0   .00
   10.    .019   .068   .230   .068  1.000   .00   .00   .0   .0   .0   .00
   15.    .019   .068   .230   .068  0.498   .00   .00   .0   .0   .0   .00
   15.    .026   .075   .230   .075   .294   .00   .00   .0   .0   .0   .00
   15.    .026   .075   .230   .075   .294   .00   .00   .0   .0   .0   .00
   30.    .025   .073   .230   .073   .380   .00   .00   .0   .0   .0   .00
   30.    .022   .069   .230   .069   .133   .00   .00   .0   .0   .0   .00
   30.    .023   .072   .230   .072   .030   .00   .00   .0   .0   .0   .00
   30.    .035   .085   .230   .085   .010   .00   .00   .0   .0   .0   .00
   -1.    .0     .0     .0     .0     .0     .0    .0     .0   .0   .0   .0
 17 Quincy, FL   Orangeburg Sandy Loam (F-loamy,silic,thermic Typ Paleudults)
   .13   9.00  00.27  84.00  21.0  29.9 1.0  1.32E-03   85.1  6.67  0.04 0.95
    5.    .125   .198   .294   .198  1.000  1.49  1.73   .0   .0   .0   .00
   10.    .125   .198   .294   .198   .874  1.49  1.73   .0   .0   .0   .00
   10.    .125   .198   .294   .198   .874  1.49  1.73   .0   .0   .0   .00
   09.    .117   .226   .323   .226   .351  1.41   .40   .0   .0   .0   .00
   09.    .117   .226   .323   .226   .351  1.41   .40   .0   .0   .0   .00
   10.    .138   .250   .332   .250   .310  1.44   .20   .0   .0   .0   .00
   11.    .138   .250   .332   .250   .310  1.44   .20   .0   .0   .0   .00
   38.    .167   .281   .331   .281   .302  1.57   .14   .0   .0   .0   .00
   43.    .182   .291   .334   .291   .077  1.59   .16   .0   .0   .0   .00
   30.    .162   .272   .320   .272   .036  1.61   .09   .0   .0   .0   .00
   28.    .154   .263   .319   .263   .006  1.58   .03   .0   .0   .0   .00
   -1.    .0     .0     .0     .0     .0     .0    .0     .0   .0   .0   .0
 18 Manhattan,KS Haynie (Coarse-silty, mixed,calcareous,mesic Typ Udifluvent)
  0.14   5.00   0.60  60.00  12.0  32.0 1.0  1.32E-03   85.0  6.67  0.04 1.00
   15.  0.072  0.225  0.275  0.225  1.000  1.15  0.61   .0   .0   .0   .00
   15.  0.070  0.240  0.290  0.240  0.700  1.16  0.61   .0   .0   .0   .00
   30.  0.040  0.154  0.194  0.154  0.200  1.21  0.59   .0   .0   .0   .00
   30.  0.032  0.091  0.141  0.091  0.050  1.23  0.29   .0   .0   .0   .00
   30.  0.032  0.087  0.137  0.087  0.030  1.31  0.24   .0   .0   .0   .00
   30.  0.032  0.087  0.137  0.087  0.010  1.31  0.20   .0   .0   .0   .00
   30.  0.032  0.087  0.137  0.087  0.010  1.31  0.20   .0   .0   .0   .00
   -1.    .0     .0     .0     .0     .0     .0    .0     .0   .0   .0   .0
 19 Swift, CAN   Wood Mountain Loam (Orthic Brown Chernozem)
  0.12   8.00   0.50  60.00   2.2  36.2 1.0  1.32E-03   85.0  6.67  0.04 1.00
    5.  0.096  0.230  0.250  0.230  1.000  0.00  1.10   .0   .0   .0   .00
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   10.  0.096  0.230  0.250  0.230  0.800  0.00  1.10   .0   .0   .0   .00
   15.  0.112  0.250  0.260  0.250  0.700  0.00  0.61   .0   .0   .0   .00
   15.  0.094  0.220  0.230  0.220  0.500  0.00  0.61   .0   .0   .0   .00
   15.  0.103  0.220  0.230  0.220  0.250  0.00  0.59   .0   .0   .0   .00
   15.  0.103  0.220  0.230  0.220  0.150  0.00  0.15   .0   .0   .0   .00
   15.  0.102  0.250  0.220  0.250  0.080  0.00  0.10   .0   .0   .0   .00
   30.  0.102  0.250  0.220  0.250  0.050  0.00  0.10   .0   .0   .0   .00
   30.  0.102  0.250  0.220  0.250  0.050  0.00  0.10   .0   .0   .0   .00
   -1.    .0     .0     .0     .0     .0     .0    .0   .0   .0   .0   .0
20 Rothamsted   Rothamsted
 0.14  6.00   0.50  60.00  14.0  27.0 1.0  1.32E-03   85.0  6.67  0.04 1.00
   10.  0.110  0.280  0.330  0.280  1.000  1.10  1.16   .0   .0   .0   .00
   15.  0.150  0.320  0.420  0.320  0.900  1.20  1.00   .0   .0   .0   .00
   20.  0.220  0.370  0.420  0.370  0.700  1.25  0.68   .0   .0   .0   .00
   20.  0.220  0.370  0.420  0.370  0.500  1.25  0.26   .0   .0   .0   .00
   30.  0.220  0.370  0.420  0.370  0.200  1.25  0.25   .0   .0   .0   .00
   30.  0.220  0.370  0.420  0.370  0.100  1.25  0.20   .0   .0   .0   .00
   30.  0.220  0.370  0.420  0.370  0.050  1.25  0.20   .0   .0   .0   .00
   -1.    .0     .0     .0     .0     .0     .0    .0   .0   .0   .0   .0
21 Aleppo, SYR  Tel Hadya (Palexerollic Chromoxerert; high AWC)
 0.14  6.00   0.50  72.00  16.4  11.5 1.0  1.32E-03   85.0  6.67  0.04 1.00
   10.  0.210  0.340  0.357  0.340  1.000  1.30  0.50   .0   .0   .0   .00
   15.  0.210  0.350  0.367  0.350  0.700  1.30  0.50   .0   .0   .0   .00
   25.  0.230  0.360  0.380  0.360  0.500  1.30  0.50   .0   .0   .0   .00
   25.  0.260  0.380  0.400  0.380  0.150  1.30  0.40   .0   .0   .0   .00
   25.  0.270  0.390  0.410  0.390  0.040  1.30  0.35   .0   .0   .0   .00
   25.  0.300  0.380  0.400  0.380  0.020  1.30  0.30   .0   .0   .0   .00
   25.  0.300  0.375  0.390  0.375  0.010  1.30  0.30   .0   .0   .0   .00
   30.  0.300  0.375  0.390  0.375  0.020  1.30  0.30   .0   .0   .0   .00
   20.  0.300  0.375  0.390  0.375  0.001  1.30  0.30   .0   .0   .0   .00
   -1.    .0     .0     .0     .0     .0     .0    .0   .0   .0   .0   .0
22 Aleppo, SYR  Tel Hadya (Palexerollic Chromoxerert; low AWC)
 0.14  6.00   0.50  72.00  16.4  11.5 1.0  1.32E-03   85.0  6.67  0.04 1.00
   10.  0.210  0.280  0.357  0.280  1.000  1.30  0.50   .0   .0   .0   .00
   15.  0.210  0.280  0.367  0.280  0.700  1.30  0.50   .0   .0   .0   .00
   25.  0.230  0.290  0.380  0.290  0.500  1.30  0.50   .0   .0   .0   .00
   25.  0.260  0.350  0.400  0.350  0.150  1.30  0.40   .0   .0   .0   .00
   25.  0.270  0.350  0.410  0.350  0.040  1.30  0.35   .0   .0   .0   .00
   25.  0.300  0.350  0.400  0.350  0.020  1.30  0.30   .0   .0   .0   .00
   25.  0.300  0.350  0.390  0.350  0.010  1.30  0.30   .0   .0   .0   .00
   30.  0.300  0.350  0.390  0.350  0.020  1.30  0.30   .0   .0   .0   .00
   20.  0.300  0.350  0.390  0.350  0.001  1.30  0.30   .0   .0   .0   .00
   -1.    .0     .0     .0     .0     .0     .0    .0   .0   .0   .0   .0
23 Florence, SC Norfolk Loamy Sand
 0.14  5.00   0.60  60.00  16.8  20.0 1.0  1.32E-03   58.0  6.67  0.04 1.00
   10.  0.075  0.210  0.250  0.210  1.000  1.55  0.30   .0   .0   .0   .00
   10.  0.075  0.210  0.250  0.210  1.000  1.55  0.30   .0   .0   .0   .00
   21.  0.100  0.240  0.290  0.240  0.800  1.67  0.17   .0   .0   .0   .00
   30.  0.210  0.310  0.350  0.310  0.400  1.54  0.01   .0   .0   .0   .00
   30.  0.210  0.320  0.360  0.320  0.100  1.54  0.01   .0   .0   .0   .00
   25.  0.180  0.280  0.320  0.280  0.100  1.68  0.01   .0   .0   .0   .00
```

```
   25.  0.180  0.280  0.320  0.280  0.100  1.74  0.01   .0   .0   .0   .00
   -1.   .0     .0     .0     .0     .0     .0    .0    .0   .0   .0   .0
 24 Marianna, FL Norfolk Sandy Loam  (F-loamy,silic,thermic Typ Paleudults)
   .18  6.00    .10  77.00  20.0  30.0 1.0  1.32E-03   90.9  6.67  0.04 0.84
    5.   .061   .145   .312   .145  1.000  1.38  1.29   .0   .0  5.5   .00
    5.   .061   .145   .312   .145  1.000  1.38  1.29   .0   .0  5.5   .00
   10.   .050   .141   .302   .141   .775  1.42   .47   .0   .0  5.5   .00
   18.   .056   .165   .270   .165   .448  1.52   .28   .0   .0  5.5   .00
   20.   .198   .304   .359   .304   .300  1.48   .25   .0   .0  5.1   .00
   21.   .198   .304   .359   .304   .300  1.48   .25   .0   .0  5.1   .00
   16.   .197   .305   .335   .305   .100  1.64   .12   .0   .0  5.1   .00
   17.   .197   .305   .335   .305   .100  1.64   .12   .0   .0  5.1   .00
   17.   .184   .292   .332   .292   .100  1.61   .06   .0   .0  5.0   .00
   18.   .184   .292   .332   .292   .100  1.61   .06   .0   .0  5.0   .00
   26.   .210   .318   .339   .318   .020  1.67   .05   .0   .0  5.0   .00
   28.   .227   .335   .350   .335   .000  1.66   .06   .0   .0  4.9   .00
   28.   .227   .335   .350   .335   .000  1.66   .06   .0   .0  4.9   .00
   -1.   .000   .000   .000   .000   .000   .00   .00   .0   .0   .0   .00
 25 Raleigh, NC  Norfolk Sandy Clay Loam (F-l,silic.,therm. Typ. Paleudults)
000.14 03.00  00.23  60.0  16.8  20.0 1.0   1.32E-03  106.9  6.67  0.04 0.95
    5.0 0.042  0.169  0.392  0.169  1.000   .00   .00   .0   .0   .0   .00
   10.0 0.042  0.169  0.392  0.169  1.000   .00   .00   .0   .0   .0   .00
   10.0 0.042  0.169  0.392  0.169   .779   .00   .00   .0   .0   .0   .00
   08.0 0.044  0.177  0.358  0.177   .349   .00   .00   .0   .0   .0   .00
   13.0 0.056  0.165  0.396  0.165   .209   .00   .00   .0   .0   .0   .00
   15.0 0.150  0.291  0.377  0.291   .070   .00   .00   .0   .0   .0   .00
   15.0 0.150  0.291  0.377  0.291   .070   .00   .00   .0   .0   .0   .00
   30.0 0.150  0.291  0.377  0.291   .017   .00   .00   .0   .0   .0   .00
   30.0 0.150  0.291  0.377  0.291   .000   .00   .00   .0   .0   .0   .00
   -1.0  .0     .0     .0     .0     .0     .0    .0    .0   .0   .0   .0
 26 Castana, IO  Ida Silt Loam
000.12 06.00  00.30  60.00  12.0  32.0 1.0  1.32E-03   89.4  6.67  0.04 1.00
    5.   .135   .290   .485   .290  1.000   .00   .00   .0   .0   .0   .00
   10.   .135   .290   .485   .290  1.000   .00   .00   .0   .0   .0   .00
   15.   .135   .290   .485   .290   .175   .00   .00   .0   .0   .0   .00
   15.   .106   .228   .514   .228   .138   .00   .00   .0   .0   .0   .00
   15.   .106   .228   .514   .228   .138   .00   .00   .0   .0   .0   .00
   30.   .105   .254   .517   .254   .188   .00   .00   .0   .0   .0   .00
   30.   .133   .290   .507   .290   .250   .00   .00   .0   .0   .0   .00
   30.   .108   .283   .505   .283   .213   .00   .00   .0   .0   .0   .00
   30.   .108   .291   .542   .291   .100   .00   .00   .0   .0   .0   .00
   -1.   .0     .0     .0     .0     .0     .0    .0    .0   .0   .0   .0
 27 Sumatra, IND Sitiung ( no subsoil acidity, Ultisol )
  0.14  5.00   0.60  60.00  22.0   7.0 1.0  1.32E-03   58.0  6.67  0.04 1.00
    5.   .328   .448   .550   .448  1.000  1.00  2.27   .0   .0   .0   .00
   10    .353   .472   .550   .472  1.000  1.00  2.27   .0   .0   .0   .00
   15.   .377   .497   .550   .497  0.750  1.05  1.10   .0   .0   .0   .00
   20.   .349   .482   .520   .482  0.350  1.17  1.41   .0   .0   .0   .00
   20.   .349   .492   .520   .492  0.150  1.22  0.59   .0   .0   .0   .00
   30.   .328   .476   .490   .476  0.100  1.22  0.36   .0   .0   .0   .00
   30.   .328   .448   .490   .448  0.001  1.17  0.27   .0   .0   .0   .00
```

```
  -1.    .0      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
28 Sumatra, IND Sitiung ( subsoil acidity, Ultisol )
 0.14  5.00   0.60  60.00  22.0   7.0 1.0  1.32E-03  85.0   6.67   0.04 1.00
   5.   .328   .448   .550   .448  1.000  1.00  2.27   .0     .0     .0    .00
  10    .353   .472   .550   .472  0.800  1.00  2.27   .0     .0     .0    .00
  15.   .377   .497   .550   .497  0.100  1.05  1.10   .0     .0     .0    .00
  20.   .349   .482   .520   .482  0.010  1.17  1.41   .0     .0     .0    .00
  20.   .349   .492   .520   .492  0.000  1.22  0.59   .0     .0     .0    .00
  30.   .328   .476   .490   .476  0.000  1.22  0.36   .0     .0     .0    .00
  30.   .328   .448   .490   .448  0.000  1.17  0.27   .0     .0     .0    .00
  -1.   .0     .0     .0     .0     .0     .0     .0    .0     .0     .0    .00
29 Hyderabad,IN Patancheru (Alfisol Udic Rhodustalf)                         .0
000.14 03.00   0.50  80.0  30.0   8.0 1.0  1.32E-03  85.0   6.67   0.04 1.00
   5.0 0.060  0.200  0.430  0.200  1.000   .00   .00   .0     .0     .0    .00
  12.0 0.060  0.200  0.430  0.200  1.000   .00   .00   .0     .0     .0    .00
  08.0 0.060  0.200  0.430  0.200  0.515   .00   .00   .0     .0     .0    .00
  15.0 0.076  0.192  0.430  0.192  0.458   .00   .00   .0     .0     .0    .00
  15.0 0.124  0.220  0.430  0.220  0.400   .00   .00   .0     .0     .0    .00
  15.0 0.160  0.220  0.430  0.220  0.286   .00   .00   .0     .0     .0    .00
  15.0 0.160  0.200  0.430  0.200  0.172   .00   .00   .0     .0     .0    .00
  15.0 0.160  0.200  0.430  0.200  0.057   .00   .00   .0     .0     .0    .00
  15.0 0.160  0.200  0.430  0.200  0.057   .00   .00   .0     .0     .0    .00
  -1.0 0.000  0.000  0.000  0.000  0.000   .0    .0    .0     .0     .0    .0
```

Table 10. File "KSAS8101.WH8".

```
KSAS8101   1 DRYLAND   - 0 KG N/HA                                   18   488
 279 289 162.00  0.000  5.50  1  1   0.00  0.00    0.0  95.00  0
KSAS8101   2 DRYLAND   - 60 KG N/HA                                  18   488
 279 289 162.00  0.000  5.50  1  1   0.00  0.00    0.0  95.00  0
KSAS8101   3 DRYLAND   - 180 KG N/HA SPLIT APPLICATION               18   488
 279 289 162.00  0.000  5.50  1  1   0.00  0.00    0.0  95.00  0
KSAS8101   4 IRRIGATED - 0 KG N/HA                                   18   488
 279 289 162.00  0.000  5.50  2  1   0.00  0.00    0.0  95.00  0
KSAS8101   5 IRRIGATED - 60 KG N/HA                                  18   488
 279 289 162.00  0.000  5.50  2  1   0.00  0.00    0.0  95.00  0
KSAS8101   6 IRRIGATED 180 KG N/HA SPLIT APPLICATION                 18   488
 279 289 162.00  0.000  5.50  2  1   0.00  0.00    0.0  95.00  0
```

Table 11. File "KSAS8101.WH6".

```
 4 KSAS8101
  96  65.
 110  78.
 117  70.
  -1  -1.
 5 KSAS8101
  96  65.
 110  78.
 117  70.
  -1  -1.
 6 KSAS8101
  96  65.
 110  78.
 117  70.
  -1  -1.
```

Table 12. File "KSAS8101.WH5".

```
 1 KSAS8101
   15.  0.205  3.4  9.8  7.0
   15.  0.170  3.2  7.3  7.0
   30.  0.092  2.5  5.1  7.0
   30.  0.065  2.2  4.7  7.0
   30.  0.066  2.7  4.3  7.0
   30.  0.066  2.7  4.3  7.0
   30.  0.066  2.7  4.3  7.0
   -1.
 2 KSAS8101
   15.  0.205  3.4  9.8  7.0
   15.  0.170  3.2  7.3  7.0
   30.  0.092  2.5  5.1  7.0
   30.  0.065  2.2  4.7  7.0
   30.  0.066  2.7  4.3  7.0
   30.  0.066  2.7  4.3  7.0
   30.  0.066  2.7  4.3  7.0
   -1.
 3 KSAS8101
   15.  0.205  3.4  9.8  7.0
   15.  0.170  3.2  7.3  7.0
   30.  0.092  2.5  5.1  7.0
   30.  0.065  2.2  4.7  7.0
   30.  0.066  2.7  4.3  7.0
   30.  0.066  2.7  4.3  7.0
   30.  0.066  2.7  4.3  7.0
   -1.
```

```
 4 KSAS8101
   15.  0.205  3.4  9.8  7.0
   15.  0.170  3.2  7.3  7.0
   30.  0.092  2.5  5.1  7.0
   30.  0.065  2.2  4.7  7.0
   30.  0.066  2.7  4.3  7.0
   30.  0.066  2.7  4.3  7.0
   30.  0.066  2.7  4.3  7.0
   -1.
 5 KSAS8101
   15.  0.205  3.4  9.8  7.0
   15.  0.170  3.2  7.3  7.0
   30.  0.092  2.5  5.1  7.0
   30.  0.065  2.2  4.7  7.0
   30.  0.066  2.7  4.3  7.0
   30.  0.066  2.7  4.3  7.0
   30.  0.066  2.7  4.3  7.0
   -1.
 6 KSAS8101
   15.  0.205  3.4  9.8  7.0
   15.  0.170  3.2  7.3  7.0
   30.  0.092  2.5  5.1  7.0
   30.  0.065  2.2  4.7  7.0
   30.  0.066  2.7  4.3  7.0
   30.  0.066  2.7  4.3  7.0
   30.  0.066  2.7  4.3  7.0
   -1.
```

Table 13. File "KSAS8101.WH7".

```
 1 KSAS8101
289   0.0  15.0  1
 -1  -1.0  -1.0 -1
 2 KSAS8101
289  60.0  15.0  1
 -1  -1.0  -1.0 -1
 3 KSAS8101
289  90.0  15.0  1
 56  90.0   1.0  1
 -1  -1.0  -1.0 -1
 4 KSAS8101
289   0.0  15.0  1
 -1  -1.0  -1.0 -1
 5 KSAS8101
289  60.0  15.0  1
 -1  -1.0  -1.0 -1
 6 KSAS8101
289  90.0  15.0  1
 56  90.0   1.0  1
 -1  -1.0  -1.0 -1
```

Table 14. File "KSAS8101.WH4".

KSAS8101	1	6500.	15.	35.	1200.
KSAS8101	2	6500.	15.	35.	1200.
KSAS8101	3	6500.	15.	35.	1200.
KSAS8101	4	6500.	15.	35.	1200.
KSAS8101	5	6500.	15.	35.	1200.
KSAS8101	6	6500.	15.	35.	1200.

Table 15. File "GENETICS.WH9.

1CONDO (DURUM)	0.5	1.5	2.0	5.3	1.9	1.9
2WARED	0.5	2.7	2.0	5.0	1.8	1.9
3WALDRON	0.5	2.7	2.0	5.0	1.7	1.9
4ELLAR	0.5	2.7	2.0	4.7	1.8	1.9
5BUTTE	0.5	2.7	2.0	2.8	2.4	1.9
6WARD (DURUM)	0.5	1.5	2.0	3.6	1.6	1.9
30RONGOTEA	0.5	2.7	2.0	1.6	3.9	1.7
31KOPARA	0.5	2.7	2.0	1.6	3.9	1.7
32BOUNTY	6.0	3.7	2.1	3.2	2.5	1.7
33MOULIN	6.0	3.9	2.1	3.8	2.1	1.8
34AVALON	6.0	4.0	2.0	3.0	2.7	1.7
178CENTURK	6.0	2.5	2.0	4.3	1.7	1.2
221HERON	0.5	2.3	2.0	2.0	2.0	4.0
222SHERPA	0.5	3.1	1.0	3.5	2.5	5.0
223GABO	0.5	3.1	2.5	1.8	3.0	5.0
224BENCUBBIN	0.5	4.5	2.5	1.2	3.0	4.9
326GAMENYA	0.5	3.3	6.0	4.6	2.7	4.9
333SST	3.0	3.0	4.0	4.4	4.9	1.7
368TRIUMPH	6.0	1.9	2.0	2.8	1.6	1.9
411CARIBO	6.0	4.4	2.0	4.0	3.1	2.6
446IMPROVED TRIUMPH	6.0	1.3	2.0	2.8	4.1	1.9
459LANCER	6.0	1.7	2.0	2.8	1.6	1.9
460LEEDS	6.0	2.7	2.0	2.8	1.6	1.9
469STURDY	6.0	1.0	2.0	3.9	2.3	1.5
470NOR.KING #812	6.0	1.0	2.0	3.9	2.3	1.9
487SCOUT 66	6.0	2.4	2.0	3.8	2.4	1.3
488NEWTON	6.0	2.5	3.5	3.4	2.6	1.4
489NEWANA	0.5	4.5	3.0	4.8	3.3	1.7
494GAGE	6.0	2.2	2.0	2.8	1.6	1.9
495KOLIBRI	0.5	3.3	2.5	4.0	3.1	2.1
496KLEIBER	0.5	3.0	3.0	3.6	3.1	2.1
500TAM 105	6.0	3.3	2.5	2.8	3.0	1.8
501IMIA 66	6.0	2.7	2.0	2.8	1.6	1.9
510PAHA	6.0	2.7	2.0	2.8	1.6	1.9
515ROLETTE	6.0	2.7	2.0	2.8	1.6	1.9
519WANSER	6.0	2.7	2.0	3.0	3.1	1.9
536COULEE	6.0	2.7	2.0	2.8	1.6	1.9
541TAM W 101	3.0	3.0	2.5	4.1	3.0	1.8

542NUGAINES	6.0	2.7	3.0	5.5	3.6	2.3
543PAWNEE	6.0	2.6	2.0	2.8	1.6	1.9
547CLOUD	6.0	2.0	2.0	2.8	1.6	1.9
548TRISON	6.0	2.7	2.0	2.8	1.6	1.9
551ARTHUR	6.0	2.7	2.0	4.2	2.1	1.9
552TITAN	3.0	2.0	4.5	4.3	3.1	1.9
553FRANKENMUTH	6.0	2.7	2.0	3.8	1.6	1.9
555ISRAEL SW	0.5	3.0	4.5	2.9	4.7	2.6
563EAGLE	6.0	3.5	2.0	3.2	3.0	1.9
599VONA	6.0	3.1	2.5	3.9	1.6	1.7
610SAGE	6.0	2.7	2.0	2.8	1.6	1.9
700BEZOSTAYA	6.0	2.9	5.0	4.3	3.1	1.9
701MIRONOVSKAYA	6.0	2.9	5.0	4.8	3.1	1.9
702ROUGHRIDER	6.0	2.9	5.0	4.8	3.1	1.9
777ESTANZ. DORADO	1.0	4.0	2.0	3.0	3.0	3.0
1001ATLE	6.0	2.7	2.0	1.3	1.6	1.9
1002CAPELLE DESPREZ	6.0	4.2	2.0	1.7	2.9	3.7
1003JUFY 2	6.0	2.7	2.0	2.8	1.6	1.9
1004LELY	6.0	3.5	2.0	4.8	2.8	4.4
1005DONATA	6.0	3.5	2.0	4.4	3.0	1.7
1006MARIS HOBBIT	6.0	2.7	2.0	3.6	3.1	3.6
1007MARIS HUNTSMAN2	6.0	2.9	2.0	3.9	3.9	2.2
1008TALENT	6.0	3.3	3.5	3.5	3.8	1.9
1009HYSLOP	6.0	2.7	2.0	3.0	1.6	1.9
1010LUKE	6.0	2.7	2.0	2.8	1.3	1.9
1011ARMINDA	6.0	2.7	2.0	4.3	4.6	1.9
1012CAPITOLE	6.0	3.2	2.5	3.1	3.6	1.0
1013TOP	6.0	3.5	3.5	3.2	3.3	1.9
1014COURTOT	6.0	3.3	2.5	3.4	3.1	1.0
1015MARIS FUNDEN	6.0	3.5	4.0	2.8	2.7	1.9
1015STEPHENS	6.0	3.3	2.5	3.5	6.8	2.7
1016YAMHILL	6.0	3.3	2.5	3.9	5.5	2.8
1017MARIS HUNTSMAN	6.0	3.5	4.0	3.9	3.0	2.2
1018HD2160(INDIA)	0.5	3.3	2.5	4.0	2.9	2.4
1019FARO	6.0	3.3	2.5	4.3	4.9	2.6
1020NIMBUS	6.0	3.3	2.5	4.6	4.0	2.1
1021SCHIROKKO	0.5	3.3	2.5	4.7	3.4	2.0
1022ARKAS	0.5	3.3	2.5	4.0	3.1	2.1
1023TURBO	0.5	3.3	2.5	4.8	3.3	2.1
1024MARIS MARDLER	6.0	3.3	2.5	4.8	3.3	2.1
1025STARKEII	6.0	3.3	1.0	4.0	2.4	2.1
1500MANITOU	0.5	3.2	0.0	4.9	1.8	1.7
1907MEXIPAK	0.5	3.0	2.0	2.9	3.0	1.7
1908SONALIKA	0.5	1.8	3.5	4.0	1.9	1.7
1909NOVI SAD	0.5	3.5	2.0	4.0	1.3	1.7
2001ANZA	0.5	3.4	2.0	3.5	2.7	4.4
2004COKER 6815	6.0	1.0	2.0	4.1	3.1	1.9
2006NADADORES	0.5	2.7	2.0	2.8	1.6	1.9
2008PENJAMO	0.5	2.7	2.0	2.8	1.6	1.9
2011PLAINSMAN	6.0	2.7	2.0	2.8	1.6	1.9
2012PRODURA	0.5	3.1	2.5	3.3	3.3	5.3

```
2013TAMU             6.0      2.7         2.0 2.8     1.6     1.9
2014WALDRON          0.5      1.5         2.0 2.8     1.6     1.9
2123EGRET            0.5      3.0         2.0 2.6     3.3     2.7
2124WW33G            0.5      3.0         2.0 3.7     1.8     2.4
4000SQUAREHD MASTER  6.0      4.7         2.0 1.1     2.2     1.9
```

Table 16. File "KSAS8101.WHA".

```
KSAS8101  1   2317. 28.9     8017.   18.  1.02  5994.  3677. 141 174
  1.91  59.2  14.9  44.3
KSAS8101  2   3330. 24.2    13760.   22.  1.78 10178.  6848. 141 174
  1.91 103.2  39.5  63.7
KSAS8101  3   4521. 23.4    19321.   24.  2.99 12649.  8128. 141 174
  2.21 166.6  66.7  99.9
KSAS8101  4   1438. 28.1     5117.   18.  0.81  3926.  2488. 141 174
  1.86  37.7  11.0  26.7
KSAS8101  5   3025. 23.9    12657.   20.  1.82  9424.  6399. 141 174
  1.88  87.8  31.0  56.8
KSAS8101  6   4695. 23.1    20325.   24.  2.88 13064.  8369. 141 174
  2.04 166.5  71.0  95.5
```

Table 17. File "KSAS8101.WHB".

```
INST_ID :KS  SITE_ID: AS  EXPT_NO: 01  YEAR : 1981  TRT_NO:  1
6 4 6 7 8 2 3
344 0.00 0.000 0.000 0.037     5.90   227.
 61 0.06 0.000 0.000 0.061     9.90   275.
 71 0.06 0.000 0.000 0.077    12.40   292.
 81 0.13 0.000 0.000 0.105    17.00   454.
 92 0.20 0.000 0.000 0.139    22.50   454.
103 0.31 0.000 0.000 0.209    33.80   616.
115 0.68 0.139 0.000 0.472    98.70   632.
125 0.96 0.267 0.000 0.753   167.00   664.
138 1.02 1.023 0.000 1.400   469.60   551.
152 0.33 1.380 0.000 0.753   512.70   437.
162 0.00 1.026 0.957 0.696   508.20   340.
168 0.00 0.993 1.325 0.680   584.80   373.
175 0.00 0.993 1.434 0.723   599.40   421.
-1
INST_ID :KS  SITE_ID: AS  EXPT_NO: 01  YEAR : 1981  TRT_NO:  2
6 4 6 7 8 2 3
344 0.00 0.000 0.000 0.065    10.50   437.  61 0.08 0.000
```

```
0.000 0.086    14.00   389.
  71 0.08 0.000 0.000 0.092    14.90   583.
  81 0.17 0.000 0.000 0.132    21.40   599.
  92 0.29 0.000 0.000 0.166    26.80   599.
 103 0.53 0.000 0.000 0.322    52.00   842.
 115 1.14 0.231 0.000 0.765   160.90   907.
 125 1.84 0.427 0.000 1.167   260.00   972.
 138 1.78 1.623 0.000 1.973   725.40   826.
 152 0.69 2.390 0.000 1.500   891.80   713.
 162 0.00 1.636 1.438 1.070   793.80   535.
 168 0.00 1.773 2.027 1.147   963.90   599.
 175 0.00 1.870 2.062 1.220  1017.80   616.
 -1
 INST_ID :KS  SITE_ID: AS  EXPT_NO: 01  YEAR : 1981  TRT_NO:  3
 6 4 6 7 8 2 3
 344 0.00 0.000 0.000 0.063    10.10   405.
  61 0.08 0.000 0.000 0.086    13.90   389.
  71 0.16 0.000 0.000 0.147    23.80   632.
  81 0.21 0.000 0.000 0.166    26.80   745.
  92 0.46 0.000 0.000 0.244    39.50   794.
 103 0.82 0.000 0.000 0.444    71.70  1102.
 115 1.73 0.245 0.000 0.918   187.90  1069.
 125 3.60 0.610 0.000 1.660   369.60  1118.
 138 2.99 1.783 0.000 2.847   920.30  1021.
 152 1.24 2.960 0.000 3.030  1172.30   842.
 162 0.00 2.324 1.769 1.548  1118.40   680.
 168 0.00 2.100 2.303 1.493  1143.80   713.
 175 0.00 2.197 2.799 1.443  1264.90   697.
 -1
 INST_ID :KS  SITE_ID: AS  EXPT_NO: 01  YEAR : 1981  TRT_NO:  4
 6 4 6 7 8 2 3
 344 0.00 0.000 0.000 0.033     5.30   211.
  61 0.05 0.000 0.000 0.059     9.50   259.
  71 0.04 0.000 0.000 0.074    11.90   275.
  81 0.09 0.000 0.000 0.080    13.00   373.
  92 0.19 0.000 0.000 0.129    20.90   421.
 103 0.28 0.000 0.000 0.192    31.10   535.
 115 0.58 0.140 0.000 0.400    87.20   470.
 125 0.83 0.247 0.000 0.610   141.10   502.
 138 0.81 0.897 0.000 1.393   457.20   486.
 152 0.31 1.263 0.000 0.703   445.30   405.
 162 0.00 0.792 0.747 0.550   400.40   275.
 168 0.00 0.713 0.823 0.507   422.20   275.
 175 0.00 0.620 0.890 0.480   392.60   259.
 -1
 INST_ID :KS  SITE_ID: AS  EXPT_NO: 01  YEAR : 1981  TRT_NO:  5
 6 4 6 7 8 2 3
 344 0.00 0.000 0.000 0.061     9.80   356.
  61 0.07 0.000 0.000 0.084    13.60   389.
  71 0.09 0.000 0.000 0.093    15.00   583.
  81 0.18 0.000 0.000 0.134    21.60   648.
```

```
 92 0.30 0.000 0.000 0.164    26.50    599.
103 0.51 0.000 0.000 0.306    49.40    648.
115 1.28 0.206 0.000 0.696   145.70    794.
125 2.02 0.460 0.000 1.057   247.30    810.
138 1.82 1.647 0.000 2.043   728.10    713.
152 0.66 2.193 0.000 1.400   790.50    616.
162 0.00 1.716 1.290 1.012   779.60    502.
168 0.00 1.927 1.495 1.307   947.80    535.
175 0.00 1.743 1.873 1.310   942.40    535.
-1
INST_ID :KS  SITE_ID: AS  EXPT_NO: 01  YEAR : 1981  TRT_NO:  6
6 4 6 7 8 2 3
344 0.00 0.000 0.000 0.054     8.80    308.
 61 0.07 0.000 0.000 0.084    13.60    373.
 71 0.16 0.000 0.000 0.148    24.00    632.
 81 0.22 0.000 0.000 0.160    25.90    664.
 92 0.48 0.000 0.000 0.258    41.60    859.
103 0.83 0.000 0.000 0.455    73.40    875.
115 2.44 0.356 0.000 1.146   242.80   1199.
125 3.56 0.607 0.000 1.650   367.30   1037.
138 2.88 2.170 0.000 2.327   889.10    956.
152 2.06 3.060 0.000 2.262  1168.00    956.
162 0.00 2.464 1.651 1.702  1177.60    729.
168 0.00 2.193 1.982 1.460  1187.90    697.
175 0.00 2.313 2.906 1.637  1306.40    794.
-1
```

Table 18. File "GLABEL.DAT".

```
1. Growth Stage (C/day)
SumDtt
2. Biomass (g/m^2)
Bioms g/m2
3. Number of Tillers
Tillers/m2
4. Leaf Area Index
LAI
5. Root Dry Weight (g/plant)
ROOT-g/plant
6. Stem Dry Weight (g/plant)
STEM-g/plant
7. Grain Dry Weight (g/plant)
GRAIN-g/plant
8. Leaf Dry Weight (g/plant)
LEAF-g/plant
9. Root depth cm
RTDEP cm
10.Daily Partitioning Factor for Shoot
Shoot Partition Ratio
```

11.Root Length Density Level 1 cm/cm3
RLD L1
12.Root Length Density Level 3 cm/cm3
RLD L3
13.Root Length Density Level 5 cm/cm3
RLD L5

Table 19. File "GLABEL2.DAT".

01.Average Plant Transpiration (mm)
EP-mm
02.Average Evapo-Transpiration (mm)
ET-mm
03.Average Potential Evaporation (mm)
EO-mm
04.Average Solar Radiation (MJ/m2)
SR-MJ/m2
05.Average Maximum Temperature (C)
Tmax-C
06.Average Minimum Temperature (C)
Tmin-C
07.Period Precipitation (mm)
Prec-mm
8. Soil Water Content level 1 cm3/cm3
SWC L1
9. Soil Water Content level 2 cm3/cm3
SWC L2
10.Soil Water Content level 3 cm3/cm3
SWC L3
11.Soil Water Content level 4 cm3/cm3
SWC L4
12.Soil Water Content level 5 cm3/cm3
SWC L5
13.Potential Extractable Water -cm
PESW-cm

Table 20. File "GLABEL3.DAT".

```
01 Tops N%
TOPS N%
02 NFAC
NFAC Ratio
03.Vegetative N-Uptake Kg/ha
VGNUP-kg/ha
04.Grain N-Uptake Kg/ha
GRNUP-kg/ha
05.No3 in Layer 1 ug N/g soil
ug N/g L1
06.No3 in Layer 2 ug N/g soil
ug N/g L2
07.No3 in Layer 3 ug N/g soil
ug N/g L3
08.No3 in Layer 4 ug N/g soil
ug N/g L4
09.No3 in Layer 5 ug N/g soil
ug N/g L5
10.NH4 in Layer 1 ug N/g soil
ug N/g L1
11.NH4 in Layer 2 ug N/g soil
ug N/g L2
12.NH4 in Layer 3 ug N/g soil
ug N/g L3
```

Table 21. File "ICTH7902.WH8".

```
CTH8001   1 Nitrogen Non-limiting soil 1              21 1907
 330 334 300.00 15.000  5.00  1  0   1.00  0.50   80.0  95.00  1  05
ICTH8001  2 Nitrogen Non-Limiting soil 2              22 1907
 330 334 300.00 15.000  5.00  1  0   1.00  0.50   80.0  95.00  1  05
```

Table 22. Sample Genetic Coefficients for Wheat Genotypes Adapted to Different Environments[a]

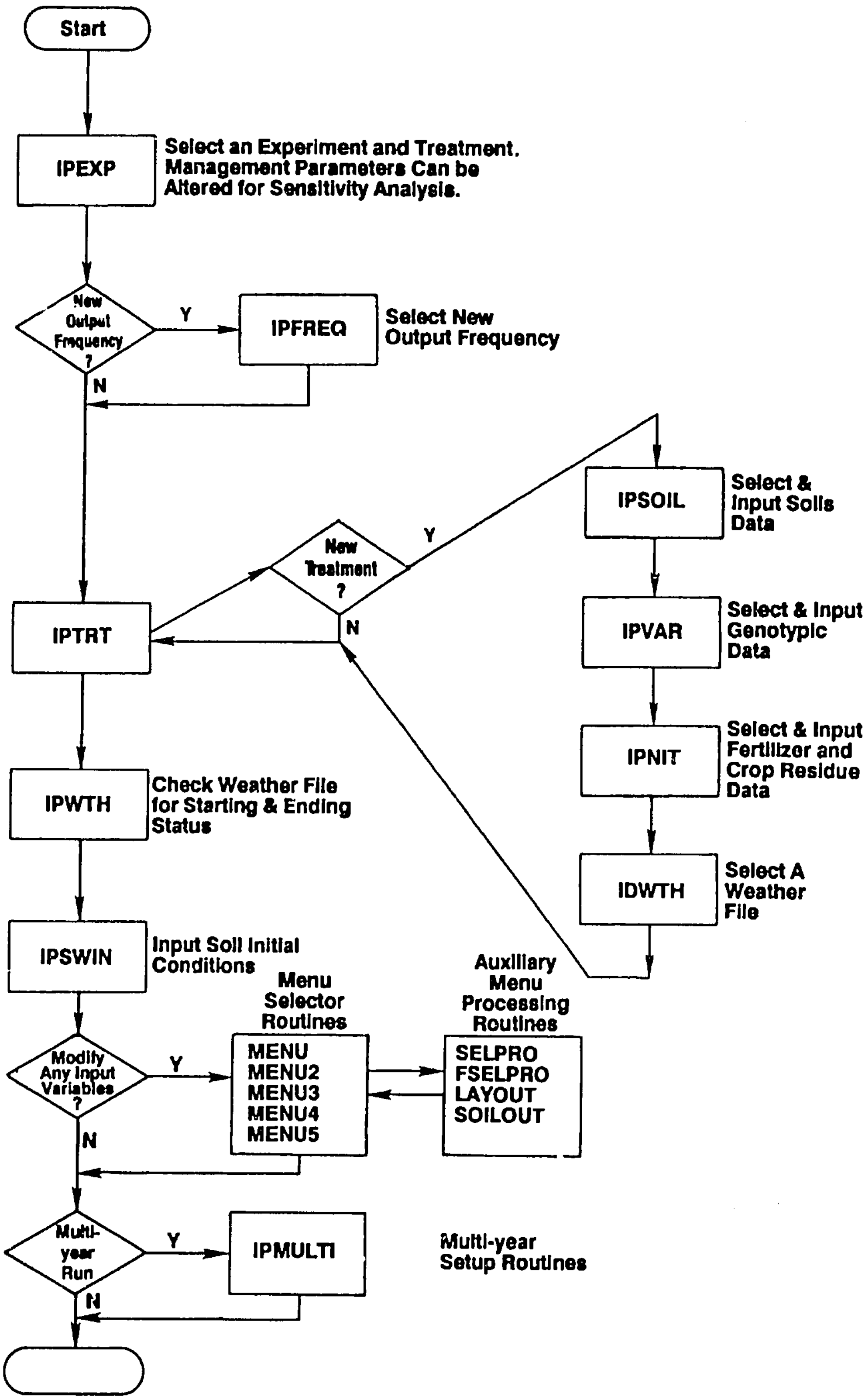
Adaptation	Genetic Coefficient					
	P1V[b]	P1D	P5	G1	G2	G3
Spring Wheats						
Northern Europe	0.5	3.5	2.5	4.0	3.0	2.0
North American prairies	0.5	3.0	2.5	3.5	3.5	2.0
Australia	0.5	2.0	2.5	2.5	2.0	4.0
India	0.5	1.5	3.5	4.0	2.0	2.0
Winter Wheats						
America						
• Pacific	6.0	3.0	2.0	3.0	2.0	2.0
• N. Plains	6.0	2.5	2.0	4.0	2.0	1.5
• S. Plains	4.0	3.0	2.5	3.0	3.0	2.0
• East	6.0	3.0	2.0	4.0	2.0	2.0
Europe						
• West	6.0	3.5	4.0	4.0	3.0	2.0
• East	6.0	3.0	5.0	4.5	3.0	2.0

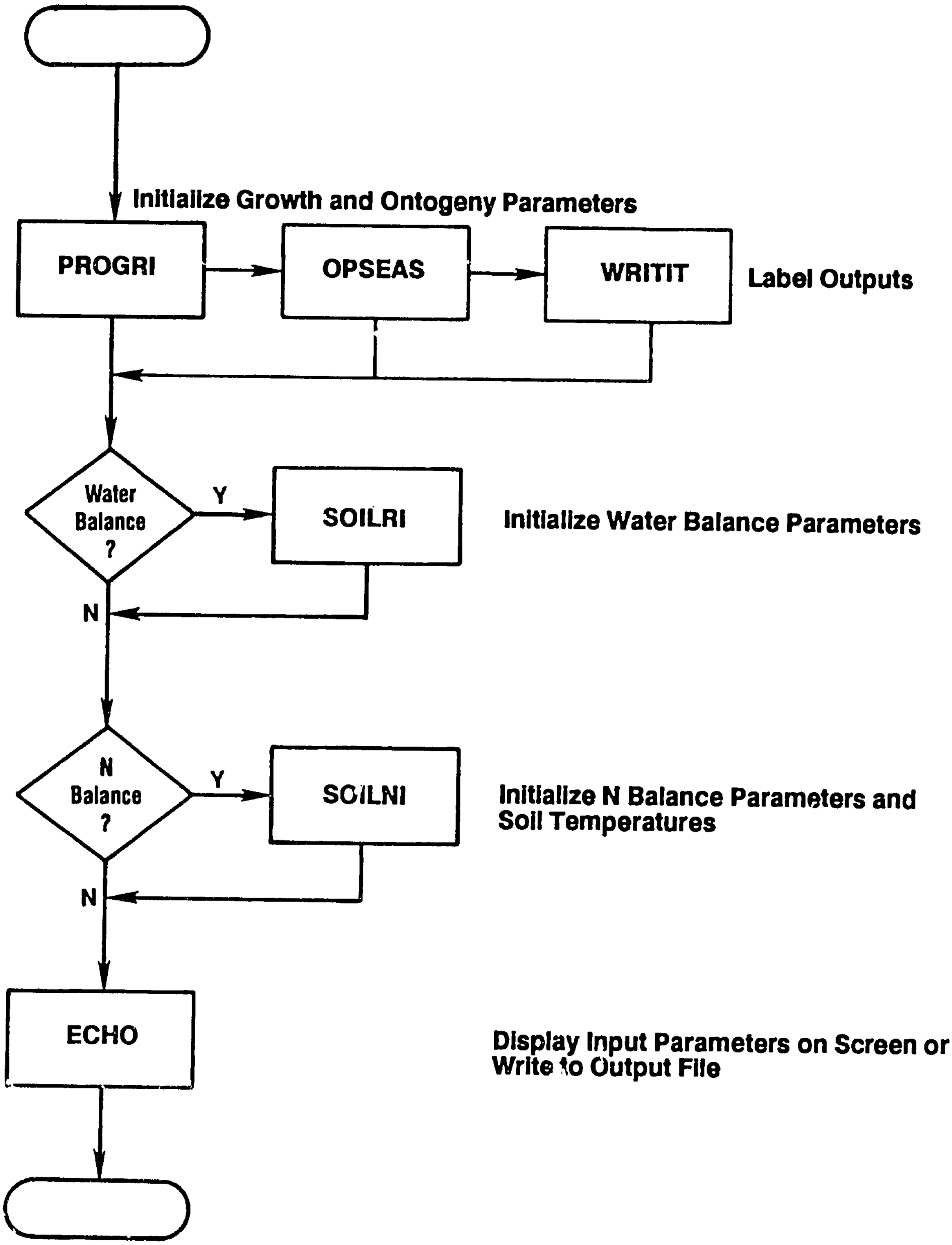
a. The values given here are based on different numbers of experiments and genotypes; they may thus change as more data are acquired and are provided as guides only.

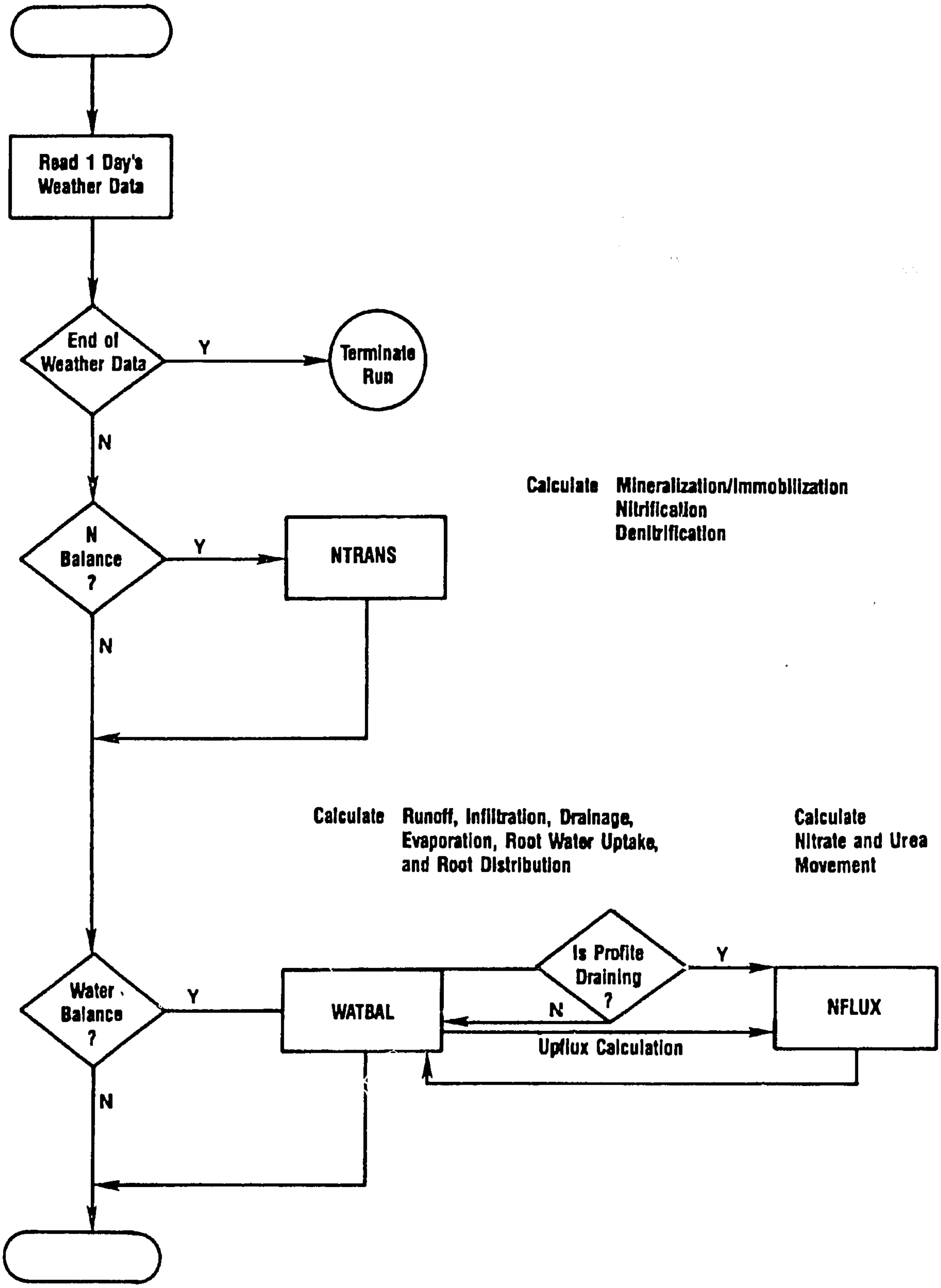
b. The vernalization groups shown here may not represent the full range of values present within the species. Examination of the literature suggests that the following range of values may occur:

P1V	Representative genotype(s) with country (region) to which adapted
0.01	Saitama (Japan)
0.3	Flavio (Italy)
0.6	Rousalka (Romania)
1.5	Blueboy (E. U.S.A.), Sava (Yugoslavia), Kita Kami Komugi (Japan)
2.0	Talent (France), Fredrick (Canada), Hyslop (N.W. U.S.A.)
4.0	Bezostaya-1 (U.S.S.R.), Mironovskaya-808 (U.S.S.R.)
6.0	Lely (Netherlands), Yorkstar (S. Canada)
8.0	Caribo (Germany), Jubilar (Germany)
9.5	Komoran (Germany), Heine-7 (Germany

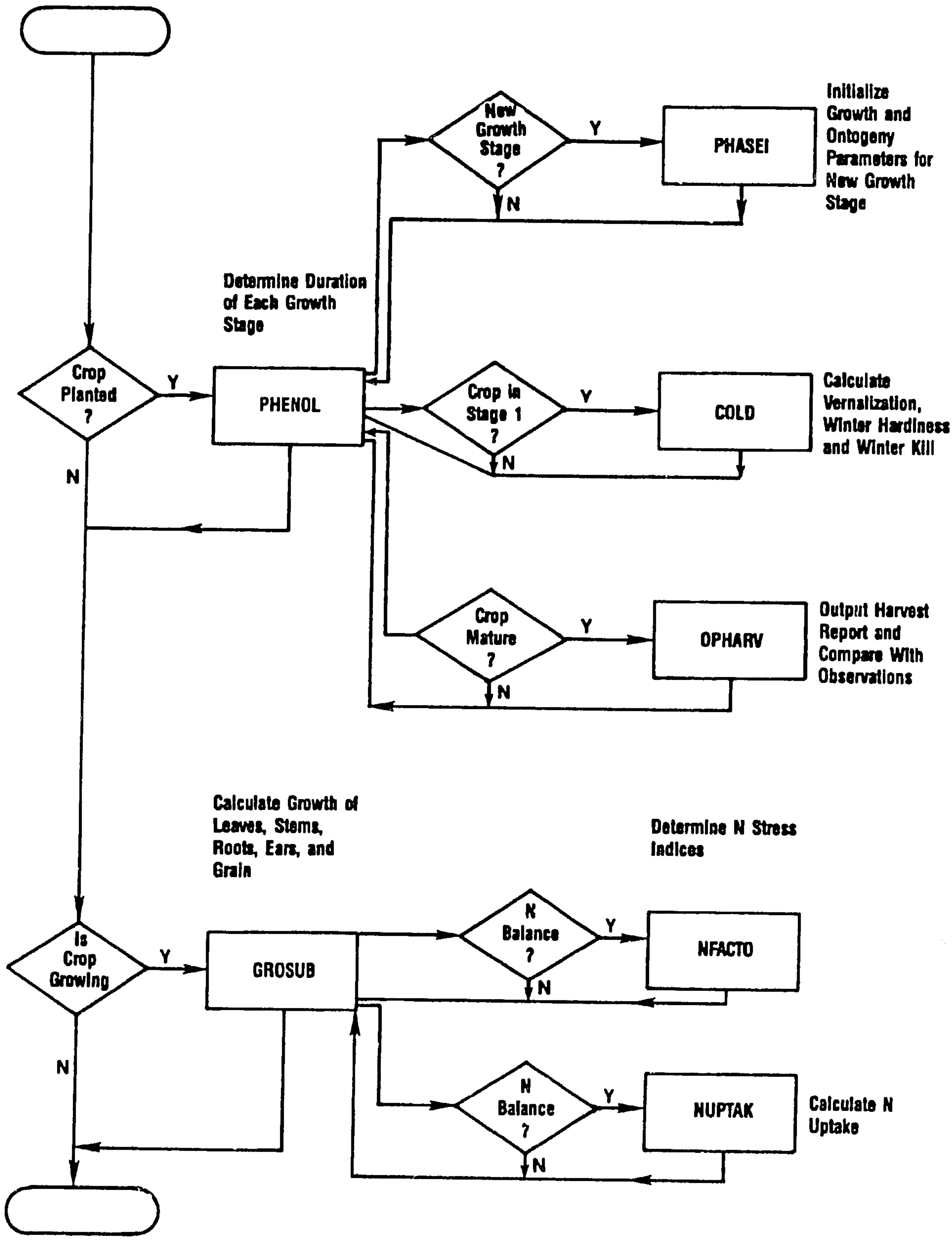
APPENDIX

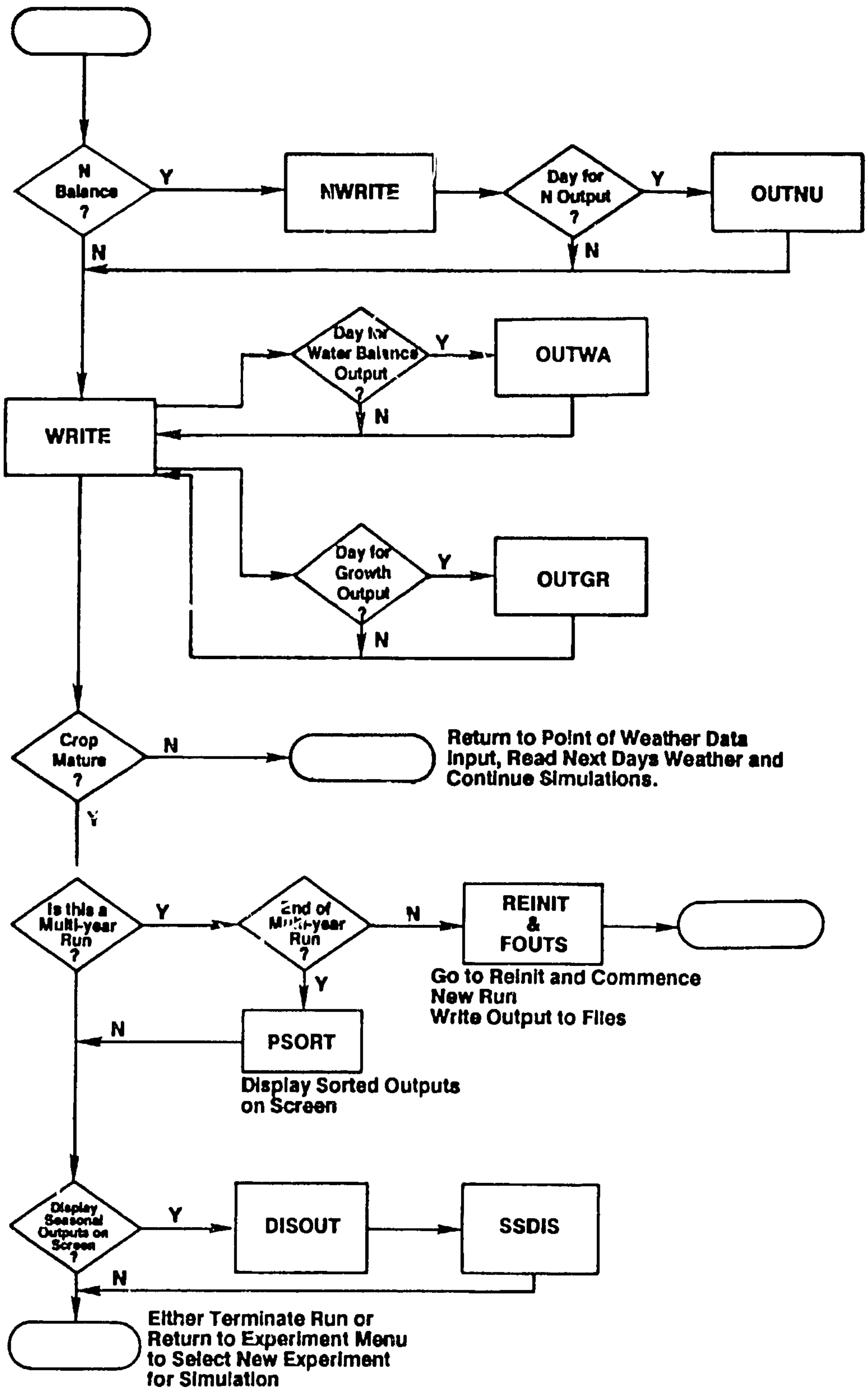

Start
IPEXP
Select an Experiment and Treatment. Management Parameters Can be Altered for Sensitivity Analysis.
New Output Frequency ?
Y
N
IPFREQ
Select New Output Frequency
IPSOIL
Select & Input Soils Data
New Treatment ?
Y
N
IPTRT
IPVAR
Select & Input Genotypic Data
IPNIT
Select & Input Fertilizer and Crop Residue Data
IPWTH
Check Weather File for Starting & Ending Status
IDWTH
Select A Weather File
IPSWIN
Input Soil Initial Conditions
Menu Selector Routines
Auxiliary Menu Processing Routines
Modify Any Input Variables ?
Y
N
MENU
MENU2
MENU3
MENU4
MENU5
SELPRO
FSELPRO
LAYOUT
SOILOUT
Multi-year Run
Y
N
IPMULTI
Multi-year Setup Routines


Initialize Growth and Ontogeny Parameters
PROGRI
OPSEAS
WRITIT
Label Outputs
Water Balance ?
Y
N
SOILRI
Initialize Water Balance Parameters
N Balance ?
Y
N
SOILNI
Initialize N Balance Parameters and Soil Temperatures
ECHO
Display Input Parameters on Screen or Write to Output File



Read 1 Day's Weather Data
End of Weather Data
Y
Terminate Run
N
N Balance ?
Y
NTRANS
Calculate Mineralization/Immobilization Nitrification Denitrification
N
Calculate Runoff, Infiltration, Drainage, Evaporation, Root Water Uptake, and Root Distribution
Calculate Nitrate and Urea Movement
Is Profile Draining ?
Y
N
Water Balance ?
Y
WATBAL
NFLUX
Upflux Calculation
N


Initialize Growth and Ontogeny Parameters for New Growth Stage
New Growth Stage ?
Y
PHASEI
N
Determine Duration of Each Growth Stage
Crop Planted ?
Y
PHENOL
N
Crop in Stage 1 ?
Y
COLD
N
Calculate Vernalization, Winter Hardiness and Winter Kill
Crop Mature ?
Y
OPHARV
N
Output Harvest Report and Compare With Observations
Calculate Growth of Leaves, Stems, Roots, Ears, and Grain
Determine N Stress Indices
Is Crop Growing
Y
GROSUB
N
N Balance ?
Y
NFACTO
N
N Balance ?
Y
NUPTAK
N
Calculate N Uptake


N Balance ?
Y
NWRITE
Day for N Output ?
Y
OUTNU
N
N
Day for Water Balance Output ?
Y
OUTWA
WRITE
N
Day for Growth Output ?
Y
OUTGR
N
Crop Mature ?
N
Return to Point of Weather Data Input, Read Next Days Weather and Continue Simulations.
Y
Is this a Multi-year Run ?
Y
End of Multi-year Run ?
N
REINIT & FOUTS
Go to Reinit and Commence New Run
Write Output to Files
Y
N
PSORT
Display Sorted Outputs on Screen
Display Seasonal Outputs on Screen ?
Y
DISOUT
SSDIS
N
Either Terminate Run or Return to Experiment Menu to Select New Experiment for Simulation