A physiological production model for cacao:

User's manual for CASE2 version 2.2 under FSE Windows

Pieter A. Zuidema & Peter A. Leffelaar

February 2002

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Copies of related reports on CASE2 ("A physiological production model for cacao: results of model simulations" and "A physiological production model for cacao: model description and technical program manual of CASE2 version 2.2") are available from the secretariat of the Plant production systems group at the above address. The CASE2 model and the FSTWin and FSEWin programs are present on CD-ROM included in this report. If the CD-ROM is not included, please report to Peter Leffelaar at the above (e-mail) address.

This report has been produced within the framework of the "Collaborative research for an agro-technological growth and quality model of cocoa" of the Dutch Cocoa Association (NVC) and Wageningen University. Financial support for this study was obtained from the Dutch cocoa processing industry, the Dutch Ministry of Economic Affairs and Wageningen University.

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Preface

This report contains a user's manual for the CASE2 model version 2.2 running in a FSE Windows environment. CASE2 is a physiological model for cacao growth and yield. It is one of the results of a cocoa research and modelling programme of Wageningen University on behalf of the Dutch Cocoa Association (NCV)[1]. The current version of the model has been developed in the period April 2001-January 2002.

The user's manual contains instructions on the installation and use of the CASE2 model and the FSE Windows programme (FSEWin). Using the information in this report, one should be able to run the CASE2 model with weather data from different locations and different soil types. Weather information of 37 locations in 10 countries are included in the program files; soil information on three soil types is also included. The report also contains information on how to add new soil types or new weather information.

Basic background information on the procedures, model assumptions and limitations of CASE2 are included in another report (Zuidema & Leffelaar, 2002). An extensive description of the model code of CASE2 can be found in the technical program manual (Zuidema *et al.* 2002). These reports and extra copies of this report and the CASE2 and FSEWin programs can be obtained from the Plant Production Systems group at Wageningen University (see author's addresses on previous page). Any queries or comments can also be sent to the authors.

Several people have contributed in the development of the CASE2 model. Wouter Gerritsma and Liesje Mommer developed previous versions of the model. Jan Goudriaan provided valuable input for model development. Wouter Gerritsma gave important reference to literature and commented on model development. Rudy Rabbinge provided overall guidance during this phase of the project. Daniel van Kraalingen developed the FSEWin program. Gon van Laar assisted in the FSEWin development and tested the program. Sander de Vries tested the CASE2 model. Weather data were kindly made available by various persons at the Department of Plant Sciences and Plant Research International (both at Wageningen University and Research Centre). Financial support was obtained from the Dutch Cocoa Association (NCV), the Dutch Ministry of Economic Affairs, and the Plant Production Systems group at Wageningen University. All contributions are gratefully acknowledged.

Wageningen, January 2002

Important notice:
The CASE2 model and the FSE Windows shell will only work when Visual Fortran is installed on the computer. See Section 2.2 for further information on purchasing and installing Visual Fortran.

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1 *"Collective research for an agro-technical growth and quality model of cocoa"*

Table of Contents

1. Introduction

1.1 What is Visual Fortran?

Visual Fortran is a program that may be used to build, edit, compile, run and debug programs written in the Fortran language. Visual Fortran works with so called projects that contain all Fortran source codes, data files, libraries and other files necessary for a larger program, for instance the CASE2 model. FSE for Windows makes use of Visual Fortran for defining projects, compiling programs and running the model.

1.2 What is FSE Windows?

FSE Windows (Fortran Simulation Environment for Windows) is a user-friendly shell to be used for simulation models written in Fortran. It can be used to edit, compile and run Fortran programs, and it produces output in charts and spreadsheets. The program has been developed by D.W.G. van Kraalingen, Wageningen Software Labs (W!SL), Alterra, the Netherlands. Version 1.04 of FSE Windows is provided with this report. The Fortran programs that run under FSE Windows make use of the Fortran Simulation Environment (FSE, van Kraalingen 1995), a system that controls simulation runs, takes care of reading weather and plant data and generates output files. Apart from running Fortran models, FSE Windows may also be used to build and adapt models. For the use of the cacao simulation model CASE2 as described in this manual, FSEWin is only used to configure and run a simulation model and view its output.

1.3 What is CASE2?

1.3.1 Purposes

CASE2 is the Cacao Simulation Engine for water-limited production. CASE2 is a physiological model that simulates cocoa growth and yield for different weather and soil conditions and cropping systems. The model serves the following purposes:

(1) To estimate cocoa yields in relation to weather and soil conditions and cropping systems;
(2) to obtain insight in factors determining production;
(3) to integrate existing knowledge on the physiology and morphology of cacao trees; and
(4) to identify gaps in knowledge in the physiological basis for estimating cocoa growth and yield.

1.3.2 A short description

Below, a short description of the model is provided. More background information on the procedures, structure and assumptions of the CASE2 model are included in another report (Zuidema & Leffelaar, 2002). An extensive description of the model code of CASE2 can be found in the technical program manual (Zuidema *et al.* 2002).

In a simplified form, model inputs and outputs are shown in Figure 1.1. A description of each group of inputs and outputs is provided below.

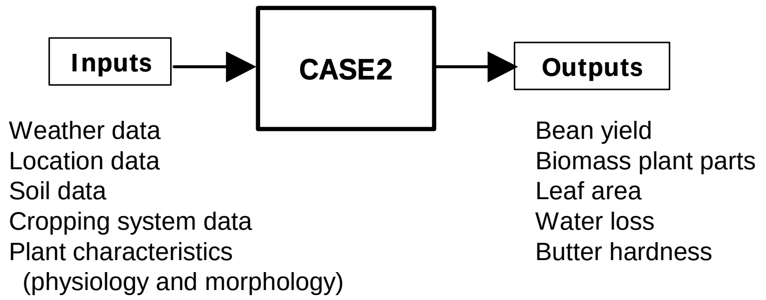


Figure 1.1. Simplified diagram of inputs and outputs in CASE2. Further explanation is provided in the main text.

Input parameters
Weather data include precipitation, radiation, minimum and maximum temperature, and vapour pressure. Soil data include information on the amount, thickness and physical characteristics of soil layers. Cropping system data include information on planting density, age at the start of the simulation and characteristics of shade trees. Plant characteristics include parameters that are used to calculate rates of photosynthesis, respiration and transpiration; parameters that are used to distribute biomass over plant parts (over leaves, wood, roots and pods); vertical distribution of roots in the soil; ripening and growth of pods; leaf age, etc.
Part of the input parameters for CASE2 are time specific. Weather information (temperatures, rain, radiation and vapour pressure) is specific for one day or for one month. In the latter case, daily values are generated by the model on the basis of the number of rain days. Input parameters on plant physiology and morphology, on soil characteristics and on cropping system are constant over time.

Output parameters
Bean yield is expressed in terms of dry fermented beans. Biomass of plant parts (leaves, wood, taproot, lateral roots and pods) as well as the growth in biomass of plant parts is obtained. Also, leaf area and leaf area index (LAI) of the cacao trees is calculated. Information on water loss through evaporation (from the soil) and transpiration (from the plant) is also obtained. Finally, the butter hardness of the harvested beans and the amount of nutrients lost due to bean harvest are calculated.
Model output can be generated for each simulation day, but also for periods of 10 days or for entire years. In the latter two cases, summed values for parameters such as growth and yield are provided in the output.

1.3.3 The model cacao tree

For the purpose of the simulations, the cacao tree is divided into “functional parts”: leaves, wood, taproot, lateral root and pods (fruits). This division is shown in Figure 2.2 Also included in this figure is the layer of leaves of the shade tree and the soil layers. Below, the characteristics of the different parts of the cacao tree and the shade tree are explained.

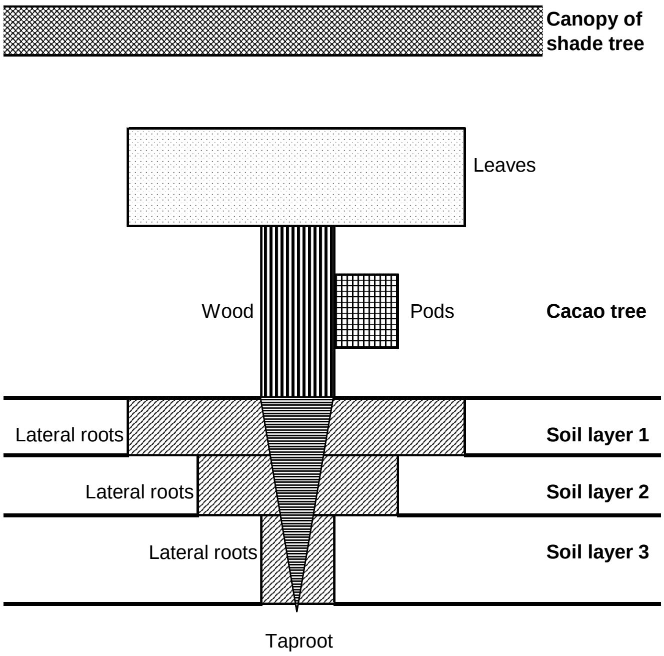


Figure 1.2. Schematic representation of the model cacao tree. The boxes indicate the different plant parts that are distinguished in the model. As the model assumes a homogeneous and closed canopy of cacao trees, the neighbouring model trees border directly to the canopy of the pictured tree. See main text for further explanation.

Shade tree

In CASE2, shade trees are characterised by their canopy only. The shade canopy is characterised by three parameters: the number of leaf layers (LAI – leaf area index), the extinction coefficient of the shade tree (this is the proportion of light intercepted by one layer of leaves) and the lower and upper height of the canopy. The first parameter may depend on the planting density of shade trees and is specific to the type of shade tree used. The second parameter is a characteristic of the shade species. The canopy heights are important to simulate growth and yield for cropping systems in which short shade trees are used, causing the canopies of cacao and shade trees to overlap.

Cacao tree

- *Leaves.* The leaf part in the model is characterised by total leaf weight and leaf area. Leaves have a certain leaf life span and die after having completed this life span. Additional leaf loss occurs in situations of water shortage. New leaves are formed continuously. The leaf area index (LAI – the number of leaf layers of the cacao tree per unit of soil surface) is another characteristic of the canopy.
- *Wood.* The wood part of the tree is characterised by total wood weight, which includes both the stem and branches of the tree. New wood is formed continuously and wood is lost as litter (fallen branches).
- *Pods.* The pods (fruits) of the model tree are characterised by their weight and development stage (ripening stage). All pods in the model are divided into age categories: pods of 1, 2, 3, etc days are treated separately in the model. Apart from their age, pods in a category are characterised by a certain weight and a certain development stage. When the development stage of a certain category reaches the mature stage, pods in that category are added to the harvest.
- *Taproot.* The taproot of the model tree has a certain weight and a certain length. The length of the taproot is determined on the basis of its weight (assuming that the taproot has the shape of a cone, with a certain relation of length and diameter, and a certain wood density).
- *Lateral roots.* The lateral roots are divided into two parts: roots that may take up water (with a diameter of <2 mm) and coarse roots. Both water-absorbing and coarse roots are characterised by their weight, and both are continuously renewed; that is: part of the roots dies off each day and this part is replaced by new roots. Water-absorbing roots are distributed over the different soil layers

following an exponential decline of root density with increasing depth (in Figure 2.2 this is shown for all lateral roots). These roots are distributed up to the depth reached by the tip of the taproot. Length and surface area of the water-absorbing roots are derived from their weight, specific length and diameter.

2. Installing the programs

Steps:	
1. Check system requirements	→ Section 2.1
2. Install Visual Fortran	→ Section 2.2
3. Install FSE Windows	→ Section 2.3
4. Copy CASE2 files	→ Section 2.4

2.1 System requirements

Most modern IBM-compatible computers equipped with at least Windows 95 operating system will be able to run CASE2 under FSE Windows. The following system configuration is required:

- A 90MHz (or faster) Intel Pentium (or compatible) processor
- Windows 95 (or higher)
- At least 24 MB of memory
- At least 300 MB free hard disk space (ca. 280 MB for Visual Fortran; 10 MB for FSE Windows and 10 MB for CASE2)
- A CD-ROM drive
- A mouse installed
- A VGA monitor (17” recommended)

2.2 Installing Visual Fortran

To purchase Visual Fortran, visit the Compaq Visual Fortran web pages at www.compaq.com/fortran. The current version of Visual Fortran is 6.6, but older versions may also be used to run FSE Windows and CASE2. Versions of Visual Fortran named “DIGITAL Visual Fortran” may also be used. DIGITAL Visual Fortran 6.0 was used successfully with FSE Windows and CASE2. Note that new versions of Visual Fortran can only be obtained from Compaq.
During the installation of Visual Fortran, choose the Standard or Typical configuration (generally the default option), without Array Visualisation (this feature is not used). **It is very important that the autoexec.bat file is updated: this is usually asked at the end of the program installation.**

2.3 Installing FST Windows

The FSEWin shell that is used for the CASE2 model makes use of a companion program called FS**T**Win (Fortran Simulation Translator for Windows). This program is present on the CD-ROM included in this report and should first be installed (in case there is no CD-ROM included, contact the authors for a free copy, see address at page 2 of this manual). In case FSTWin has already been installed on the computer, proceed with the copying of the FSEWin and CASE2 files as described in Section 2.4.

To install the FSTWin program:

- ➔ Place the CD-ROM in the CD-ROM player
- ➔ Choose “Run” from the Windows Start Menu

- ➔ Type: "<drive>:setup.exe" in which <drive> is the letter assigned to the CD-ROM player. For example: "D:setup.exe" in case the CD-ROM drive has letter D.
- ➔ Click on OK

The installation program is started:

- ➔ Follow the instructions on the screens: enter name and company name when requested and select the default destination directory and program folder. **It is important that you do not change the destination directory (C:\Program Files\FSTWin).**

The installation program copies program files and adjusts settings.

- ➔ Click on Finish when the installation is complete.

2.4 Copying the FSEWin and CASE2 files

The FSEWin and CASE2 files are present on the CD-ROM that is included in this report (in case there is no CD-ROM included, contact the authors for a free copy, see address at page 2 of this manual). The files are packed in a self-extractable ZIP-file and will be automatically copied to the directories C:\Program Files\FSTWin (the FSEWin files; note the directory name \FS**T**Win and not \FS**E**Win) and C:\Case2 (the CASE2 files).

To copy the FSEWin and CASE2 files:

- ➔ Place the CD-ROM in the CD-ROM player
- ➔ Choose "Run" from the Windows Start Menu
- ➔ Type: "<drive>:copycase.exe" in which <drive> is the letter assigned to the CD-ROM player. For example: "D:copycase.exe" in case the CD-ROM drive has letter D.
- ➔ Click on OK

A WinZip self-extractor window is opened.

- ➔ Click on "Unzip" to start the extraction of the files. **It is important that you do not change the destination directory (C:) mentioned.**

The self-extractor program copies the FSEWin and CASE2 files to different directories.

- ➔ Click on Finish when the installation is complete.

To facilitate starting FSEWin, make a shortcut of the FSEWin.exe file. To do so:

- ➔ Open the Windows Explorer
- ➔ Go to the directory C:\Program Files\FSTWin
- ➔ Select FSEWin.exe
- ➔ Right-click on the FSEWin.exe file to open the menu
- ➔ Select "Send to" and then "Desktop (shortcut)"

A new icon is placed on the desktop (Windows opening screen)

3. General modelling procedure

Choice:

The modelling procedure depends on the following choice:

a. Normal runs. Do simulations for different locations, soil types and cropping systems but without adding new soil types or new weather information → Section 3.1
b. Add soil types or weather data. → Section 3.2

3.1 Procedure for normal runs

Steps:

1. Start FSEWin → Section 4.1
2. Open the CASE2 model → Section 4.2
3. Configure the CASE2 model → Chapter 5
4. Run the CASE2 model → Chapter 7
5. Obtain model output in:
   – table format → Chapter 8
   – chart format → Chapter 9
6. Export model output (optional)
   – table format → Chapter 8
   – chart format → Chapter 9
7. Close the CASE2 model and end FSEWin → Chapter 10

3.2 Procedure for runs with new soil or weather data

Steps:

1. Start FSEWin → Section 4.1
2. Open the CASE2 model → Section 4.2
3. Configure the CASE2 model → Chapter 5
4. Add new:
   – soil data → Section 6.1
   – weather data → Section 6.2
5. Run the CASE2 model → Chapter 7
6. Obtain model output in:
   – table format → Chapter 8
   – chart format → Chapter 9
7. Export model output (optional)
   – table format → Chapter 8
   – chart format → Chapter 9
8. Close the CASE2 model and end FSEWin → Chapter 10

4. Starting CASE2

Steps:		
1.	Start FSEWin	→ Section 4.1
2.	Start CASE2	→ Section 4.2

4.1 Starting FSEWin

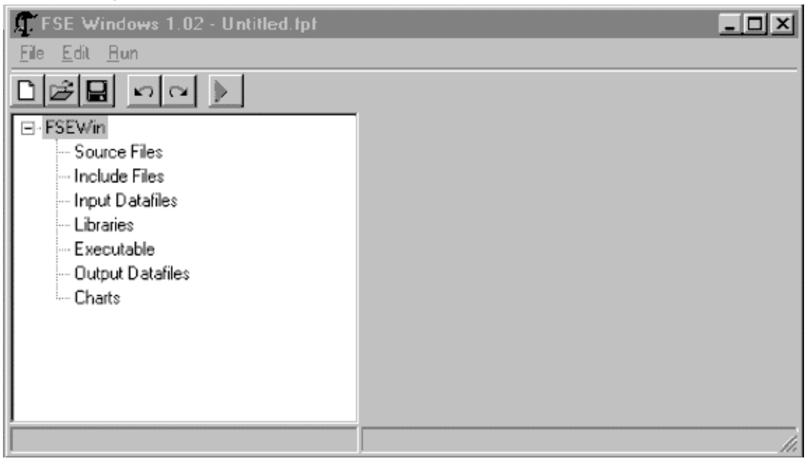
To start FSEWin:

➔ Double-click on the FSEWin button at the desktop

Or:

➔ Double-click on the FSEWin.exe file in the directory C:\Program Files\FSEWin\

FSE Windows will start, and you will see the FSEWin screen:



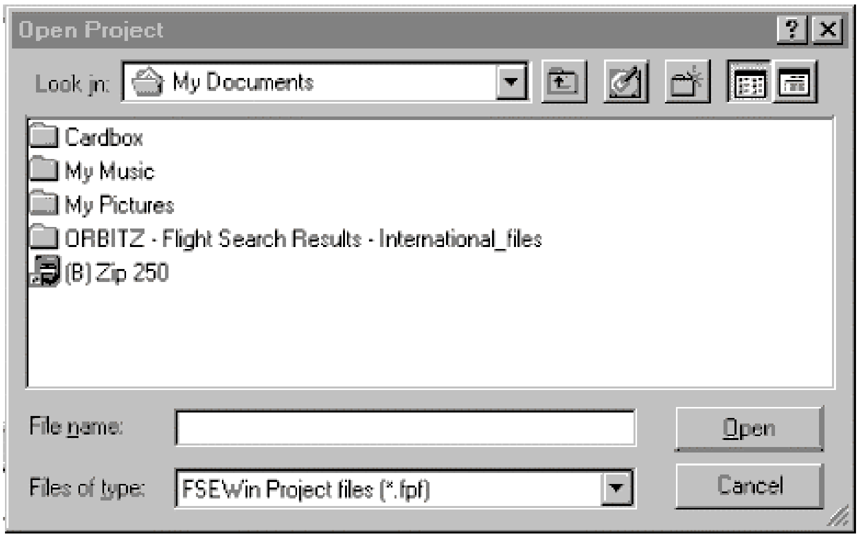
For explanation on the opening window and its menu's: → Section 4.3

4.2 Open the CASE2 model

To open the CASE2 model:

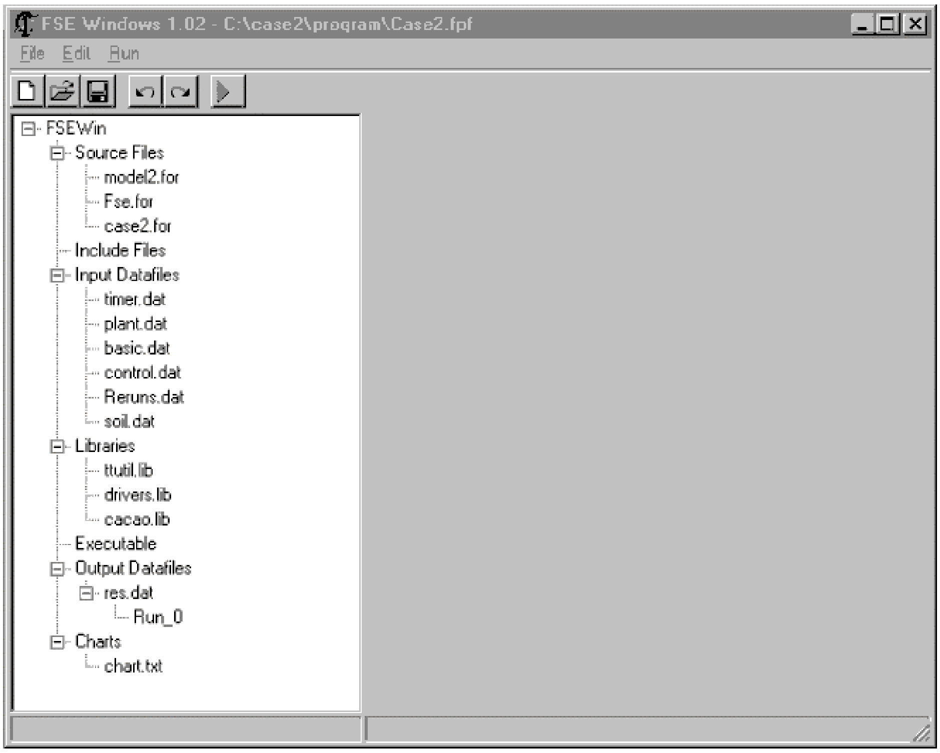
➔ Select "Open project" in the File menu, or Press Ctrl+O, or Click on .

The "Open Project" window appears:



- ➔ Select the case2.fpf in the C:\CASE2\program directory
- ➔ Click on "Open" or, double-click on the case2.fpf file

The case2.fpf is opened and the following screen appears:



All source files, input files, output files and libraries used for the CASE2 model are shown in the left pane. The following files should be present in the left pane of the FSEWin main screen:

Branch name	*File name*
Source Files:	model2.for, fse.for and case2.for
Include Files:	(none)
Input Datafiles:	timer.dat, plant.dat, basic.dat, control.dat, reruns.dat and soil.dat
Libraries:	ttutil.lib, drivers.lib, cacao.lib
Executables:	(none)
Output datafiles:	res.dat

Charts chart.txt

Now, the CASE2 model can be configured (specifying the location, soil type and cropping system) and can subsequently be run.

For instructions on configuring CASE2: → Chapter 5

4.3 The FSEWin main screen

4.3.1 Menu’s and icons

File menu

For use with CASE2 as described in this manual, only four options are used. Their functions are:

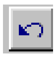
Open project:  Opens a project, for instance the CASE2 model. The project (with extension *.fpf) can be selected in the Open Project window that appears.

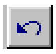
Print: Prints all text in the right pane of the FSE Windows screen to the default printer.

Save all:  Saves all files belonging to the project (all files that are shown in the left pane)

Exit: Exits FSEWin.

Edit menu

Undo:  Reverses the last change made in the text in the right pane. The 10 latest modifications in the text can be undone.

Redo:  Repeats the last change made in the text in the right pane. The 10 latest modifications can be redone.

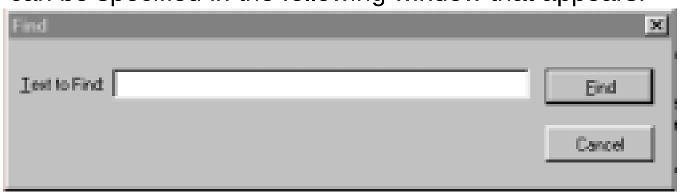
Cut: Removes the selected text from the text in the right pane and moves it to the clipboard for later use. (The text can be moved elsewhere using “Paste”).

Copy: Copies the selected text from the text in the right pane and moves it to the clipboard for later use. (The text can be moved elsewhere using “Paste”).

Paste: Inserts the contents of the clipboard at the position of the cursor in the text.

Select All: Selects all text in the right pane.

Find: Searches for characters or words in the text of the right pane. The search text can be specified in the following window that appears:



Click on “Find” to start the search.

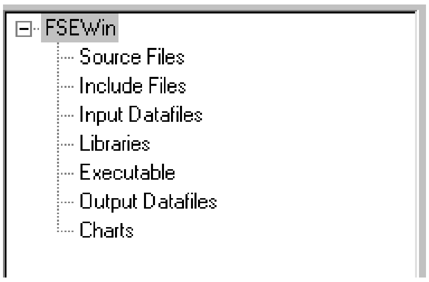
Find Next: Searches for the next appearance of the text specified in last search.

Run menu

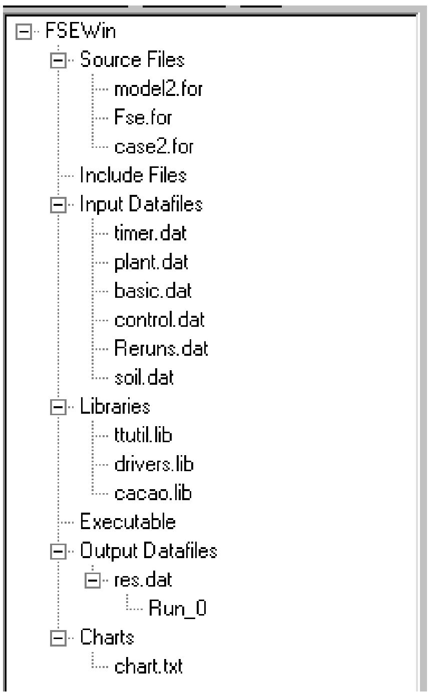
Run — Runs the model specified in the project, in this case the CASE2 model. A DOS screen is invoked in which the time coarse of the simulation can be followed.

4.3.2 Left pane

The left pane (screen part) of the FSEWin main screen contains a list of the files that are used for a certain project, in the case of CASE2 this is the case2 project. If no project is opened the left pane contains only file types:



In case the case2 project has been opened (see instructions in Section 4.2), it contains the names of the files:



Explanation of left pane contents:

⊟	Indicates that branch of the file tree is expanded (all files and file groups below this level are shown). To collapse this branch, click on the symbol
⊞	Indicates that branch of the file tree is collapsed (no files or file groups below this level are shown). To expand this branch, click on the symbol.
Source files	Branch containing the Fortran source files for the CASE2 model. **Fortran source files should not be edited.**
Include files	(Not used for the CASE2 model)

Input Datafiles — Branch containing the data files used by the CASE2 model. The basic.dat file is used to configure the CASE2 model. The reruns.dat file can be used to specify multiple model runs (reruns). Two others (soil.dat and timer.dat) can be used to add new soil or weather data.
The control.dat and plant.dat files should not be edited.

Libraries — Branch containing the library files used by the CASE2 model. The library files contain Fortran source files in a different format used by the model.

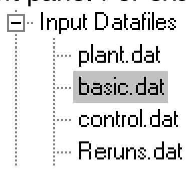
Executables — (Not used for the CASE2 model)

Output Datafiles — Branch containing a text file with all simulation results and tables with simulation results for each (re-)run separately.

Charts — Branch containing the chart.txt file which provides access to charts in the Chart screen.

4.3.3 Right pane

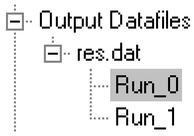
The right pane (screen part) of the FSEWin main screen contains the contents of the file selected in the left pane. Files can be selected in the left pane by clicking on the file name. The selected file is highlighted in the left pane. For example (basic.dat selected):



The selected file can be edited in the right pane by typing or removing text. The text editing options in the Edit menu can be used.

Note that only four data files can be edited: basic.dat, reruns.dat and part of soil.dat and timer.dat. The other files should *not* be edited. Changing values or text in other files may corrupt the model, impeding proper model functioning and making model output useless.

In case a “Run_” file is selected in the left pane:



the right pane contains the a table with model output for a specific run (Run 0 is the default run, Run 1 is the first rerun, etc..). For example:

TIME	AGEYR	WTOT	WTOTPP	WTRT	WLRT	WLV	WWD
365.000	5.1068	31516.	31.516	1629.4	4241.5	4971.8	19316.
730.000	6.1068	37737.	37.737	1904.1	5005.0	5742.0	23628.
1095.00	7.1068	39752.	39.752	1987.4	5233.7	6121.1	24940.
1461.00	8.1096	40148.	40.148	2005.1	5281.1	6185.6	25214.
1826.00	9.1096	40441.	40.441	2029.7	5338.0	6084.7	25595.
2191.00	10.110	40760.	40.760	2037.9	5371.8	6214.9	25726.
2556.00	11.110	41588.	41.588	2063.5	5444.5	6383.6	26134.

For more information on working with Tables: → Section 8.1

5. Configuring the CASE2 model

Steps:

1.	Specify the location	→ Section 5.1
2.	Specify the soil type	→ Section 5.2
3.	Specify the cropping system (shade level, age of cacao trees and cacao tree density)	→ Section 5.3
4.	Specify the "production level" (potential or water-limited)	→ Section 5.4
5.	Specify the output frequency	→ Section 5.5
6.	Specify reruns (optional)	→ Section 5.6

5.1 Specifying a location

Weather data for 37 locations in 10 countries are included in the program. There are three types of weather information: daily weather data, containing weather information on a daily basis and over a period of several years; monthly weather information containing average data for each month and for a period of several years; and long-term average weather data containing values for each month of the year averaged over the month and over a period of usually several decades. The following scheme explains some of the differences between the three types of weather data:

	Type of weather data		
	Daily weather	Monthly weather	Long-term weather
Data are specific for:	Each day during a certain period of years	Each month during a certain period of years	Each month (Jan-Dec), but not for a certain year.
Data are:	Actual values per day	Averages or totals per month, but specific for one year	Averages or totals per month, and also averaged for a number of years
Rainfall is:	Just read from the file for each day.	Distributed randomly over the days in a month depending on the number of rain days and total monthly rainfall.	Distributed randomly over the days in a month depending on the number of rain days and total monthly rainfall. The monthly total rain and rain days are furthermore randomly varied among simulation years (depending on the average values).
Simulations may be carried out:	For only the period for which data are available.	For only the period for which data are available.	For any period.

Daily weather information is available for 8 locations in 4 countries; monthly data for 10 locations in 4 countries and long-term averages for 19 locations in 8 countries. Table 5.1 lists the 18 locations for which daily and monthly weather information is included in the model. Table 5.2 contains information on the 19 locations for which long-term average weather data are available.

Table 5.1. List of locations for which daily or monthly weather data are included in the model. Nr refers to the LOCATION number in the basic.dat file. Start year, end year and period refer to the availability of climatic data. Type refers to the type of weather data for the location: d for daily weather data (CABO weather format) and m for monthly weather data (WOFOST format).

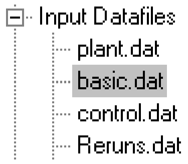
Nr	Country	Location name	Latitude [degr]	Longitude [degr]	Altitude [m]	Start year	End year	Period [y]	Type
1	Brazil	Maceio (Alagoas)	-9.67	-35.7	64.5	1961	1969	9	d
2	Costa Rica	El Carmen	10.2	-83.5	15	1974	1991	18	d
3	Costa Rica	La Lola	10.1	-83.4	40	1973	1990	18	d
4	Costa Rica	La Mola	10.4	-83.8	70	1980	1989	10	d
5	Costa Rica	Puerto Limon	10	-83.1	3	1970	1990	21	d
6	Ghana	Tafo	6.25	-0.4	200	1963	1997	35	m
7	Indonesia	Bah Lias	3.16	99.3	30	1979	1993	15	m
8	Ivory Coast	Abidjan	5.25	-3.93	6	1987	1996	10	m
9	Ivory Coast	Adiake	5.3	-3.3	39	1987	1995	9	m
10	Ivory Coast	Daloa	6.87	-6.4	277	1987	1996	10	m
10	Ivory Coast	Dimbokro	6.65	-4.7	92	1987	1996	10	m
11	Ivory Coast	Gagnoa	6.13	-5.95	214	1986	1997	12	m
12	Ivory Coast	Man	7.38	-7.52	340	1987	1996	10	m
13	Ivory Coast	San Pedro	4.75	-6.6	30	1987	1996	10	m
15	Malaysia	Telok Chengai	6.1	100.3	1	1978	1988	11	m
16	Papua New Guinea	Dami Oil Palm Research St.	-5.5	150	5	1970	1991	22	d
17	Philippines	IRRI wet station site	14.2	121.3	21	1979	1995	17	d
18	Philippines	Batac MMSU	18		18	1976	1995	20	d

Table 5.2. List of locations for which long-term weather data are included in the model. Nr refers to the LOCATION number in the basic.dat file.

Nr	Country	Station	Longitude [degr.]	Latitude [degr.]	Elevation [m]
51	Brazil	Belem	-48.47	-1.45	24
52	Brazil	Salvador	-38.33	-12.9	6
53	Brazil	Vitoria	-40.33	-20.32	36
54	Cameroon	Batouri	14.37	4.47	656
55	Cameroon	Douala	9.73	4	9
56	Colombia	Andagoya	-76.67	5.1	65
57	Colombia	Villavicencio	-73.62	4.17	423
58	Ghana	Hon	0.47	6.6	158
59	Ghana	Kumasi	-1.6	6.72	287
60	Ghana	Tafo	-0.4	6.25	200
61	Ivory Coast	Abidjan	-3.93	5.25	6
62	Ivory Coast	Gagnoa	-5.95	6.13	214
63	Ivory Coast	Man	-7.52	7.38	340
64	Malaysia	Kuala Trengganu	103.13	5.33	34
65	Malaysia	Penang	100.27	5.3	4
66	Malaysia	Sandakan	118.07	5.9	12
67	Malaysia	Tawau		5	150
68	Papua New Guinea	Madang	145.78	-5.22	4
69	Papua New Guinea	Rabaul	152.2	-4.22	4

The location for which simulations are carried out (and the corresponding type of weather data used) are selected in the basic.dat file. To do so:

➔ Click on the basic.dat file in the left pane of the FSE Windows main screen. This file is located in the "Input Datafiles" part of the tree:



The basic.dat file appears in the right pane of the screen

➔ Go to the following text in Part A of the file:

```
!--------------------------------!
! Location                       !
!--------------------------------!

* Specify location number
* Possible values:
* 1-50 for daily or monthly weather data (1-18 are included with program)
* >50  for long-term weather data (51-69 are included with program)
* For location numbers see the table at end of this file or in the Manual.
LOCATION = 15
```

➔ Specify the location for which you wish to run the CASE2 model by editing the number in the text "`LOCATION = <number>`". The `LOCATION` number corresponds to the number in Tables 5.1 and 5.2. Location numbers >50 indicate that long-term average weather data are used. Location numbers 1-50 (of which 1-18 are included in the program) indicate the use of daily or monthly weather data. An example: if "`LOCATION = 2`" simulations will be carried out for El Carmen in Costa Rica, using daily weather data. Note that the number should *not* be followed by a period (.).

➔ Go to the following text in Part A of the file:

```
!--------------------------------!
! Start and duration of simulation!
!--------------------------------!

* Specify the start year of the simulation (IYEAR) and the number of
* years for which simulations should be carried out.
* Possible values depend on the availability of weather data for the
* location specified above. Please check the Table in the User's Manual
* or the Table at the end of this file.
  IYEAR   = 1973
  NRYEARS = 10               ! [y]
```

➔ Specify the start year of the simulations by editing the number in the text "`IYEAR = <number>`"
For daily or monthly weather data (location numbers 1-50), the start year depends on the years for which data are available (check the availability of weather data for the location in Table 5.1 or the table at the end of the basic.dat file). For long-term weather data (location numbers >50): enter the value 1000.

➔ Specify the duration of the simulations by editing the number in the text "`NRYEARS = <number>`"
For daily or monthly weather data (location numbers 1-50), the possible duration of the simulation depends on the period for which weather data are available and on the start year (check the availability of weather data for the location in Table 5.1 or the table at the end of the basic.dat file). For long-term weather data (location numbers >50): any number of years may be entered (with a maximum of 37 years as the minimum and maximum ages of simulated trees are 3 and 40 years, respectively).

An example: in case `LOCATION = 2` the values of IYEAR should not be smaller than 1974 and the value of NRYEARS may in any case not be larger than 18. If for this location 1980 is chosen as start year (IYEAR) the simulation period (NRYEARS) may not exceed 12. Note that the numbers for IYEAR and NRYEARS should *not* be followed by a period (.).

Now, a soil type can be specified: → Section 5.2

If you wish to add weather data for a new location: → Section 6.2

5.2 Specifying a soil type

Information on soil texture for three soil types is included in the CASE2 model. The characteristics of these soil types is described in Table 5.3. Only texture characteristics of the soil types are used by CASE2 (nutrient limitation is not included in the model). Soil type 1 is a loamy soil with favourable water-holding capacity. Soil type 2 is a sandy soil, soil type 3 a clayey soil. Both have a lower water-holding capacity than soil 1. (Most simulations of which results are presented in the Zuidema & Leffelaar (2002) report are carried out using soil type 1.)

One of the 3 locations should be selected in the basic.dat file. To do so:

- ➔ Open the basic.dat file as described in Section 5.1.
- ➔ Go to the following text in Part A of the file:

```
!--------------------------------!
! Soil type                      !
!--------------------------------!

* Specify the soil type.
* Possible values: 1-3 for standard soil types (1=Loamy soil,2=Sandy
* soil, 3=Clayey soil, 4-8 for user-defined soils)
  SOILTYPE = 1
```

- ➔ Specify the soil type for which you wish to run the CASE2 model by editing the number in the text "`SOILTYPE = <number>`". The `SOILTYPE` number corresponds to the number in Table 5.2 An example: "`SOILTYPE = 2`". Note that the number should *not* be followed by a period (.).

Now, the production level can be specified: → Section 5.3

If you wish to add soil data for a new soil type: → Section 6.1

Table 5.3. A comparison of the characteristics of three soil types of which texture information is available with the CASE2 model. Soil 1 (SOILTYPE =1) is a loamy soil, data from Nigeria (Wessel 1971). Soil 2 (SOILTYPE = 2) is a sandy soil present in cocoa planting areas in Rondonia, Brazil. Soil 3 (SOILTYPE = 3) is a clayey soil present in a plantation in Tawau, Sabah, Malaysia (Table Estate). The percentages sand, silt and clay given for these soils are translated into texture classes on the basis of the sand-silt-clay triangle (see for example Driessen 1986). Texture class numbers refer to the Driessen texture classes: 1= Coarse sand; 7= Loamy medium coarse sand; 8= Loamy fine sand; 9= Sandy loam; 12= Silt loam; 14= Sandy clay loam; 17= Light clay; 19= Heavy clay. Water content at field capacity (pF=2.0) and wilting point (pF=4.2) are calculated using the water retention curve (Driessen 1986). Sources: Soil 1 (Wessel, 1971), Soil 2 (Table 3.8 in Wood & Lass 1985), Soil 3 (Table 3.17 in Wood & Lass 1985).

Soil layer	Depth of layer [cm]			Texture class			Water content at					
							field capacity [cm^3 cm^{-3}]			wilting point [cm^3 cm^{-3}]		
	Soil 1	*Soil 2*	*Soil 3*	*Soil 1*	*Soil 2*	*Soil 3*	*Soil 1*	*Soil 2*	*Soil 3*	*Soil 1*	*Soil 2*	*Soil 3*
1	10	9	2	12	1	12	0.359	0.065	0.359	0.108	0.0001	0.108
2	30	14	54	9	7	17	0.273	0.180	0.378	0.044	0.031	0.204
3	30	12	48	8	9	19	0.233	0.273	0.493	0.027	0.044	0.361
4	150	119	52	8	14	19	0.233	0.349	0.493	0.027	0.168	0.361

5.3 Specifying production level

Simulations in CASE2 can be carried out for a *potential* situation without water limitation and for a *water-limited* situation. In the latter case the growth and production of the cocoa crop is limited by the availability of water in the soil (which depends on rain fall, evapotranspiration and soil characteristics). Note that for both situations, nutrients are not limiting. This so called “Production level” can be specified for each simulation.

The production level should be specified in the basic.dat file. To do so:

- ➔ Open the basic.dat file as described in Section 5.1.
- ➔ Go to the following text in Part A of the file:

```
!--------------------------------!
! Potential or water-limited      !
!--------------------------------!

* Specify whether simulations should be carried out for a potential
* or water-limited situation.
* Possible values: 1=Potential; 2=Water-limited
  PRODLEVL = 2
```

- ➔ Specify the production level: 1 = potential production; 2 = water-limited production. Edit the number in the text “`PRODLEVL = <number>`”. Note that the number should *not* be followed by a period (.).

Now, the output frequency can be specified: → Section 5.4

5.4 Specifying output frequency

The output of CASE2 simulations may be generated at different intervals: annually, 10-daily or daily. Depending on the output frequency, different sets of parameters will be included in the model output.

The output frequency should be specified in the basic.dat file. To do so:

- ➔ Open the basic.dat file as described in Section 5.1.

➔ Go to the following text in Part A of the file:

```
!--------------------------------!
! Output frequency               !
!--------------------------------!

* Specify the frequency at which output is generated in table and
* graph format.
* Possible values: 1=annual output; 2=10-day output; 3=daily output
  OUTPUTFQ = 2
```

➔ Specify the output frequency: 1 = annual output; 2 = output each 10 days; 3 = daily output. Edit the number in the text "`OUTPUTFQ = <number>`". Note that the number should *not* be followed by a period (.).

Now, the cropping system can be specified: → Section 5.5

5.5 Specifying the cropping system and pod characteristics

5.5.1 Cropping system

Several characteristics of the cocoa cropping system can be specified in the CASE2 model to study the effects on cocoa growth and yield. These attributes are specified in Part B of the basic.dat file.

To change the cropping system settings:

➔ Open the basic.dat file as described in Section 5.1.

➔ Go to Part B of the file:

```
!=====================================================================!
!                                                                     !
! PART B. Specify cropping system characteristics here                !
!         (planting density, cacao tree age and shade tree information)!
!                                                                     !
!=====================================================================!
```

➔ And to the cropping system heading:

```
!--------------------------------!
! Cropping system                !
!--------------------------------!
```

To change the planting density of cacao trees in the simulated plantation:

➔ Go to the following text:

```
* Specify density at which cacao trees are planted in trees per ha.
* Possible values: 700.-2500. Note that number should be followed
* by a period sign (e.g. "1000.").
  NPL    = 1000.             ! [trees ha-1]
```

➔ Specify the planting density in number of cacao trees per ha, within the range of 700-2500. The standard value used in most simulations reported in Zuidema & Leffelaar (2002) is 1000 ha^{-1}. Make sure that the value contains a period, e.g. "1000.".

Several characteristics of the shade trees in the simulated plantation can be changed by the user. To change the leaf area index (the number of leaf layers per unit ground area; in ha leaves ha^{-1} ground):

➔ Go to the following text:

```
* Specify leaf area index (LAI) of shade trees in ha leaf per ha ground.
* Possible values: 0.-3. Note that number should include
* a period sign (e.g. "1." or "0.2").
```

```
  SLAI  = 0.2               ! [ha leaf ha-1 ground]
```

- ➔ Specify the leaf area index for shade trees in ha leaves per ha soil, within the range of 0.0 (unshaded) – 3.0 (heavily shaded). The standard value used in most simulations reported in Zuidema & Leffelaar (2002) is 0.2 ha leaves ha^{-1} ground. Make sure that the value contains a period, e.g. "1.5".

Note that the level of shading is determined by both the leaf area index and the extinction coefficient of the shade trees. The level of shading increases with increasing values of both parameters. For more background information, see Zuidema & Leffelaar (2002).

To change the extinction coefficient for the leaves of the shade trees (this is the proportion of light intercepted by one layer of leaves):

- ➔ Go to the following text:

```
* Specify extinction coefficient for shade trees.
* Possible values: 0.4 - 0.8.
  SKDFL = 0.6               ! [-]
```

- ➔ Specify the extinction coefficient for shade trees, within the range of 0.4 (low light absorption and high light transmission) – 0.8 (high light absorption and low transmission). The value for oil palms is typically 0.44. That of most shade trees is between 0.6-0.7. The standard value used in most simulations reported in Zuidema & Leffelaar (2002) is 0.6. Make sure that the value contains a period, e.g. "0.44".

Note that the level of shading is determined by both the leaf area index and the extinction coefficient of the shade trees. The level of shading increases with increasing values of both parameters. For more background information, see Zuidema & Leffelaar (2002).

To change the total and lower height of the shade tree canopy:

- ➔ Go to the following text:

```
* Specify height of the shade tree canopy in m. SHGHL for height of lower
* canopy boundary; SHGHT for height of upper canopy boundary
* Possible values: 0.-40. Note that number should include
* a period sign (e.g. "5." or "7.5").
* Note that SHGHL should be less than SHGHT
  SHGHL = 4.0               ! [m] Lower height of shade tree crowns
  SHGHT = 10.               ! [m] Upper height of shade tree crowns
```

- ➔ Specify the lower height (SHGHL) and total height (SHGHT) of the shade tree canopy in meters. The lower height may not be larger than the total height and both heights should not exceed 40 m (higher values are unrealistic). The standard value used in most simulations reported in Zuidema & Leffelaar (2002) is 4.0 m for the lower height and 10 meter for the upper height. Make sure that the value contains a period, e.g. "4.0".

Note that in the CASE2 model, canopies of cacao trees and shade trees may overlap, as is the case in real cacao plantations in some cases. Canopies overlap when the range of lower and total height of the shade tree overlaps with that of the cacao tree (see instructions below in Section 5.5.2).

5.5.2 Cacao tree input

Several characteristics of the cacao tree can be specified in the CASE2 model to study the effects on cocoa growth and yield. These attributes are specified in Part B of the basic.dat file.

To change the cacao input settings:

- ➔ Open the basic.dat file as described in Section 5.1.
- ➔ Go to Part B of the file:

```
!=====================================================================!
!                                                                     !
! PART B. Specify cropping system characteristics here                !
!         (planting density, cacao tree age and shade tree information)!
!                                                                     !
!=====================================================================!
```

➔ And to the cacao tree heading:

```
!--------------------------------!
! Cacao tree                     !
!--------------------------------!
```

Model simulations should start with a cacao tree of a certain size or age. A switch parameter determines whether size or age is used as input for model initialisation.
To specify the age-size switch:

➔ Go to the following text:

```
* Specify whether tree size or age is used for initial input
* Both plant size (biomass) and plant age can be used as input.
* The switch parameter SWINPUT determines which of the two is used.
* Possible values: 1=age is used as input; 2=size is used as input.
  SWINPUT = 1                !{-}
```

➔ Specify the switch by putting 1 in case the initial age will be used as input or 2 in case the initial biomass (dry weight) will be the input. Make sure that the value does *not* contain a period, e.g. "1".

Depending on the choice for SWINPUT, either the initial tree age (SWINPUT = 1) or the initial tree biomass (SWINPUT = 2) should be specified.
If SWINPUT = 1, specify the initial tree age:

➔ Go to the following text:

```
* Specify initial tree age in years.
* Note: this value is only used in case SWINPUT = 1
* Possible values: 3. - 40. Note that number should include
* a period sign (e.g. "5." or "12.5").
  AGEIYR  = 4.11             ! [y]
```

➔ Specify the initial age in years. The value should be within the range of 3-40 y, as the model does not perform well at lower or higher ages. The value used in many of the simulations reported in Zuidema & Leffelaar (2002) is 4.11 y (or 1500 days). Make sure that the value contains a period, e.g. "5.".

If SWINPUT = 2, specify the initial tree age:

➔ Go to the following text:

```
* Specify initial tree size (biomass per tree).
* Note: this value is only used in case SWINPUT = 2
* Possible values: 18.5 - 70.0. Note that number should include
* a period sign (e.g. "20." or "22.5").
  WTOTI   = 18.5            ![kg DW tree-1]; NOTE: Minimum size=18.5 kg
```

➔ Specify the initial total biomass in kg dry weight. The value should be within the range of 18.5-70 kg, as the model does not perform well at lower or higher weights. Make sure that the value contains a period, e.g. "20.".

5.5.3 Pod characteristics and processing

Several characteristics related to the pods and processing of beans may be changed in the CASE2 model to study their effects on cocoa growth and yield. These attributes are specified in Part B of the basic.dat file.

To change the pod and processing characteristics:

- ➔ Open the basic.dat file as described in Section 5.1.
- ➔ Go to Part B of the file:

```
!=====================================================================!
!                                                                     !
! PART B. Specify cropping system characteristics here                !
!         (planting density, cacao tree age and shade tree information)!
!                                                                     !
!=====================================================================!
```

- ➔ And to the pod characteristics and processing heading:

```
!----------------------------------!
! Pod characteristics and processing !
!----------------------------------!
```

Nib fat content has an influence on the assimilate requirements ("costs") to produce a kg of cacao beans (assimilate requirements increase with increasing fat content). The effect of fat content on bean yield can be investigated by changing the fat content value.

To change the fat content:

- ➔ Go to the following text:

```
* Specify the fat content of nibs
* The standard value is 0.55 (Wood and Lass 1985)
  FATCONTENT = 0.55                         ![-]
```

- ➔ Specify the fat content within the range of 0.5-0.6. The standard value used in all simulations reported in Zuidema & Leffelaar (2002) is 0.55.

The fraction beans in one pod may vary among cacao varieties and cultivars. The effect of this fraction on beans yield can be investigated by changing its value.

To change the fraction beans per pod:

- ➔ Go to the following text:

```
* Specify the fraction of beans per pod
* The standard value is 0.55
  FBEANS = 0.55                             ![-]
```

- ➔ Specify the fraction beans. The standard value used in all simulations reported in Zuidema & Leffelaar (2002) is 0.55.

The pod index or pod value denotes the number of pods required for one kg of beans. In the model, this value has an effect on the amount of pods produced (HARPODS).

To change the pod value:

- ➔ Go to the following text:

```
* Specify the pod index or pod value
* This is the number of pods needed for one kg of dry beans
* The standard value is 30.
  PODVALUE = 30.                            ![kg-1 DW]
```

- ➔ Specify the pod value. The standard value used in all simulations reported in Zuidema & Leffelaar (2002) is 30. Other values range from 16-24 (Wood & Lass 1985, Teoh *et al.* 1986, Yapp & Hadley 1994).

During fermentation, the dry weight of beans decreases. The degree to which weight is lost depends on the duration of the fermentation period.

To change the length of the fermentation period:

- ➔ Go to the following text:

```
* Specify the fermentation duration in hours.
* The standard value is 5.(Humphries, 1944)
```

```
  FMTDUR   = 5.                            ![d]
```

- ➔ Specify the fermentation duration in days. The value should be within the range of 1-10 days. The standard value used in all simulations reported in Zuidema & Leffelaar (2002) is 5 days.

Dry and fermented beans in reality still contain a certain percentage of moisture. The dry weight of beans calculated in CASE2 should be changed to account for the bean moisture content.
To change the moisture content of dry beans:

- ➔ Go to the following text:

```
* Specify the moisture content of the beans
* The standard value is 0.075 (Wood & Lass 1985)
  MOISTC  = 0.075                          ![-]
```

- ➔ Specify the moisture content as a fraction. The value should be within the range of 5-8 %. The standard value used in all simulations reported in Zuidema & Leffelaar (2002) is 0.075.

5.6 Specifying reruns

With the standard model run procedure in CASE2, one simulation run is carried out at a time, using one set of input parameters. Using the reruns option, several model runs can be carried out using different values for certain input parameters. For instance, shade levels can be varied at three levels, or model runs can be carried out for different soil types. When reruns are done, several sets of output parameters are generated and model output of these runs can be compared in tables and combined in charts.

Reruns are specified in the reruns.dat file by putting the value of one or more input parameters (see instructions below). For each of the reruns specified in reruns.dat, an extra model run is performed. Thus, after the run using values specified in the basic.dat file as many extra runs as specified in reruns.dat will be performed. The output of the first default run is called “Run 0”, the output for the reruns “Run 1” for the first specified rerun, “Run 2” for the second, etc. For each run, a separate table with results is produced. Output of several runs can be combined in one chart using the Runs-tab in the chart screen (see Section 9.3 for instructions).

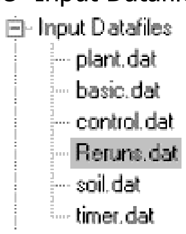
For instruction on the use of the example reruns → Section 5.6.1
For instruction on specifying new reruns → Section 5.6.2

5.6.1 Using the example reruns

The reruns.dat file delivered with the CASE2 model already contains some example reruns.

To specify reruns, first open the reruns.dat file:

- ➔ Click on the reruns.dat file in the left pane of the FSE Windows main screen. This file is located in the “Input Datafiles” part of the tree:



The reruns.dat file appears in the right pane of the screen

➔ Go to Part A of the file:

```
!======================================================================!
!                                                                      !
! PART A. EXAMPLE RERUNS                                               !
!          To use one of the example reruns, simply remove the “*”-sign !
!          at the start of the line. Do not forget to place an “*” again!
!          when you do not wish to do reruns for that parameter.        !
!======================================================================!
```

To carry out a rerun with a different production level:

➔ Go to the following text:

```
!---------------------------------!
! Production level                !
!---------------------------------!
*When removing the * in the below line, an extra run will be performed
*for PRODLEVL = 1 (potential production).
*PRODLEVL = 1
```

➔ Remove the “*” sign from the last line of the above text. Make sure that there are no other lines without a “*” sign as in this case more reruns will be done. To de-activate a line in the reruns.dat file, put an “*” sign as the first character of the line.

To carry out reruns with different soil types:

➔ Go to the following text:

```
!---------------------------------!
! Soil type                       !
!---------------------------------!
*When removing the * in the below lines, 2 extra runs will be performed
*for SOILTYPE = 2 and 3 (sandy and clayey soils).
* SOILTYPE = 2
* SOILTYPE = 3
```

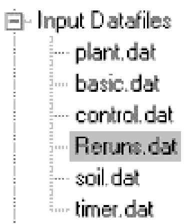
➔ Remove the “*” signs from the last two lines of the above text. Make sure that there are no other lines without a “*” sign as in this case more reruns will be done. To de-activate a line in the reruns.dat file, put an “*” sign as the first character of the line.

5.6.2 Specifying new reruns

New reruns may be specified in reruns.dat file. Follow the instructions below or use one of the example reruns as guidance.

To specify new reruns, first open the reruns.dat file:

➔ Click on the reruns.dat file in the left pane of the FSE Windows main screen. This file is located in the “Input Datafiles” part of the tree:



The reruns.dat file appears in the right pane of the screen.

➔ Go to Part B of the file:

```
!======================================================================!
!                                                                      !
! PART B. USER-DEFINED RERUNS                                          !
```

```
!         To add a user-defined rerun, simply write one line of the    !
!         type:     <PARNAME> = <VALUE>                                !
!         in which <PARNAME> is the name of an input parameter and     !
!         <VALUE> is the value for which a rerun is wanted.            !
!         To de-select the rerun, simply put an "*" mark in front of   !
!         the line. More instructions in the User's manual             !
!==============================================================!
```

- ➔ Go to a new line below the above text.
- ➔ Put a "*" sign followed by an explanation of the input parameter used for this rerun.

For example, if the rerun is carried out for different initial cacao tree age:

```
* Reruns for different start age (AGEYR)
```

- ➔ Go to the next line
- ➔ Put the name of the input parameter, followed by a "=" sign and the value for the input parameter. For example, if the rerun is carried out for different initial cacao tree age:

```
AGEIYR = 10.
```

Any input parameter that is used in the basic.dat file can be used for a rerun. Note that for some input parameters, a period should be included in the value (e.g. for AGEIYR: "10." is correct, but "10" is not), whereas for others no period should be included (e.g. for PRODLEVL: "1" is correct but "1." is not). It is recommended to check whether the value for the input parameter specified in the reruns.dat file is actually different from that in the basic.dat file. If this is not the case, the output of the two reruns will be exactly the same.

- ➔ Repeat the instructions in the above two paragraphs in case you wish to carry out more than one rerun. For example, if the rerun is carried out for three different ages:

```
AGEIYR = 10.
AGEIYR = 15.
AGEIYR = 20.
```

More input parameters can be changed for one rerun. To do so, put two or more statements for input parameters on the same line. Separate statements with a ";". For example:

```
SOILTYPE = 2.; PRODLEVL = 2
SOILTYPE = 3.; PRODLEVL = 2
SOILTYPE = 1.; PRODLEVL = 1
```

In this case, three reruns will be carried out: one for soil type 2 under water-limited conditions, one for soil type 3 under water-limited conditions and one for soil type 1 for potential production (not water-limited).

When combining input parameters in reruns, all input parameters should be included in each of the rerun lines. The following rerun specification is **wrong**:

```
SOILTYPE = 2.
SOILTYPE = 3.
SOILTYPE = 1.; PRODLEVL = 1
```

6. Adding new soil or weather data

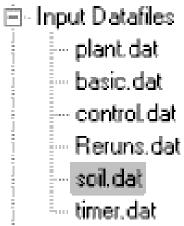
Choice:	
1. Add a new soil type	→ Section 6.1
2. Add weather data for a new location	→ Section 6.2

6.1 Adding a new soil type

New soil types may be added to the soil.dat data file. Three types of parameters should be specified for a soil type: the number of soil layers; the thickness of all soil layers and the texture type (following the Driessen texture classes) per soil layer. Note that the total soil depth (the sum of the thickness of all layers should not be smaller than 1.5 m. It is recommended to keep the number of layers between 3-6 layers, as a lower or higher number of layers may result in unrealistic simulation of the soil water balance.

To add a soil type:

➔ Click on the soil.dat file in the left pane of the FSE Windows main screen. This file is located in the "Input Datafiles" part of the tree:



The soil.dat file appears in the right pane of the screen.

➔ Go to Part A of the file:

```
!====================================================================!
!                                                                    !
! PART A. Information may be added to this part of the file.         !
!         Please follow the instructions in the User's Manual        !
!                                                                    !
!====================================================================!
```

➔ And then to the first soil type for which only zero's are specified as parameter values (in the standard soil.dat file delivered with the CASE2 model, this is Soil type 4):

```
* < specify type of soil and information source here >
* < specify country and area here >
NL4    = 0                      ! Number of layers
TKL4   = 0., 0., 0., 0.         ! Thickness of layers (m)
TYL4   = 0., 0., 0., 0.         ! Driessen texture classes for layers
```

➔ Specify the type of soil and the information source in the first line. Specify the country and area from which the data were obtained, if applicable, on the second line. The "*" sign should be maintained at the first position on both lines to prevent model errors. For instance:

```
* Clayey soil taken from Wood & Lass(1985), Table 3.17
* Malaysia, Tawau
```

➔ Change the "0" value for the NL.. parameter to the right number of soil layer.

➔ Specify the thickness of the soil layers (in meter) following "TKL.. = " by replacing the zero values. The first value is for the uppermost (top) soil layer. Make sure that each value contains a period, e.g. "1.0". Note that the sum of all soil layers should be at least 1.5 m. A reasonable build-up of soil layers is 0.15, 0.25, 0.50 and 0.60 cm thickness for the first through the fourth layer, but this may be adapted to the horizons observed in the field.

- ➔ Specify the texture type for the layers following "TYL.. = " by replacing the zero values. The first value is for the uppermost (top) soil layer. Make sure that each value is followed by a period, e.g. "9.0". A list with possible types is included in Table 6.1.

Now, save the changes to the timer.dat file:

- ➔ Press the button, or select "Save all" in the File menu, or press Ctrl+S

Table 6.1. Description and characteristics of Driessen soil texture types as used in the soil.dat file. The code refers to the value of the TYL.. parameter. Gamma (γ) is a texture-specific constant describing the water-retention curve (Driessen 1986). Water content is the volumetric percentage of water in the soil at different amounts of suction pressure. Source: Driessen 1986.

Code	Description	Gamma	Water content at			
			Saturated	field capacity	wilting point	air dry
1	Coarse sand	0.0853	39.5%	6.5%	0.0%	0.0%
2	Medium coarse sand	0.045	36.5%	14.1%	0.5%	0.0%
3	Medium fine sand	0.0366	35.0%	16.1%	1.1%	0.0%
4	Fine sand	0.0255	36.4%	21.2%	3.3%	0.0%
5	Humous loamy medium coarse sand	0.0135	47.0%	35.3%	13.3%	1.4%
6	Light loamy medium coarse sand	0.0153	39.4%	28.5%	9.4%	0.7%
7	Loamy medium coarse sand	0.0243	30.1%	18.0%	3.1%	0.1%
8	Loamy fine sand	0.0299	43.9%	23.3%	2.7%	0.0%
9	Sandy loam	0.0251	46.5%	27.3%	4.4%	0.1%
10	Loess loam	0.0156	46.5%	33.4%	10.8%	0.8%
11	Fine sandy loam	0.0186	50.4%	34.0%	8.8%	0.4%
12	Silt loam	0.0165	50.9%	35.9%	10.8%	0.7%
13	Loam	0.0164	50.3%	35.5%	10.8%	0.7%
14	Sandy clay loam	0.0101	43.2%	34.9%	16.8%	3.1%
15	Silty clay loam	0.0108	47.5%	37.8%	17.3%	2.9%
16	Clay loam	0.0051	44.5%	39.9%	27.6%	11.8%
17	Light clay	0.0085	45.3%	37.8%	20.4%	5.0%
18	Silty clay	0.0059	50.7%	44.7%	29.2%	10.9%
19	Heavy clay	0.0043	54.0%	49.3%	36.1%	17.7%
20	Peat	0.0108	86.3%	68.6%	31.4%	5.2%

6.2 Adding weather data for a new location

Weather data for new locations can be used by the CASE2 model. Three types of weather data may be used: (1) daily weather, (2) monthly weather data and (3) long-term weather data. Daily weather data (CABO weather format) contain information on rainfall, radiation, vapour pressure and temperature for every day. Monthly data (WOFOST weather format) contain average values for radiation, temperature, vapour pressure and total values for rainfall for one month. In the latter case, the monthly summary values are used to generate daily values for all weather parameters (using interpolation in the case of monthly averages and random generation of daily values in the case of rainfall). In both cases, weather data should be available for a number of consecutive years, preferably 10 or more years. For long-term weather data, on the other hand, the information is not specific for one year but an average over a (large) number of years. The average values are valid for one month. Thus, 12 values are included for each weather parameter.

For the three types of weather data, there are certain physical boundaries defined for the model. Altitude should not exceed 1400 m; average day temperature should not be outside the 10-40ºC range and average annual precipitation should be higher than 1250 mm yr^{-1}.

Weather data are stored in separate data files. For daily weather data, one year of weather information is stored in one file. For monthly weather data, the information of all years is stored in one file. For long-term weather data, the information is also stored in one file. To add weather data to the CASE2 model, data files containing the actual data should be available and placed in the correct directory. Secondly, reference to the new weather files should be made in the timer.dat file.

For instructions on adding daily weather data → Section 6.2.1
For instructions on adding monthly weather data → Section 6.2.2
For instructions on adding long-term weather data → Section 6.2.3

6.2.1 Daily weather

To add new daily weather data, a text file (ASCII format) should be made for each year. The extension of the file name are the three last numbers of the year (e.g. .989 for the year 1989). File names should be build from a country code in 3 letters (e.g. idn or Indonesia) and a station number of one or two numbers (e.g. 24). Official country codes can be found in Stol (1994). The weather file for weather station 24 in Indonesia for the year 1989 would then be: “idn24.989”. Daily weather data files should be stored in the c:\case2\weather\daily directory.

A daily weather data file for one year should contain the following information in the following order:

File header: a continuous block of lines that start with a <*> in the first column. The file header contains general information about the data and their origin.

line 1: (the first line below the header) the longitude, latitude, altitude for the site and the coefficients A and B for the Angstrom formula. The last two parameters are only required when global radiation is derived from sunshine duration. Put values 0.0 in case the Angstrom coefficients should not be used.

line 2-367: daily weather data; one line per day.

in these lines: Column 1: station number
Column 2: year
Column 3: Julian day number
Column 4: irradiation (kJ m^{-2} d^{-1}) or sunshine duration (h d^{-1})
Column 5: minimum temperature (°C)
Column 6: maximum temperature (°C)
Column 7: early morning vapour pressure (kPa)
Column 8: mean wind speed at 2 m above ground level (m s^{-1})
Column 9: precipitation (mm d^{-1})

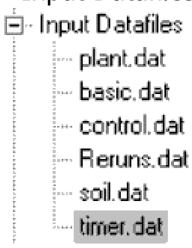
Notes:
- The values should be separated by at least one space character.
- Day numbers range from 1-365, and in the case of leap years to 366
- Missing values should be indicated by the value “-99”; some missing values are allowed (see van Kraalingen et al. 1990). Wind speed may be missing as it is not used in CASE2.

An example of part of a daily weather data file for Bah Lias Estate (North Sumatra, Indonesia) is shown below:

```
*-----------------------------------------------------------*
*   Country: Indonesia
*   Station: Bah Lias
*      Year: 1989
…
*-----------------------------------------------------------*
99.3  3.16  30.0  0.00  0.00
 3  1989   1  10627  21.7  28.9  2.757  1.01    0
 3  1989   2  13190  22.4  30.9  2.923  0.74    0
 3  1989   3  12046  23.3  31.3  3.034  0.57    9
 .
 .
 .
 3  1989 364  16146  21.9  30.8  2.851  1.08    4
 3  1989 365  17413  22.7  32.1  2.979  0.90   25
```

Reference to the new weather files should be made in the timer.dat file:

- ➔ Click on the timer. dat file in the left pane of the FSE Windows main screen. This file is located in the "Input Datafiles" part of the tree:



The timer.dat appears in the right pane of the screen.

- ➔ Go to the location specification heading in Part A of the file:

```
!========================================================================!
!                                                                        !
! PART A. Information may be added to this part of the file.             !
!         Please follow the instructions in the User's Manual            !
!                                                                        !
!========================================================================!
!----------------------------------!
! Location specifications          !
!----------------------------------!
```

- ➔ And then below the " Daily or monthly weather data" heading to the first location number for which only zero's are specified as parameter values (in the standard timer.dat file delivered with the CASE2 model, this is Location 19):

```
* LOCATION 19
* < specify location name and period of weather data here >
  WTRDIR19 = ' '
  CNTR19   = ' '
  CLFILE19 = ' '
  ISTN19   = 0
  IWEATH19 = 0
  IRNDAT19 = 0
  STRTYR19 = 0
  ENDYR19  = 0
```

- ➔ Specify the weather directory between quotation marks. This should be:
  `WTRDIR19 = 'c:\case2\weather\daily'`
- ➔ Specify the country code (CNTR..), that is, the first three letters of the file names for this weather station. For instance idn if the file name is idn24.989:
  `CNTR19 = 'idn'`
- ➔ The following line (for CLFILE..) can be skipped, as this does not apply to daily weather data. Leave the text as is:
  `CLFILE19 = ' '`

- ➔ Specify the station number (ISTN..), that is, the first three letters of the file names for this weather station. For instance 24 if the file name is idn24.989:
  `ISTN19 = 24`
- ➔ Specify the type of weather data (IWEATH..). This should be 2 for daily weather data:
  `IWEATH19 = 2`
- ➔ Specify the type of rainfall data (IRNDAT..). This should be 2 for daily weather data:
  `IRNDAT19 = 2`
- ➔ Specify the first year of the consecutive period for which weather data are available (STRTYR..). For instance 1989:
  `STRTYR19 = 1989`
- ➔ Specify the last first year of the consecutive period for which weather data are available (STRTYR..). For instance 1999:
  `ENDYR19 = 1999`

Now, save the changes to the timer.dat file:

- ➔ Press the  button, or select "Save all" in the File menu, or press Ctrl+S

6.2.2 Monthly weather

To add new monthly weather data, one text file (ASCII format) should be made including weather data for all years. The extension of the file name is usually *.wof. File names should preferably not exceed 8 characters (e.g. indjava.wof or indo24.wof). Monthly weather data files should be stored in the c:\case2\weather\monthly directory.

A monthly weather data file for should contain the following information in the following order:
Line 1: name and number of the weather station (comment line)
line 2: year of observation, latitude of location, altitude of the location
line3-14: average monthly weather data; one line per month, from January to December
in these lines: Column 1: minimum temperature (°C)
Column 2: maximum temperature (°C)
Column 3: irradiation (MJ m^{-2} d^{-1})
Column 4: vapour pressure (hPa[mbar])
Column 5: windspeed (m s^{-1})
Column 6: precipitation (mm month^{-1})
Column 7: number of rain days (month^{-1})

Notes:
- The values should be separated by at least one space character.
- Temperatures, irradiation, vapour pressure and windspeed are monthly averages
- Rainfall is the monthly total
- Number of rain days is the actual number of rain days per month
- Missing values are not allowed, except for wind speed as this is not used in CASE2

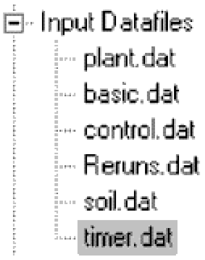
An example of part of a monthly weather data file for Gagnoa in Ivory Coast is shown below:

```
Côte d'Ivoire/Gagnoa
1987     6.06    214.00
19.70    33.30   15.16   28.07   0.00    14.     4.
22.00    34.49   15.88   27.00   0.00    105.    9.
22.13    33.31   17.57   28.40   0.00    109.    10.
22.04    32.98   17.77   30.18   0.00    192.    12.
22.50    31.94   17.08   29.86   0.67    87.     11.
21.92    30.22   13.43   28.89   1.00    148.    12.
21.39    28.85   14.25   25.97   0.67    69.     11.
21.31    28.82   13.51   28.63   0.33    159.    17.
```

```
21.70     29.78   14.68   28.71   1.33    347.    19.
21.89     30.90   17.03   29.07   1.00    123.    17.
21.93     31.59   16.02   28.91   2.00    78.     5.
21.19     31.43   14.63   26.20   0.00    6.      1.
Côte d'Ivoire/Gagnoa
1988      6.06    214.00
19.70     33.30   15.77   24.17   0.67    2.      1.
22.00     34.49   16.23   26.11   1.00    28.     1.
22.13     33.31   17.10   27.33   0.33    176.    8.
22.04     32.98   16.89   28.62   0.33    130.    5.
22.50     31.94   17.95   28.75   0.00    128.    7.
21.92     30.22   14.31   28.04   2.33    202.    10.
21.39     28.85   14.08   26.43   1.00    33.     6.
21.31     28.82   11.36   26.43   1.00    114.    8.
21.70     29.78   14.92   26.93   1.00    411.    15.
21.89     30.90   16.86   27.72   0.00    90.     4.
21.93     31.59   15.56   28.26   0.00    82.     8.
21.19     31.43   15.29   26.90   0.00    25.     4.
```

Reference to the new weather files should be made in the timer.dat file:

➔ Click on the timer. dat file in the left pane of the FSE Windows main screen. This file is located in the "Input Datafiles" part of the tree:



The following file appears in the right pane of the screen.

➔ Go to the location specification heading in Part A of the file:

```
!======================================================================!
!                                                                      !
! PART A. Information may be added to this part of the file.           !
!         Please follow the instructions in the User's Manual          !
!                                                                      !
!======================================================================!
!----------------------------------!
! Location specifications          !
!----------------------------------!
```

➔ And then below the " Daily or monthly weather data" heading to the first location number for which only zero's are specified as parameter values (in the standard timer.dat file delivered with the CASE2 model, this is Location 19):

```
* LOCATION 19
* < specify location name and period of weather data here >
  WTRDIR19 = ' '
  CNTR19   = ' '
  CLFILE19 = ' '
  ISTN19   = 0
  IWEATH19 = 0
  IRNDAT19 = 0
  STRTYR19 = 0
  ENDYR19  = 0
```

➔ Specify the weather directory between quotation marks. This should be:

```
WTRDIR19 = 'c:\case2\weather\monthly'
```

➔ The following two lines (CNTR.. and CLFILE..) can be skipped, as they only apply to daily weather data. Leave the text as is:

```
CNTR19 = ' '
ISTN19 = 0
```

- ➔ Specify the file name (CLFILE..) between quotation marks, and ending with the *.wof extension. For example:
  `CLFILE19 = 'indo24.wof'`
- ➔ Specify the type of weather data (IWEATH..). This should be 1 for monthly weather data:
  `IWEATH19 = 1`
- ➔ Specify the type of rainfall data (IRNDAT..). This should be 1 for monthly weather data:
  `IRNDAT19 = 1`
- ➔ Specify the first year of the consecutive period for which weather data are available (STRTYR..). For instance 1989:
  `STRTYR19 = 1989`
- ➔ Specify the last year of the consecutive period for which weather data are available (ENDYR..). For instance 1999:
  `ENDYR19 = 1999`

Now, save the changes to the timer.dat file:

- ➔ Press the button, or select "Save all" in the File menu, or press Ctrl+S

6.2.3 Long-term weather

To add new long-term weather data, one text file (ASCII format) should be made. The extension of the file name is usually *.ltm or *.avg or *.000. File names should preferably not exceed 8 characters (e.g. indjava.ltm or indo24.ltm). Long-term weather files should be stored in the c:\case2\weather\longterm directory.

A long-term weather data file for should contain the following information in the following order:

Line 1: name and number of the weather station (comment line)
line 2: year of observation (always 1000), latitude of location, altitude of the location, A and B coefficients for the Angstrom formula (these coefficients are not used in the current version of CASE2 and therefore do not have to be specified)
line3-14: average monthly weather data; one line per month, from January to December
in these lines: Column 1: minimum temperature (°C)
Column 2: maximum temperature (°C)
Column 3: irradiation (MJ m^{-2} d^{-1})
Column 4: vapour pressure (hPa[mbar])
Column 5: wind speed (m s^{-1})
Column 6: precipitation (mm month^{-1})
Column 7: number of rain days (month^{-1})

Notes:
- The values should be separated by at least one space character.
- Temperatures, irradiation, vapour pressure and windspeed are averages per month and over a period of years
- Rainfall is the monthly total, averaged over a number of years
- Number of rain days is the number of rain days per month, averaged over a number of years
- Missing values are not allowed, except for wind speed as this is not used in CASE2

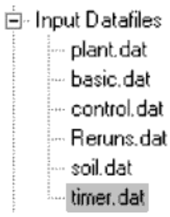
An example of part of a long-term weather file for Abidjan in Ivory Coast is shown below:

```
*--------------------------------------------------------*
*   Country: Brazil
*   Station: Belem
*      Year: Long-term Climatic Data
*    Source: FAOCLIM Global Weather Database - Release
```

```
*            20 July 1990.
*    Author: Agrometeorology group, Remote Sensing Centre,
*            Research and Technology Division, FAO.
* Longitude: 048 28 W
*  Latitude: 01 27 S
* Elevation: 24 m.
*  WMO-code: 82.1910
*  Comments: Number of rain days added from Mueller database
*            February 2002, Pieter Zuidema
*
*  Columns:
*  ========
*  minimum temperature (degrees Celsius)
*  maximum temperature (degrees Celsius)
*  irradiation (MJ m-2 d-1)
*  vapour pressure (kPa)
*  mean wind speed (m s-1)
*  precipitation (mm month-1)
*  number of rain days
*---------------------------------------------------------*
Belem    Brazil
1000     -1.45   24.     0.00    0.00
22.6     31.0    16.998  2.84    0.6     325.    27.
22.7     30.4    15.910  2.86    0.6     406.    26.
22.8     30.3    15.952  2.88    0.6     429.    28.
23.0     30.8    16.412  2.92    0.6     318.    27.
22.9     31.4    17.710  2.90    0.7     296.    26.
22.5     31.8    18.799  2.81    0.8     153.    22.
22.2     31.7    20.055  2.75    0.8     138.    17.
22.1     32.0    21.143  2.78    0.9     119.    15.
22.0     31.9    21.604  2.78    0.8     131.    18.
22.0     32.0    22.148  2.81    0.9     110.    15.
22.1     32.2    21.311  2.81    1.0     114.    13.
22.4     31.8    19.845  2.83    0.8     196.    19.
```

Reference to the new weather files should be made in the timer.dat file:

➔ Click on the timer. dat file in the left pane of the FSE Windows main screen. This file is located in the "Input Datafiles" part of the tree:



The following file appears in the right pane of the screen.

➔ Go to the location specification heading in Part A of the file:

```
!======================================================================!
!                                                                      !
! PART A. Information may be added to this part of the file.           !
!         Please follow the instructions in the User's Manual          !
!                                                                      !
!======================================================================!
!---------------------------------!
! Location specifications         !
!---------------------------------!
```

➔ And then below the " Long-term weather data" heading to the first location which no information and file name are specified (in the standard timer.dat file delivered with the CASE2 model, this is Location 70)o to the location specification heading in Part A of the file:

```
* LOCATION 70
* < specify location name and period of weather data here >
  CLFILE70 = ' '
```

- Specify the country and station name in the second line and file name (CLFILE..) on the third line between quotation marks (file names may have extensions *.ltm, *.avg or *.000). For example:

```
* Ivory Coast, Station 100
CLFILE70 = 'Civ100.ltm'
```

Now, save the changes to the timer.dat file:

- Press the  button, or select "Save all" in the File menu, or press Ctrl+S

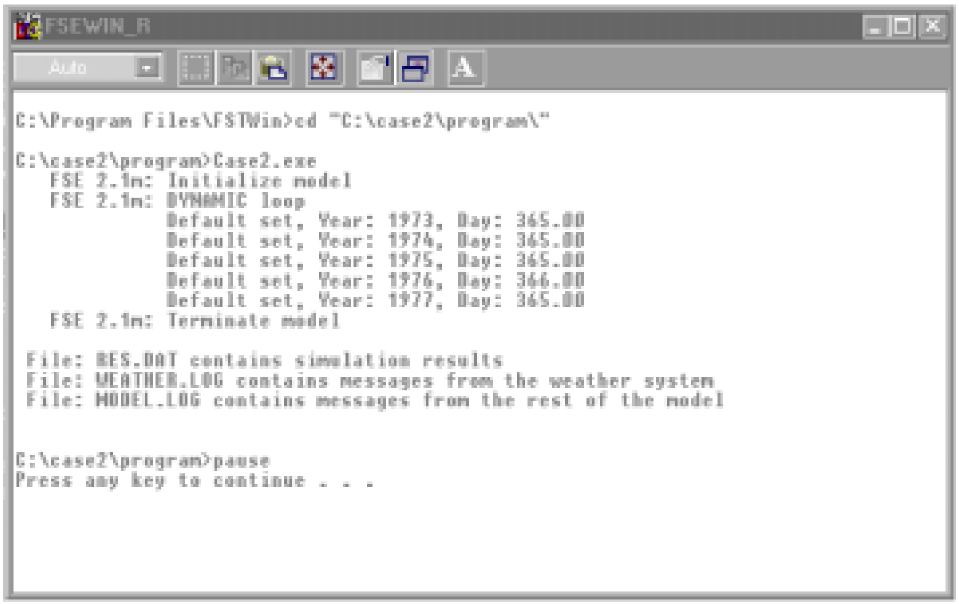
7. Running the CASE2 model

7.1 Running the model

To run the CASE2 model:

➔ Click on , or choose "Run" from the Run menu, or Press F9

FSEWin now prepares the model to run. This may take some time, depending on the type of computer and on the configuration of the CASE2. During the model run, a DOS screen is invoked in which the time coarse of the simulation can be followed. An example of the DOS screen:



➔ Check the DOS screen for any warning or error messages. A list of possible warning and error messages is included in Appendix II. A Warning message that will always be shown is "WARNING from DRSAHE: initial soil moisture in hydrostatic equilibrium not implemented. Instead, field capacity is used." This implies that water availability at the start of the model run is assumed to be optimal (water content at field capacity). This should be kept in mind in the interpretation of the model output for the first few days.

When the text "`Press any key to continue`" appears:

➔ Press any key

➔ Click on the button in the right upper corner of the DOS screen to close it.

Or:

➔ Press Alt+F4

The DOS window closes and you return to the FSEWin main screen.

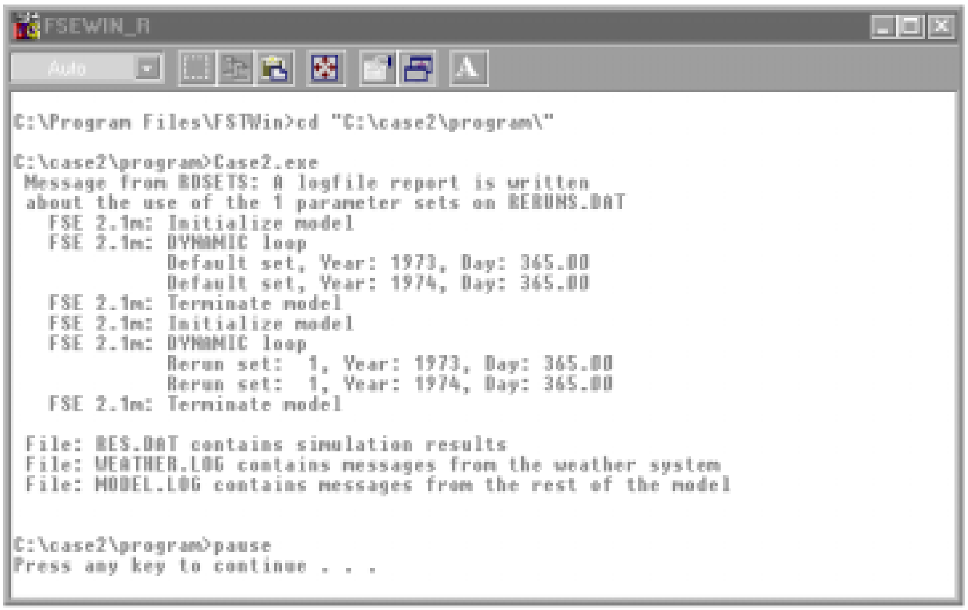
Now, the new simulation results can be viewed. Note that in case error messages were issued during the model run, no output is generated. See Section 11.1 for information on error and warning messages in the DOS screen.

For information on running the CASE2 model with reruns → Section 7.2
To view the table output of the last simulation run: → Section 8.1
To view the chart output of the last simulation run: → Chapter 9

7.2 Reruns

In case reruns have been defined in the reruns.dat file (see Section 5.6 on how to specify reruns), reruns will be automatically performed in the order indicated in the reruns.dat file. Follow the normal procedure to run the model (see Section 7.1).

In the DOS window lines for reruns will start with the text “Rerun set: “ followed by the number of the rerun. The following DOS screen is an example of model simulations with one rerun: the time information on the normal run is indicated by the text “Default set,”, whereas that for the rerun is labelled “Rerun set: 1, “.



For information on viewing table output of different reruns: → Section 8.1
For information on obtaining charts for different reruns: → Section 9.3

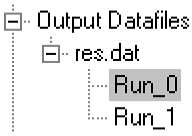
8. Model output in tables

Choice:	
1. Model output in table format	→ Section 8.1
2. Exporting tables to Excel	→ Section 8.2

8.1 Model output in table format

To obtain model output in table format:

→ Select a "Run_" file in the left pane of the FSEWin main screen. For instance:



Run_0 refers to the default run, Run_1 to the first rerun, etc., Run_2 to the second rerun, etc. The output will be shown in a table. If no reruns have been specified in the reruns.dat file, only RUN_0 will be shown. An example of a table:

TIME	AGEYR	WTOT	WTOTPP	WTRT	WLRT	WLV	WWD
365.000	5.1068	31516.	31.516	1629.4	4241.5	4971.8	19316.
730.000	6.1068	37737.	37.737	1904.1	5005.0	5742.0	23628.
1095.00	7.1068	39752.	39.752	1987.4	5233.7	6121.1	24940.
1461.00	8.1096	40148.	40.148	2005.1	5281.1	6185.6	25214.
1826.00	9.1096	40441.	40.441	2029.7	5338.0	6084.7	25595.
2191.00	10.110	40760.	40.760	2037.9	5371.8	6214.9	25726.
2556.00	11.110	41588.	41.588	2063.5	5444.5	6383.6	26134.

The time steps (rows) at which output is shown as well as the parameters for which output is shown (columns) depend on the specification of the output frequency (see Section 5.4).

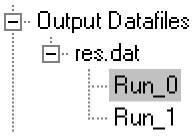
For instructions on exporting table information to Excel: → Section 8.2
For explanation on output parameters in tables → Appendix I

8.2 Exporting tables to Excel

FSEWin tables can be exported to Excel in a simple way.

To export a Table to Excel,

→ Select a "Run_" file in the left pane of the FSEWin main screen. For instance, Run_0:



→ Click on any cell within the table
→ Click on the  button, or select "Copy" from the Edit menu, or press Ctrl+C

- ➔ Go to an open Excel sheet
- ➔ Select the cell where the left-upper corner of the table should be located
- ➔ Click on the button, or select “Paste” from the Edit menu, or press Ctrl+V

The entire table including headings with the parameter names will be copied to the Excel sheet.

This procedure can be repeated for different reruns.

9. Model output in charts

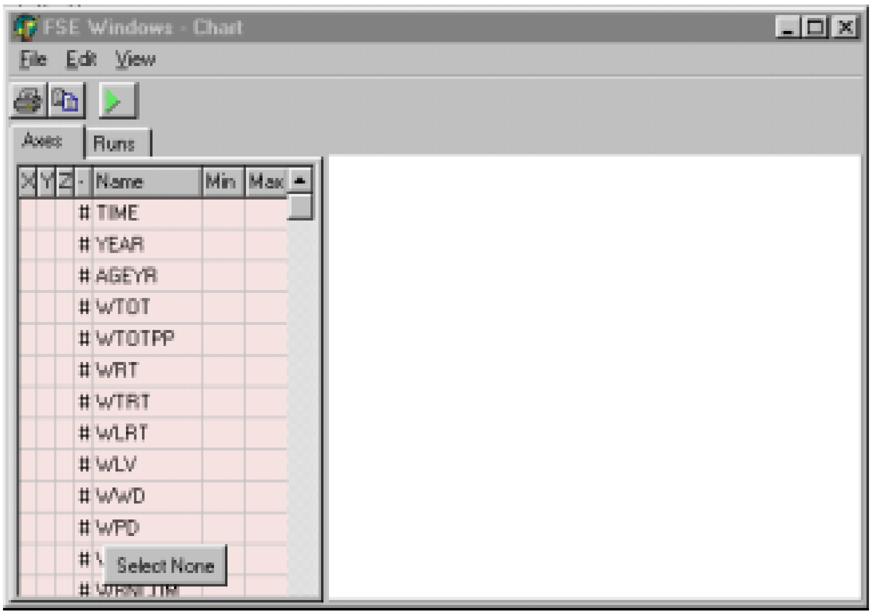
Steps:	
1. Open the chart screen	→ Section 9.1
2. Select parameters	→ Section 9.2
3. Select reruns (optional)	→ Section 9.3
4. Zooming in a chart (optional)	→ Section 9.4
5. Copy chart as a picture (optional)	→ Section 9.5
6. Close the chart screen	→ Section 9.6

9.1 Opening the chart screen

To open de chart screen:

➔ Click on the chart.txt file name below the Charts branch in the left pane:

The chart screen appears on top of the FSEWin main screen:



The list of parameters included in this screen depends on the output frequency specified in basic.dat (see Section 5.4).

For more information on menu's and icons in the chart screen: → Section 4.3
For instruction on selecting parameters for the chart → Section 9.2

In case the following window appears in the chart screen:

the last model simulation has not been successful. Probably an error occurred during model execution, and no output was generated. To obtain model output, the error has to be resolved (see Section 11.1 for explanation on error messages and Appendix II for a list of error messages and their possible solutions).

9.2 Selecting parameters for a chart

Model output of different parameters can be combined in charts. Parameters can be selected and de-selected. Note that the z-axis cannot be used.

First, make sure the “Axes” tab is selected in the chart screen. That is, the “Axes” tab should be in front of the “Rerun” tab:

If this is not the case:

➔ Click on the word “Axes”

Then, follow the instructions depending on what you wish to do:

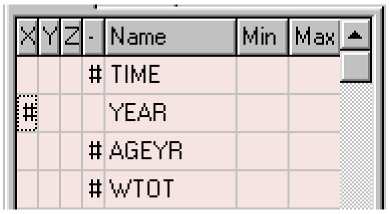
To select and de-select x-axis parameters → ***A***
To select y-axis parameters → ***B***
To select additional y-axis parameters → ***C***
To de-select y-axis parameters → ***D***

A. Select and de-select x-axis parameters

To select the parameter for the x-axis:

➔ Choose which of the parameters in the list should be on the x-axis
➔ Click on cell in the “X” column pertaining to that parameter to place the “#” mark in that cell.

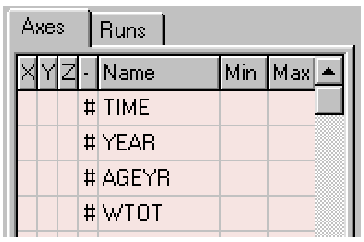
For example, in case “YEAR” is chosen as x-axis variable, the first lines will look like:



To de-select a parameter:

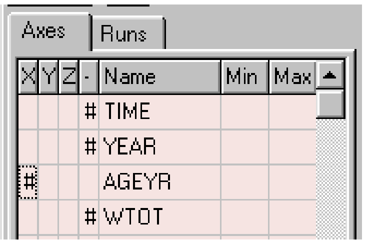
➔ Click on cell in the “-” column pertaining to the selected parameter to place the “#” mark in that cell.

For example, in case “YEAR” is de-selected as x-axis variable, the first lines will look like:



To change the x-axis parameter:

- ➔ Choose which of the parameters in the list should be on the x-axis
- ➔ Click on cell in the "X" column pertaining to that parameter to place the "#" mark in that cell.



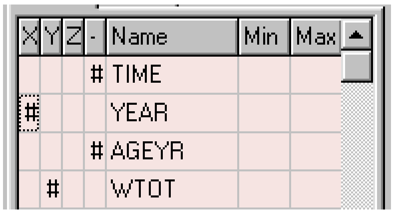
For example, in case "AGEYR" is now chosen as x-axis variable, the first lines will look like:

B. Select y-axis parameters

To select the parameter for the y-axis:

- ➔ Choose which of the parameters in the list should be on the y-axis
- ➔ Click on cell in the "Y" column pertaining to that parameter to place the "#" mark in that cell.

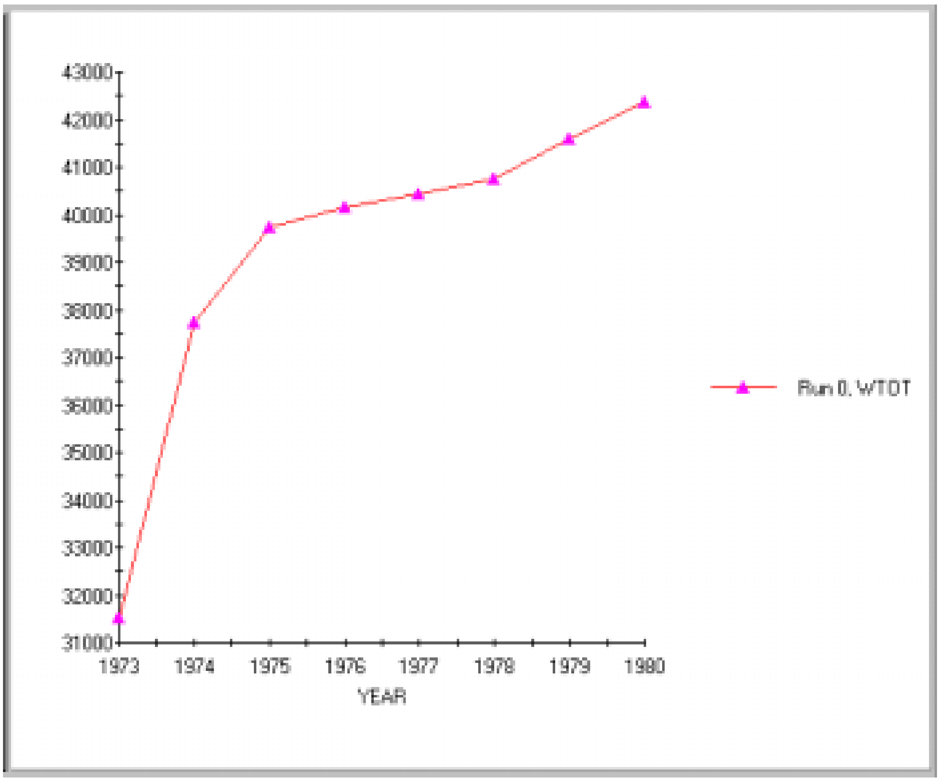
For example, in case "WTOT" (the total dry biomass per ha) is chosen as y-axis variable, the first lines will look like:



To show the chart in the right pane of the chart screen:

- ➔ Click on the button, or select "Show graph" in the View menu, or click at any location within the right pane of the chart screen.

The chart will be shown. The y-axis parameter is shown in the legend; the x-axis parameter is shown with the graph. Note that only one y-axis scaling is used. For example (using the above choice of x and y-axis parameters):For example (using the above choice of x and y-axis



parameters):

C. Select additional y-axis parameters

More y-axis parameters can be included in one chart, by selecting other parameters:

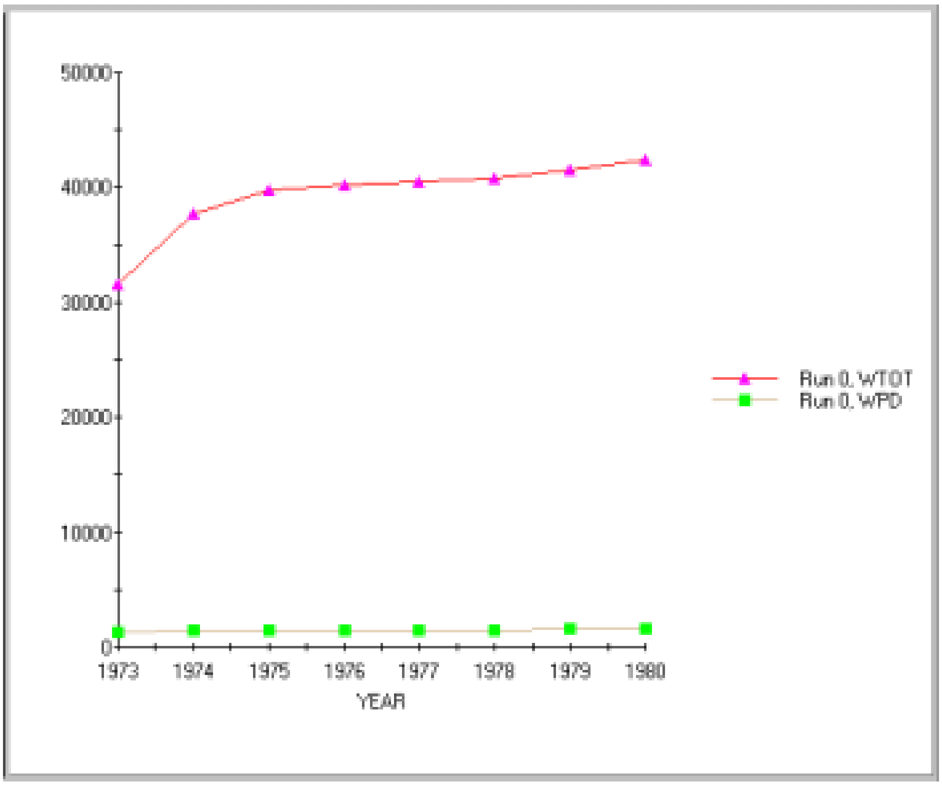
- ➔ Choose which of the parameters in the list should also be on the y-axis
- ➔ Click on cell in the "Y" column pertaining to that parameter to place the "#" mark in that cell. For example, in case "WPD" (the dry biomass of pods per ha) is chosen as x-axis variable, the first lines will look like:

X	Y	Z	-	Name	Min	Max
			#	TIME		
#				YEAR		
			#	AGEYR		
	#			WTOT		
			#	WTOTPP		
			#	WRT		
			#	WTRT		
			#	WLRT		
			#	WLV		
			#	WWD		
	#			WPD		

Now, update the chart:

- ➔ Click on the button, or select "Show graph" in the View menu, or click at any location within the right pane of the chart screen.

The updated chart will be shown. The y-axis parameters are shown in the legend; the x-axis parameter is shown with the graph. For example (using the above choice of x and y-axis parameters):



D. De-select y-axis parameters

To de-select a parameter:

- ➔ Click on cell in the "-" column pertaining to the selected parameter to place the "#" mark in that cell.

Now, update the chart:

- ➔ Click on the button, or select "Show graph" in the View menu, or click at any location within the right pane of the chart screen.

For information on zooming in: → Section 9.4
For information on getting output of reruns in charts: → Section 9.3
For information on copying a chart as a picture → Section 9.5
For general information on the contents of the chart screen → Section 9.7

9.3 Selecting reruns for a chart

Model output for different reruns can be combined in one chart.

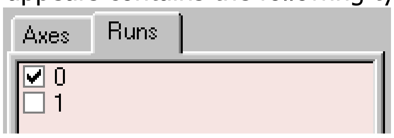
To select model runs → ***A***
To de-select model runs → ***B***

A. Select model run

To select model run(s) for which model output should be included in the chart:

- ➔ Click on the "Runs" tab in the Chart screen.

The screen that appears contains the following type of information:



The number of runs shown in the screen depends on the number of reruns specified in reruns.dat (see Section 5.6).

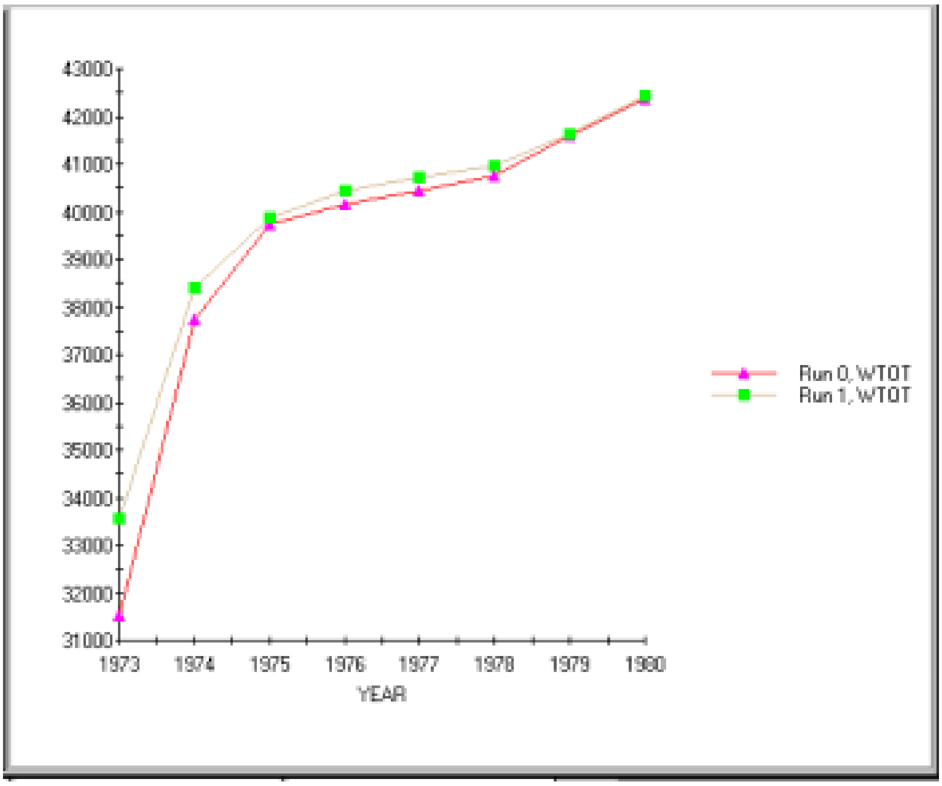
- ➔ Select run(s) for which information should be included in the chart by ticking the box(es) pertaining to the run(s).

For example, if both the default run 0 and rerun 1 should be included:

Now, update the chart:

- ➔ Click on the button, or select "Show graph" in the View menu, or click at any location within the right pane of the chart screen.

The updated chart will be shown. The run number is shown in the legend. For example:



B. De-select model run

To de-select model run(s) for which information should *not* be included in the chart:

➔ Click on the "Runs" tab in the Chart screen.

For example, if runs 0 and 1 have been ticked:

➔ Click on the ticked box(es) for the run(s) that should not be included

For example, if run 0 is de-selected:

Now, update the chart:

➔ Click on the  button, or select "Show graph" in the View menu, or click at any location within the right pane of the chart screen.

The updated chart will be shown.

9.4 Zooming-in a chart

A part of a chart can be selected to be shown (zoom-in).

To zoom in:

➔ Place the mouse arrow in one of the corners of the desired part of the chart

- ➔ Hold the Shift key and press the left mouse button while moving the mouse arrow to the opposite corner of the desired chart part

While moving the mouse you will see a rectangle enclosing the selected part

- ➔ Loosen the mouse button to show a new chart of the selected part.

To zoom out to the original chart size:

- ➔ Click on the button, or select "Show graph" in the View menu, or click at any location within the right pane of the chart screen.

9.5 Copying a chart as a picture

FSEWin charts can be copied as a picture to other programs (e.g. word-processing programs or presentation software). The chart is first copied to the clipboard. The file format is Enhanced Metafile.

To copy a chart:

- ➔ Click on the button, or select "Copy" in the Edit menu, or press Ctrl+C.
- ➔ Open the program to which you wish to copy.
- ➔ Press Ctrl+V or select "Paste" from the Edit menu (which is usually available)

9.6 Closing the chart screen

When you wish to return to the FSEWin main screen, the chart screen should first be closed. To close the chart screen:

- ➔ Click on the button in the right upper corner of the chart screen, or select "Close" from the File menu, press Alt+F4

9.7 Contents of the chart screen

9.7.1 Menu's and icons

File menu

Print: Prints the chart in the right pane of the chart screen to the default printer.

Close: Closes the chart screen and returns to the FSEWin main screen. Note that charts are *not* saved

Edit menu

Copy: Copies the chart and moves it to the clipboard for later use. (The chart can be pasted in word processing or presentation software).

View menu

Dynamic output: This option indicates whether dynamic output (output during model run) of the model is shown in the chart. **This option should always be ticked.**

Initial and terminal output: This option indicates whether initial and terminal output (the initial situation and the situation at the end of the model simulation) of the model is shown in the chart. **This option should *not* be ticked.** In case this option is ticked no output parameters will be available for the chart.

9.7.2 The left pane

The left pane of the FSEWin chart screen may be used to select parameters and reruns for inclusion in the chart. Two tabs are available:

The “Axes” tab is used to select and de-select parameters for inclusion in the chart. Parameters for the x and y axes of the chart can be selected. The z-axis is not available at this stage. The “Select none” button is used to de-select all parameters:

The “Runs” tab is used to select and de-select runs (the default run 0 and possible reruns).

For instructions on selecting parameters for charts → Section 9.2
For instructions on selected reruns for charts → Section 9.3

9.7.3 The right pane

The right pane of the FSEWin chart screen contains the charts. The parameters included in the chart are mentioned in the chart legend, the x-axis parameter is shown below the x-axis. Charts can be updated by clicking on any position within the right pane. A selection of the chart can be shown by using pressing Shift while selecting the area with the mouse (keeping both the Shift key and the left mouse button pressed). See Section 9.4 on zooming in a chart.

No changes can be made to the layout of the chart: the colours of lines and markers, the axis division, font size used and other attributes of the layout are default settings, More complex graphs should be produced in other packages such as Microsoft Excel using the option to copy data from tables (see Section 8.2).

10. Closing CASE2 and FSEWin

10.1 Closing CASE2

To close the CASE2 model, first save the changes in input files:

- ➔ Click on the button, or select "Save all" in the File menu, or press Ctrl+S
- ➔ In the "Open Project" window, select the case2.fpf in the C:\CASE2\program directory and click on "Open" (or double-click on the case2.fpf file)

10.2 Exiting FSEWin

To exit FSEWin:

- ➔ Select "Exit" in the File menu

In case changes in one or more CASE2 files have not been saved, the following screen appears:

- ➔ Click on "Yes" to save changes. The FSEWin program will close.

In case all changes in the CASE2 files have been saved, the following screen appears:

- ➔ Click on "Yes"

For more information on the FSEWin screen and menu's: → Section 4.3

11. Trouble shooting and support

11.1 Warnings and errors in the DOS screen

During or prior to the CASE2 model run, warning messages or error messages may appear in the DOS screen. Warnings and errors are essentially different:

Message	What does is imply?	Example	What happens?
Warning:	This indicates that the model is running in an unusual way, or that a certain parameter has an unusual value.	(1) The maximum tree age is reached during the simulation. (2) The tree's reserves are depleted due to low radiation or low rain fall.	- Model run continues (usually) - Output generated
Error:	This indicates that the model cannot be run properly due to an error at the start or during the model run.	The simulation period specified in basic.dat is longer than the period for which weather data is available.	- Model halted - No output

For a list of possible warnings and errors: → Appendix II

11.2 Some possible problems in FSEWin

When does the problem occur?

- While running CASE2 but not in the DOS screen? → ***A***
- When viewing charts → ***B***

A. Problems while running the CASE2 model before the DOS screen is opened

1. Error message:

This is probably caused by settings of the autoexec.bat file, which was not changed during the installation of Visual Fortran. To solve the problem:

➔ Open the C:\autoexec.bat file in a word processing program or the Notepad program
➔ Make a backup of the file, changing the *.bat to *.bck (for backup)
➔ Check whether the following lines are included. It is not important that the lines starting with "rem" contain exactly the same information as in the example; the call to DFVARS.BAT should be included in any case:

```
rem - Lines added by Visual Fortran 6.0.A Setup on 5-17-2001
CALL C:\PROGRA~1\MICROS~1\DF98\BIN\DFVARS.BAT AUTOEXEC
rem - End of lines added by Visual Fortran 6.0.A Setup
```

➔ If not, add these lines at the end of the file
➔ Save the file as autoexec.bat, overwriting the old version
➔ Shut down the computer and start it again.

2. Compilation failed or linking failed
   Changes have probably been made in the fortran source files (fse.for, model2.for or case2.for). **These changes should be undone!** In case the problem persists, re-install the CASE2 model.

B. Problems when viewing graphs

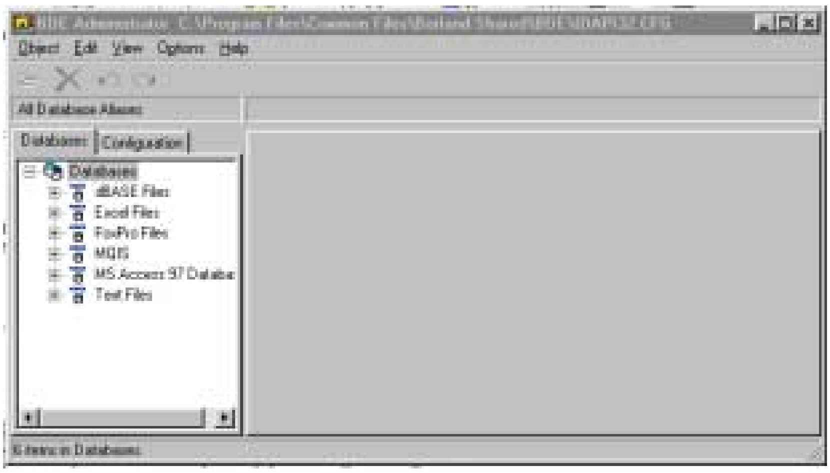
3. Do not see entire chart.
   This is probably caused by the choice of large letters in the Windows screen setting. To solve the problem, choose Settings and Configuration window from the Windows Start menu. In the Configuration window, choose Display properties and within this window, the Settings tab. Either change the font size from Large font to Small font in this window or do so in the window that is opened after pressing the "Advanced" button.

4. No chart and message:

   This problem is probably caused by an error during the last model run (an error mentioned in the DOS screen during model run). The message "No variables found" may be displayed as well. No model output is generated in this case. To solve this problem, the cause of the error during model run should be solved. (see Appendix II for a list of possible problems and possible solutions).

5. No chart and message:

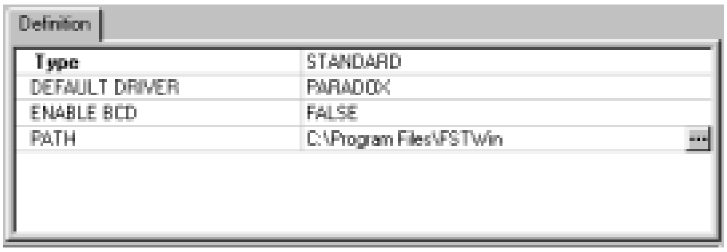
   This problem is caused by the lack of a database definition in the installation of FSTWin. To solve the problem:
   ➔ Open the Control panel (by selecting "Settings" in the Windows Start menu and then "Control Panel")
   ➔ Double-click on "BDE Administration"
   The following screen appears:



   Now, create a new "database":
   ➔ Select "New.." from the Object menu

- ➔ Select “STANDARD” in the “New Database Alias” screen
- ➔ Replace the text “STANDARD1” with “FSTdb”
- ➔ Type the path “C:\Program Files\FSTWin” for the PATH

The following information should now be in the right pane of the screen:



- ➔ Select “Exit” from the Object menu, saving the changes
- ➔ Start FSEWin again

6. No chart and message: “Table is full”
   This is probably when daily output frequency is selected (OUTPUTFQ=3) and the simulation is done for a long period of time. Limit the time period of the simulation or select another output frequency.

7. No chart and message “License information for Tchart2D is invalid”
   This is probably due to a problem during the installation of FSTWin. Try to install FSTWin again. If the problem persists, contact the authors.

8. The chart window does not open; the following message appears in the right pane:
   `The file C:\case2\program\chart.txt was not found`
   This is caused by an error during the last model run. When this problem is solved and a new model run is performed, the chart screen will open, containing the output of the new model run.

9. Other problems.
   Please contact the authors at the mail or e-mail address indicated on page 2 of this report.

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Appendix I: List of input and output parameters

This appendix contains tables with input and output parameters of CASE2.

Input parameters

Input parameters are those that are included in the *.dat files (basic.dat, timer.dat, plant.dat and soil.dat). Note that only part of these parameters may be changed by the user. Standard values for most of the parameters are included in the prints of *.dat files in Appendix III.

Table I-1. A list of codes, units and descriptions of all input parameters. °C = degrees Celsius; C = carbon; CH2O = carbohydrates (sugars or assimilates); CO2 = carbo-dioxide; D= day; DW = dry weight; h = hour; ha = hectare; kg = kilogram; m = meter; y = year.

Input parameters

Code	Unit	Description
AGBIORA	kg DW d^{-1}	Regression coefficient for age-biomass relation
AGBIORB	kg DW	Regression coefficient for age-biomass relation
AGEIYR	y	Initial cacao tree age
AMINIT	-	Factor accounting for lower photosynthesis in young leaves
AMTMPT	-	Table with reduction factor for temperature effects on AMX
AMX	kg CO2 ha^{-1} leaf h^{-1}	Maximum rate of photosynthesis
ASRQLRT	kg CH2O kg^{-1} DW d^{-1}	Assimilate requirement for the production of 1 kg lateral roots
ASRQLV	kg CH2O.kg^{-1} DW	Assimilate requirement for the production of 1 kg leaves
ASRQPDTB	-	Table of pod assimilate requirements depending on fat content
ASRQTRT	kg CH2O kg^{-1} DW	Assimilate requirement for the production of 1 kg taproot
ASRQWD	kg CH2O kg^{-1} DW	Assimilate requirement for the production of 1 kg wood
AVGLVAGE	d	Estimated average and minimum leaf age
BHRA	$°C^{-1}$	Butter hardness regression coefficient
BHRB	-	Butter hardness regression coefficient
CFFRT	kg C kg^{-1} DW	Mass fraction carbon in the fine roots
CFLV	kg C.kg^{-1} DW	Mass fraction carbon in the leaves
CFPDTB	-	Table of pod C content depending on fat content
CFTRT	kg C kg^{-1} DW	Mass fraction carbon in the taproot
CFWD	kg C kg^{-1} DW	Mass fraction carbon in the wood
CLFILE	-	File name for weather files with monthly data
CNTR	-	Country code for weather file
COPINF	-	Switch variable what should be done with
DELT	d	Time step of integration
DELTMP	-	Switch variable what should be done with
DEVRR1A	d^{-1} $°C^{-1}$	Regression coefficient on relation between temperature and pod ripening
DEVRR1B	d^{-1}	Regression coefficient on relation between temperature and pod ripening
DEVRR2A	d^{-1} $°C^{-1}$	Regression coefficient on relation between temperature and pod ripening
DEVRR2B	d^{-1}	Regression coefficient on relation between temperature and pod

Input parameters

Code	Unit	Description
		ripening
DIAM1	m	Mean diameter of fine roots (diameter < 1 mm)
DIAM2	m	Mean diameter of fine roots (diameter between 1 and 2 mm)
EES	m^{-1}	Evaporation proportionality factor
EFF	(kg $CO2$ ha^{-1} h^{-1})/(J m^{-2} s^{-1})	Initial light use efficiency for individual leaves
ENDYR1	-	Final year of simulation
ETMOD	-	Evapotranspiration module (standard = Penman)
FATCONTENT	-	Fat content of nibs
FBEANS	-	Dry weight fraction of beans in pod
FLRTRA	kg DW lateral roots kg^{-1} DW whole plant	Regression coefficient on relation between lateral root and total biomass
FLRTRB	kg DW lateral root	Regression coefficient on relation between lateral root and total biomass
FLVRA	kg DW leaf kg^{-1} DW whole plant	Regression coefficient on relation between leaf and total biomass
FLVRB	kg DW leaves	Regression coefficient on relation between leaf and total biomass
FMTA	-	Regression coefficient on biomass loss due to fermentation
FMTB	d^{-1}	Regression coefficient on biomass loss due to fermentation
FMTDUR	d	Duration of the fermentation process
FPDRA	kg DW pod kg^{-1} DW whole plant	Regression coefficient on relation between pod and total biomass
FPDRB	kg DW pod	Regression coefficient on relation between pod and total biomass
FRPAR	-	Fraction of photosynthetically active radiation (PAR)
FTRTRA	kg DW taproot kg^{-1} DW whole plant	Regression coefficient on relation between taproot and total biomass
FTRTRB	kg DW taproot	Regression coefficient on relation between taproot and total biomass
FWDRA	kg DW wood kg^{-1} DW whole plant	Regression coefficient on relation between wood and total biomass
FWDRB	kg DW wood	Regression coefficient on relation between wood and total biomass
FWURT	-	Fraction of lateral roots that is able to extract water
HGHL	m	Lower height of cacao tree crowns
HGHT	m	Upper height of cacao tree crowns
HRTWDAGE	d	Age at which softwood is transformed into non-respiring heartwood
IFLAG	-	Indicates where weather error and warnings are stored
IOBSD	-	Lists year-day combinations for which output is requested
IPFORM	-	Format of output file:
IRNDAT1	-	Indicates type of rainfall data
ISTN1	-	Weather station number (only for daily weather data)
IWEATH1	-	Indicates type of weather data used
IYEAR	-	Start year of the simulation
KCONTBN	kg K kg^{-1} bean DW	K (potassium) content of dry beans
KDFL	-	Extinction coefficient for cacao leaves
KDFT	-	Extinction coefficient for cacao trunk
LOCATION	-	Location number for which simulations are conducted
LRTWURTDR	kg dead lateral roots	Loss of coarse lateral roots relative to that of water-uptaking roots

Input parameters

Code	Unit	Description
	kg^{-1} dead water-uptaking roots	
MAINLRT	kg CH2O kg^{-1}DW d^{-1}	Maintenance respiration coefficient for lateral roots
MAINLV	kg CH2O.kg^{-1} DW.d^{-1}	Maintenance respiration coefficient of leaves
MAINPD	kg CH2O kg^{-1}DW d^{-1}	Maintenance respiration coefficient for pods
MAINT	kg CH2O.ha^{-1}.d^{-1}	Maintenance respiration rate of the crop
MAINTRT	kg CH2O kg^{-1}DW d^{-1}	Maintenance respiration coefficient for taproot
MAINWD	kg CH2O kg^{-1}DW d^{-1}	Maintenance respiration coefficient for wood
MAXLAI	m^2 leaves m^{-2} ground	Maximum LAI used in the photosynthesis subroutines
MINCON	kg CH2O kg^{-1} DW	Minimum concentration of carbohydrate reserves
MINLVAGE	d	Minimum leaf age
MOISTC	-	Moisture content of dry, fermented beans
NCONTBN	kg N kg^{-1} bean DW	N (nitrogen) content of dry beans
NL	-	Number of soil layers
NPL	trees ha^{-1}	Cacao tree planting density
NRYEARS	y	Number of years for which simulation should be conducted
OUTPUTFQ	-	Frequency at which output is generated
PCONTBN	kg P kg^{-1} bean DW	P (phosphorus) content of dry beans
PLTMOD	-	Name of plant module
PODVALUE	kg^{-1} DW	Pod index or pod value (number of pods per kg dry beans)
PRODLEVL	-	Production level: either potential or water-limited
PRSEL	-	Selection of variables to be included in output and table
Q10	-	Factor accounting for increase of maintenance
RTOWURT	d^{-1}	Turnover rate of water-uptaking roots
SHGHL	M	Lower height of shade tree crowns
SHGHT	m	Upper height of shade tree crowns
SKDFL	-	Extinction coefficient for leaves of shade trees
SLAI	ha leaf ha^{-1} ground	Leaf area index of shade trees
SLAR1A	ha leaf kg^{-1} leaf DW kg^{-1} plant DW	Regression coefficient on leaf area per unit leaf biomass
SLAR1B	ha leaf kg^{-1} leaf DW	Regression coefficient on leaf area per unit leaf biomass
SLAR2A	ha leaf kg^{-1} leaf DW kg^{-1} plant DW	Regression coefficient on leaf area per unit leaf biomass
SLAR2B	ha leaf kg^{-1} leaf DW	Regression coefficient on leaf area per unit leaf biomass
SOILTYPE	-	Soil type to be used in model simulation
SPRTL1	m kg^{-1}	Specific root length, root diameter < 1 mm
SPRTL2	m kg^{-1}	Specific root length, root diameter between 1-2 mm
SSTB	-	Table with sink strength values for pod growth
STRTYR	-	Start year of the simulation
STTIME	d	Start time of the simulation
SW	kg m^{-3}	Specific weight of wood
SWINPUT	-	Switch for initial cacao tree input: either age or biomass
SWIT6	-	Switch for type of initialisation in water balance module
SWIT8	-	Switch for type of equation used in water balance module
SWIT9	-	Switch for type of soil input in water balance module
TAU	d	Time coefficient

Input parameters

Code	Unit	Description
TFALA	-	Regression coefficient for through fall
TFALB	mm d^{-1}	Regression coefficient for through fall
TKL1	m	List with thickness of soil layers
TRANSC	mm d^{-1}	Characteristic potential transpiration rate
TREF	°C	Reference temperature for calculation of maintenance respiration
TYL1	-	Driessen texture classes for layers
VDWURTRA	-	Regression coefficient on vertical distribution of fine roots
VDWURTRB	kg DW ha^{-1} m^{-2}	Regression coefficient on vertical distribution of fine roots
WCWET	cm^3 cm^{-3}	Volumetric water content where water logging begins
WDLVDR	kg dead wood kg^{-1} dead leaves	Loss of wood relative to that of leaves.
WTOTI	kg DW tree1	Total initial dry weight of the cacao tree
WTOTMIN	kg DW $tree^{-1}$	Total dry weight of the cacao tree at which fruiting starts
WTRDIR1	-	Directory in which weather data are stored

Output parameters

Output parameters are those that are included in the tables or charts. Which of the output parameters is included in the output depends on the output frequency specified by the user (by the parameter OUTPUTFQ in basic.dat; see Section 5.3). The table below provides information on the output frequency value at which each parameter is included in the table or chart output. More information on the calculation of a number of parameters can be found in Zuidema & Leffelaar (2002).

To facilitate interpretation of output parameters, the same letters are used for related parameters:

Parameter starting with:	*indicates (in most cases):*
D…	Death rate in biomass (dry weight) of the cacao tree or a plant part
D10…	A value for a period of 10 days
G…	Growth rate in biomass (dry weight) of the cacao tree or a plant part
W…	Dry weight of the cacao tree or a plant part
Y…	An annual total

Parameter containing:	*is related to:*
..BH..	Butter hardness of harvested beans
..BN..	Bean yield
..LRT..	Lateral roots
..LV..	Leaves
..PD..	Pods
..RAIN..	Rainfall
..RT..	Roots
..TRT..	Taproot
..TRANS..	Evapotranspiration
..WD..	Wood
..WURT..	Water-uptaking lateral roots (fine roots)

Table I-2. List of codes, units, description of output parameters. The column Output frequency indicates for which value of the input parameter OUTPUTFQ (specified in the basic.dat file) this parameter is included in the table and chart output. 1 = annual output; 2 = output every 10 days; 3 = daily output.

Output parameters

Code	Unit	Description	Output frequency
AGEYR	y	Age of the cacao tree in years	1,2,3
ATRANS	mm d^{-1}	Total daily actual transpiration rate of the canopy	3
ATWURT	m2 ha^{-1}	Total area of water-uptaking roots	3
AWURT	m2 ha^{-1}	Area of water-uptaking roots per soil layer	3
BHYLD	-	Butter hardness of the daily bean production	3
D10GTOT	kg DW ha^{-1} 10 d^{-1}	Total biomass growth during 10 days	2
D10HARPD	10 d^{-1}	Number of harvested pods during 10 days	2
D10RAIN	mm 10 d^{-1}	Amount of rainfall during 10 days	2
D10RDD	J m-2 10 d^{-1}	Amount of short-wave radiation during 10 days	2
D10YLDBN	kg DW ha^{-1} 10 d^{-1}	Yield of dry, fermented beans during 10 days	2
D10YLDPD	kg DW ha^{-1} 10 d^{-1}	Yield of pods during 10 days	2

Output parameters

Code	Unit	Description	Output frequency
DLRT	kg DW ha^{-1} d^{-1}	Daily death rate of lateral root biomass	3
DLV	kg DW ha^{-1} d^{-1}	Daily death rate of leaves biomass	3
DLV1	kg DW ha^{-1} d^{-1}	Daily death rate of leaves biomass due to ageing	3
DLV2	kg DW ha^{-1} d^{-1}	Daily death rate of leaves biomass due to drought	3
DOY	-	Day number since 1 January (day of year)	2,3
DWD	kg DW ha^{-1} d^{-1}	Daily death rate of wood biomass	3
FLRT	-	Fraction of biomass production allocated to lateral roots	3
FLV	-	Fraction of biomass production allocated to leaves	3
FPD	-	Fraction of biomass production allocated to pods	3
FRABS(1)	-	Fraction of total radiation absorbed by cacao trees	3
FTRT	-	Fraction of biomass production allocated to taproot	3
FWD	-	Fraction of biomass production allocated to wood	3
GLRT	kg DW ha^{-1} d^{-1}	Daily growth rate of lateral root biomass	3
GLV	kg DW ha^{-1} d^{-1}	Daily growth rate of lateral leaf biomass	3
GPD	kg DW ha^{-1} d^{-1}	Daily growth rate of lateral pod biomass	3
GPHOT	kg CH2O ha^{-1} d^{-1}	Daily total gross CH2O assimilation	3
GRT	kg DW ha^{-1} d^{-1}	Daily growth rate of root biomass	3
GTOT	kg DW ha^{-1} d^{-1}	Daily growth rate of total biomass	3
GTOT1	kg DW ha^{-1} d^{-1}	Daily growth rate of total biomass: growth accounting for lost plant parts	3
GTOT2	kg DW ha^{-1} d^{-1}	Daily growth rate of total biomass: growth leading to net growth of plant parts	3
GTRT	kg DW ha^{-1} d^{-1}	Daily growth rate of taproot	3
GWD	kg DW ha^{-1} d^{-1}	Daily growth rate of wood	3
HARPODS	d^{-1}	Daily number of harvested pods	3
LAI(1)	ha leaf ha^{-1} ground	Leaf area index of the cacao trees	2,3
LTRT	m	Length of taproot	3
LTWURT	m ha^{-1}	Total length of water-uptaking roots	3
MAINT	kg CH2O ha^{-1} d^{-1}	Daily rate of maintenance respiration	3
PCEW	-	Factor that accounts for reduced photosynthesis due to water stress	2,3
PTRANS	mm d^{-1}	Daily potential transpiration rate	3
RAIN	mm d^{-1}	Daily amount of rainfall	3
RDD	J m-2 d^{-1}	Daily short-wave radiation	3
TIME	d	Day during the simulation	1,2,3
TMAV	°C	Daily average temperature	2,3
TRWL	mm d^{-1}	Daily actual transpiration rate per soil layer	3
WBNCUM	kg DW ha^{-1}	Cumulative weight of harvested dry, fermented beans	1,2,3
WLRT	kg DW ha^{-1}	Actual lateral root biomass	1,2,3
WLV	kg DW ha^{-1}	Actual leaf biomass	1,2,3
WPD	kg DW ha^{-1}	Actual pod biomass	1,2,3
WPDCUM	kg DW ha^{-1}	Cumulative weight of harvested pods	1,2,3
WRT	kg DW ha^{-1}	Actual root biomass	1,2,3
WTOT	kg DW ha^{-1}	Actual total biomass	1,2,3

Output parameters

Code	Unit	Description	Output frequency
WTOTPP	kg DW ha^{-1}	Actual total biomass per tree	1,2,3
WTRT	kg DW ha^{-1}	Actual taproot biomass	1,2,3
WTWURT	kg DW ha^{-1}	Total biomass of water-uptaking roots	3
WWD	kg DW ha^{-1}	Actual wood biomass	1,2,3
WWURT	kg DW ha^{-1}	Biomass of water-uptaking roots per soil layer	3
YEAR	-	Calendar year	1,2,3
YGPHOT	kg CH2O ha^{-1} y^{-1}	Annual total gross CH2O assimilation	1
YGTOT	kg DW ha^{-1} y^{-1}	Annual total biomass production	1
YHARPD	y^{-1}	Annual number of harvested pods	1
YHI	-	Annual harvest index (more info in Zuidema & Leffelaar, 2002	1
YHINCR	-	Annual harvest increment (more info in Zuidema & Leffelaar, 2002)	1
YKLOSS	kg ha^{-1} y^{-1}	Annual loss of K (potassium) from harvested beans	1
YLDBN	kg DW ha^{-1} d^{-1}	Daily yield of dry, fermented beans	3
YLDPD	kg DW ha^{-1} d^{-1}	Daily yield of pods	3
YLVD	kg DW ha^{-1} y^{-1}	Annual production of dead leaf biomass	1
YMNBH	-	Mean annual butter hardness	1
YMNIPOD	d	Mean annual pod ripening period	1
YMNLAI	ha leaf ha^{-1} ground	Mean annual number of leaf area index (LAI)	1
YNLOSS	kg ha^{-1} y^{-1}	Annual loss of N (nitrogen) from harvested beans	1
YPLOSS	kg ha^{-1} y^{-1}	Annual loss of P (phosphorus) from harvested beans	1
YRAIN	mm y^{-1}	Annual rainfall	1
YRDD	MJ m-2 y^{-1}	Annual short-wave radiation	1
YRDEFF	kg DW ha $^{-1}$ (MJ m-2)$^{-1}$	Radiation "efficiency" of bean production	1
YRNEFF	kg DW ha $^{-1}$ mm	Rain "efficiency" of bean production	1
YTRANS	mm y^{-1}	Annual amount of actual transpiration	1
YWDD	kg DW ha^{-1} y^{-1}	Annual production of dead wood biomass	1
YYLDBN	kg DW ha^{-1} y^{-1}	Annual yield of dry, fermented beans	1
YYLDPD	kg DW ha^{-1} y^{-1}	Annual yield of pods	1

Appendix II: Error and warning messages

This appendix contains lists of error and warning messages that may appear in the DOS screen while running CASE2. For information on the differences between errors and warnings see Section 11.1. Part of the warning and error message are numbered (only those from the CASE2 subroutines).

Error messages

Error messages always contain the following text: “ERROR in <Subroutine>: <Error message>”, in which <Subroutine> is the name of the subroutine (source code file) in which the error occurred and <Error message> is the error message itself. For example:

```
ERROR in CASE2: FE6 - LAI of shade trees too high: >3. ha ha-1.
Press <Enter>
```

Table II-1. List of error messages displayed in the DOS screen while running CASE2 together with possible solutions for the problems. When the possible solution is “Contact authors” , the warning message text together with all *.dat files can be sent by e-mail to the author’s e-mail address mentioned at page 2 of the report.

Error messages

Subroutine	Error message text	Possible solution
CASE2	FE1 - Time step (DELT) too small: <1 day	Change DELT back to 1 in timer.dat
CASE2	FE2 - Total thickness of soil layers too low: <1.5 m	Increase thickness of soil layers in soil.dat
CASE2	FE3 - Planting density too low: < 700 ha-1	Increase planting density (NPL) in basic.dat
CASE2	FE4 - Planting density too high: > 2500 ha-1	Decrease planting density (NPL) in basic.dat
CASE2	FE5 - Extinction coefficient of shade trees too low	Increase extinction coefficient for shade trees in basic.dat
CASE2	FE6 - LAI of shade trees too high: >3. ha ha-1	Decrease LAI for shade trees in basic.dat
CASE2	FE7 - Shade tree height too high: should be <40 m	Decrease height for shade trees in basic.dat
CASE2	FE8 - Upper shade tree height <= lower height	Decrease lower height or increase upper height for shade trees in basic.dat
CASE2	FE9 - Cacao tree height too high: should be <20 m	Decrease height for cacao trees in basic.dat
CASE2	FE10 - Upper cacao tree height <= lower height	Decrease lower height or increase upper height for cacao trees in basic.dat
CASE2	FE11 - Initial tree biomass too low: < 18.5 kg	Specify higher initial biomass in basic.dat
CASE2	FE12 - Initial tree biomass too high: > 70.0 kg	Specify lower initial biomass in basic.dat
CASE2	FE13 - Initial tree age too low: < 3 y	Specify higher tree age in basic.dat
CASE2	FE14 - Initial tree age too high: > 39 y	Specify lower tree age in basic.dat
CASE2	FE16 - Av. greater than 40 C.	Do simulations for other location: this location is not suitable due to extremely high temperatures
CASE2	FE17 - Minimum temperature below 10 C.	Do simulations for other location: this location is not suitable due to extremely low temperatures
CASE2	FE18 - Actual allometry is wrong: sum of proportions (CHKPART1) does not equal 1	Contact authors

Error messages

Subroutine	Error message text	Possible solution
CASE2	FE19 - The ideal biomass fraction of one or more organs is below 0	Contact authors
CASE2	FE20 - Partitioning is wrong,	Contact authors
CASE2	FE21 - Carbon balance is wrong total partitioning (CHKPART2) is not equal to 1	Contact authors
CASE2	FE22 - Carbon balance is wrong for one organ, CHK** larger than 0.001	Contact authors
CASE2	FE23 - Maximum leaf age greater than one year	Change leaf age to less than 1 yr in plant.dat
CASE2	FE24 - Minimum leaf age less than zero (0)	Change leaf age to more than 0 days in plant.dat
CASE2	FE25 - Maximum leaf age less than minimum leaf age	Increase maximum leaf age or decrease minimum leaf age in plant.dat
CASE2	FE26 - Too many layers in external arrays	Change number of soil layers to less than 11 (and preferably not more than 6)
CLIMRD	cannot find requested year	Compare start year and duration of simulation (in basic.dat) with start and end year of weather data (in timer.dat)
CLIMRD	error while reading climate data	Check whether weather file is opened in another program; or check the format of the weather file
CLIMRD	illegal rainfall option	Change the value of IRNDAT.. to 0,1 or 2
DRSAHE	delt too large	Change DELT back to 1 in timer.dat
DRSAHE	error in water balance	Contact authors
DRSAHE	evaporation rate greater than zero	Contact authors
DRSAHE	Illegal SWIT8 value	Change SWIT8 value back to 1 in soil.dat
DRSAHE	No information for this SOILTYPE in soil.dat	Change soil type in basic.dat to a value for which data have been specified in soil.dat
DRSAHE	number of irrigation data is not multiple of three	Contact authors
DRSAHE	SWIT6 wrong value ; should be 1, 2 or 3	Change SWIT6 value back to 1 in soil.dat
DRSAHE	SWIT8 wrong value ; should be 1 or 2	Change SWIT8 value back to 1 in soil.dat
DRSAHE	SWIT9 wrong value ; should be 1 or 2	Change SWIT9 value back to 2 in soil.dat
DRSAHE	too few layers in external arrays	Contact authors
DRSAHE	too many layers defined in data file	Reduce number of layers to less than 11 (preferably not more than 6)
DRSAHE	water content greater than field capacity	Contact authors
DRSAHE	water content less than air dry	Contact authors
DRSAHE	wrong ITASK	Contact authors
FSE	Simulation period exceeds period for which weather data are available: select an earlier start year (IYEAR) or a shorter period (NRYEARS) in BASIC.dat	Select an earlier start year (IYEAR) or a shorter period (NRYEARS) in BASIC.dat
FSE	LOCATION number too high, should not exceed 23	Change location to a value <24 in basic.dat
FSE	No weather data available for start year specified in BASIC.dat choose later start year (IYEAR)	Specify a later start year (IYEAR) in basic.dat
FSE	No weather data available for start year	Specify an earlier start year (IYEAR) in basic.dat

Error messages

Subroutine	Error message text	Possible solution
	specified in BASIC.dat choose earlier start year (IYEAR)	
FSE	Output frequency value (OUTPUTFQ) is invalid	Change output frequency (OUPUTFQ) to 1, 2 or 3
LEAFPA	Negative X or canopy height	Contact authors
LEAFRE	Negative X or canopy height	Contact authors
METEO	current weather option not supported	Contact authors
METEO	DBMETEO option not supported	Contact authors
MODELS	unknown module name for evapotranspiration	Restore original timer.dat file
MODELS	unknown module name for plant	Restore original timer.dat file
MODELS	Wrong value for PRODLEVL	Specify PRODLEVL in
RANDOM	illegal random set	Contact authors
RANDOM	set not initialised	Contact authors
RANDOM	wrong ITASK	Contact authors
RNDIS	number of rainy days too large	Check number of rain days in weather file, should not > 30
RNREAL	error in day numbers on file	Contact authors
RNREAL	rain year not found	Check data availability in weather file
SASTRO	LAT > 90 or LAT < -90	Check latitude values in weather file
SETPMD	illegal longwave radiation option	Contact authors
SETPMD	Undefined iteration	Contact authors
SETPMD	unimplemented surface value	Contact authors
SSKYC	total shortwave irradiation <= zero	Check radiation values in weather file
SWSE	WCWET < WCCR	Contact authors

Warning messages

Warning messages always contain the following text: “WARNING from <Subroutine>: <Warning message>”, in which <Subroutine> is the name of the subroutine (source code file) in which the warning is issued and <Warning message> is the warning message itself. For example:

```
WARNING from CASE2: WA3 - Reserves depleted
Press <Enter>
```

Table II-2. List of warning messages displayed in the DOS screen while running CASE2 together with possible solutions for the problems. When the possible solution is “Contact authors” , the warning message text together with all *.dat files can be sent to the author’s e-mail address mentioned at page 2 of the report.

Warning message

Subroutine	Warning message text	Cause and possible solution
CASE2	WA1 – Very low annual rainfall, < 1000 mm	A year with very low rainfall occurred. No solution required.
CASE2	WA2 – Maximum tree age (40 yr) is reached	No solution. This is a model constraint.
CASE2	WA3 – Maximum tree size (70 kg DW) is reached	see above
CASE2	WA4 – Reserves depleted	The model tree’s reserves have probably been depleted due to lack of water availability. This may be due to a combination of low rainfall and poor water retention in the soil. Possible solution: try with favourable soil (e.g. Soil type 1)
CASE2	WA5 - Sum leaf class weights not equal to total leaf weight	Contact authors
CASE2	WA6 - Sum leaf class weights not equal to total lf weight	Contact authors
CASE2	WA7 - Sum pod class growth not equal to total pod growth	Contact authors
CASE2	WA8 - Sum pod class weight not equal to total pod weight	Contact authors
DRSAHE	initial soil moisture in hydrostatic equilibrium not implemented. Instead, field capacity is used.	This implies that water availability in the soil is optimal at the start of the model run. No solution required. Of importance for the interpretation of model output of the first days.
DRSAHE	initial soil moisture content larger than field capacity	Contact authors
DRSAHE	initial soil moisture content less than air dry	Contact authors
DRSAHE	potential soil evaporation has negative sign ! To extract water from the soil, the sign should be positive.	Contact authors
DRSAHE	rainfall has negative sign ! To add water to the soil through rainfall, the sign should be positive.	Contact authors
DRSAHE	transpiration has negative sign ! To extract water from the soil, the sign should be positive.	Contact authors
DRSAHE	Transpiration extracted water below wilting point in layer	Water content in one of the soil layers has been very low.
FSE 2.1m	There have been errors and/or warnings from the weather system, check file WEATHER.LOG	Check the errors. Change weather data file if necessary
MTYPE	Warning in WEATHR: estimated	No solution required
MTYPE	Warning in WEATHR: estimated and interpolated	No solution required
MTYPE	Warning in WEATHR: interpolated	No solution required

Warning message

Subroutine	Warning message text	Cause and possible solution
SASTRO	latitude above polar circle, daylength=0 hours	Check latitude in weather data file.
SASTRO	latitude within polar circle, daylength=24 hours	Check latitude in weather data file.
SETPMD	Low short-wave radiation ** J/m2/d	Check short-wave radiation in weather data file
SETPMD	Vapour pressure more than 40% greater than saturated !	Check vapour pressure values. No solution required.
SSKYC	ATMTR = ** , value very large	Atmospheric transmission very high. Contact authors
SVPS1	Extreme temperature: ** d. Celsius	Check weather files for extreme temperatures (>50 or < -20 °C

Appendix III: Complete listing of input files

Below the contents of the basic.dat, soil.dat, timer.dat and reruns.dat files is shown as they are included on the CD-ROM.

BASIC.DAT

```
************************************************************************
* File name: BASIC.DAT                                                 *
*                                                                      *
* Use      : With CASE2 (Cacao Simulation Engine), version 2.2         *
* Author(s): Pieter Zuidema                                            *
* Date     : January 2002                                              *
* Purpose  : Contains values of input parameters that can be changed.  *
*            For instance, location, and planting density              *
************************************************************************

!======================================================================!
!                                                                      !
! PART A. Specify information on location, simulation duration,        !
!         soil type, production level and output frequency here.       !
!                                                                      !
!======================================================================!

!----------------------------------!
! Location                         !
!----------------------------------!

* Specify location number
* Possible values:
* 1-50 for daily or monthly weather data (1-18 are included with program)
* >50  for long-term weather data (51-69 are included with program)
* For location numbers see the table at the end of this file or in the Manual.
  LOCATION = 15

!----------------------------------!
! Start and duration of simulation!
!----------------------------------!

* Specify the start year of the simulation (IYEAR) and the number of
* years for which simulations should be carried out.
* Possible values for IYEAR:
* for daily/monthly weather data:
*     Years for which weather data are available. Check the availability
*     of weather data for the location in Table 5.1 in the User's or the
*     table at the end of this file.
* for long-term weather data:
*     enter the value 1000
*
* Possible values for NRYEARS:
* for daily/monthly weather data:
*     This depends on the period of years for which weather data are
*     available. Check this in Table 5.1 in the User's or the table at
*     the end of this file.
* for long-term weather data:
*     any period of years
  IYEAR   = 1980
  NRYEARS = 10              ! [y]

!----------------------------------!
! Output frequency                 !
!----------------------------------!

* Specify the frequency at which output is generated in table and graph format.
* Choose 1 for annual output; 2 for output every 10 days
* and 3 for daily output
  OUTPUTFQ = 1

!----------------------------------!
! Soil type                        !
!----------------------------------!
```

```
* Specify the soil type.
* Possible values: 1-3 for soil types included with the program
* (1=Loamy soil,2=Sandy soil, 3=Clayey soil); >3 for user-defined soils
  SOILTYPE = 1

!---------------------------------!
! Potential or water-limited      !
!---------------------------------!

* Specify whether simulations should be carried out for a potential or water-
limited
* situation.
* Possible values: 1=Potential; 2=Water-limited
  PRODLEVL = 2


!=====================================================================!
!                                                                     !
! PART B. Specify cropping system characteristics here               !
!         (planting density, cacao tree age and shade tree information)!
!                                                                     !
!=====================================================================!

!---------------------------------!
! Cropping system                 !
!---------------------------------!

* Specify density at which cacao trees are planted in trees per ha.
* Possible values: 700.-2500. Note that number should be followed
* by a period sign (e.g. "1000.").
  NPL    = 1000.             ! [trees ha-1]

* Specify leaf area index (LAI) of shade trees in ha leaf per ha ground.
* Possible values: 0.-3. Note that number should include
* a period sign (e.g. "1." or "0.2").
  SLAI  = 0.2                ! [ha leaf ha-1 ground]

* Specify extinction coefficient for shade trees.
* Possible values: 0.4 - 0.8.
  SKDFL = 0.6                ! [-]

* Specify height of the shade tree canopy in m. SHGHL for height of lower
* canopy boundary; SHGHT for height of upper canopy boundary
* Possible values: 0.-40. Note that number should include
* a period sign (e.g. "5." or "7.5").
* Note that SHGHL should be less than SHGHT
  SHGHL = 4.0                ! [m] Lower height of shade tree crowns
  SHGHT = 10.                ! [m] Upper height of shade tree crowns

!---------------------------------!
! Cacao tree                      !
!---------------------------------!

* Specify height of the cacao tree in m: HGHL for height of lower canopy
* boundary; HGHT for height of upper canopy boundary
* Possible values: 0.-20. Note that number should include
* a period sign (e.g. "1." or "2.5").
* Note that HGHL should be less than HGHT
  HGHL = 0.75                ![m]
  HGHT = 3.50                ![m]

* Specify whether tree size or age is used for initial input
* Both plant size (biomass) and plant age can be used as input.
* The switch parameter SWINPUT determines which of the two is used.
* Possible values: 1=age is used as input; 2=size is used as input.
  SWINPUT = 1                ![-]

* Specify initial tree age in years.
* Note: this value is only used in case SWINPUT = 1
* Possible values: 3. - 40. Note that number should include
* a period sign (e.g. "5." or "12.5").
  AGEIYR  = 4.11             ! [y]

* Specify initial tree size (biomass per tree).
* Note: this value is only used in case SWINPUT = 2
```

```
* Possible values: 18.5 - 70.0. Note that number should include
* a period sign (e.g. "20." or "22.5").
  WTOTI   = 18.5            ![kg DW tree-1]; NOTE: Minimum size=18.5 kg

!-----------------------------------!
! Pod characteristics and processing !
!-----------------------------------!

* Specify the fat content of nibs
* The standard value is 0.55 (Wood and Lass 1986)
  FATCONTENT = 0.55                       ![-]

* Specify the fraction of beans per pod
* The standard value is 0.55
  FBEANS = 0.55                           ![-]

* Specify the pod index or pod value
* This is the number of pods needed for one kg of dry beans
* The standard value is 30.
  PODVALUE = 30.                          ![kg-1 DW]

* Specify the fermentation duration in hours.
* The standard value is 5.(Humphries, 1944)
  FMTDUR   = 5.                           ![d]

* Specify the moisture content of the beans
* The standard value is 0.075 (Wood & Lass 1985)
  MOISTC  = 0.075                         ![-]


!====================================================================!
! TABLE WITH LOCATION NUMBERS AND PERIODS WITH AVAILABLE WEATHER DATA  !
!====================================================================!

!--------------------------------------------------------------------!
! A.DAILY AND MONTHLY WEATHER DATA                                   !
!--------------------------------------------------------------------!
!LOCATION    Country           Site             Start Yr  End Yr Period!
! 1          Brazil            Maceio (Alagoas)   1961      1969   8  !
! 2          Costa Rica        El Carmen          1974      1991  18  !
! 3          Costa Rica        La Lola            1973      1990  18  !
! 4          Costa Rica        La Mola            1980      1989  10  !
! 5          Costa Rica        Puerto Limon       1970      1990  21  !
! 6          Ghana             Tafo               1963      1997  35  !
! 7          Indonesia         Bah Lias           1979      1993  15  !
! 8          Ivory Coast       Abidjan            1987      1996  10  !
! 9          Ivory Coast       Adiake             1987      1995   9  !
! 10         Ivory Coast       Daloa              1987      1996  10  !
! 11         Ivory Coast       Dimbokro           1987      1996  10  !
! 12         Ivory Coast       Gagnoa             1986      1997  12  !
! 13         Ivory Coast       Man                1987      1996  10  !
! 14         Ivory Coast       San  Pedro         1987      1996  10  !
! 15         Malaysia          Tawau (Sabah)      1951      1993  43  !
! 16         Malaysia          Telok Chengai      1978      1988  11  !
! 17         Papua New Guinea   Dami              1970      1991  22  !
! 18         Philippines    IRRI wet station site  1979      1995  17  !
! 19         - user-defined -                                         !
! 20         - user-defined -                                         !
! 21         - user-defined -                                         !
! 22         - user-defined -                                         !
! 23         - user-defined -                                         !
! etc.                                                                !
!--------------------------------------------------------------------!

!--------------------------------------------------------------------!
! B.LONG-TERM WEATHER DATA                                           !
!--------------------------------------------------------------------!
!LOCATION    Country           Site                                  !
! 51         Brazil            Belem                                 !
! 52         Brazil            Salvador                              !
! 53         Brazil            Vitoria                               !
! 54         Cameroon          Batouri                               !
! 55         Cameroon          Douala                                !
! 56         Colombia          Andagoya                              !
! 57         Colombia          Villavicencio                         !
! 58         Ghana             Hon                                   !
```

```
! 59        Ghana              Kumasi                                    !
! 60        Ghana              Tafo                                      !
! 61        Ivory Coast        Abidjan                                   !
! 62        Ivory Coast        Gagnoa                                    !
! 63        Ivory Coast        Man                                       !
! 64        Malaysia           Kuala Trengganu                           !
! 65        Malaysia           Penang                                    !
! 66        Malaysia           Sandakan                                  !
! 67        Malaysia           Tawau                                     !
! 68        Papua New Guinea   Madang                                    !
! 69        Papua New Guinea   Rabaul                                    !
! 70        - user-defined -                                             !
! 71        - user-defined -                                             !
! 72        - user-defined -                                             !
! 73        - user-defined -                                             !
! 74        - user-defined -                                             !
! etc.                                                                   !
!------------------------------------------------------------------------!
```

RERUNS.DAT

```
**********************************************************************
* File name: RERUNS.DAT                                              *
*                                                                    *
* Use      : With CASE2 (Cacao Simulation Engine), version 2.2       *
* Purpose  : Contains values of input parameters that can be changed.  *
*            For instance, location, and planting density            *
**********************************************************************

!====================================================================!
!                                                                    !
! PART A. EXAMPLE RERUNS                                             !
!         To use one of the example reruns, simply remove the "*"-sign !
!         at the start of the line. Do not forget to place an "*" again!
!         when you do not wish to do reruns for that parameter.       !
!====================================================================!

!---------------------------------!
! Production level                !
!---------------------------------!
*When removing the * in the below line, an extra run will be performed
*for PRODLEVL = 1 (potential production).
*PRODLEVL = 1

!---------------------------------!
! Soil type                       !
!---------------------------------!
*When removing the * in the below lines, 2 extra runs will be performed
*for SOILTYPE = 2 and 3 (sandy and clayey soils).
* SOILTYPE = 2
* SOILTYPE = 3

!---------------------------------!
! Shade level                     !
!---------------------------------!
*When removing the * in the below lines, 7 extra runs will be performed
*for LAI of the shade tree SLAI = 0 ... 3 (no shading to heavy shading).
*SLAI = 0.
*SLAI = 0.5
*SLAI = 1.
*SLAI = 1.5
*SLAI = 2.
*SLAI = 2.5
*SLAI = 3.

!====================================================================!
!                                                                    !
! PART B. USER-DEFINED RERUNS                                        !
!         To add a user-defined rerun, simply write one line of the   !
!         type:     <PARNAME> = <VALUE>                              !
!         in which <PARNAME> is the name of an input parameter and   !
!         <VALUE> is the value for which a rerun is wanted.          !
!         To de-select the rerun, simply put an "*" mark in front of  !
!         the line. More instructions in the User's manual           !
!                                                                    !
!====================================================================!
```

SOIL.DAT

```
**********************************************************************
* SOIL.DAT                                                           *
*                                                                    *
* To be used with CASE2 (CAcao Simulation Engine), version 2.2       *
* This data        file contains soil information used by CASE2          .   *
*                                                                    *
**********************************************************************

**********************************************************************
* INFORMATION IN PART A OF THIS THIS DATA FILE MAY BE CHANGED        *
**********************************************************************

!====================================================================!
!                                                                    !
! PART A. Information may be added to this part of the file.         !
!         Please follow the instructions in the User's Manual        !
!                                                                    !
!====================================================================!

!---------------------------------!
! Soil type specifications        !
!---------------------------------!

* Soil type 1
* Loamy soil with 4 layers, soil characteristics from Wessel (1971)
* Nigeria
NL1    = 4                        ! Number of layers
TKL1   = 0.10,0.30, 0.30, 1.50    ! Thickness of layers (m)
TYL1   = 12., 9., 8., 8.          ! Driessen texture classes for layers
                                 ! See table in User's Manual or below

* Soil type 2
* Sandy soil taken from Wood & Lass(1985), Table 3.8
* Brazil, Rondonia
NL2    = 4                        ! Number of layers
TKL2   = 0.09,0.14, 0.12, 1.19    ! Thickness of layers (m)
TYL2   = 1., 7., 9., 14.          ! Driessen texture classes for layers
                                 ! See table in User's Manual or below

* Soil type 3
* Clayey soil taken from Wood & Lass(1985), Table 3.17
* Malaysia, Tawau
NL3    = 4                        ! Number of layers
TKL3   = 0.02,0.54, 0.48, 0.52    ! Thickness of layers (m)
TYL3   = 12., 17., 19., 19.       ! Driessen texture classes for layers
                                 ! See table in User's Manual or below

* Soil type 4
* < specify type of soil and information source here >
* < specify country and area here >
NL4    = 0                       ! Number of layers
TKL4   = 0., 0., 0., 0.          ! Thickness of layers (m)
TYL4   = 0., 0., 0., 0.          ! Driessen texture classes for layers
                                 ! See table in User's Manual or below
* Soil type 5
* < specify type of soil and information source here >
* < specify country and area here >
NL5    = 0                       ! Number of layers
TKL5   = 0., 0., 0., 0.          ! Thickness of layers (m)
TYL5   = 0., 0., 0., 0.          ! Driessen texture classes for layers
                                 ! See table in User's Manual or below
* Soil type 6
* < specify type of soil and information source here >
* < specify country and area here >
NL6    = 0                       ! Number of layers
TKL6   = 0., 0., 0., 0.          ! Thickness of layers (m)
TYL6   = 0., 0., 0., 0.          ! Driessen texture classes for layers

* Soil type 7
* < specify type of soil and information source here >
* < specify country and area here >
NL7    = 0                       ! Number of layers
TKL7   = 0., 0., 0., 0.          ! Thickness of layers (m)
```

```
TYL7   = 0., 0., 0., 0.         ! Driessen texture classes for layers

* Soil type 8
* < specify type of soil and information source here >
* < specify country and area here >
NL8    = 0                      ! Number of layers
TKL8   = 0., 0., 0., 0.         ! Thickness of layers (m)
TYL8   = 0., 0., 0., 0.         ! Driessen texture classes for layers


!=======================================================================!
!                                                                       !
! PART B. NO changes may be made to this part of the data file.         !
!                                                                       !
!=======================================================================!

* Evaporation proportionality factor
EES = 20.                        ! m-1

* Type of equation used
SWIT8 = 1               ! (1) Driessen equation
                        ! (2) van Genuchten equation
                        ! (3) Linear interpolation

* Type of soil input
SWIT9 = 2               ! Use predefined texture classes

* Initialization
SWIT6 = 1               ! (1) Initial water content field capacity
                        ! (2) Initial water content user defined
                        ! (3) Initial water content wilting point

!=======================================================================!
! TABLE WITH RIJTEMA/DRIESSEN SOIL TEXTURE TYPES (Driessen, 1986)       !
!=======================================================================!

!-----------------------------------------------------------------------!
!    TYL  Description               TYL  Description                    !
!                                                                       !
!      1. Coarse sand                11. Fine sandy loam                !
!      2. Medium coarse sand (mcs)   12. Silt loam                      !
!      3. Medium fine sand           13. Loam                           !
!      4. Fine sand                  14. Sandy clay loam                !
!      5. Humous loamy mcs           15. Silty clay loam                !
!      6. Light loamy mcs            16. Clay loam                      !
!      7. Loamy mcs                  17. Light clay                     !
!      8. loamy fine sand            18. Silty clay                     !
!      9. Sandy loam                 19. Heavy clay                     !
!     10. Loess loam                 20. Peat                           !
!-----------------------------------------------------------------------!
```

TIMER.DAT

```
**********************************************************************
* TIMER.DAT                                                          *
*                                                                    *
* To be used with CASE2 (CAcao Simulation Engine), version 2.2       *
* This data file contains timer and weather information used by CASE2  *
*                                                                    *
**********************************************************************

**********************************************************************
* INFORMATION IN PART A OF THIS THIS DATA FILE MAY BE CHANGED        *
**********************************************************************

!====================================================================!
!                                                                    !
! PART A. Location specifications.                                   !
!         Information may be added to this part of the file.         !
!         Please follow the instructions in the User's Manual        !
!                                                                    !
!====================================================================!

!--------------------------------------------------------------------!
! Explanation of parameters:
! WTRDIR  = Directory of weather data
! CLFILE  = File with weather data when IWEATH = 0,1 (WOFOST or
!           longterm weather data)
! IWEATH  = Flag indicating the weather system used:
!           Possible values: 0,1 for Wofost monthly weather;
!           2 for Cabo daily weather
! CNTR    = Country of weather data; only to be used in combination
!           with Cabo daily weather (IWEATH = 2)
! ISTN    = Station number of weather data; only to be used
!           in combination with Cabo daily weather (IWEATH = 2)
! IRNDAT  = Flag indicating rainfall system when IWEATH = 0, 1:
!           Possible values: 0 for generated rain,
!           1 for distributed rain, 2 for observed rain.
! STRTYR1 = First year for which weather data are available
! ENDYR1  = Last year for which weather data are available
!--------------------------------------------------------------------!

!---------------------------------!
! Daily or monthly weather data   !
!---------------------------------!

* LOCATION 1
* Brazil, Maceio (Alagoas) 1961  1969 d
  WTRDIR1 = 'c:\case2\weather\daily\'
  CNTR1   = 'brazil'
  ISTN1   = 2
  IWEATH1 = 2
  IRNDAT1 = 2
  STRTYR1 = 1961
  ENDYR1  = 1969

* LOCATION 2
* Costa Rica  El Carmen        1974  1991 d
  WTRDIR2 = 'c:\case2\weather\daily\'
  CNTR2   = 'cr'
  ISTN2   = 1
  IWEATH2 = 2
  IRNDAT2 = 2
  STRTYR2 = 1974
  ENDYR2  = 1991

* LOCATION 3
* Costa Rica        La Lola       1973         1990     18       d
  WTRDIR3 = 'c:\case2\weather\daily\'
  CNTR3   = 'cr'
  ISTN3   = 4
  IWEATH3 = 2
  IRNDAT3 = 2
  STRTYR3 = 1973
  ENDYR3  = 1990

* LOCATION 4
* Costa Rica        La Mola       1980         1989     10       d
```

```
  WTRDIR4 = 'c:\case2\weather\daily\'
  CNTR4   = 'cr'
  ISTN4   = 6
  IWEATH4 = 2
  IRNDAT4 = 2
  STRTYR4 = 1980
  ENDYR4  = 1989

* LOCATION 5
* Costa Rica, Puerto Limon 1970      1990     21       d
  WTRDIR5 = 'c:\case2\weather\daily\'
  CNTR5   = 'cr'
  ISTN5   = 5
  IWEATH5 = 2
  IRNDAT5 = 2
  STRTYR5 = 1970
  ENDYR5  = 1990

* LOCATION 6
* Ghana    Tafo         1963 1997     35       m
  WTRDIR6 = 'c:\case2\weather\monthly\'
  CLFILE6 = 'ghataf.wof'
  IWEATH6 = 1
  IRNDAT6 = 1
  STRTYR6 = 1963
  ENDYR6  = 1997

* LOCATION 7
* Indonesia         Bah Lias           1979    1993     15       m
  WTRDIR7 = 'c:\case2\weather\monthly\'
  CLFILE7 = 'idnbhl.wof'
  IWEATH7 = 1
  IRNDAT7 = 1
  STRTYR7 = 1979
  ENDYR7  = 1993

* LOCATION 8
* Ivory Coast       Abidjan       1987         1996     10       m
  WTRDIR8 = 'c:\case2\weather\monthly\'
  CLFILE8 = 'civabi.wof'
  IWEATH8 = 1
  IRNDAT8 = 1
  STRTYR8 = 1987
  ENDYR8  = 1996

* LOCATION 9
* Ivory Coast       Adiake        1987         1995     9        m
  WTRDIR9 = 'c:\case2\weather\monthly\'
  CLFILE9 = 'civadi.wof'
  IWEATH9 = 1
  IRNDAT9 = 1
  STRTYR9 = 1987
  ENDYR9  = 1995

* LOCATION 10
* Ivory Coast       Daloa    1987     1996     10       m
  WTRDIR10 = 'c:\case2\weather\monthly\'
  CLFILE10 = 'civdal.wof'
  IWEATH10 = 1
  IRNDAT10 = 1
  STRTYR10 = 1987
  ENDYR10  = 1996

* LOCATION 11
* Ivory Coast       Dimbokro  1987    1996     10       m
  WTRDIR11 = 'c:\case2\weather\monthly\'
  CLFILE11 = 'civdim.wof'
  IWEATH11 = 1
  IRNDAT11 = 1
  STRTYR11 = 1987
  ENDYR11  = 1996

* LOCATION 12
* Ivory Coast       Gagnoa        1986         1997     12       m
  WTRDIR12 = 'c:\case2\weather\monthly\'
  CLFILE12 = 'civgag.wof'
```

```
  IWEATH12 = 1
  IRNDAT12 = 1
  STRTYR12 = 1986
  ENDYR12  = 1997

* LOCATION 13
* Ivory Coast       Man              1987     1996     10       m
  WTRDIR13 = 'c:\case2\weather\monthly\'
  CLFILE13 = 'civman.wof'
  IWEATH13 = 1
  IRNDAT13 = 1
  STRTYR13 = 1987
  ENDYR13  = 1996

* LOCATION 14
* Ivory Coast       San  Pedro        1987    1996     10       m
  WTRDIR14 = 'c:\case2\weather\monthly\'
  CLFILE14 = 'civsan.wof'
  IWEATH14 = 1
  IRNDAT14 = 1
  STRTYR14 = 1987
  ENDYR14  = 1996

* LOCATION 15
* Malaysia Tawau (Sabah)     1951     1993     43       m
  WTRDIR15 = 'c:\case2\weather\monthly\'
  CLFILE15 = 'mystab.wof'
  IWEATH15 = 1
  IRNDAT15 = 1
  STRTYR15 = 1951
  ENDYR15  = 1993

* LOCATION 16
* Malaysia Telok Chengai1978 1988     11       m
  WTRDIR16 = 'c:\case2\weather\monthly\'
  CLFILE16 = 'mals002a.wof'
  IWEATH16 = 1
  IRNDAT16 = 1
  STRTYR16 = 1978
  ENDYR16  = 1988

* LOCATION 17
* Papua New Guinea  Dami 1970         1991     22       d
  WTRDIR17 = 'c:\case2\weather\daily\'
  CNTR17   = 'png'
  ISTN17   = 1
  IWEATH17 = 2
  IRNDAT17 = 2
  STRTYR17 = 1970
  ENDYR17  = 1991

* LOCATION 18
* Philippines       IRRI         1979 1995     17       d
  WTRDIR18 = 'c:\case2\weather\daily\'
  CNTR18   = 'phil'
  ISTN18   = 1
  IWEATH18 = 2
  IRNDAT18 = 2
  STRTYR18 = 1979
  ENDYR18  = 1995

* LOCATION 19
* < specify location name and period of weather data here >
  WTRDIR19 = ' '
  CNTR19   = ' '
  CLFILE19 = ' '
  ISTN19   = 0
  IWEATH19 = 0
  IRNDAT19 = 0
  STRTYR19 = 0
  ENDYR19  = 0

* LOCATION 20
* < specify location name and period of weather data here >
  WTRDIR20 = ' '
  CNTR20   = ' '
```

```
  CLFILE20 = ' '
  ISTN20   = 0
  IWEATH20 = 0
  IRNDAT20 = 0
  STRTYR20 = 0
  ENDYR20  = 0

* LOCATION 21
* < specify location name and period of weather data here >
  WTRDIR21 = ' '
  CNTR21   = ' '
  CLFILE21 = ' '
  ISTN21   = 0
  IWEATH21 = 0
  IRNDAT21 = 0
  STRTYR21 = 0
  ENDYR21  = 0

* LOCATION 22
* < specify location name and period of weather data here >
  WTRDIR22 = ' '
  CNTR22   = ' '
  CLFILE22 = ' '
  ISTN22   = 0
  IWEATH22 = 0
  IRNDAT22 = 0
  STRTYR22 = 0
  ENDYR22  = 0

* LOCATION 23
* < specify location name and period of weather data here >
  WTRDIR23 = ' '
  CNTR23   = ' '
  CLFILE23 = ' '
  ISTN23   = 0
  IWEATH23 = 0
  IRNDAT23 = 0
  STRTYR23 = 0
  ENDYR23  = 0

!----------------------------------!
! Long-term weather data           !
!----------------------------------!

* LOCATION 51
* Brazil   Belem
  CLFILE51 = 'Bra9.ltm'

* LOCATION 52
* Brazil   Salvador
  CLFILE52 = 'Bra99.ltm'

* LOCATION 53
* Brazil   Vitoria
  CLFILE53 = 'Bra144.ltm'

* LOCATION 54
* Cameroon Batouri
  CLFILE54 = 'Cmr7.ltm'

* LOCATION 55
* Cameroon Douala
  CLFILE55 = 'Cmr6.ltm'

* LOCATION 56
* Colombia Andagoya
  CLFILE56 = 'Col16.ltm'

* LOCATION 57
* Colombia Villavicencio
  CLFILE57 = 'Col27.ltm'

* LOCATION 58
* Ghana    Hon
  CLFILE58 = 'Gha10.ltm'
```

```
* LOCATION 59
* Ghana    Kumasi
  CLFILE59 = 'Gha8.ltm'

* LOCATION 60
* Ghana    Tafo
  CLFILE60 = 'Gha99.ltm'

* LOCATION 61
* Cote d'Ivoire     Abidjan
  CLFILE61 = 'Civ8.ltm'

* LOCATION 62
* Cote d'Ivoire     Gagnoa
  CLFILE62 = 'Civ7.ltm'

* LOCATION 63
* Ivory Coast       Man
  CLFILE63 = 'Civ5.ltm'

* LOCATION 64
* Malaysia Kuala Trengganu
  CLFILE64 = 'Mys8.ltm'

* LOCATION 65
* Malaysia Penang
  CLFILE65 = 'Mys1.ltm'

* LOCATION 66
* Malaysia Sandakan
  CLFILE66 = 'Mys37.ltm'

* LOCATION 67
* Malaysia Tawau
  CLFILE67 = 'Mys99.ltm'

* LOCATION 68
* Papua New Guinea  Madang
  CLFILE68 = 'Png3.ltm'

* LOCATION 69
* Papua New Guinea  Rabaul
  CLFILE69 = 'Png9.ltm'

* LOCATION 70
* < specify location name and period of weather data here >
  CLFILE70 = ' '

* LOCATION 71
* < specify location name and period of weather data here >
  CLFILE71 = ' '

* LOCATION 72
* < specify location name and period of weather data here >
  CLFILE72 = ' '

* LOCATION 73
* < specify location name and period of weather data here >
  CLFILE73 = ' '

* LOCATION 74
* < specify location name and period of weather data here >
  CLFILE74 = ' '

* LOCATION 75
* < specify location name and period of weather data here >
  CLFILE75 = ' '

!=======================================================================!
!                                                                       !
! PART B. NO changes may be made to this part of the data file.         !
!
!=======================================================================!

!---------------------------------!
! Output                          !
```

```
!--------------------------------!

* per yr
PRSEL1='YEAR','ageyr','YRAIN','YRDD','YTRANS','WTOT','WRT','WTOTPP','WLV','WWD','WT
RT','WLRT','WPD','YGPHOT','YGTOT','YYLDPD','YYLDBN','YLVD','YWDD','WPDCUM','WBNCUM'
,'YHI','YHINCR','YMNBH','YMNLAI','YMNIPOD','YHARPD','YRDEFF','YRNEFF','YNLOSS','YPL
OSS','YKLOSS','<TABLE>'

* per 10 days
PRSEL2='year','doy','ageyr','tmav','pcew','lai(1)','WTOT','wtotpp','wrt','wlrt','wt
rt','wlv','wwd','wpd','WPDCUM','WBNCUM','D10GTOT','D10YLDPD','D10YLDBN','D10RAIN','
D10RDD','D10HARPD','<table>'

* per day
PRSEL3='year','doy','ageyr','rdd','rain','tmav','atrans','ptrans','pcew','frabs(1)'
,'lai(1)','WTOT','wtotpp','wrt','wlrt','wtrt','wlv', 'wwd', 'wpd',
'gphot','maint','GTOT','gpd','glv','grt','glrt','gtrt','GWD','GTOT1','GTOT2','FLV',
'FWD','FPD','FTRT','FLRT','dwd','dlrt','dlv','dlv1','dlv2','ltrt','yldpd','YLDBN','
BHYLD','harpods','WPDCUM','WBNCUM','<table>'

* years and days for which output is generated in case of annual output
IOBSD  = 1000, 365
         1956, 366, 1957, 365, 1958, 365, 1959, 365, 1960, 366,
         1961, 365, 1962, 365, 1963, 365, 1964, 366, 1965, 365,
         1966, 365, 1967, 365, 1968, 366, 1969, 365, 1970, 365,
         1971, 365, 1972, 366, 1973, 365, 1974, 365, 1975, 365,
         1976, 366, 1977, 365, 1978, 365, 1979, 365, 1980, 366,
         1981, 365, 1982, 365, 1983, 365, 1984, 366, 1985, 365,
         1986, 365, 1987, 365, 1988, 366, 1989, 365, 1990, 365,
         1991, 365, 1992, 366, 1993, 365, 1994, 365, 1995, 365,
         1996, 366, 1997, 365, 1998, 365, 1999, 365, 2000, 366,
         2001, 365, 2002, 365

                           ! List of observation data for which output
                           ! is required. The list should consist of
                           ! pairs of <year>,<day> combinations.

IPFORM = 5                 ! Format of output file:
                           !    0 = no output table,
                           !    4 = normal table,
                           !    5 = tab-delimited (Excel),
                           !    6 = TTPLOT format
COPINF = 'N'               ! Switch variable what should be done with
                           ! the inputfiles:
                           !   'N' = do not copy inputfiles into
                           !         outputfile,
                           !   'Y' = copy inputfiles into outputfile
DELTMP = 'Y'               ! Switch variable what should be done with
                           ! the temporary and binary output file:
                           !   'N' = do not delete,
                           !   'Y' = delete
STTIME = 1.                ! Start day of simulation
DELT   = 1.                ! Time step of integration


* Radiation parameter
  FRPAR = 0.5

IFLAG  = 1101              ! Indicates where weather error and warnings
                           ! go (1101 means errors and warnings to log
                           ! file, errors to screen, see FSE manual)

PLTMOD = 'CACAO'
* PLTMOD = 'NO CROP'

ETMOD = 'PENMAN'
* ETMOD = 'MAKKINK'
* ETMOD = 'PRIESTLEY/TAYLOR'
```