DSSAT v4.5 - Canegro Sugarcane Plant Module

User Documentation

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Contents

1. Introduction

This document guides the user to set up and execute a Canegro simulation run within the DSSAT environment, manipulate weather soil and crop management input data, calibrate plant input parameters, and compare simulated output data with observed data. It takes the form of a tutorial, where a complete simulation is set up from scratch. Each step in this process is described. Emphasis is placed on sugarcane-specific aspects of the DSSAT system; further comprehensive documentation, covering general aspects of operating the DSSAT software, is provided with the DSSAT distribution.

Every DSSAT simulation consists of an Experiment file (FileX), which references soil (FileS) and weather (FileW) files. This document describes how to go about creating a FileX for running sugarcane simulations, as well as providing some information on creating weather and soil files, particularly where these have special relevance for sugarcane.

The Canegro model in DSSAT makes use of genetic information defined in species, ecotype and cultivar files. Some guidance for creating new cultivar and ecotype definitions is presented in this document.

2. Inputs

Every DSSAT simulation consists of an Experiment file (FileX), which defines crop management for a particular ‘experiment’ (set of model runs or ‘treatments’) and references soil (FileS) and weather (FileW) files. These resources are separated in this way because soil definitions and weather data can be used in several simulations (even for different crops), whereas the experimental setup file is unique to a particular experiment. This document describes how to go about creating a FileX for running sugarcane simulations, as well as providing some information on creating weather and soil files, particularly where these have special relevance for sugarcane.

Crop modelling has a complex nature. While DSSAT is among the most user-friendly systems available for crop modelling, care must be taken to ensure that the simulations are reliably set up. Several resources potentially need to be defined – soil, weather, crop management, cultivar/genetic information and simulation options. Technical errors can creep in within any of these resources. Scientific errors are not considered (i.e. the scientific bases for the model are assumed to be correct). DSSAT can, however, assist in detecting technical input errors, but this is beyond the scope of this document.

These technical errors can be minimised, and more importantly, more easily detected, if an iterative process is followed when setting up a simulation. This process includes the following:

Define the **management first** – associate the treatments within an experiment with **existing soil and weather data, existing cultivars, and standard simulation options**. See if the model runs and check for any errors. Use of these ‘placeholders’ is recommended because they have been tested and shown in general to be free of technical errors.

Step 1: Define the **weather data**; **update the management** file (FileX) such that these new weather data are used **instead** of the ‘placeholder’ weather data set up in step 1. **Test** to ensure that the simulation still runs and results make sense.

Step 2: Set up any special simulation **options** (e.g. specifying FAO-56 PET method). Run the simulation to **check** that it still works and makes sense.

Step 3: **Define the soil; update the management file** (FileX) such that this new soil profile definition(s) is/are used instead of the ‘placeholder’ soil data set up in step 1. Test to ensure that the simulation still runs and results make sense.

Step 4: Set up new cultivars by copying an existing one and updating the variables one-by-one; **update the management file** (FileX) such that these new cultivar definitions are used instead of the 'placeholder' cultivars set up in step 1. **Test** to ensure that the simulation still runs and results make sense.

Step 5: The simulation setup is now complete.

If the model ceases to operate at any step in this process, the user will know immediately where the error has occurred and remedial action can be taken without delay.

If such an iterative process is not followed, the user runs the risk of not knowing where an error has occurred – the model might simply 'crash', leaving the user with the potentially large task of tracking down the error(s).

An alternative error-minimising approach is to first create each of the resources – soil, weather, cultivars, etc. – and then modify a known functioning simulation to use these. Again, an iterative approach is used – one change is made, the model is run, results checked, and then the next change is made. If, for example, the model ran fine with one soil and then crashed on the new soil profile, it could be inferred that the new soil definition has an error and should be checked.

2.1. Soil

The DSSAT SBuild program is used for creating soil files. Click on the Sbuild icon on the main DSSAT screen to load this software.

Each soil in DSSAT is defined as a soil profile and stored in a soil file. Soils are named and coded. The soil code is used in the experiment file to refer to soil information. Each soil profile has a number of soil layers. Each layer is associated with specific physical and chemical characteristics. DSSAT-Canegro only uses physical aspects. The physical water-holding effects of Soil Organic Matter are modelled by the DSSAT v4.5 system and might affect Canegro simulations.

The most important soil variables are:

2.1.1. Water holding characteristics

DUL – drained upper limit. This is the maximum stable soil water content the soil can maintain. It is equivalent to Field Capacity. It is determined by watering the soil very well, covering it and then leaving it for several days, after which the water content is determined gravimetrically (or otherwise).

LL – lower limit. This is soil water content of the soil at which the plant can no longer extract water from the soil. It is equivalent to the Permanent Wilting Point. It can be determined using a pressure plate system, and is soil water content at which no more water can be extracted at 15 bars of pressure.

SAT – saturated water capacity. This is the highest soil water content above which water will immediately drain from the profile.

Units: all soil water holding measures are volumetric, i.e. volume of water per volume of soil, typically cm3/cm3 .

2.1.2. Infiltration characteristics

SWCN – saturated water conductivity. This is the speed with which water traverses from one soil layer to a lower one. In a wet soil, surface water infiltration rate is dependent on the SWCN of the slowest layer (cm/hr).

2.1.3. Rooting characteristics

WR – root distribution weighting. Root distribution is plant and soil dependent since root mass and volume in sugarcane tend to decline with depth. If the soil has an impermeable layer or a water table, roots will not grow below that layer.

In addition to these, soil albedo (light reflectivity) and Curve Number (for runoff calculations) need to be set.

DSSAT prompts for entry of nutritional and soil organic matter data, but DSSAT-Canegro does not model nutrients. If you have this information, it is worth entering it, because future model updates will hopefully include nutrient support, and this soil definition can also be used for other crops that do model nutrients.

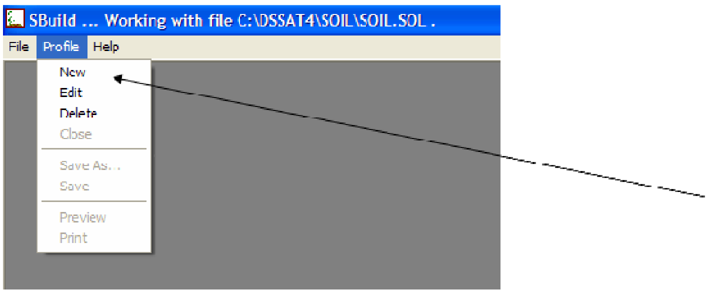
DSSAT also stores other soil information that may not be used by the model – e.g. soil colour. Again, it is good practice to enter all known soil information because this is a useful database of soil information and these variables may be used in future.

There are several optional parameters, some of which are used only as of v4.5 of the DSSAT software (e.g. the effect of soil organic matter on moisture retention of the soil).

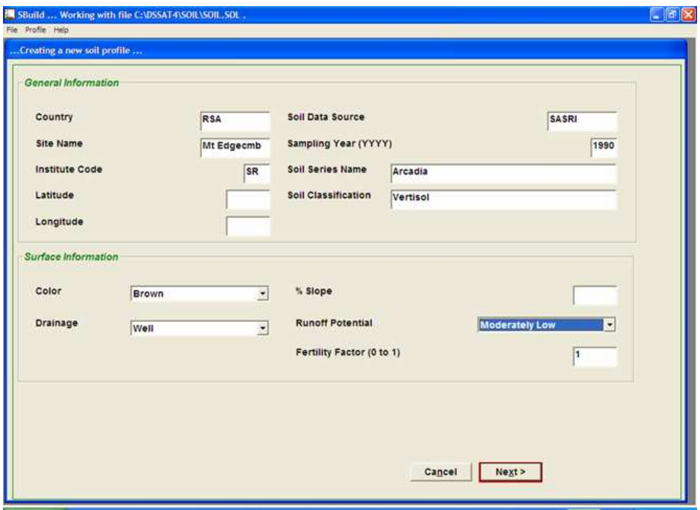
2.1.4. Creating a new soil

Step1. Open Sbuild.

Step 2. Access the Profile menu and select ‘New’.



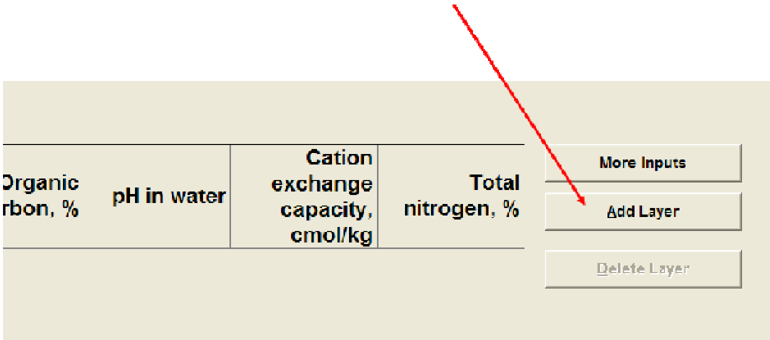
Step 3. Enter general soil data. This is used for selecting the soil and for various calculations (e.g. runoff).



Step 4. Create all layers first (by clicking on the ‘Add Layer’ button several times) – then characterise them, e.g. if there are 10 soil layers, add all 10 first and then enter values.

Step 5. Look at the Exercise handout – you will see the number of layers (7).

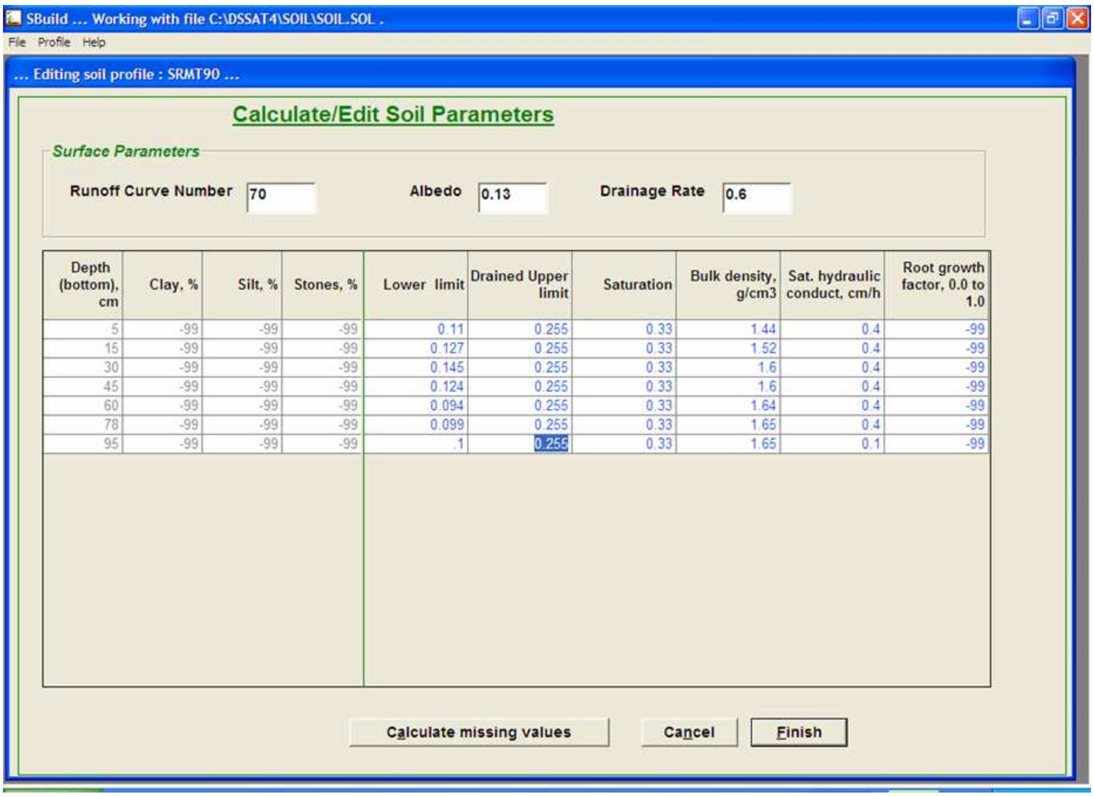
Step 6. Click Next.



Step 7. Then define soil layer thicknesses (depths of lower layer boundaries); Note: start from the deepest layer and work your way up.

Step 8. Click Next.

Step 9. Then enter the attribute values – e.g. DUL, LL, etc (remember the soil albedo etc. at the top!).

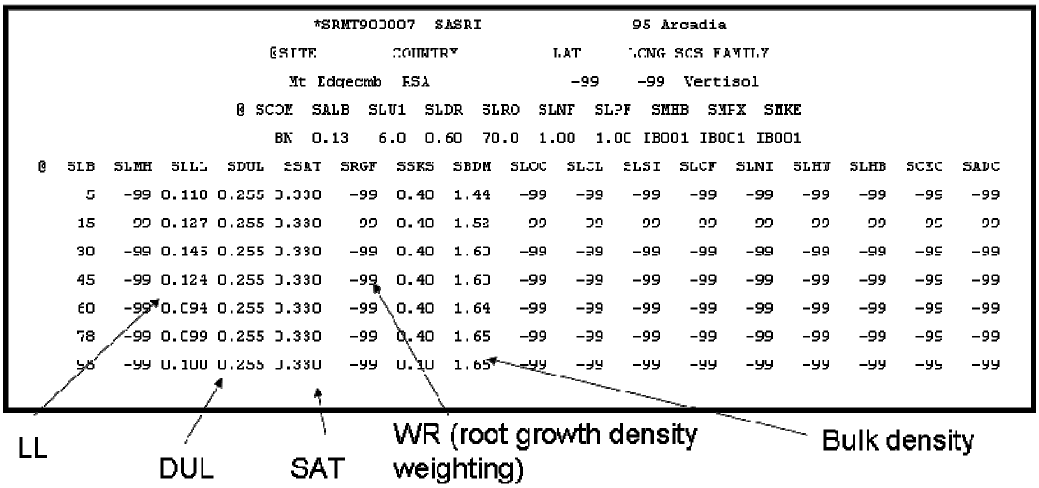


Step 10. Click on ‘Finish’.

Step 11. VERY IMPORTANT! – click on Profile → Save. If you forget to do this, you will lose the information you have entered

Step 12. Then click 'File → Save'.

Step 13. If you look in C:\DSSAT4\Soil, in the Soil.sol file, you should see your new soil.



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*SRMT900007  SASRI                95 Arcadia
@SITE        COUNTRY          LAT     LONG SCS FAMILY
 Mt Edgecmb  RSA                -99    -99  Vertisol
@ SCOM  SALB  SLU1  SLDR  SLRO  SLNF  SLPF  SMHB  SMPX  SMKE
   BN   0.13   6.0  0.60  70.0  1.00  1.00 IB001 IB001 IB001
@  SLB  SLMH  SLLL  SDUL  SSAT  SRGF  SSKS  SBDM  SLOC  SLCL  SLSI  SLCF  SLNI  SLHW  SLHB  SCEC  SADC
     5   -99 0.110 0.255 0.330   -99  0.40  1.44   -99   -99   -99   -99   -99   -99   -99   -99   -99
    15    99 0.127 0.255 0.330    99  0.40  1.52    99    99    99    99    99    99    99    99    99
    30   -99 0.145 0.255 0.330   -99  0.40  1.60   -99   -99   -99   -99   -99   -99   -99   -99   -99
    45   -99 0.124 0.255 0.330   -99  0.40  1.60   -99   -99   -99   -99   -99   -99   -99   -99   -99
    60   -99 0.094 0.255 0.330   -99  0.40  1.64   -99   -99   -99   -99   -99   -99   -99   -99   -99
    78   -99 0.099 0.255 0.330   -99  0.40  1.65   -99   -99   -99   -99   -99   -99   -99   -99   -99
    [illegible]   -99 0.100 0.255 0.330   -99  0.40  1.65   -99   -99   -99   -99   -99   -99   -99   -99   -99
```


Notes:

i. Always remember to open/save PROFILES, which are within soil FILES.

ii. To work with a different FILE, use the File menu.

iii. You may have to copy the updated soil.sol file into the sugarcane directory if the model has trouble finding it.

iv. If you cannot find the new soil profile in XBuild, click on the 'Refresh' menu in Xbuild.

v. To work with a different PROFILE, use the profile menu.

vi. The 'quirky' nature of SBuild may make it necessary to modify the file directly (e.g. using Notepad):

- Ensure that your columns line up correctly.
- Ensure that the changes / additions you make to the files are as consistent as possible with the existing information in the files.
- Files are fixed-format, so exact numbers of spaces are important!
- Use spaces, not the TAB key.

2.2. Weather

Use the WeatherMan software to enter weather data – click on the WeatherMan icon on the main DSSAT screen to load the program.

Variables required for good sugarcane modelling are:

- Bare minimum:
- Minimum temperature (oC)
- Maximum temperature (oC)
- Rainfall (mm)
- Solar Radiation (MJ/m2)

The following are highly recommended:

- Maximum relative humidity (%)
- Windspeed (km/day)

or

- Dewpoint temperature (oC)

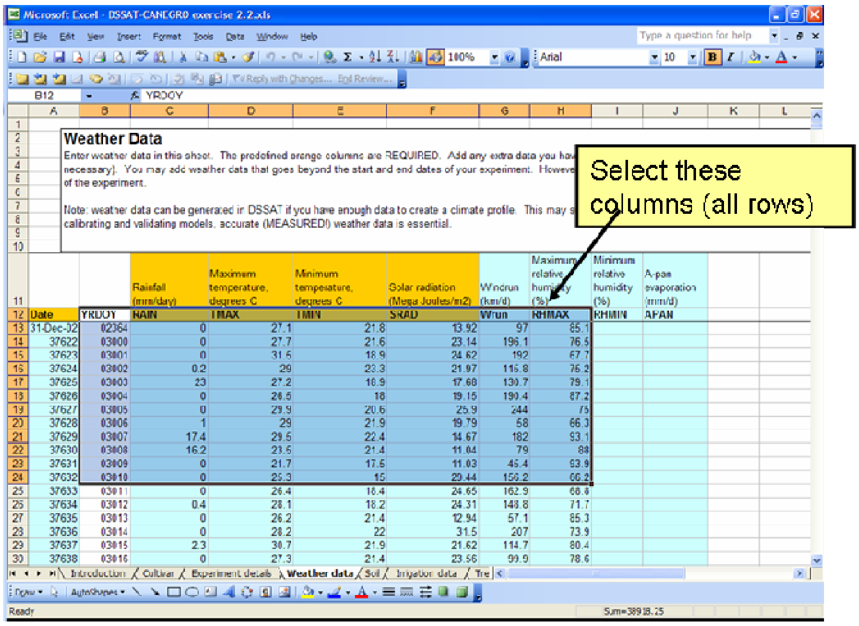
The last one/two variables are for the FAO-56 Potential Evapotranspiration calculation. If you do not have these variables, you will have to use the less accurate Priestley-Taylor method (an Xbuild setting – see the management section for this).

WeatherMan makes provision for only one measure of humidity; we decided that that would represent maximum humidity, and is assumed to occur at the same time as minimum temperature. This allows the model to calculate Dewpoint Temperature. If dewpoint temperature is calculated more accurately outside of DSSAT (e.g. with wet and dry bulb temperatures), this should be imported into WeatherMan, because it will be more accurate than the internal calculation.

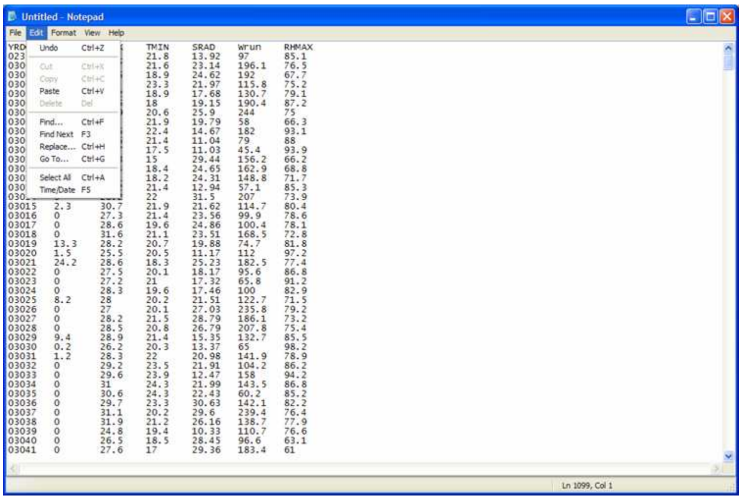
The easiest way to enter information into WeatherMan is to import a text file of weather data:

Step 1. Import the text file into Excel.

Step 2. Assuming the data are in a spreadsheet, select the appropriate columns of the weather data and paste into a blank Excel worksheet.

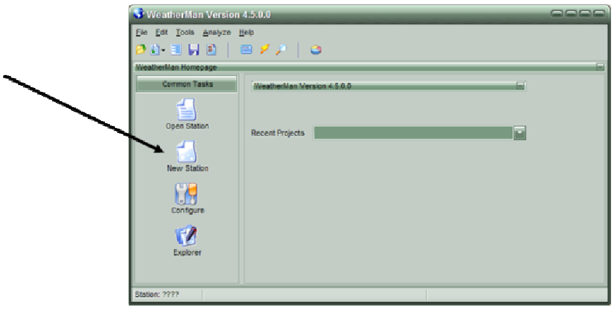


Step 3. Then copy these columns and paste into a Notepad window. Save this file as a text file, e.g. ‘Station25_data.txt’.

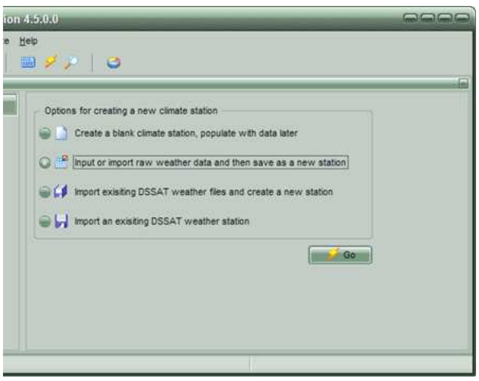


Step 4. Use the WeatherMan wizard to import this data into WeatherMan:

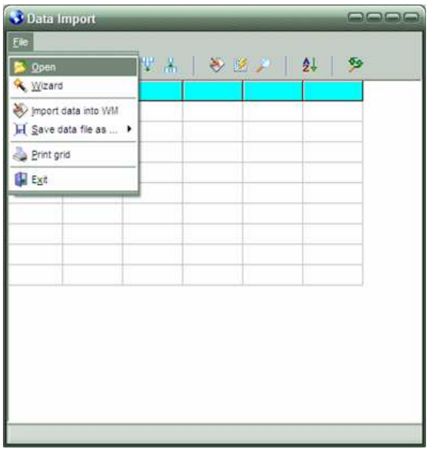
Step 5. Click on ‘New station’:



Step 6. Select the ‘Input or import raw weather data and save as a new station’ option.

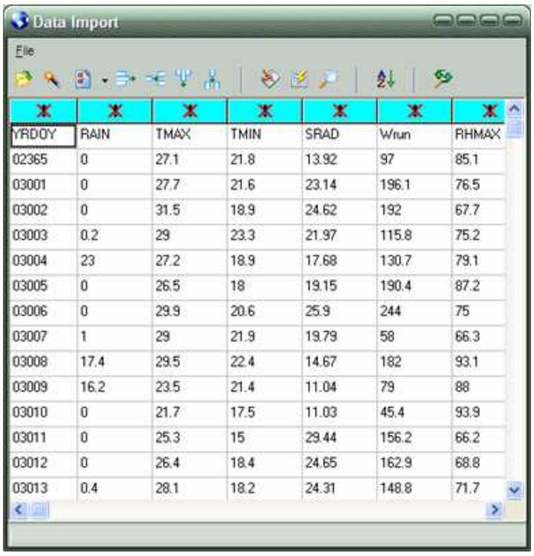


Step 7. Then click File → Open.



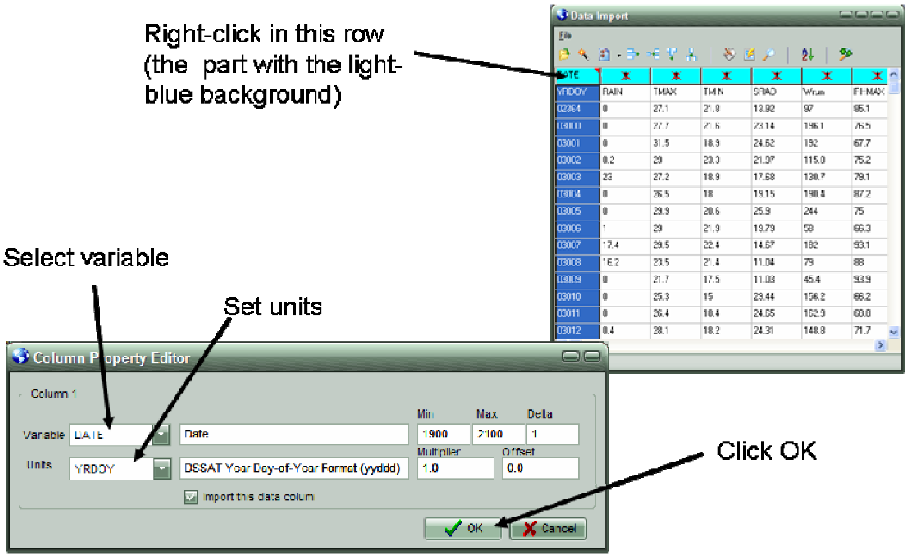
Step 8. Browse to the text file you have just created, select it, click ok.

Step 9. The screen will look something like this:



Step 10. You will be presented with your data in grid form, but it will need to be manipulated slightly first:

- Define the columns (right-click on the column header and select a variable and units).
- When all columns are defined, remove the header row.



Note: In the example above, an Excel formula was used to create the YRDOY date format. This is not strictly necessary, but ensures that WeatherMan is not confused by the computer's regional date format. For this reason, it is recommended to try to reformat dates into this format. In general, it is recommended that data are entered in a form as close as possible to the final stored form – and any processing required should be performed outside of WeatherMan. Rainfall should be in mm/day, temperatures in degrees C, solar radiation in MJ/m^2, humidity in percentages; column headings can also be correctly named (DATE, RAIN, SRAD, RHUM, WIND, TMIN, TMAX).

2.3. Management

Setup of management information is very important and perhaps also the most difficult. This difficulty is associated with actually using the program (which occasionally displays unexpected behaviour) and conceptual difficulties associated with factor levels and treatments. The technical difficulties can be mitigated somewhat by carefully and closely following these instructions.

2.3.1. Concepts of factors, levels and treatments

An agricultural experiment is usually intended to compare different crop management approaches, with the intention of e.g. deriving descriptive information to advise growers, or perhaps inferring information about the physiology of the plant. Each 'management approach' is a treatment – a combination of different management factor levels. For example, if an agronomist is interested in the effect of different rowspacings and cultivars of sugarcane on growth and development, he will be assessing two management factors (rowspacing and cultivars). If he compares three different rowspacings (e.g. 0.6, 1.0 and 1.4 m) and two cultivars (e.g. NCo376 and R570), he will have three factor levels within the rowspacing management factor and two factor levels within the cultivar factor. He will have six treatments – the six unique combinations of the management factor levels:

Table 1. Management factor row spacing

Level	Value
1	0.6 m
2	1.0 m
3	1.4 m

Table 2. Management factor cultivar

Level	Value
1	NCo376
2	R 570

Table 3. Treatments

Treatment Level	Row spacing factor level	Cultivar factor level	Description
1	1	1	0.6 m rowspacing, cultivar NCo376
2	1	2	0.6 m rowspacing, cultivar R570
3	2	1	1.0 m rowspacing, cultivar NCo376
4	2	2	1.0 m rowspacing, cultivar R570
5	3	1	1.4 m rowspacing, cultivar NCo376
6	3	2	1.4 m rowspacing, cultivar R570

In DSSAT, all treatments are constructed in this way. It is first necessary to define each management factor level. Each level is assigned a level number, and the user can associate a short description to each level to aid identification when it comes to constructing the treatments. Defining the treatments – as combinations of management factor levels – is done last.

Note: Rather than providing every possible management factor for treatments, DSSAT arranges management factors into categories. Row spacing, for example, falls into the 'planting' management factor. If several row spacings are to be assessed, rather than have different rowspacing factor levels, the user will have different planting factor levels; each planting factor level will be characterised by different row spacings.

2.3.2. Setting up an experiment (management) file in DSSAT using XBuild

The following steps describe how an experiment – the definition of treatments with factor levels (management) – is set up. The Xbuild program is used; a FileX is created.

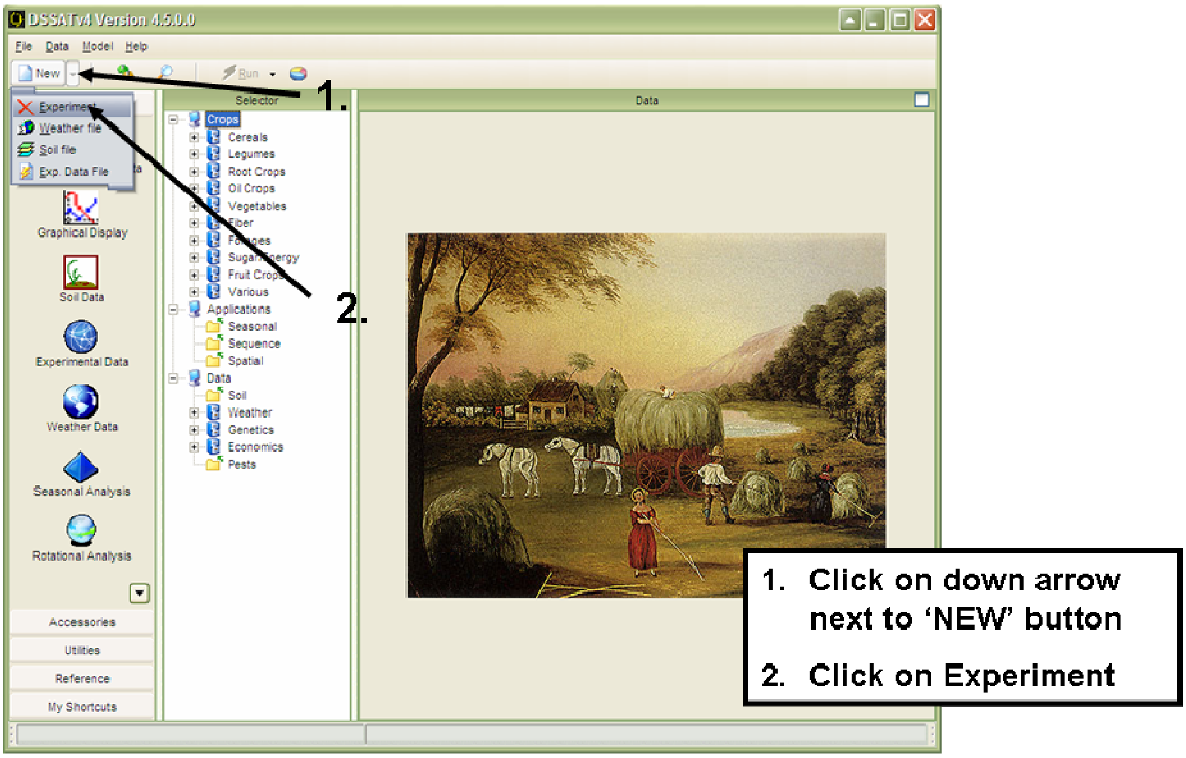
Use of Xbuild is described via an example. The details of this simulation are as follows:

- Location: Mount Edgecombe, South Africa
- Years: 1989, 1990
- Row spacing: 1.2 m
- Cultivar NCo376
- Harvest at 12 months
- Treatments: irrigated and non-irrigated, April and October ratooning

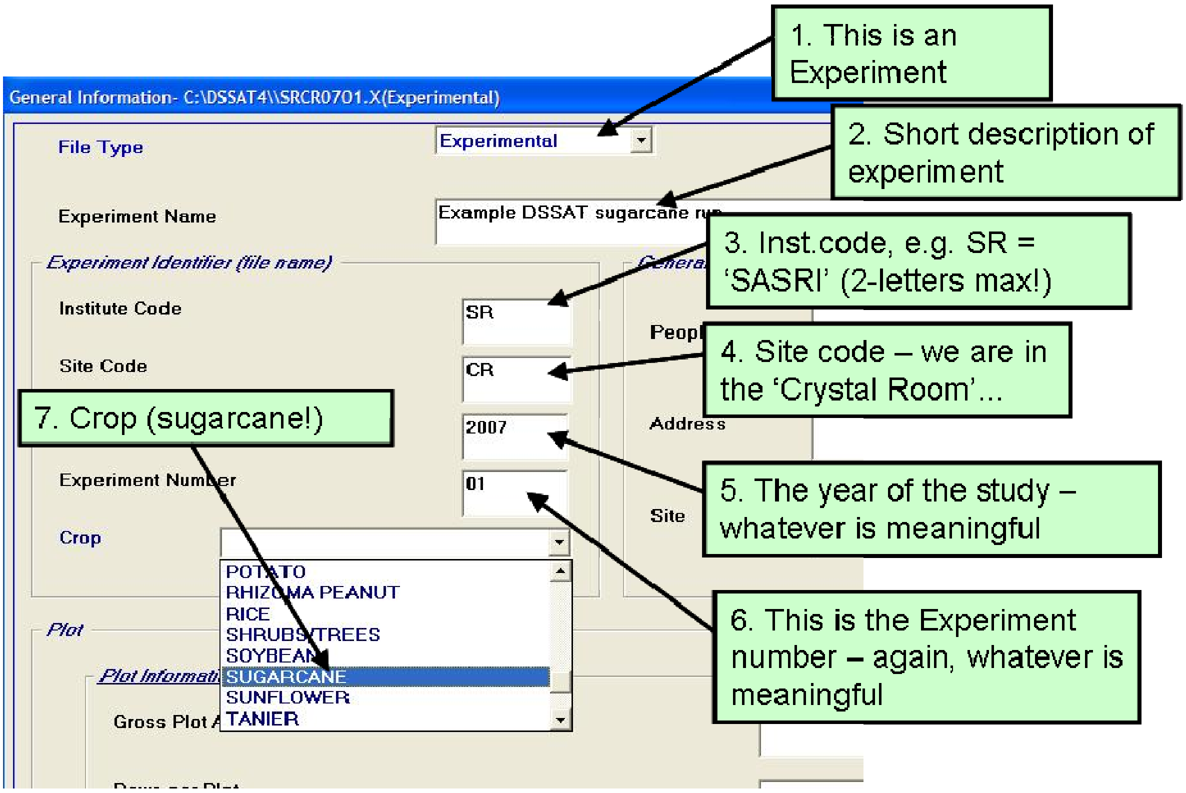
4 treatments:

Level	Plant date	Irrigation/rainfed
1	Treatment 1 – start 1 April 1989	rainfed
2	Treatment 2 – start 1 October 1989	rainfed
3	Treatment 3 – start 1 April 1989	irrigated
4	Treatment 4 – start 1 October 1989	irrigated

Step 1. Open DSSAT and create a new experiment.



Step 2. Xbuild should load. Enter the following information:



i. Choose 'Experimental' for File Type

ii. Enter a short description of the experiment

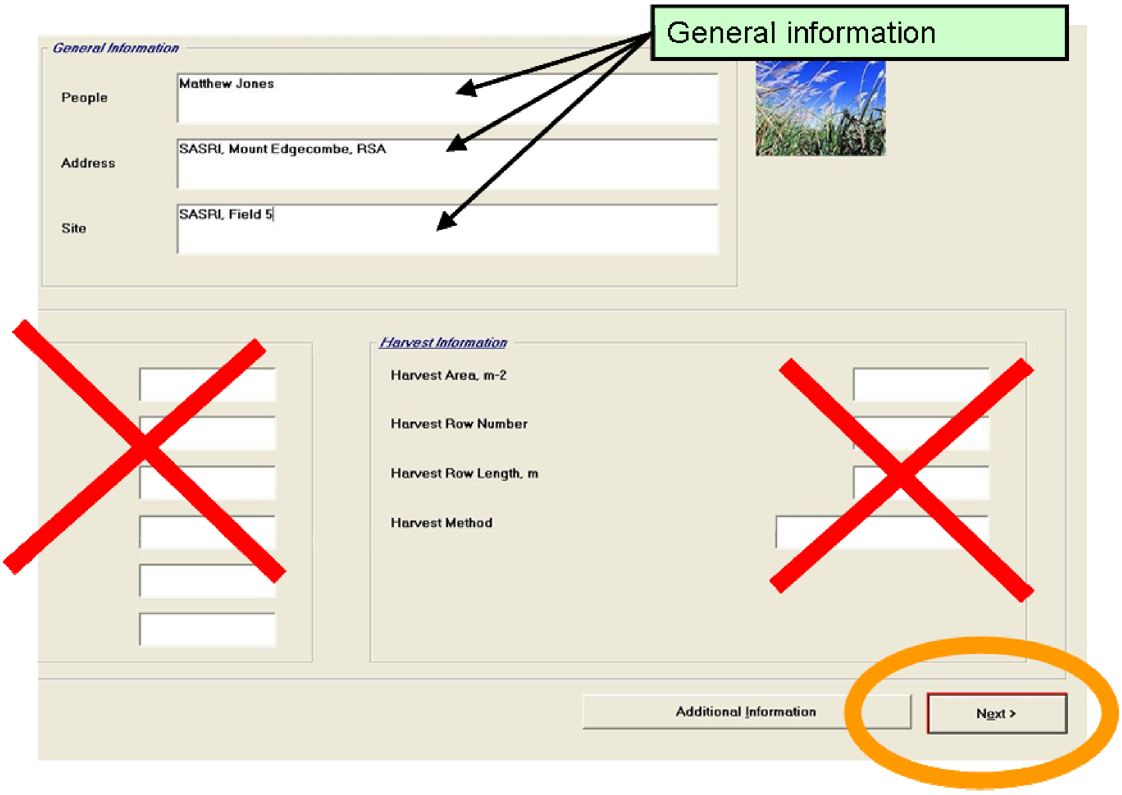
iii. Enter a 2-letter institute code

iv. Enter a 2-letter site code

v. Enter a meaningful year; either the simulated year of the experiment or the year that the simulation is being run

vi. Enter an experiment number; choose something appropriate

vii. Very importantly, choose 'Sugarcane' as the Crop.



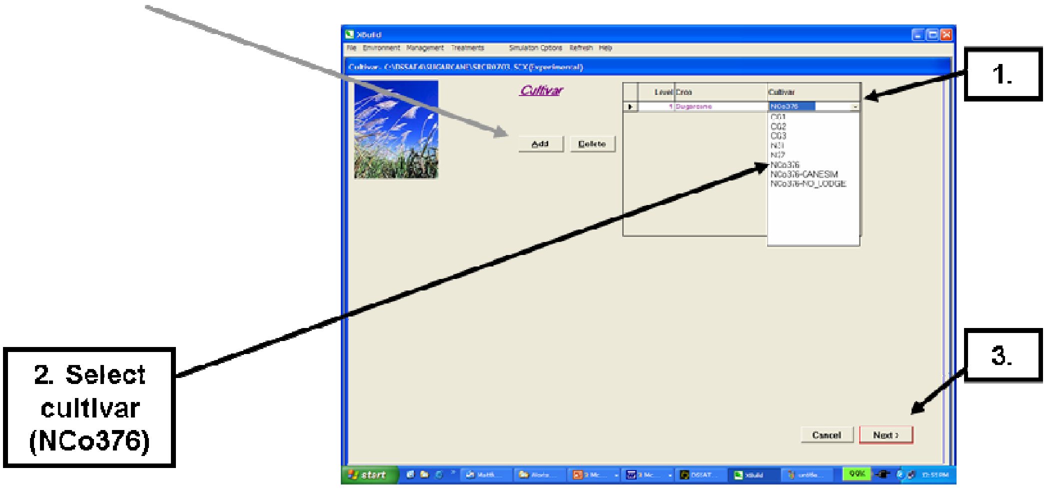
viii. Enter general information (follow on-screen indications); ignore the other sections of the screen.

ix. Click Next

x. Click on File→Save. Using the information you have entered, DSSAT will assign a unique code for this experiment. This code will be used as the filename for this FileX.

Remember, Xbuild caters for ALL crops. For this reason, it must support all of the inputs required for all crops. Not all of these inputs are used by the sugarcane model. If you have this information, however, it is worth entering, because it is possible that a future version of the sugarcane model will use that input. Unfortunately, despite certain inputs not being used by the sugarcane model, Xbuild itself requires certain inputs to be set. In such cases, a default value should be entered (some examples will follow). Inputs that are not used by the sugarcane model cannot be used as factor levels, because the model will effectively run exactly the same simulation for every such level.

Step 2. Choose cultivars to use in the simulation:



Click on the Add button to add another cultivar factor level. Click on the cultivar code in the rightmost column of the Cultivar table to get a drop-down to select which cultivar you want to use. In this example simulation, NCo376 was used.

Step 3. Field setup.

Note: if you are not presented with the Fields screen, click on the 'Environment' menu and then click on 'Fields'.

The field has two basic components – a soil, and a location.

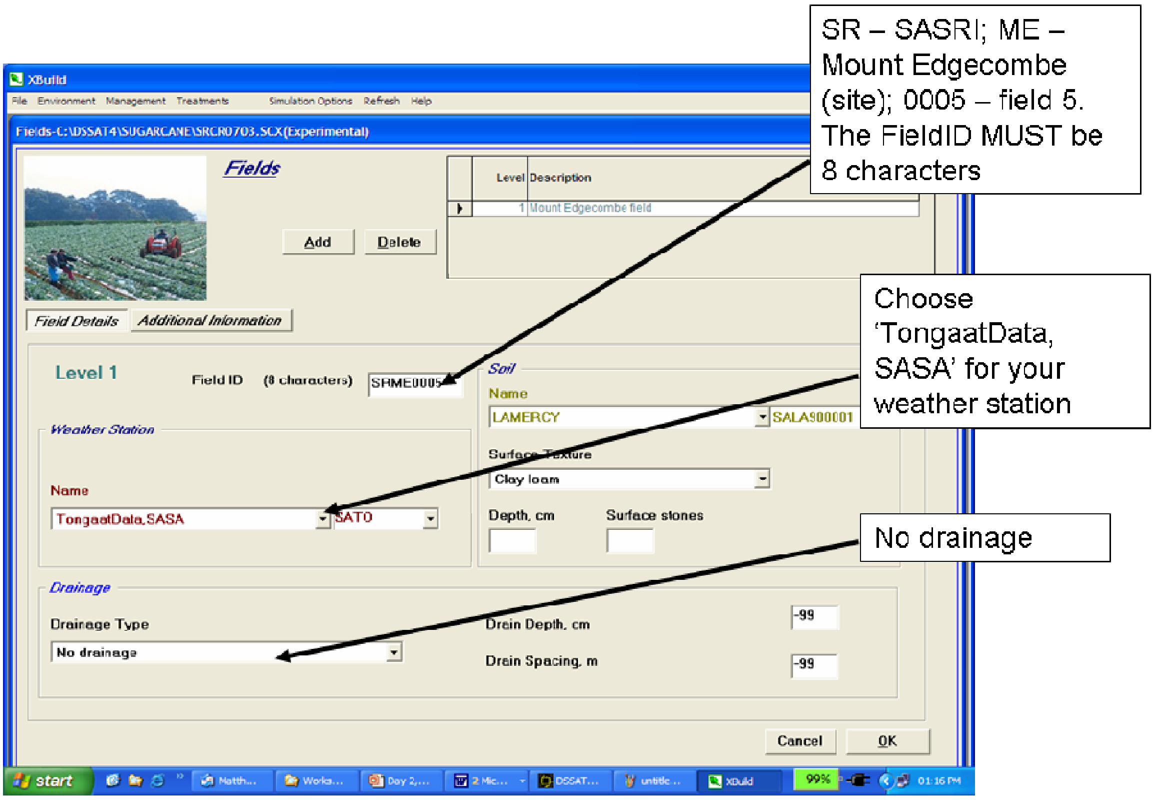
i. Choosing a soil

Choose a soil from the drop-down list on the right-hand side of the screen. If you have not yet created a soil profile/file for this experiment, simply choose any soil from the list. It is a placeholder until you have set up the correct soil, after which you will come back to this screen and choose the correct soil instead. Select a surface texture if you know this.

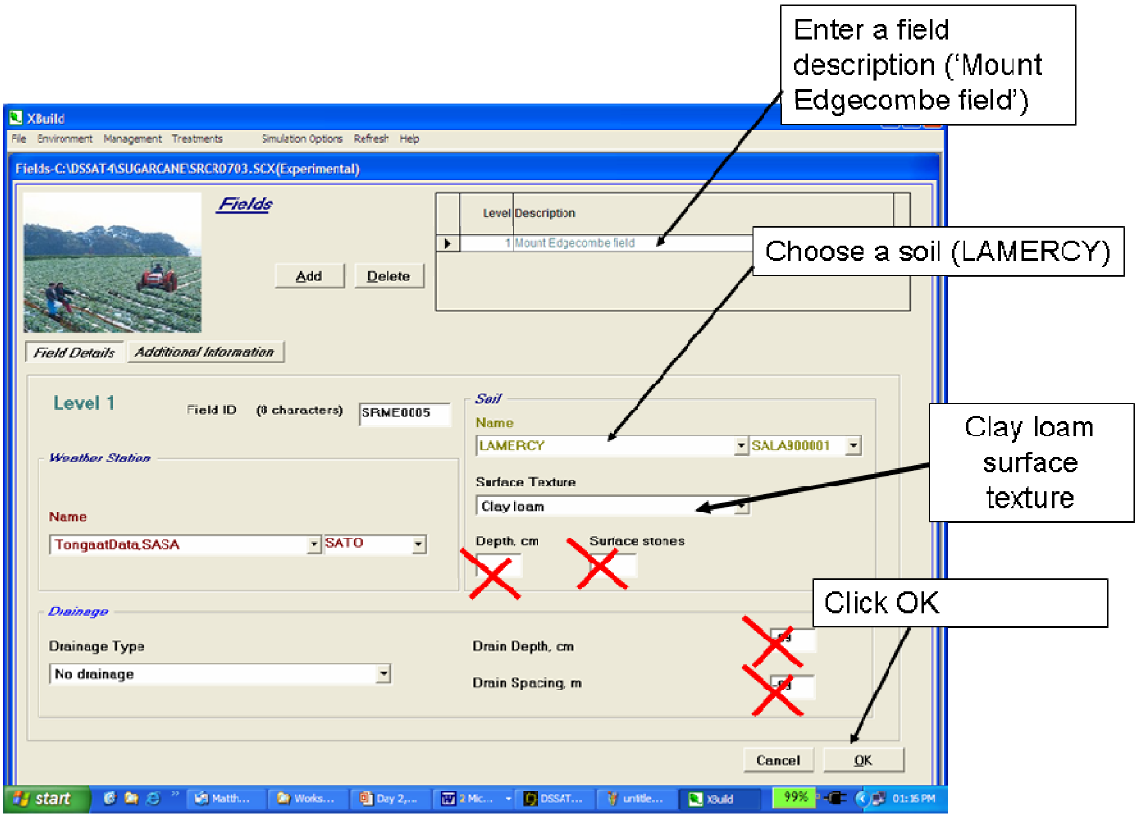
The other soil parameters can be ignored, but if you have the information it is worth entering it. Remember, although this is basically just a model configuration file you are setting up, it can contain enough information that it becomes a really useful tool for storing historical experiment/trial information.

ii. Choosing a location (weather station)

The location is defined by choice of weather station: as it is the weather that is driving the model, it is assumed that the weather station is at the trial site. In practice, weather stations tend to be some way away from the trial site, but this is unavoidable. If you have not yet entered weather data for this experiment, either choose the next nearest station available on the drop-down list, or choose any station. *For now, this is a placeholder*; when you have entered weather data for this experiment, you will come back and update this so that the correct weather data is used.



You will need to choose an 8-character FieldID. At the top right of the screen, you will see that you are currently editing Level 1 of the Fields management factor. You can (and should) enter a short description of this field. If your experiment treatments require more than one weather station or soil, you will need to add new field factor level(s) using the Add button.



Click OK.

Step 4. Set up the planting details.

Note 1: if you are not presented with the Planting Details screen, click on the 'Management' menu and then click on 'Planting'.

Note 2: Xbuild has a bug in it where it misreads dates unless they are entered in the American date format. Xbuild definitely works best if you have the Short Date Format of your PC set to the US convention of MM/DD/YYYY. This can be set in the Windows Control Panel – Start Menu→Control Panel→Regional & Language Settings (icon)→Customise (button)→Date (tab)→Short date (drop-down list)

In this example, planting date is one of the factors varied for the treatments. Two factor levels are required – planting on 1 April 1989 and 1 October 1989.

i. Enter a description for this planting factor level.

ii. Type in the planting date in the planting date textbox (see Note 2 above). You will see the available weather data years for the currently-selected station listed on the left-hand side.

iii. Omit emergence date.

iv. Select 'Dry seed' if this is a sugarcane plant crop (no 'sett' option exists) or 'Ratoon' if this is a ratoon crop.

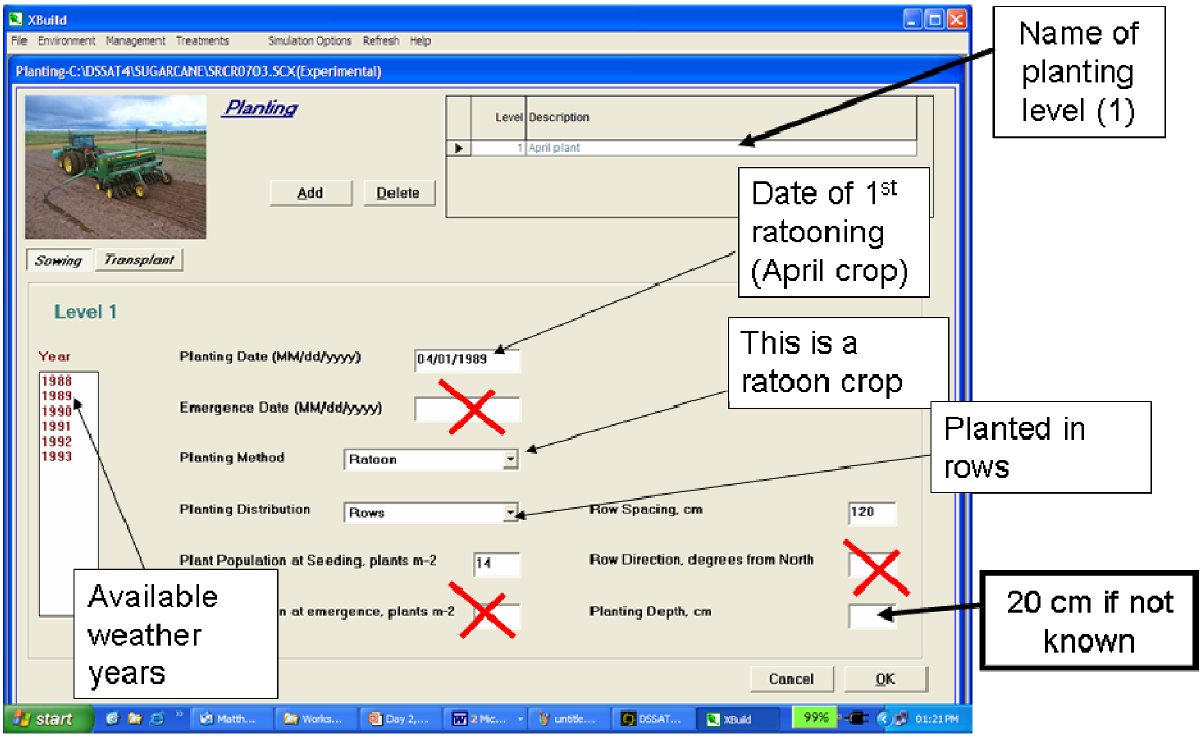
v. Select 'Rows' from planting distribution.

vi. It is necessary to enter a seed population, despite this not being used by the model; choose any value (preferably the correct value).

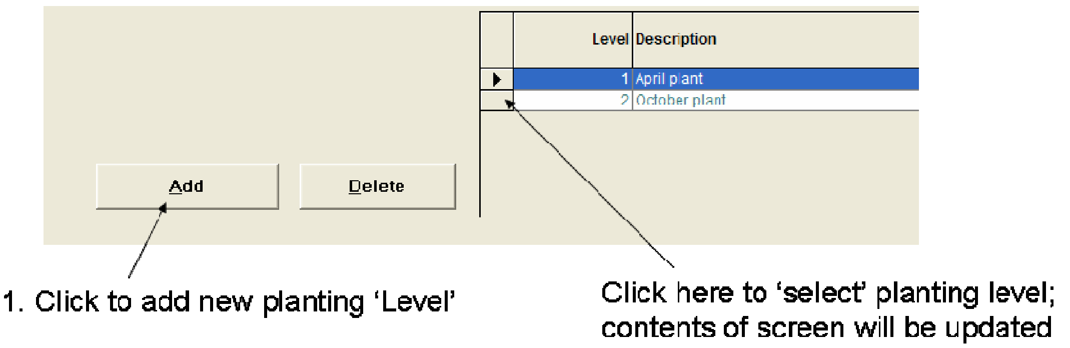
vii. Ignore population at emergence and row direction.

viii. Enter row spacing (in cm).

ix. Enter Planting Depth (in cm); again, this is not used by the model but DSSAT will crash if it does not find this input. 20 cm is a plausible default.

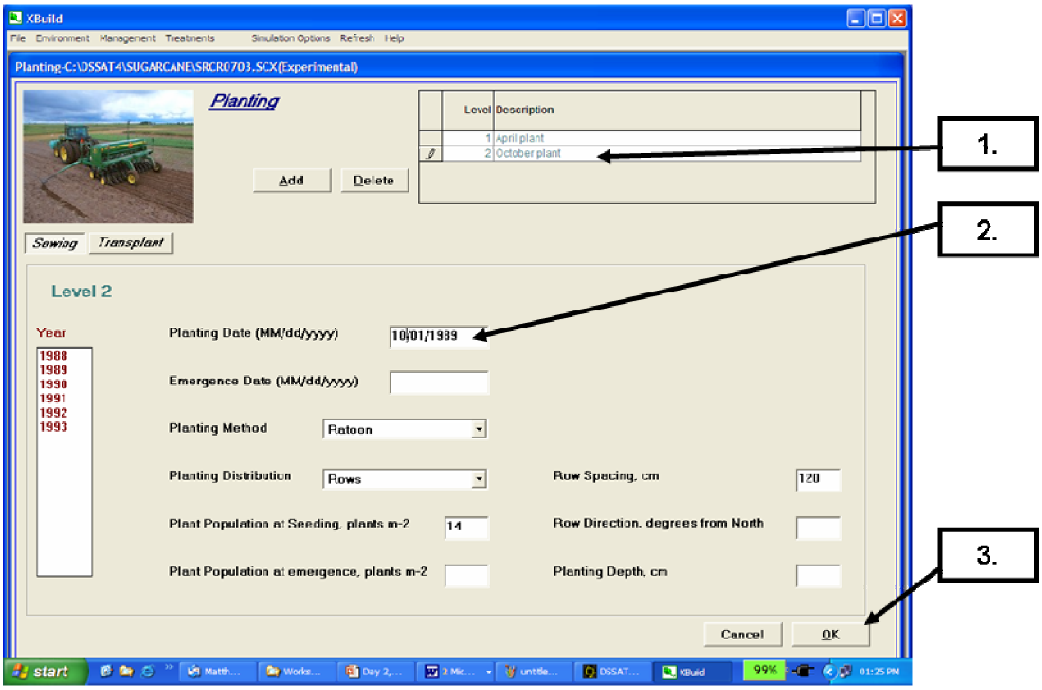


x. Then add the new factor level for the October planting:



NOTE: if you have already set up Level 1, Level 2 will automatically be a copy of Level 1; you will only have to update the actual date – all other details are identical

xi. Make the appropriate changes such that it correctly reflects what we are trying to achieve with the treatments; (1) give the new level a meaning short description, (2) add the new planting date and (3) click OK to complete:



You have now created a 'bare bones' simulation. Xbuild will return to its main screen. If you have not yet saved, this is a very good time to do so: File→Save.

Further work is required to define a basic practically-functional simulation:

Harvest dates **must** be set for sugarcane. Failure to do so will result in the model running until the weather data runs out.

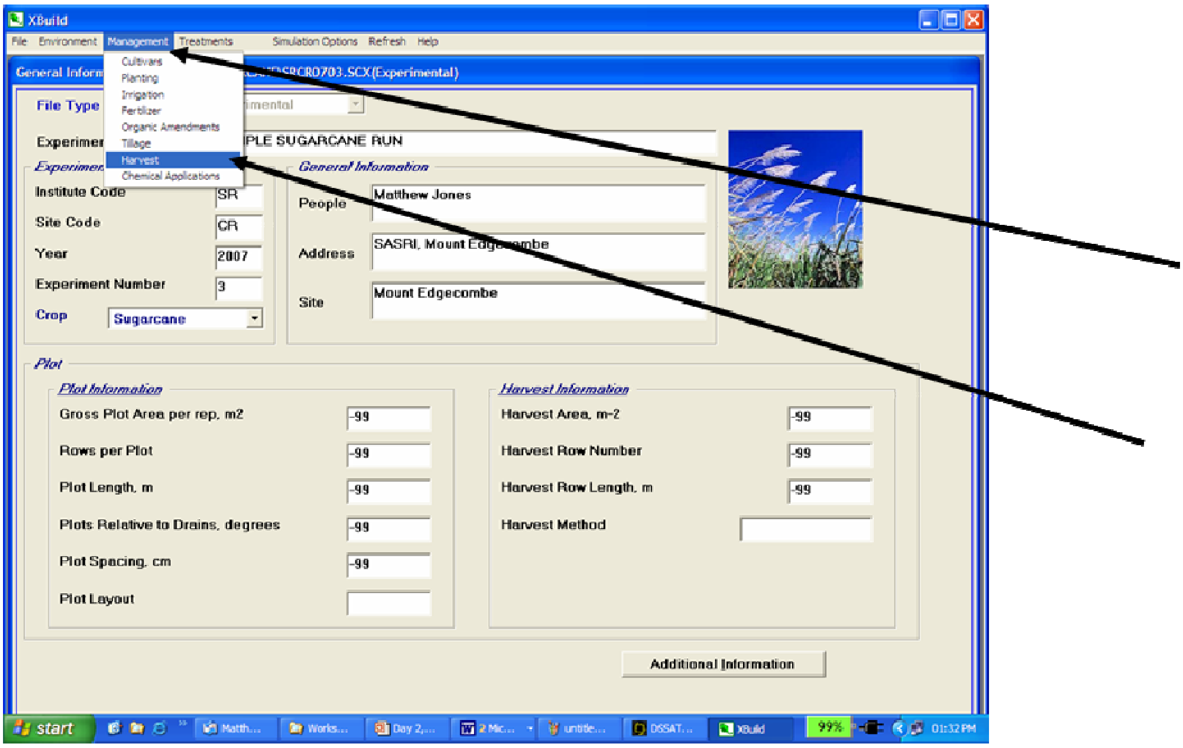
Note: Unlike many other crops, sugarcane, in most climatic circumstances, does not 'mature' and die, so the farmer must choose when to harvest. In contrast, Maize, for example, will calculate its own harvest date and DSSAT will inform the user when the crop was harvested.

The treatments need to be defined as combinations of factor levels.

Step 6. Set up harvest dates

It is now necessary to set harvest dates. This can be achieved in two ways - by date or by age at harvest.

i. Click on the 'Management' menu and select 'Harvest':



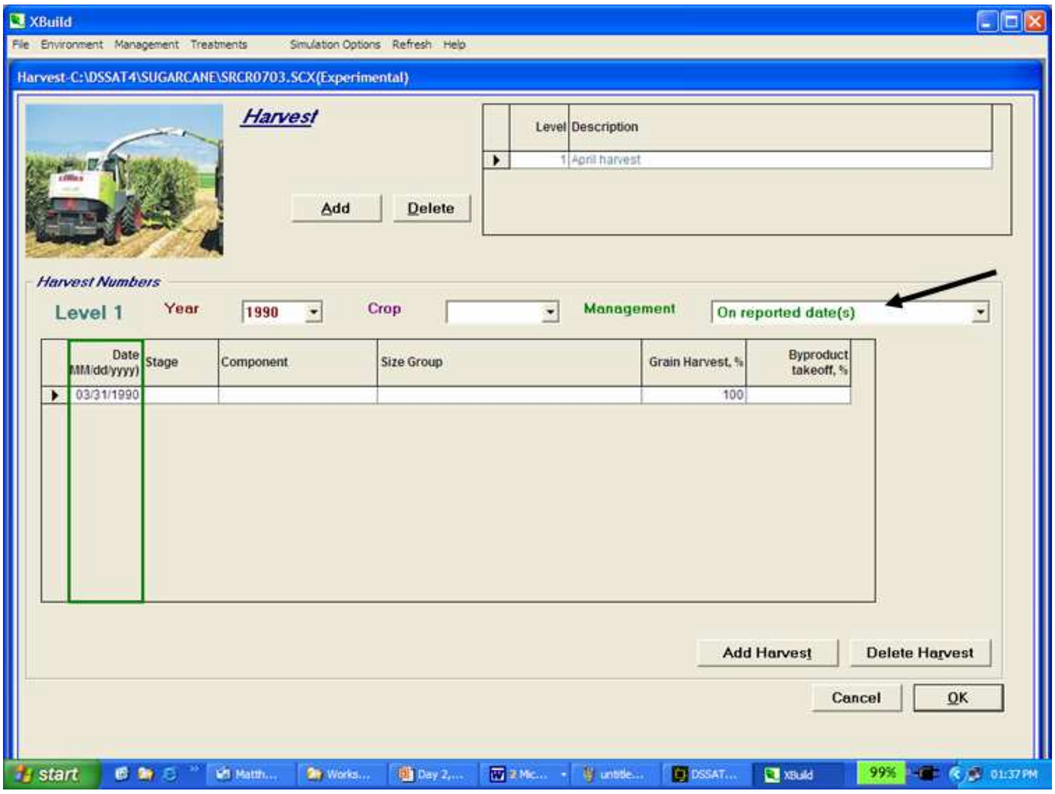
ii. Give the harvest factor level a name/description (e.g. 'April crop harvest')

iii. Click on the drop-down menu and select 'On reported date(s)', even if it already says this (this is an Xbuild quirk).

Note: if you wanted to specify a number of days after planting to harvest, select the Age/Days from planting option from this menu.

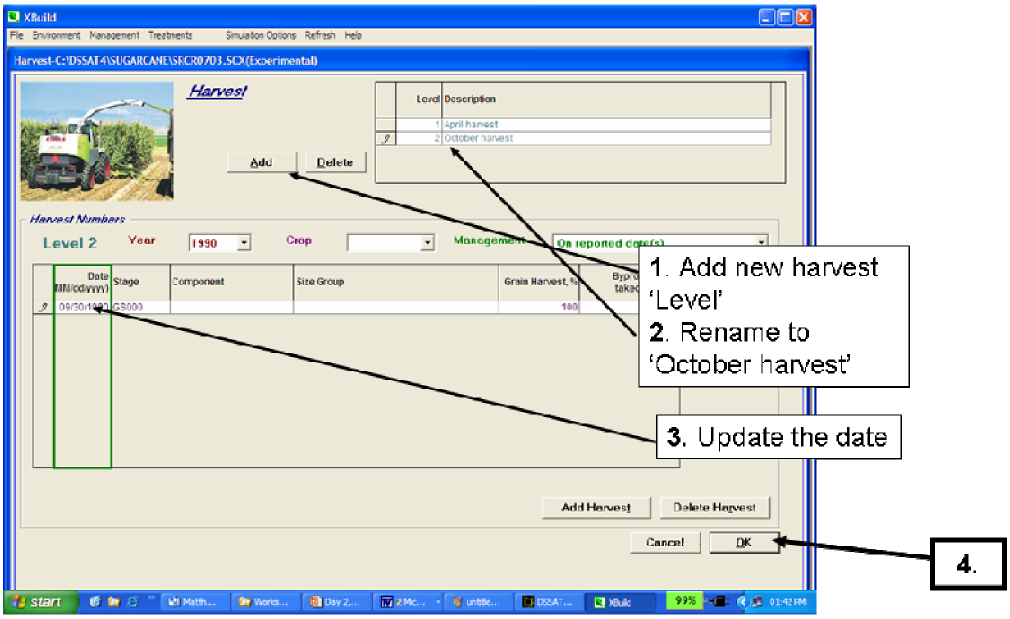
iv. Enter the date of harvest in the Date column. The date format issue applies here too – input MUST be in the USA-style MM/DD/YYYY format.

v. Press OK and Save.



If you are using more than one Harvest factor level:

- Now repeat step (i) to re-access the Harvests screen
- Check that the date was entered correctly for factor level 1
- Click the Add button at the above mid-left to add a new Harvest factor level
- Enter a description (e.g. ‘October harvest’)
- Repeat steps (iii – v)



The harvest factor levels have now been set up. Defining the treatments is all what remains of setting up the basic simulation.

Step 7. Defining treatments

In the example, four treatments need to be set up. So far, the following have been defined:

- Two planting factor levels (for the two planting dates)
- One field factor level
- One cultivar factor level
- Two harvest factor levels (corresponding with the planting dates)

This is only enough for two treatments – the other two are for irrigation, which needs to be set up. As this is a simulation option, it will be ignored for the time being. The user is invited to go ahead and define the two rainfed treatments prior to setting up irrigation.

Procedure for defining the two treatments:

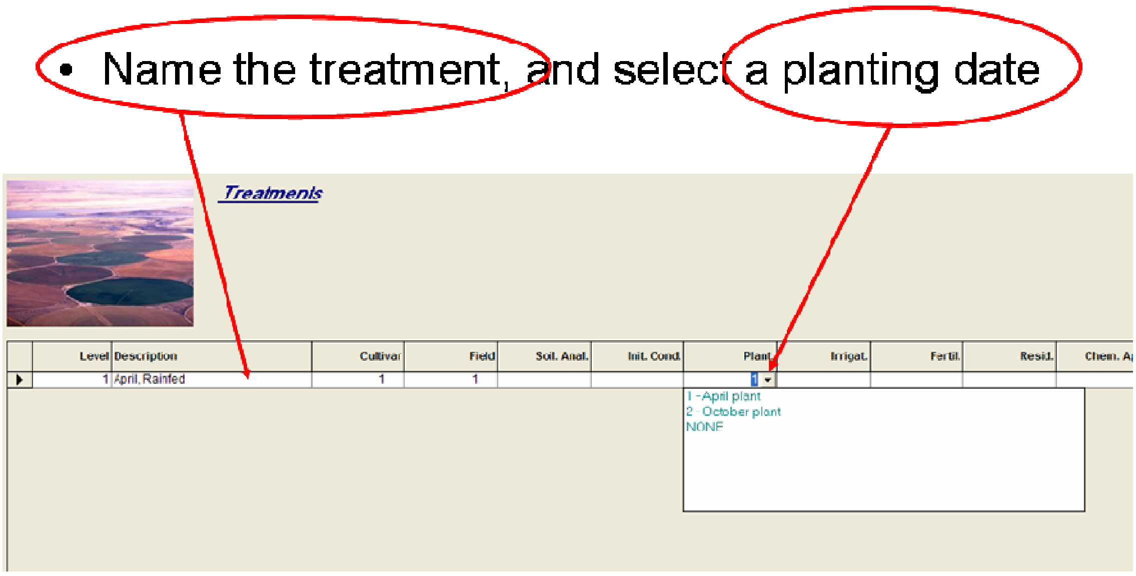
i. Click on the Treatments menu.

ii. Type in a name for the first treatment (level 1).

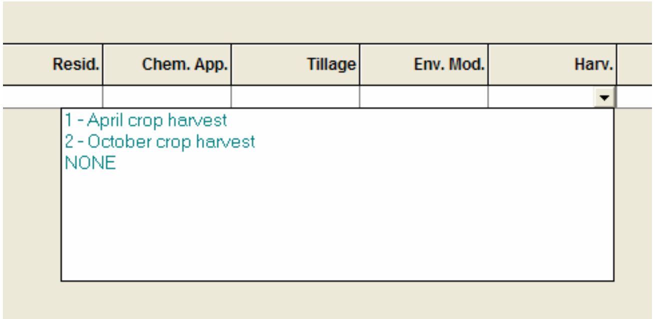
iii. Click on the table cell in the cultivar column, treatment 1 row; a drop-down of cutivars should appear. Select one.

iv. Click on the cell in the Field column. Select the field you have just defined.

v. Click on the cell in the Plant column and select the first planting date.



vi. In the 'Harv.' Column cell, select the first harvest level.



vii. Click OK, and the File→Save.

viii. Click on the Treatments menu again.

ix. Click on the little arrow on the leftmost extreme of the table row defining Treatment 1.This will highlight the treatment.

x. Click on the Add button. This will create a copy of the first treatment, but numbered '2'.

xi. Repeat step (v) but select the second planting date.

xii. Repeat step (vi), but select the second harvest date.

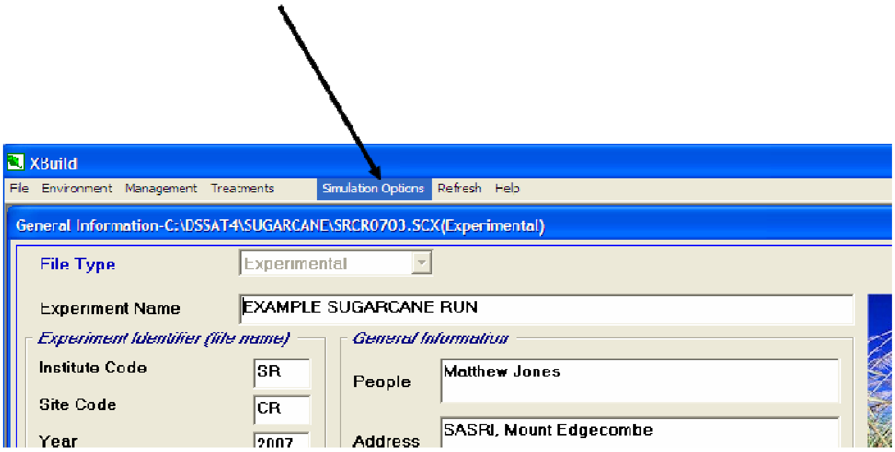
xiii. Click OK and save.

Step 8. Defining simulation options and irrigation

Defining irrigation in Xbuild sits awkwardly between crop management and DSSAT simulation controls. Please read the section on Simulation Options before proceeding. Other simulation options MUST be set, even if no irrigation is planned.

First, general simulation options must be set:

i. Click on the Simulation Options menu.



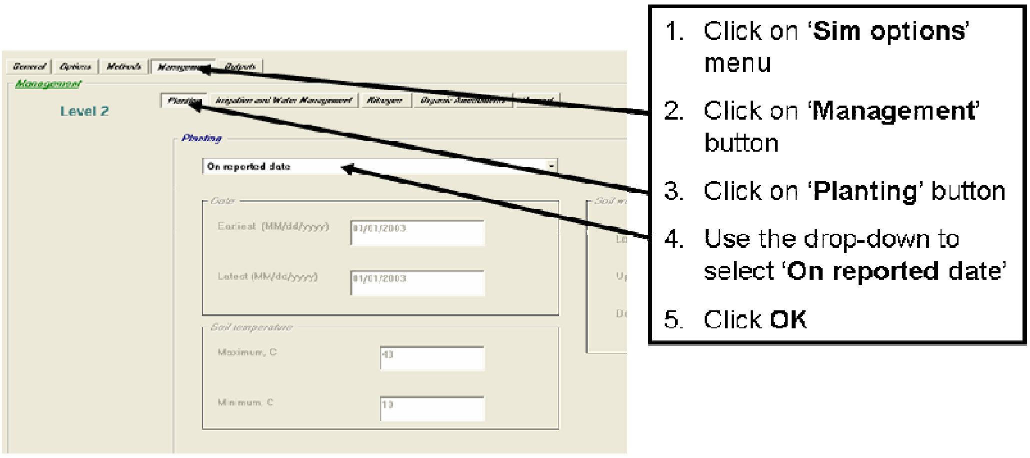
ii. Set the simulation start date to the earliest planting date; click OK and save.

iii. Re-open Simulation Options (step i).

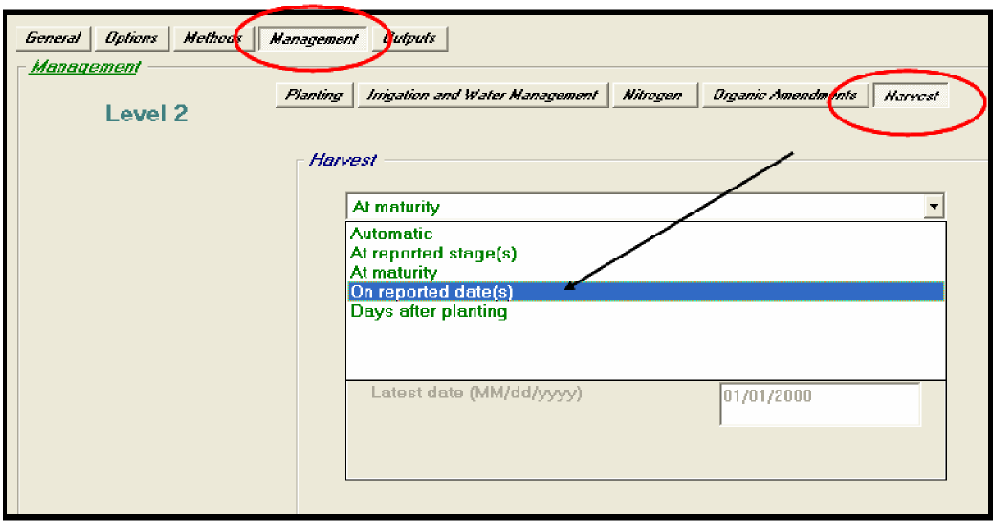
iv. Rename DEFAULT SIMULATION OPTIONS to ‘Rainfed simulation options’.

v. Click OK and save, then reopen Simulation Options (step i).

vi. Set planting to ‘On reported date’ in the Management section (button):



vii. Tell DSSAT to harvest on reported dates; click on the Management button, then on the harvest button, and select “On reported date(s)” from the drop-down menu.



viii. Click OK and save.

ix. Re-open Simulation Options (step i).

x. Tell DSSAT to simulate water but not nutrients (Canegro does not yet support nutrients – all simulations are presumed to have adequate fertiliser): Click on the Options button, in the water drop-down select ‘Yes’, and make sure everything else is set to ‘No’.

xi. Click OK and save.

xii. Re-open Simulation Options (step i).

xiii. Click on the Methods button.

xiv. Select Weather→Measured data.

xv. In the Evapotranspiration drop-down, select FAO-56. This is important for sugarcane, so long as humidity and windspeed or dewpoint data are available in the weather dataset. If not, select Priestley-Taylor. Click OK, Save, reopen, etc.

Now, the irrigation options can be set.

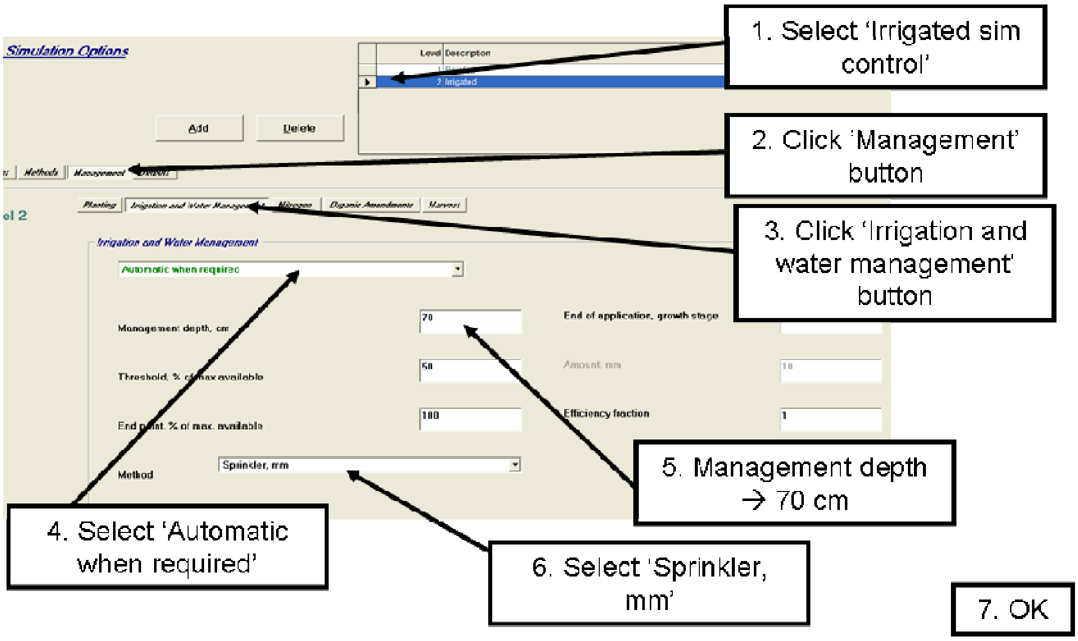
i. Add a new Simulation Options level and rename to ‘irrigated simulation options’. This will be a copy of the rainfed options.

ii. Click OK, save, and reopen, and select the Irrigated simulation option factor level by clicking on the arrow on the left of the factor levels list.

iii. Click on the ‘Management’ button.

iv. Click on the ‘Irrigation and water management’ button.

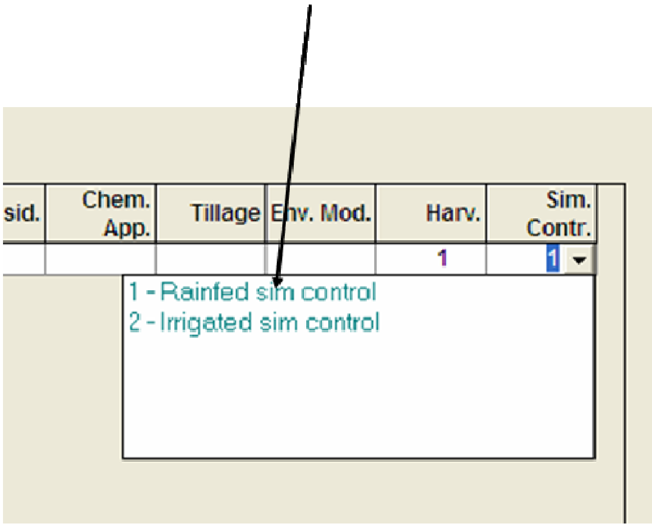
v. Select ‘Automatic when required’, and appropriate values for the management depths and thresholds.



vi. Click OK, save.

vii. Click on the treatments menu.

viii. For the two existing treatments, select the ‘Rainfed simulation option’ factor level in the ‘Sim Contr.’ Column:



ix. Select the first treatment and click Add.

x. Rename this to ‘April planting, irrigated’; modify the ‘Sim. Contr.’ for this to reference the Irrigated simulation control.

xi. Select the second treatment, click Add, rename to ‘October planting, irrigated’; modify the ‘Sim. Contr.’ for this to reference the Irrigated simulation control.

xii. Check that the set up factor levels for each treatment make sense.

xiii. Click OK and Save.

Setup of this example experiment is now complete. The experiment should run. If the model runs and produces some output, all is well. Check the output to ensure that the planting/harvest dates operated as intended and that the correct number of treatments ran, etc. Soil definition and weather files may now need to be created and this experiment file modified to reference these new data.

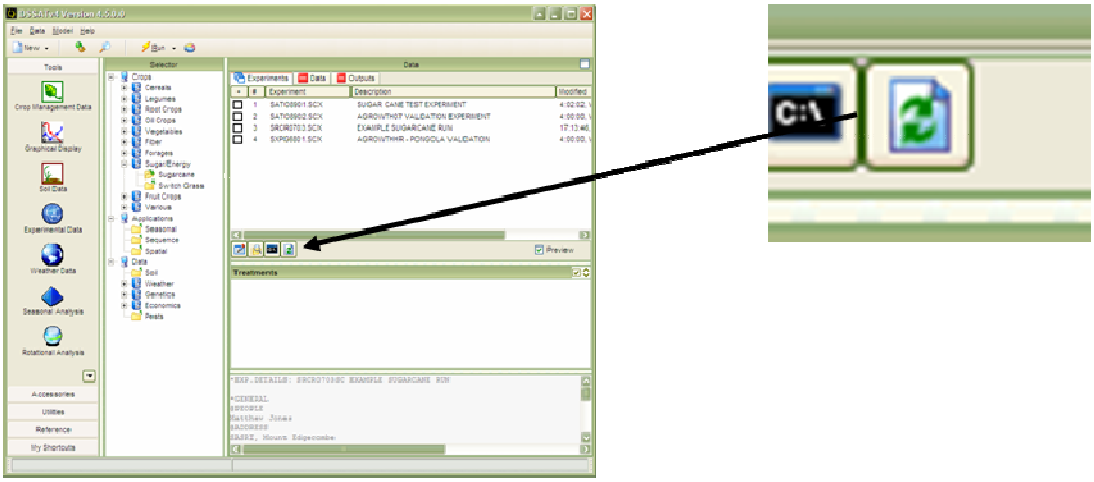
Step 9. Updating FileX to use new soil profile

Having set up this experiment and established that it is functioning, and then having set up the soil profile following the instructions in section 2.1, it is now necessary to update the FileX (experiment) to use the new soil.

i. Assuming you are no longer in Xbuild (save and close if necessary), load up the main DSSAT program (if it is not already open).

ii. Navigate to the sugarcane directory using the navigation tree on the mid-left of the screen.

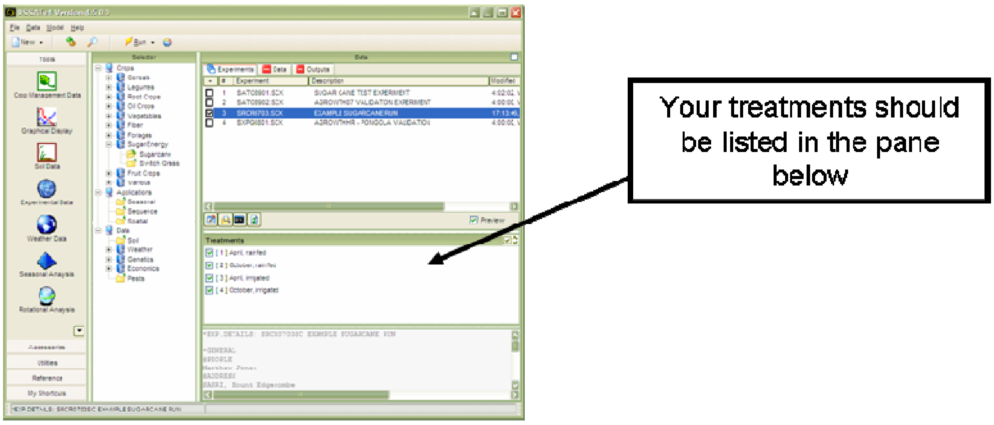
iii. Click on the refresh button to ensure that the experiment you have just set up is displayed:



iv. You will now see a complete list of sugarcane simulations in the upper right pane of the DSSAT window.

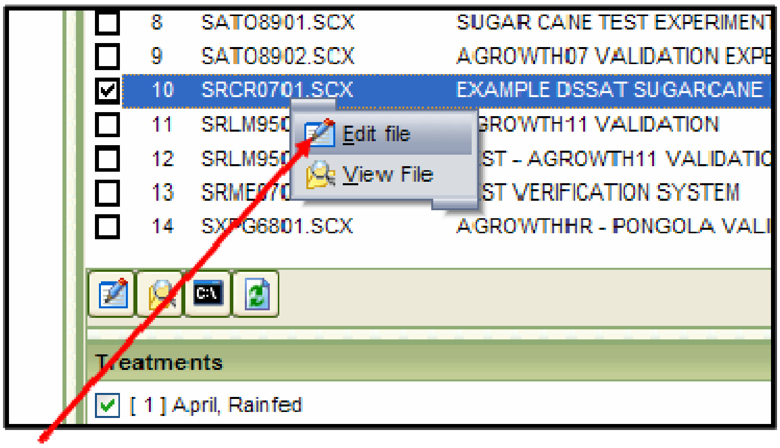
v. Locate the experiment (by code or description).

vi. Click on the checkbox next to it; the treatments you have set up should appear in the pane below:

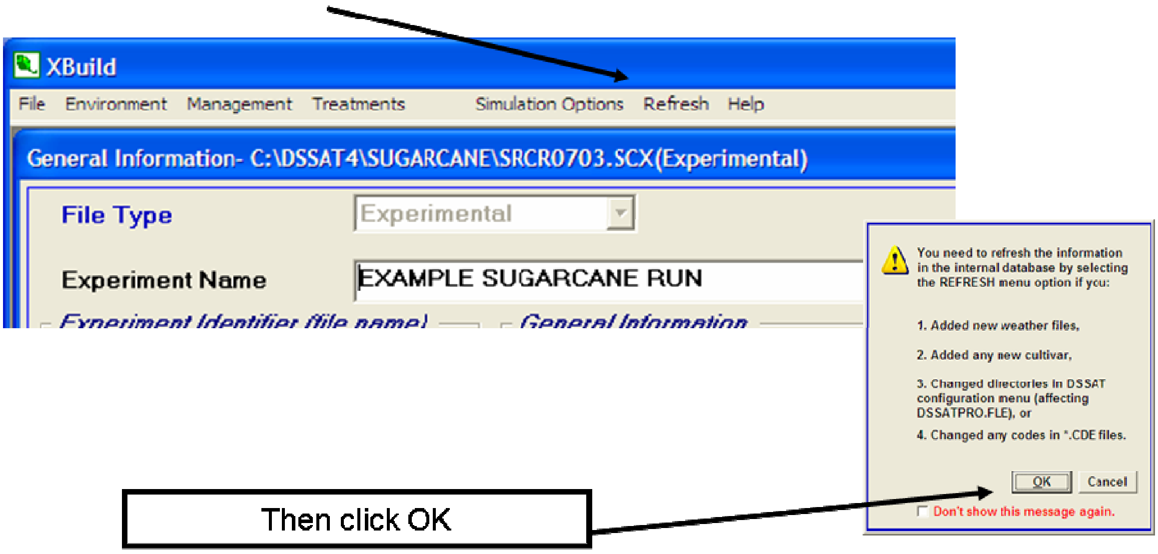


vii. Click on the name of the simulation (the row should then be highlighted).

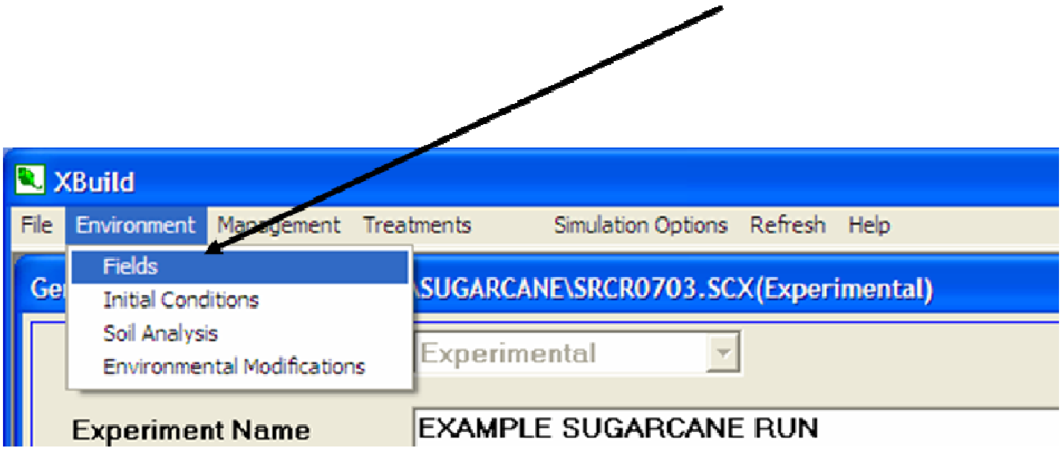
viii. Right-click and select ‘Edit file’ (the file will open in XBuild) [If you select ‘View file’, it will open in Notepad]:



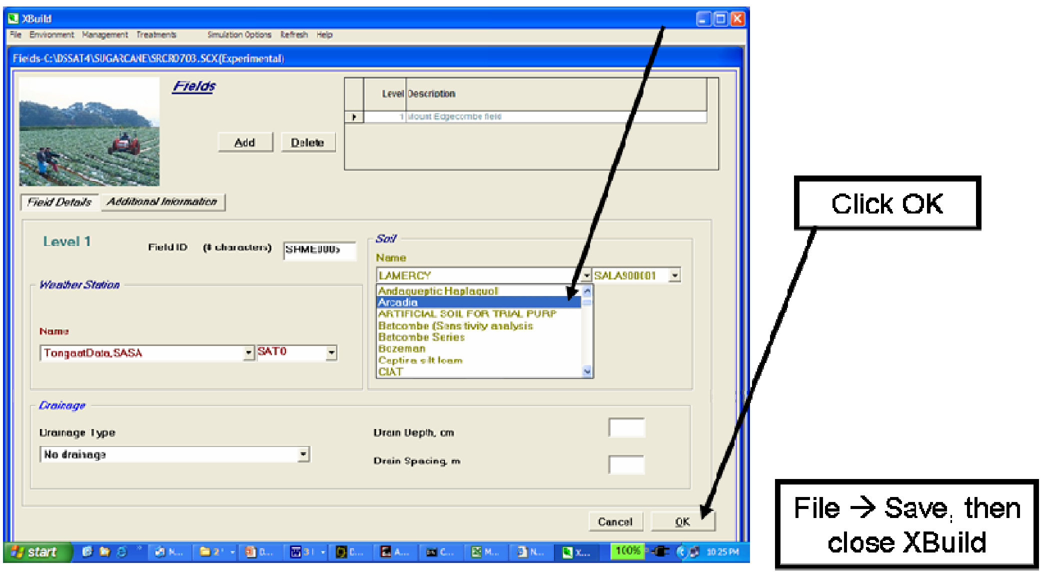
ix. Refresh Xbuild by clicking on the Refresh menu in the Xbuild program:



x. Click on the ‘Environment’ menu, → ‘Fields’.



xi. Select the new soil from the drop-down list (if the soil is not listed, try Refreshing again (step ix)).



xii. Then click on File→Save, and then close Xbuild.

xiii. Refresh the experiment list in DSSAT (step iii).

xiv. If the experiment is rerun, it should use the new soil and give different results.

Step 10. Updating FileX to use new weather data

Updating the FileX to use new / correct weather data is very similar to updating for a new soil.

i. Follow steps i → x above.

ii. In the weather station list, select the station just set up (if it does not appear, try Refreshing Xbuild (step 9, iii) again.

iii. File → Save.

iv. Close Xbuild.

v. Re-run the simulation – results should be different.

Step 11. Updating the FileX to use a new / different cultivar

If a new cultivar definition is set up, Xbuild needs to be updated in a similar manner as soil and weather files.

i. Follow steps i → x under Step 9.

ii. Access the cultivar screen (Management → Cultivars).

iii. Select the new cultivar, OK, File → Save

Having thus set up the experiment file (FileX), and the soil and weather files (and possibly the cultivar file), and then updated the FileX to use these, the experiment setup is now complete.

2.4. Cultivar

2.4.1. Introduction

Genetic parameters are used to capture the genetic control of how sugarcane plants respond to environmental and management factors. These are normally grouped into three categories, namely species (identical values for all cultivars), ecotype (identical values for groups of similar cultivars) and cultivar parameters (specific to cultivars).

With the DSSAT Canegro project we attempted to transfer all implicit parameters in the code to the appropriate parameter files. The genetic parameterization of sugarcane is new ground, and insufficient information and knowledge is available to have necessarily rationally allocated all parameters to the species, ecotype and cultivar categories. The approach was to allocate the majority of parameters to the ecotype and cultivar categories to allow user access. Although this resulted in a large number of parameters in these two categories, we believe that the 22 parameters contained in the cultivar file provides sufficient flexibility to assess the impact of these on crop growth and development. The 26 parameters in the ecotype file provide further flexibility if needed, although these parameters are sometimes quite empirical and difficult to determine.

Twenty-three parameters were allocated to the species category based on circumstantial evidence (see Table 3.1 in scientific documentation). As more cultivar information and knowledge about the mechanisms of genotypic control of crop response to the environment becomes available, the number of cultivar parameters is likely to change and the definitions of some may also change.

2.4.2. Parameter definitions and values

Ecotype parameters are fully described in Table 3.2 in the scientific documentation. Parameter values for a few ecotypes are proposed in Table 4.

Cultivar parameters are fully described in Table 3.3 in the scientific documentation. Parameter values are proposed for a few real and hypothetical cultivars in Table 5. This is based on published reports (Inman-Bamber, 1991; Singels & Bezuidenhout, 2002; Donaldson et al., 2003; Zhou et al., 2003 and Zhou 2003) and unpublished data.

Often, too little information is available to choose an ecotype or determine values for the ecotype or cultivar parameters. When this is the case, it is suggested that qualitative information about key traits are used to estimate values. Table 6 proposes phenotypic trait categories for selected real and hypothetical cultivars, while Table 7 suggests parameter values that will best emulate the required phenotypic trait category.

Users who wish to create new cultivars within DSSAT without adequate quantitative information can use the information in Tables 6 and 7 to guide them.

Table 4. Parameter values for the different ecotypes. *Note: the greyed-out blocks indicate to the sugarcane model that the simpler 'Canesim' canopy option should be used. This is used when detailed leaf values are not available.*

Parameter	Category	Description	SC001	SC002	SC003	SC004	SC005	SC006
DELTTMAX	Sucrose accumulation	Max. change in sucrose content per unit change in stalk mass in the un-ripened section of the stalk (/t)	0.07					
SWDF2AMP	Sucrose accumulation	Sucrose partitioning sensitivity to water stress parameter	0.5					
CS_CNREDUC	Canopy - CANESIM	Canopy reduction due to water stress	0.3					
CS_CNPERIOD	Canopy - CANESIM	Canopy water stress period (days)	21.					
Tthalfa	Canopy - CANESIM	Half canopy thermal time adjustment for row width	125.					
DPERdT	Canopy - height	Change in plant extension rate (mm/h) per unit change in temperature (^{o}C)	0.176					
EXTCFN	Canopy - light extinction	Maximum canopy light extinction coefficient	0.84					
EXTCFST	Canopy - light extinction	Minimum canopy light extinction coefficient	0.58					
LFNMXEXT	Canopy - light extinction	Leaf number (including dead leaves still attached) at which maximum light extinction occurs	20.					
AREAMX_CF(1)	Canopy - leaves	Cultivar parameter for quadratic equation defining maximum leaf area	0.					
AREAMX_CF(2)	Canopy - leaves	Cultivar parameter for quadratic equation defining maximum leaf area	27.2					
AREAMX_CF(3)	Canopy - leaves	Cultivar parameter for quadratic equation defining maximum leaf area	-20.8					
WIDCOR	Canopy - leaves	Parameter affecting the width of leaves	1.					
WMAX_CF(1)	Canopy - leaves	Cultivar parameter for quadratic equation defining leaf width	-0.0345					
WMAX_CF(2)	Canopy - leaves	Cultivar parameter for quadratic equation defining leaf width	2.243					
WMAX_CF(3)	Canopy - leaves	Cultivar parameter for quadratic equation defining leaf width	7.75					
LMAX_CF(1)	Canopy - leaves	Cultivar parameter for quadratic equation defining max leaf length per leaf number	-0.376					
LMAX_CF(2)	Canopy – leaves	Cultivar parameter for quadratic equation defining max leaf length per leaf number	12.2					
LMAX_CF(3)	Canopy – leaves	Cultivar parameter for quadratic equation defining max leaf length per leaf number	21.8					
MAXLFLENGTH	Canopy – leaves	Absolute maximum leaf length	100					
MAXLFWIDTH	Canopy - leaves	Absolute maximum leaf width	3.5					

Table 4. (continued)

Parameter	Category	Description	SC001	SC002	SC003	SC004	SC005	SC006
POPCF(1)	Tiller population	Stalk population coefficient, in ideal conditions (no stresses), as function of thermal time	1.826	1.4	1.6	2.0	2.2	1.826
POPCF(2)	Tiller population	Stalk population coefficient, in ideal conditions (no stresses), as function of thermal time	-.002	-.0015	-.0018	-.002	-.002	-.002
POPDECAY	Tiller population	Tiller senescence rate expressed as the fraction of tillers above the future mature tiller population (at a thermal time of 1600 ^{o}C.d), that senesce per unit thermal time	0.004					
TTBASEEM	Phenology	Base temperature for emergence (^{o}C)	10.					
TTBASELFEX	Phenology	Base temperature for leaf phenology (^{o}C)	10.					
TTBASEPOP	Phenology	Base temperature for stalk phenology (^{o}C)	16.					
TBASEPER	Phenology	Base temperature for plant extension (^{o}C)	10.057					
LG_AMRANGE	Lodging	Range in aerial mass from the start to the end of lodging (t/ha)	30.					
LG_GP_REDUC	Lodging	Reduction in gross photosynthesis due to full lodging, as a fraction (Singh, et al.)	0.28					
LG_FI_REDUC	Lodging	Reduction in fractional interception by the canopy due to full lodging	0.1					

Table 5. Proposed cultivar parameters for selected cultivars (actual and hypothetical).

Parameter	Category	Description	Nco 376	N31	N37	ZN6	ZN7	Q138	Q141	CG1	CG2	CG3
Ecotype		Determines tillering phenotype	SC001	SC004	SC001	SC001	SC002	SC003	SC003	SC001	SC003	SC004
PARCEmax	Biomass accumulation	Maximum (no stress) radiation conversion efficiency expressed as assimilate produced before respiration, per unit PAR (g/MJ).	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9
APFMX	Biomass partitioning	Maximum fraction of dry mass increments that can be allocated to aerial dry mass (t/t)	0.88	0.92	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.9
STKPFMAX	Biomass partitioning	Fraction of daily aerial dry mass increments partitioned to stalk at high temperatures in a mature crop (t/t on a dry mass basis)	0.65	0.69	0.65	0.65	0.65	0.65	0.68	0.65	0.635	0.625
SUCA	Sucrose accumulation	Sucrose partitioning parameter: Maximum sucrose contents in the base of stalk (t/t)	0.58	0.55	0.61	0.62	0.6	0.59	0.65	0.6	0.62	0.58
TBFT	Sucrose accumulation	Sucrose partitioning: Temperature at which partitioning of unstressed stalk mass increments to sucrose is 50% of the maximum value	25	25	25	26	27	25	27	26	27	25
Tthalfo	Canopy - CANESIM	Thermal time to half canopy (^{o}C.d)	250	225	250	300	300	250	250	275	300	250
Tbase	Canopy - CANESIM	Base temperature for canopy development (^{o}C)	16	15	16	16	17	16	16	16	16	16
LFMAX	Canopy - leaves	Maximum number of green leaves a healthy, adequately-watered plant will have after it is old enough to lose some leaves.	12	12	12	12	12	12	12	12	12	12
MXLFAREA	Canopy - leaves	Max leaf area assigned to all leaves above leaf number MXLFARNO (cm^2)	360	390	480	420	420	360	360	500	600	600
MXLFARNO	Canopy - leaves	Leaf number above which leaf area is limited to MXLFAREA	14	14	14	16	18	14	14	16	17	17
PI1	Leaf phenology	Phyllocron interval 1 (for leaf numbers below Pswitch, ^{o}C.d (base TTBASELFEX))	69	69	90	100	100	69	69	110	110	90
PI2	Leaf phenology	Phyllocron interval 2 (for leaf numbers above Pswitch, ^{o}C.d (base TTBASELFEX))	169	169	170	200	200	169	169	200	200	170
PSWITCH	Leaf phenology	Leaf number at which the phyllocron changes	18	18	14	14	18	18	18	14	14	14
MAX_POP	Tiller phenology	Maximum tiller population (stalks/m2)	30	40	40	30	30	30	30	30	30	40

Table 5 (continued)

Parameter	Category	Description	Nco 376	N31	N37	ZN6	ZN7	Q138	Q141	CG1	CG2	CG3
POPTT16	Tiller phenology	Stalk population at/after 1600 degree days (/m2)	13.3	15.0	12.0	11.0	7.0	13.3	13.3	11.0	9.0	13.0
TTPLNTEM	Phenology	Thermal time to emergence for a plant crop (^{o}C.d, base TTBASEEM)	428	428	428	428	428	428	428	428	475	375
TTRATNEM	Phenology	Thermal time to emergence for a ratoon crop (^{o}C.d, base TTBASEEM)	203	203	203	203	203	203	203	203	250	150
CHUPIBASE	Phenology	Thermal time (baseTTBASEEM) from emergence to start of stalk growth	1050	790	1050	1150	1050	1050	1050	1050	1150	950
TT_POPGROWTH	Phenology	Thermal time to peak tiller population (^{o}C.d, TTBASEPOP)	600	600	600	700	700	600	600	600	600	600
LG_AMBASE	Lodging	Aerial mass (fresh mass of stalks, leaves, and water attached to them) at which lodging starts; t/ha	220	220	220	220	220	220	220	220	220	220

Table 6. Subjective estimates (based on experimental data and expert opinion) of phenotypic trait values (categories) for selected cultivars. Each trait is categorized into very (s)low (VL), (s)low (L), medium (M), high or rapid (H) or very high or rapid (VH). Trait categories for hypothetical varieties are also suggested (CG1, CG2 and CG3).

Trait	Cultivars															
	CG1	CG2	CG3	NCo376	N31	N37	R570	ZN6	ZN7	N14	N19	N26	N12	N14	Q138	Q141
Primary tiller emergence	M	L	H	M												
Tiller population	M	L	H	H	H	H	VL	M	VL	M	M	L	VH	H	M	M
Leaf emergence	M	M	H	H	M	M	VH	H	M	H			M	H	H	H
Leaf size	M	H	H	L	M	H	VH	H	M	H	H		M	L	L	L
Canopy development	M	L	H	H	H	H		H	L	H		L	L	H	H	H
Biomass accumulation	M	L	H	M	H	H		M	M	M	L	L	M	M	M	M
Stalk growth	M	L	H	M	H	H		M	H	M	L	L	M	M	M	M
Sucrose content	M	H	L	L	VL	H		H	M	L	H	VH	M	L	M	H
Lodging tolerance	M	M	M	L												

Table 7. Suggested values for key cultivar parameters for different phenotypic trait categories.

			Trait category				
Parameter	Trait	Description	Very low	Low	Med	High	Very high
PARCEmax	Biomass accumulation	Maximum (no stress) radiation conversion efficiency expressed as assimilate produced before respiration, per unit PAR. (g/MJ)	9.7	9.8	9.9	10.0	10.1
APFMX	Biomass accumulation	Maximum fraction of dry mass increments that can be allocated to aerial dry mass (t/t)	0.84	0.86	0.88	0.90	0.92
STKPFMAX	Biomass partitioning	Fraction of daily aerial dry mass increments partitioned to stalk at high temperatures in a mature crop (t/t on a dry mass basis)	0.62	0.635	0.65	0.675	0.68
SUCA	Sucrose content	Sucrose partitioning parameter: Maximum sucrose contents in the base of stalk (t/t)	0.56	0.58	0.6	0.62	0.64
TBFT	Sucrose content	Sucrose partitioning: Temperature at which partitioning of unstressed stalk mass increments to sucrose is 50% of the maximum value	24	25	26	27	28
Tthalfo	Canopy development - CANESIM	Thermal time to half canopy (^{o}C.d)	325	300	275	250	225
Tbase	Canopy development - CANESIM	Base temperature for canopy development (^{o}C)	18	17	16	15	14
LFMAX	Canopy - leaves	Maximum number of green leaves a healthy, adequately-watered plant will have after it is old enough to lose some leaves	10	11	12	13	13
MXLFAREA	Leaf size	Max leaf area assigned to all leaves above leaf number MXLFARNO (cm^2)	300	400	500	600	700
MXLFARNO	Leaf size	Leaf number above which leaf area is limited to MXLFAREA	18	16	14	14	14
PI1	Leaf emergence	Phyllocron interval 1 (for leaf numbers below Pswitch, ^{o}C.d (base TTBASELFEX))	150	130	110	90	70
PI2	Leaf emergence	Phyllocron interval 2 (for leaf numbers above Pswitch, ^{o}C.d (base TTBASELFEX))	260	230	200	170	150
PSWITCH	Leaf emergence	Leaf number at which the phyllocron changes.	14	14	14	16	18
MAX_POP	Tiller population	Maximum tiller population (stalks/m^2)	30	30	30	40	50
POPTT16	Tiller population	Stalk population at/after 1600 degree days (/m^2)	7	11	12	13	15
TTPLNTEM	Primary tiller emergence	Thermal time to emergence for a plant crop (^{o}C.d, base TTBASEEM)	550	475	428	375	325
TTRATNEM	Primary tiller emergence	Thermal time to emergence for a ratoon crop (^{o}C.d, base TTBASEEM)	250	225	200	150	100
TT_POPGROWTH	Canopy development	Thermal time to peak tiller population (^{o}C.d, TTBASEPOP)	800	700	600	500	400
LG_AMBASE	Lodging tolerance	Aerial mass (fresh mass of stalks, leaves, and water attached to them) at which lodging starts; t/ha	220	230	240	250	270

2.4.3. Parameter calibration procedure

Cultivar information is split into two files – the cultivar file, and the ecotype file. The intention of the ecotype file is to contain the same information for groups of cultivars; i.e. one ecotype definition serves many cultivars. A set of cultivar parameters is intended to represent a cultivar for ALL field situations. It is recommended that if any parameters are modified/adjusted, it should only be done on the basis of several sets of measured experimental data across a variety of management regimes – different start/harvest dates, locations, soils, etc.

If an ecotype definition is modified, bear in mind that these changes may affect other cultivar definitions. If in doubt, always make a copy of an ecotype definition, rename/recode it, and modify this instead (instructions provided below).

IMPORTANT NOTE CONCERNING GENETIC PARAMETERS: In the input files (cultivar and ecotype files), all numbers are read as Fortran REAL numbers. Every number MUST therefore have a decimal point, even integer values. This will be addressed in a later version of DSSAT-Canegro.

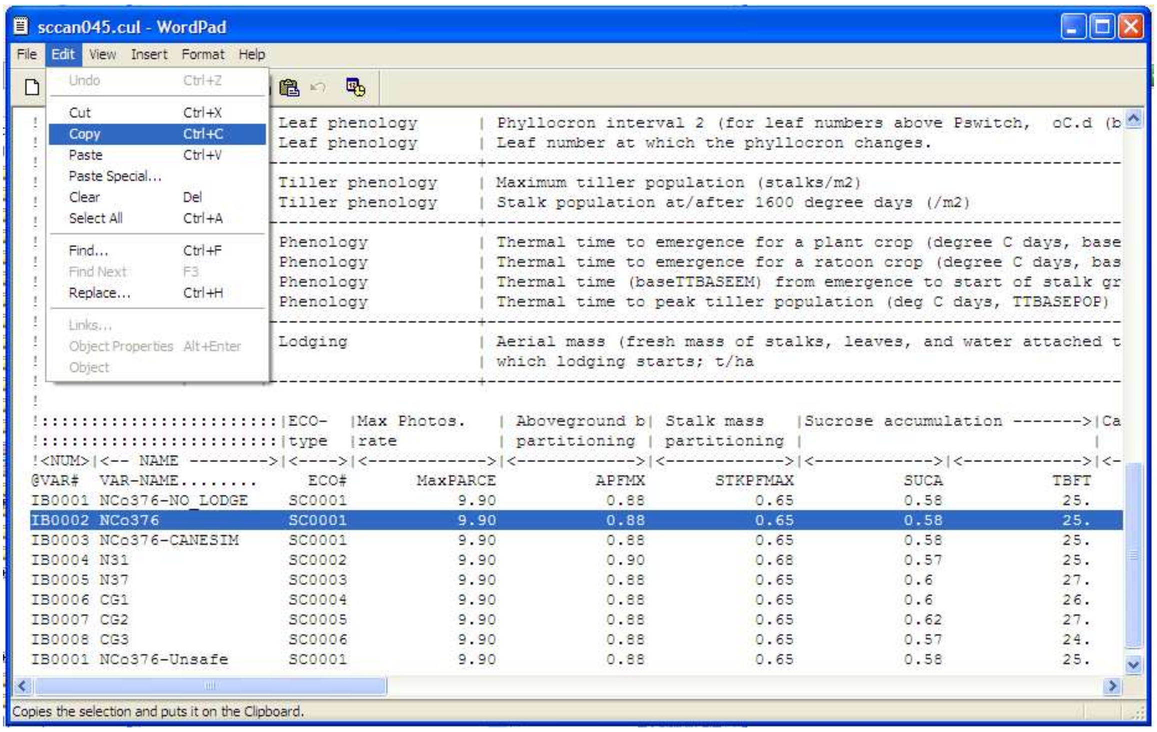
The following calibration procedure is proposed:

- Ensure that soil, weather and management inputs are correct.
- Compare simulated and observed values of the variables indicated below, in the order given below. If an unacceptably large discrepancy exists, make an adjustment in the appropriate cultivar parameter(s). Two approaches are possible here. Firstly appropriate experimental data can be analysed to derive the values of parameters (explained below). The alternative, less preferred option is to qualitatively benchmark the cultivar's phenotypic characteristics using Table 6 and then to select the appropriate value for key parameters from Table 7.

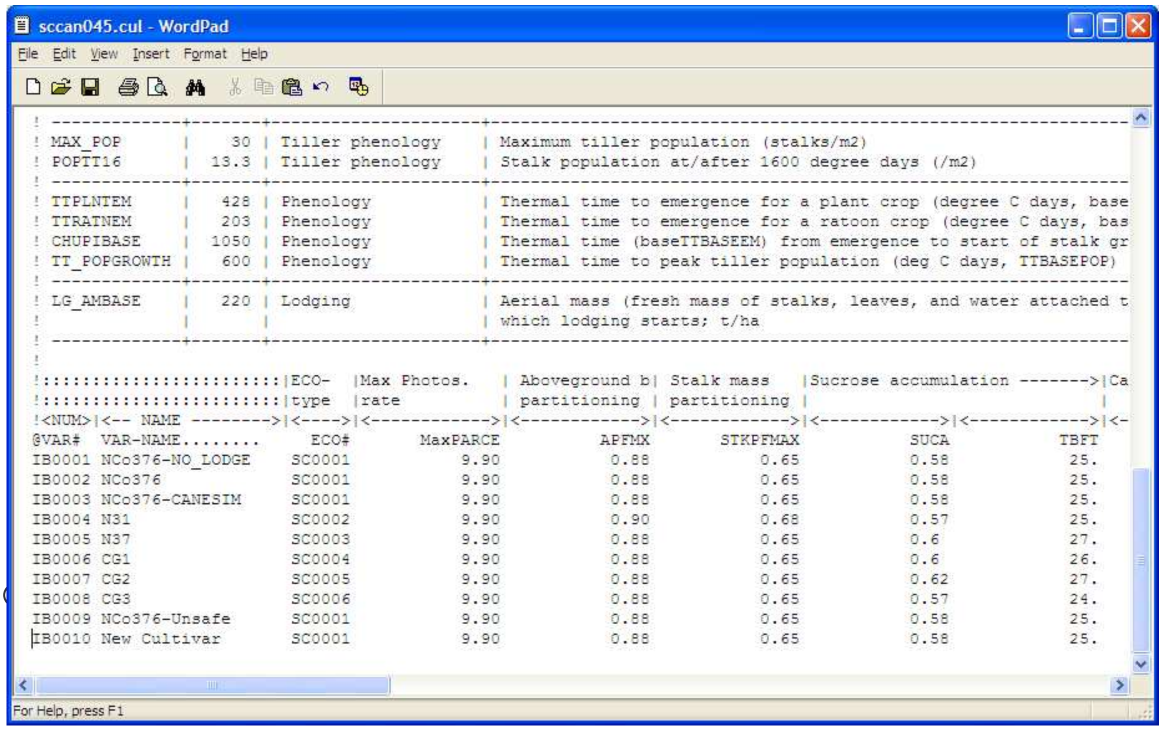
2.4.4. Creating a cultivar definition

The following steps should be followed when attempting to define/determine new cultivar coefficients:

i. Copy the NCo376 cultivar line in the cultivar file to a new line in this file:
   - Open the cultivar file C:\DSSAT4\Genotype\SCCAN045.cul *(select Notepad or Wordpad).*
   - Select the NCo376 line – Edit [menu]→copy



- Scroll to the bottom of the screen and paste – Edit [menu] → paste



ii. Increment the cultivar number (SC0000x) to one that has not yet been used:

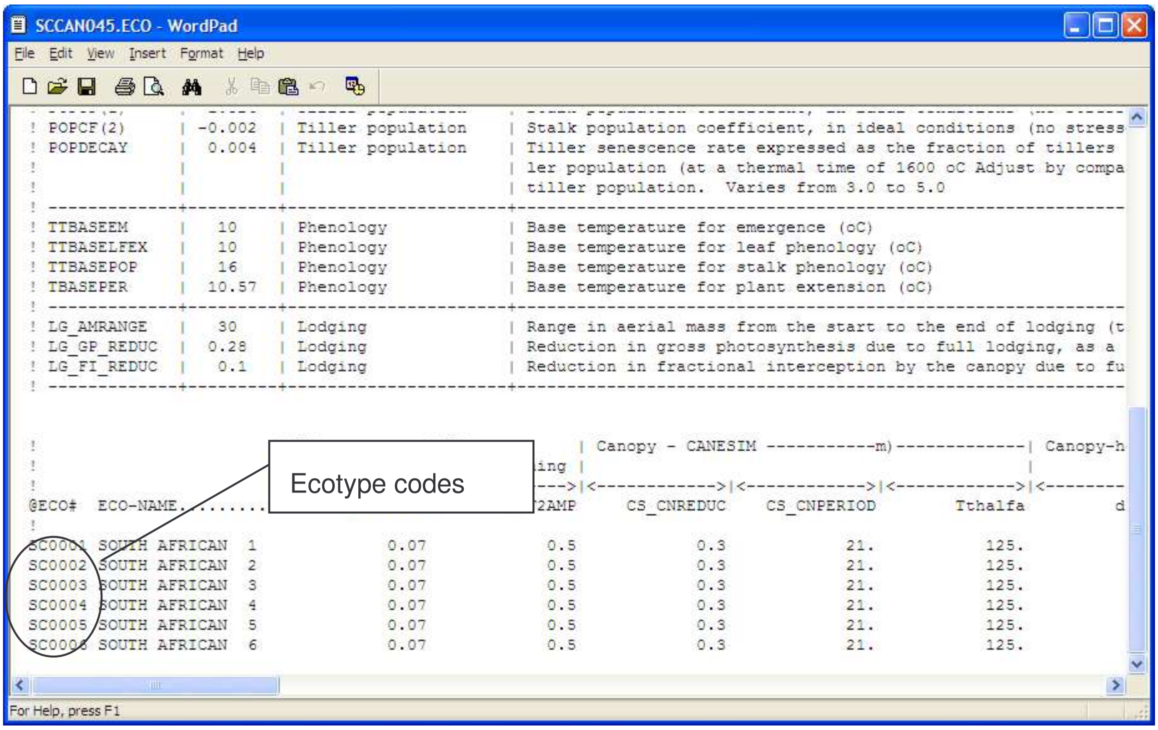
- Type the new number into the first column; use spaces to ensure that the columns line up. THE COLUMNS MUST LINE UP.

iii. Give the new cultivar definition a (unique) name:

- Type this into the second column (again ensuring that the columns line up)

iv. Open the ecotype file and choose an ecotype whose parameters appear the closest match to those of the cultivar whose parameters are attempting to be defined. Note the ecotype number (code).

- Open the ecotype file - C:\DSSAT4\Genotype\SCCAN045.eco (using Notepad or Wordpad)
- Search for an ecotype with desired characteristics – i.e. that match the characteristics of the actual cultivar in the field (see discussion above)
- Note the ecotype code/number



v. Back in the cultivar file, update the ecotype reference number in the cultivar line that has just been added to the cultivar file.

- Edit the ecotype reference in the new cultivar definition line to match the code of the ecotype just identified.

vi. Test the simulation and examine tiller population (see below).

vii. If this is not appropriate, try changing the ecotype number in the cultivar definition to refer to a different ecotype.

viii. If performance is still unsatisfactory, make a copy of the most suitable ecotype definition in the ecotype file (copy the line and paste at the bottom), updating the name and number. Then update the new cultivar definition to refer to this new ecotype definition – see below for more discussion of creating new ecotype definitions.

ix. Experiment with different tiller population coefficients in the new ecotype definition (until the model appears to simulate tiller population reasonably well).

x. Then examine leaf area index and canopy variables (see below), and adjust accordingly if necessary, again working with new cultivar and/or ecotype definitions

xi. After this, address aboveground biomass parameters and performance (see below), again following a similar procedure of adapting new cultivar and/or ecotype definitions

xii. Finally, follow a similar procedure for calibrating sucrose; details are presented below.

2.4.5. Creating new Ecotype definitions

If none of the existing ecotypes defined in the ecotype file are satisfactory, it will be necessary to define a new ecotype definition. Follow a similar procedure to defining a new cultivar definition:

i. Open the ecotype file (C:\DSSAT4\Genotype\SCCAN045.ECO).

ii. Find the ecotype whose characteristics best match the desired characteristics of the new ecotype definition.

iii. Copy this line and paste at the bottom of the file.

iv. Update the ecotype code number.

v. Edit the various parameter values accordingly; remember to always enter REAL values (i.e. with a decimal point) and ensure that the columns line up.

vi. Save the file.

vii. Update the cultivar definition to use the new ecotype number in place of whatever was there before.

It is not highly recommended to change existing ecotype definitions – doing this might adversely affect many cultivars.

2.4.6. Tiller population

Primary tiller emergence of plant or ratoon crop (TTPLNTEM and TTRATNEM): calculate the modelled discrepancy in number of days and convert this to thermal time by using the average daily thermal time observed during this period. Adjust the parameters by adding or subtracting this amount.

Tiller population curve parameters (POPCF1, POPCF2, POPTT16): select an ecotype by viewing the parameters in the ecotype file (Table 4). The impact of these parameters on the tiller population curve is shown in Figure 1.

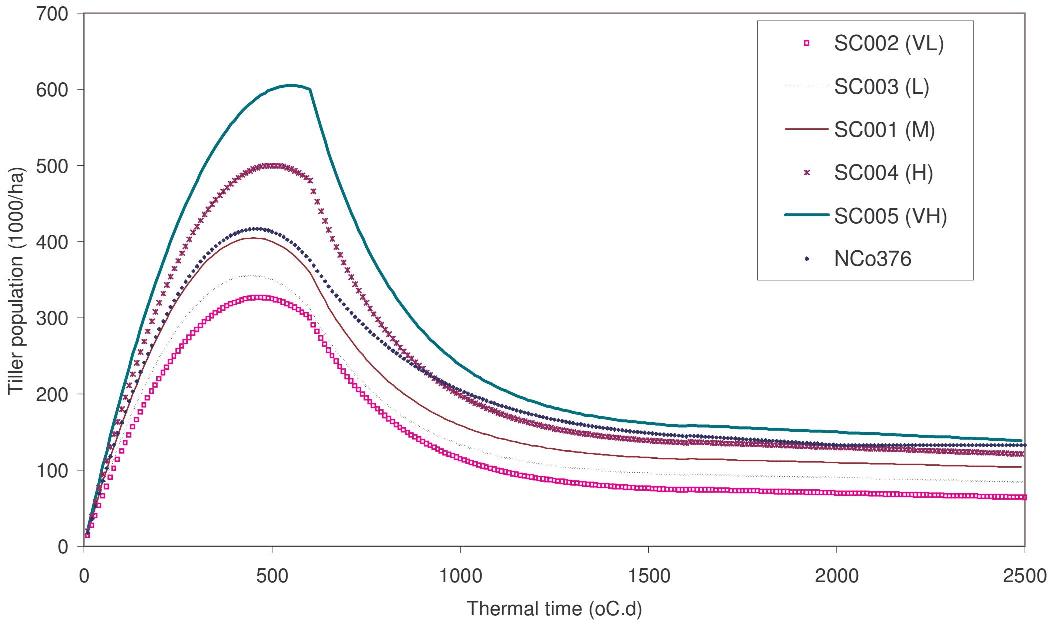


Figure 1. Tiller population curves for one cultivar (NCo376) and five ecotypes (SC00*). We have assumed that a strong correlation exists between rate of tillering and final stalk population.

The peak tiller population is regarded as a cultivar parameter and can be set in the cultivar field (MAX_POP in Table 5). The curves shown in Figure. 1 would be capped at the value of MAX_POP. In the absence of measured data we suggest that the value of MAX_POP does not 30 stalks/m^2.

2.4.7. Canopy

The DSSAT-Canegro model has two canopy methods – the standard sophisticated canopy, where each leaf on a stalks is modelled according to the parameters described below, and the simpler ‘Canesim’ canopy, which uses the Hill thermal time canopy model. The latter is invoked automatically if leaf parameters (AREAMX_CF, WIDCOR, WMAX_CF) are left blank in the ecotype definition in the ecotype file. Stalk population, although not used in the canopy calculations in such a case (when using the Canesim canopy), is still calculated using Nco376 parameters and will be output in PlantGro.out.

2.4.8. Leaf area index

Leaf emergence parameters (PI1, PI2, PSWITCH): determine the values of these parameters by plotting number of emerged leaves vs thermal time (base 10) and then calculating the inverse of the slope of two linear regressions fitted to the data (see Figure. 2 for an example).

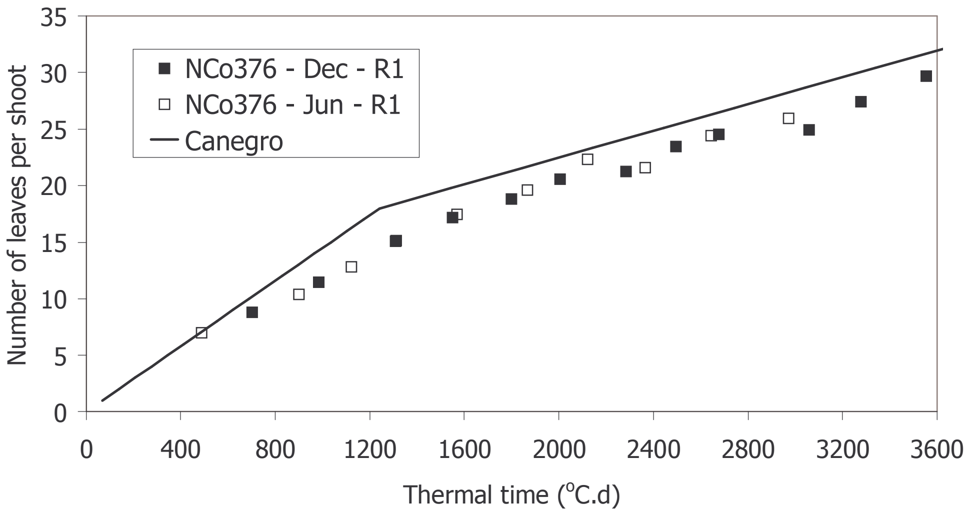


Figure 2. Number of emerged leaves as a function of thermal time (from Singels et al., 2005)

Leaf size parameters (MXLFAREA, MXLFARNO): determine the size (surface area) and the leaf number of the biggest leaf from leaf size *vs* thermal time data.

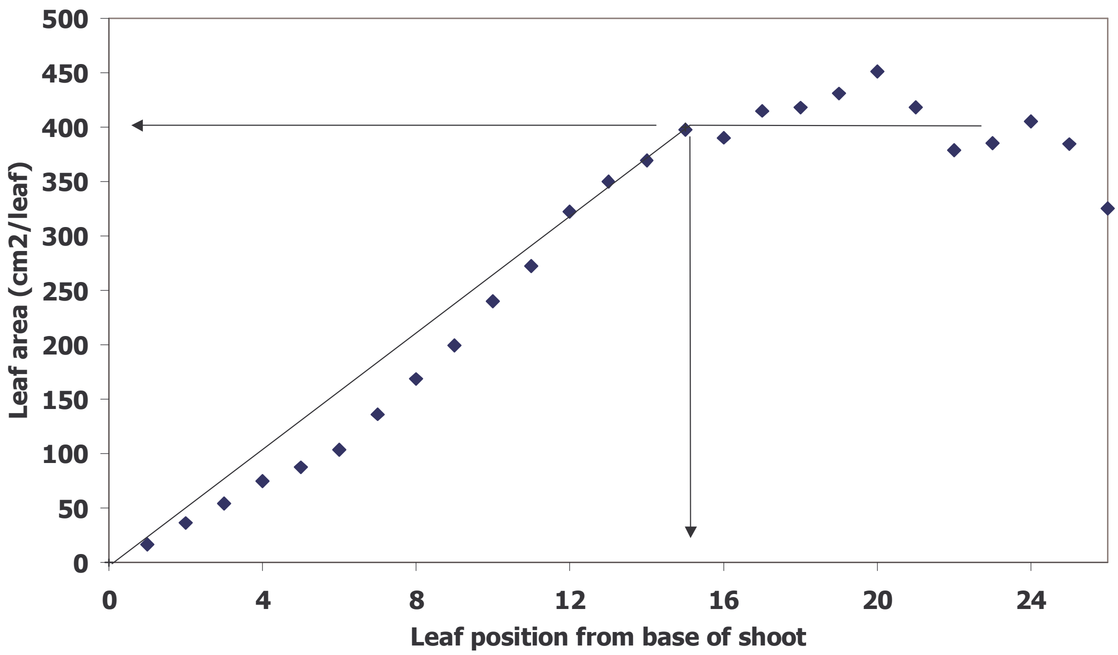


Figure 3. An example of how to derive leaf size parameters from leaf size *vs* leaf number data.

2.4.9. Aboveground biomass

Two options exist for adjusting the rate of aboveground biomass accumulation. Firstly, adjusting the efficiency of converting PAR to biomass in the species file (PARCE) will alter the total amount of biomass produced. Secondly, the partitioning of biomass to above-ground parts can be altered by adjusting the partitioning fraction AFPMX. The relative response in biomass accumulation to adjustments will be similar to the relative magnitude of the adjustments.

2.4.10. Stalk mass

Stalk partition fraction (STKPFMAX): determine the slope of the linear regression of stalk mass *vs* aerial dry mass. An example is illustrated in Figure. 4.

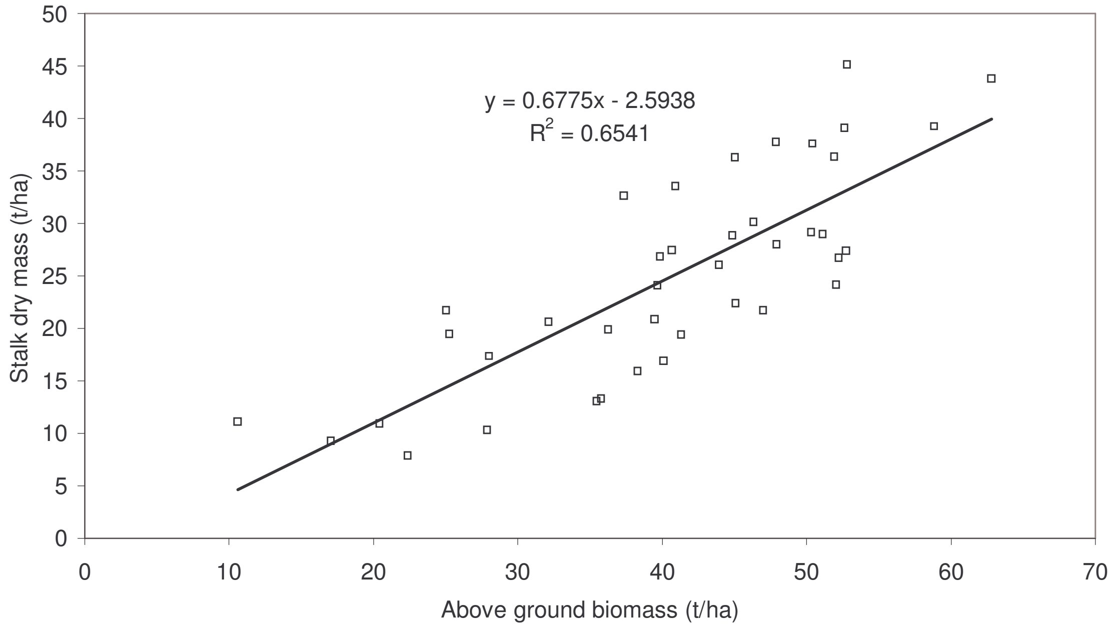


Figure 4. An example of deriving the value of the stalk partition fraction from stalk dry mass *vs* above ground biomass data.

Thermal time from primary tiller emergence to start of stalk elongation (CHUPIBASE): calculate thermal time (base10) from the date of 50% primary tiller emergence to date of start of stalk elongation.

2.4.11. Sucrose mass

Sucrose parameters (SUCA, TBFT): select a parameter set for the different sucrose accumulation types from Table 6. Increasing SUCA values will result in higher simulated sucrose contents (and *vice versa*), while increasing TBFT results in a flatter (less response to temperature) and higher seasonal sucrose content curve. Figure 5 shows typical seasonal sucrose curves for a low and high sucrose variety, under fully irrigated conditions for Pongola, South Africa.

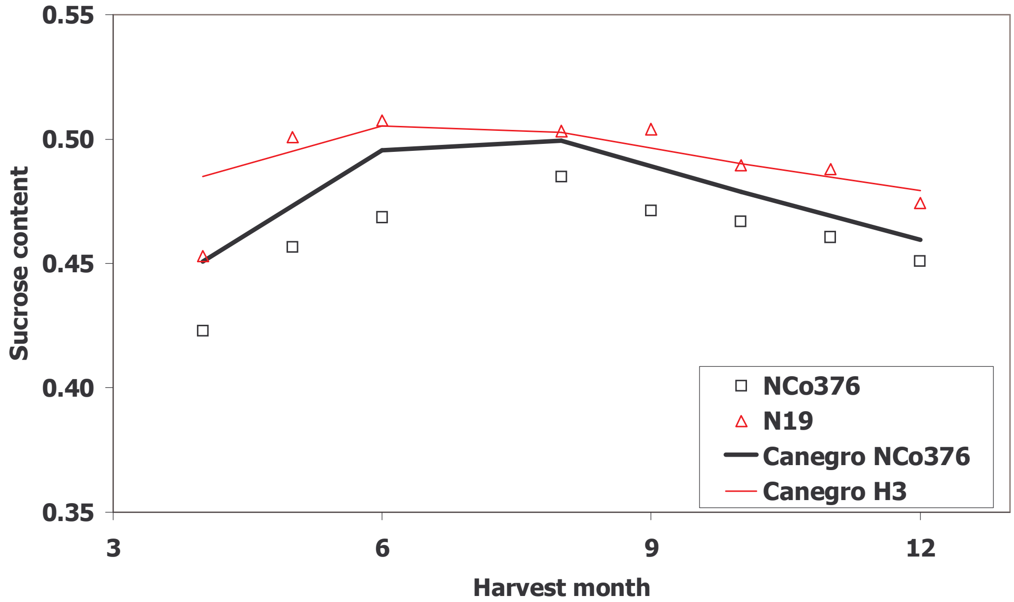


Figure 5. Actual and simulated stalk sucrose content (tons sucrose/tons stalk dry matter) for a low and high sucrose content variety, fully irrigated at 12 months, at Pongola, South Africa, (adapted from Singels, et al., 2005).

2.5. Experimental data

2.5.1. Overview of Experiment data files in DSSAT (for sugarcane)

One of the powerful features of DSSAT is the ability to store and analyse measured experimental data along with simulated values. By comparing simulated and actual/measured values for a particular experiment (i.e. a field experiment is conducted, then simulated in DSSAT), it is possible to:

- Document experiments
- Validate crop models
- Visually/statistically assess model performance

Two kinds of measured/experimental data files are used in DSSAT: ‘T’ files, which are ‘time course’ files and contain values for variables sampled throughout the season (e.g. daily soil water content, leaf area index, etc.); and ‘A’ files, which contain single end-of-season values for each variable (sucrose yield, stalk yield, final soil water content, etc.) – these are either final values or average values over the course of the crop (hence ‘A’).

The FileT and FileA experimental data files are plain formatted-text files with a tabular structure. Column headers define variables via data codes (which are explained in C:\DSSAT4\DATA.CDE), and the columns of data contain measurements of these variables. Each row represents a sample for a particular treatment.

In a FileT (time course file), every record will feature a treatment number and the date that the sample was taken:

```
@TRNO  DATE  STKD STKW  SUCD
    1 69210 24.70  109 10.14
    1 69266 33.90  133 15.03
    1 69315 34.70  130 15.34
    1 70013 40.60  145 17.84
    1 70069        136 15.23
    1 70125 39.30  143 18.73
    2 69266 17.80   80 6.56
    2 69315 23.80  102 9.69
    2 70013 31.50  132 13.60
    2 70069 39.00  159 17.81
```

In file excerpt above, TRNO is the treatment number, DATE is the date in YRDOY format (e.g. 69210 is day 210 of 1969, which is 29 July 1969). STKD is stalk dry mass (t/ha), STKW is stalk fresh mass (t/ha), and SUCD is sucrose dry mass (t/ha). The data definitions were looked up in DATA.CDE. The '@' sign identifies the column headings.

In a FileA (Average / harvest data file), there is a single record for each treatment and no date:

```
@TRNO SUCH  TRSH GLAI  STKH  CHTA L#SM HIAM  AELH SDAH
    1 16.80 10.90  2.6 34.70 1.792  7.8 .482 52.80 13.2
    2 13.00 8.200  2.6 26.70 1.685  9.2 .487 41.00 13.2
    3 14.70 10.80  2.8 33.40 2.083  9.8 .440 50.40 14.5
    4 14.70 10.10  3.7 34.70 2.209 10.4 .422 52.80 13.4
    5 19.20 13.30  3.7 42.50 2.360  8.9 .452 62.80 15.5
    6 19.90 15.30  2.1 38.30 2.223  6.7 .521 58.90 14.9
    7 16.50 12.10  1.7 30.50 1.935  7.4 .540 46.30 12.9
    8 14.10 12.80  1.3 27.90 2.216  9.2 .506 45.10 10.8
```

In the excerpt above, a single set of measurements is listed for each treatment (TRNO). SUCH is sucrose mass at harvest (t/ha), TRSH is trash mass at harvest (t/ha), GLAI is final leaf area index (m^2/m^2), STKH is stalk dry mass at harvest (t/ha), CHTA is canopy height at harvest, etc. (the data definitions were looked up in DATA.CDE).

FileA data appear in the Overview.OUT file generated by the DSSAT model when it runs. Here is an example:

```
*MAIN GROWTH AND DEVELOPMENT VARIABLES

@   VARIABLE                                  SIMULATED   MEASURED
   --------                                   ---------   --------
   Sucrose dry mass (t/ha) at harvest             12.00     16.80
   Aerial dry biomass (t/ha) at harvest           44.89     52.80
   Stalk (millable) dry mass, t/ha) at harvest 24.88     34.70
   Trash (residue) dry mass (t/ha) at harvest     7.62     10.90
   Green leaf area index (m2/m2)                   2.16      2.6
   Leaf area index, maximum                        3.76      -99
   Canopy height (m)                               2.62     1.792
   Harvest index at maturity                       0.48      .482
   Leaf number per stem at maturity                9.67      7.8
```

FileA data also appear in EVALUATE.OUT.

FileT (time course) data are used primarily in the graphing program, Gbuild. Measured data points, being independent samples, are plotted as single points on the graphs. Simulated data, being determined on a continuous daily basis, are plotted as lines.

2.5.2. Entering FileT and FileA files

Data are collected in various ways from the field. Electronic instruments generally either download to text files or spreadsheets. Sensors are also frequently connected to dataloggers, which are downloaded to text files. Measurements are also taken by hand and captured into databases and spreadsheets. Two avenues are available to the DSSAT user for entering the data into DSSAT:

- Using the DSSAT ATCreate program
- Using a text editor (e.g. Notepad) to create the files manually

The ATCreate program is slightly unstable and the experience of the authors suggests that users take particular care when using this software. Editing the files manually can be an arduous task, and ATCreate is the recommended approach. However , it is recommended that:

- Users make use of Excel to perform all data processing such that ATCreate has simply to convert from an Excel / CSV document into FileT or FileA format.
- Any subsequent editing is performed manually with a text editor.

The process of creating T and A files is exactly the same for sugarcane as any other crop in DSSAT, so the reader is directed to the general DSSAT v4 and v4.5 documentation in this regard.

3. Simulation settings

When the crop management / experiment file (FileX) is set up, the user describes the experimental crop management setup such that the crop model has enough information to run a simulation. This crop management setup includes planting details, choice of cultivars, when to harvest, and so on. As a whole, these can be considered 'management' configuration.

It is also necessary, however, to provide some MODEL configuration – guidelines to the crop model itself as to how it should go about running the simulation. These guidelines take the form of, for example, how to schedule irrigation; how reference evaporation should be calculated; on what date should the simulation start; and so on. Complication is introduced in some cases where these guidelines correspond with management settings – if a harvest factor level (i.e. harvest date) is defined, for example, the model needs to be explicitly instructed to end the simulation on the specified harvest date; otherwise, DSSAT will wait for the crop itself to 'mature' and end the simulation itself, which is the default DSSAT CSM behaviour.

The user is invited to explore the options presented under the Simulation Options menu in Xbuild. Simulation Options are treated as a factor, and a set of Simulation Options is associated as a factor level with each treatment. In this way, irrigation regimes can be compared in different treatments, and so on.

3.1. Specific Sugarcane simulation options

Some simulation options are particularly relevant to sugarcane. It is important that these are set. Failure to do so will either result in the model crashing or the model simulating poorly:

- **Harvest:** In the Simulation Options [menu] → Management [button] → Harvest [button] section, the simulation MUST be instructed to harvest 'On reported date' OR 'Days after planting'. This choice MUST correspond with a harvest crop management factor level setting (Management menu → 'Harvests') – see section 2.3, step 6.
- **Planting:** In the Simulation Options [menu] → Management [button] → Planting [button] section, the simulation MUST be instructed to plant 'On reported date'. This choice MUST correspond with a planting crop management factor level setting (Management menu → 'Planting') – see section 2.3, step 5.
- **Reference evaporation:** If TDEW (dewpoint temperature) or relative humidity and windspeed are available in the weather data used by this simulation, the FAO-56 reference evaporation method should be chosen. Set this by clicking Simulation Options [menu] → Methods [button] → Evapotranspiration [drop down].
- **Plant/ratoon crops:** if a plant crop is to be simulated, the correct choice on the planting screen is 'Dry seed'. 'Ratoon' can be chosen on this list as well for a ratoon crop.

3.2. Irrigation

Irrigation details are generally set in the Simulation Options section of Xbuild. The only exception to this is if a record of daily irrigation amounts was kept. These must be entered in the Management [menu]→Irrigation screen, but even then the simulation option for irrigation must still be set. In this specific case the irrigation management under the Simulation Options menu should be set to 'On reported dates'.

Irrigation will usually be automatic. If extremely generous irrigation is desired, set the management depth to a small value and the threshold percentage to a high value, in the irrigation management section under Simulation Options. The top of the soil profile dries out faster, so this will result in more frequent irrigations.

Please see the Management section (2.3, step 8) for an example of how simulation options can be used.

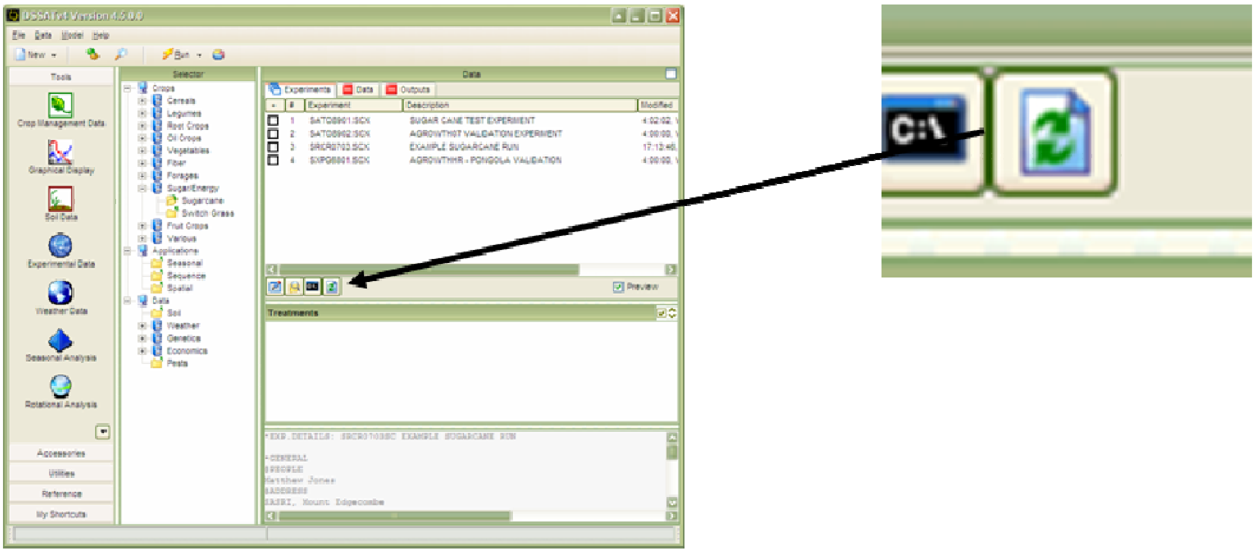
4. Running the model and viewing outputs

4.1. Running the sugarcane model

The sugarcane model is now part of the DSSAT Cropping System Model, so behaves like any other crop in terms of the user experience.

i. In DSSAT, navigate to the sugarcane section using the navigation tree on the mid-left side of the screen.

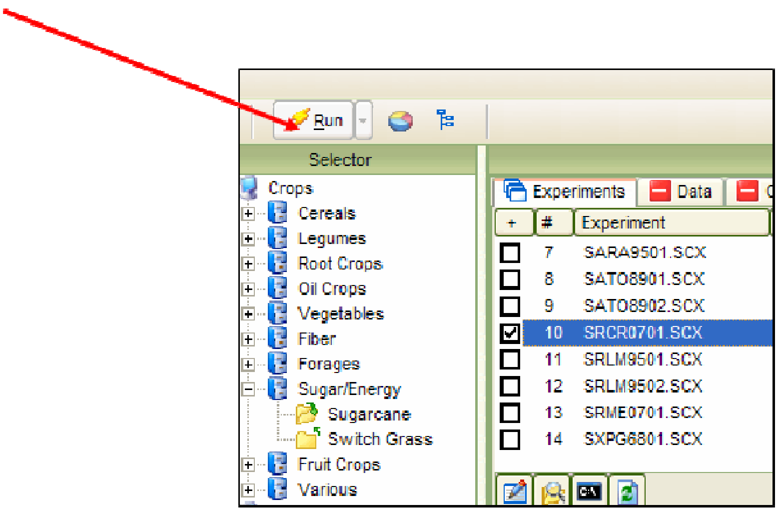
ii. Click the Refresh button to ensure that experiment lists are updated.



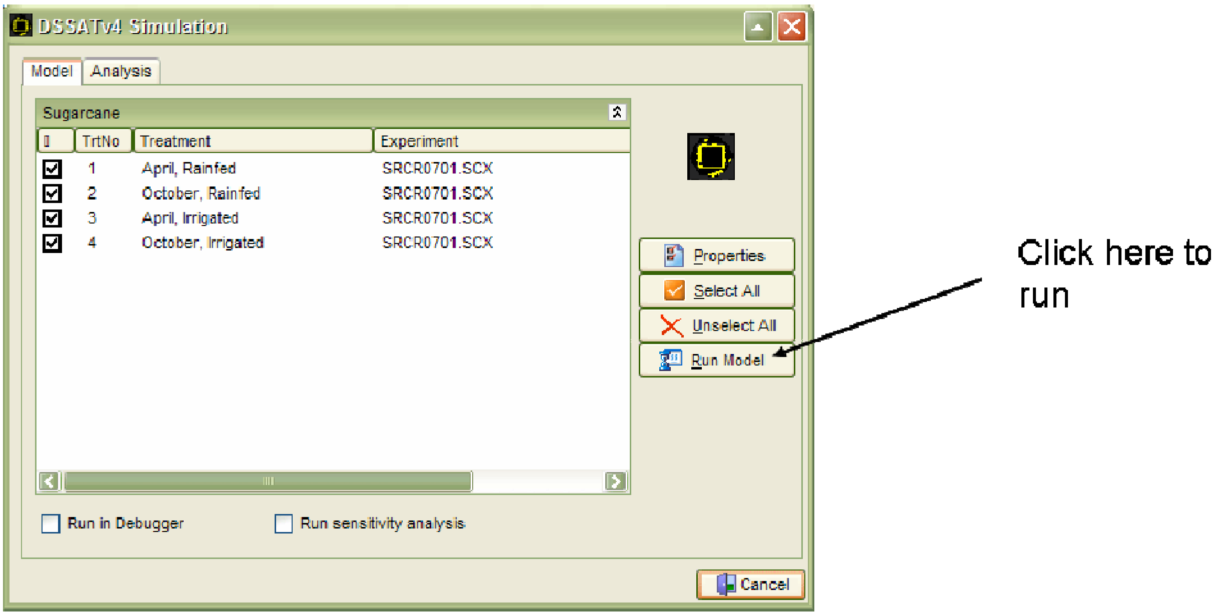
iii. Locate the experiment (by code or description); click on the checkbox next to it.

iv. The treatments belonging to this experiment will be listed in the pane below. Ensure that the treatments that need to be run have their checkboxes ticked.

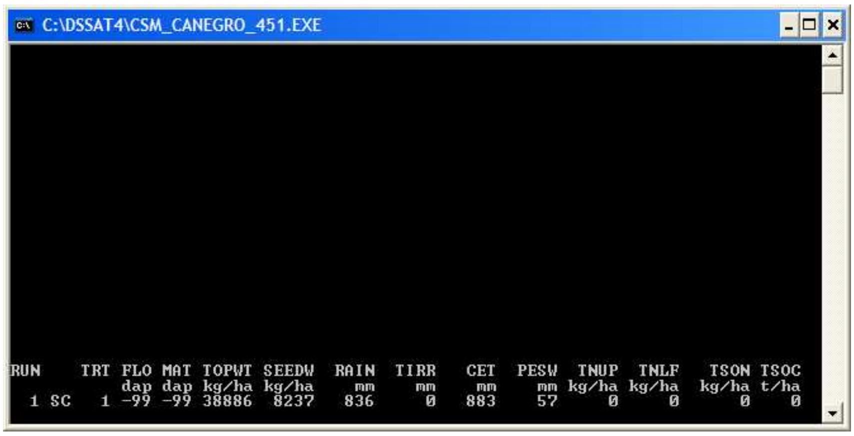
v. Click on the Run button at the above-left of the screen:



vi. You will then get this screen:



vii. Click on the ‘Run Model’ button to run the simulation; a DOS-prompt screen will briefly appear:

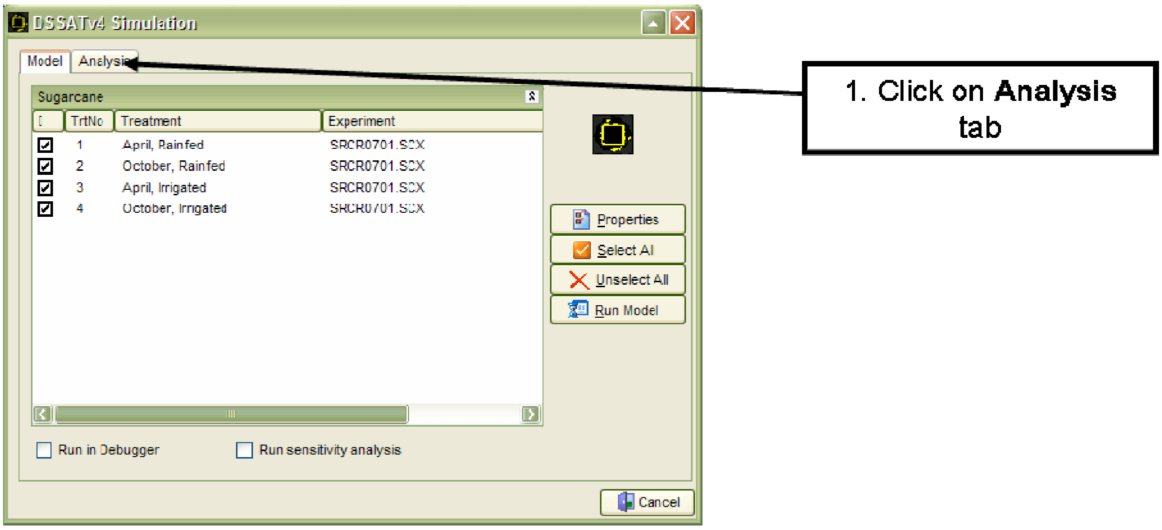


viii. When the DOS screen disappears, the simulation is complete.

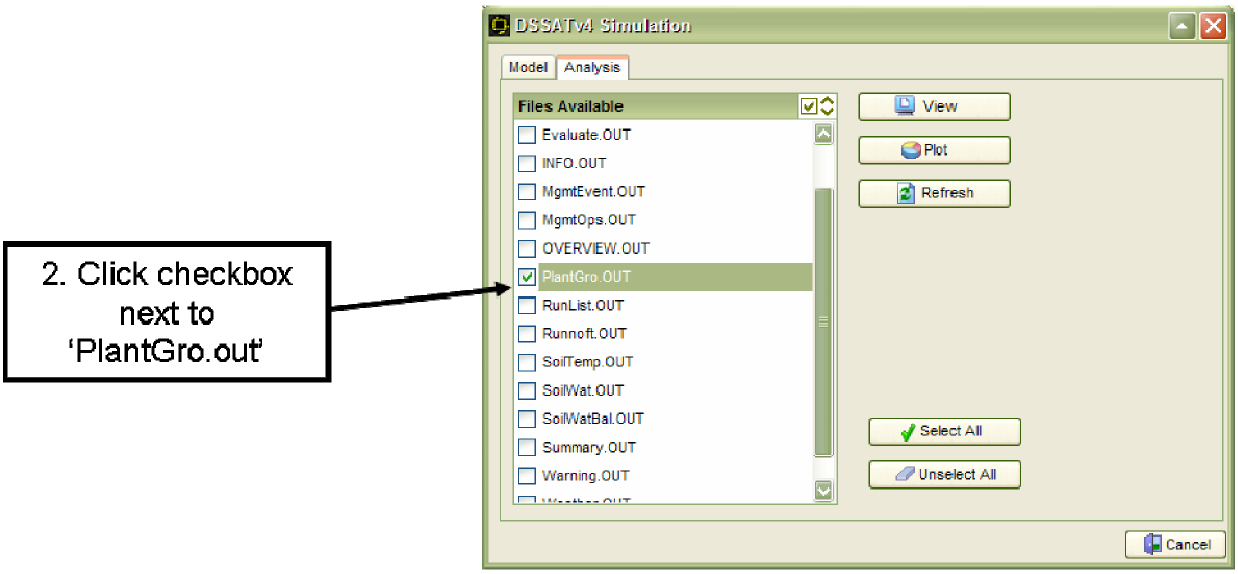
4.2. Viewing and graphing model output

In order to visulaise model output, the following steps are required:

i. Back on the Run screen, click on the ‘Analysis’ tab; this displays a list of .OUT files in the DSSAT sugarcane directory.

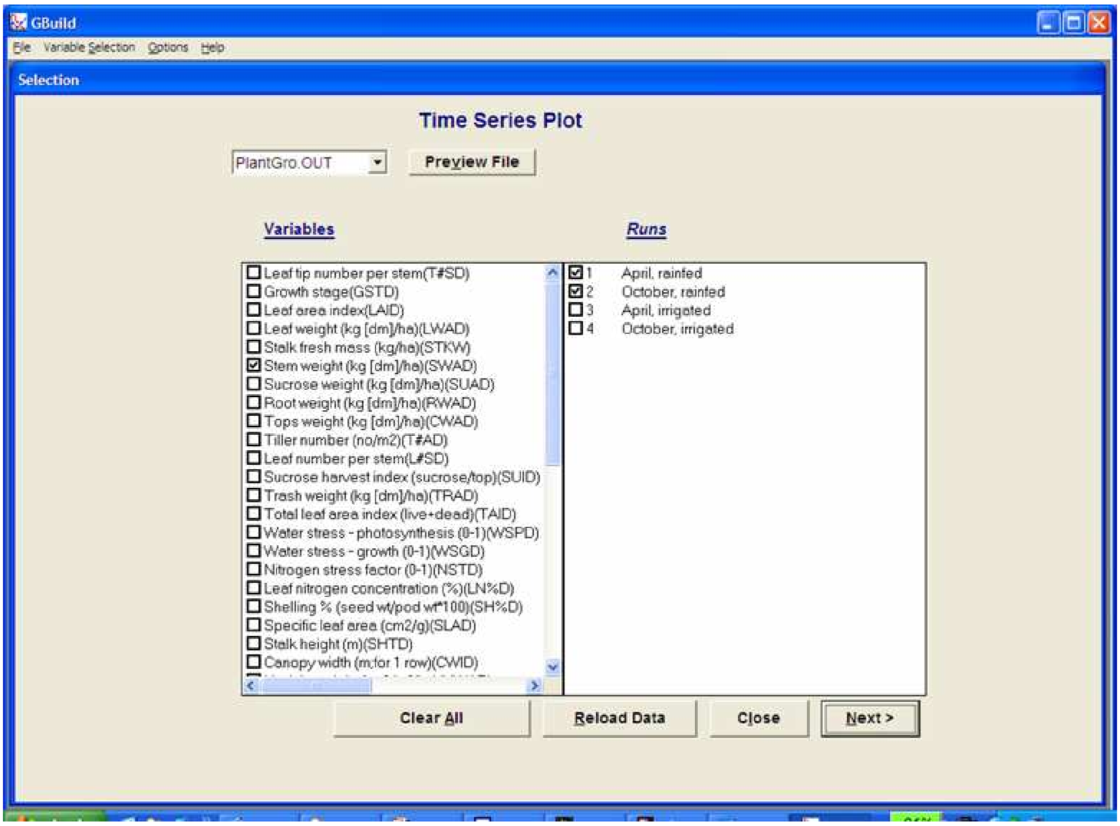


ii. Now click on the checkbox next to 'PlantGro.OUT':

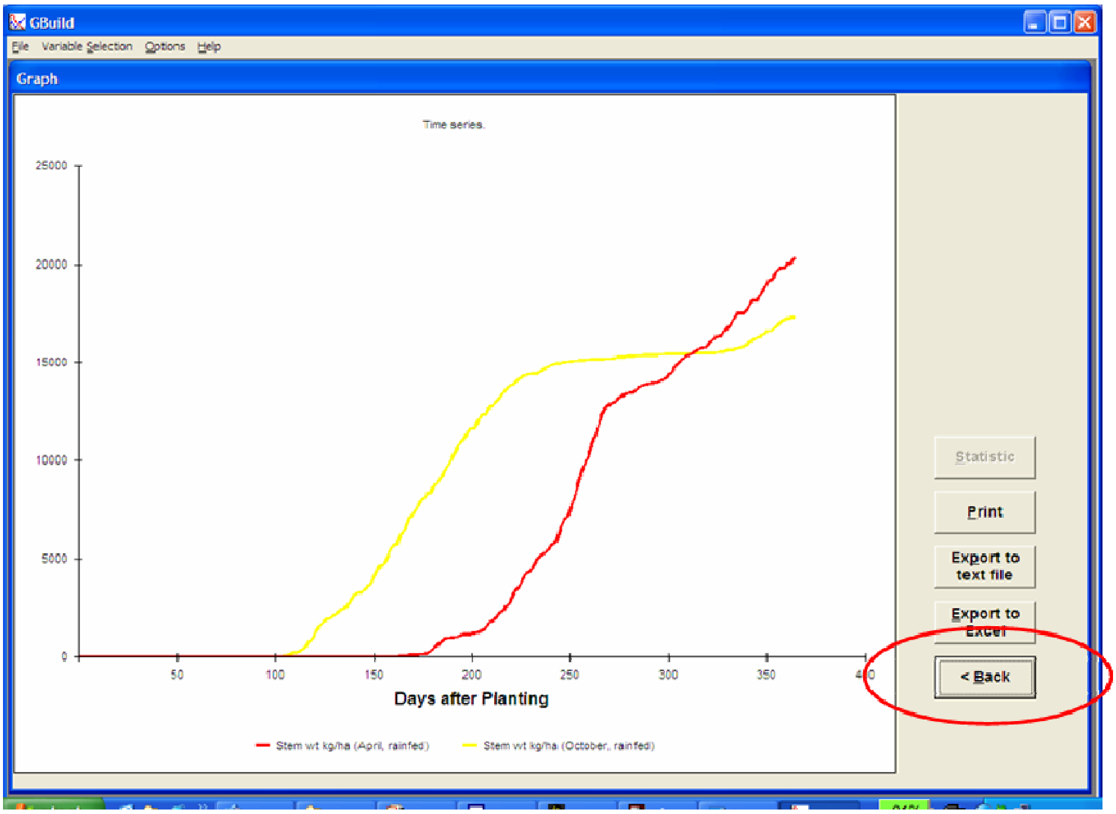


iii. Clicking on the 'View' button will load up any checked files in Notepad. If the 'Plot' button is pressed, the Gbuild graphing program opens with the checked files loaded (although only one file's variables can be graphed at a time).

iv. The Gbuild screen presents a list of variables in the loaded file on the lefthand side of the screen, and a list of treatments on the right. Click on the checkboxes next to the variables that need to be graphed, mark the checkboxes next to the treatments for which these variables need to be graphed.



v. The figure below shows a sample of an output graph:



vi. Clicking on the Back button brings the user back to the variable/treatment selection screen. If experimental data are available for this experiment and the currently-graphed treatments, these data points will be graphed in the same colour as the corresponding model-simulated series line. The Statistic button will be enabled, and if this is pressed, Gbuild calculates statistics such as RMSE, mean, d-stat, etc. for each treatment.

4.3. General discussion of model outputs

The sugarcane model in DSSAT (the Canegro CSM module) produces sugarcane-specific output. This output is found in the Plantgro.OUT file, primarily; Plantgro.OUT contains all of the plant information – yields, root mass, water stress, canopy cover, and so on. Other outputs are put in OVERVIEW.OUT and INFO.OUT. DSSAT also generates ET.OUT (output variables associated with evapotranspiration), WATBAL.OUT (variables associated with soil water content), Weather.OUT (daily weather values), and various others.

In any output file, the definition of a variable output code can be looked up in C:\DSSAT4\DATA.CDE.

All output from a sugarcane simulation is stored in C:\DSSAT4\sugarcane. Other sugarcane-specific files are also stored here – e.g. the sugarcane FileX files. Soil and weather files, on account of being able to be used for other crops too, are stored in C:\DSSAT4\Soil and C:\DSSAT4\Weather respectively. If a sequence of crops is simulated (whether not sugarcane is in this sequence), output will always go into C:\DSSAT4\Sequence. Cultivar, ecotype and species files are stored in C:\DSSAT4\Genotype.

The DSSAT CSM model (which contains the sugarcane module) can also be run from the command line. When DSSAT is run from the user interface program, a file called d4batch.dv4 is created. This contains a list of runs that DSSAT must execute. The model could then be run with the following commands in DOS:

c:

cd \DSSAT4\sugarcane

c:\DSSAT4\DSCSM045.exe b d4batch.dv4

This is running the CSM executable called DSCSM045.exe, which is stored in C:\DSSAT4. If all requisite files – exe, soil, weather, cultivar, FileX, dv4, etc – are put in an arbitrary directory, the model can run from that directory, in the form:

C:

cd \arbitrary_directory\

DSCSM045.exe b d4batch.dv4

It can be extremely useful to run the model in this way. The design of DSSAT is such that treatments from many different experiments (and crops) can run from a single batch (dv4) file. All output goes into single files as well, generally making analysis much easier.

5. Simulating a sequence of plant and ratoon crops and a fallow period.

5.1. Introduction

This section describes how DSSAT can be used to simulate a sugarcane replant cycle. This will involve planting a sugarcane crop, harvesting, allowing it to ratoon/harvest three times, leaving it for a three-month fallow, replanting, and running for another three ratoons. An example is used to illustrate the steps required to run this simulation.

It is assumed that the user is familiar with setting up DSSAT simulations. Only the parts that differ for a plant/ratoon sequence will be discussed.

5.2. Scenario

Weather data: Tongaat automatic weather station, KZN, South Africa

Soil: Arcadia (Mount Edgecombe)

Crop: Sugarcane, fallow

Cultivar: NCo376

Dates: See Table 8.

Table 8. Dates for simulating a sugarcane cropping sequence

Event	Start	Harvest
Plant	1 December 2000	1 December 2001
Ratoon 1	2 December 2001	2 December 2002
Ratoon 2	3 December 2002	3 December 2003
Fallow	4 December 2003	4 March 2004
Plant	5 March 2004	5 March 2005

5.3. Method

5.3.1. Create a FileX

Use the Xbuild program to create a new FileX.

5.3.2. Experiment details

This is a crop sequence (the fallow is treated as a crop), so the **'Sequence'** option is to be chosen in XBuild.

5.3.3. Crops

Because this is a sequence, each crop in the sequence must be added. Choose 'Sugarcane', 'NCo376', for Sequence Level 1, and 'Fallow', 'fallow' for fallow period.

5.3.4. Planting

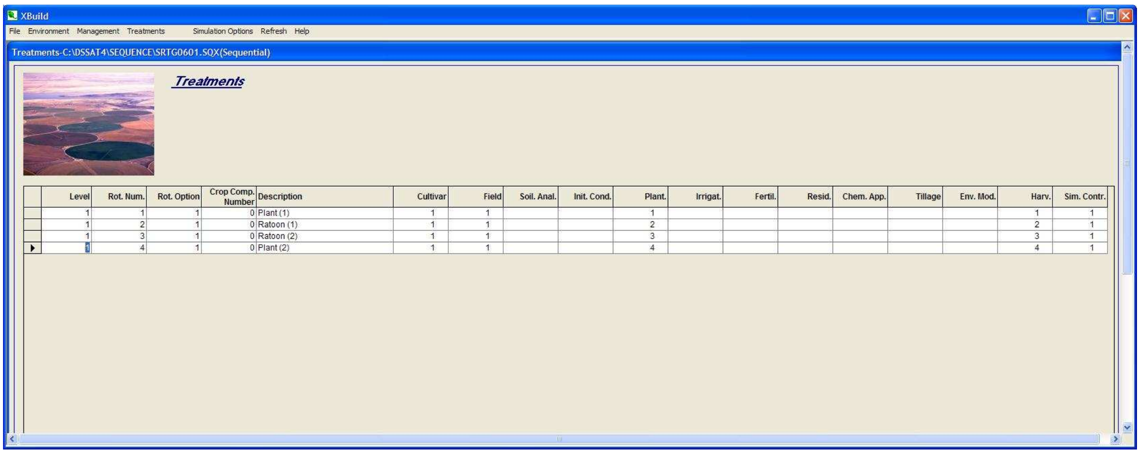
Create a planting 'factor level' called 'Plant cane (1)', representing the first sugarcane plant crop. Enter start date from table above (1 December 2000). Planting method is set as 'dry seed'. Click 'Add' to add another planting factor level. This is the ratoon cane; all settings are the same, except the date (2 December 2001), and the planting method (ratoon). Add in all ratoon plant dates and plant plant dates as planting factor levels.

5.3.5. Harvests

Click on the 'Management' menu, and select 'Harvest'. Enter each harvest date, and a harvest 'level' for each one. Add in harvest dates for all plants and ratoons.

5.3.6. Treatments

Create a new treatment rotation for each plant/harvest combination, i.e. one for the first planting and harvest, one for the first ratoon and harvest, etc. In this case, four treatment rotations are set up.



5.3.7. Simulation options

Set start sim date, replications (1), years (4). Set 'on reported dates' for plant and harvest. No applications of irrigation or fertiliser. Options: simulate water, not Nitrogen. Output: 1 day frequency, growth, water. Four-year run (not 5), because this simulation fits within four years of weather data (and the weather data does not span from the first planting date to first planting date + 5 years). Weather data must be 'measured', not generated.

Notes: This may seem obvious, but make sure the weather data set spans the entire duration of the simulation. It is easy to mistakenly set DSSAT to 'overrun', i.e. attempt to simulate beyond the last available weather date.

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