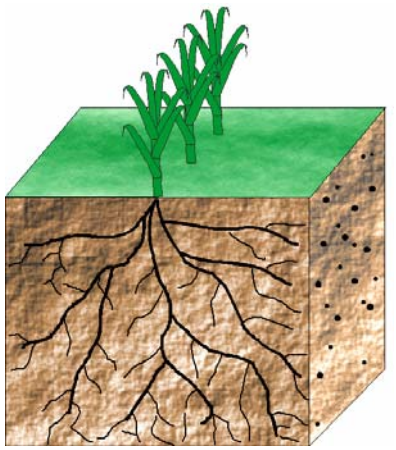
Département PERSYST
UR Systèmes de Cultures Annuelles

RACINE2:
Software Application for Processing Root Data from Impact Counts on Soil Profiles. User Guide

JL Chopart, L Le Mézo, M Mézino.



November 2008

[1] **CIRAD-CA station Ligne Paradis, 7, chemin de l'IRAT, 97410, St Pierre La Réunion.**
chopart@cirad.fr

PRELIMINARY REMARKS

This document comes directly from the contextual help integrated in the software tool, and which is easy to access while using RACINE 2. The content of this user guide is very close to the pages displayed by the tool.

It contains little or no scientific justifications or calculation procedures.

Other documents provide information on the scientific approach (Chopart 1999, 2002, 2004). The justification models for estimating the root length densities (RLD) from the counting of impacts counted on soil profiles and entered into RACINE2 have also been published elsewhere for maize (Chopart et Siband 1999), for sugar cane (Chopart et al. 2008), and for sorghum (Chopart et al 2008). For rainfall rice, work should be published soon (Ducerre et al.)

SUMMARY

1. Basic principles and procedure 4
Basic principle 4
A overview of the successive stages 4
2. Structure 6
2.1. Creating a structure 6
2.2. Structure management 7
2.3. Exporting and importing structures 7
3. Impact capture 8
3.1. Data entry windows 8
3.2. Windows for viewing root impacts and copying images 10
4. Calculation models 11
4.1. Entering equations 12
4.2. Creating the scenarios 13
5. Calculating and viewing calculated values 13
6. Formatting 15
6.1. Aggregation 16
6.2. Spreadsheet or image output 17
Spreadsheet 17
Image 18
7. IT management 21
Annex 1 : Limits of the application. 23
Annex2: From RACINE1 to RACINE2. 24
Bibliography 26

1. Basic principles and procedure

Basic principle

RACINE 2 is a software application for processing root data based on counts of root impacts via a grid placed on soil profiles. This method can measure the intersections between a plane represented by the profile of soil and roots. It provides access to the density of impacts and their spatial distribution (gradients, heterogeneity). Then, by modeling, we can estimate various characteristics of the root system (volume root length, Average Distance between Roots, roots exploration rate and their spatial distribution).

The more detailed scientific principles of this approach are also given (Chopart 1989, 1996, 1999, 2002, 2004)…

The conceptual and practical limits, together with the computer system choices, are set out in annex 1

A overview of the successive stages

1) First, the user must have field data (counting impact on soil profiles) and much information to identify this profile in a data set of a study (site name, treatment, repetition, measurement date etc.)
2) When RACINE 2 is started up for the first time, the application contains only a structure for example. The first stage consists in creating and setting a new structure corresponding to the data to be processed for entering impact data (name of the site, treatment, repetition, date etc.). This allows to create tables sheets counting impacts.
The tree structure facilitates data management.
3) Once this structure has been set up, the user enters, in the adequate table, the root impacts observed in-situ.
4) Then, in order to calculate the different output parameters (length etc.), it is necessary to write algorithms for each of these parameters and associate them in a scenario.
5) RACINE 2 calculates the root characteristics (length, etc.), for each grid unit from the counting of impacts identified in each mesh.
6) The calculated values can be edited (average for depth, distribution etc.) and use to create maps.
7) The results of calculations are then exported to a spreadsheet and image maps for further analysis.

RACINE2 : Main work screen

When you click on the RACINE 2 icon, a home page (Figure 1) gives a concise presentation of the software and asks the user if he wishes to activate the application, either by clicking on the “Start” button or by pressing “Enter” on the keyboard.

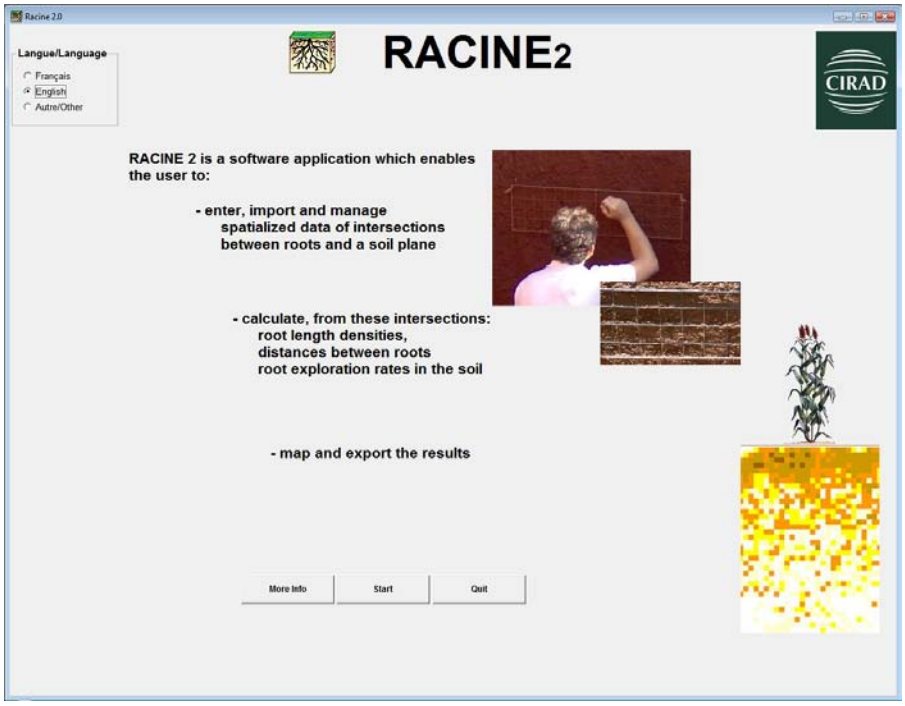


Figure 1 : Home page of RACINE2

The main work screen open (Figure 2) concern the structure management.

The main work screen contains:

- At the top (i) several menus: File, Edit, Structure, Calculation Models, Results or an image and on-line contextual help;
- on the left: a tree structure of sites and folders (including an example);
- on the right: four tabs for the various stages. The user begins by **creating or modifying the structure** of the folder, and then **entering** root intersection data before the calculations and then the formatting.
- Middle : information for setting a structure

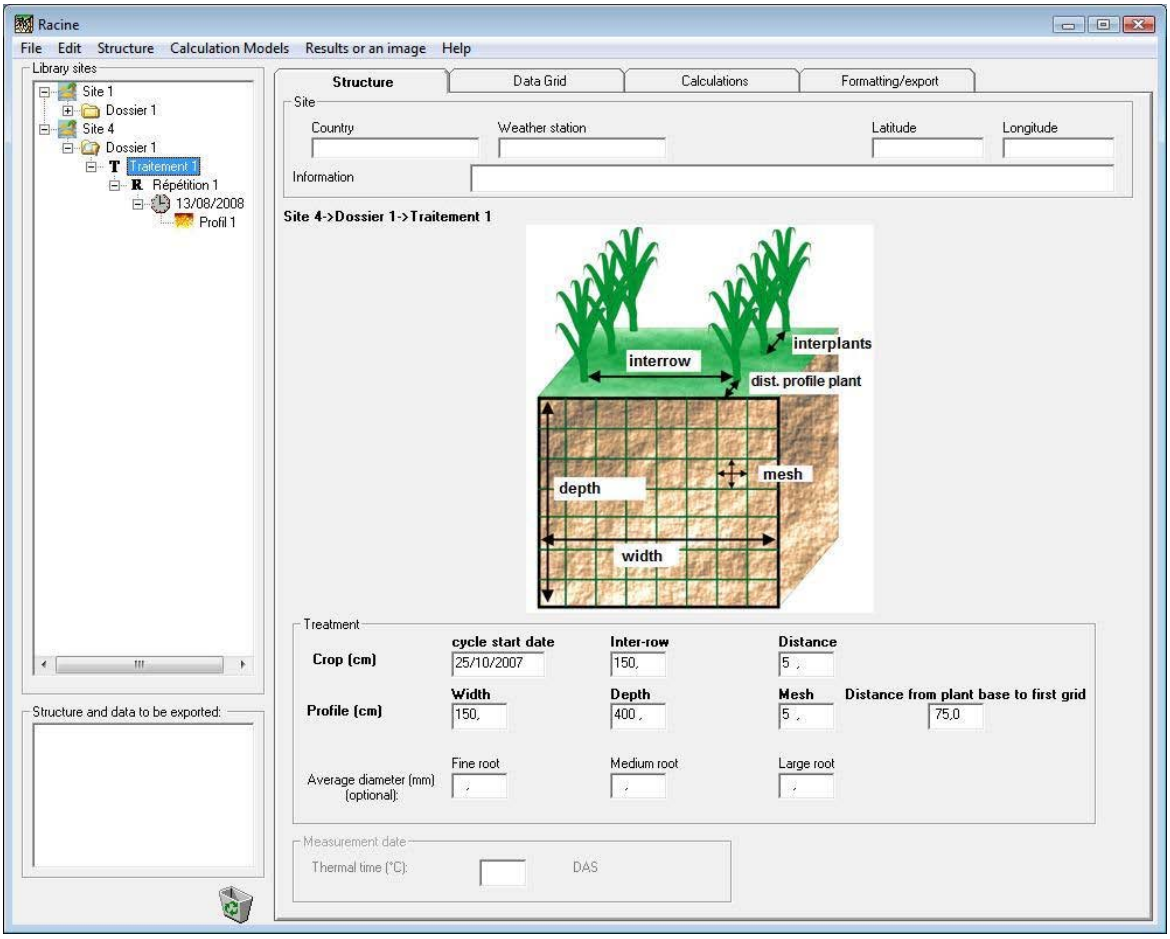


Figure 2: Main work screen of RACINE2

The first stage consists in creating a structure for entering in a table root impact reading in the field.

2. Structure

2.1. Creating a structure

The structure is organized in the following way:

- Site: this includes the non-essential information (country, meteorological station, latitude, longitude; this data is only accessible when the site is selected). There is an open entry window available for saving all types of information on the site.
- Folder: the folder name must be typed in by replacing "folder" with the actual name via a right click (Cf. par 22)
- Treatment : this is characterized by information relating to:

  - the crop **(crop start date, inter-row distance, distance between plants);**

  - the maximum dimensions of the depth of the soil studied (the **width**, **depth,** and **width of the grid unit of the data grid**). The grid unit is always a square.

- the average diameters of the roots. Entering diameters is optional as only certain models estimate useful soil volume by differentiating the diameters of the roots;

- the distance between the plant base and the first grid unit. By convention, the first grid unit is the one located on the very top left of the soil profile.

This data is only accessible when processing is selected.
The words in bold type above indicate compulsory values.

Attention:	The width and depth must be multiples of the grid unit. The inter-row distance must be a multiple or submultiple of the width. The cycle start date must be prior to the measurement date.

- Repetition: the names of the repetitions can be modified (see Paragraph 22). All the repetitions must have the same characteristics, defined at the "Treatment" level.
- Date: date at which the measurement is made. The folder creation date is given by default; then the user modifies this date with a right-click. According to this date and the cycle start date, the number of days after the cycle start (JAS) is calculated and the temperature aggregation (sum of degrees per day) for this period can be entered. This optional information can be used as a parameter when using the equations.
- Profile: a root profile can be composed of several planes at different plant distances. These planes are considered as having been analyzed at the same date.

2.2. Structure management

A management menu for the structure elements is accessed by a right click on the element to be managed, making it possible to **add**, **rename** or **delete** the selected element.
These actions involve the selected level and the lower levels.
Regarding **deletion**, only the "Site" level goes via the Trash Bin (on the bottom left) before being permanently deleted. The other levels are deleted without going via the Trash Bin.
It is possible to retrieve a site placed in the Trash Bin by a right click on the Trash Bin and then on "**Restore**". The site will be reactived in the tree structure.
When the application is closed, a message asking the user to confirm deletion appears for the Trash Bin to be emptied.

NB: Modifying the treatment configuration elements affects all the data grids already created. Therefore, such modifications are to be avoided or need to be carried out with care:

- Modifying width: creating or deleting columns and information loss on planes that have already been captured. In order to avoid losing impacts that have already been entered, it is necessary to copy the captured values into a spreadsheet file, modify the width of the grid and then paste the impacts from the spreadsheet into the new grid in their initial position.
- Modifying depth: it is possible to create rows without information loss; but when a row is deleted, please note that there is a risk of losing data.
- Modifying the grid unit: changing the size of the grid unit after capturing the impacts brings about the creation of a new grid with redistribution of the impacts according to methods that have **no scientific basis.** **To be avoided at all costs.**

2.3. Exporting and importing structures

The user can export part or the whole of a site's tree structure, by selecting the structure element to be

sent and then dragging and dropping this element into the “Structure and data to be exported” window (on the bottom left). In the main menu, the “Structure” command followed by “Export the Data” brings up a dialog box for the user to specify the storage name and place of this zipped file.

When the application is closed, the sites placed in the “Structure and data to be exported” window will be reactivated in the tree structure.

Also, the user can import a part or the whole of the tree structure of a site created on RACINE 2. Via the main menu “Structure”, access and activate the “Import” menu, and a dialog box is displayed for selection of the elements to be imported. The selected file will complete the existing tree structure.

3. Impact capture

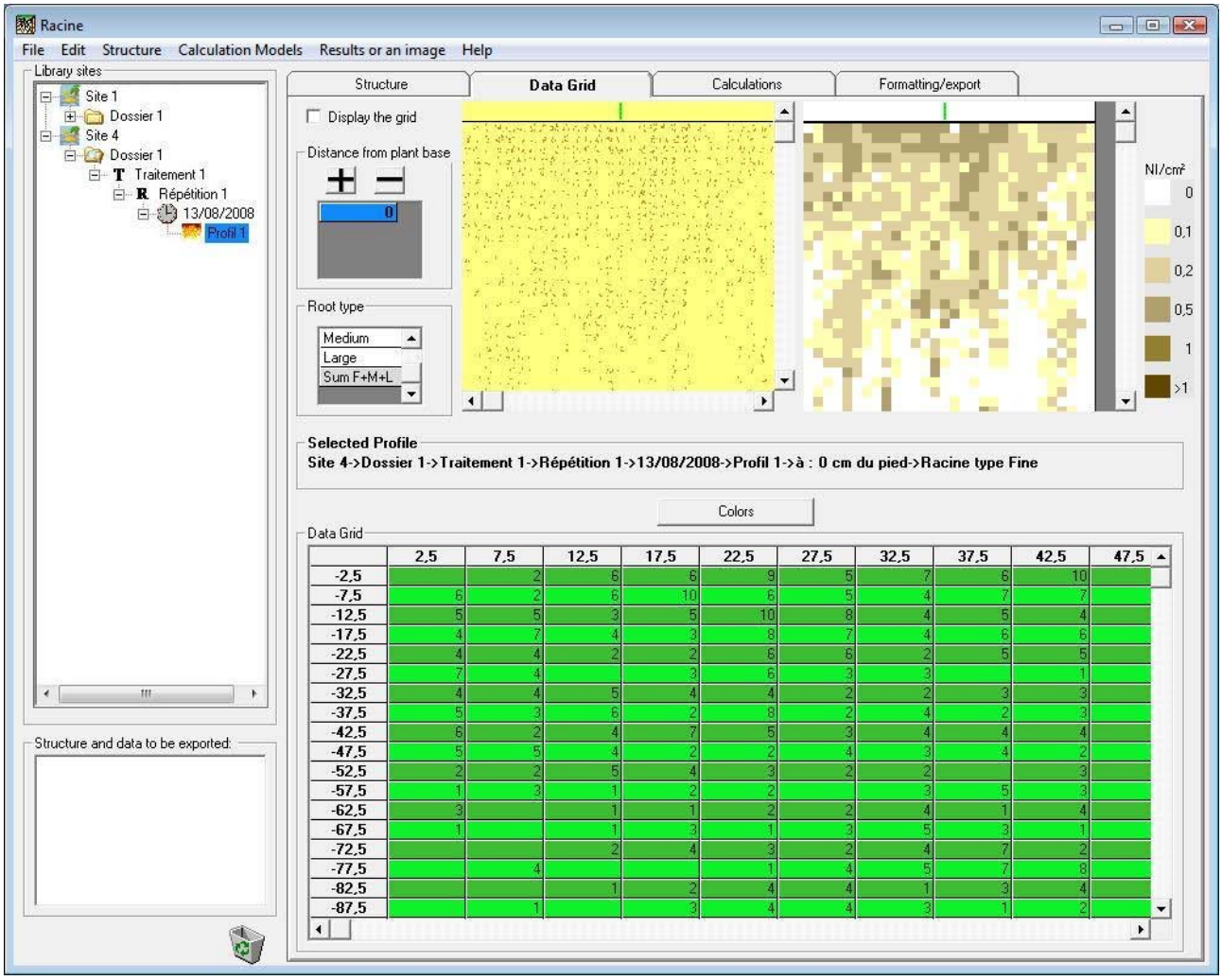
To enter impact data, the user accesses the tab "Data grid" by positioning itself at “profile” in the tree structure. The tab “Data grid” becomes available after having established the structure and recorded the configuration of the treatment.

This tab (Figure 3) is actually composed of:
- 3 windows accessible for data capture: distance from the plant base, root type, and an impact entry table
- 2 windows for visualizing images of root profiles.

The tree structure of the profile that is being captured is displayed in the center of the tab.
The table was created automatically by RACINE2 based on information provided when creating the structure (defining characteristic of treatment). This table is not changed in the tab “Data grid”.

3.1. Data entry windows

Before entering the impacts root, the user must define the counting (depending on the distance to the plant base, then the root type that he will enter.

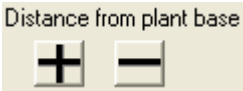


	2,5	7,5	12,5	17,5	22,5	27,5	32,5	37,5	42,5	47,5
-2,5		2	6	6	9	5	7	6	10	
-7,5	6	2	6	10	6	5	4	7	7	
-12,5	5	5	3	5	10	8	4	5	4	
-17,5	4	7	4	3	8	7	4	6	6	
-22,5	4	4	2	2	6	6	2	5	5	
-27,5	7	4		3	6	3	3		1	
-32,5	4	4	5	4	4	2	2	3	3	
-37,5	5	3	6	2	8	2	4	2	3	
-42,5	6	2	4	7	5	3	4	4	4	
-47,5	5	5	4	2	2	4	3	4	2	
-52,5	2	2	5	4	3	2	2		3	
-57,5	1	3	1	2	2		3	5	3	
-62,5	3		1	1	2	2	4	1	4	
-67,5	1		1	3	1	3	5	3	1	
-72,5			2	4	3	2	4	7	2	
-77,5		4			1	4	5	7	8	
-82,5			1	2	4	4	1	3	4	
-87,5		1		3	4	4	3	1	2	

Figure 3 : page data entry impacts roots

Distance from plant base

The distance from the plant base is the distance between the measurement plane and the vertical plane from the crop base. This value is zero by default; the measurement plane is located vertically from the plant base.

The buttons 

enable the user to add or remove a measurement plane.

Each measurement plane corresponds to an impact count of one or several root types.

Root types:

For impact capture, it is necessary to select a root type. The grid for entering impacts of fine roots is presented by default.
The root type "Sum F+M+L" presents the sum of impacts per grid unit of the different root types captured. It is not possible to enter impacts for this category.
The average diameter of each root type has already been entered in the preceding tab at the treatment level.

Impact data entry

According to the information entered in the "Structure" tab at the level of the profile width, the depth and the grid unit, a data entry grid for the whole of the profile is displayed. This grid corresponds to the field readings grid. The width is divided by the grid unit to obtain the number of columns; the depth is divided by the grid unit to calculate the number of rows. The row and column headings correspond to the average value of the distances between the start of each row or column and the point (0; 0).
After selecting the grid unit an information bubble appears, specifying the coordinates of the selected grid unit.

It is possible to modify the color of the rows in the entry field. After a right-click on a row, the user accesses a color palette and selects one. The line the mouse pointer is positioned on and then one row in two will take on the chosen color. Colors are alternated for better readability of the data entry grid. The colors chosen are applied to all the data entry grids in the entire tree structure.

When the application is used for the first time, the proposed plane is vertical to the plant base (distance from the plant base = zero) and the "fine" root type is activated. The user can now begin entering the number of impacts in each grid unit.

The user takes the field readings to capture the data for each grid unit, one by one. On the keyboard, the arrow keys validate and move the cursor. The "Entry" key validates and moves downward.

The "Copy" and "Paste" menus are accessed by a right-click on the grid, enabling the user to duplicate impact entries on the grid or in a spreadsheet after selecting one or several grid units.

It is possible to validate a grid containing a number of impacts with decimal values. The mean values may have originated in a spreadsheet.

NB : An empty cell will be considered as containing no roots for the calculations: it is not necessary to enter zeros in the grid units with no root impacts.

3.2. Windows for viewing root impacts and copying images

As impact data is entered, the visualization images are updated.
The first of these shows the number of impacts entered per grid unit. The position of the root impacts in each grid unit is random: the actual position of the grid unit's impacts in the field is not given.

The second image displays the density of root impacts in cm^2 per value class.
The position of the mouse pointer is displayed simultaneously on the data entry grid and the visualizations.
Two methods are available for copying the root impact visualization images to the ".bmp" format.

- Position the cursor on the image then press the right button on the mouse to copy the image.
- Select "Result or Image" in the main menu, then "Export", which will open a window for naming and exporting the image.

Above both of these windows, the base of the crop plant is positioned according to the information entered when processing was created. Cf. Distance between the plant base and the first grid unit.

4. Calculation models

The user selects the "Calculation Models" menu from the main menu. RACINE2 opens a page for the management of calculations model and scenarios (Figure 4).

In the upper part of this window, the user types in the equations enabling a shift from the basic data (counts of root impact numbers per grid unit) to the output variables (Root Volume Length LVR, Average Distance between Roots EMR, Root Exploration Rate TE). More detailed information on the scientific content of these equations is available elsewhere:

- for Root Volume Length LVR : van Noordwijk (1987), Chopart (1999, 2004), Chopart and Siband (1999)
- for Average Distance between Roots (EMR) : Newman (1996), quoted by Chopart (1999 et 2004)
- for Root Exploration Rate (TE) : Chopart (1999, 2004)

These equations are associated in various scenarios in the bottom part of the window before calculation of the output variables begins.
Calculating the LVR, EMR and TE is carried out sequentially, with the calculating of the subsequent value leaning on the results of the preceding one. With a view to this, the user creates a calculation scenario of these three root traits. In this scenario a mode of calculating RVL, ADR and ER is chosen. RACINE 2 offers a catalog of equations that are either available or may be created by the user. Indeed, RACINE 2 offers models and equations validated for several crop types: maize (Chopart and Siband, 1999) sorghum (Chopart et al., 2008) sugar cane (Chopart et al. 2008). References for these equations are provided in the bibliography.

These equations of calculation of LVR, EMR, TE are already written into the software, but others may be added.

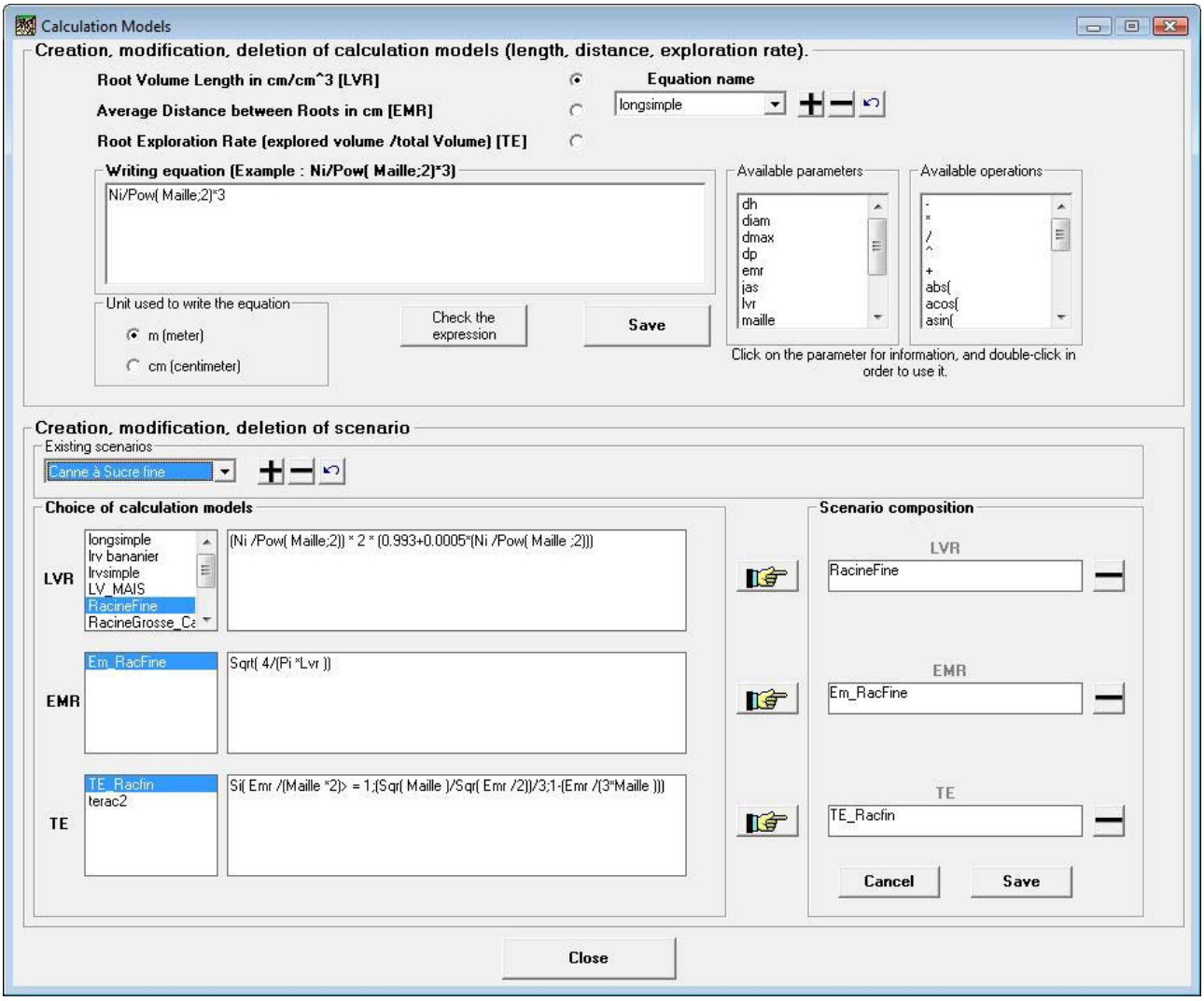


Figure 4: entering and management of calculation models and scenarios

4.1. Entering equations

The first stage consists in writing, if necessary, the equations. An equation writer is available at the top of the window. The user chooses which parameter he wishes to define out of the three proposed:

- root volume length (LVR);
- average distance between roots (EMR);
- exploration rate (TE).

The button  must be activated to write a new equation.
After naming it, the user types in the equation resulting from the modeling, aided by the list of available parameters and operations (to the right).
* clicking the parameter or operation gives access to a tooltip;
* a double click shifts the parameter or operation into the equation writer window.
After checking the syntax via the "Check the expression" button, the user must "Save" the new equation in its respective list. The user must check the unit used to write the equation.

After checking the syntax via the "Check the expression" button, the user must "Save" the new

equation in its respective list. The user must check the unit used to write the equation.
The "Check the expression" button checks only the equation structure (brackets, completing arguments, spelling of arguments). For instance, the writing of an equation may include a division by 0. The expression check returns a compliance message; the result of the calculation will be the absence of value.

To modify an equation, the user must select it and then carry out the required modifications in the equation writer window. Next, he must activate the "Check the expression" button, before saving it. The changes made to an equation that has already been selected in a scenario will automatically be updated in the scenario.

To delete an equation, the button be selected, and will be validated before confirming deletion.

An equation can only be deleted if it is not allocated to a scenario (Cf. creating the scenarios).

4.2. Creating the scenarios

Creating

Creating a scenario consists of combining equations (one per parameter). An equation is transferred into a scenario by using the button.

The user clicks on the button to create the scenario.

Then, he enters the new scenario name, selects an equation per parameter, transfers the selected equation and saves the scenario (below). The scenario name must specify which type of root it applies to, because in the output parameter calculation stage, the list of scenarios displayed by root type is the same whatever the root type.

A scenario can be limited to just one equation according to the available parameters.

Modifying, deletion

To modify a scenario, the user must select it in the list of existing scenarios and then carry out the required changes.
One equation is replaced by another by using the button.

An equation is replaced by an empty field via the button.

A scenario is deleted by using the button.

The Return arrow allows the equation to be abandoned while it is being displayed without it being saved.

5. Calculating and viewing calculated values

To access the page to calculate and display results, click on the tab "Calculations". (Fig. 5).

The procedure consists in choosing a scenario by root type, and then starting off the calculations to be made in accordance with the equations in the chosen scenario. The calculations are carried out on all of the elements below the selected one in the tree structure (on the left of the screen).
For instance:

I choose a site, and the calculations are carried out on all the folders included in this site.

I choose a folder, and the calculations are carried out on all the processing in this folder.

Once the scenario has been chosen, the selected elements appear in the "Profile" window.

On the page, the user gives the value of Ra (Ra: maximal travel distance of an element of the soil to root in cm). If this parameter is used in one of the scenarios, the user can modify the range value of Ra; Ra otherwise does not need to be filled.

The "Calculate" button starts off the calculation of the output variables on all the elements displayed in the "Profile" window according to the scenario chosen by root type.

To view the results, the user chooses:
- the name of the profile to be viewed (in "Profiles")
- the distance from plant base, and the root type;
- the root parameter

The values calculated appear in the lower part of the table when used for first use.

The lower part of the tab displays the values per grid unit according to:

- the scenario;
- the selected profile;
- the distance from the plant base;
- the root type;
- the activated parameter.

The value presentation table is identical to the basic data entry table.

The buttons - in the "Choice of scenarios" window enable the user to reinitialize his choices.
Any modification of the choice of one of the scenarios resets the selected profiles.
The user must restart the calculations.
When one of the following choices is modified (distance from plant base, root type, or parameters), the display window is refreshed.

NB: An empty cell is considered as being without roots.

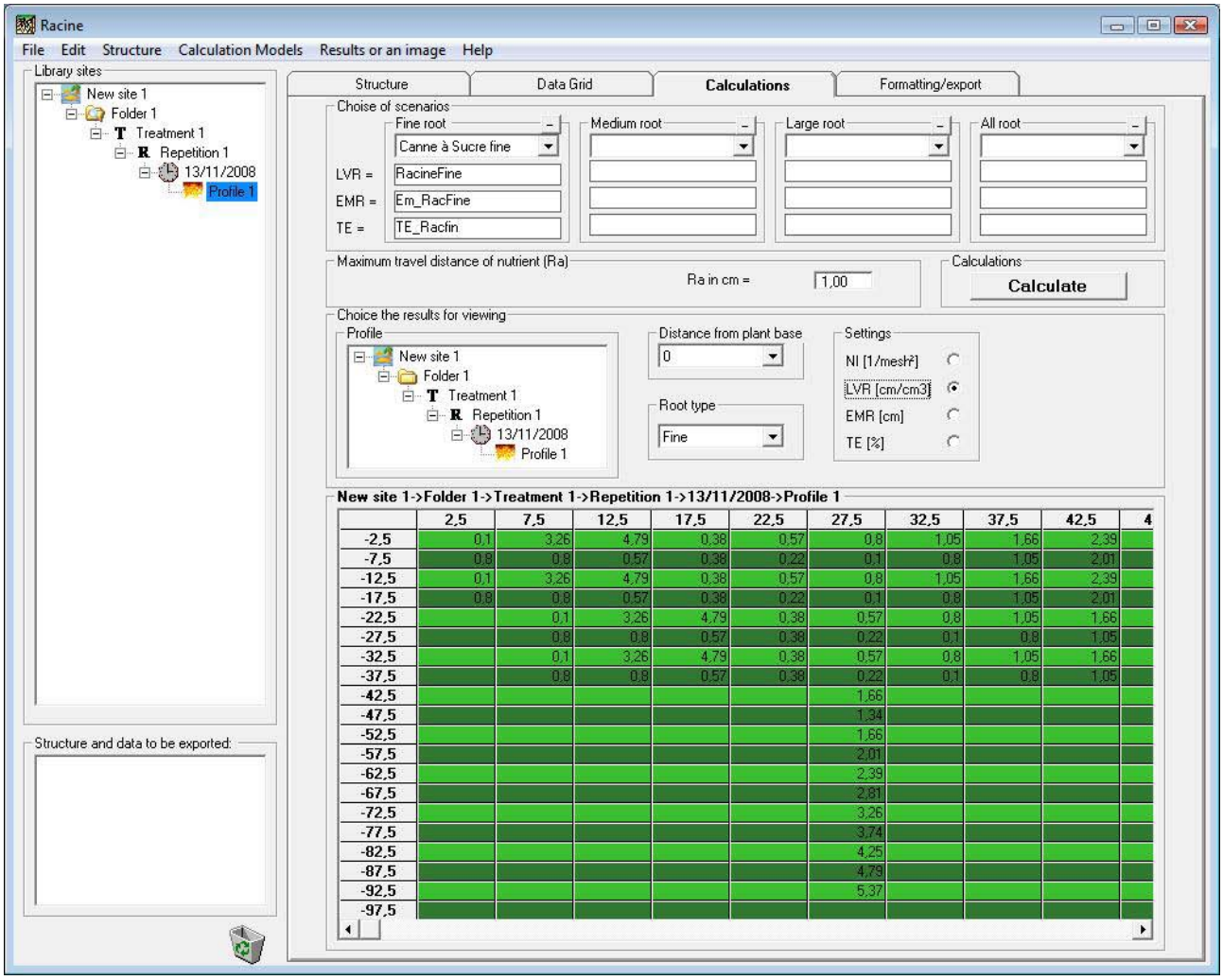


Figure 5 : Tab « Calculation » and display calculated values

Warning: RACINE 2 only stocks the calculated values momentarily, they are lost when the software is closed or a new calculates. Therefore the user must format them and export the calculated data before modifying his choices or quitting the application.

6. Formatting

The user can access the formatting calculations by clicking the tab " Formatting/export".

Principle

The tab " Formatting/export" permits various forms of aggregation of data calculated by mesh grid:

- Average by level (profile, measurement data, treatment)
- Displayed by unit area (grid unit, depth, width).

The procedure of formatting allows a first data treatment before **expor**t. The results are formatted and exported into a spreadsheet. The maps are exported in a format image. The data and images are then recovered following the usual procedures for the management of spreadsheet files and images.

6.1. Aggregation

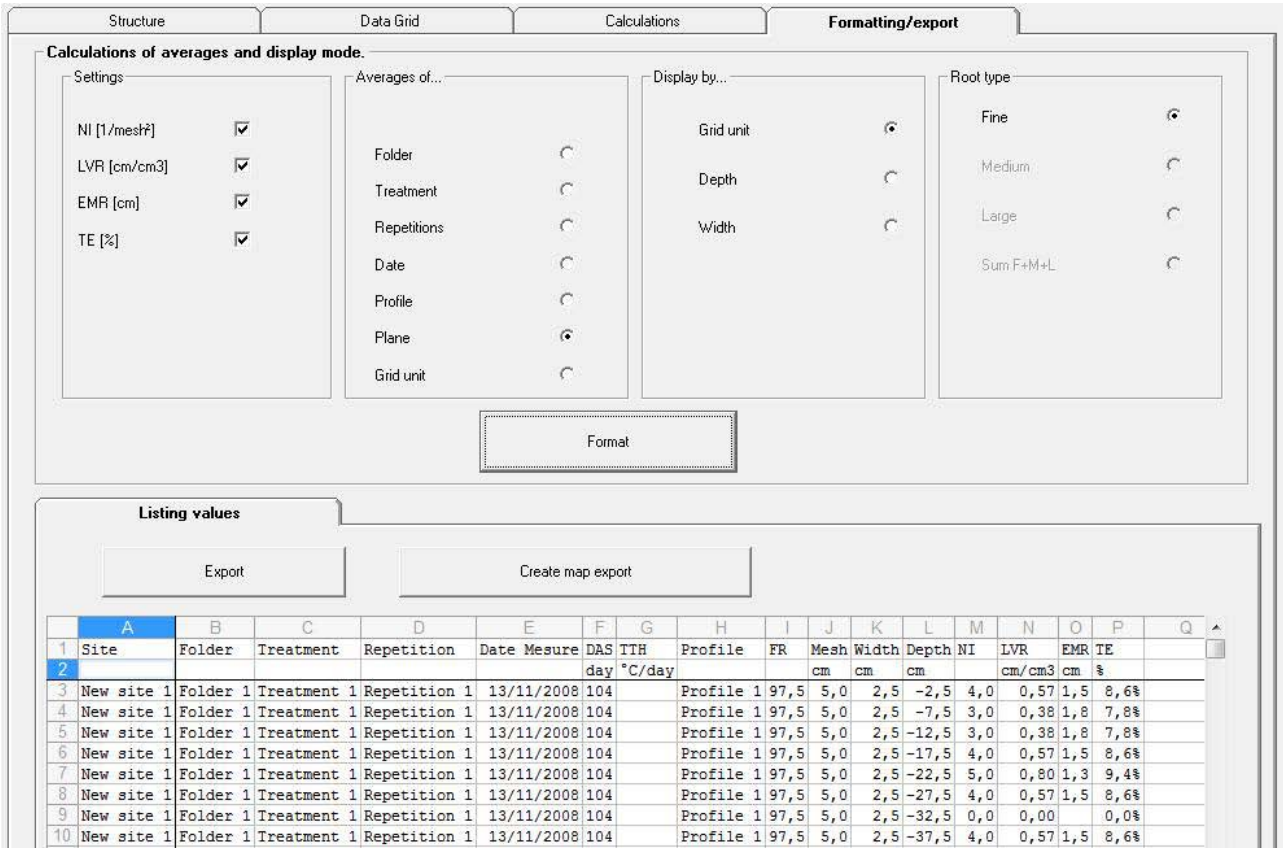
The user may aggregate or view the entered values or calculated parameters.
In the absence of any aggregation, display is made via the grid units, with a column appearing giving the grid unit number.
Aggregation consists in calculating the means of the output parameters according to the chosen structure level.
The calculations are carried out on a maximum of one site; the maximum level of aggregation is the site. This level of aggregation is possible if all the processing in the site shares the same configuration. Otherwise, the maximum level of aggregation is the "Repetition" level, to offer an average for each processing.

The user can also format sets of values per grid unit by averaging or not the parameters.

To obtain the complete dataset per grid unit, the user selects the level "Grid Unit" in the category "Averages of…", then "Grid Unit" in the category "Display by…"

The user selects:

- one or several parameters;
- the structure level at which the average is to be calculated;
- the display mode (by grid unit, width or depth);
- the root type: only the roots of this type will be taken into account.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Site	Folder	Treatment	Repetition	Date Mesure	DAS	TTH	Profile	FR	Mesh	Width	Depth	NI	LVR	EMR	TE	
2						day	°C/day			cm	cm	cm		cm/cm3	cm	%	
3	New site 1	Folder 1	Treatment 1	Repetition 1	13/11/2008	104		Profile 1	97,5	5,0	2,5	-2,5	4,0	0,57	1,5	8,6%	
4	New site 1	Folder 1	Treatment 1	Repetition 1	13/11/2008	104		Profile 1	97,5	5,0	2,5	-7,5	3,0	0,38	1,8	7,8%	
5	New site 1	Folder 1	Treatment 1	Repetition 1	13/11/2008	104		Profile 1	97,5	5,0	2,5	-12,5	3,0	0,38	1,8	7,8%	
6	New site 1	Folder 1	Treatment 1	Repetition 1	13/11/2008	104		Profile 1	97,5	5,0	2,5	-17,5	4,0	0,57	1,5	8,6%	
7	New site 1	Folder 1	Treatment 1	Repetition 1	13/11/2008	104		Profile 1	97,5	5,0	2,5	-22,5	5,0	0,80	1,3	9,4%	
8	New site 1	Folder 1	Treatment 1	Repetition 1	13/11/2008	104		Profile 1	97,5	5,0	2,5	-27,5	4,0	0,57	1,5	8,6%	
9	New site 1	Folder 1	Treatment 1	Repetition 1	13/11/2008	104		Profile 1	97,5	5,0	2,5	-32,5	0,0	0,00		0,0%	
10	New site 1	Folder 1	Treatment 1	Repetition 1	13/11/2008	104		Profile 1	97,5	5,0	2,5	-37,5	4,0	0,57	1,5	8,6%	

The "formatting" button carries out the synthesis according to the user's choices and the calculations made in the previous stage. The results are displayed in a spreadsheet format in the lower part of the tab; each row corresponds to a surface unit.

Next, the user chooses the formatting mode :

- for the creation of an XML file towards a spreadsheet

- for the creation of a map

If the aggregation is made by depth or by width, the map cannot be viewed.

6.2. Spreadsheet or image output

Spreadsheet

The "Export" button opens a dialog box in which the user specifies the file name and storage directory.

The file (.XML) created this way has 6 tabs:

- Tab 1, "Operations": all the synthesized data based on user choice
- Tabs 2, 3, 4 and 5: all the data distributed by root type → "Fine", "Medium", "Large" and "Total" tabs;
- Tab 6: information sheet specifying the structure of the sites and the equations used.

The following table presents all the headings of the data columns, with each tab including all or part of these headings. In the table below, the rows correspond to the columns in the XML table.

Table n°1. Headings of the data columns in the exported files, unit and description.

Heading	name	unit	description
Site	Site name		
Folder	Folder name		
Treatment	Treatment name		
Repetition	Repetition name		
Measurement date	Measurement date		
JAS	Number of days after sowing	Days	Calculated between the cycle start date and the measurement date
TTH	Thermal time	°C	Accumulated degrees/day entered
Profile	Profil name		
Distance	Distance from the plane	cm	Distance between the measurement plane and the vertical at the crop base
Diameter	Root diameter	mm	
Grid Unit	Grid unit	cm	Size of the captured grid unit
FR	Root front	cm	Maximum depth attained on the profile
Type	Root type		"Fine", "M" Medium, "L" Large, "S" Sum
Width	Column identifier		
Depth	Row identifier		
N°	Grid unit number		From the first unit on the top left by row to the last on the bottom right
DH	Horizontal distance	cm	Horizontal distance between the center of the grid unit and the plant base
DP	Distance from plant base	cm	Distance between the center of the grid unit and the plant base
DR	Distance from plant base	cm	Distance between the center of the grid unit and the plant base, DP/FR
NI	Impact number		
lvr	Root volume length	cm/cm3	
emr	Average distance between roots	cm	
te	Root exploration rate	%	

NB. The opening of the XML format in Microsoft Excel can not access the menu "insert sheets". In Microsoft Excel, you must access the "Tools" menu and then "Protection" and "Unprotect workbook".

Image

When the button "Create map export" is clicked, the lower part of this window offers 3 stages:

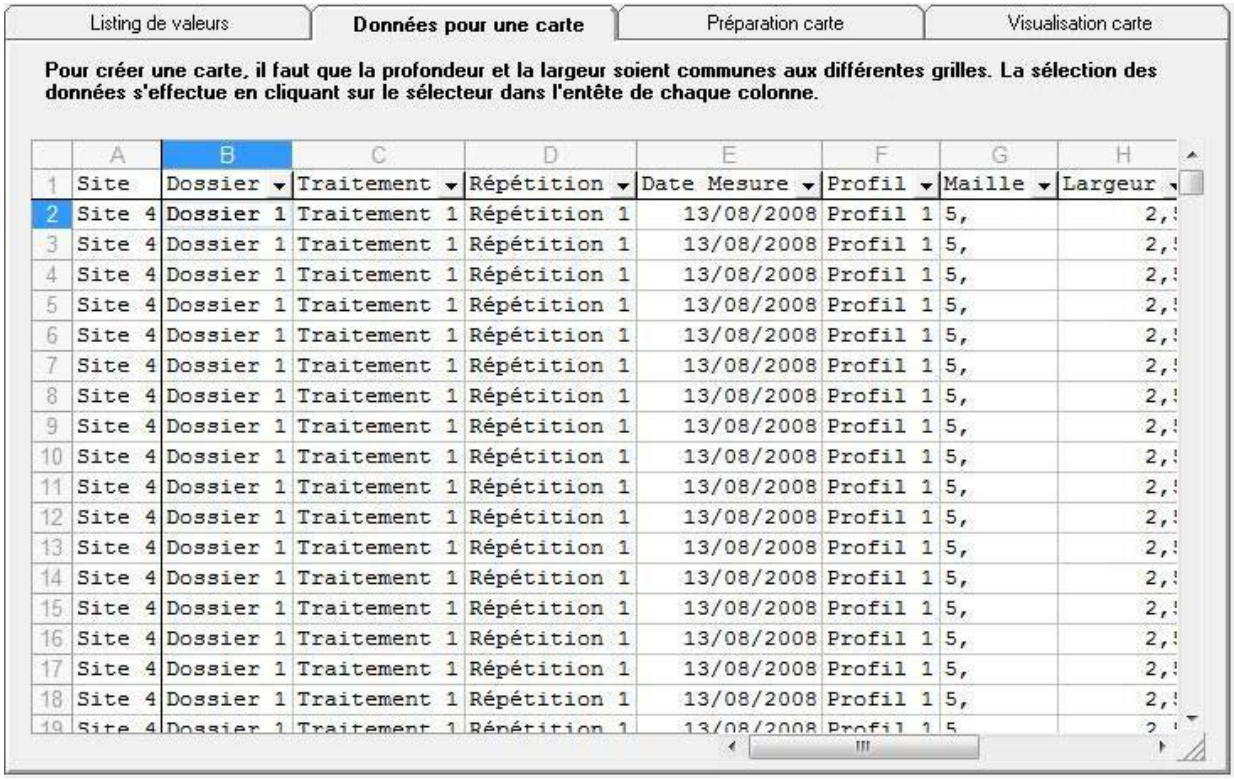
- Map data
- Map preparation
- Map viewing

The first stage, "Map Data", allows the user to refine his choices in order to map a plane. This plane can correspond to that of a single entry of impacts or to that of the average of the tree structure's different levels. This average is to be calculated in the "Formatting" tab, where the user synthesizes his

data.

To create a map, only the depths and horizontal distances can be variable. The other elements must be unique.

The user selects the data with the aid of cursors placed to the right of the column headings, deactivating the other elements.



	A	B	C	D	E	F	G	H
1	Site	Dossier	Traitement	Répétition	Date Mesure	Profil	Maille	Largeur
2	Site 4	Dossier 1	Traitement 1	Répétition 1	13/08/2008	Profil 1	5,	2,
3	Site 4	Dossier 1	Traitement 1	Répétition 1	13/08/2008	Profil 1	5,	2,
4	Site 4	Dossier 1	Traitement 1	Répétition 1	13/08/2008	Profil 1	5,	2,
5	Site 4	Dossier 1	Traitement 1	Répétition 1	13/08/2008	Profil 1	5,	2,
6	Site 4	Dossier 1	Traitement 1	Répétition 1	13/08/2008	Profil 1	5,	2,
7	Site 4	Dossier 1	Traitement 1	Répétition 1	13/08/2008	Profil 1	5,	2,
8	Site 4	Dossier 1	Traitement 1	Répétition 1	13/08/2008	Profil 1	5,	2,
9	Site 4	Dossier 1	Traitement 1	Répétition 1	13/08/2008	Profil 1	5,	2,
10	Site 4	Dossier 1	Traitement 1	Répétition 1	13/08/2008	Profil 1	5,	2,
11	Site 4	Dossier 1	Traitement 1	Répétition 1	13/08/2008	Profil 1	5,	2,
12	Site 4	Dossier 1	Traitement 1	Répétition 1	13/08/2008	Profil 1	5,	2,
13	Site 4	Dossier 1	Traitement 1	Répétition 1	13/08/2008	Profil 1	5,	2,
14	Site 4	Dossier 1	Traitement 1	Répétition 1	13/08/2008	Profil 1	5,	2,
15	Site 4	Dossier 1	Traitement 1	Répétition 1	13/08/2008	Profil 1	5,	2,
16	Site 4	Dossier 1	Traitement 1	Répétition 1	13/08/2008	Profil 1	5,	2,
17	Site 4	Dossier 1	Traitement 1	Répétition 1	13/08/2008	Profil 1	5,	2,
18	Site 4	Dossier 1	Traitement 1	Répétition 1	13/08/2008	Profil 1	5,	2,
19	Site 4	Dossier 1	Traitement 1	Répétition 1	13/08/2008	Profil 1	5	2,

Figure 6: Elements to develop a map root: stage 1

Next, in the "Map Preparation" stage, the user chooses:

- an output parameter, of which he can choose only one in the drop-down list.
- a distribution "method" per value class.
  - → Same number of records: each class contains approximately the same number of records. If the number of records is not perfectly divisible by the number of classes, RACINE 2 places the remaining records in the most appropriate classes.
  - → Same amplitude for each value class: the difference between the minimum and maximum values of each class is the same.
  - → Manual intervals: the user enters his lower and upper limits.

The "Calculate" button proposes the percentages and number of values per class. A tool tip on the percentage column shows the cumulative percentage of classes displayed.

- A color among the four proposed. These colors are not modifiable.
- A map title and several options for the caption.

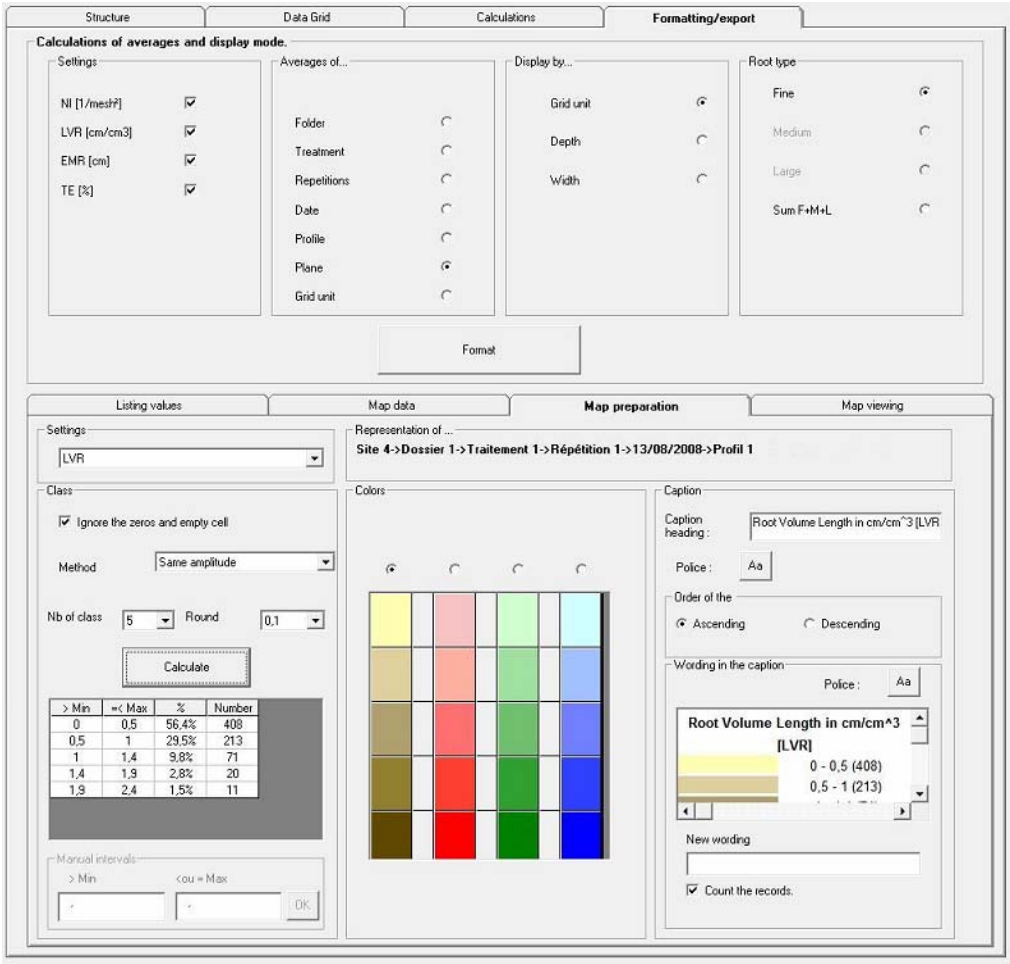


Figure 7: Elements to develop a map root: stage 2

Finally, the user goes to the last tab, "View Map", where he can view the image and caption.

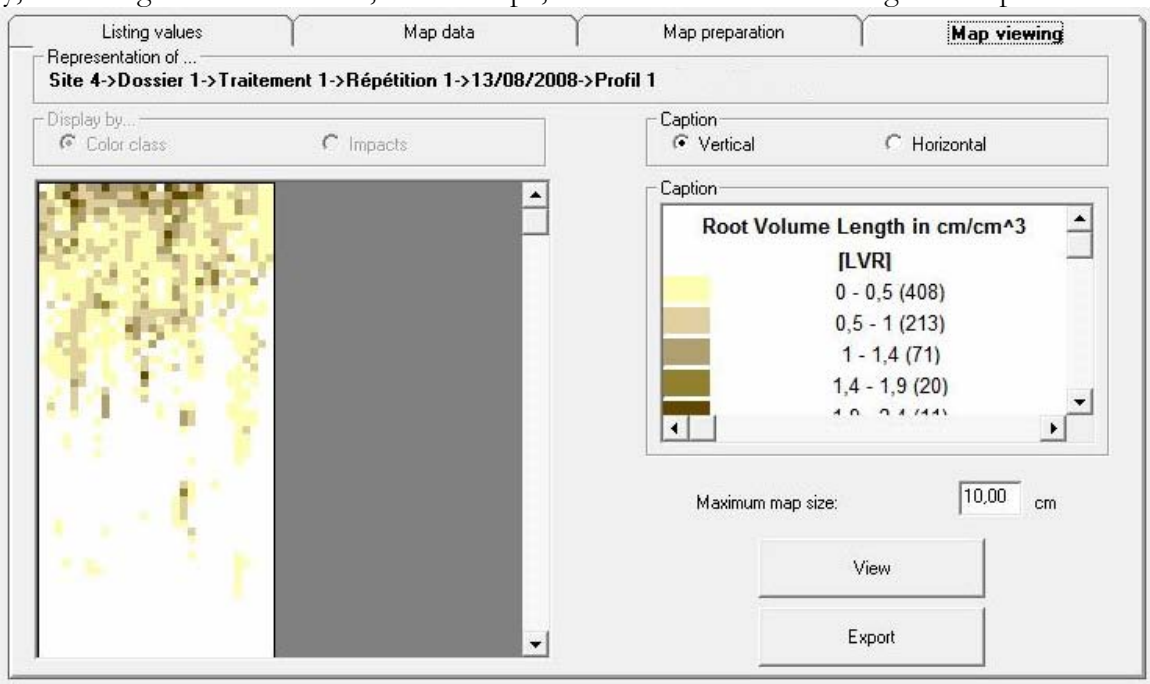


Figure 8: Elements to develop a map root: stage 3

"View" button refreshes the map window according to the user's choices (color class or impacts for the number of impacts) and the modifications made to the map dimensions.
The value entered gives the maximum height or width of the map according to the largest row or column size.
The maximum dimension of the caption corresponds to 80% of the maximum dimension of the map.

The "Export" button opens a dialog box in which the user specifies the file name and storage directory of both images (map and caption) in the ".bmp" format.

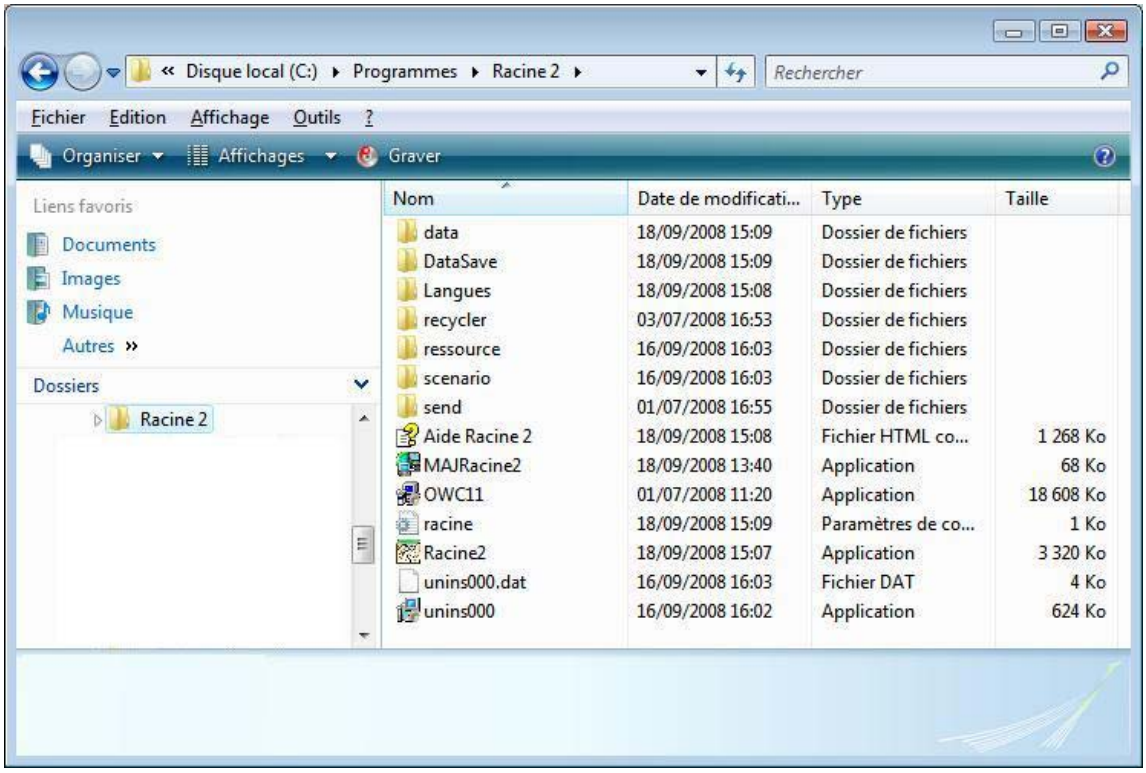
The images obtained can be used in a word processor.
The units of the mapped parameters can be specified in the caption heading or outside this viewing.

7. IT management

RACINE 2 makes an auto save every 5 minutes. For additional security, a "Save" command is available in the main menu, "File".

When the application is installed, 7 directories are created in the RACINE 2 folder:

- Data: this contains all the basic data (impacts).
- DataSave: this folder stores all the folders that are either ongoing or have been created in RACINE 2.
- Langues: this contains the translations of the application. The language is chosen by the application according to the system. It is possible to select another language via the home page when the application is started up.
- Recycler: this folder stores the elements that are pending processing (deletion).
- Ressource: this contains the sound file that is played when the Trash Bin is emptied, together with several icons.
- Scenario : this contains the equations and scenarios that are supplied by default or created by the user. These files, one per equation and one per scenario, bear the same name as in the "Equations and Scenarios" tab; they can be opened by a text editor.
- Send : this folder contains the history of sent elements.



When RACINE 2 is installed, two other software applications are installed at the same time:

- « MAJRacine2 » enables the automatic updating of the application via a server that is accessed via the Internet. When this application is started up, the installed version is compared to the server's version and is updated as required.

- « OWC11.exe » enables the installation and validation of Office Web Components. This is used by RACINE 2 to carry out calculations on root impacts. Its installation is optional if the user has an Office 2003 license, and is compulsory if he does not.

The application "unins000" uninstalls the application part of the RACINE 2 software on the computer. The files created by the user and stored in the tree structure must be deleted by the user after the application has been uninstalled. The application "unins000" deletes the files that were created when the software was installed, but does not delete those that were created as the software was used.

Apart from the contextual help to be found on-screen or on part of a screen, certain buttons offer specific help. The symbol can be seen when the mouse pointer is passed over these buttons.

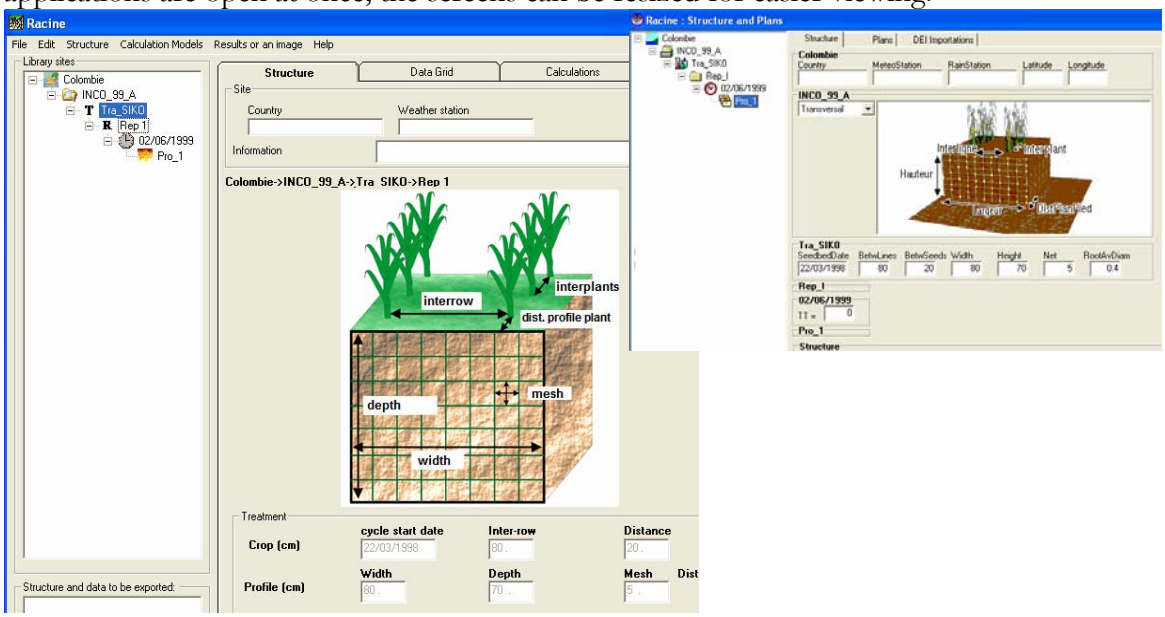
Annex 1 : Limits of the application.

Conceptual limits of RACINE 2	Practical limits	IT choices
The grid unit is a square. The measurements must be taken along a vertical plane perpendicular to the row for a row crop. In order to calculate the distance between the plant base and the grid unit position to be calculated, the user is limited to the distances on a plane, i.e. vertical distance and horizontal distance from the plant base.	Profile : width : 0< <=200 cm Depth : 0< <=1000 cm Grid unit : 1< <=50 cm Distance from plant base: 0< <=9999 cm Metric system and °C for thermal time The first grid unit is always the one located in the top left of the grid. RACINE 2 uses the RAM to store data while the application is running. If your machine does not have much RAM, it may be useful to keep only the sites containing data on which you are working and to export or delete the others. After calculations, the results are not stored in RACINE 2. Only the basic data is. Consequently the calculation results must be exported as soon as they are obtained.	RACINE 2 can only be run on Windows operating system. It is impossible to open two sessions of RACINE 2 simultaneously for reasons of security in saving data.

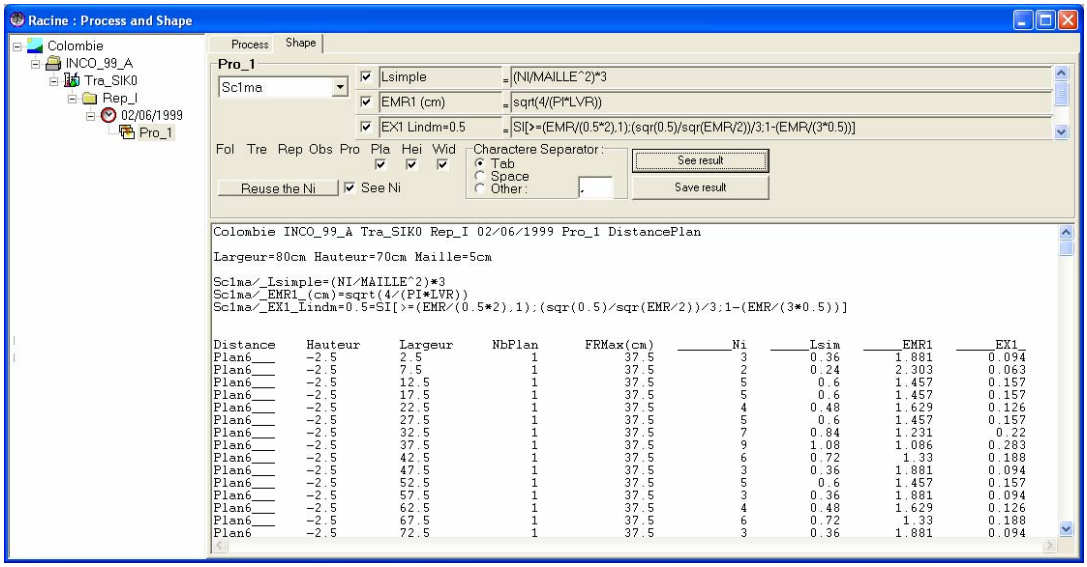
Annex2: From RACINE1 to RACINE2.

Method for transferring root impacts entered
in RACINE1 towards RACINE2.

1- It is necessary to start by recreating the structure existing in RACINE 1 in the new version. Both applications are open at once; the screens can be resized for easier viewing.



2- In RACINE 1, the "Calculations and Formatting" form must be opened.
After selecting the profile to be transferred, the calculations must be carried out and the results displayed, mainly the impacts.
The other impacts can be recalculated in RACINE 2.



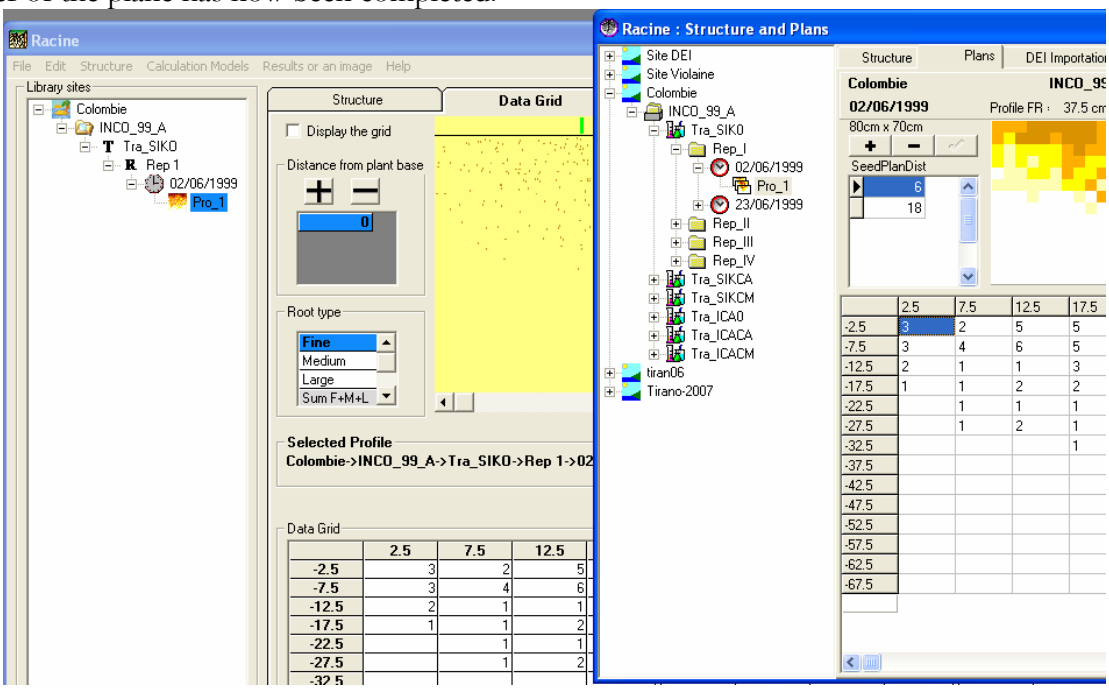
Next, the user saves the results in Text format.

3- In Excel, when the file is opened with the text import assistant, the Impact Numbers (NI) can be displayed in columns. In order to do this, activate the “Delimited” button in Stage 1, then “Tabulation” in Stage 2, and then finish.
Next, the “Height”, “Width” and “Impact Number” columns must be extracted.
The user makes a pivot table to create a table of the dataset.

	A	B	C
1	Hauteur	Largeur	Ni
2	-2.5	2.5	3
3	-2.5	7.5	2
4	-2.5	12.5	5
5	-2.5	17.5	5
6	-2.5	22.5	4
7	-2.5	27.5	5
8	-2.5	32.5	7
9	-2.5	37.5	9
10	-2.5	42.5	6
11	-2.5	47.5	3
12	-2.5	52.5	5
13	-2.5	57.5	3
14	-2.5	62.5	4
15	-2.5	67.5	6
16	-2.5	72.5	3
17	-2.5	77.5	4
18	-7.5	2.5	3
19	-7.5	7.5	4
20	-7.5	12.5	6
21	-7.5	17.5	5
22	-7.5	22.5	8
23	-7.5	27.5	7

Somme de Ni	Largeur															
Hauteur	2.5	7.5	12.5	17.5	22.5	27.5	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5	77.5
-2.5	3	2	5	5	4	5	7	9	6	3	5	3	4	6	3	4
-7.5	3	4	6	5	8	7	4	7	6	5	4	7	4	4	3	5
-12.5	2	1	1	3	4	4	4	8	4	4	4	5	5	4	6	4
-17.5	1	1	2	2	1	1	5	3	1	2	1	1	2	1	0	1
-22.5	0	1	1	1	4	1	3	3	3	6	3	0	1	1	0	0
-27.5	0	1	2	1	0	1	3	3	6	1	2	2	1	0	0	0
-32.5	0	0	0	1	0	0	0	1	0	10	1	2	0	0	0	0
-37.5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
-42.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-47.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-52.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-57.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-62.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-67.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

4- The final stage consists in copying the data from the Excel spreadsheet and pasting it into the plane in RACINE2.
Transfer of the plane has now been completed.



Bibliography

Chopart J.L., 1989. Scruter les racines à travers des grilles. Une méthode fort utile. Article dans "Info R3S" lettre du réseau CORAF R3S: n° 2, p 5.

Chopart J.L., 1996. Comparison of several methods of studying the maize deep root system under field conditions. Poster 5ème Symp. Int de la Soc. Int. de recherches sur les racines. Clemson Univ. Caroline du sud (USA). Conf. prog. and abstracts: 14-18 07 96. p.138.

Chopart J.L., 1999. Relations entre état physique du sol, systèmes racinaires et fonctionnement hydrique du peuplement végétal : outils d'analyse in situ et exemples d'études en milieu tropical à risque climatique élevé. Thèse Université Grenoble 1, soutenue le 25 oct. 1999. T.I 115 p., TII 335 p.

Chopart J.L., 2002. Comment évaluer in situ les racines des cultures ? Guide pratique de différentes méthodes d'études racinaires. In Mémento de l'agronome, 2002. Ouvrage 1 691 p. (cédérom principal), CIRAD, GRET, Ministères des Affaires étrangères, France.

Chopart J.L. 2004. Les systèmes racinaires des cultures tropicales : rôle, méthodes d'étude in situ, développement, fonctionnement. Doc. CIRAD Réunion, 7, ch. de l'Irat, St Pierre, La Réunion, 42 p.

Chopart J.L., 2004. RACINE. Logiciel de traitement de données racinaires à partir de comptages sur profils de sol. Notice d'utilisation. Note CIRAD Réunion, 7 ch. de l'Irat, St Pierre, La Réunion, août 2004, 15 p.

Chopart J.L.and Siband P., 1999. Development and validation of a model to describe root length density of maize from root counts on soil profiles. Plant and Soil 214: 61-74.

Chopart J.L., Siband P., Dingkuhn M., Roveda G., 2001. From single plane profiles to root length density in space. Validation of a model in the field. The 6th Symp. of the Int. Society of Root Research, Nagoya, Japon.» In : « Root Research, vol 10, extra issue 1, 2001 ISSN 0919-2182 », pp. 586-567.

Chopart J.L, Rodrigues S.R., Azevedo M, Medina C 2008. Estimating sugarcane root length density through root mapping and orientation modelling. Plant Soil, vol. 138,

Chopart JL., Sine B., Dao A., Muller B, 2008. Root orientation of four sorghum cultivars: application to estimate root length density from root counts in soil profiles. Plant Root 2 67-75.

Newman J. 1966. A method of estimating the total length of root in a sample. J. App. Ecol. : 3 139-145.

Van Noordwijk M., 1987. Methods for quantification of root distribution pattern and root dynamics in the field. *In* : "20th Colloq. Int. Potash Institute", Bern, Int. potash Inst. Publishers Berne. 247-265.