



CARROT

**Collecting and Analyzing Rhizodeposits:
Reviewing and Optimizing Tool**

Version: 2026-02-25

User manual - version R Shiny

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1 Aims & purpose

CARROT is a decision support tool aiming to guide a user towards the protocol of rhizodeposits collection and analysis best suited for his/her own objectives and constraints. The tool enables to move along a complex decision tree in order to identify options for successive protocol steps that are recommended, alternative or incompatible with the set of choices progressively selected by the user. *CARROT* does not intend to create a complete, operational protocol of rhizodeposit collection & analysis, but rather aims to orientate the user towards the best methods by giving him/her synthetic information.

This document provides practical information about the way to use this tool. A scientific article describing the origin and the associated principles of this tool is referred at the end of this document.

2 How to start *CARROT*

CARROT has been written as an R Shiny application, and can be either:

- i) launched online without any installation at the GitHub Page
<https://frees86.github.io/carrot/>
- ii) used as an R program by executing the file “app.R” in an R console, available on
<https://github.com/frees86/carrot>
→ Note that the file “app.R” needs to be located in the same folder as the folder ‘source’ containing the supporting tables. Alternatively, writing an explicit path to load the source files in the R script might be necessary.

3 How to use CARROT

After launching the program, the first step is to select one of the five groups of instructions from which to start:

1. Scientific questions & objectives
2. Growth conditions
3. Sampling method
4. Sample treatment
5. Sample analysis

Note: It is recommended to start by “Scientific questions & objectives” and to follow the logical order of these successive groups of instructions. However, the user can choose to go through these groups of instructions in any order, knowing that this order has consequences on the evaluation of the compatibility of successive options to one another.

The starting page of the CARROT software. At the top left is the logo featuring a magnifying glass over a root system. To its right, the text "CARROT" is written in a stylized font, followed by "Collecting and Analyzing Rhizodeposits: Reviewing and Optimizing Tool". Below this, the text "Version: 2026-02-24" is displayed. A message at the top says "You first need to define where to start building your protocol." Below this, a box contains the text "Please select a group of instructions:" followed by a list of five options, each with a radio button. The first option, "1: Scientific objectives", is selected. At the bottom of this box is a blue "START" button. To the right of this box is a larger panel titled "Supporting information" and "Updated protocol".

Fig. 1: Starting page of CARROT

The next step is to select one of the possible options corresponding to the first instruction. For this instruction and all subsequent ones, a Supporting Information table is displayed on the right panel and aims to provide relevant, synthetic information to support the decision. Additional information is also usually provided in the companion scientific article.

The decision-making screen for the first instruction, "SCIENTIFIC OBJECTIVES & QUESTIONS". At the top left is the logo and title. Below this, the text "Current group: SCIENTIFIC OBJECTIVES & QUESTIONS" is shown. A box on the left lists seven options for the main objective, with the first one, "1: To characterize the composition of (all or specific) rhizodeposit fractions", selected. At the bottom of this box are two buttons: "▶ Skip this" and "Confirm and go to the next instruction". To the right of this box is a table titled "Supporting information" and "Updated protocol". The table includes a note: "[For more information, please refer to the Section 2 in the companion article]". The table has three columns: "Option", "Main objective", and "Prestions & warnings". Four rows are listed, each corresponding to one of the seven options. The "Prestions & warnings" column contains bullet points for each row.

Option	Main objective	Prestions & warnings
1	Characterizing the composition of all exudates or rhizodeposits	<ul style="list-style-type: none"> • Does not require to be fully quantitative, but requires to collect all the compounds/materials from a given rhizodeposit fraction • Characterizing the composition of all rhizodeposits with one single protocol is virtually impossible
2	Identifying specific rhizodeposits	<ul style="list-style-type: none"> • Does not require to be fully quantitative • Targeted collection and analysis is easier to handle than non-targeted approaches
3	Quantifying rhizodeposition rates	<ul style="list-style-type: none"> • Requires to be fully quantitative and to avoid rhizodeposits' degradation • Hardly compatible with the full screening of all rhizodeposits
4	Characterizing the concentrations of rhizodeposits in the rhizosphere	<ul style="list-style-type: none"> • Does not require sterility • The composition of the rhizosphere is usually affected by microbial activity, and compounds analyzed in the rhizosphere may not correspond to genuine rhizodeposits

Fig. 2: A decision can be supported by a synthetic table summarizing information about the different options

Once a first option has been selected and the instruction for a new protocol step is considered, a compatibility test is activated, and automatically labels each option as “Recommended”, “Possible” or “Incompatible”, based on previous choices. The reason for which a given option is deemed incompatible can be further explored by ticking the box “*Show details about incompatible options*” displayed above the instruction.

Note: If all possible options of a given instruction are deemed incompatible with previous choices, the instruction will be skipped and the program will automatically display the next instruction without notice.

Note: Depending on your progression within a given group of instructions, you can click on “Go back” to move back to the previous instruction of the current group of instruction, or click on “Skip this” to move directly to the next instruction without deciding - this may be used in particular to avoid a step to influence the compatibility suggested for the options of the next instructions. The decision to skip instruction will appear in the final results (see below).

Option	Growth substrate	Supporting information	Updated protocol
1	Natural soil or artificial, reactive soil (ex: potting peat mixtures)	<ul style="list-style-type: none"> Closest to natural plant growth conditions; allows to grow plants for several months Cheap and easily scalable to many plants Possibility to apply stress, such as water stress The natural biotic interactions with native soil organisms can be accounted for 	<ul style="list-style-type: none"> Soil heterogeneity: less repeatable Soil properties are soil-dependent and hard to monitor over growth Soil adheres to roots, complicifying the collection on “clean” roots Sorption of rhizodeposits on soil particles and difficulty in differentiating rhizodeposits from microbial deposits Microbial degradation/mineralisation
2, 3	Artificial inert solid substrates (ex: sand, glass beads, perlite, vermiculite)	<ul style="list-style-type: none"> Easy control of growth conditions (sterility, nutrient solution, temperature, etc.) 	<ul style="list-style-type: none"> Artificial growth conditions Not suitable to all types of plants Possible issues with water

Fig. 3: When options have been deemed incompatible with previous choices, details can be obtained by checking the box “Show details about incompatible options”.

Once all possible instructions within one group of instructions have been covered, a new group of instructions can be selected, and the selection procedure can continue. Note that a group of instructions can be revisited later on. In such case, a warning is displayed to confirm the choice, and, when confirmed, the previous choices related to this group of instruction will be overwritten.

Fig. 4: Selecting an incompatible option remains possible, but raises a warning message.

At any moment within the protocol construction, the user can access and download the resulting protocol corresponding to the selected choices by moving to the tab “Updated protocol”. There the user can either:

- i) **download the protocol as a CSV file or an Excel file** summarizing the instruction and corresponding choice in each group, as well as detailing the compatibility test for each option,
- ii) **download a text file** summarizing the main steps of the protocol.

Once all possible options within each group of instructions, the user can leave or continue the program. Two options are available:

- i) **RE-START:** All previous answers will be erased and the program will reinitialize at the starting page.
- ii) **RESUME:** The user can reconsider one of the previously visited groups of instructions. If so, the answers corresponding to this group of instructions will be erased, but other previous answers will be kept and will influence the compatibility of options for the revisited group.

The screenshot shows the CARROT software interface. At the top left is the logo with a magnifying glass icon and the text "CARROT Collecting and Analyzing Rhizodeposits: Reviewing and Optimizing Tool Version: 2026-02-24". Below the logo is a "Congratulations!" message stating: "You have now covered all possible instructions. You can download the final protocol in .csv or in .txt. The first file corresponds to a table containing the instructions, and, for each one, the corresponding options along with their compatibility with previous choices, and the corresponding final choice. The second file corresponds to a synthetic, complete summarized text corresponding to your protocol. You can leave the program here, restart from the beginning, or continue your exploration by re-visiting a specific group of instructions." Below this message are two buttons: "RE-START" and "RESUME". On the right side of the screen is a table titled "Supporting information" under the "Updated protocol" tab. The table has columns for "Group", "Instruction", and "Choice". It contains three entries:

Group	Instruction	Choice
1 SCIENTIFIC OBJECTIVES & QUESTIONS	What is your main objective?	To characterize the composition of (all or specific) rhizodeposit fractions
2 SCIENTIFIC OBJECTIVES & QUESTIONS	What is the fraction of rhizodeposits you intend to collect?	All rhizodeposits without distinction
3 GROWTH CONDITIONS	What is the type of plant?	Annual plants

At the bottom of the table are two download buttons: "Download the updated protocol (.csv)" and "Download the updated protocol (.xlsx)".

Fig. 5: The results can be checked and downloaded at any time by reaching the tab “Updated protocol” on the right.

4 Troubleshooting

To report bugs, persisting issues or possible improvements, please contact Frédéric Rees (frederic.rees@inrae.fr).

5 Credits

This work originates from discussions held within the French network *RhizosPHARE* and the previous project *PHARE* (2021-2022) funded by INRAE.

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6 Reference

The decision support tool *CARROT* is associated to the following scientific article:

Frédéric Rees, Virginie Lauvergeat, Gabin Piton, Aude Tixier, Sylvain Chéreau, Sylvie Dinant, Barbara Pawlak, François Perreau, Emmanuelle Personeni, Jean-Bernard Povreau, Anouk Zancarini, Jean-Benoît Peltier, and Agnès Attard (2026). **Unlocking research on rhizodeposition: a step-by-step guide for producing, sampling and analyzing rhizodeposits.** Currently under reviewed by the *Peer Community In Plants*.