Microscopic analysis of root cellular architecture in different coffee species: a preliminary comparison of the main phenotypical traits in controlled conditions.

Paola Crisafulli[1] (paola.crisafulli@illy.com), Mélanie Bordeaux[3], Frédéric Georget[2], Eveline Lefort[2], Sophie Léran[2], Kerstin Neumann[4], Luciano Navarini[1]

[1] illycaffé, via Flavia 110, Trieste, Italy; [2] UMR DIADE, Université de Montpellier, CIRAD, Montpellier, IRD, France; [3] FONDATION NICAFRANCE, Managua, Nicaragua;

[4] Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), 06466 Seeland, Germany

Introduction

In the last years, due to the climate change, much attention has been paid to coffee plant resilience and to agronomic solutions related to different stress tolerance in the field. In this perspective, the recently activated EU-funded BOLERO project will develop phenotyping tools, apply them to evaluate coffee root system architecture traits and root plasticity. Few descriptions of coffee root have been reported so far, especially in non-commercial species. This preliminary study aims to describe the main phenotypical root traits in different coffee plants kept under controlled conditions to deepen the knowledge and to possibly reveal interspecific differences.

Fig.1 Young plants of *Coffea arabica*, *C. congensis*, *C. stenophylla*, *C. eugenioides*, *C. canephora* (*C. anthonyi* not shown)

Materials/Methods:

Lateral roots with radicles of 6 Coffea sp. young plants kept under greenhouse optimal conditions (*C. arabica* cv. Marsellesa, *C. anthonyi* OE1, *C. canephora* var. robusta, *C. eugenioides* OD61, *C. stenophylla* FB61, *C. congensis* CC73; UMR DIADE, Montpellier, fig.1) were sampled, put in ethanol 50% and immediately delivered to illycaffé (Trieste, Italy). Portion of roots were embedded in agarose blocks (3% in aqueous solution), cut by hand, then directly observed by an optical microscope (Leica Leitz DMRXE) or preserved in ethanol 50%.

Specific histochemical techniques were used to highlight starch grains (Lugol solution, Sigma) and suberin in cell walls (Sudan black B in ethanol 70%), fig.2. For the SEM preparations, root sections were frozen and observed at -10° C, using a coolstage (Deben). Phenotypic characteristic of plant samples were monitored during the root sampling (data not reported).

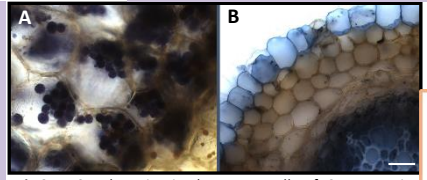
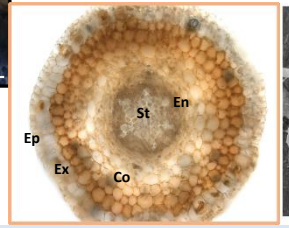
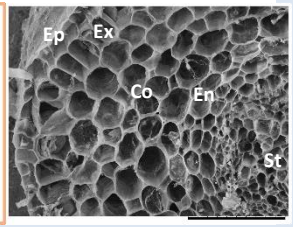


Fig.2 A: Starch grains in the cortex cells of *C. congensis* (Lugol test); B: Ex. of Sudan BB staining in coffee root, exodermis and endodermis in dark blue. Bars: 25 µm.

Fig.3 Anatomy of *C. arabica* root in transversal section, St: stele (hexarch); En: endodermis (+ pericycle); Co: cortex; Ex: exodermis; Ep: epidermis. A: Root diameter, 0,56 mm; B: bar 100 µm





Coffea sp	*anthonyi*	*arabica*	*canephora*	*congensis*	*eugenioides*	*stenophylla*
exodermis cell lenght	21,6	34,7	34,4	34,7	42,0	19,8
cortex cell diameter	21,1	27,2	25,4	28,8	36,0	23,0
xylem archs	pentarch	hexarch	tetrarch	tetrarch	tetrarch	tetrarch
metaxylem diameter	5,0	21,2	7,7	10,0	10,0	7,7
starch grains size	1,0	1,0	2,5	6,5	1,9	1,4
cortex cell layers nr	5	4	4	5	4	5

Tab.1 Preliminary measures of the main phenotypical traits (µm, average of 10 cells)

However, special cells traits characterized each species: peculiar 'window' cells are observed in *C. canephora* and *C. arabica* root exodermis, highly suberized (fig.4). Measures of cell types for all the species investigated were reported in tab.1. *C. arabica* xylem vessel are the greatest (21 µm) compared to the other species. *C. eugenioides* is characterized by large exodermis cells (42 µm) and cortical cells whereas *C. stenophylla* presents quite opposite characteristics. *C. congensis* is particularly rich in epidermal hairs and starch grains in the cortex cells.

Results

The root primary cell architecture is quite the same for all the investigated species (fig.3) and it is composed by a raw of epidermal cells, sometimes with hairs in different size, an exodermis characterized by the presence of suberin, 4-5 layers of cortical cells without air spaces (any species developed an aerenchyma), a suberized endodermis not always well visible, that separate the cortex from the stele, a pericycle that surround the stele and a central stele, characterized by different number of xylem archs. No pit presence in the middle region was observed.

Conclusion/Perspectives

Coffee roots of the species investigated in controlled conditions are characterized by the same tissue composition in primary structure (epidermis, exodermis, cortex, endodermis + pericycle and central stele), with slight difference in cell size, especially in the exodermis and in the cortex. The above-mentioned phenotypical traits could be differently affected under stress conditions. In facts, the 'window' cells presence in the exodermis (ex. fig.4) increases the transport of nutrients and the suberin presence together with large cortical cells are associated to tolerance to drought. In view of these preliminary results, it will be interesting in the next studies to discover the strategies adopted by various coffee spp. root cells in response to abiotic or biotic stresses.

Fig.4 A window cell not suberified (yellow arrow) in the root exodermis of *C. arabica* (Sudan BB stain)

References:

Ferreira de Andrade 2022 Photosynthetic efficiency and root plasticity promote drought tolerance in coffee genotypes. Acta Physiologiae Plantarum 44: 109.

Kawa and Bradi 2022 Root cell types as an interface for biotic interactions. Trends in Plant Science 27: 1173-1186.

Karlova et al. 2021 Root plasticity under abiotic stress. Plant Physiology 187: 1057-1070.

Funded by the European Union under the Grant Agreement N°101060693 (BOLERO Project). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.