Three Dimensional Spatial Characterization of Coffee Plant Root System

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Introduction

During growth and development of roots into the soil matrix, plant genetic characteristics and soil environment govern the way roots penetrate and exploit the soil around them. Genetic characteristics will determine root branching and growth patterns (Waisel et al., 2002). Soil environment will affect not only the way roots grow, but also other related processes such as water absorption, nutrient transport and biological activities in the vicinity of root system (Bengough, 2003 ; Paglis,1999 ; Passioura, 1983; Shenk, 2005).

Uneven distribution of root growth may vary in such way that roots may be found clustered in the soil. Root clustering is caused not only by the soil environment, but also by plant characteristics, i.e., root geometry and branching (Tardieu and Manichon, 1987). In addition, competition and chemical interaction among roots will also affect the way roots colonize the soil. Also, roots can be found clustered in the soil due to different other reasons, such as: bio-pores, soil cracks, around peds and planes of weakness in the soil (Dardanelli et al., 1997, 2003).

So, the proper comprehension of how roots are distributed in the soil might help to avoid misleads in agricultural practices.

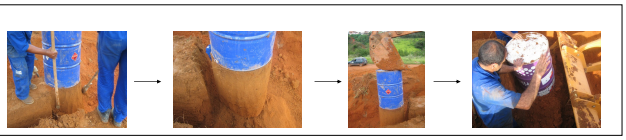
Knowing the economical importance of coffee crop as a source of income in several countries, and Brazil is not an exception, the aim of this research was to characterize the spatial distribution of coffee plant root system in order to maximize agricultural practices.

For this characterization, geostatistical analyses were performed, and rendered images of the volume occupied by roots were obtained by using Voxler software.

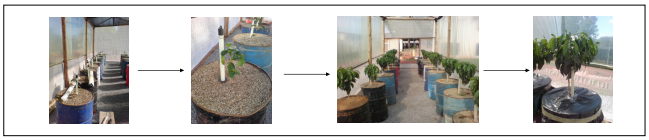
Material and Methods

1 - Soil core preparation

Three undisturbed soil cores were collected and cultivated with 18 months old coffee plants during 18 months. The soil was classified as Red-Yellow Latosol.



2 - Coffee plants at greenhouse



Inter-specific hybrid between *Coffea arabica* and *C.racemosa, named as Siriema cultivar*

3 - Root sampling

Forty four soil samples were taken in a grid pattern at depths of 10, 30, 50 and 70 cm for each soil core.

Soil sampler

Grid pattern used

These soil samples were washed and sieved in order to separate the roots, which were analyzed by using the STD 1600 WhinRhizo system.

4 - Washed roots ⟶ 5 - Image analysis ⟶ 6 – Root Length maps

Results

10 cm	min	39,40
	max	644,37
	mean	312,47
	Standard deviation	162,88
	CV (%)	52,13
30 cm	min	74,41
	max	835,80
	mean	415,30
	Standard deviation	224,98
	CV (%)	54,17
50 cm	min	45,00
	max	292,77
	mean	113,55
	Standard deviation	52,44
	CV (%)	46,18
70 cm	min	35,98
	max	139,33
	mean	65,62
	Standard deviation	26,17
	CV (%)	39,88

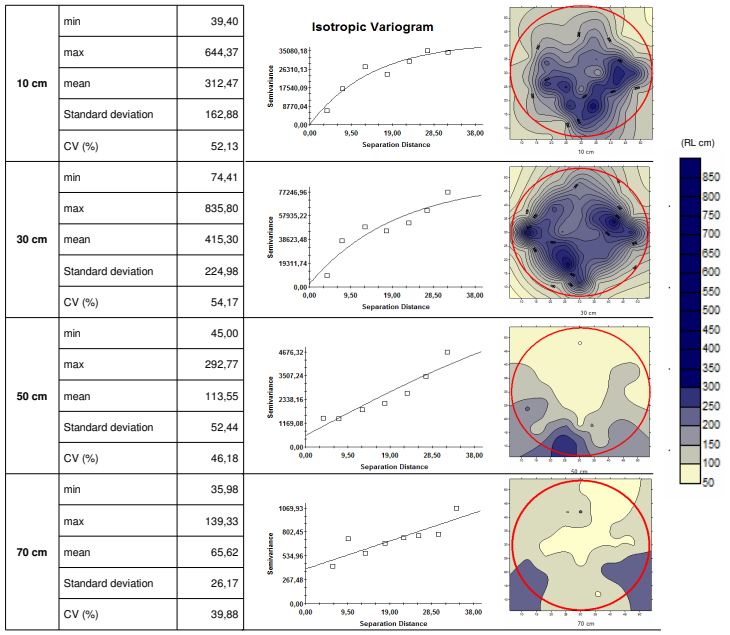


Fig.1. Descriptive statistics, semi-variograms and contour maps for root length (cm) at four soil depths.

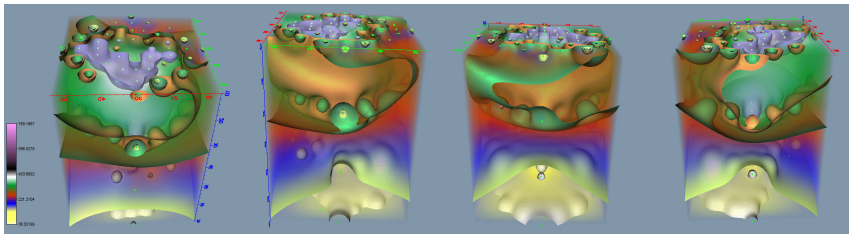


Fig.2. Volume render and isosurface images for root length (cm) distribution at four soil depths. The green dots show the sampling position.

Comments

These plants did not have any water restriction during the growth period. The statistical and geostatistical analyses performed show a spatial distribution of roots for each soil layer. The preliminary studies are an attempt to visualize the root system 3D images through volume rendering and isosurfaces. The obtained images confirm the results observed in previous analyses, showing a higher root concentration at the first 30 cm depth. These 3D images confirm a spatial distribution and show the soil volume occupied by roots. More analyses are being done in order to try a correlation among roots, soil clay content and available soil water for all soil depths. It is expected, with these new analyses to explain the behavior of the root distribution.

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