Estimations of fine root biomass in eucalyptus plantations. A comparison of 4 sampling methods.

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U.R. 2P.I.

CIRAD – Centre de coopération international en recherche agronomique pour le développement

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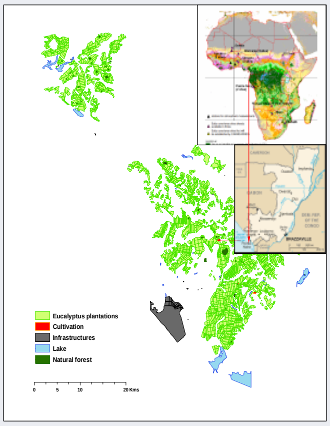
Objective: *To determine the most efficient method to evaluate fine root biomass in forest ecosystems*

1- Study site



Forest area :

- 42000 ha planted in savanna
- Kondi, Pointe noire, Rep. of Congo.

Stand sampled:

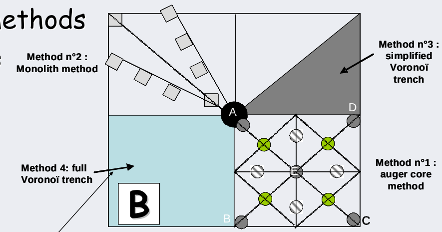
- 6 year old stand,
- Clone 18-52 (*Eucalyptus Urophylla x Grandis*)
- Density 800 trees/ha (3,75m x 3,33 m)

Figure 1: situation of study site, Kondi, Rep. Of Congo

2- Roots observation methods

Four excavating root biomass methods:

- auger sampling method;
- monolith sampling method;
- simplified Voronoï trench;
- full Voronoï trench.



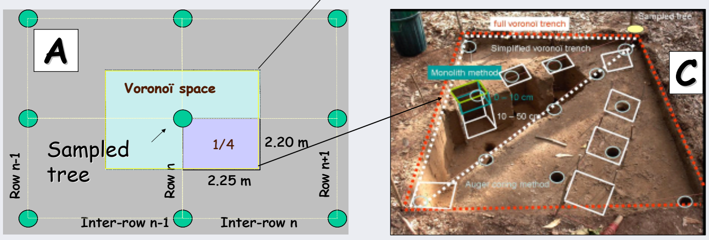


Figure 2: A- the space around the sampled tree is delimited using a Voronoï diagram, B- design pattern around each sampled tree, C- superposition of the four methods on one quart of Voronoï.

3- Statistical analysis and accuracy estimate

***Precision and accuracy:**

Use confidence interval at 95% (IC95) assuming a Gaussian distribution ($IC95 = 1.98\,\sigma/\sqrt{n}$, where σ is the standard deviation and *n*, the number of samples).

N10% : number of samples to be collected → 10% precision for fine root biomass estimations (Chave et al. 2003).

***Labour time:**

Sampling and sieving times are reported for each method and transformed in man/day (on a basis of 6 hours of field work /day).

***Comparison and variance analysis:**

Differences between methods are tested with an analysis of variance (proc GLM SAS) associated with Bonferroni's test for means comparisons.

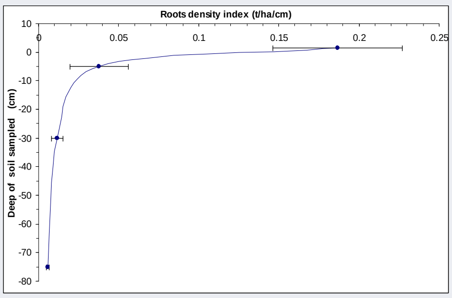
4- Results : fine root biomass stocks and roots density distribution

Method	Horizon	
Auger core	H0 (root mat)	0.56
25x25 cm Monolith core	H1	0.49
Auger core	H1	0.42
Voronoï trench	H1	0.40
Mean	H1	0.38
25x25 cm Monolith core	H2	0.38
Auger core	H2	0.52
Voronoï trench	H2	0.50
Mean	H2	0.47
25x25 cm Monolith core	H3	0.33
Auger core	H3	0.33
Voronoï trench	H3	0.29
Mean	H3	0.29
25x25 cm Monolith core	Total (H1, H2, H3)	1.20
Auger core	Total (H1, H2, H3)	1.27
Voronoï trench	Total (H1, H2, H3)	1.19
Mean	Total (H1, H2, H3)	1.14

Mean total fine root biomass up to 1m soil depth was 1.70 Mg.ha-1 with large differences among soil depths (table 1).

There was no significant difference between the four methods for fine root biomass estimation.

Table 1: Fine root biomass as a function of soil depth (H0: pure organic soil layer at surface layer (0-3cm thick); H1: 0-10, H2: 10-50 and H3: 50-100 cm).



Fine roots were concentred in root mat and in the first 10 cm of soil (figure 3).

→Result consistent with previous studies demonstrating on an other clone planted in Congo that the surface soil (0-25cm) was highly prospected by fine roots (Bouillet *et al* 2002).

Figure 3: Root density index by horizon (root biomass divided by the thickness of the soil horizon). Standard deviation is given for each horizon (horizontal bar)

5- Time labour versus accuracy

Auger cores:

312 auger cores (N10%, table 2) are required to achieve 10% accuracy on the mean fine root biomass for H1 (0-10 cm)→24 trees, and 13 auger core samples/tree.

→These figures fall down to about 150 auger cores for the 10-50 cm and 50-100 cm layers.

About 6 men/day are required to sample and sieve soil auger cores (table 2).

Monolith methods:

Reduce of total number of samples by 100% for H1 (compared to auger cores) but total time required for sieving operations increases by 30%.

Other methods

Time consuming is higher to obtain the same accuracy for simplified Voronoï trench (19 men/day) and for full Voronoï trench (79 men/day).

(a) Auger Cores

Horizon	Fine roots data	Total (t/ha)	Nb samples	IC95	IC95 %Means	Means/10	N10%	Time man/day
H1	Means	0.42	103	0.07	17%	0.042	312	3
	Standard Dev.	0.37						
H2	Means	0.55	100	0.06	12%	0.055	134	2
	Standard Dev.	0.32						
H3	Means	0.35	99	0.04	12%	0.035	150	1
	Standard deviation	0.21						
	Total	1.31					Total	6

(b) Monolith method

Horizon	Fine roots data	Total (t/ha)	Nb samples	IC95	IC95 %Means	Means/10	N10%	Time man/day
H1	Means	0.43	64	0.06	14%	0.043	127	3
	Standard Dev.	0.25						
H2	Means	0.45	64	0.06	14%	0.045	125	3
	Standard deviation	0.25						
H3	Means	0.32	61	0.05	14%	0.032	125	2
	Standard deviation	0.18						
	Total	1.20					Total	8

(c) simplified Voronoï trench

Horizon	Fine roots data	Total (t/ha)	Nb samples	IC95	IC95 %Means	Means/10	N10%	Time man/day
H1	Means	0.40	16	0.10	26%	0.040	106	11
	Standard Dev.	0.21						
H2	Means	0.50	16	0.09	18%	0.050	54	7
	Standard Dev.	0.19						
H3	Means	0.29	16	0.03	11%	0.029	20	1
	Standard Dev.	0.06						
	Total	1.19					Total	19

(d) full Voronoï trench

Horizon	Fine roots data	Total (t/ha)	Nb samples	IC95	IC95 %Means	Means/10	N10%	Time man/day
H1	Means	0.40	8	0.14	36%	0.040	103	42
	Standard Dev.	0.20						
H2	Means	0.50	8	0.13	25%	0.050	50	26
	Standard Dev.	0.18						
H3	Means	0.29	8	0.05	16%	0.029	20	6
	Standard Dev.	0.06						
	Total	1.19					Total	74

Table 2: Accuracy and labour time for different method, N10% represent number of samples to achieve 10% precision

6- Conclusion in the case study of Eucalyptus plantations in Congo

→ fine root biomass was highly variable, with a marked tree effect on superficial horizon (0-50cm) and a "distance to the tree" effect on deeper horizon (50-100 cm).

→ no significant differences between the 4 methods to estimate the total fine root biomass.

→**best sampling design**:

- from a stand inventory, 6 basal area classes and 4 trees/class should be selected (for example by tree height sorting within each basal area class),
- then 13 auger core samples by tree should be collected in order to get a precision of 10% on the total fine root biomass.

7- Conclusion within the framework of CDM

→Methodology to find the optimum sampling design for fine roots biomass assessment in tree plantations in order to find the best choice in terms of sample size and labour time.

→based on an elementary space (Voronoï diagram) which can be implemented in every forest ecosystem.

Eucalyptus Fibre Congo

République du Congo

Bibliography

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Chave *et al.* 2003, Spatial and temporal variation of biomass in a tropical forest: results from a large census plot in Panama. Journal of Ecology, 91: 240–252, 2003.