# HERITABILITY OF ROOT TRAITS OF DWARF PLANTAIN HYBRIDS

*L. SADOM MBOULA[1,2], K. TOMEKPE[3], X. DRAYE[1]*

[1] *Earth and Life Institute, Université catholique de Louvain, Croix du Sud L7.05.11, 1348 Louvain-la-Neuve, Belgium*

[2] *Centre Africain de Recherche sur Bananiers et Plantains (CARBAP), PO Box 832, Douala, Cameroon*

[3] *Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), Station de Neufchâteau, Sainte-Marie, 97 130 Capesterre-Belle-Eau Guadeloupe (French West Indies)*

Centre Africain de Recherches sur Bananiers et Plantains

## CONTEXT

Plantain is a major staple food in West and Central Africa where its production is estimated at approximately 8 million tons.yr-1 (Tomekpe et *al.*, 2011). Lodging and drought are major constraints to the productivity of almost all plantain cultivars and their improved hybrids and is exacerbated by their superficial root systems (Draye et *al.*, 2003, Turner et *al.*, 2007).

## OBJECTIVES

This study aims to develop a simple rhizotron system to estimate the main root architectural parameters and to exploit available genetic material to estimate the heritability of root traits and the potential for further improvement of plantains.

## MATERIALS AND METHODS

### Genetic material

A population deriving from dwarf euploid tetraploid hybrids (AAAB) (CRBP 753 and CRBP 776) crossed with improved diploid *acuminata* (DS 11, DS 26, DP 192 and M 53) was used in the experiments.

### Experimental system

The experimentation took place at Njombe (Cameroon) in a shaded area from 04 October to 06 December 2011. Experimental plants according to the "Plants Issus des Fragments de tige" technique (Kwa, 2003) cleared of all roots and transplanted into transparent perforated pots (cylindric rhizotrons) allowing the observation of roots growing at the pot surface.

### Shoot and Root measurements

Several measures were obtained on the shoot of each plant at days: 0, 36, 62 and most observations performed on the roots (at harvest plants) are reported in **table 1**. Impacts of roots on the pot surface were marked and angle (αi, °) was calculated (**Figure 1**). ImageJ software was used to estimate the length and branch position of individual laterals. Shoot and root dry matter were determined after drying at 105°C during 24 hours.

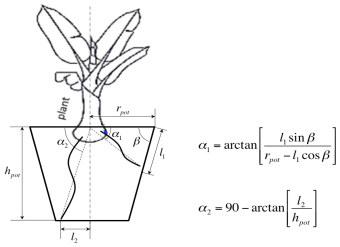


**Figure 1. Method used to compute growing angles for root impacts on the side (1) and bottom (2) of the pot. Symbols as follows: hpot (height of pot), l1 (distance root impact – top of the pot), rpot (top radius of pot), l2 (distance root impact – pot axis), α1 (root angle to the horizontal).**

### Formulas for estimating the heritabilities

variance parameters *σr2* and *σl2* were estimated with PROC MIXED (SAS) and used to compute the broad sense heritability $H^2 = \frac{\sigma_l^2}{\sigma_l^2 + (\sigma_r^2/n)}$ where *n* is the number of replicates per line. Narrow-sense heritabilities were computed using the general combining abilities assuming a diallel cross, as $h^2 = \sigma_f^2 / (\sigma_f^2 + \frac{\sigma_{gca}^2}{14.5} + \frac{\sigma_{sca}^2}{59})$ .

## RESULTS

### Genotypic variability and heritability

- A wide range of variation was observed between lines for all traits **(Table 1).** This could be partly explained by the existence of initial variation for leaf area, while initial root system differences were largely reduced by the transplanting.
- We observed highly significant differences for the leaf area increase and for the number of root axes. This could be linked to the structural relation between the production of leaves and roots.
- Broad-sense heritabilities ($H^2$) were above 40% for all traits which showed significant differences between lines. Narrow-sense heritabilities ($h^2$) were null for most shoot traits (that were the most variable) and higher for all root traits.
- Weak correlations were found between the initial leaf area and most traits **(Figure 2)**, Which showed a tendency for lines with larger initial leaf area to produce more and larger roots, longer lateral roots and a larger final leaf area. Surprisingly, the root growth rate was negatively related to the initial leaf area, suggesting that assimilates are allocated in priority to the production of new leaves and roots.

**Table 1. Range of genotypic variation, significance of the line factor and estimates of broad-sense and narrow-sense heritabilities for the most important trait(some traits are not reported). Note that broad- and narrow-sense heritabilities were estimated on different population samples.**

| | Trait | Range | Pr < F | $H^2$ | ~$h^2$ |
|---|---|---|---|---|---|
| Shoot trait | Shoot dry mass [g] | 6.8 - 23.9 | 0.0099 | 0.48 | < 0.51 |
| | Initial leaf area [cm²] | 25 - 900 | 0.06 | 0.37 | 0.00 |
| | Final leaf area [cm²] | 50 - 2400 | 0.03 | 0.40 | 0.00 |
| | Largest leaf area [cm²] | 200 – 800 | 0.13 | 0.10 | 0.00 |
| | Leaf area increase | 1.4 - 47.2 | < 0.0001 | 0.76 | 0.00 |
| | Final nb of leaves | 3.0 - 7.3 | < 0.0001 | 0.68 | 0.00 |
| Root trait | Root dry mass [g] | 0.9 - 4.5 | 0.07 | 0.30 | < 0.46 |
| | Number of root axes | 41489 | 0.0004 | 0.61 | < 0.25 |
| | Root axis diameter [cm] | 0.13 - 0.44 | 0.02 | 0.46 | < 0.86 |
| | Root axis growth [cm/day] | 0.5 - 3.2 | 0.08 | 0.31 | < 0.70 |
| | Root axis angle [°] | 21.5 - 49.7 | 0.021 | 0.43 | < 0.85 |
| | Lateral root length [cm] | 2.4 - 7.0 | 0.05 | 0.33 | < 0.08 |

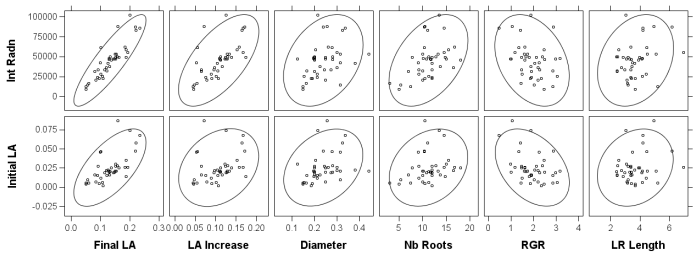


**Figure 2. Illustration of the dependency of key traits (line means) on their intercepted radiation and initial plant size (here, leaf area).**

## CONCLUSIONS

The experiment suggests that root traits should be amenable to selection. This study therefore highlights the importance of adjusting initial plant size for this type of design and traits, although the impact of the confounding effect depends on the measured variable.

## ACKNOWLEDGEMENTS

This study was supported by the PIC-Cameroun project (Coopération Universitaire au Développement, Communauté Française de Belgique) and by a PhD fellowship from the Université Catholique de Louvain to LSM.

## REFERENCES

Draye X. Lecompte F. and Pagès L. (2003). Distribution of banana roots in time and space. New tools for an old science. Banana Root System: towards a better understanding for its productive management. *in: Proceedings of an international symposium* held in San José, Costa Rica

Kwa M. (2003). 'Activation de bourgeons latents et utilisation de fragments de tige du bananier pour la propagation en masse de plants en conditions horticoles in vivo', *Fruits* 58, 315-328.

Tomekpe K., Kwa M., Dzomeku B. M. & Ganry J. (2011). CARBAP and innovation on the plantain banana in Western and Central Africa. *International Journal of Agricultural Sustainability*, 9(1), 264–273. doi:10.3763/ijas.2010.0565.

Turner D. W., Fortescue J. A. & Thomas, D. S. (2007). Environmental physiology of the bananas (*Musa spp.*). *Brazilian Journal of Plant Physiology*. doi:10.1590/S1677-04202007000400013.