Dynamic high throughput analysis of root growth in a diversity panel of maize

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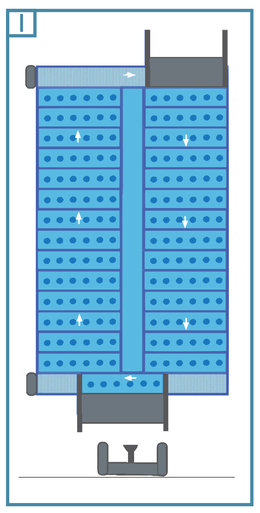
Introduction

Aeroponics has proven to be an efficient and cost-effective way to phenotype non-invasively dynamic root traits (e.g. elongation rates, emergence dynamics) in addition to static characteristics on a large number of plants with a high temporal resolution [De Dorlodot *et al*, 2005]. Image analysis tools allow for a large amount of data but often require a considerable amount of input from the user, rendering the process very time-consuming and thus contributing to the so-called "phenotyping bottleneck" [Zhu *et al*, 2011].

Method

A panel of 100 maize genotypes was grown for nearly three weeks in our aeroponic platform (fig.1). Plants were automatically moved through the box and root systems were imaged every two hours using a 4 MP IR camera. Dynamic root traits were assessed semi-automatically for individual roots using a in-house software tool.

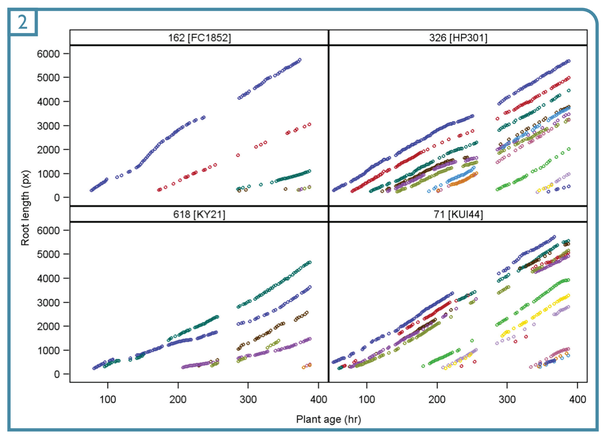
1



Results

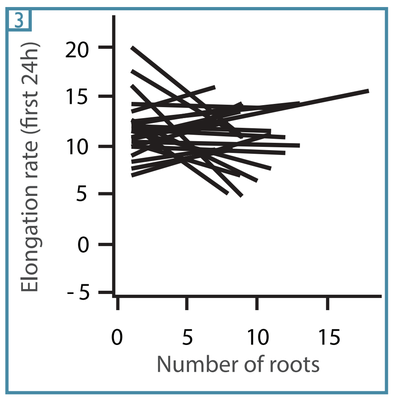
Elongation rates (ER) of individual roots were remarkably constant through the whole experiment (r^2 > 0,9). Intra-plant differences in root emergence dynamics and ER depended on the genotype but not on the root type (fig 2, four genotypes, one color for each root).

2



Source-sink relationships were assessed by comparing the ER of each root during the first 24 hours following their emergence compared to the number of previously emerged roots. The resulting linear regressions by genotype showed important variability (fig 3).
High broad-sense heritability was found for ER (86%) and the intercept of those linear regressions (70%).

3



The seed weight had a small effect on early leaf development and in late roots ER.

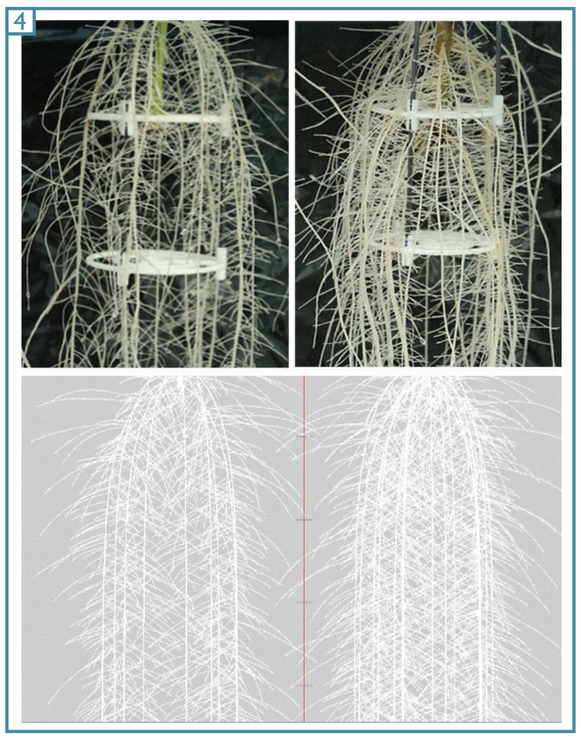
Perspectives

The stability of roots ER opens possibilities for fully-automated image analysis for dynamic root traits. For this purpose, a new aeroponics platform is being finalized with several improvement. A root holding structure has been added to maintain initial root angles (fig 4), and the images will be taken with a linear camera allowing a spatial resolution of 720 dpi. The separation in two boxes allows for differential treatments, for a total of 900 plants.

The reliability of the automatic motion has been improved to insure full time-lapse imaging during three-weeks experiments.

The overall improved stability of the platform will allow the use of FSPM-assisted automated image analysis (illustrated in fig 4 with Root Typ [Pagès *et al*, 2004]) and will drastically reduce the time and input needed between seed sowing and final data analysis.

4



Conclusions

Elongation rates of maize roots showed to be independant of the root type but dependant on the genotype and steady over time, with a high heritability.

The variations in source-sink relationships during the development of the root system was found to be highly genotype-dependant according to our indicators.

With an increased reliability, better root support and higher image quality, our next aeroponic phenotyping platform will allow us to develop a fully automated, model-assisted analysis pipeline.

References

De Dorlodot *et al*, 2005. Aspects of Applied Biology 73, 41-54.

Pagès *et al*, 2004. Plant and Soil 258, 103-119.

Zhu et al, 2011. Current Opinion in Plant Biology 14, 310-317.

Watch the platform in action !

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