

NEW PIPELINE ENABLING HIGH-THROUGHPUT PHENOTYPING OF DYNAMIC ROOT TRAITS IN BREAD AND DURUM WHEAT

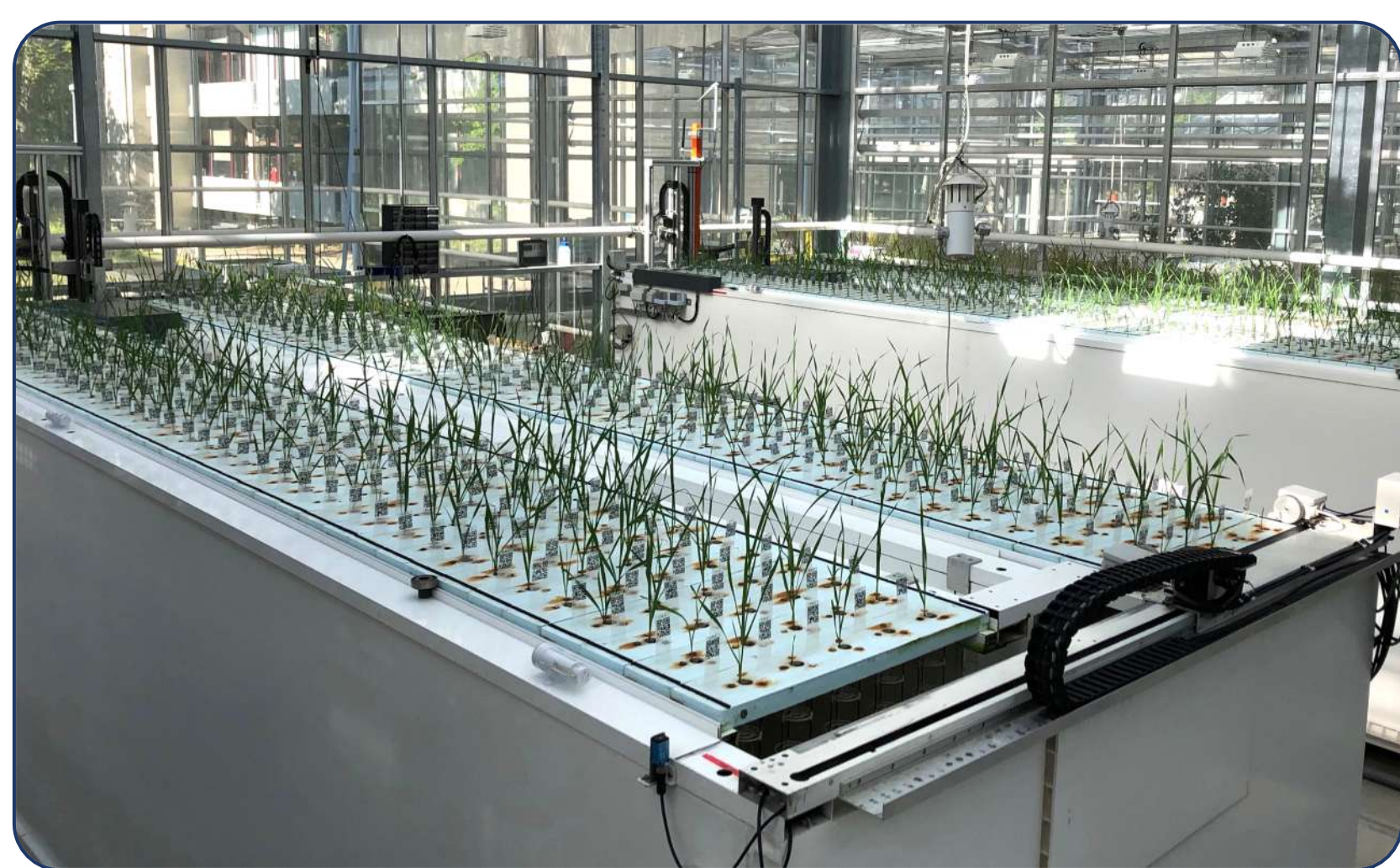
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Introduction

Over the last years, high throughput phenotyping has become increasingly popular in plant biology and breeding. But, root phenotyping has been progressing at a slower pace, mainly due to observation constraints, but also because root scientists are still not unanimous on how to represent root system morphology.

Our group has developed a root phenotyping installation that allows us to evaluate root morphology at high spatial and temporal resolutions. The platform has required throughput for modern genetic quantitative experiments, it captures images that simplified segmentation and with the very high spatial and temporal resolution, it can yield quantitative root information in many different formalisms (model parameters, tracing, densities, shapes...)



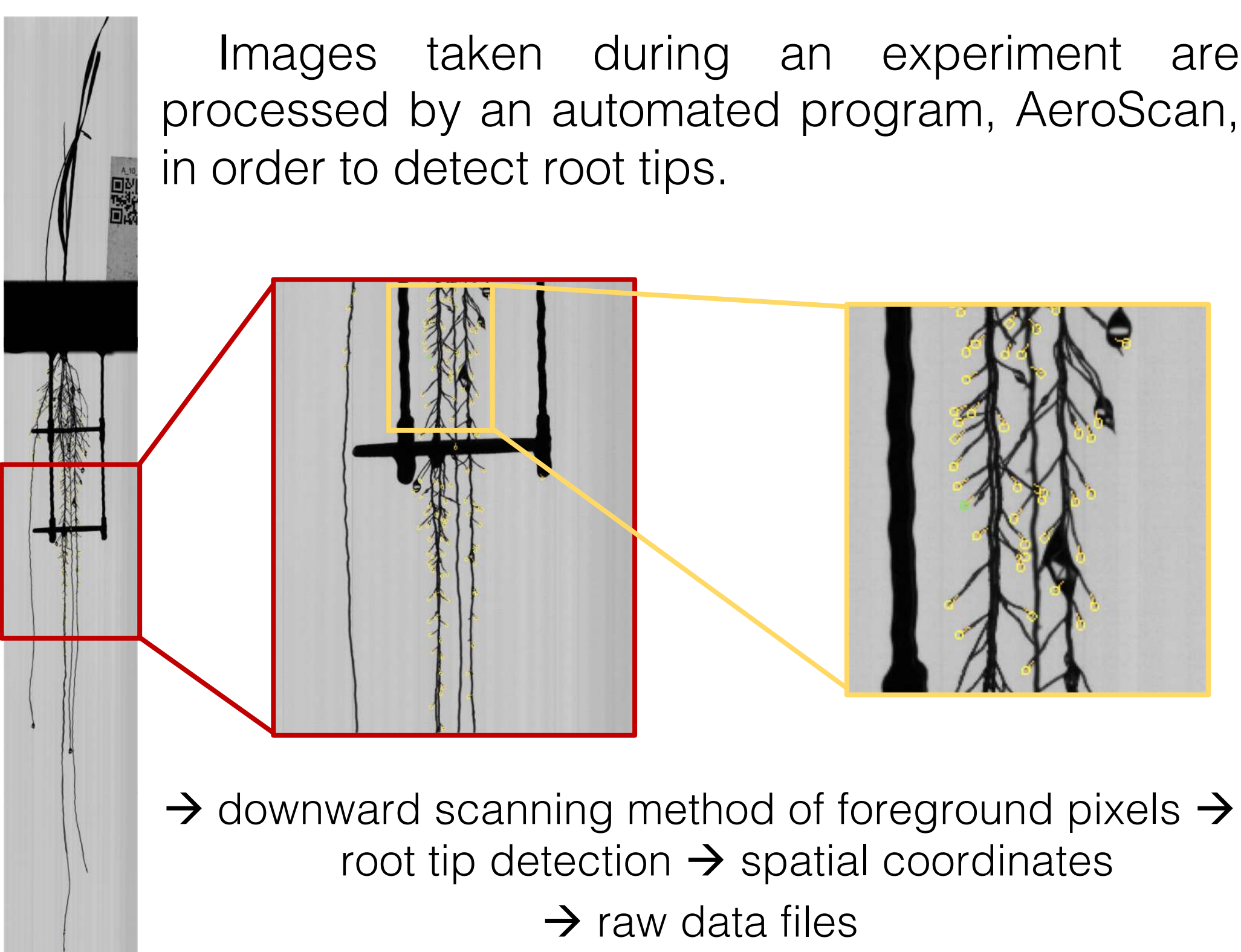
RootPhAir is aeroponics platform where plants are growing in a contact-free environment.

This automated platform enables 990 root systems to be captured by a backlight scanner every 2 hours. The quality of images taken is 700 DPI spatial resolution.

We illustrate here a new image and data analysis pipeline that yields information on the dynamics of root growth and production by showing results of experiments on durum and bread wheat diversity panels.

Root phenotyping

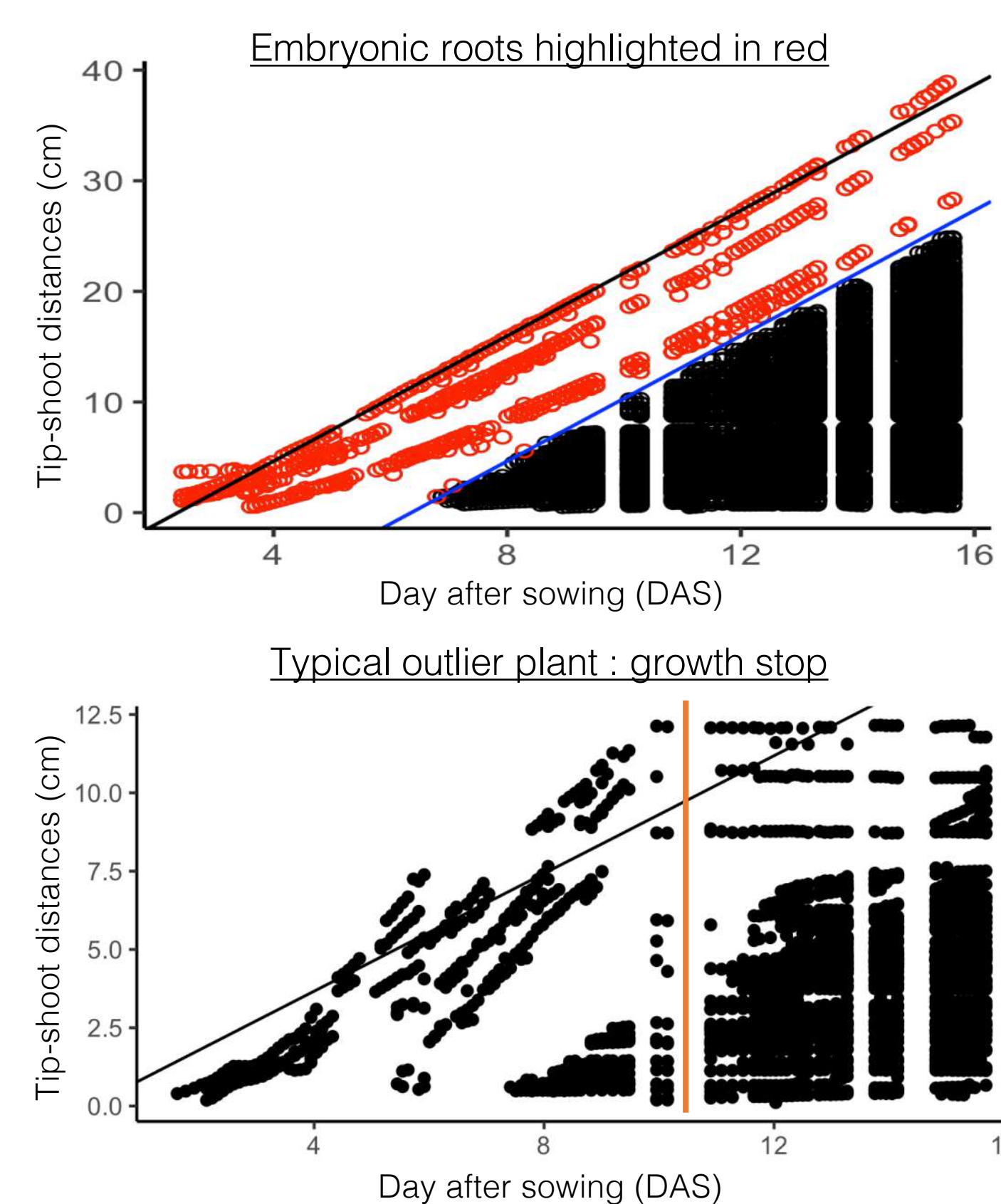
Image processing



Raw data files obtained are then analysed with a R script in order to extract values of dynamic root traits. We base our analysis on the graph showing the tip-shoot distances over time for the whole tip population. This graph highlight the identities of the different root types (see graph on the right : embryonic roots in red, lateral roots in black).

During this process, we filter out the outlier tips:

- Non-germinated plants
- Late germination
- Growth stop (mainly due to a water stress after a machine jam)
- Present of non-root objects recognized as tips



Filtering

Root traits

After analysing raw data, we obtain several root traits and, most importantly, some related to the dynamic of root growth. We have classified them in 3 databases depending on whether they are related to the entire plant, the time or only one root tip. This list of traits is in constant evolution since image analysis is improving.

Plant database

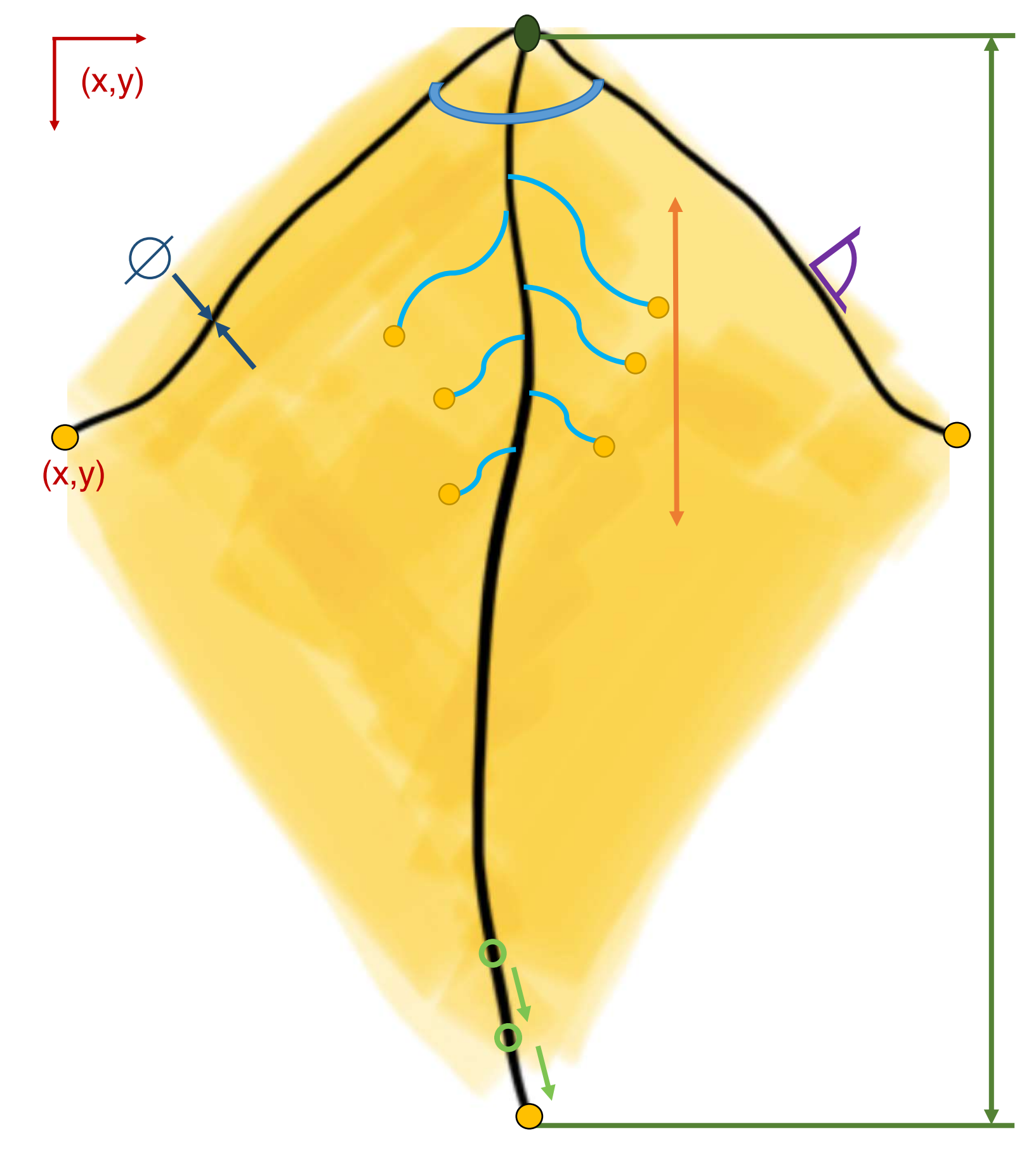
- Functional starting day (DAS)
- Maximum root length (cm)
- Primary root elongation rate (cm.day⁻¹)
- Embryonic roots number (nb of tips)
- Lateral root density (nb of lateral.cm⁻¹ of ramified embryonic root)
- Root angle between 2 first pair of seminals (° or rad)
- Mean/mode/median diameter (embryonic roots, lateral roots & all, cm)
- Fresh/dry shoot and root weight (g)

Datetime database

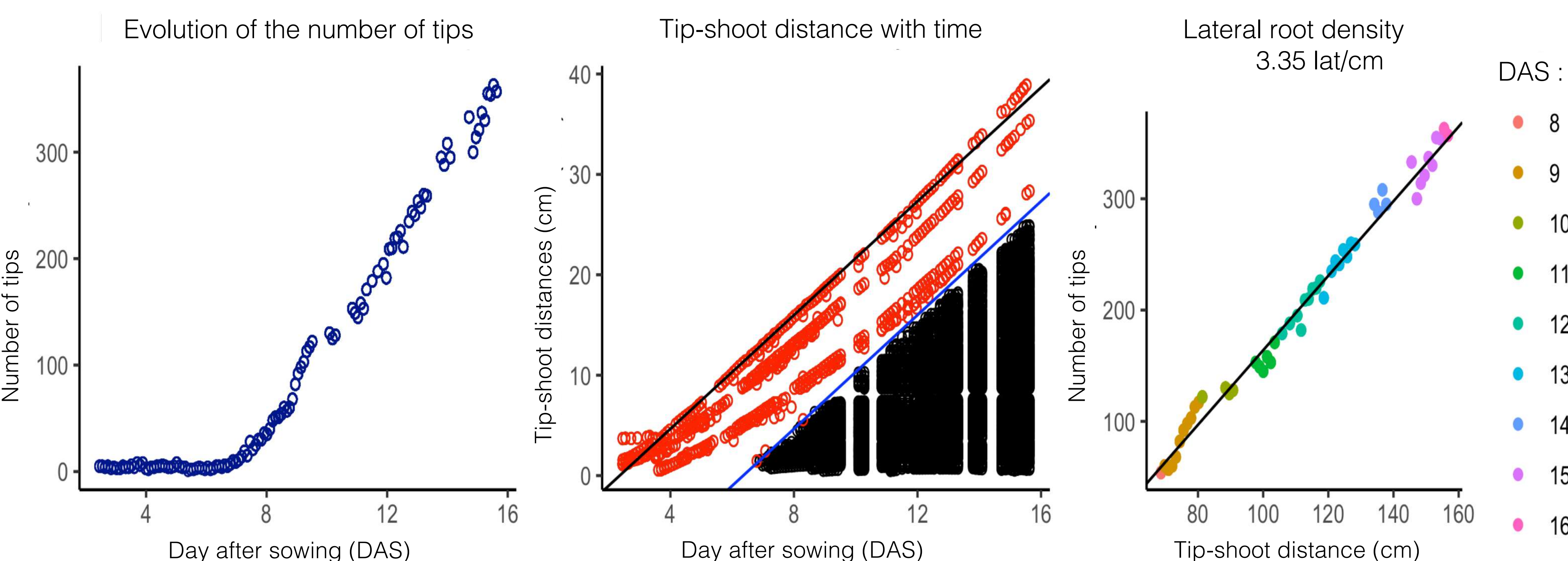
- Convex hull area (cm²)
- Number of tips (nb)
- Total ramified zone of embryonic root (cm)

Tips database

- x and y coordinates of the tip
- Tip-shoot distance, estimated root length (cm)
- Growth direction (rad)
- Diameter (cm)



Graphs needed to determine lateral root density



Defined root traits can be now used to carry out quantitative genetic analysis (GWAS) and used as parameters for mathematical models of root system architecture.

Indeed, use root traits as inputs of models like RootTyp or CRootBox can generate lots of simulations and predict the functions of root systems (water and nutrients uptake, anchorage...)

Modelling perspectives