



# Studying the role of soil microorganisms in chickpea root system architecture regulation

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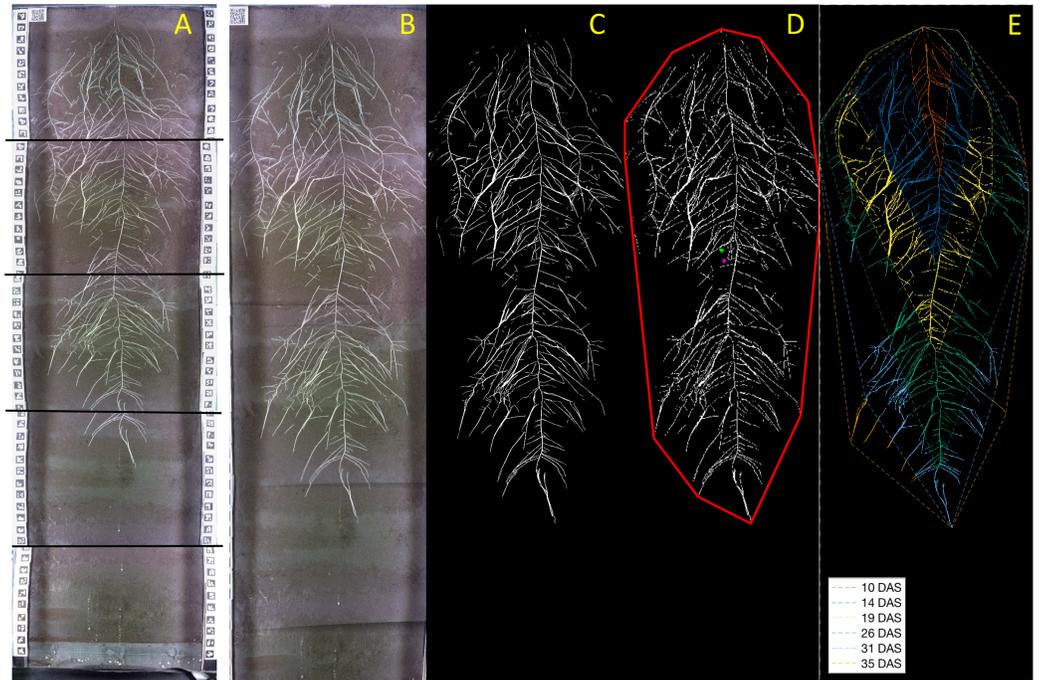
## Introduction

Root system architecture (RSA), the spatial distribution of roots in soil, is critical for optimum water and nutrient acquisition and therefore yields, but soil limits root imaging. Chickpea is a relevant food source in low-income countries, cultivated under arid conditions in nutrient poor soils, making the study of its RSA important. Rhizobia fixes  $N_2$  in legume roots and boost yields, and enhances root growth under soilless-conditions, but little is known about their effect on soil-grown chickpea RSA. To quantify it, and compare varieties with different RSA, a growth (mesocosm), imaging system and software were developed.

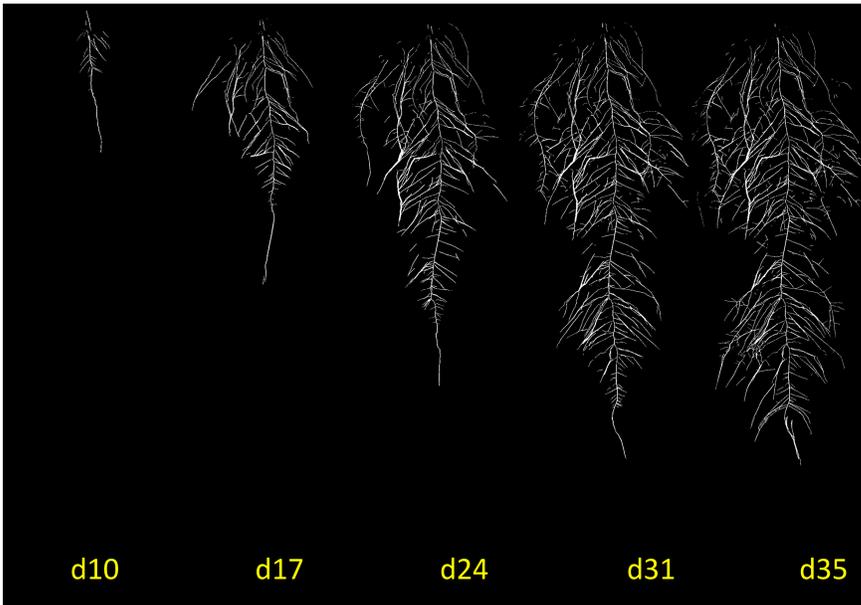
## Results



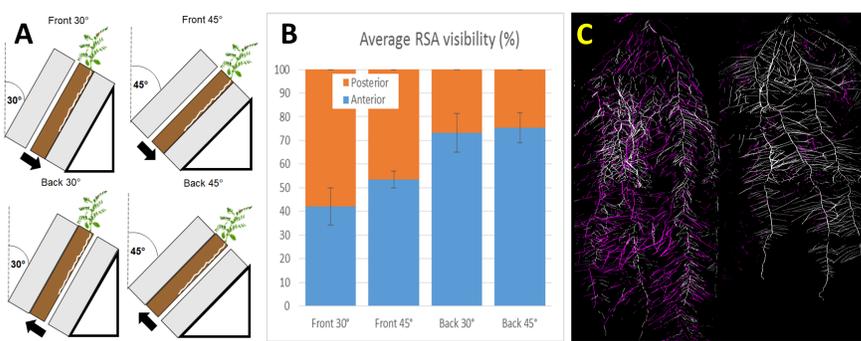
**1. Component design.** A) Mesocosm. 150cm x 45cm. Roots grow in a 0.6cm space with soil, with frontal glass for imaging. Placement at an angle increases root growth against the glass; B) Imaging station. Five cameras capture different parts of a mesocosm, which are stitched together (lighting not visible).



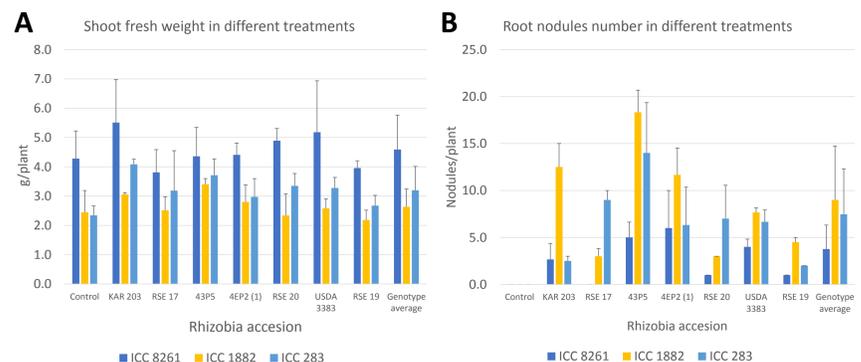
**2. Root system parameters (RSP) acquisition.** A) Five captured sections of a mesocosm (35days after sowing). Aruco markers (on sides) and overlap between contiguous pictures helps to stitch them; B) Sections stitched together (markers and overlaps removed; picture magnified for clarity); C) Roots detected and digitalised; D) Several RSP can be detected. The convex hull (red), the area that encompasses the entire root system, and the centroid, the centre of mass of the convex hull (magenta) and root system (green), respectively, are shown; E) Root development over time. Colours indicate growth between two time points. Dashed-lines corresponds to convex hull at a time point.



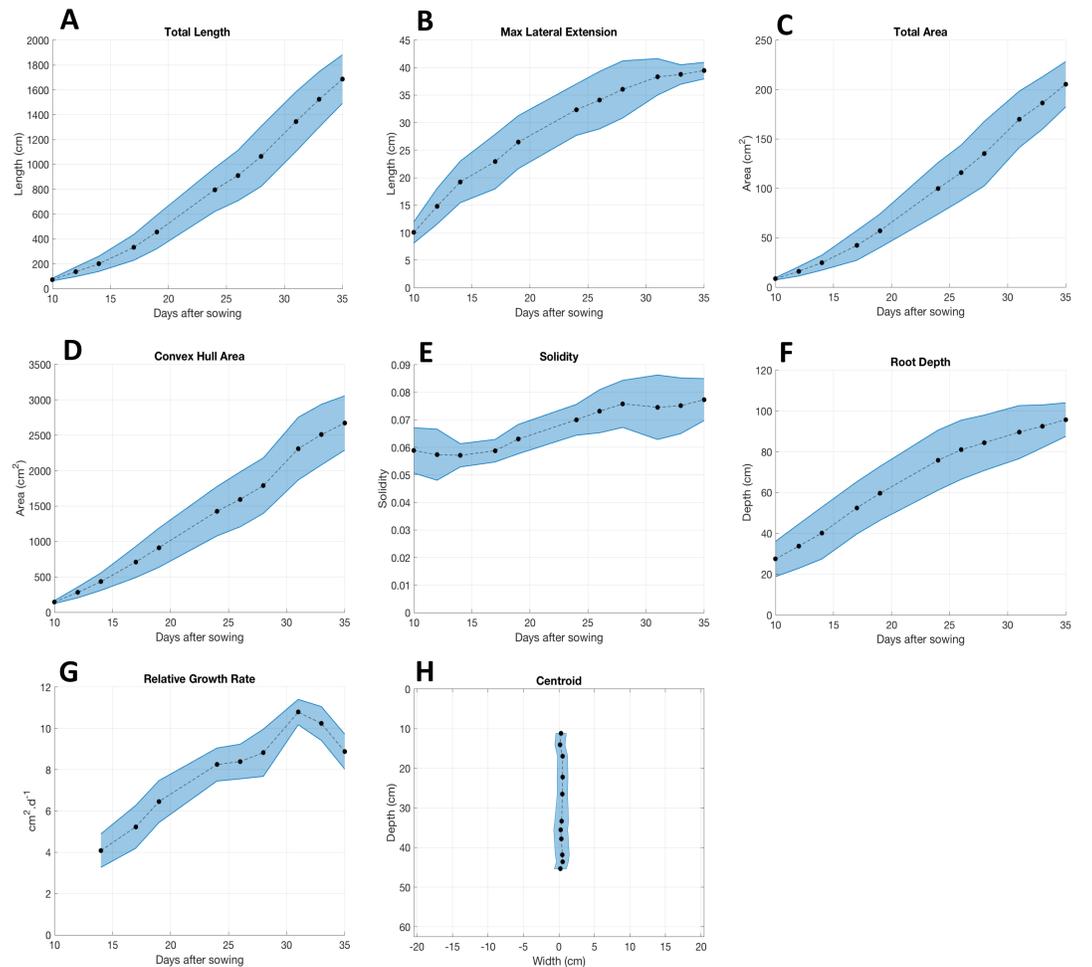
**3. Time-lapse of chickpea RSA development.** The root system grows over time, with primary, secondary and tertiary roots growth rate and orientation forming the RSA. 31 days after planting, when flowering starts, growth rate slows down considerably and most happens at the bottom (d=days after planting).



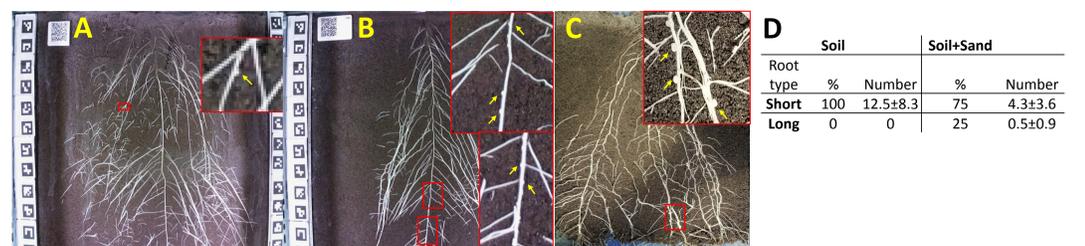
**5. Placement angle and direction of soil compression effect on percentage of visible roots.** A) Schematic of treatments to maximise root visualization. To observe root growth against the "back", glass was used on both sides; B) Average root area against the front and back (48das, n=4); C) Front/30° (left) and Back/45° (right) are shown. The latter was selected due to higher percentage of visible roots, and more visible sections of the primary and secondary roots with fewer gaps, for proper RSP detection (not shown).



**6. Selection of chickpea varieties and rhizobia strains in pots to be studied in mesocosms.** A) Shoot fresh weight; B) Nodule number/plant. ICC 8261=long-rooted variety, ICC 283 & ICC 1882=short-rooted varieties. Seven rhizobia strains were tested (n=3). ICC 8261 and ICC 1882, and strain 43P5, were chosen. Nodulation in mesocosms was further evaluated.



**4. Changes in RSP over time.** Several RSP can be quantified to study chickpea RSA. A) Total root length; B) Maximum lateral extension; C) Total root area; D) Convex hull area; E) Solidity of the root network (root area/area of the convex hull); F) Maximum root depth; G) Relative root growth rate; H) Centroid (scale modified to indicate position relative to the middle of the mesocosm). Growth period of 35days, imaging interval of 3-4 days after first image (10das). Average (dots) and standard error (blue region) shown (n=4).



**7. Nodulation in mesocosms under different conditions.** A) Rhizobia applied to the top (21days); B) Rhizobia applied to all the soil (soil:sand; 1:1) (18 days); C) Rhizobia applied to all the soil (small mesocosm; 30x20cm) (26 days); D) Nodulation (%) and nodule number/plant in soil and soil:sand mix in small mesocosms at 14days. SD shown (n=4). Images of ICC 1882 (root nodules indicated by arrows). 100% nodulation is necessary to study rhizobia effect on chickpea RSA in soil, which has not been obtained yet.

Root type	Soil		Soil+Sand	
	%	Number	%	Number
Short	100	12.5±8.3	75	4.3±3.6
Long	0	0	25	0.5±0.9

## Conclusions and future work

A system to grow and image chickpea RSA in soil and software to quantify RSP was developed. Future work will focus on quantifying RSA variation between the selected varieties, as well as the effect of rhizobia on chickpea RSA in soil under several environmental conditions once improved nodulation is achieved. Funding: BB/P023487/1 and CONICYT PFCHA/DOCTORADO BECAS CHILE/2016 – 72170128.