Sugarbeet fine root distribution: root imaging analysis platform for root system measurement

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Introduction

Roots are an important and invisible/unexplored organ for yield stability in sugarbeet and a relevant parameter for decision making in plant breeding. To make fine roots visible, we used a root imaging system with transparent tubes with increased throughput. The fine root distribution was measured with the imaging system in transparent tubes at different depths and at different development stages of sugarbeet growing in the field. To develop and analyze the complex trait of fine root distribution over time, we developed a measuring platform.

Platform Description

The platform includes 4 steps: 1) tube preparation and installation at an optimum angle in field trials and their deinstallation after the season (Image 1); 2) image data collection of tubes at the most important development stages during the growing season of the sugarbeet breeding material (Image 2); 3) the image analysis and raw data preparation for later analysis and 4) the statistical analysis of extracted values of the fine root distribution of each sugarbeet variety at different soil depths over time (Fig. 1).

Image 1: The laborious installation of transparent tubes in a breeding field trial. Each plot receives up to two or more tubes, depending on the trial design. Each tube is recognized individually by a respective code.

Image. 2: Image recording via a scanner in a field trial and an example image of sugarbeet fine roots (all pictures: KWS).

Results

The fine root distribution data were collected in sugarbeet variety field trials on multiple locations over 3 years and revealed differences in fine root distribution over different development stages and soil layers.

In June, the fine roots explore the upper soil layers more and in July there are the first roots visible in deeper soil layers. The soil layer with maximum fine root distribution progressed over time to deeper layers.

The investigated KWS sugarbeet varieties produce significantly more roots and greater variation under drought stress conditions. Moreover, the KWS inbreeding lines showed a larger variation in fine root distribution/ density over different development stages and soil layers.

Conclusion/Outlook

With the further development of climatic changes and the high risk of drought stress during the growing season, farmers need sugarbeet varieties with stable yield performance.

This improved root imaging method & image analysis pipeline of KWS now allows to screen breeding material nondestructively, enabling us to explore the sugarbeet root system and its response to drought stress. Breeders could potentially achieve gains in the breeding process by assessing fine root traits in early stages of variety development under sub-optimal field conditions.

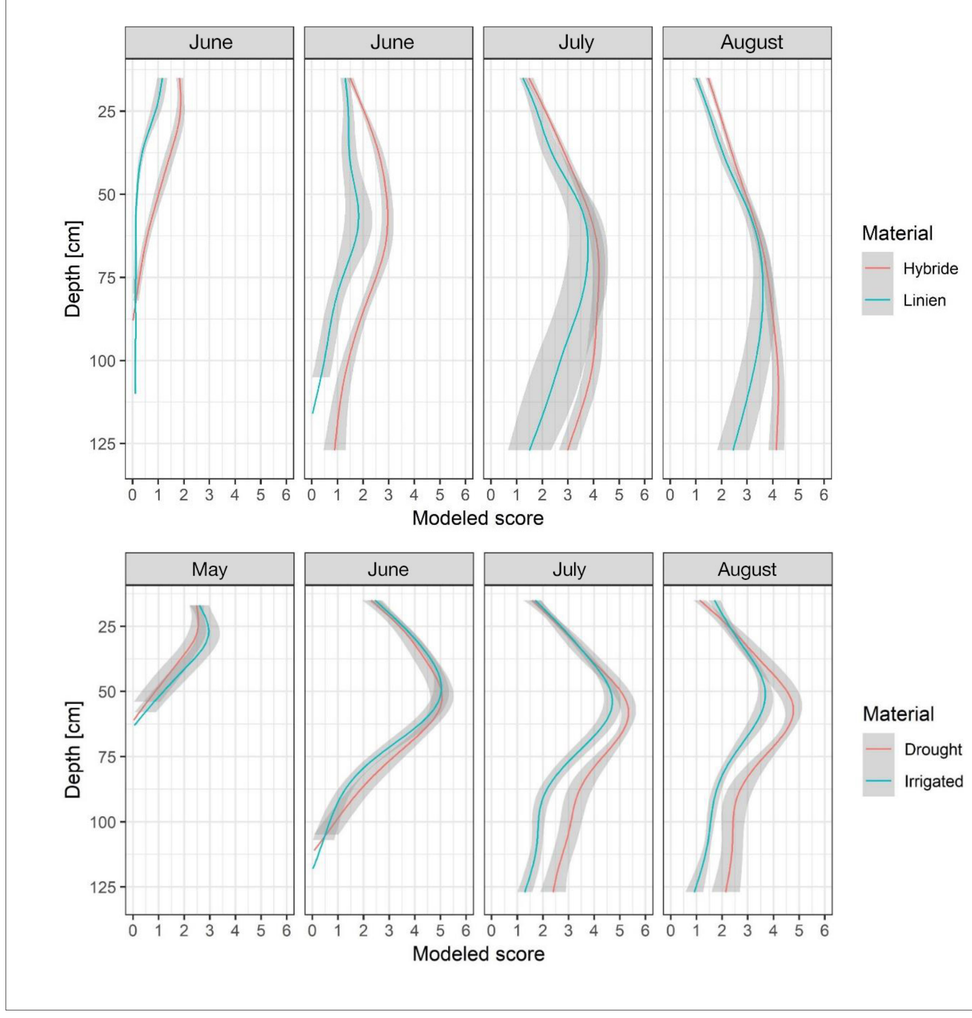

Fig. 1: Root distribution expressed as a score ranging from 0 to 9 (where 0 indicates no roots and 9 indicates a high density of roots) throughout the soil profile at four time points: a) comparison between breeding lines and their corresponding hybrids, and b) root development of the same genotypes under irrigated and drought stress conditions.

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