As of 2030, new European Union regulations will impose stricter limitations on the use of artificial fertilizers. To ensure the continued sustainability and competitiveness of European agri- and horticulture, alternative approaches to improve crop performance are urgently needed. The HortiRoot Lab at Ghent University is playing a pivotal role in addressing this challenge.

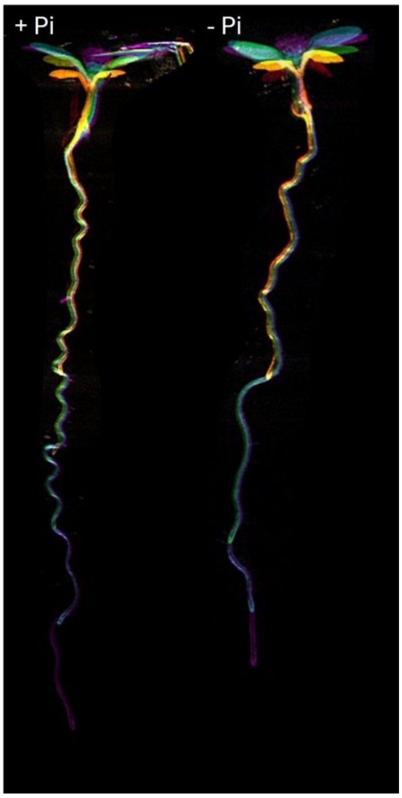
“2030 is rapidly approaching,” warns Professor Dr. Inge Verstraeten, head of the HortiRoot Lab. She currently supervises two PhD candidates and a postdoctoral researcher. “HortiRoot was established as a completely new laboratory in September 2023, starting entirely from scratch. Since then, we have hosted numerous Master’s and Bachelor’s students, and through our ongoing experiments, we have now established high-quality datasets to build upon. Combined with the technologies we have developed, this lays the foundation for continued growth.”

Prof. Dr. Inge Verstraeten demonstrates the lab's scanning device. © HortiRoot

Rooting the future: understanding nutrient stress

At HortiRoot, research focuses on how plant roots respond to nutrient scarcity —a critical topic, given that crop yields, and by extension global food security, depend on the availability and uptake of soil nutrients through the roots. Among the most essential nutrients are nitrogen and phosphorus, both of which are frequently limiting due to soil fixation or regulatory restrictions. Fertilization is therefore standard practice; however, excessive or ill-timed application can result in environmental contamination. Under the EU Green Deal, fertilizer use will be further restricted, opening the door to innovative plant science research.”

“If we can better understand how plants adapt to nutrient limitations, we can leverage that knowledge to improve crop resilience and performance,” explains Verstraeten. “This is the core mission of the HortiRoot laboratory.”



Seedling response to Pi-sufficient and Pi-deficient treatments. Colours represent different timeframes. © HortiRoot

Investing in roots

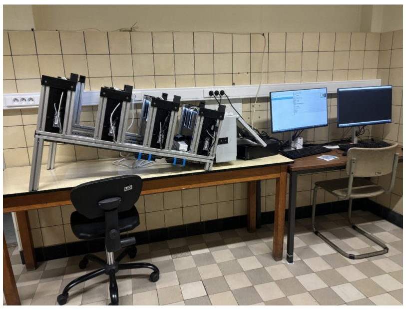
“When mobile organisms such as humans encounter adverse conditions—like insufficient food—they can relocate,” says Verstraeten. “Plants, being sessile, do not have that option. A plant must cope with the environment in which its seed germinated. The plant adapts, reallocating energy towards root development to explore for additional nutrients, while temporarily limiting shoot growth. Such evolutionary adaptive responses to nutrient deprivation are well-documented.”

HortiRoot’s research focuses specifically on how roots sense, signal, and adapt to low nutrient conditions. “We are especially interested in the immediate sensing and fast signalling events that precede long-term architectural changes in the root system. These early responses form the basis of our investigations.”

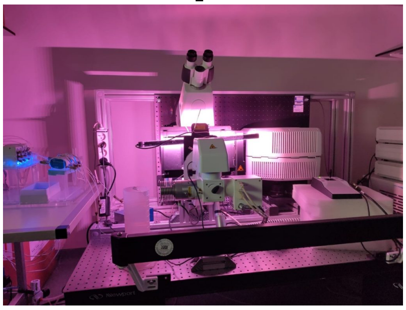
Reframing the research: from starvation to signal

“Why wait until morphological changes become visible, which can take days?” Verstraeten asks. “Instead, we investigate early sensing events that trigger a plant’s response to nutrient depletion.

In doing so, we also reconsider our terminology –what is traditionally called 'starvation' is a long-term consequence, whereas we are studying short-term, rapid 'depletion' responses."



Scanner setup. © HortiRoot



HortiRoot developed a vertical confocal microscopy system integrated with automated tracking and analysis tools. Only two other institutes have such microscope. © HortiRoot

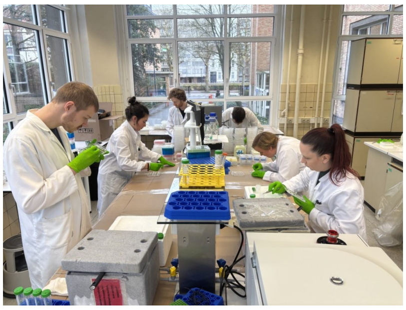
Confocal microscope

To capture these rapid changes, the lab uses hydroponics and microfluidic growth systems, allowing real-time observation of plant responses to environmental shifts. "We have developed a vertical confocal microscopy system integrated with automated tracking and analysis tools," Verstraeten explains. "This setup enables us to image roots in their natural growth direction. Globally, only two other institutes –IST Austria and VIB-PSB Belgium – have such microscope."

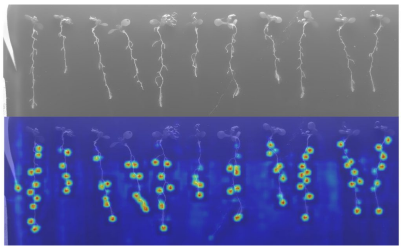
Using customized microchips to cultivate the model plant *Arabidopsis thaliana* (thale cress), the lab can detect root cell responses to nutrient depletion within seconds. "We can then correlate these cellular changes with broader physiological responses, helping to identify key signalling pathways and systemic regulators of plant development," she adds. "Our research is extended to tomato plants as well."

OMICs and genetic analysis

Understanding the timing of the root's responses allows for precise sampling. HortiRoot has initiated OMICs-based research to identify molecular players involved in the fast signalling and adaptation to nutrient stress. “These datasets are rich with potential,” says Verstraeten. “They contain promising candidate genes and proteins. In parallel, we are exploring natural variation in nutrient responses using GWAS populations and screening receptor-like kinase mutants for their role in these rapid reactions.”



The HortiRoot team at work. © HortiRoot



Output of neural network trained to automatically detect root tips in images (main root and branches) for quantitative growth measurements. © HortiRoot

Strategic collaborations

To bridge the gap between laboratory findings and real-world applications, HortiRoot collaborates with Agrotopia (Belgium) to study nutrient acquisition in crops grown in vertical farming and hydroponic systems. On an international scale, the lab works closely with Margaret Frank at the School of Integrative Plant Science (Cornell University, USA) and Matyáš Fendrych at the Institute of Experimental Botany, Academy of Sciences (Czech Republic).

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