As of 2030, 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 are urgently needed. The HortiRoot Lab at Ghent University is playing a pivotal role in addressing this challenge from the plants' side.

"2030 is rapidly approaching," warns Professor Dr. Inge Verstraeten, head of the HortiRoot Lab. She currently supervises three PhD candidates and a postdoctoral researcher. "HortiRoot was established as a new laboratory in September 2023, starting entirely from scratch. Since then, we've 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."



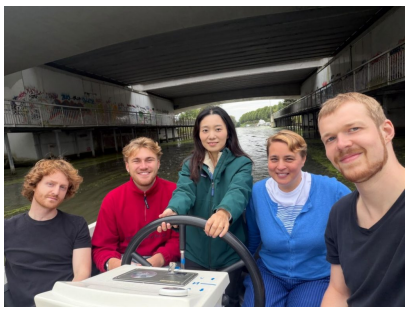
Prof. Dr. Inge Verstraeten demonstrates the lab's scanning device. © HortiRoot

Rooting the future: understanding nutrient stress

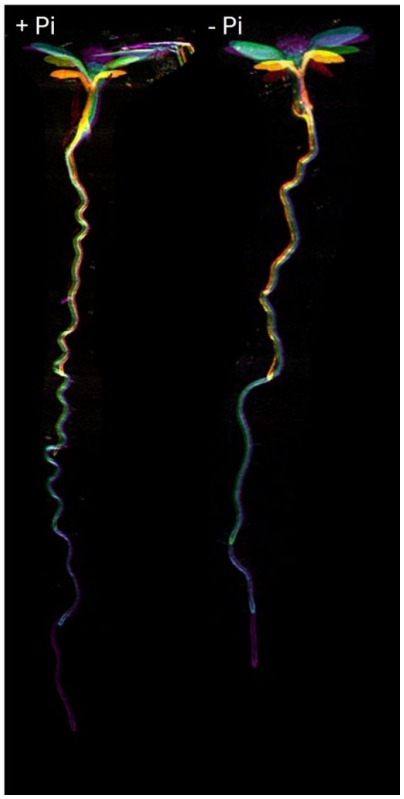
At HortiRoot, research focuses on how plant roots respond to nutrient scarcity, a critical topic, given that crop yields and by extension global food security, depend on the availability and uptake of soil nutrients through the roots. Among the most essential nutrients are nitrogen and phosphorus, both of which are frequently limiting due to soil fixation or regulatory restrictions. Fertilization is standard practice; however, excessive or ill-timed application can result in environmental pollution or degradation. 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 plant roots dynamically 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."



The HortiRoot team. © HortiRootrip



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

Investing in roots

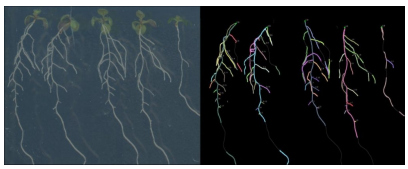
"When mobile organisms such as humans encounter adverse conditions like insufficient food, they can relocate," says Verstraeten. "Plants, being sessile, do not have that option. A plant must cope with the environment in which its seed germinated. This response is not a matter of cognition but an evolutionary strategy. The plant adapts, reallocating energy towards root development to explore for additional nutrients, while

temporarily limiting shoot growth. Such 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."



Automated detection of root architectural instances to allow quantitative measurements relevant for fast root responses. © HortiRoot

Confocal microscope

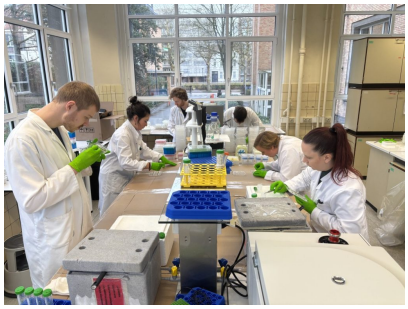
To capture these rapid changes, the lab uses hydroponics and microfluidic growth systems, allowing real-time observation of plant responses to environmental shifts. "Together with Daniel Van Damme (VIB-PSB Belgium), we have developed a vertical confocal microscopy system integrated with automated tracking and analysis tools," Verstraeten explains. "This setup enables us to image roots in their natural growth direction. Globally, only few other – among which IST Austria and Nottingham University – 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. Similar research is being extended to tomato plants as well.

OMICs and genetic analysis

Understanding the timing of these responses allows for precise sampling during rapid molecular events. 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.”

Rethinking and engineering biological nitrogen fixation



The HortiRoot team at work. © HortiRoot

Leguminous plants such as soybean, clover and peas have evolved remarkable partnership with soil bacteria. Within specialized root nodules they host these symbiotic bacteria and they convert atmospheric nitrogen into nutrients that plants can use for their growth. While this symbiosis has been studied extensively, the HortiRoot lab is taking the next step. “In collaboration with Prof. Sofie Goormachtig (VIB-PSB, Belgium) we harness symbiotic plant cell cultures to develop innovative fertilization strategies that reduce dependence on synthetic fertilizers and support more sustainable crop production.”

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. Institutional collaborations cover Prof. Emmy Dhooghe (HortiCulture), 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) and Christin Naumann at the Leibniz-Institut für Pflanzenbiochemie (Germany).

HortiRoot lab

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