Detecting the invisible to protect European horticulture, forestry, and agriculture

European scientists are determining plant pest-related odours to stop the spread of harmful organisms

DO YOU ever wonder where the plants around you come from? What is behind forest decline and agricultural yield failure? And how can we keep European landscapes safe from pests and diseases? There are no easy answers and no silver bullets. However, a lot of work is being done to keep plants healthy and the public unaffected by the damage inflicted on plants by insects, nematodes, and pathogens. Most of us are still unaware of the pests attacking our silent companions that provide oxygen, shade, food, fodder, and escape from cities dominated by concrete and steel.

Pest spread via plant importation

In 2025, the EU imported $2.5bn worth of live trees and other plants, bulbs, roots, and cut flowers from Asia, Africa, and the Americas (UN Comtrade Database) to populate our gardens, orchards, landscapes, and forests. With nature restoration high on national agendas, this number is expected to increase significantly. But an imported plant might rarely move alone. Plant import routes are ideal passageways for pests and diseases hitchhiking in pots, hiding under leaves and contaminating the soil. Slipping through import inspections unseen, these invasive aliens have a high potential for establishment in new areas and are quickly spread from the point of entry to private gardens, fields, and forests.

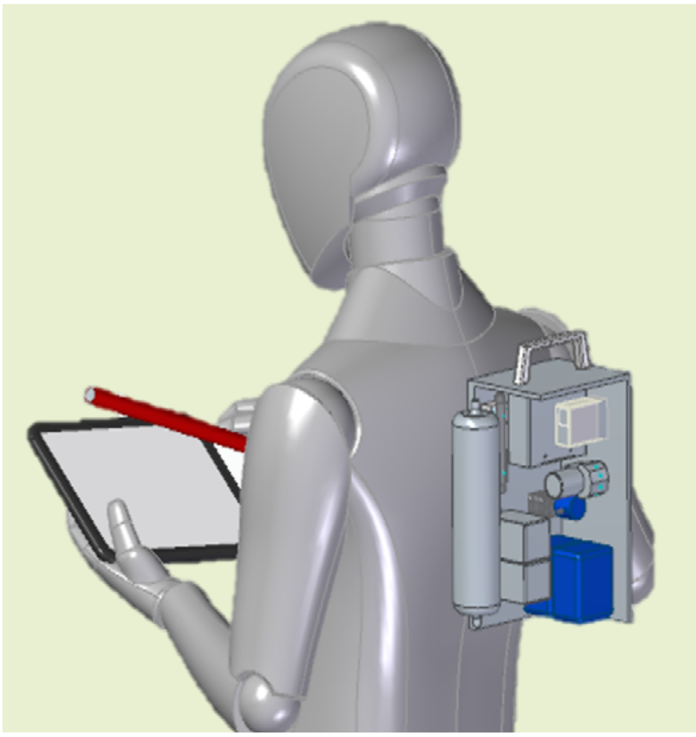
According to EU regulation, all potted plants, bedding plants or tub plants, as well as plant propagating material, need to be accompanied by a phytosanitary passport.

This plant passport contains information of the country of production and is supposed to guarantee that the plant is free from pests and diseases. However, the plant inspection from the plant health authorities at the place of origin is often solely based on visual evaluation and depends on the experience and expertise of the plant inspector. Many plants with passports arrive at their destination containing alien plant pests and diseases, showing that this well-intended scheme is not always reliable and requiring additional plant health checks at the receiving country. Research has shown that only 3% of incoming plants are actually visually inspected upon entry, which means 97% of plants and plant material move across Europe without any inspection at all. Visual inspection fails to detect microscopic pathogen spores, plant-invading nematodes, dormant bacterial or viral diseases, and is often inadequate to register insect eggs well-hidden on the underside of leaves.

Insufficient pest inspections

One of the biggest challenges for proper plant inspection and detection of pests and diseases is the lack of time and resources at border control sites. Plants can move in groups of more than 1,000 individual pots of various sizes and types, containing different pests and diseases in one transporter. This makes individual plant inspection and taking representative samples for molecular analysis simply impossible. We need a gamechanger to keep pests and diseases outside our borders.

Instead of one-by-one inspection, remote sensing of pests and diseases on multiple plants at the same time is the only way to inspect plants in a timely and reliable manner. However, remote visual inspection using cameras will not be sufficient to determine the subtle changes as the plant health status shifts.



Pest Sensor Prototype

Plants communicate their physiochemical status by emitting chemical signals, such as volatile organic compounds (VOCs). These odours can be produced passively or in response to an attack by insects or pathogens. Some of these compounds are generic, some are highly specific, but most are quickly diluted in air and need highly sensitive detection technology to be discovered.

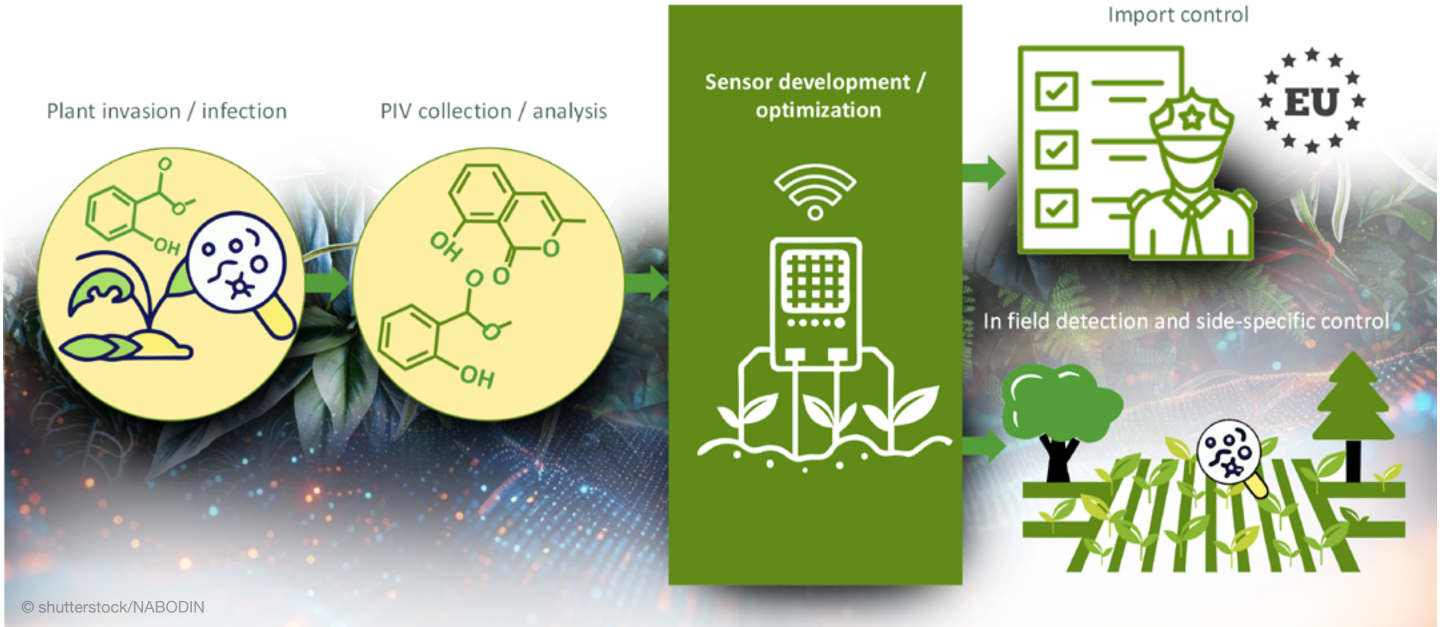
PurPest project

In the four-year Horizon Europe project 'Plant Pest Prevention by technology-guided monitoring and site-specific' control (PurPest), a transdisciplinary group of plant scientists, entomologists, chemical ecologists, plant pathologists, chemists, physicists, sensor developers, data modellers, and social scientists work together to identify VOCs that can be linked to specific plant pests and diseases. The goal of the project is to develop a sensor system prototype that can be actively used for rapid and reliable inspection of imported plants and stop invasive pests at the border. This project is proving the concept of utilising VOCs for plant health inspection by collecting VOCs from host plants attacked by one of five serious and highly invasive pests and diseases.

First, we collected VOC from the target pests, including the fall armyworm (*Spodoptera frugiperda*), the brown marmorated stink bug (*Halyomorpha halys*), the pinewood nematode (*Bursaphelenchus xylophilus*) and 25 different *Phytophthora* species, pathogenic on woody plants. In the next step, we collected, identified, and analysed the VOCs emitted from different host plants with their respective pathogen. In those experiments, we also included the cotton bollworm (*Helicoverpa armigera*).

There can be a lot of natural variation of VOC profiles between plants of the same species. Identifying the ones only related to infection can be difficult. We have conducted a number of different experiments to identify those VOCs or VOC signatures that are signalling the presence of at least one of our five target pests in different host plants. Different species of pine (*Pinus pinaster, P. nigra* and *P. sylvestris*) were inoculated with the pinewood nematode to compare the VOC profiles between the infected and healthy trees. Potted apple and pear trees with and without previous infection of another pathogen were exposed to the brown marmorated stink bug and their VOC profiles were compared with the VOC profiles of plants exposed to draught and heat stress. We also collected VOCs from maize, rice, sorghum, radish, soybean, and sunflowers to identify the compounds emitted only from the plants that were attacked by the fall armyworm and not by the healthy controls. VOCs were collected from peas, tomatoes, and sunflowers invaded by the cotton bollworm larvae and compared to VOCs emitted by healthy

ILLUSTRATION OF THE PurPest CONCEPT



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plants exposed to water, light, and heat stress. As one of the most destructive diseases in horticulture and forestry is caused by *Phytophthora* species, we collected and identified VOCs from cork oak, beech, larch, and rhododendron inoculated with eight different *Phytophthora* or *Phytophthora* related isolates over several weeks and compared those profiles with healthy host plants. The results of our study, together with information about experimental set up and growing conditions, are curated in a database containing over 4,100 entries organised in the common format. This list will be publicly available on in the PurPest group on Zenodo.org at the end of the project.

The information on potential signal VOCs generated by our plant pest scientist was then used by our sensor technology colleagues and software developers to test different sensing approaches. The sensors adequate to detect pest-infested plants would need to be highly selective and very sensitive, as the concentration of VOCs produced by the plant is very low. Not all VOCs are equally stable and can be detected by the same sensor principles as others. Currently, we are working on the second version of the sensory system platform (SSP) and will test this device on cork oak and beech trees infected with Phytophthora species, before we optimise the SSP further and test it on the cotton bollworm, on tomatoes and peas, and finally on the pinewood nematode-infected material.

Bridging the gap and building trust

Moving science beyond the lab bench or the controlled conditions of the greenhouse requires trust and engagement from interested stakeholders. We have developed an effective communication strategy to raise awareness of the pests and pathogens entering Europe via trading routes and import sites. Our social scientists are describing the consequences of the continued influx and spread of invasive of the five target pests, both from economic and ecologic perspectives. We are working to increase awareness on how a sensory system platform can keep our fields, forests, and gardens pest-free.
By combining pest expertise, sensor know-how and economical, ecological and societal approaches, we hope to turn the tide on plant pest invasions and build a plant health alliance between nurseries, foresters, plant health inspectors, policymakers, agronomists, and scientists that will implement ecologically sound and economically viable solutions.

Disclaimer

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