Importance of volatile compounds on the infection cycle of Pine Wilt Disease (PWD)

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The plant parasitic pinewood nematode (PWN), *Bursaphelenchus xylophilus*, causes pine wilt disease (PWD) in susceptible pine trees. In Europe, PWD greatly impacts the Iberian pine forest, leading to economic losses in the wood industry. The early detection and faster monitoring in the field or at border transport entrance points is of the utmost importance if this disease is to be contained. The utilization of volatile organic compounds (VOCs) for the detection of plant diseases relies on the fact that when plants are subjected to pathogenic infections, they elicit distinct VOC emissions in response. The analysis of these VOC signatures can provide a non-invasive approach for the early detection of PWD. However, in the PWD disease complex, several organisms contribute to VOC emissions, making disease detection more intricate. Furthermore, specific VOC profiles associated with early infection, symptom development, and advanced stages may differ. Addressing these challenges is necessary for the development of reliable and practical VOC-based diagnostic tools, enhancing the overall capacity for early PWD detection and monitoring.

P. pinaster showing the characteristic symptoms of PWD (Faria et al. 2023).

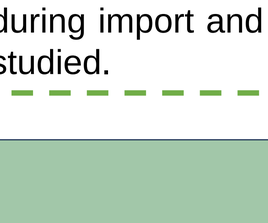
PWD complex

The PWD infection cycle is primarily driven by PWN, dispersal by its insect vector, and interaction with the pine species itself. The pine sawyer beetle plays a crucial role in the spread of PWN, serving as a vector for nematode transmission between trees. Inside the pine tree, PWN migrates through the tree's vascular system, hindering sap circulation by feeding on parenchyma and epithelial cells, leading to a progressive decrease in resin production. Within the PWD complex, various VOCs are implicated in the interactions among healthy pine trees, the PWN, insect vectors, and the infected host pines, and can serve as either attractants or deterrents depending on the stage of the disease cycle and the actors engaged. Additionally, some VOCs may be involved in the defensive responses of pine trees to PWN infestation, potentially influencing the severity and progression of the disease.

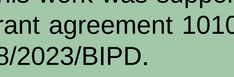
VOCs

Healthy pine trees

α-Pinene is a major monoterpene emmited by pine trees. It attracts insect vector as well as the PWN reproductive form (Jn), while ethanol appeared to be an important synergistic compound causing significant increase in attraction.



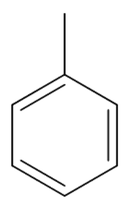
α-pinene

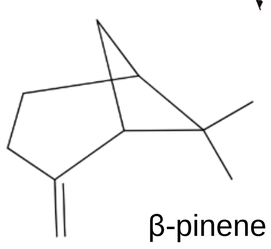


ethanol

Pine sawyer beetle

toluene



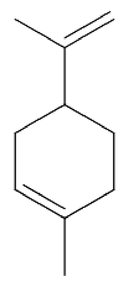


β-pinene

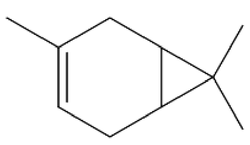
Toluene, a beetle cuticular hydrocarbon, likely acts as one of the components in a combination of cues that initiate the entrance of JIV into beetle tracheae before adult beetle emergence from pine, while JIII PWN are attracted to a sawyer battle emitting a specific ratio of terpenes, with elevated β-pinene and longifolene.

Infected pine trees

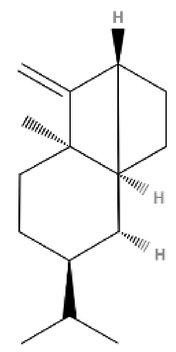
Several VOCs, like limonene, sativene and camphor show elevated levels in infected trees. δ-3-carene exhibits distinct enhancement following PWN inoculation. Furthermore, high concentrations of limonene have also been found in healthy resistant pine species.



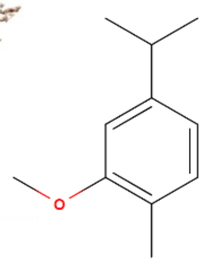
limonene



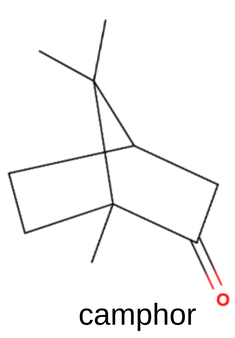
δ-3-carene



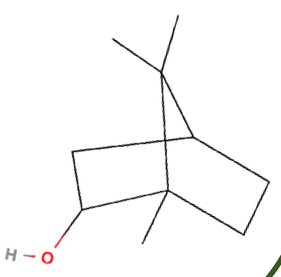
sativene



carvacrol methyl ether



camphor



borneol

The PurPest project

Plant Pest Prevention through technology-guided monitoring and site-specific control (PurPest) is an international collaboration among 18 institutions, including Institutes, Universities, Small and medium-sized enterprises (SMEs) and Government bodies from 11 European countries. The project exploits volatile organic compounds (VOCs) released by pests, or by the plants attacked by certain pests, to develop the **sensor system prototype (SSP)** that will rapidly detect the VOCs and identify target pests. SSP is aimed at the development of a simple, robust and reliable method for the identification of VOCs emitted from plant materials infected by a specific plant pest, allowing detection under laboratory conditions, during import and in the field. At INIAV, VOCs connected to pine wilt disease (PWD) caused by the Pinewood nematode (PWN) are collected and studied.

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PurPest

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