Plant-plant communication for sustainable pest management

Velemir Ninkovic, Associate Professor at the Swedish University of Agricultural Sciences (SLU), explores plant-plant communication for sustainable pest management

Our society and farmers are in the need of knowledge and tools required to maximise ecosystem services for the production of crops while minimising the environmental impacts of agriculture and ensuring the profitability of farming. Our research aims to provide new strategies for plant protection whilst improving our insight into the world of plant-plant communication.

Why do plants communicate with each other?

Plants live in a crowded environment surrounded by other plants from the same or different species. Coexistence with other neighbouring plants is constant and include competition for the same available resources during their life span. As a consequence of their sessile lives, plants can't fly away from their competitors and other treats, instead they directly dependent on their sensitivity and have the ability to respond to challenges in a timely manner. To set face against a potential competitor, every individual plant has to monitor surrounding cues and detect those pointing on an upcoming treat.

Permanent exposure to diverse cues makes an appropriate plant response even more difficult, as they have to distinguish important cues from insignificant ones. Among the cues that every plant may perceive, volatile organic compounds (VOCs) constantly released by neighbours are one of the most reliable. The information available to the plant through the interpretation of VOCs can help it to adapt to specific neighbours as they provide unique information about the physiological status of the emitter. Those cues may also contain elicitors of defence responses in plants. Based on the type of cues perceived plant can then react to compete when necessary or avoid unfavourable competition.

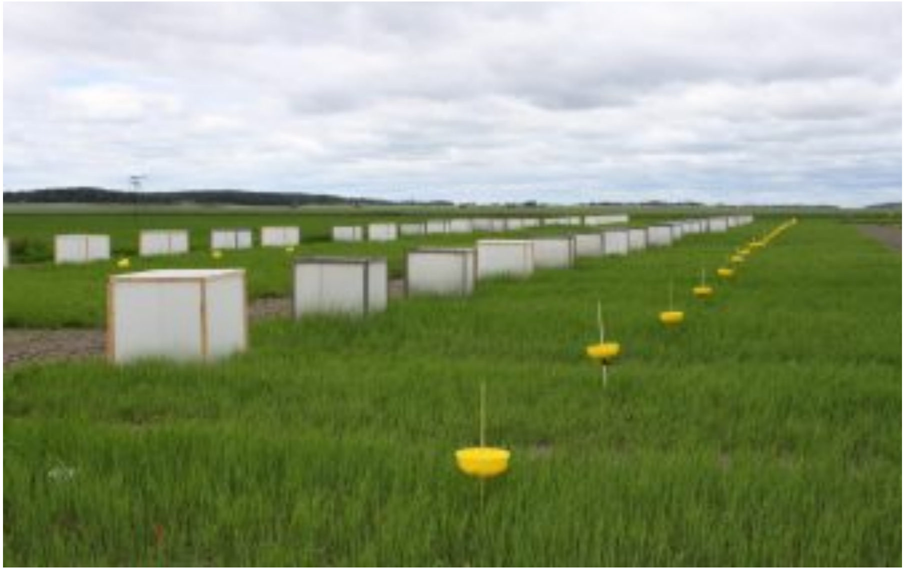
The role of the volatile communication between undamaged plants

We are studying volatile interactions between undamaged plants and their potential ecological significance. In particular, we focus on volatile interactions among different genotypes of the same plant species and their effect not only on direct competition but also as a source of information that can be used to adapt to upcoming events.

Volatile profiles are genotype-dependent and differ between cultivars of the same plant species, indicating that exposure effects can occur only in certain cultivar combinations. Depending on the type of volatile cues received, exposed plants show specific responses that include physiological and morphological changes such as biomass allocation, shade avoidance and volatile emission. For instance, under normal light conditions, exposure to volatiles from one barley cultivar induces biomass allocation to the roots in another cultivar. In the same cultivar combination, when only emitter plants were exposed to low light conditions, they released less VOCs that affected exposed plants to allocate more biomass to the shoots. We have also shown that volatile interaction between plants of different species can induce changes in the volatile profile of exposed plants making them less attracted to herbivore insects.

Plants are not interacting by VOCs only with each other but also with other organisms at higher trophic levels. Those changes in VOCs have further implications on herbivore insects as they elicit natural defence in exposed plants and, thus, reduce their acceptability. However, VOCs induced plant responses to insect pest suppression occur only in specific combinations of plant species. The advantage of increased within species diversity is that plants are already induced when migrant aphids arrive and attempt to settle in the crop.

We have observed a significant reduction of aphis attack both in the lab and field and an increase in the yield only in specific combinations of plant genotypes and species. Volatile cues from responding genotypes can attract aphid predators, such as ladybirds when searching for favourable food sources. Taken together, the results from our studies suggest that plant-plant communications change olfactory



A field experiment with volatile communication between different barley genotypes, testing induced changes in the plants and their influences on the occurrence of aphids and their natural enemies

cues of diversified plant stands which is an important underlying mechanism in predator attraction to sites with a complex botanical diversity, which can be utilised in the development of sustainable pest management.

Plant communication by touching

Mechanical contact with other plants is another early detections cue that reveals the actual presence of competitive neighbour and induces changes in their establishment strategy. We have tested plant response to touch and demonstrated that touch may have a potential role in the detection of neighbouring plants and may affect plant-insect interactions. Our results show that one minute of touching per day can induce changes in biomass allocation and increase trichome production via a systemic effect. Plants response to touch also induced changes in the blend of volatile organic compounds released what resulted in the reduced olfactory attraction of insect herbivores and ladybirds, their natural enemies.

Exposure to touch-induced volatiles has demonsrated an important ecological role as these cues are directly involved in plant-plant communication as an effective trigger for rapid defence in nearby plants. Perception of those VOCs induces activation of same defence-related genes in non-touched neighbouring plants, showing a mirroring effect in the expression of specific genes upregulated by touch. Such coordinated defence responses significantly reduced aphid acceptance on both touched and exposed plants.

These examples show the potential of volatile plant interactions and mechanical contact to induce direct plant defences against herbivores or indirect through biological control, which can be a promising strategy for the development of sustainable cropping systems. It is becoming obvious that the application of plant signals in sustainable agriculture has great potential as they demonstrate to modify plant metabolism and affect the behaviour of herbivore insects. However, there is a need for more detailed knowledge that will contribute to fine-tuning sustainable pest management from an environmental, social and economic perspective.

Plant communication in the practice

To go even further within the European H2020 EcoStack project, we are now testing the effect of within-species plant-plant communication and other ecosystem services on insect pest occurrence and population development. When we utilise this knowledge, we can improve pest management in a sustainable way, increase biodiversity and reduced pesticides usage. We can take advantage of the already existing natural defence capacities of our crops and put them into the function. Ultimately, together with EcoStack, we will provide a range of sustainable practices for future agricultural strategies in Europe.

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