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The Role of Volatile Organic Compounds in the Indirect Defense of Plants Against Insect Herbivores Above- and Belowground

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Plants respond to attacks by herbivorous insects by releasing specific blends of volatile organic compounds (VOCs). These herbivore-induced VOCs are known to play a major role in the interaction between plants and insects and may directly protect the plant by being toxic or deterrent, but may also benefit the plant indirectly by attracting natural enemies of the herbivores.

The chemical composition of herbivore-induced VOC blends is known for many plant–herbivore systems. Some VOCs are taxon-specific, whereas other VOCs appear to be common to many different plant families. These common compounds mainly include 'green leaf volatiles' (C6 aldehydes, alcohols and derivatives), cyclic and acyclic terpenes, phenolic compounds and nitrogenous compounds.

Our model plant is maize, which shows a rapid reaction to an attack by caterpillars and root feeding beetle larvae. Belowground, maize roots respond within hours to feeding of larvae by releasing the sesquiterpene (*E*)-beta-caryophyllene. The emission of this compound results in increased recruitment of entomopathogenic nematodes (tiny worms that parasitize and kill insect larvae). Similarly, after being attacked by caterpillars aboveground, maize leaves emit a complex blend of volatiles that is attractive to parasitic wasps, which use the volatiles to find and kill the caterpillars. It remains largely unclear which VOCs within the blend are the key compounds mediating this parasitoid attraction.

To study the importance of individual volatiles we combine different methods to generate and modify herbivore-induced VOC blends by manipulating the plant genotype, the plant phenotype and the headspace of volatiles produced by the plant. We focus on 'subtractive' approaches used to obtain blends differing in only few known VOCs and 'additive' approaches to generate blends of known composition. All blends are analyzed with gas chromatography/mass spectrometry and tested for attraction to the wasps in olfactometer studies. **By combining the above approaches, we aim to provide new insights into the relevance of individual VOCs involved in indirect defenses, which might help to develop ecologically sound methods to control pest insects**.

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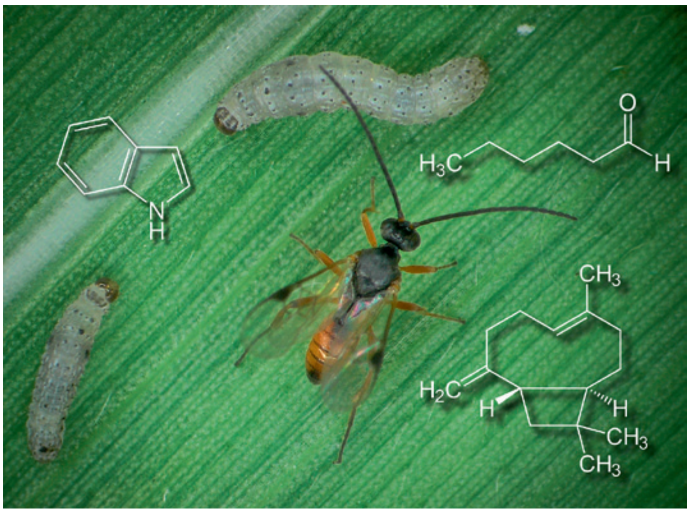
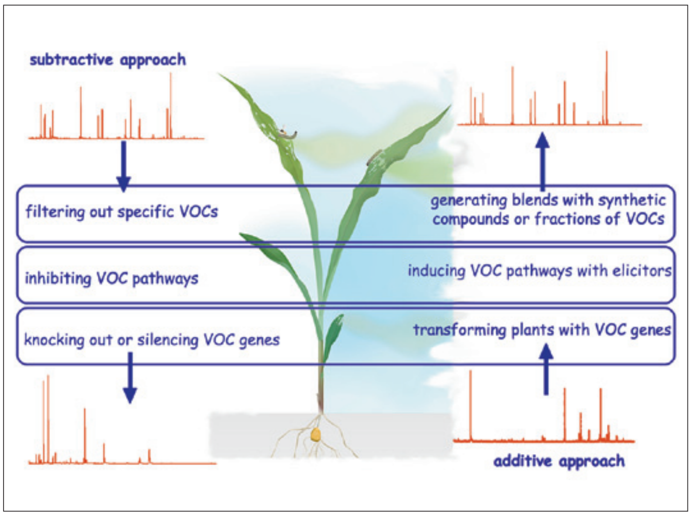


The parasitic wasp *Cotesia marginiventris* hunting for *Spodoptera littoralis* caterpillars on a maize leaf. Molecular structures illustrate some important volatiles released by maize plants after herbivore attack such as indole, hexanal and caryophyllene (photo by M. Held)



Modifying maize odor blends by manipulating plant genetics, plant physiology and plant headspace to identify the importance of individual volatile compounds for parasitoid attraction

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