CROP PROTECTION

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Repellent odours to protect crops from aphids

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ABSTRACT

Phytophagous insects like aphids use plant odours to locate host plants and to assess the suitability of plants as food source. The importance of odours for insects to discriminate between host and non-host plants, opens possibilities to interfere in the process of host selection by using plant odours to mislead insects. Application of repellents, e.g. non-host odours, on host plants could be used to avoid colonisation by insects and consequently protect the crop. In order to discover the components of plant odours that are used by aphids for decision making, a series of experiments was carried out ranging from the study of olfactory receptor responses by the electroantennogram (EAG) technique, to field experiments using formulated repellents. The results show that repellent odours can be used to protect plants from aphids.

INTRODUCTION

Phytophagous insects use olfactory, visual, gustatory and other cues to select host plants (Figure 1). The sequence of approaching a plant, landing, probing, feeding and ovipositing can be interrupted at each stage depending on the information the insect perceives about the quality of the plant. Toxic plant compounds for instance will interrupt probing or feeding. Olfactory cues, however, will play a role at the beginning of the host plant selection process and may prevent the insect from landing on non-host plants.

In aphids, the olfactory sensilla are located on the antennae (Figure 2). With these sensilla aphids perceive host and non-host odours like general green leaf volatiles, benzaldehydes, isothiocyanates and terpenes (1). It is possible to measure the responses of the receptors in these sensilla to plant odours and, in this way, to determine which odours aphids perceive. Subsequently, it can be assessed which of the well-perceived odours are attractive and which are repellent for the aphid.

Repellent odours are of special interest because they could be used for plant protection. The application of these repellents on the aphids' host plants could prevent the insects from colonising particular crops.

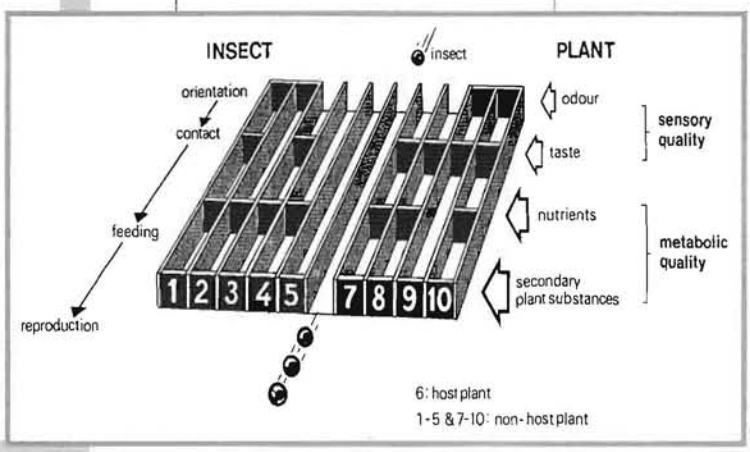
Since many aphid species are vectors of plant viruses it is of special importance to interfere with host colonisation at an early stage, preferably before probing, because already during probing non-persistent viruses are transmitted (2). Repellent odours could prevent aphids from landing or probing and therefore are potentially of great interest to crop protection.

WHAT DO APHIDS SMELL?

The aphids' sensilla are located on the antennae (3,4). An amputated antenna can be used to measure the overall responses of the olfactory receptors to odours using the electroantennogram (EAG) technique (1,5). To this end an antenna is placed between two glass capillaries filled with 0.1 M KCl that serve as electrodes. Ag-AgCl wires connect the preparation to amplification and recording devices. When odour-loaded air is blown over the antenna, EAG responses can be recorded.

In this way, for several aphid species, EAGs were recorded in response to a range of plant odour compounds (Figure 3). From these EAG studies, odour compounds were selected that are well perceived by aphids and therefore may play a role in host selection. These compounds can be either attractive or repellent to the aphids. For example, isothiocyanates (specific odour compounds of cruciferous species) are well perceived by aphids. The function of the perception of isothiocyanates however differs among aphid

Figure 1 - General scheme of host selection by phytophagous insects



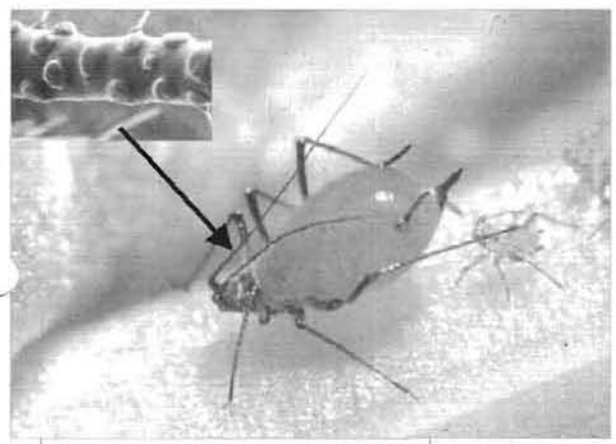


Figure 2 - Vetch aphid, *Megoura viciae*, with SEM picture of olfactory sensilla (secondary rhinaria) located on the antennae

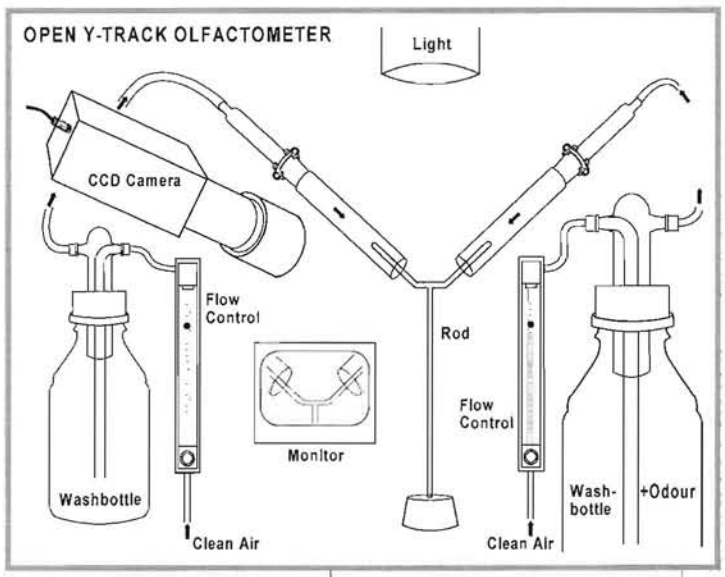
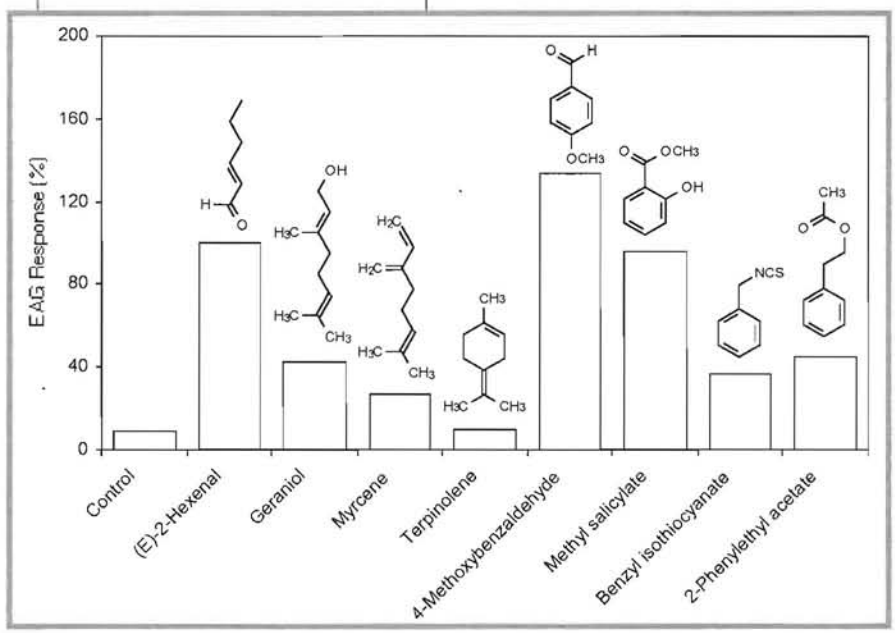


Figure 4 - An olfactometer to measure the behavioural response of aphids to plant odours. An aphid released at the base of the rod, will walk upwards and at the junction, has to decide to walk towards the odour or the control side.

species. For some species, like the cabbage aphid *Brevicoryne brassicae*, they act as attractants, but for other species, like the bean aphid *Aphis fabae*, they are repellent (6).

Figure 3 - Example of an EAG-response profile of winged *Myzus persicae* to several plant odours. A high EAG response indicates that the odour is well perceived by the aphid.



WHICH ODOURS ARE REPELLENT?

In order to determine which of the odours that are perceived by aphids are repellent an olfactometer was constructed (7) (Figure 4). In the olfactometer set-up, winged aphids are released at the base of a Y-shaped rod. After release the aphids will start to move upwards and, arriving at the junction, have to choose to walk either to the left or the right side. A repellent odour on one side versus clean air on the other side will result in the majority of the aphids moving to the control side. Choice assays conducted with the olfactometer set-up revealed that some compounds were strongly repellent to several aphid species (Figure 5).

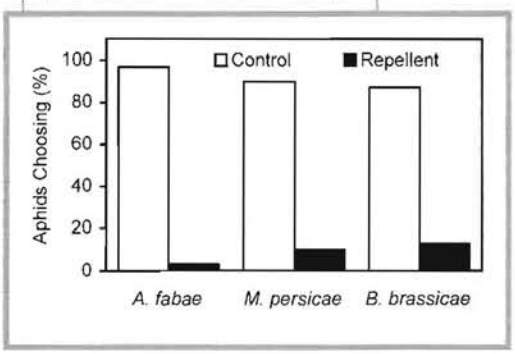
In order to prevent aphids from settling on a host plant, these repellents should be able to "outcompete" the attractive odour of the host plant itself. Therefore, repellents were applied on host plants and aphid settling was studied.

EFFECT OF REPELLENT COMPOUNDS ON APHID SETTLING ON THE HOST PLANT

Leaf discs of Chinese cabbage plants were dipped in a solution of a repellent compound or a control solution. The two leaf discs were placed in a petri dish on a layer of agar and ten aphids were released

CROP PROTECTION

Figure 5 - Responses of three aphid species, *Aphis fabae, Myzus persicae* and *Brevicoryne brassicae*, to a repellent odour in olfactometer assays



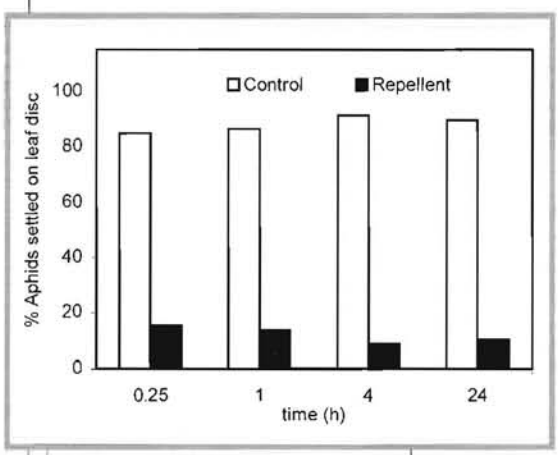


Figure 6 - Dual-choice assay showing that aphids (*Myzus persicae*) prefer control leaf discs over leaf discs treated with repellent odour

in the dish. In this way aphids could choose to settle either on the treated leaf disc or on the control. It could be shown that several of the previously selected repellents prevented aphids from settling on the treated leaf discs (Figure 6).

To study the effect of repellents under field conditions an experiment with roses was carried out. Roses were sprayed weekly with a formulation of repellent in mineral oil. Water, mineral oil, or the insecticide imidacloprid served as control treatments.

After natural infestation the numbers of aphids per shoot were recorded (Figure 7). In this experiment, the level of aphid control by the repellent was comparable to imidacloprid.

At present several field and greenhouse experiments are conducted in order to evaluate the efficacy of aphid repellents more extensively.

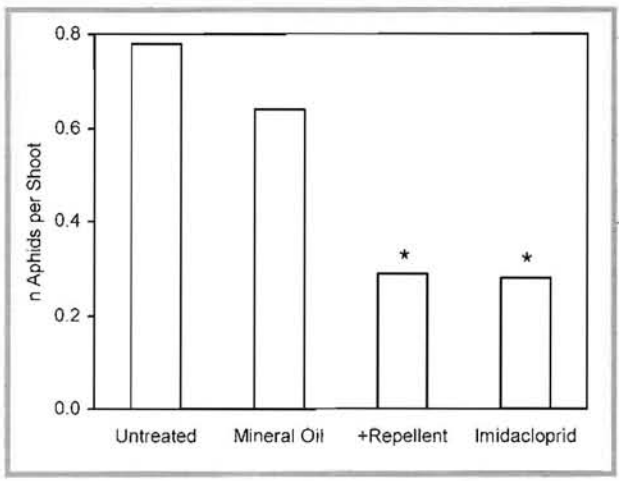


Figure 7 - Effect of a repellent odour on aphid colonisation of roses under field conditions

CONCLUSION

Research on repellent odours for aphids shows that these odours can be useful for aphid control. Future research will focus on the development of efficient applications for commercial use.

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