



Are carrots able to tolerate some carrot psyllid feeding without considerable yield loss? Is it possible to develop an ecological control method of carrot psyllid based on push-pull strategy? This was recently investigated in a Finnish study.

Looking for ecological control of carrot psyllid

Overwintered adult carrot psyllids (*Trioza apicalis*) start phloem-feeding on carrot immediately after entering carrot fields, and the damage symptoms (curled leaves, stunted growth) become visible on average in two days. The migration flight from conifers to carrot fields continues for several weeks in June-July. Therefore, crop covers are the only effective method to protect the yield in organic farming.

In conventional farming several insecticide treatments are used annually to control carrot psyllids in the main carrot cultivation areas. Even after control measures were applied 3–18 % of carrots were moderately or seriously damaged (leaf damages exceeding 15 %) in conventional carrot fields in 2005–2006 in Finland. The aims of this study were to determine if carrots are able to tolerate some carrot psyllid feeding without considerable yield loss, and to assess the

possibility of developing an ecological control method of carrot psyllid based on a push-pull strategy*.

Difficult to monitor

In Finland carrot psyllid flight is monitored by yellow sticky traps changed once a week. However, conventional farmers complain that a week is a too long monitoring period, resulting in delayed application of control measures. Another problem is to define the beginning of the flight of carrot psyllid. Several *Trioza*-species are caught in the traps in May-June. The most difficult species to distinguish from *Trioza apicalis* is *T. anthrisci*, which lives on cow parsley (*Anthriscus sylvestris*) and apparently does not damage carrot.

Carrots are vulnerable at early growth stages

One gravid carrot psyllid female feeding for three days on a carrot seedling at

cotyledon stage reduced the carrot yield at harvest on average 35 % whereas three psyllids feeding for three days was needed to cause significant yield loss at the one-leaf stage. Yellow, purple and bronze discolouration appeared in leaves over one month after the psyllids were removed. Therefore, a part of the symptoms could be caused by a plant disease, such as phytoplasma infection.

An attractive cultivar was found

Carrot psyllids preferred an old yellow-rooted cultivar over Splendid (hybrid cultivar) in a two-choice egg laying test. For four cultivars, Splendid, Parano, Panther, and Napoli, a negative linear correlation was found between numbers of eggs-laid and limonene concentration of leaf essential oils. However, in larger data concerning 15 cultivars (majority non-hybrids) and wild carrot, no correlation was found. Possible trap crops were searched among carrot cultivars



since carrot psyllids prefer cultivated carrot among *Apiaceae*-species. Non-hybrid cultivars were studied since they would be economical as a trap crop owing to cheaper seeds. In addition to trap crop, the use of repellents could help preventing the carrot psyllids damage. However, the repellent effect of limonene or a mixture of limonene and carvone was not shown in greenhouse experiments, even though it was previously observed in the field in Swedish experiments.

High light intensity attracts carrot psyllids

One possible reason to the failure to show repellent effect of limonene in greenhouse was that carrot psyllids were strongly attracted to higher light intensity in laboratory. The effect of light intensity on host plant selection of carrot psyllids was studied, since carrot psyllid behaviour varied from experiment to experiment in different laboratory and greenhouse assays. The strong attraction especially of virgin individuals to higher light intensity may be connected to their migratory behaviour, since virgin adults make up the migrating cohort in nature. Another explanation is that the continuous rearing of carrot psyllid on summer host only may alter their behaviour. Therefore, I recommend conducting the behavioural assays of carrot psyllid in the field.

Research on carrot injuries continues

During the season 2007, the effect of a three-day feeding period of carrot psyllids on carrot seedlings at one-, two- and four-leaf stage was studied on carrot yield. The discolouration symptoms were also observed in these experiments and the possible phytoplasma infection is being investigated. Major sugars and phenolic compounds were analysed from damaged and healthy roots to assess the internal quality of the carrots. These

results will be published later on.

Conclusions

The results suggest that a one-week trap replacement period, which is the current practise in carrot psyllid monitoring, is too long at the early growth stages of carrot. Regardless of the oviposition (laying of eggs) preference for a certain carrot cultivars, the possibility of a functional push-pull control strategy based on limonene seems unlikely, since the repellent effect of limonene could not be verified. However, reliable behavioural assays with carrot psyllid turned out to be difficult to conduct in laboratory or greenhouse conditions, since this species reacts to very small changes in light intensity. Therefore, further field studies

with possible repellent compounds, such as winter host volatiles, will be needed to develop an efficient ecological control method for this species. ■

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* Push-pull strategies involve the behavioral manipulation of insect pests and their natural enemies via the integration of stimuli that act to make the protected resource unattractive or unsuitable to the pests (push) while luring them toward an attractive source (pull) from where the pests are subsequently removed.