PREVENTIVE CONTROL OF APHIDS IN ORNAMENTAL PLANTS WITH COMPLEMENTARY PARASITOIDS

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SUMMARY

Biological control of aphids can be achieved with parasitoids. A parasitoid is a wasp able to parasitize aphids in a host-specific way. These natural enemies of aphids are used in organic or integrated pest management strategies. In order to apply the matching parasitoid against a given aphid species, the aphid has to be detected in the crop and subsequently identified. By the time the aphids are spotted by the grower and then identified by himself or a specialist, it is usually more difficult to gain control over an increasing aphid population.
Viridaxis developed a new concept of aphid control, based not on the species identified but on the crop treated. There was a need for a product controlling the largest possible spectrum of aphid species susceptibly present in ornamental crops. As the first step of development, an inventory of the aphid species attacking ornamental crops was made in various regions. A unique cocktail of parasitoids species (OrnaProtect) controlling all these aphids was then developed.
OrnaProtect contains six different species of natural aphid enemies, and is able to control all commonly appearing aphids attacking ornamental crops. The fact of mixing different species not only covers the entire spectrum of aphids, but also contributes to prolonged hatching. To reinforce this long lasting emergence, mummies of different ages are mixed, older mummies (stored at low temperature) emerging earlier after release than young mummies. With that prolonged hatching dynamics, a release every two weeks assures a permanent presence of fresh adult parasitoids in the crop.
The ready-to-use units of OrnaProtect contain an integrated feeding point which contributes to longevity and efficiency of the parasitoids. Its application in the crop is much faster than even any chemical treatment.
Here, we show the results of trials made with OrnaProtect in 2011 on several crops (*Hydrangea macrophylla, Solanum jasminoides, Argyranthemum frutescens* and *Osteospermum ecklonis*).
OrnaProtect controlled the aphids in all trials. In one trial, aphids were already present at the time of first release and a localized treatment on about ten plants, compatible with beneficial insects, was applied. After that, an excellent control of the aphids was achieved by the parasitoids. In the other trials, when used in a really preventive way (no aphid at the time of first release, the aphid population was immediately controlled and all plants could be sold as first quality plant without any insecticide treatment.

Key words: natural aphid control, parasitoid cocktail, prolonged hatching, ready-to-use units, integrated pest management

INTRODUCTION

Aphids are one of the most important pests on ornamental crops. They can reduce production of marketable plants and their impact on the visual aspect of the plants can impair commercialisation. Their simple presence is already a problem since the consumers' tolerance for aphids is very low. Aphicide application is the most commonly used control method against aphids. However, each year, more pesticides are withdrawn from the market and banned from use in different crops. With the few remaining allowed active substances, resistant strains of aphids appear always faster (Foster *et al*., 1998). In addition, most of the

growers realize that systematic chemical treatment presents risks for the environment, the consumers, and themselves, and a growing pressure is coming from new legislations as well as from the consumers to dispose of more environmentally friendly products. For all these reasons, biological or integrated pest management is the most sustainable solution and is increasingly adopted by growers.

The biological control of aphids can be done with parasitoid wasps (Order: *Hymenoptera*, Family: *Braconidae* (subfamily: *Aphidiinae*) and *Aphelinidae*). The result of the parasitism is the mummification of the aphid (a mummy is the pupae of the parasitoid enclosed in the aphid cuticle). In culture and market of ornamental plants, aphid (and aphid visual evidences such as exuviae or honeydew) tolerance is very low. The same is true for visual evidences of beneficial insects (mummies). It is thus necessary to adopt a preventive strategy to keep insect populations as low as possible, ideally under the observation threshold.

Parasitoids have a high detection capacity allowing them to find isolated aphids or winged aphids entering the greenhouse. This capacity makes them the best preventive tool against aphids. Parasitoid species can arrive in the greenhouse naturally but almost always too late to perform an effective control of aphids. It is thus necessary to release parasitoids in due time (augmentative biocontrol). However, as the host range of each species of parasitoid is limited, a grower has to know which species of aphid is/are present to know which species of parasitoid he has to release. By the time the aphids are spotted by the grower and then identified by himself or a specialized technician, the aphids continue to develop and the control is much more difficult to reach on a growing aphid population. To solve this problem and to be really preventive, that is that the right parasitoids are present in the crop before aphids arrive, Viridaxis developed a cocktail (OrnaProtect) containing six species of aphid parasitoids (*Aphidius colemani, A. ervi, A. matricariae, Ephedrus cerasicola, Aphelinus abdominalis* and *Praon volucre*) which have been shown to parasitize the most frequent aphid species found on ornamental plants (Table 1). Table 1 shows how the parasitoid species present in OrnaProtect are effective and complementary for the control of aphids that can be observed on ornamental plants.

An innovative release device has been developed by Viridaxis to apply parasitoid mixes in the field in a user-friendly manner (de Menten, 2011). OrnaProtect is a cardboard tube containing mummies of the six parasitoid species. It contains a feeding point (honey), allowing the emerging parasitoids to feed before they start to search aphids in the greenhouse. The feeding of parasitoids has been shown to increase their lifespan (El Heneidy *et al*., 2008). OrnaProtect contains six different parasitoid species to be effective on a wide range of aphid species. Besides covering a high spectrum of aphids, another advantage of the mix is that, due to different cycle characteristics (mainly lag time before emergence begins and lifespan), the emergence of parasitoids is spaced in time, assuring a permanent presence of fresh adult parasitoids in the crop between two releases (Rosemeyer *et al*., 2011). To reinforce the long lasting emergence, mummies of different ages are mixed, older mummies (cold stored) emerging earlier after release than fresh mummies.

Here, we show the results of trials made with OrnaProtect in 2011 in Germany on several crops in heated greenhouses (*Hydrangea macrophylla, Solanum jasminoides, Argyranthemum frutescens* and *Osteospermum ecklonis*).

Table 1. List of the main aphids found on ornamental plants based on a survey made in 2009-2010 on several ornamental crops (*Hydrangea, Cyclamen, Chrysanthemum, Begonia, Kalanchoe, Muehlenbeckia*…) in Germany, France and Belgium. Host specificity of the six species of parasitoids of OrnaProtect for the control of the main species that can be found on ornamental plants.

Aphid/ parasitoid species	*Aphidius colemani*	*Aphidius ervi*	*Aphidius matricariae*	*Aphelinus abdominalis*	*Ephedrus cerasicola*	*Praon volucre*
Aphis fabae	*x*		*+*	*x*		*+*
Aphis gossypii	*+++*		*++*	*x*	*x*	*+*
Aulacorthum circumflexum		*+++*	*x*	*++*	*++*	*++*
Aulacorthum solani	*x*	*++*	*x*	*++*	*+++*	*++*
Brachycaudus helichrysi	*x*	*x*	*x*	*x*	*x*	*x*
Macrosiphum euphorbiae	*x*	*+++*		*+++*		*+++*
Macrosiphum rosae	*x*	*++*		*++*		*+++*
Myzus ascalonicus			*x*	*x*	*x*	*x*
Myzus ornatus	*++*	*x*	*++*		*x*	*+*
Myzus persicae	*+++*	*+*	*++*	*++*	*++*	*++*
Rhodobium porosum		*++*		*+++*	*x*	*x*

The table lists the most important aphid species attacking ornamental plants (left column, in bold are the most common species or those which are economically important). The parasitoids present in OrnaProtect are listed in the first line. Their efficacy in the control of the different aphids is indicated by '+' for proven control under field conditions (+++: very high efficacy, ++: high efficacy, +: good efficacy) or 'X' for control under laboratory and semi field conditions.

MATERIALS AND METHODS

Trial setting

Trial 1: Hydrangea macrophylla

The trial was conducted in a heated greenhouse of 1800 m² in Geldern (Germany). The plants were introduced in the greenhouse as overwintering plants in pots (without leaves) in December 2011. OrnaProtect tubes were installed every two weeks at a rate of 1 tube for 200 m² (1.2 individuals/m²) from January to April 2012 on nine fixed release points.

Trial 2: Solanum jasminoides

The trial was conducted in a greenhouse of 500 m² with *Solanum jasminoides* mother plants (used for cuttings) in Kempten (Germany). OrnaProtect tubes were installed every two weeks at a rate of 1 tube for 200 m² (1.2 individuals/m²) from mid-February to July 2012 on three fixed release points.

Trial 3: Argyranthemum frutescens and Osteospermum ecklonis

The trial was conducted in two different greenhouses of 1000 m² with mixed *Argyranthemum frutescens* and *Osteospermum ecklonis* in pots in Straelen (Germany). In one glasshouse, OrnaProtect tubes were installed every two weeks at a rate of 1 tube for 200 m² (1.2 individuals/m²) from mid-February to April 2012 on five fixed release points. In the second glasshouse, the usual management of the grower was applied (chemical control if needed).

Trial monitoring

Each trial site was monitored every two weeks to evaluate the level of infestation of aphids and the presence of mummies of parasitoids. In each greenhouse 25 randomly chosen plants of each species were examined using the evaluation key shown in Table 2. The proportion of plants present in each counting class was then computed. Additional qualitative observations were done at each visit: aphid identification, mummies identification, state of the plants, presence of honeydew, good utilization of the tubes... The use of chemical treatments was also recorded.

Table 2. Key for aphid and mummies counting.

	Key for aphid "intensity"		Key for mummy "intensity"
0	Absence of aphids	0	absence of mummies
1	1-4 aphids per plant present	1	1-2 mummies per plant present
2	5-10 aphids per plant present	2	> 2 mummies per plant present
3	spot with colonies	3	> 10 mummies per plant present

RESULTS AND DISCUSSION

At the beginning of the trial with *Hydrangea macrophylla* (Figure 1), 8 % of the plants were already infested with *Aulacorthum solani*, which is not ideal since parasitoids are mostly efficient as preventive tool. After one month, up to 30 % of the plants had some aphids (level 1-2) and only 4 % had more (level 3). At this time, the first mummies of *Aphidius sp.* appeared but the grower applied a localized pirimicarb treatment on those few plants (~10 pots) with level 3. Two weeks later, the proportion of plants with aphids decreased to 15 % (level 1 only) and 30 % of the plants had mummies (level 1 for most of them, some level 2). The treatment was most probably not necessary because most the aphids treated were already parasitized. Indeed, mummies appeared also (level 2) on those treated plants. After two additional weeks, aphids totally disappeared. In March, very few unparasitized aphids could be seen. At the time of sale, no economic loss was recorded.
In the trial with *Solanum jasminoides* (Figure 2), the trial started in excellent conditions (no aphid was present). The first aphid (a winged *Aulacorthum solani*) was observed the 21th of March. In mid-April, 20 % of plants had isolated aphids and the first mummies appeared. End of April, the proportion of plants with aphids reached 65% but with only 4% at level 3.Two weeks later, the proportion of plants with aphids was 85% but there was no plant at level 3 anymore and the proportion of plants with mummies reached 72% (level 1-2). After two additional weeks, the proportion of plants with mummies reached its maximum (76%, level 1-2) and there was no aphid anymore. After that, the proportion of plants with mummies decreased and no aphid could be seen until the end of the trial. From mid-May to mid-June, some fresh mummies could be seen at each visit. This can be explained by the immediate

parasitism of all the aphids arriving the greenhouse during this period in order that these aphids could not reproduce. In this trial, no aphicide application was needed in contrast to other greenhouses in the same company where several chemical treatments were needed to control the aphid population on *S. jasminoides*.

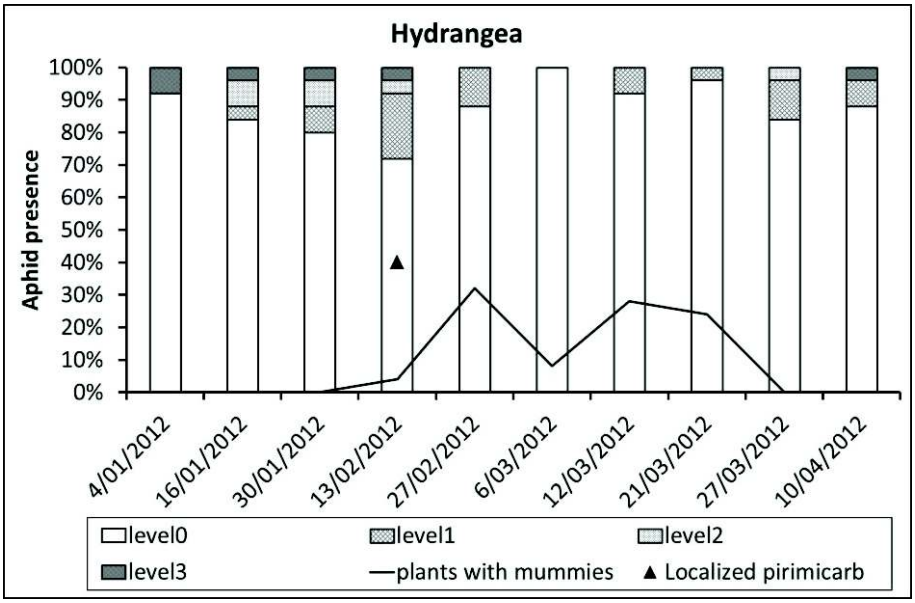

Figure 1. Proportion of plants with aphids and mummies in the trial with *Hydrangea macrophylla*. Aphid "intensity", level 0: no aphid, level 1: 1-4 aphids/plant, level 2: 5-10 aphids/plant, level 3: spot with colonies.

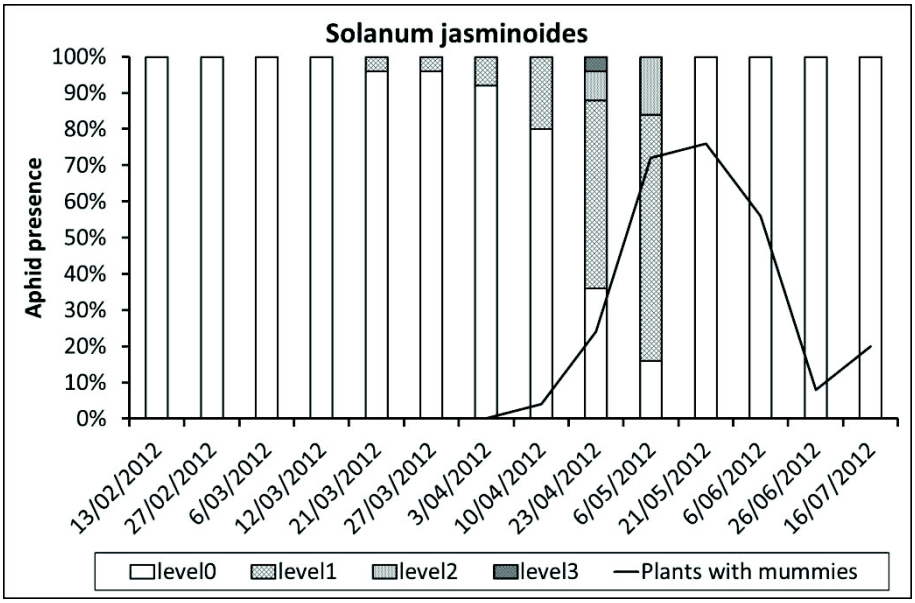

Figure 2. Proportion of plants with aphids and mummies in the trial with *Solanum jasminoides*. Aphid "intensity", level 0: no aphid, level 1: 1-4 aphids/plant, level 2: 5-10 aphids/plant, level 3: spot with colonies.

In the trial with *Argyranthemum frutescens* and *Osteospermum ecklonis* (Figure 3), the conditions at the start were optimal (no aphid in both greenhouses). In the greenhouse with OrnaProtect, an excellent control of the aphids (*Aulacorthum solani*) was observed. A small proportion of plants with mummies (level 1) could be seen from end of March to end of April with only once 8% of plants with one or two aphids. In the control greenhouse (without OrnaProtect, chemical treatment when needed), the first aphid was observed the 10th of March. One week later, according to the grower, the proportion of plants with aphids rapidly increased to approximately 35 % and he decided to make a generalized pirimicarb treatment. The treatment was efficient and no living aphid could be seen the week after.

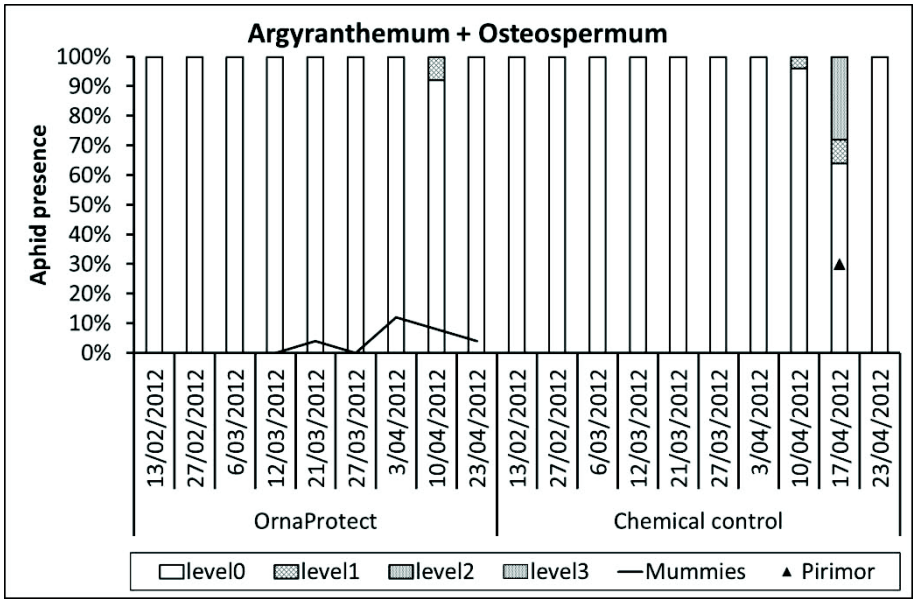

Figure 3. Proportion of plants with aphids and mummies in the trial with *Argyranthemum frutescens* and *Osteospermum ecklonis*. Aphid "intensity", level 0: no aphid, level 1: 1-4 aphids/plant, level 2: 5-10 aphids/plant, level 3: spot with colonies.

CONCLUSION

In the three trials, a very good control of the aphids was observed. When used in a really preventive way (no aphid at the time of first release: Trial with *S. jasminoides, A. frutescens* and *O. ecklonis*), the control was rapidly achieved. This allows to keep a low density of aphids and also a low density of mummies, which is important at the time of sales. It must be noticed that the real proportion of plants with mummies is most probably underestimated. Indeed, one of the parasitoid species included in the mix, *Ephedrus cerasicola*, has the particularity to modify the aphid behaviour. It has been observed that aphids parasitized by this parasitoid species hide (for example under the pots) before mummification occurs (Thielemans *et al*., 2012). As a consequence, the mummies are difficult to find, and this is, of course, an advantage in ornamental plants. In the trial with *H. macrophylla*, it took longer for the control to be achieved at the beginning because of the presence of some aphid colonies at the time of first release. During the first weeks, the population of aphids has slowly spread without any visual evidence (mummies) of control by the parasitoids. This situation led the grower to make a treatment compatible with beneficials on the ten most infested plants. Indeed, parasitoids can be integrated in an integrated pest management program and allow the use of some active substances when needed. However, in this case, the treatment was most probably not necessary. Indeed, the number of mummies the week after was quite high on those treated plants. This means that the aphids treated were already parasitized (but not yet mummified) for most of them. In the two other trials, no insecticide had to be used during the entire production cycle and there was no economic loss due to aphids.

ACKNOWLEDGEMENT

We thank all growers implied in trials for their availability and for their trust.

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