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The use of a mix of parasitoids to control all aphid species on protected vegetable crops

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Abstract: Viridaxis is a Belgian company which developed a new, plant-less way of mass-rearing aphid parasitoids. Due to its innovative and unique technology, Viridaxis has been able to add one new selected parasitoid species every year. A parasitoid is a wasp able to parasitize aphids in a relatively host-specific way. These natural enemies of aphids are used in organic and/or Integrated Pest Management (IPM) 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. To protect vegetables against their main aphids, VerdaProtect contains six different species of natural aphid enemies. When used preventively, it is able to control all commonly appearing aphids attacking vegetable crops. Here, we show the results of trials conducted in 2011 in sweet pepper crops. In Germany, the comparison of the VerdaProtect strategy with the "traditional" biological strategy based on single species release showed that the VerdaProtect strategy was as efficient as the traditional strategy in controlling aphids but was much easier, less time consuming and also much cheaper. The trial in a company growing sweet pepper in a large scale hydroponic greenhouse in integrated pest management in The Netherlands showed a high efficacy of the parasitoid mix and contrary to the widely used banker plants strategy, it did not encounter the widespread hyperparasitoid problem.

Key words: natural aphid control, parasitoid cocktail, prolonged hatching, ready-to-use units, banker plants

Introduction

Aphids such as the glasshouse potato aphid (*Aulacorthum solani*) or the cotton aphid (*Aphis gossypii*) are one of the most troublesome pests in the production of greenhouse vegetables (sweet pepper, cucumber, eggplants, etc). The chemical control of aphids is becoming more and more difficult since the number of available active substances as well as the accepted maximal residue level is constantly reduced. In addition, the insecticide multiresistance problem becomes critical for several aphid species (Foster *et al.*, 1998). Biological or Integrated Pest Management (IPM) is the most sustainable and tends to become the most frequent way to produce vegetables. Biological control of aphids can be achieved with parasitoid wasps (Order: Hymenoptera, Family: Braconidae (subfamily: Aphidiinae) and Aphelinidae). These insects have a good capacity to detect even isolated aphids which allows using them as a preventive strategy. Parasitoids are used since several decades as single species but the strategies still know some weaknesses. Traditionally, two main solutions are available to release parasitoids in a greenhouse. The first one is to spread in the crop the mummies of single species (mainly *Aphidius colemani* or *A. ervi*) mixed with buckwheat hulls or wood sawdust. This method is somewhat laborious. And, as the host range of each species of parasitoid is limited, the aphid species has to be identified to apply the right parasitoid. In addition, this method raises concerns about the real preventive character of the release since the first release is generally done after aphid detection and identification. During this loss of time, the aphids continue to develop and the control is much more difficult to reach on a growing aphid population. The second method is the use of banker plants. Banker plants serve as a reservoir of parasitoids in the greenhouse by providing them with an alternative non pest host (generally a cereal aphid on wheat or barley). This strategy is preventive as long as the aphids arriving in the greenhouse are accepted by the parasitoids reared on the banker plants. It is, indeed, difficult to rear more than one parasitoid species on a banker plant. Moreover, it has been recently demonstrated that the banker plants system attract a considerable number of secondary parasitoids (hyperparasitoids) which often results in the failure of the biological control (Nagasaka *et al.*, 2010).

Table 1. List of the main aphids found on vegetables based on a survey made in 2009-2010 on several vegetables crops (sweet pepper, eggplant, tomato, cucumber) in different European countries. Host specificity of the six species of parasitoids of VerdaProtect for the control of the main aphid species that can be found on vegetables.

Aphid/Parasitoid	*Aphidius colemani*	*Aphidius ervi*	*Aphidius matricariae*	*Aphelinus abdominalis*	*Ephedrus cerasicola*	*Praon volucre*
Acyrtosiphon pisum	x	++				+++
Aphis craccivora	+++		++	x		+
Aphis fabae	+		+	x		+
Aphis frangulae	+++		++		x	+
Aphis gossypii	+++		++	x	x	+
Aphis nasturtii			++			+
Aphis spiraecola	++		++	x		x
Aulacorthum circumflexum		+++	x	++	++	++
Aulacorthum solani	x	++	x	++	+++	++
Macrosiphum euphorbiae	x	+++		+++		+++
Myzus ascalonicus			x	x	x	x
Myzus nicotianae	+		+++		x	x
Myzus ornatus	++	x	++		x	+
Myzus persicae	+++	+	++	++	++	++

The table lists the most important aphid species attacking vegetable plants (left column, in bold are the most common species or those which are economically important). The parasitoids present in VerdaProtect 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.

In order to solve all these problems, Viridaxis developed a cocktail (VerdaProtect) 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 vegetable plants (Table 1). With the six species no aphid identification is required.

An innovative release device has been developed (de Menten, 2011) by Viridaxis to apply parasitoid mixes in the field in a user-friendly manner. VerdaProtect (Figure 1) 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.

Figure 1: VerdaProtect in a sweet pepper crop and in a cucumber crop. VerdaProtect is a cardboard tube containing a mix of aphid parasitoid mummies. The perforated plastic lid (closed during shipment) allows the parasitoids to exit after hatching. After opening, installation of VerdaProtect is easily done with a small wood stick.

VerdaProtect is to be used preventively (first release within the two weeks after plantation) and thanks to the long lasting emergence of the mummies (mummies of different ages are mixed, older mummies emerging earlier after release than fresh mummies. See Rosemeyer *et al.*, 2011), a release every two weeks ensures the permanent presence of fresh parasitoids of the six species in the crop.

VerdaProtect has been tested in different European countries, in plain soil and hydroponic cultures and in several types of vegetables including sweet pepper, eggplant, tomatoes and cucumber. We observed an excellent control of aphid populations incuding *Aphis gossypii, Macrosiphum euphorbiae* and *Aulacorthum solani.*

Here, we describe the results of two trials made in 2011 on sweet pepper in Germany and the Netherlands.

Material and methods

Comparison of "traditional" biological method vs. VerdaProtect in plain soil pepper crop in unheated tunnel

In two similar 800m² tunnels in an organic farm in Bornheim (Germany), a sweet pepper crop was implanted in plain soil in May 2011. In one tunnel, VerdaProtect tubes were installed every two weeks at a rate of 1 tube for 200m² (1.2 individuals/m²) from May to October. In the other tunnel ("traditional"), *Aphidius ervi* were dispersed on the crop with buckwheat at a preventive rate of 0.25 individuals/m² in May. Then, according to the aphid species found and to the infestation level, other beneficials were released (*Aphidius colemani*, *Aphidoletes aphidimyza*, *Episyrphus balteatus*). Regular visits in both greenhouses were done in order to assess the state of the crop, the aphid pressure and the beneficial insects' efficacy. Temperature data (minimum, maximum and mean temperature) were also recorded during the summer period (June to September) to check for efficiency of the beneficials at high temperature.

Parasitoid mix trial in a hydroponic pepper culture under Integrated Pest Management

The yellow sweet pepper was implanted in October 2010 in a 1.4ha heated greenhouse with an automatized hydroponic system. Banker plants with *Aphelinus abodominalis* were used before the start of the trial period (until March 2011). Parasitoid mixes were applied between March and October 2011. Regular visits were done in order to assess the state of the crop, the aphid pressure and the beneficial insects' efficacy.

Results and discussion

Comparison of "traditional" biological method vs. VerdaProtect in plain soil pepper crop in unheated tunnel

Four different aphid species were observed in both tunnels along the whole growing season: *Aphis nasturtii, Aphis gossypii, Macrosiphum euphorbiae* and *Myzus persicae*. With VerdaProtect, the four species can be controlled (Table 1). On the other hand, in the "traditional" tunnel, two parasitoid species (*A. ervi* and *A. colemani*) and two predator species (*Episyrphus balteatus* and *Aphidoletes aphidimyza*) had to be released in order to cover all the aphids that appeared during the growth season.

In both tunnels, the aphid pressure never reached the economic damage threshold. In both tunnels also, most of the mummies found were from *Aphidius spp.* and *Praon volucre* (naturally occuring *Praon volucre* in the "traditional" tunnel). In the "traditional" tunnel, however, the release of two species of parasitoids was not sufficient and several curative releases of predators had to be done to reach the same control level as in the VerdaProtect tunnel. The natural presence of ladybeetles in both tunnels in the summer also contributed to the control of the aphids. In both tunnels, no losses in harvest due to aphids were recorded.

The temperature recorded in the tunnels from June to September varied between 8.6 and 41.6°C (Table 2). Despite this very high temperature, no parasitoid mortality was recorded and the rate of parasitism remained high during all the summer period.

In conclusion, the two strategies gave good results with no damage to the plant and a good control of the four species of aphids that appeared. However, the "traditional" strategy had the disadvantage to be much more time-consuming: aphid identification and installation of the beneficials (thirty minutes to one hour per tunnel for each beneficial release against five minutes for each release of VerdaProtect). The installation of VerdaProtect is also easier as the tubes are ready to use. The "traditional" strategy needs also a tighter monitoring. From an economic point of view, the VerdaProtect strategy is very cost effective.

Table 2. Minimum, maximum and mean temperatures in the tunnels during the summer.

	Min	Max	Mean
June	9.3	41.6	22.1
July	10.9	35	19.4
August	9.2	36.2	20.4
September	8.6	33.3	18.9

Parasitoid mix trial in a hydroponic pepper culture under Integrated Pest Management

Aphids appeared in the greenhouse during the all year: *Aulacorthum solani* (during the all year), *Aphis gossypii* (June) and *Myzus persicae* (October). A very good control was observed on isolated aphids and small spots. Only eight hotspots developed during the eight months of the trial on the 1.4ha of the greenhouse. These hotspots were generally well controlled by parasitoids (*Aphidius* spp., *Praon volucre* and *Aphelinus abdominalis*). According to our observations, a localized pirimicarb treatment was necessary only once in mid-September (a generalized treatment was however done). All the species of parasitoids of the mix were observed in the crop.

Formerly, the IPM strategy against aphids used in this company was banker plants. With this former strategy, the control of aphids generally failed in June-July due to the abundance of the hyperparasitoids. As a consequence, from June to the end of the crop in October, predators and/or chemicals had to be used to compensate the strongly reduced efficacy of parasitoids. This problem of hyperparasitoids is well known. In Japan, Nagasaka *et al.* (2010) showed that the hyperparasitation rate on banker plants in eggplants and pepper crops at the end of the season can reach 70%. In this trial, on 338 mummies collected on the field in October, hyperparasitoids only emerged from 11 of them (3.8%). The preventive use of parasitoid mix seems thus to be a good solution against hyperparasitoids. The reduction of hyperparasitoid presence is probably due to the very low density of parasitized aphids in the greenhouse.

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