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The use of mirids and anthocorid bugs as polyphagous predators in greenhouse crops

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Abstract: Polyphagous predators have shown to be a viable solution for IPM programs in vegetable crops. In this paper advantages and disadvantages of using polyphagous predators are discussed. We also summarize existing experiences on the use of refuge plants to implement conservation programs. Recent experiences conducted by our group for the conservation of mirid and anthocorid bugs in tomato and lettuce Mediterranean crops are explained. The presence of refuge plants in the crop margins can increase the abundance of those polyphagous predators, advance their presence in the crop and facilitate their establishment, contributing to control crop pests, besides to be also beneficial to other neighbouring vegetable crops.

Key words: biological control, anthocorid bugs, mirid bugs, polyphagous predators, refuge plants

Background

Greenhouse vegetables and ornamentals are attacked by a number of pests that are common among several crops, and application of biological control (BC) when based in the use of specific natural enemies (NE) can result in an expensive and complicated puzzle to solve. The release of specific NE was the strategy proposed in the 90's when companies producing beneficials started to grow up and offered biological solutions for greenhouse pests. They offered extensive lists of NE and the search for new species of beneficials became a race for gaining the market. But, the expansion of the control strategy was limited to few crops and to areas with growers that could afford it. Polyphagous beneficials were thought to be ineffective because their population growth was not perfectly matching that of a specific prey and could theoretically present a risk for other beneficials. However, the use of predatory mirid and anthocorid bugs, which are quite polyphagous, has represented an important step forward in the broad application of BC in vegetable crops in Europe and more specifically in the Mediterranean region (Albajes & Alomar, 1999).

Most polyphagous predators consume prey as immatures and as adults, in contrast with parasitoids, therefore both developmental stages are effective in reducing high pest densities that occur in greenhouse crops. Although they have their preferences for certain prey types and plants, they usually consume miscellaneous prey and are present in a range of plants in order to fulfil their nutritional needs. This behavior has the advantage that they can feed on a non-preferred prey up to a certain point when it is present in the crop, and prevent their expansion as a pest. Also, because they are not dependent on a single prey type, they can persist in the crop (agroecosystem) by feeding on other pests or on non-pest prey to maintain their populations. These characteristics enabled their use as BC agents to simplify the pest control in vegetable crops and greatly expanded the application of this control strategy (Leigh *et al*., 2010).

Advantages/disadvantages

There is a complex of mirid and anthocorid species, all native in the Mediterranean area, that spontaneously colonize vegetable crops when no broad spectrum insecticides are applied. These populations could be managed by developing conservation strategies in order to protect crops. This has been the case of the mirids *Dicyphus tamaninii* Wagner and *Macrolophus pygmaeus* Rambur in North-East Spain, where a control program was developed that has been applied for several years in open field and greenhouse tomatoes (Alomar & Albajes, 1996). In the case of anthocorids, a program based in the colonization of spontaneous populations of *Orius* spp. bugs on greenhouse peppers has been also applied in the South-East of Spain.

Their polyphagy allows them to easily adapt feeding on new prey in the agroecosystem, being then an important tool for facing the problem of the continuous appearance of invasive species. In many cases, these invasive populations of new pests are highly resistant to insecticides and no active ingredients are really effective against them, making NE the only effective method to control those pests. This has been the case of the recent invasion of tomato crops by the moth *Tuta absoluta* Meyrick in the Mediterranean region. The existence of a conservation program of mirid populations was effective in keeping the populations of this new pest under control in the North-East of Spain, and in the South-East of Spain, inoculative introductions of mirid bugs in greenhouses has been the most effective strategy for the control of this tomato leafminer (Zappala *et al*., 2013).

They have a long developmental time and this is a disadvantage for establishing their populations in vegetable crops, which have short cycles (Sanchez *et al*., 2009). Some introduction strategies have been developed to overcome this handicap, like the introduction of adults in seedlings with the aim of laying eggs on the small plantings and to have newly emerged nymphs in those plants when transplanting the seedlings. This strategy has been effective for the establishment of the mirid *Nesidiocoris tenuis* (Reuter) in tomato for the control of *T. absoluta* in the South of Spain (Zappala *et al*., 2013).

They need a certain level of prey in order to remain in the crop, to lay eggs and produce a new generation, which will be the one that should keep crop pests under control. But, in newly planted crops, the level of pests is usually low when the predator population has to be well established in order to be effective. The addition of factitious prey has allowed to overcome this problem and, in the case of mirids bugs, *Ephestia kuehniella* Zeller eggs or *Artemia* spp. cysts have proved to be a good strategy to keep the released adults in the crop and to feed them enough to lay eggs. This strategy has been applied in several greenhouse crops. For anthocorid bugs, the release of phytoseiid mites (*Amblyseius swirskii* Athias-Henriot or other species) in peppers have been conducted at the beginning of the crop for maintaining thrips and whitefly populations low as long as possible. At the same time, these mites are also used by *Orius* spp. as prey in order to grow its population and lay eggs in the crop while pepper plants reach the flowering stage and thrips and/or whiteflies populations reach a higer density level.

Some species of mirid bugs have been shown to cause damage to plants when prey is scarce due to their zoophytophagous habits. This can be an important handicap for their use because the balance between their high voracity for consuming prey, and therefore for controlling pests at high density, and the risk of causing yield loss when they have depleted the prey has to be worked out in order to use them properly. This is the case of *D. tamaninii* and *N. tenuis*. For the first species, a decision chart for tomato crops was developed relating the density of prey and predator populations at which the crop is safe or at which a treatment for reducing mirid population has to be performed (Castañé *et al*., 2011).

Implementation of conservation programs using refuge plants

Within Conservation Biological Control (CBC) programs, the importance of some non-cultivated plants that provide food (pollen, nectar, other prey), refuges and breeding sites for NE is increasingly recognized. The presence of the so called insectary or refuge plants in the vicinity of crops can increase their populations and lead to a better CBC (Messelink *et al*., 2014). The effectiveness of most NE is linked to an early establishment in the crop. Early colonization has been observed in many greenhouses and it has been related to the proximity of refuge plants. However, in early spring crops, spontaneous colonizations are not always sufficient and inoculations of predators are being done, as is the case of *M. pygmaeus* (De Backer *et al*., 2014; Perdikis *et al*., 2011).

Surveys conducted at IRTA have shown that the plants *Ononis natrix* and the pot marigold, *Calendula officinalis*, can hold important populations of the predator *M. pygmaeus*. Consequently, field margins with *O. natrix* and *C. officinalis* have been established by several growers in the region to promote the presence of this predator in their crops. Recent surveys indicated that another species of *Macrolophus*, *M. melanotoma* (Costa) is also hosted in these two plants. This last species is not known to be present in tomato or to be predatory, but it cannot be distinguished from *M. pygmaeus* by its external morphology. Recently, molecular methods have been developed to discriminate between them (Castañé *et al*., 2013). Therefore, unless conducting molecular analyses, it is not easy to determine the relative abundance of both mirid species in a particular insectary plant, which could interfere with the control program based on the colonization by *M. pygmaeus*. This situation revealed the need for more extended taxonomic studies that will enable, with certainty to recognize which is the entomophagous species that is being conserved. The use of molecular analyses has allowed to know that 13% of the mirid bugs found on *C. officinalis* were *M. melanotoma* and up to 64% on *O. natrix*. Furthermore, in the latter plant species some *Dicyphus* spp. and *N. tenuis* were also found.

Another CBC strategy tested in our group was the use of insectary plants to ensure the conservation of *M. pygmaeus* from the old to the new crop inside the greenhouse, acting as relay plants between crops. *Calendula officinalis* was able to keep populations of this predator when no crop was present, allowing also its reproduction. Placed between the tomato rows just after being transplanted, a greater abundance of *M. pygmaeus* was seen in the rows of tomatoes nearest to marigolds, matching or surpassing the commercial dose of inoculation. Thanks to the use of a topical marker applied to plants and insects, and the use of a molecular DNA analysis, it has been confirmed that predators collected on tomato plants were all *M. pygmaeus* coming from the marigolds. However, when using insectary plants the risk that pests or diseases are favoured by those plants has to be evaluated. The presence of *N. tenuis* in marigolds and tomato plants has been observed in some vegetable greenhouses. In these cases a chemical treatment was recommended to avoid starting the new crop with high populations of this polyphagous predator that could actually damage the crop when their populations were too high and the existing level of pest low (Arnó *et al*., 2010).

Pest control through the conservation of indigenous polyphagous NE has also great potential in other horticultural crops, such as lettuce. Plants as *Lobularia maritima* can favor the presence of *Orius* spp. and hoverflies, which are attracted by the flowers and colonize the crop, reducing levels of thrips (*Frankliniella occidentalis* Pergande) and aphids (*Nasonovia ribisnigri Mosley*). The use of molecular methods has allowed to identify the predator species present in the crop, being not just one, but a complex of several *Orius* and syrphid species (Gomez-Polo *et al*., 2013, 2014). These molecular methods have also confirmed their polyphagy under field conditions, showing that a high percentage of analyzed predators had fed not only on thrips and aphids, but also on other non-pest species present in the crop (Gomez-Polo *et al*., 2015a, b).

The creation and maintenance of margins with insectary plants can increase the abundance of NE, advance its presence in the crop and facilitate their establishment, contributing to control crop pests. Additionally, increasing the abundance of polyphagous NE in a particular crop may also be beneficial to other neighbouring vegetable crops.

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