Perspectives for functional agro biodiversity in Brussels sprouts

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Abstract: The commercial production of Brussels sprouts generally involves a high input of insecticides. Conservation biological control in this crop is hampered by the diversity of economic pests involved, and by the high economic losses associated with failing pest control. Within the Dutch Functional Agro Biodiversity (FAB) project, other methods of non-chemical pest control have also received attention. One of these methods is the identification and containment of local sources of winter pest propagation. Another method to prevent pests from entering the crop may be the growing trap plants in the field margins. Some possible trap plant species have been identified, but more studies are required to show the feasibility of this method. Finally, monitoring insecticide-free sprout plots with flowering field margins showed that during summer, natural enemies can contribute considerably, although not always sufficient, to the control of cabbage aphids and caterpillars. For cabbage whitefly some natural enemies have been identified, but in 2007 they arrived with too little and too late to have sufficient impact on the fast growing whitefly populations.

Key words: cabbage pests, conservation biological control, field margins, trap crops, winter host plants, regional pest control, natural enemies, diamondback moth, cabbage whitefly

Introduction

In a regional pilot on enhancing natural control in Dutch arable and vegetable cropping, called the Functional Agro Biodiversity (FAB) project (see Van Rijn et al., this volume), the focus was on three crops: wheat, potato and Brussels sprout. In Brussels sprouts the development and adoption of biological control methods are complicated by the high crop value and the number and nature of the pest species involved. The more specific problems and approaches related to this crop are discussed in this paper.

In Brussels sprouts pest species come from a range of insect orders: in our region especially aphids and whiteflies (*Brevicoryne brassicae, Myzus persicae, Aleyrodes proletella*), moths (*Plutella xylostella, Mamestra brassicae*), and (root) flies (*Delia radicum*). In some years, thrips and slugs may also cause significant crop losses. To control these pests (as far as possible) the farmers used to treat the plants with Imidacloprid before planting, and spray the fields 8 or 9 times a year with other insecticides (e.g. Lambda-cyhalothrin and Dimethoate). Within the framework of FAB three approaches have been addressed that may contribute to reduce the amount of insecticides applied: (1) Reducing pest pressure from local winter refuges, (2) trap cropping, and (3) enhancing biological control of pests. Whereas the first approach is discussed in a separate paper by Den Belder et al. (this volume), the other approaches are discussed below.

Trap plants for cabbage pests

One method to reduce the pest pressure onto a crop is to intercept pest insects on trap plants around the field before entering the crop. In order to develop and test this method, several plant species have been tested in the field as potential trap plants for diamondback moth and cabbage whitefly.

For diamondback moth (*P. xylostella*) two trap plant species were already known from literature: yellow rocket (*Barbarea vulgare*) and Indian mustard (*Brassica juncea* cv scimitar). Field cage studies (Badenes-Perez et al. 2004) have shown that both species are preferred as oviposition substrate over cultivated cabbage. Yellow rocket has the additional advantage of being unsuitable as host plant for the larvae, making it a rare example of a dead-end trap plant.

In the field Indian mustard appeared to be unsuitable due to its short life cycle compared to the growing season of Brussels sprouts. Yellow rocket, on the other hand, remains low during the first year and does not flower before the second year. We did find some *Plutella* eggs on these plants and only few small larvae, as was expected. Due to experimental problems we were unable to check the impact on pest pressure in the adjacent field, so further studies are required to confirm its suitability as trap crop.

For cabbage whitefly (*A. proletella*) no studies on trap plants were available yet. The selection of plants to be tested was based on a list of reported host plant species (NPAG 2001). We selected 10 species distributed over four plant families of which seeds were available. In 2007 each of these 10 species were sown or planted in two $9m^2$ meter plots adjacent to an experimental sprouts field.

The well-known host plant, *Chelidonium majus*, failed to germinate, as well as two other species. From the remaining 7 species the 4 non-cruciferous species and the cruciferous wallflower (*Erysimum cheiri*) did not attract any whiteflies, despite the high density of whiteflies in the adjacent field. Chinese cabbage, *B. campestris* var. *chinensis,* attracted some whiteflies, but only young kale plants, *B. oleracea* var. *acephala*, attracted many whiteflies. The latter plant may therefore be an effective trap crop, especially since killing off the pest on this host plant appeared to be feasible: Treating the plants with an experimental insecticide against cabbage whitefly killed 95% of the eggs.

Conservation biological control

Parasitoids are probably the main natural enemies of cabbage moths and butterflies, whereas (cabbage) aphids are also attacked by the larvae of hoverflies, lacewings and gall midges. As these natural enemies solely feed on sugar sources or pollen during their adult stage, they may benefit from growing suitable flowers in the field margins.

Materials and methods

Within the FAB project a 3 meter wide annual flower strip was sown adjacent to each target field (see Van Rijn et al., this issue). The flower species were selected for their suitability in providing (floral) food for the natural enemies and the low risk of supporting pests. The mixture included Buckwheat, Borage, Common Vetch, Coriander, Fennel, Cornflower, and Corn Marigold. To match the flowering period with the long growing period of Brussels sprouts the mixture was sown in May and supplemented with short Sunflowers.

The fields were sampled every 3 weeks in a fixed grid at various distances from the edge. At each monitoring row 20 Brussels sprouts plants were inspected, recording the pests and their natural enemies (if possible) per species and life stage. For early detection of diamondback moth, pheromone emitting delta traps were put in and around sprouts fields and checked every 2 weeks. The main results were quickly communicated with the farmers, to help them with pest management decisions. In addition to commercial fields, small experimental sprouts field with field margins have been created where no chemical insecticides were applied after planting, in order to evaluate the impact of natural enemies.

Results and conclusions

In the commercial fields a regular treatment with insecticides appeared to be inevitable. In the absence of selective pesticides, this left very little room to benefit from the field margins or from natural pest control in general.

In the experimental fields the numbers of natural enemies (especially hoverflies, gall midges and parasitoids) were, consequently, much higher than in the commercial fields. By the end of August, however, their numbers declined rapidly each year. In the experimental fields cabbage aphid (*B. brassicae*) levels remained low or at least stable during June, July and August. The numbers per plant fluctuated around 10 and 25 in 2004 and 2005 respectively. In 2007, when the plants were treated with Imidacloprid before planting, the average density was even less that one per plant. However, in all years the populations started to increase exponentially in early September, causing economic damage to the sprouts by November. The resurgence of the cabbage aphids in September when natural enemies, such as hoverflies, virtually disappear, suggests that natural enemies can play an important role in keeping the aphids under control during summer, although not always at a sufficiently low level, when Imidacloprid cannot be applied (see also Van Rijn et al., 2006).

Of all caterpillars, those from diamondback moth were the most numerous, especially in 2006 (when no experimental field was available) and 2007. In all years and months about 50% of the pupae appeared to be parasitized (mainly by *Diadegma semiclausum*). The experimental field was treated an few times with a *Bt* product, when the infection tended to surpass the action threshold. Ultimately no economic damage from this species to the sprouts has been observed.

Cabbage whitefly is a growing pest problem in the last five years in the Netherlands. This species seems unaffected by natural enemies, and by any insecticide registered for this crop. Two parasitoids have been identified so far: *Encarsia tricolor*, which occurred at very low percentages only, and *Encarsia inaron*, which have been observed in high numbers locally in Belgium only.

Laboratory studies with insects from commercial rearings (Koppert BV) confirmed that most predators are hampered by the wax on the surface the Brussels sprout plants (Eigenbrode 2004), especially when released by the whiteflies. For the predatory mite *Amblyseius swirskii* and the bug *Orius majusculus* their movement and attachment was strongly hampered by the wax. The larvae of the green lacewing *Chrysoperla carnea* could cope with the wax slightly better and were able to feed on the eggs and nymphs of the whitefly. A proportion of the larvae was even able to develop into adulthood on this prey. The legless larvae of the hoverfly *Episyrphus balteatus,* are apparently not hampered by the wax at all. These larvae were able to kill many whitefly eggs and some nymphs each day, and to develop into pupae and adults on this diet. Moreover, adult females were triggered to oviposit on plants with whiteflies, this in contrast to clean plants.

Field observations confirm these laboratory studies. Hoverfly eggs and larvae could be found on all sprout plants with high numbers of cabbage whitefly, even when aphids were absent. When some of the larvae were reared to adulthood, they yielded both *E. balteatus* and *Platycheirus peltatus*. Eggs and larvae of green lacewings could also be found on these plants. However, their numbers were too low, compared to the fast growing numbers of whitefly, to have a notable impact on this pest.

Discussion

When using Functional Agro Biodiversity as a means for pest control we can consider not only methods to augment natural enemies, but also methods to diminish pests directly. The reduction of pest refuges that can act as sources of reinfestation is one example at the landscape scale. Trap cropping is another example at the field level.

Implementation of the first method may be difficult as it requires concerted action of various growers in the region. The second method may be applied only after some technical issues have been solved. This require serious studies on *e.g.* (1) the attractiveness of trap plants relative to the crop at different stages of development, (2) the level of pest reduction within the crop that can be obtained and (3) the type of pest management needed to prevent secondary spread of the pest.

The conservation of natural enemies can only be effective when pesticides that are harmful for natural enemies are not or only incidentally applied. In a crop such as Brussels sprouts, where many pests have to be controlled at the same time, this is a challenging task. When measures at the landscape and farm level to support natural enemies and diminish pest pressure, are effective for some pests only, we may consider the efficient production and release of natural enemies against other pests, as well as the development of more predator-friendly (glossy) cultivars.

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References

Badenes-Perez, F.R., Shelton, A.M. and Nault, B.A. 2004. Evaluating trap crops for diamondback moth, *Plutella xylostella* (Lepidoptera: Plutellidae). Journal of Economic Entomology 97: 1365-1372.

NPAG (New Pest Advisory Group), 2001. Aleyrodes proletella, brassica whitefly. NPAG Data Sheet [www.pestalert.org].

Van Rijn, P.C.J., Kooijman, J. & Wäckers, F.L. 2006. The impact of floral resources on syrphid performance and cabbage aphid biological control. IOBC/WPRS Bulletin Vol. 29(6): 149-152.

Eigenbrode, S.D. 2004. The effects of plant epicuticular waxy blooms on attachment and effectiveness of predatory insects. Arthropod Structure & Development 33 (1): 91-102.