EVOLUATION OF APHIDOPHAGOUS LADYBIRD POPULATIONS IN A VEGETABLE CROP AND IMPLICATIONS AS BIOLOGICAL AGENTS

F. FRANCIS, P. COLIGNON, P. HASTIR, E. HAUBRUGE & C. GASPAR
Zoologie générale et appliquée, Faculté universitaire des Sciences agronomiques
Passage des Déportés 2, B-5030 Gembloux
e-mail: francis.f@fsagx.ac.be

ABSTRACT

Aphidophagous predators such as hoverfly and ladybird beetles are effective biological agents to control aphid pests in perennial and annual cultivated species. Introduction and conservation of beneficial insects are two ways to increase natural control of pests. Whether massive releases of entomophagous insects are expensive and time consuming, the preservation of predator natural populations can be expected by reducing and by adapting chemical treatments in crop fields. Vegetable cultivated areas increased in Belgium for several years, mainly Fabaceae species such as peas and beans. In this work, the evolution of ladybird species population was assessed from May to June in broad bean fields (*Vicia faba* L.) between Waremme and Hannut, in Hesbaye. Weekly, the aphid and aphidophagous beetle populations were collected from yellow traps and determined on plants by visual observations. Even if five ladybird species were identified, three of them represented more than 95% of the collected insects (*Coccinella septempunctata* L., *Propylea quatuor-decimpunctata* L. and *Psyllobora vingintiduopunctata* L.). Evolution of coccinellid populations during the cultivation season was discussed in relation to the presence of potential aphid preys and the agrochemical treatments which were applied. Integrated pest management in vegetable fields constitute a reliable way to increase the quality level of fresh vegetables in terms of pesticide residue limitations.

Key-words: aphidophagous ladybird, broad bean, yellow trap, insecticide, biological control

INTRODUCTION

Areas of diversified crop productions such as vegetables increased largely for the last decade in Wallonia. Vegetable crops constitute more than 65% of the Walloon horticultural areas and represent a third of the national vegetable production (APHW, 1997). In Hesbaye, the region we investigated, the vegetables cultivated areas increased with a 3-fold factor, leading to have more than 6000 ha in 1999. More than 30 % of the Walloon vegetables were produced in the Liège region (APHW, 1997). Fabaceae species such as pea, bean and broad bean are cultivated on 75 % of the available vegetable areas in Hesbaye and they are continuously present in agroecosystems. Peas and broad beans are sown from March, followed by beans in May. The use of *Medicago sativa* L. and *Vicia sativa* L. as green fertiliser also provide some alternative habitat for aphids. Every year, aphid infestations are largely observed in cultivated species and lead to the application of several insecticide treatments. In regard to the limitation of the pesticide residue occurrence in vegetables, alternative aphid control had to be develop to ensure safe quality products. To assess the impact of insecticide treatments on both pest and beneficial insects in vegetable crops, a monitoring of the entomofauna in broad bean was begun in 2000 and will continue in 2001. General results, in terms of insect diversity and density at the family taxonomical level were presented elsewhere (Colignon *et al.*, 2001 a,b). Here we focused on two insect families: the Aphididae and the Coccinellidae. The evolution of the aphid and ladybird populations were assessed in broad bean fields for the cultivation season by visual observations and using yellow traps. The effect of insecticide treatments on the entomofauna was discussed in relation to the role of aphidophagous ladybirds as biological agent in vegetable fields.

MATERIALS AND METHODS

A total of 72 yellow traps were weekly visited from May to July to assess the entomological populations (pests and beneficial species) in terms of both diversity and density depending on the insecticide applications (λ-cyhalothrin and pyrimicarb, both alone or in combination as Okapi commercial insecticide). Two sets of 3 traps in a triangle were placed in each field (in a treated and a control plots, 6 traps per field). Most of insects were identified until the family taxonomical level at the laboratory. Individuals belonging to the Coccinellidae and Aphididae families were determined until the species level. Visual observations on 20 plants per field (10 in control and 10 in treated plots) were weekly realised in the 12 investigated fields. Insects were brought in the laboratory to be determined.

Statistical analysis were performed using the Minitab (12.2 version) software. ANOVA were realised after a log (x+1) transformation of the data's (Dagnelie, 1973) followed by mean comparison test using the Tukey method when necessary.

RESULTS

In yellow traps, more than 8000 aphids were caught. The main species which was found was *Cavariella aegopodii* Scop., corresponding to 87,1% of the trapped aphids. *Aphis fabae* Scop. and *Acyrthosiphon pisum* Harris were also present at a 1.5 and 1.6 % rate respectively. According to a 2-way ANOVA, no significant interaction was observed for aphid populations in yellow traps between the treatment and week factors ($F = 0.79$ and $P = 0.608$). While no significant difference of aphid density was observed between treated and control plots ($F = 2.87$ and $P = 0.091$), the aphid number significantly differed depending on the considered week ($F = 41.15$ and $P < 0.001$). When one-way ANOVA were realised separately for each week, significant difference of aphid density between treated and untreated plots was observed only for week 6 ($F = 4.21$ and $P = 0.044$). The latter corresponded to the second week of insecticide applications in broad bean fields.

More than 1200 ladybirds were also trapped. *Coccinella septempunctata* L. represented 84,3% of the captures. *Propylea quatuorpunctata* L. (8,6%), *Adalia decempunctata* L. (4,8%) and *Psyllobora vigintiduopunctata* L. (2,1%) were also present in the traps. Only some individuals of *Adalia bipunctata* L. were found. Evolutions of aphid and aphidophagous ladybird populations caught in the yellow traps are presented in Figure 1A and B respectively. The mycetophagous *P. vigintiduopunctata* coccinellid was not included as beneficial predator in the graphs.

The ladybird density in yellow traps was significantly lower in treated plots than in untreated control plots ($F = 4.16$ and $P = 0.042$) but also significantly differed depending on the considered week ($F = 32.05$ and $P < 0.001$). One-way ANOVA was performed for each separate week. The coccinellid density in yellow traps was significantly higher in control than in treated plots during weeks 5 to 6 which corresponded to the insecticide application period ($F = 4.01$ and $P = 0.049$; $F = 6.97$ and $P = 0.010$ respectively). No significant difference of ladybird number in traps was observed for weeks 1 to 4 and 7 to 9 ($1.61 < F < 0.01$ and $0.208 < P < 0.918$).

Ladybird and aphid populations were also assessed for the bean cultivation season by visual observations (Figure 2 A and B). *A. fabae* corresponded to more than 98% of the observed aphids while 89% of the ladybirds belonged to the *C. septempunctata* species. According to the 2-way ANOVA using both week and treatment as factors, a significant interaction was observed for aphid populations between the two latter factors ($F = 5.79$ and $P < 0.001$). One-way ANOVA had to be performed using separately the week and treatment factors. The aphid density was significantly higher on plants in control than in treated plots whatever the insecticide treatment which was applied ($F = 33.19$ and $P < 0.001$). In regard to the cultivation duration, one-way ANOVA had to be performed for each week separately. While no significant difference was observed for weeks 1 to 3 and 8 to 9 ($0.33 < t < 2.59$ and $0.571 < P < 0.122$), the aphid density was lower on bean plants which were treated by insecticides than that on plants in control plants for weeks 4 to 7 ($4.11 < t < 42.19$ and $0.049 < P < 0.001$). Insecticide were applied during weeks 5 and 6, from 10th to 22th of June.

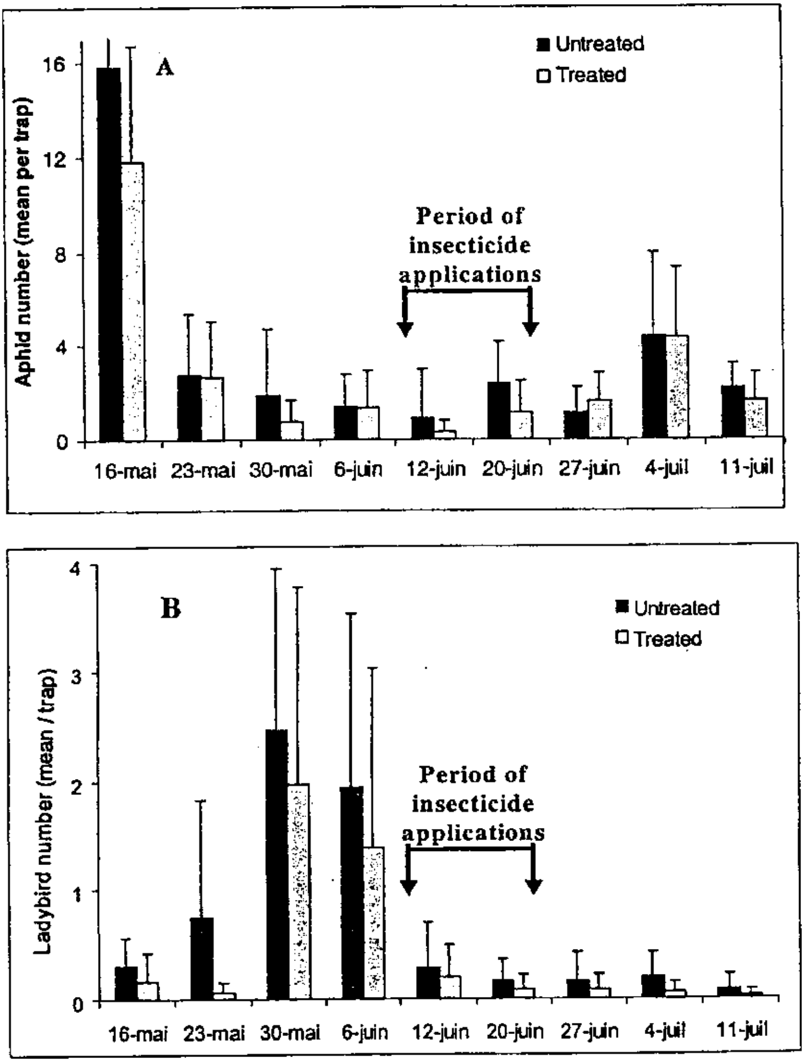

Figure 1: Evolution of the aphid (A) and ladybird (B) populations using yellow traps in control (untreated) and insecticide treated plots. Insecticide treatments were applied between the 10^{th} and 22^{th} of June.

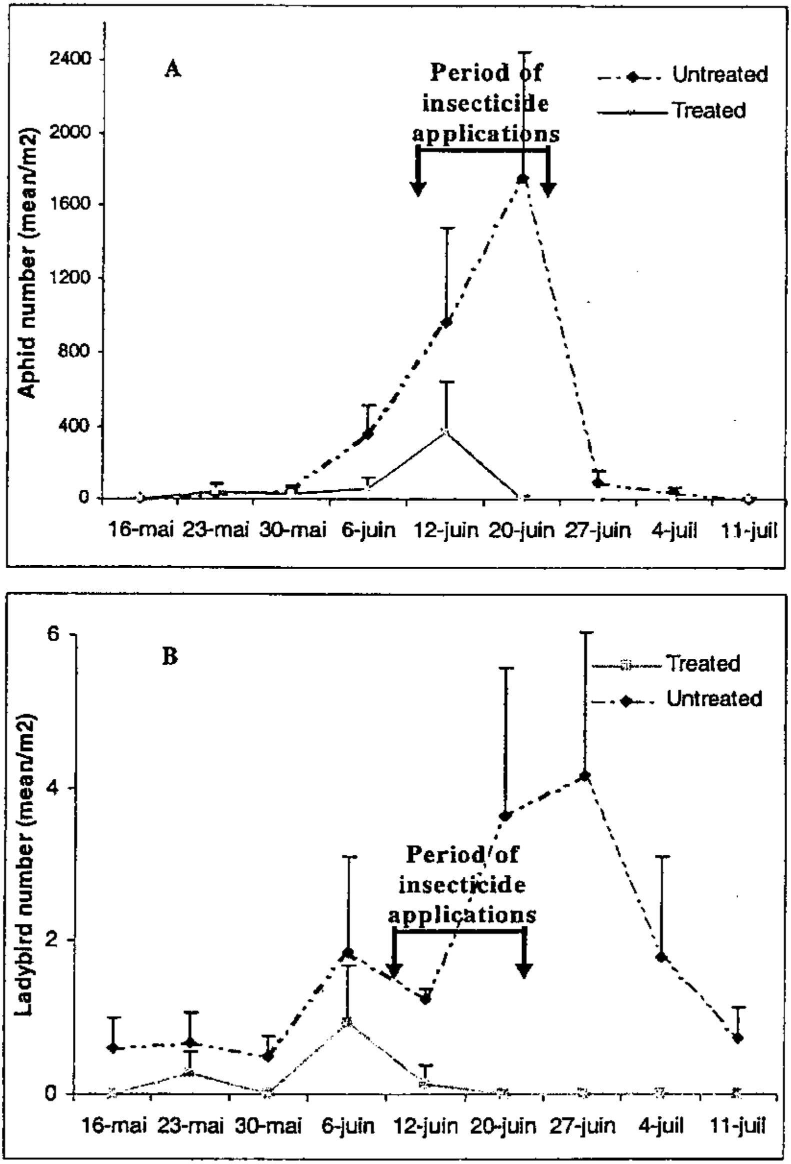

Figure 2: Evolution of the aphid (A) and ladybird (B) populations determined by visual observations in control (untreated) and insecticide treated plots. Insecticide treatments were applied between the10th and 22th of June.

Significant interaction was observed for aphidophagous ladybird populations when a 2-way ANOVA was realised using both week and treatment as factors ($F = 2.13$ and $P = 0.035$). One-way ANOVA had to be performed using separately the week and treatment factors. The coccinellid density determined by visual observations on plants was significantly higher in control than in treated plots whatever the insecticide treatment which was applied ($F = 22.44$ and $P < 0.001$). In regard to the cultivation duration, one-way ANOVA had to be performed for each week separately. While no significant difference of aphidophagous ladybird density was observed for weeks 1 to 5 and 9 ($0.19 < t < 3.67$ and $0.666 < P < 0.069$), the coccinelid density was higher on untreated bean plants than that on plants which were insecticide treated for weeks 6 to 8 ($5.16 < t < 7.75$ and $0.033 < P < 0.011$). The insecticide application period corresponded to weeks 5 and 6, from 10th to 22th of June.

DISCUSSION

Biological control can be approached by different ways. Beside massive introductions by inundative releases, the conservative control intends to amplify the abundance and the effect of the naturally present beneficials. Even if forests and orchards constitute permanent habitats for many predatory ladybirds, the latter move to others habitats such as crop fields during the breeding season. Amongst the five trapped ladybird species, the ubiquitous *P. quatuor-decimpunctata* was present but *C. septempunctata* was the more abundant. The large occurrence of the latter in broad bean fields was not surprising, this beetle species is mainly found in herbaceous habitats and is very polyphagous (Majerus, 1994). Visual observations confirmed the dominant presence of the 7-spot ladybird in vegetable fields. The respective abundance of the observed aphid species was very different depending on the evaluation method. While the large majority of aphid caught in yellow traps belonged to the *C. aegopodii* species, *A. fabae* was nearly the only one species which was visually observed on bean. While plant observation method was more sensitive to estimate the entomofauna diversity and density from a closed plot, yellow trap gave an evaluation at a larger scale due to its attractiveness. The higher aphid density in traps was due to the appearance peak of *C. aegopodii* which had no impact on broad bean.

The density of aphidophagous beetle in the fields is directly linked to the prey abundance but is also largely influenced by insecticide applications (Hodek and Honek, 1996). Visual observations of the entomofauna on plants allowed us to determine a negative effect of the insecticide treatments on predatory beetle density from the 20th of June until the 4th of July (weeks 6 to 8) in treated plots when compared to control ones. Pyrethrinoïd insecticide which was commonly used (alone or in combination with pyrimicarb) in broad beans were already known for their low specificity towards several beneficial insects such as ladybirds (Gendrier and Reboulet, 1992). Considering the aphid density, the latter was higher in untreated plots from the 6th to the 20th of June. Whether a rainy period of a few days occurred in mid-June and contributed to the aphid population decrease, a direct relation between the evolution of both aphid and ladybird populations was also observed. Even if ladybird populations decreased when aphid density dropped to zero, the predators stayed in the fields for the three next weeks and ensured a protection towards potential further aphid infestations.

Impact of insecticide applications was also observed on the aphidophagous ladybird number using yellow traps. Predatory beetles were fewer in treated plots for a three week period following the insecticide applications. A significant effect of agrochemical treatments was only observed on aphid density for week 6 which corresponded to the second week of insecticide use. Differences in insect density and diversity in this kind of trap are strongly influenced by the closed environment of the crop field. The presence of set-aside or woodlands closed to the cultivated vegetable areas greatly influence the entomofauna abundance and diversity (Colignon et al, 2001a). Whether systematic trapping is useful to assess insect populations, visual observations stay an accurate and necessary method to quantify the occurrence of both pests and beneficials in small plots of open fields.

In conclusion, insecticide applications showed a negative effect on the aphidophagous predator populations in bean fields even if a part of the treatment was made using pyrimicarb. Last year, natural ways of aphid control such as the presence of beneficials and the occurrence of a rainy period in June appeared to be sufficient to decrease aphid populations. Even if pest population observation is more time consuming than applying insecticides on vegetable crops, this work showed that it worth to promote integrated pest management in terms of biodiversity conservation and high quality food production including lower pesticide residues.

ACKNOWLEDGEMENTS

The authors would like to thank the Walloon Region and more particularly the Agriculture Minister, Mr J. Happart, for the funding of this work which is a part of a research program (convention 2585) entitled "Evaluation et utilisation de l'entomofaune utile en cultures maraîchères de plein champs".

REFERENCES

APHW (1997). Evaluation du potentiel de production horticole en Wallonie. Gembloux,138 pages.

Colignon P., Hastir P., Gaspar C. and Francis F. (2001). Effects of insecticide treatments on insect density and diversity in vegetable open fields. *Med. Fac. Landbouw. Univ. Gent* (in press).

Colignon P., Hastir P., Gaspar C. and Francis F. (2001a). Effet de l'environnement proche sur la biodiversité entomologique en culture maraîchères de plein champ. *Parasitica* (in press).

Dagnelie, P. (1973). *Théories et méthodes statistiques*, tome 2, Presses agronomiques, Gembloux, Belgium, 463 pages.

Gendrier J.P. and Reboulet S.N. (1992). Choix des produits sanitaires en vergers. Phytoma 438, 26-30.

Hodek I. and Honek A. (1996). *Ecology of Coccinellidae*, Kluwer Academic Publisher, The Netherlands, 464 pages.

Majerus M.E.N. (1994). *Ladybirds*. The New Naturalist, London, 367 pages.