EFFECTS OF INSECTICIDE TREATMENTS ON INSECT DENSITY AND DIVERSITY IN VEGETABLE OPEN FIELDS

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ABSTRACT

Vegetable open field areas increased for 15 years in Wallonia, mainly in Hesbaye. To be in accordance with quality standards, especially in terms of agro-chimical residues (R.M.L.), biological pest control was developed and allowed to reduce the insecticide use, leading to have safer fresh products. Among cultivated species in Wallonia, leguminous crops represent more than 85% of the vegetable production. To assess the impact of insecticide treatment on both pests (mainly aphids) and beneficial insects (predators and parasitoïds), broad bean (*Vicia faba* L.) fields were investigated during all the production duration. Twelve fields between Waremme and Hannut were visited weakly from May to July. In each field, control untreated and treated plots were investigated. Insects were caught using yellow traps and determined until the family level. Approximately 90.000 insects belonging to 59 major families (99% of captures) and 64 minor families were identified. These results showed that biodiversity in terms of family numbers was significantly higher in unsprayed plots. In addition, biodiversity and biomass (insect density) increased gradually during the season. Evaluation of pest and beneficial diversity and density was discussed in relation to aphicid (λ-cyhalothrin, pirimicarb) treatments and the development of I.P.M. program in vegetable crops.

Key-words: broad been, aphids, insecticides, yellow traps, biological control

INTRODUCTION

For the middle of '80 vegetables areas increased in Wallonia (South of Belgium) because of a will to diversify agricultural productions. More than 30% of the Walloon vegetable production is produced in Hesbaye (APHW, 1997), the region we investigated. We choose broad been according to the economic importance of Leguminous in this region and to crucial aphid control problems. Indeed, among cultivated species in Wallonia, leguminous crops represent more than 85% of the vegetables production (APHW, 1997) moreover *Fabaceae* species are such as pea, bean and broad been are continuously present in agro-ecosystems as crop or as green fertiliser. Like this, alternative habitats for pests are always available. The main problem associated with such crops is aphid control. To avoid outbreaks, insecticides are widely sprayed, leading to problems as resistance to active substances, environment pollution and agro-chemical residues on food.
Natural enemies contribute greatly to reducing aphid populations and corollary damage in broad been crops. But, the widespread and routine use of insecticides display negative effects on beneficial species populations.

Several studies such as LOWE *et al.* (1983) have shown that unselective insecticide sprayings lead to a worsening of aphid problems by suppressing beneficials. Future integrated pest management strategies in broad been crops will be developed especially to minimise adverse effects of insecticide spraying on natural enemies. The conservation of beneficials to control aphid pest by using selective insecticides at lower concentrations is one of the potential ways to promote I.P.M. . The first step of this approach is to determine the effects of common insecticide treatments on broad been field entomofauna, especially on aphidiphagous natural enemies. The results will be discussed in relation to the impact on aphid control.

MATERIAL AND METHODS

Twelve broad bean fields were investigated in Hesbaye region between Hannut and Waremme. Each field was divided in an untreated plot of 250 square meters which only herbicide sprayings received and a normally treated one constituted by the remaining area. In treated plots, required fungicidal and aphicidal treatments were applied at recommended doses. Active substances sprayed were λ-cyhalothrin, pirimicarb (aphicids) alone or in combination and vinclozolin and carbendazim (fungicids). An average of two insecticide and two fungicidal treatments were applied on each field for the ten weeks of cropping. Spraying period was variable for each field but more than nine applications on ten were mad between 25th May and 28th June, with a maximum at sixth week. Eleven on the 12 fields received both pirmicarb and λ-cyhalothrin in association ("Okapi®") or in pure formulation ("Pirimor®" and "Karaté®") and ten on the 12 have been sprayed with both vinclozoline ("Ronilan®") and carbendazim ("Virolex®"). One field received λ-cyhalothrin only and two fields have been sprayed only with "Virolex". Insects were trapped using tree yellow traps per plot. Each trap was disposed on the corner of a on meter triangle and weekly emptied. Insects caught were determined until the family taxonomical level except for *Thysanoptera* (to order) and for some particular beneficials and pests which were determined until the species. Results of the latter work was presented elsewhere (FRANCIS *et al.*, 2001). Trapping last ten weeks (as long as the crop was present), from 2th Mai to 11th July.
Statistical analysis were performed using the Minitab® software (12.2 version). ANOVA was realised on data after a log (x+1) transformation.

RESULTS

General diversity

Amount of 89579 insects belonging to nine orders and 123 families were caught and determined on the bean cultivation. More than 99% of them belong to 59 families while 64 families were represented only by 325 individuals (Appendix 1). *Diptera* (57108 indiv.) was largely the most abundant order (Fig. 1). *Hemiptera* (9999 indiv.), *Hymenoptera* (8394 indiv.), *Coleoptera* (6855 indiv.) and *Thysanoptera* (6107 indiv.) represent each one from 11 to 7%. The four other orders (*Neuroptera, Mecoptera, Lepidoptera* and *Odonatoptera*) corresponded to only 1103 individuals.

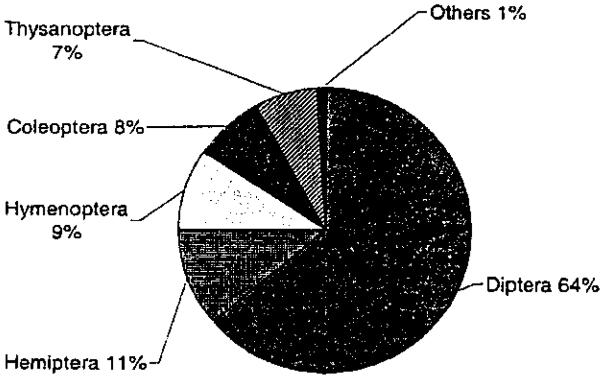


Figure 1 : Insects repartition according to taxonomical orders

Effects of treatments on insect density

Insects density in traps remained relatively low and stable between 54.1 and 91.7 insects during weeks 2 to 5 (Fig. 2). Then captures became fewer on week 6 before to increase constantly the two following weeks. Insect density dropped on week 9 before to increasing again last week. On the whole spraying period (weeks 4 to 10), no significant was observed between the two plots in term of insects density difference ($P = 0.367$; $F = 0.82$). Considering each trapping week separately, significant difference between plots was observed only week 6 ($P = 0.02$; $F = 9.90$). At this time, insect density was higher in untreated plots traps (59.5 indiv./trap) than in treated ones (54.1 indiv./trap).

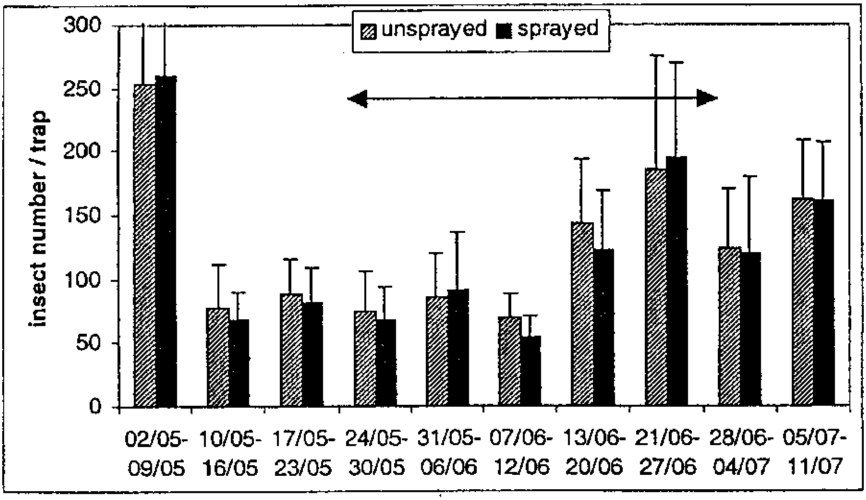


Figure 2: Mean insect number per yellow trap in relation to insecticide applications (arrow on the graph indicates treatments period)

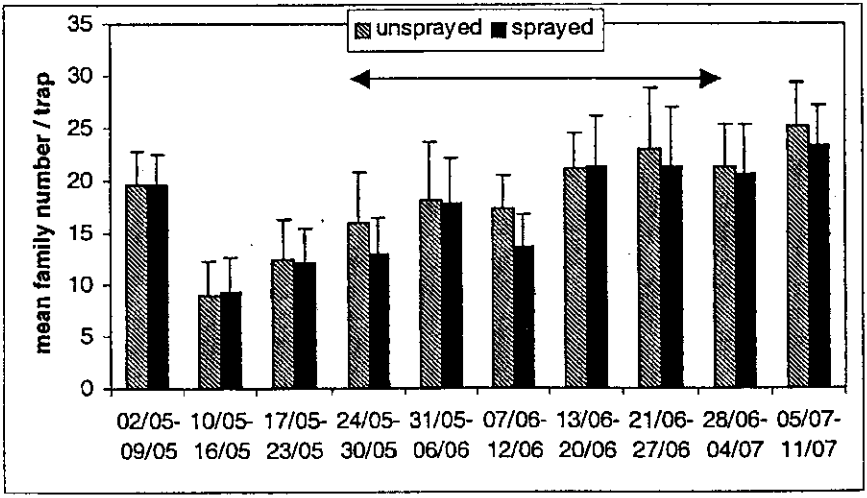


Figure 3: Mean insect number per yellow trap in relation to insecticide applications (arrow on graph indicates treatments period)

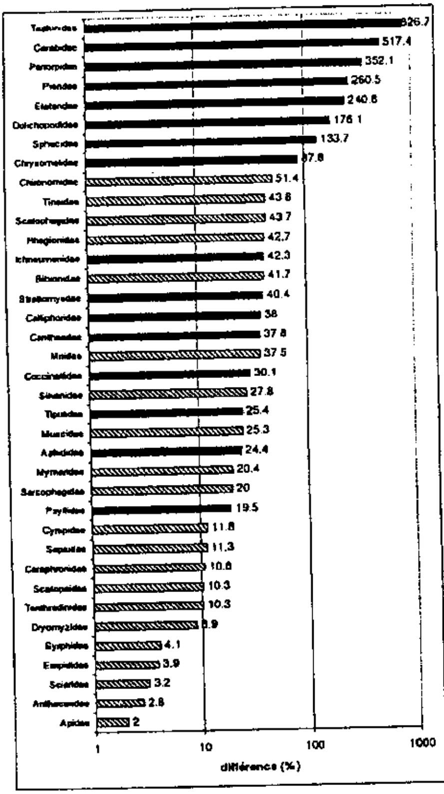
Effects of treatments on insect diversity

Insect diversity in term of family number per trap showed a trend to increase through the time (Fig. 3). Untreated plot traps (20.3 families) were

significantly richer in families on the spraying period than treated plot ones (18.8 families) (P = 0.023; F = 5.17).
Obvious difference between treated and untreated plots started at the beginning of spraying period (fourth week). Except at week seven, treated plots remained less diversified until crop end. Significant differences were observed week four and six (0.000 < P < 0.005; 8,58 < F < 9.90).

Effects of treatments on insect families

Fifty eight families were sufficiently numerous to allow statistical analysis. During insecticide spraying period, 37 families were more abundant in untreated plot traps (Fig. 4) whereas 22 families were caught in higher number in treated plot traps (Fig. 5). Marked differences are observed for height families more abundant in untreated plots (*Crysomelidae, Sphecidae, Dolichpodidae, Elateridae, Pieridae, Panorpidae, Carabidae* and *Tachinidae*). Fifteen families including important pests or beneficials (*Carabidae, Elateridae, Tipulidae, Cantharidae, Coccinellidae, Aphididae*) in broad been crop, were significantly more present in untreated plot traps (0.000 < P < 0.054; 3.18 < F < 22.18). Only two families of micro-wasps were significantly (0.050 < P < 0.055; 3.18 < F < 3.87) more numerous in treated plots.



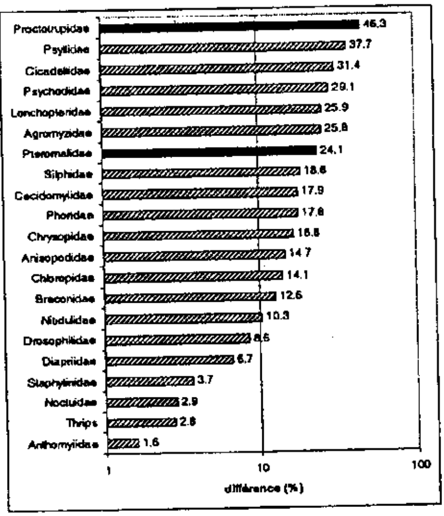


Figure 4: Differences of insect families (in %) between treated and untreated plots (families decreasing in untreated plots)
Significant differences at P = 0.05 are black colored

Figure 5: Differences of insect families (in %) between treated and untreated plots (families increasing in treated plots)
Significant differences at P = 0.05 are black colored

DISCUSSION

Effects of treatments on insect density were unclear (may be due to the relatively low pressure of treatment in comparison on a "standard season"). During weeks 2, 3, 4, 6 and 9 mean insect density in untreated plots was higher than in treated ones. Inverse phenomenon was observed on weeks 5 and 8, in the middle of spraying period. Small differences (never more than 23%) and large standard deviations explained than significant differences were never observed, except on sixth week. The spring fly of *Cavariella aegopodii* Scop., an aphid species not damageable for broad bean, explained abnormal density in traps observed on first week. Treatment effects on broad bean insect fields diversity was more obvious. From the beginning of insecticide sprayings, treated plots remained globally less diversified and effects on diversity continued after the end of sprayings. Information on insect density were disconcerting. This could be due to a rapid re-colonisation from surrounding environment which was frequently observed in small plots (Holland *et al.*, 2000). While we observed a decrease of aphid populations after insecticide treatments, negative effects on numerous beneficial insects families were also demonstrated. Among predator families, *Carabidae* and *Dolichopodidae* were highly affected by insecticide applications and were confirmed to be very sensible families (Vickerman *et al.*, 1987). Moreover, *Coccinellidae* were significantly less present in sprayed plots ($P = 0.042$; $F = 4.19$) and. This is more worring concerning the aphid control. Beetle density in the field is influenced by insecticide applications but is also linked to the prey abundance (Hodek and Honek, 1996). Prey host scarcering could partially explain the reduction of *Coccinellidae* presence in treated plots. At the opposite, syrphid adults are extremely mobile and were present in traps not depending on treatments which not seemed affect syrphid abundance. Indeed, yellow traps are adapted to catch only insect mobile stages like syrphid adults. Then, only observations of nymphal larvae could provide accurate information on insecticide treatments effects and allow to conclude in term of aphid control. Paradoxically, treatments were not negative towards 21 families and demonstrate the presence of indirect and complex interactions between insect species. This phenomenon was frequently observed with phytophagous species (Evans *et al.*, 1996). Here, no serious pest family was clearly favoured by sprayings. At the opposite, treatments enhance two important families of parasitoïd (*Pteromalidae* and *Proctotrupidae*). Nevertheless, beneficial effects of spraying were globally less marked than noxious ones. Finally, treatment didn't cause the disappearance of one of the 58 families which were statistically discussed. Observed disappearance of *Bibionidae* and *Cantharidae* seemed to be only linked to their own phenology. Indeed, they have disappeared from untreated plots at the same time.

CONCLUSIONS

This study showed that there is a possibility that prophylactic and systematic treatments exacerbate the problems of aphids in broad bean by reducing important natural enemies populations, even if a part of treatments was mad using pirimicarb. Proposed solutions should be monitor insect populations in the field and reduce insecticide concentrations whose increase selectivity. These actions, linked to closed environment survey (Colignon *et al.*, 2000), should contribute to a future integrated pest management strategy in broad been crops.

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Appendix 1: Insect total numbers according to families

Order	Family	Number
THYSANOPTERA		6107
HEMIPTERA	*Aphididae*	8797
	Cicadellidae	292
	Psyllidae	647
	Miridae	221
	Anthocoridae	18
NEUROPTERA	*Chrysopidae*	316
MECOPTERA	*Panorpidae*	74
LEPIDOPTERA	*Pieridae*	64
	Noctuidae	576
	Tineidae	57
DIPTERA	*Syrphidae*	6464
	Anthomyiidae	20501
	Muscidae	1176
	Calliphoridae	7987
	Scatophagidae	565
	Sarcophagidae	475
	Tachinidae	36
	Agromyzidae	192
	Anisopodidae	74
	Bibionidae	997
	Cecidomyiidae	106
	Chironomidae	87
	Chloropidae	1523
	Dolichopodidae	581
	Drosophilidae	4850
	Dryomyzidae	133
	Empididae	4847
	Lonchopteridae	180
	Mycetophilidae	400
	Phoridae	224
	Psilidae	117
	Psychodidae	70
	Rhagionidae	37
	Scatopsidae	315
	Sciaridae	422
	Sepsidae	1811
	Stratiomyidae	892
	Tipulidae	1938
HYMENOPTERA	*Tenthredinidae*	1685
	Ichneumonidae	1066
	Apidae	2487
	Braconidae	629
	Ceraphronidae	106
	Cynipidae	1051
	Diapriidae	135
	Mymaridae	150
	Proctotrupidae	170
	Pteromalidae	809
	Sphecidae	27
COLEOPTERA	*Cantharidae*	560
	Carabidae	34
	Chrysomelidae	1010
	Curculionidae	819
	Elateridae	53
	Nitidulidae	1830
	Silphidae	58
	Silvanidae	419
	Staphilinidae	725
	Coccinellidae	1262

Order	Family	Number
ODONATOPTERA	*Platycnemidae*	1
ORTHOPTERA	*Acrididae*	5
	Tetrigidae	2
HEMIPTERA	*Coreidae*	5
	Lygaeidae	2
	Nabidae	11
	Pentatomidae	5
	Reduviidae	1
	Cercopidae	6
NEUROPTERA	*Hemerobiidae*	1
LEPIDOPTERA	*Incurvariidae*	1
	Nymphalidae	7
	Oecophoridae	1
	Papilionidae	4
	Pterophoridae	1
DIPTERA	*Anthomyzidae*	1
	Asilidae	3
	Ceratopogonidae	1
	Chamaemyiidae	1
	Coelopidae	5
	Conopidae	5
	Culicidae	5
	Ephydridae	2
	Heleomyzidae	11
	Lauxaniidae	9
	Lonchaeidae	1
	Micropezidae	8
	Opomyzidae	6
	Otitidae	4
	Pallopteridae	1
	Pipunculidae	2
	Platystomatidae	6
	Sciomyzidae	10
	Simuliidae	8
	Tephritidae	16
	Xylophagidae	3
HYMENOPTERA	*Bethylidae*	3
	Chrysidae	8
	Encyrtidae	2
	Eucharitidae	1
	Eulophidae	2
	Eumenidae	2
	Eupelmidae	8
	Eurytomidae	3
	Evaniidae	1
	Formicidae	7
	Leucospidae	1
	Perilampidae	17
	Pompilidae	4
	Trichogrammatidae	3
	Torymidae	10
	Vanhorniidae	1
	Vespidae	6
COLEOPTERA	*Buprestidae*	1
	Cerambycidae	1
	Cetoniidae	6
	Histeridae	29
	Hydrophilidae	16
	Lucanidae	1
	Oedemeridae	13
	Melyridae	1
	Mordellidae	11
	Scarabaeidae	4
	Tenebrionidae	2