

IOBC / WPRS

Working Group “Integrated Protection in Field Vegetable Crops”

OILB / SROP

Groupe de Travail « Lutte Intégrée en Culture de Légumes »

**Proceedings of the Meetings
Comptes Redus de les Réunions**

at / à

**Gödöllö (Hungary)
31.10. – 3.11.1999**

and

**Krakow (Poland)
15. – 17.10.2001**

Edited by Stefan Vidal

**IOBC wprs Bulletin
Bulletin OILB srop**

Vol. 26 (3), 2003

The content of the contributions is in the responsibility of the authors

The IOBC/WPRS Bulletin is published by the International Organization for Biological and Integrated Control of Noxious Animals and Plants, West Palearctic Regional Section (IOBC/WPRS)

Le Bulletin OILB/SROP est publié par l'Organisation Internationale de Lutte Biologique et Intégrée contre les Animaux et les Plantes Nuisibles, section Regionale Ouest Paléarctique (OILB/SROP)

Copyright: IOBC/WPRS 2003

The Publication Commission of the IOBC/WPRS:

Horst Bathon
Federal Biological Research Center
for Agriculture and Forestry (BBA)
Institute for Biological Control
Heinrichstr. 243
D-64287 Darmstadt (Germany)
Tel +49 6151 407-225, Fax +49 6151 407-290
e-mail: h.bathon.@bba.de

Luc Tirry
University of Gent
Laboratory of Agrozoology
Department of Crop Protection
Coupure Links 653
B-9000 Gent (Belgium)
Tel +32-9-2646152, Fax +32-9-2646239
e-mail: luc.tirry@ rug.ac.be

Address General Secretariat:

INRA – Centre de Recherches de Dijon
Laboratoire de recherches sur la Flore Pathogène dans le Sol
17, Rue Sully,
BV 1540
21034 DIJON CEDEX
France

ISBN 92-9067-151-1

Web: <http://www.iobc-wprs.org>

The effects of undersowing (Brussels sprouts – black mustard) on population density of *Brevicoryne brassicae* and natural enemies of aphids

T. Bukovinszky^{1,2}, V. Rasztik³, J.C. van Lenteren¹, L.E.M. Vet¹ & G. Bujáki²

¹ Wageningen University, Binnenhaven 7, 6709PD Wageningen, The Netherlands

² Szent István University, Páter K. út 1., 2100 Gödöllő, Hungary

³ Szent István University, Villányi út 29-43., 1118 Budapest, Hungary

Abstract: The changes of population sizes of the cabbage specialist aphid *Brevicoryne brassicae* and its parasitism by the specialist *Diaeretiella rapae* were followed in undersown plots (Brussels sprouts – black mustard) and monocultures of sprouts in 1998. The effects of undersowing on the parasitoid complexes of aphids and on the syrphid communities organised in the mixed and monocropped stands were also investigated. Mustard was mown to promote a uniform 2nd flowering period, thus we could test the effects of flowering and the disturbance of mowing. Significantly lower incidence and densities of *B. brassicae* populations were observed in the undersown plots. The densities of all observed natural enemy groups of aphids were positively affected by undersowing. Rate of parasitism of *B. brassicae* by *D. rapae* was significantly higher during flowering periods. Members of Neuropteroidea were also more frequent in the undersown stands. Removal of flowers (to induce second flowering) adversely affected the populations of *D. rapae* and the syrphid species. No differences were found in the diversity and similarity of aphid parasitoid complexes between the treatments. However, different syrphid communities were organised in the undersown culture due to flowering with higher species richness and diversity. Mowing of mustard was followed by decline in the number of species till the next flowering period.

Key words: *Brevicoryne brassicae*, *Diaeretiella rapae*, predatory insects, diversity, undersowing, black mustard;

Introduction

Population densities of herbivorous insects are frequently lower in vegetationally diverse habitats than in simple ones (Risch *et al.* 1983). Diverse vegetation can affect herbivore populations directly, through limited resources and interfering with host plant searching behaviour (e.g. disruptive crop hypothesis). Growing different plant species together can lead to decreased herbivore populations through increasing the success of natural enemies. This has placed greater emphasis on how factors such as resource enrichment, disturbance and vegetational diversity affect arthropod species richness and population abundance. The role these factors play in affecting community structure will help to explain agricultural problems including the development of herbivores and pests and stimulate the development of effective biological control programs, especially in annual crops (Herzog and Fundenburk, 1985 in Murphy *et al.* 1998).

The purpose of this study was to investigate the effects of intercropping on pest populations and their natural enemies. As the subject of our investigations we chose the distinctive entomofauna of cruciferous plants with regard to aphid populations and the communities of their natural enemies.

The comparison of densities of *Brevicoryne brassicae* populations and density changes of natural enemies of aphids were carried out in monocropped and undersown plots in 1998. Community structures of aphid parasitoid complexes and syrphid communities were also analysed in relation to cropping system.

Materials and methods

The experiment was carried out in the experimental field of the Wageningen Agricultural University in 1998. Monocropped fields of Brussels sprouts (*Brassica oleracea* cv. gemmifera) (coded as S) and the undersown culture of Brussels sprouts and black mustard (*Brassica nigra*) (coded as Sm) were compared. The black mustard was chosen because it is an intensively flowering species presumably providing pollen and nectarine sources for natural enemies. In an earlier study it was found that the presence of wild mustard has considerably increased the parasitism of *Pieris brassicae* by *Cotesia glomerata* (Telenga 1957 in Altieri 1994).

Three plots of each treatment were embedded in a barley field in a randomised Latin block design, about 30 m distance to each other (Fig.8). Each plot was surrounded by a 4 m wide boundary of *Lolium multiflorum*. Mowing of the grass was carried out when it was necessary. The spacing of Brussels sprouts plants was 75 cm. No pesticide was applied. After the first flowering (14.07.) the mustard was cut back to promote a uniformly dense second flowering of mustard. During the experiment, the mustard flowered two times. Flowering started at approximately the same time (1-2days difference between plots). The mowing provided the uniform removal of flowers for about 20 days. The fields were surrounded by barley, except the eastern side where an orchard was situated. Individual plant observations were carried out to estimate the incidence and relative population densities of *Brevicoryne brassicae*. Whole Brussels sprouts plants (20 plants/plot in each week, the last week the sample size was reduced to 15 plants/plot) were chosen as sample units and the total numbers of *B. brassicae* individuals/plant were counted or estimated in case of high population densities. The density changes of Neuropteroid eggs and larvae and the larvae and pupae of syrphids were also monitored. Primary parasitism of aphids was determined by counting the number of intact mummies per plant on each week. The community structures of aphid parasitoid complexes and syrphid communities were compared between the treatments by using yellow dishes (1dish/each plot, with 14 cm diameter). Differences in species richness, diversity and similarity were calculated.

Data analysis

The Univariate Analysis of Variance (ANOVA) and t-test for independent samples were used to compare the population densities of the observed species and rates of parasitism of aphids within and between the treatments. Statistical data analysis was carried out by use of SPSS 8.0. All differences were calculated with 95% confidence interval. The species composition of communities and complexes was compared by the similarity index of Jaccard (Southwood, 1984) and Morosita (Morosita, 1959 in Krebs 1989). The diversity of complexes and communities was calculated by using the Shannon-Weaver- (Southwood, 1984), Williams- α (Williams, 1943), and Berger Parker indexes (Southwood, 1984). To compare the structure of the communities, hierarchical clustering and PCoA analysis were applied based on Horn-index (Podani, 1997; Krebs 1989).

For the multivariate data analysis, Syntax 5.1 program package was applied.

Results and discussion

Lower incidence and population levels of *B. brassicae* were found in the undersown culture (Fig. 1, 2). This indicates the slower colonisation of plants and progress of population by *B. brassicae* in the undersown plots. The numbers of individuals were not corrected according to the different plant size. The use of a planimeter was not possible because of lack of time and because aphids were counted on all plant parts. This might have influenced the accuracy of the data to a certain extent.

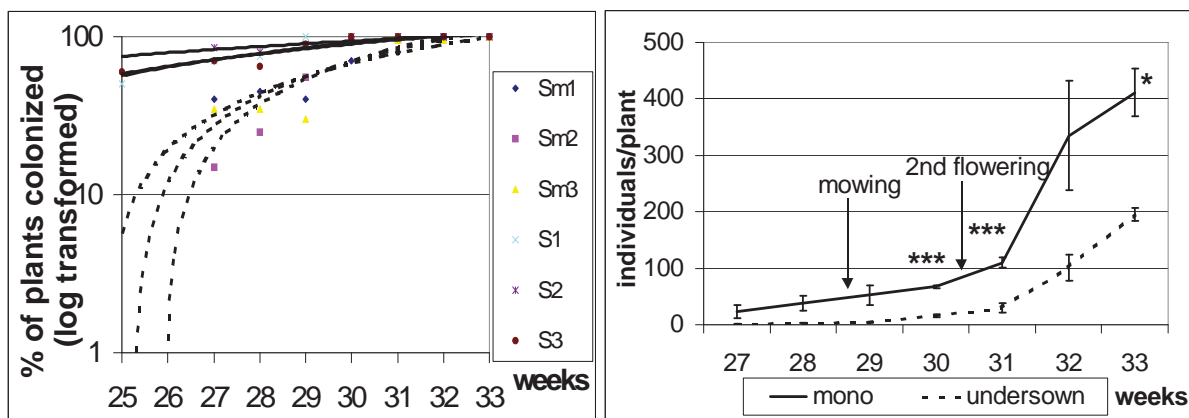


Fig. 1. The incidence of *B. brassicae* in the treatments. Sm-undersown; S-monocropped. $R^2(\log S_1) = 0.823$; $R^2(\log S_2) = 0.75$ $R^2(\log S_3) = 0.83$; $R^2(\log Sm_1) = 0.9$; $R^2(\log Sm_2) = 0.87$; $R^2(\log Sm_3) = 0.76$; Difference between the slopes $P = 0.006$ (independent sample t-test).

Fig. 2. The changes in density of *Brevicoryne brassicae* in the monocropped and undersown cultivated plots. Error bars are standard error of the mean.

*= significant difference; $0.01 < P \leq 0.05$. **= $0.001 < P \leq 0.01$ ***= $0.0001 < P \leq 0.001$

It is possible that aphids were not able to find Brussels sprouts plants due to high vegetation density, so the relative number of individuals/plant could have been smaller in the undersown than in the monocropped fields. The contrast between the vegetation and its background has a basic influence on the host-plant finding by specialist herbivores (Kostal and Finch, 1994). This contrast was totally different in the two systems. In intercropping experiments with Brussels sprouts *B. brassicae* was found to react strongly to the contrast of background and crop plants (Theunissen and Den Ouden, 1980 in Theunissen, 1989). Because Brussels sprouts plants were smaller in the undersown culture, herbivores which react to plant size (aphids as well) might have difficulties in finding crop-plants.

Since *B. brassicae* is a crucifer specialist, the presence of another host plant in high densities might have hindered the colonisation of *B. sprouts* plants. Black mustard contains sinigrin and some related compounds in higher concentrations than other crucifer plants (Kjaer in Read et al. 1970), which are feeding stimulants to crucifer specialists. However, this does not mean necessarily that *B. brassicae* prefers black mustard above Brussels sprouts, it might have hindered host plant finding of this species. Aphids on mustard tend to aggregate on the germinative plant parts thus by mowing this part of the population was removed.

The huge differences in plant growth parameters (data are not shown) indicate the presence of interspecific competition, so poor host plant quality could inhibit the progress of aphid populations. *B. brassicae* prefers sites of high protein synthesis, like growing parts of

plants (Van Emden, 1966). This preference behaviour corresponds with different reactions of the species to water budget of tissues. *B. brassicae* suffers adversely from a decrease of turgor, which affects reproduction and longevity of females (Van Emden, 1966).

The presence of interspecific competition between plants implies the adverse effects of plant quality on development of *B. brassicae*.

Parasitoids

4700 mummies of *B. brassicae* were collected and reared out (92% emerged, the others were dissected). Among the primary parasitoids *Diaeretiella rapae* was the dominant (more than 99%), and a few individuals were parasitised by a *Praon* sp. (very few specimens emerged from these mummies). Percent parasitism of *B. brassicae* by *Diaeretiella rapae* was significantly higher in the undersown culture than in the monocropped plots (Figure 3). Percent of parasitism was higher in the undersown lots during the first flowering, and a week after the onset of the second flowering of the black mustard. This tendency was observed in the yellow dish material as well. Mowing was followed by a decline in rates of parasitism approximately a week later. Therefore the changes in rates of parasitism in time were compared in the two plots. Within treatments the fraction of two weeks were taken and compared. Significantly greater changes in percent of parasitism were found in the undersown plots than in the monocropped ones. These changes were observed after mowing ($t=-3.81$, $P=0.019$) and a week after the onset of the 2nd flowering period ($t=3.826$, $P=0.019$).

Higher rates of parasitism in the mixed culture could occur as a result of a different response of parasitoids to the different host densities in the two cultures. However, the better response of parasitoids to equal host densities in the undersown plots is also possible. Point estimation was done to investigate whether the different responses of parasitoids at equal host density categories resulted in the higher rates of parasitism by *D. rapae* in the undersown plots. According to the 3 distinctive periods of the flowering, data were divided into three groups. *D. rapae* parasitised *B. brassicae* at higher rates both at low and higher population densities during flowering periods in the undersown plots than in the monocropped ones (Figure 4).

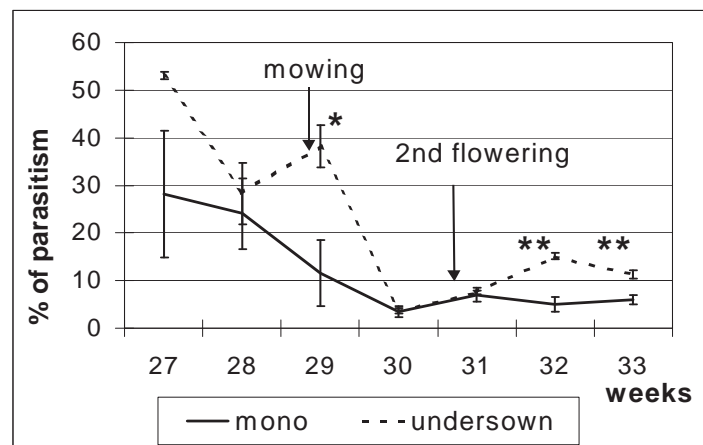


Fig. 3. Rate of parasitism of *B. brassicae* by *Diaeretiella rapae* in the mono- and undersown cultures. Error bars are standard error of the mean. *= significant difference; $0.01 < P \leq 0.05$. ** = $0.001 < P \leq 0.01$ *** = $0.0001 < P \leq 0.001$

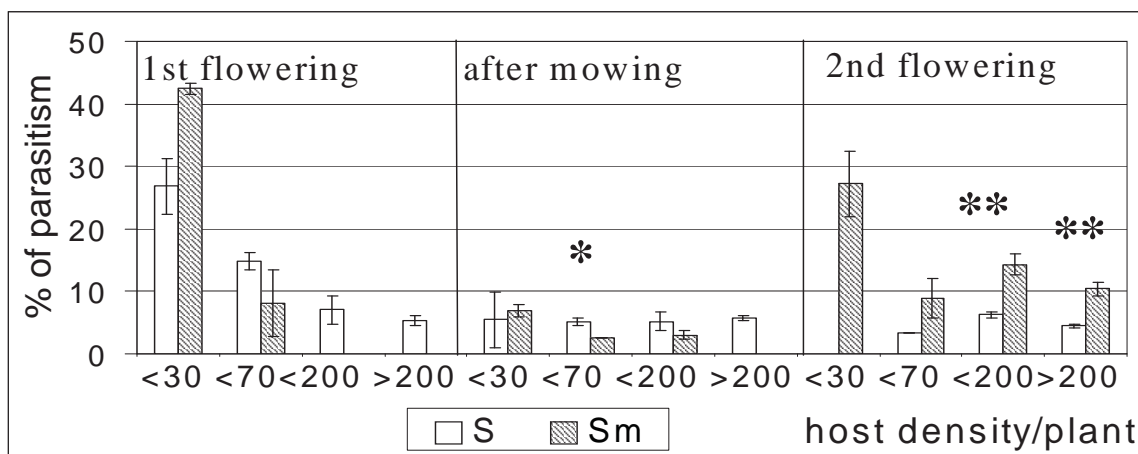


Fig. 4. Point estimation of parasitism at different density categories during 1st and 2nd flowering and mowing. Error bars are standard error of the mean.

*= significant difference; $0.01 < P \leq 0.05$. **= $0.001 < P \leq 0.01$ ***= $0.0001 < P \leq 0.001$

Percent of parasitism was higher at lower host density categories than at higher ones. After mowing, rate of parasitism in undersown plots showed significantly lower value in the undersown plots than in the monocropped ones or no difference was found at other density categories.

Although it is not known whether *D. rapae* feeds on mustard flowers in nature or not, it might have been attracted to undersown plots by flowering, either by the colour or by the presence of additional (pollen/nectarine) resources. *Diaeretiella rapae* has an innate response to infochemicals (mustard oil allyl isothiocyanate) emitted by cruciferous plants which is the most important cue in its habitat selection, followed by visual searching for the host (Read et al. 1970). In some species of Brassicaceae, especially in *B. nigra*, the major mustard oil component is allyl isothiocyanate (Kjaer, 1960 in Read et al. 1970). Chemical stimuli together with a more suitable, shady moist microenvironment could accumulate individuals and increased tenure time of this parasitoid species in the undersown stands. The increase in rate of parasitism was probably the outcome of higher density of *D. rapae* populations and the response to generally lower host density/plant in the undersown plots. However, responses to different plant sizes of sprouts in the mixed culture might have led to higher success of individuals during their host searching. It is probable that huge numbers of active primary parasitoids were removed from the plots by mowing. Also other factors may have contributed to the experienced differences, like the change in microclimatic conditions in the undersown stands, differences in composition and concentration of secondary plant metabolites within the treatment.

Comparison of aphid parasitoid complexes

Plant variation could influence the primary- and hyperparasitoid densities of *B. brassicae*. The effects of undersowing were further investigated at the level of aphid parasitoid complexes. 439 specimens were collected which belonged to 13 genera. Designation to species level was not always possible. The composition and the dominance order of the species caught by yellow dish were very similar to that reared from the mummies of *B. brassicae*. The overall comparison of the species composition of the two habitats showed high similarity (Jaccard-index: 86.7%), and the comparison based on the species they had in common and their

frequency also suggested that aphid parasitoid complexes were highly similar (Morosita's index: 83.4%) in the treatments.

Cluster analysis and ordination based on Horn-index showed high similarity values. Differences in organisation of aphid parasitoid complexes were independent of treatment effects (Figure 5, 6). The diversity indexes of aphid parasitoid complexes showed rather low values, which was due to the low species richness (Table 1). There were no differences found between the treatments.

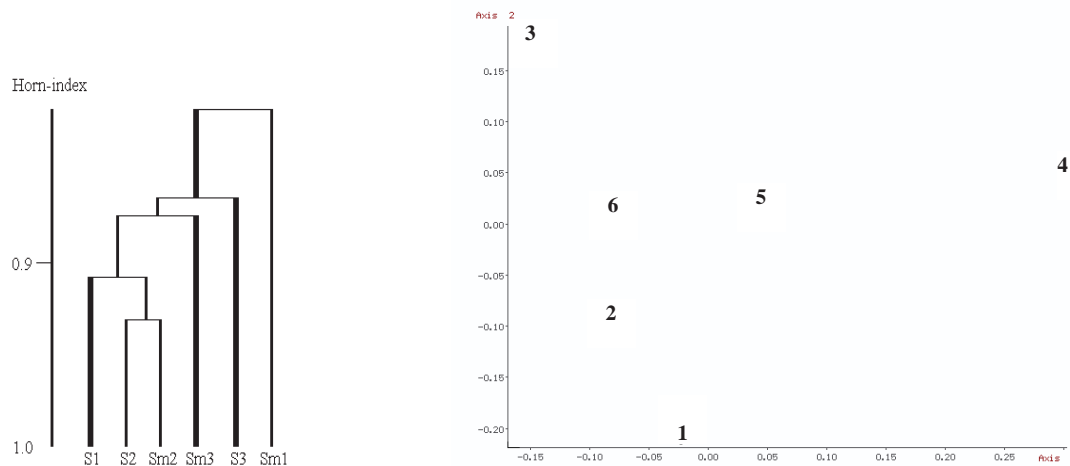


Fig. 5-6. Hierarchical clustering and PCoA for the comparison of structure of aphid parasitoid complexes in the mono and undersown plots based on Horn-index (1,2,3,7 monocropped plots; 4,5,6 undersown plots).

Table 1. The diversity of the parasitoid complexes of aphids in the treatments.

	Berger-Parker	Shannon-Weaver	Williams- α
Undersown	0,34	1,95	3,35
Monocropped	0,34	2,03	3,49

Certain disadvantages must be considered when using the yellow dishes for sampling in this case. The results of observations through using yellow dish are affected by the selectivity of the traps. A prerequisite to use such traps is differences between habitats should not affect the efficiency of traps (Southwood, 1984). This case the catches by the traps in the undersown plots were expected to be relatively smaller than those in the monocropped plots, due to the lack of contrast with the background. The vegetation characteristics (height and density) made the application of other techniques (sweep netting or D-Vac sampling) impossible.

Habitat characteristics may exert a basic influence on the occurrence and dominance order of parasitoid species in a particular system. We discuss the possibility that adding another plant species to the system did not enhance higher species diversity of parasitoid complexes. It is possible that the relative abundance of certain species (*D. rapae*) was higher in the undersown stands, but overall species richness was hardly influenced. It seems that species diversity was not affected by undersowing, and highly similar complexes were organised in the stands. However, differences in similarity were found between the plots

independently to treatment effect, which suggests that more data is needed to underpin this theory.

It is possible that adding black mustard as flowering plant to the system did not provide any additional resource to be utilized by other aphid parasitoid species. However, tourists of other species could have arrived from e.g. cereal aphid-parasitoids, they might have problems to settle due to lack or rarity of suitable host(s).

Predatory populations

All observed predatory populations were favoured by applying undersowing. Significantly higher numbers of eggs and larvae of lacewings were found in the intercropped culture, although their populations were very low (Fig. 7). In most cases only eggs were found, in some cases larvae were observed as well. Adults were recovered neither from individual plant observations nor from yellow dishes. Maredia et al (1992) found that *Chrysoperla carnea* predominantly preferred yellow colour and to a less extent green and red. This species is one of the most common cosmopolitan chrysopid species. Although no Neuropteroidea species was found in the yellow dish material, it is possible, that flowering attracted them, or they preferred the shady, more humid mesoclimate of the undersown culture.

Significantly more syrphid larvae and pupae/plant were found in the undersown culture (Fig. 8). Their density declined after mowing, to a significantly lower level than that in the monocropped plots. After the onset of 2nd flowering their density increased again, their numbers seemed to fluctuate as a consequence of mowing. They seemed to respond to the flowering; not only by visiting the flowers in higher numbers, they also laid more eggs on the undersown Brussels sprout plants, though prey densities were considerably lower in these stands. The total number of species found was significantly higher in the undersown treatment than in the monocropped one. In the monocropped plots the predator guild was dominant, while in the undersown plots the saprophyte guild occurred most frequently, though members of predatory guild was also more abundant in the undersown plots (Table 2). The higher species richness, due to flowering apparently declined after mowing, and the second flowering was followed by subsequent increase in species number (Fig. 9). Characteristically different communities were structured in the undersown plots when compared to monocultures. Similarity based on the extent to which the two habitat had species in common (Jaccard-index) was low (41.6%). If we consider the abundance of the common species (Moroshita-index) the similarity was higher, 80.1%. Similarity of communities based on hierarchical clustering and ordination revealed differences between the structures of syrphid communities organised in the two treatments (Fig. 10, 11). Differences between the undersown plots were less than between the monocropped plots. Estimations of diversity based on the moderately abundant species (Williams- α) showed higher values for syrphid assemblages in the undersown treatment (Table 3).

Table 2. The proportions of different guilds of syrphids in the treatments. Numbers in brackets represent mean number of individuals/dish.

	Undersown	Monocropped
Phytophagous	2(23)	6(2)
Predatory	21(23.3)	52(16)
Saprophyte	77(87.3)	42(13)

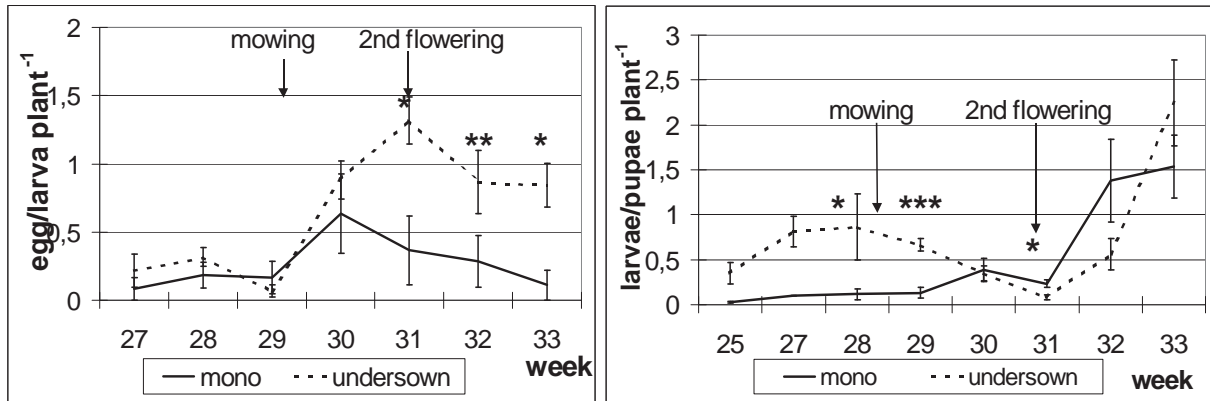


Fig. 7-8. Changes in densities of Neuropteroidea and syrphid larvae and pupae in the treatments. Error bars are standard error of the mean.
 *= significant difference; $0.01 < P \leq 0.05$. ** = $0.001 < P \leq 0.01$ *** = $0.0001 < P \leq 0.001$

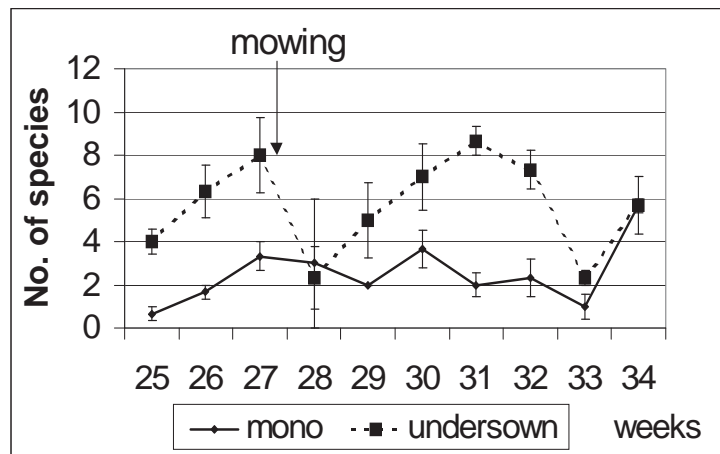


Fig. 9. Changes in syrphid species richness of the two treatments. Error bars are standard error of the mean.

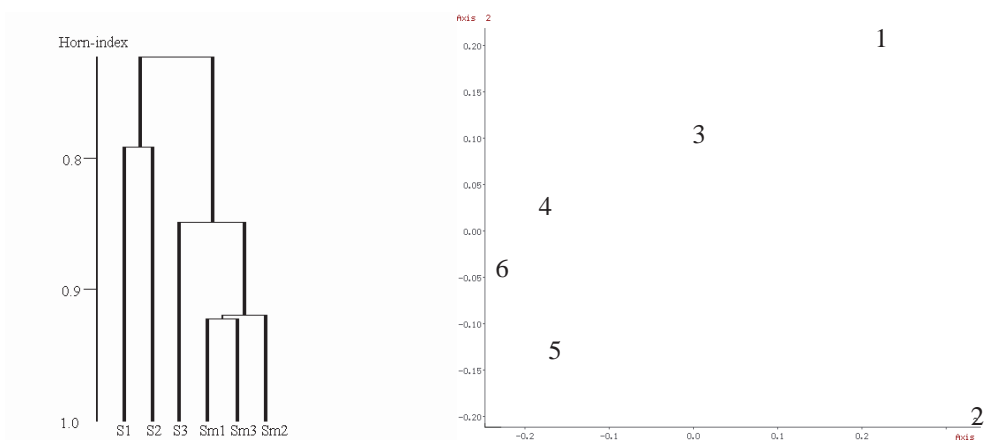


Fig. 10-11. Hierarchical clustering and PCoA for the comparison of structure of syrphid communities in the mono and undersown plots based on Horn-index(1,2,3= monocropped plots; 4,5,6= undersown plots).

Table 3. The diversity of Syrphid communities in the treatments.

	Berger-Parker	Shannon-Weaver	Williams- α
Undersown	0.25	2.4	8.67
Monocropped	0.16	2.56	7.23

It is well known that pollen and nectarine resources are essential for syrphids as the only protein staple (Kevan and Baker, 1983). Their high densities and species richness in the yellow traps during flowering prove this suggestion. The preference of different syrphid species to flower colours is mentioned by several authors (Cowgill et al., 1993; Haslett, 1989, Kevan and Baker, 1983). These observations revealed the influence of physiological and ecomorphological characteristics on flower selectivity of syrphids. Nectarine/pollen sources and the colour of flowers together can shape the species composition of syrphids visiting a certain habitat. It is very likely that in our experiment both pollen/nectarine sources and the colour of flowers structured syrphid communities. The species composition in the undersown plots was quite different to those of monocultures. Larger population size, higher species richness and diversity of syrphids were concomitant to flowering.

An additional effect of intercropping might have been the alteration of microclimatic conditions, which resulted in larger populations of syrphids in the diverse stands. Tenhumberg and Poehling (1995) mentions that besides aphid density, the egg-laying behaviour of syrphids is affected by temperature (Ankersmit et al., 1986), humidity (Wahbi, 1967), light, aphid species, and plant density (Chandler, 1968). The oviposition by gravid females in the undersown plots might have been enhanced by the different mesoclimate as well. The effect of floral density on foraging decisions is not known. It is probable that the combined effects of additional pollen/nectarine resources and the altered mesoclimatic conditions led to the experienced differences. Further conclusions cannot be drawn in this context because of the non-mechanistic approach of the work.

Species diversity largely depends on the relative abundance of species. Diversity patterns of natural communities follow certain seasonal dynamics. In agroecosystems cultivation practices might cause changes in the diversity of communities. It should be mentioned that calculated overall diversity values might reflect the differences between the treatments, they are not dynamic, and could eliminate the differences caused by disturbance to a certain extent (mowing). However, the dynamics of species richness could be followed in this case, suggesting that species diversity also declined after mowing. This proves that mowing disturbed syrphid populations and led to temporal extinction of several species from the stands. Unfortunately the degree of efficiency of syrphids in the suppression of developmental rate of aphid populations to lower levels in this case is not known because of the complexity of interacting factors in pest regulations.

We conclude that undersowing Brussels sprouts with black mustard effectively reduced the populations of *B. brassicae* and it is likely that direct effects of vegetation (disruptive crop hypothesis) was mostly responsible to this phenomenon. The presence of black mustard enhanced the efficiency of natural enemies. The application of flowering non-crop plants species seems to be a perspective way to increase efficiency of biological control. It would be worthwhile to search for more efficient flowering species compatible with the demand of vegetable production. It is important to find and quantify the sources of disturbance because they can lead to temporal extinction of species from the system, so population interactions are disrupted. Since natural enemies are often more susceptible to disturbances originating from e.g. cultural practices, these situations can lead to increase in pest population sizes. It is

important to know how fast communities of natural enemies are able to recover following disturbances.

References

- Altieri, M.A. 1994. Biodiversity and Pest Management in Agroecosystems. Food Products Press, The Haworth Press Inc.: 185 pp.
- Ankersmit, G.W., Dijkman, H., Keuning, N.J., Mertens, H., Sins, A. & Tacoma, H.M. 1986. *Episyrphus balteatus* as a predator of the aphid *Sitobion avenae* on winter wheat. Entomol. Exp. Appl. 42: 271-277.
- Chandler, A.E.F. 1968. Some factors influencing the occurrence and site of oviposition by aphidophagous Syrphidae (Diptera). Ann. Appl. Biol. 61: 435-446.
- Cowgill, S. E., Wratten, S.D. & Sotherton, N.W. 1993. The selective use of floral resources by the hoverfly *Episyrphus balteatus* (Diptera: Syrphidae) on farmland. Ann. appl. Biol. 122: 223-231.
- Haslett, J.R. 1989. Interpreting patterns of resource utilization: randomness and selectivity in pollen feeding by adult hoverflies. Oecologia. 78: 433-442.
- Kevan, P.G. & Baker, H.G. 1983. Insects as flower visitors and pollinators. Ann. Rev. Entomol. 28: 407-453.
- Kjaer, A. 1960. Naturally derived isothiocyanates (mustard oils) and their parent glucosides. Fortschr. Chem. Org. Naturst. 18: 122-176.
- Kostal, V. & Finch, S. 1994. Influence of background on host-plant selection and subsequent oviposition by the cabbage root fly (*Delia radicum*). Entomol. exp. appl. 70: 153-163.
- Krebs, C.J. 1989. Ecological Methodology. HarperCollinsPublishers, Inc.: 654 pp.
- Maredia, K.M., Cage, S.H., Landis, D.A. & Wirth, T.M. 1992. Visual response of *Coccinella septempunctata* (L.), *Hippodamia parenthesis* (Say), (Coleoptera: Coccinellidae), and *Chrysoperla carnea* (Stephens), (Neuroptera: Chrysopidae) to colors. Biological Control 2: 253-256.
- Murphy, B.C. et al. 1998. Habitat diversification tactic for improving biological control: parasitism of the western grape leafhopper. Entomol. Exp. Appl. 87: 225-235.
- Podani, J. 1997. Bevezetés a többváltozós biológiai adatfeldtárás rejtelmeibe. [Introduction to the multivariate analysis of biological data.] Scientia Kiadó, Budapest: 412 pp.
- Read, D.P. et al. 1970. Habitat selection by the aphid parasite *Diaeretiella rapae* (Hymenoptera: Braconidae) and hyperparasite *Charips brassicae* (Hymenoptera: Cynipidae). Can. Entomol. 102: 1567-1578.
- Risch, S.J., Andow, D. & Altieri, M.A. 1983. Agroecosystem diversity and pest control: Data, tentative conclusions, and new directions. Environ. Entomol. 12, 625-29.
- Southwood, T.R.E. 1984. *Ecological Methods with particular reference to the study of insect populations*. Chapman & Hall. University Printing House, Cambridge: 524 pp.
- Tenhumberg, B. & Poehling, H-A. 1995. Syrphids as natural enemies of cereal aphids in Germany: Aspects of their biology and efficacy in different years and regions. Agric. Ecosyst. & Environ. 52: 39-43.
- Theunissen, J., 1992. Cabbage-clover intercropping: oviposition of *Delia radicum*. Proc. Exp. Appl. Entomol., N.E.V. Amsterdam 3: 191-96.
- Van Emden, 1966. Studies on the relations of insects and host plant. III. A comparison of the reproduction of *Brevicoryne brassicae* and *Myzus persicae* (Hemiptera: Aphididae) on brussels sprout plants supplied with different rates of nitrogen and potassium. Entomol. Exp. Appl. 9: 444-60.
- Wahbi, A.A. 1967. Untersuchungen über den Einfluß der Temperatur und der relativen Luftfeuchtigkeit auf das Fraßvermögen von Syrphidenlarven (Diptera, Syrphidae). Ph.D. Thesis, University of Göttingen.