

Impact of intercropping white cabbage with Pot Marigold
(*Calendula officinalis* L.) and French Marigold
(*Tagetes patula nana*) on the occurrence of cabbage aphid
(*Brevicoryne brassicae* L.), its parasitoid *Diaeretiella rapae*
M'Intosh and predatory *Syrphidae*

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Introduction

Diversity of plants in agrocenosis may be an important factor that influences the presence of pests as well as their natural enemies. Intercropping is one way of diversifying the species on the fields. Such intercropping in many cases limits the number of pests and increases the resistance of the environment (WIECH & KAŁEMUK, 2005). In the research on crop species diversification's impact on the presence of 198 pest species, a decrease in their number was confirmed in 59% of cases (RISCH *et al.*, 1983). Entomofauna of such systems is also richer in useful organisms (VAN EMDEN, 1979; ROOT, 1973). Cabbage aphid, *Brevicoryne brassicae* L. is a very important phytophag for cabbage-like vegetables (SZWEJDA, 2004; JANKOWSKA & WIECH, 2004). The parasitoid *Diaeretiella rapae* M'Intosh (MACKAUER & KAMBHAMPATI, 1984; JANKOWSKA & WIECH, 2003) and the aphidophagous *Syrphidae* (WNUK & WOJCIECHOWICZ, 1993; JANKOWSKA 2005) are of greatest importance in limiting the number of this aphid. The aim of this work was to determine the impact of intercropping of white cabbage with pot marigold *Calendula officinalis* L. and French Marigold, *Tagetes patula nana* on the presence of *B. brassicae*, its parasitoid *D. rapae* and the predatory *Syrphidae*.

Material and methods

The research was carried out in 2003-2005 at the Experimental Station in Mydlniki near the city of Kraków. Late headed white cabbage of the 'Bentley F1' cultivar was used for the experiment. Pot marigold (*Calendula officinalis* L.) of the 'Promyk' cultivar and French Marigold (*Tagetes patula nana* L.) of the 'Kolombina' cultivar were used for intercropping. The plants were sown on plots in three replications. In the case of cabbage grown in a homogenous crop the plants were sown in the area of 40x50 cm. In plots with intercropped cabbage, rows of cabbage (sown every 40 cm in a row) were separated with rows of Pot Marigold or French marigold. Analyses were carried out once a week. Each time 10 identified plants from each plot were searched; winged and wingless aphids, which occurred either in colonies or singly, were counted. The method of direct observation, which relied on the counting of mummies present in aphid colonies, was used to assess the degree of parasitizing. The number of mummies testifies to the activity of parasitoids and informs one of their so called real field effectiveness (BARCZAK, 1992). The mummies were left on plants to enable the flight of subsequent generations of the parasitoid. From all the plants on plots larvae and pupae of *Syrphidae* were collected and reared to obtain adult forms which were consequently identified with a key by BAŃKOWSKA (1963). Duncan's test was used to compare the significance of differences ($\alpha < 0.05$).

Results and discussion

First spring flights of migrants took place in the second (2003) or third (2004, 2005) decade of June. The highest number of winged aphids was recorded on cabbage of the homogenous crop, while a much smaller number was recorded on cabbage intercropped with Pot Marigold and French Marigold (Tab. 1.). Dynamics of flights depending on the kind of crop based on the example of year 2005 is presented in Fig. 1.

Table 1. Selected information on cabbage aphid's presence depending on the kind of cultivare (Mydlniki 2003-2005)

Selected information	Kind of crop		
	Homogenous crop	Cabbage with French Marigold	Cabbage with Pot Marigold
2003			
Mean number of winged aphids per plant	1.8 b	0.01 a	0 a
Mean number of aphids per plant	44.2 c	5.73 b	0.2 a
Percentage of infested plants			
17.06	33.3 b	0 a	0 a
03.07	50 b	10.a	33 a
Parasitising %	42 a	46 a	47 a
2004			
Mean number of winged aphids per plant	3 b	0.9 a	0.4 a
Mean number of aphids per plant	54.6 c	11.3 b	2.3 a
Percentage of infested plants			
28.06	64 b	30 a	26 a
09.07	93 b	36 a	30 a
Parasitising %	37 a	39 a	42 a
2005			
Mean number of winged aphids per plant	2.18 b	0.3 a	0.2 a
Mean number of aphids per plant	165.7 c	64.5 b	20.6 a
Mean number of aphids in the peak of appearance	435.9 c	151.9 b	49.3 a
Percentage of infested plants			
22.06	69.2	19.2	7.5
13.07	100	99	74
10.08	100	100	80
Parasitising %	35 a	38 a	40 a

Means in rows marked the same letters they are without statistical significant differences ($\alpha < 0.05$)

In all the years of research the percentage of plants infested by aphids was significantly higher in plots with cabbage sown in homogenous crop (Tab. 1.). In 2005 when aphid number was the highest, 100% plants were settled by

aphids already in mid-July, while 20% of plants intercropped with Pot Marigold were free from aphids until the end of season (French Marigold did not prove to be so effective) (Tab. 1.). Since the beginning of aphid population development clear differences were noticed. On cabbage of homogenous crop the number of aphids was much higher and it continued to grow fast, while on the intercropped cabbage the number of aphids remained at almost the same level for a long time (Fig. 1.).

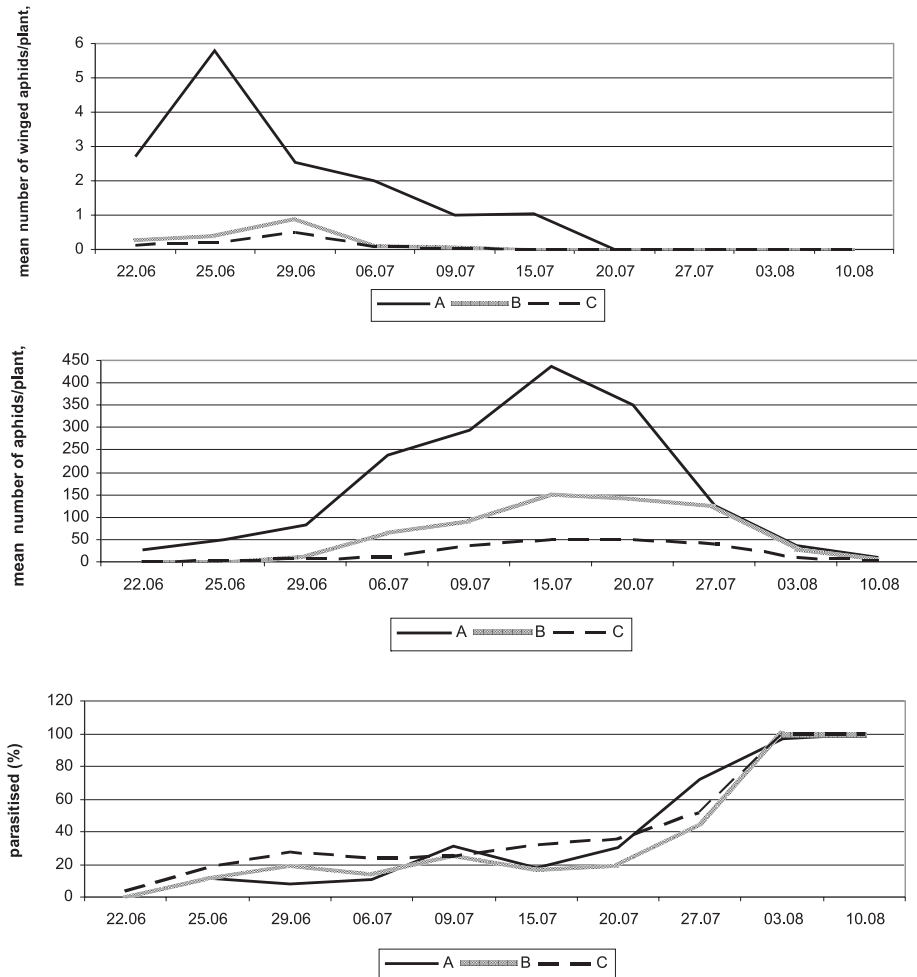


Fig. 1. Comparison of cabbage aphid (*Brevicoryne brassicae*) dynamics and its parasitizing by *Diaeretiella rapae* in relation to the cultivation method (Mydlniki 2005)

A – cabbage in homogenous crop

B – cabbage intercropped with French Marigold (*Tagetes patula nana*)

C – cabbage intercropped with Pot Marigold (*Calendula officinalis*)

In all the years of research a smaller number of aphids was registered on plants intercropped with Pot Marigold. These differences were significant not only in relation to the homogenous crop but also in relation to the intercropping with French Marigold (Tab. 1.). Increasing of aphid number on cabbage intercropped with white clover and French bean was registered by WIECH & WNUK (1991) and WIECH (1993). LEHMUS *et al.* (1999) also reported a lowering of *B. brassicae* number when cabbage was intercropped with clover. KIENEGGER *et al.* (2003) registered fewer aphids on Brussels sprouts intercropped with rows of blossoming plants, and KOTLINSKI (2001) on cauliflowers grown in combinations with cover plants. TUKAHIRVA & COAKER (1982) point out to the role of visual factors in finding a host plant. They claim that in a homogenous crop the soil of the intercrop contrasts with the host plant which makes it more visible and attractive for the aphids flying in. However, neither this theory of 'appropriate and inappropriate landings' nor the one provided by FINCH & COLLIER (2000) explains why in an intercropping of cabbage with Pot Marigold the number of aphids was significantly smaller than in an intercropping with French Marigold. Thus, it seems that chemical stimuli have a decisive role in this respect. In the process of finding the host plant it is the glucosinolanes which are present in all cabbage-like vegetables that are important phagostimulants for the cabbage aphid (ZABZA, 1989; OSTROUMOW, 1992; GABRYŚ, 1999). The proximity of plants which are not a host may mask the scent of host plant which hampers its finding (TAHVANAINEN & ROOT, 1972; PERRIN & PHILIPS, 1978; UTAH & COACKER, 1984). Some authors even claim that *Tagetes* with its odour may scare off the flying migrants (ROVIRA, 1969). In all the years of research the number of aphids on plants was greatly reduced by the parasitoid *Diaeretiella rapae* M'Intosh (Tab. 1.). The dynamics of parasitizing was similar irrespective of the way of cropping (Fig. 1.). In all the years of research the greatest degree of parasitizing was registered in aphid colonies feeding on cabbage intercropped with Pot Marigold, and the smallest on cabbage of homogenous crop. These, however, were not statistically significant differences (Tab. 1.). Significantly greater parasitizing of aphids on cabbage intercropped with French bean and clover was recorded by WIECH (1993).

Syrphidae, whose predatory larvae fed in cabbage aphid colonies were the second important factor to reduce the aphid number. The predator population dynamics in relation to its prey was similar in all the years of research which is presented in Fig. 2., based on year 2005 as an example. The presence of seven hoverfly species was confirmed: *Episyrphus balteatus* (Deg.), *Syrphus vitripennis* Mig., *Sphaerophoria scripta* (L.), *Sphaerophoria rueppelli* (Wied.), *Sphaerophoria menthastri* (L.), *Metasyrphus corollae* (Fabr.), *Scaeva pyrastris* (L.) (Tab. 2.).

All these species are common and their role is important in limiting the number of cabbage aphid which is confirmed by studies by other authors (WNUK & WOJCIECHOWICZ, 1993; JANKOWSKA, 2005). *E. balteatus* was a species that was the most numerous in all the years and kinds of research. According to WNUK & STARMACH (1977), and SANDERS (1980) hoverflies select plants which are more attacked by aphids for a place to lay their eggs. In spite of this a similar number of larvae was recorded in the *B. brassicae* colonies on plants intercropped with Pot Marigold and French marigold as in the homogenous crop (Tab. 2.) although many fewer aphids were registered there. Therefore, on plots with cabbage intercropped with pot marigold the relation of predator to the prey was the best which is significant also from the plant protection point of view and also since it favours quick elimination of the colony (WOJCIECHOWICZ-ŻYTKO, 2000). Also WIECH (1993) asserted a significantly higher number of hoverflies on cabbage intercropped with white clover and French bean where the number of aphids was small in comparison with the homogenous crop. This may suggest that hoverfly females when selecting a spot to lay their eggs are guided by many factors other than the size of colony. HUREJ *et al.* (1998) claim that rows of blossoming flowers attract adult *Syrphidae*. KIENEGGER *et al.* (2003) registered more eggs and larvae of *Syrphidae* on Brussels sprouts intercropped with rows of blossoming flowers than on those cropped under control. An increasing number of useful organisms in diverse agroecosystem is also highlighted by ROOT (1973).

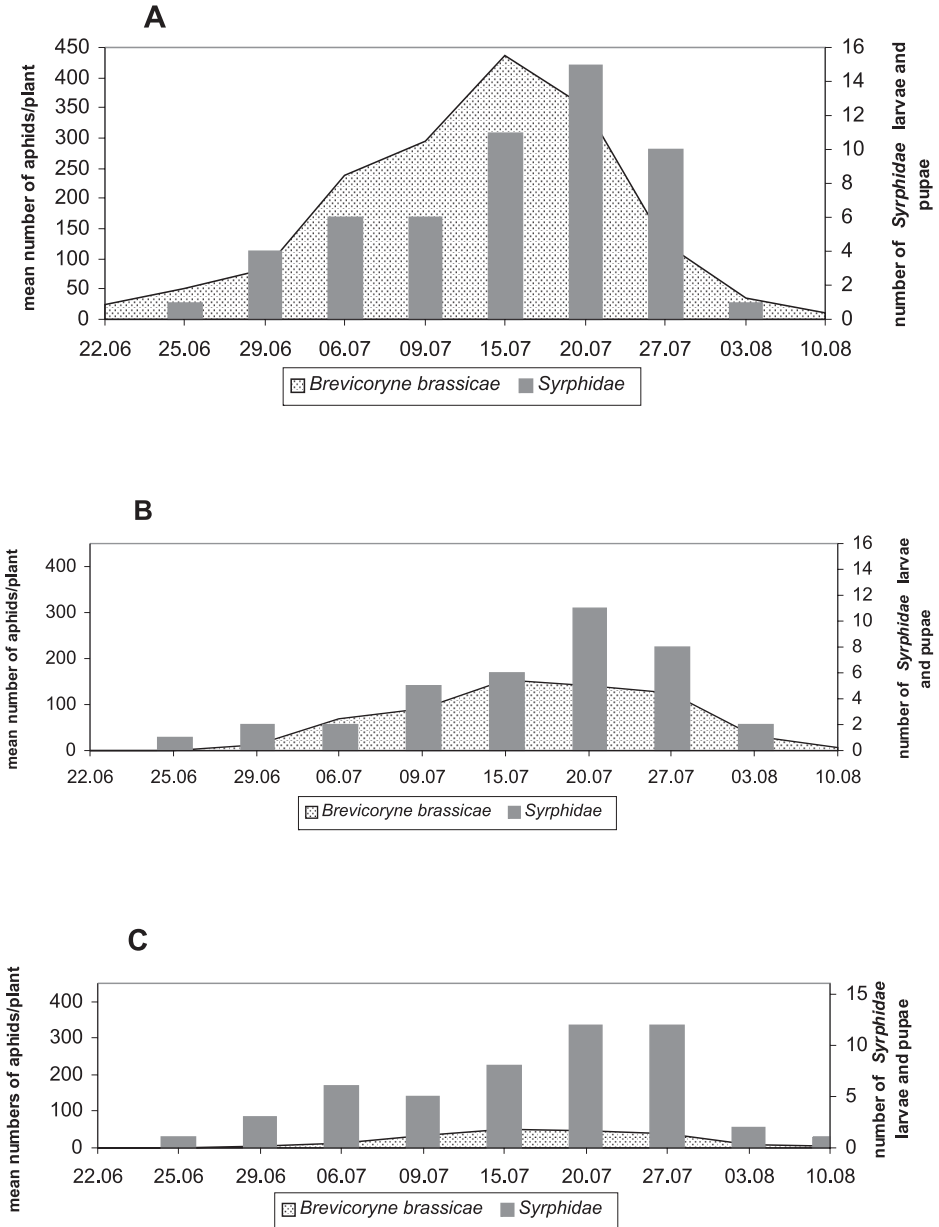


Fig. 2. Predatory *Syrphidae* number dynamics in relation to the cultivation method (Mydlniki 2005)
 A cabbage in homogenous crop
 B cabbage intercropped with French Marigold (*Tagetes patula nana*)
 C cabbage intercropped with Pot Marigold (*Calendula officinalis*)

Table 2. Checklist and number of hoverflies *Syrphidae* species in relation to the cultivation method (Mydlniki 2003-2205)

Species of <i>Syrphidae</i>	Kind of crop		
	Homogenous crop	Cabbage with French Marigold	Cabbage with Pot Marigold
2003			
<i>Episyrphus balteatus</i> (Deg.)	3	2	4
<i>Sphaerophoria rueppelli</i> (Wied.)		1	1
<i>Sphaerophoria scripta</i> (L.)	1	1	
Parasitized larvae	1	1	1
total	5 a	5 a	6 a
2004			
<i>Episyrphus balteatus</i> (Deg.)	5	5	4
<i>Sphaerophoria rueppelli</i> (Wied.)	3	1	1
<i>Sphaerophoria scripta</i> (L.)	1	1	2
<i>Sphaerophoria menthastri</i> (L.)	0	0	1
<i>Syrphus vitripennis</i> Meig	1		
Parasitized larvae		3	2
total	10 a	7 a	10 a
2005			
<i>Episyrphus balteatus</i> (Deg.)	36	27	26
<i>Metasyrphus corollae</i> (Fabr.)	6	3	5
<i>Sphaerophoria scripta</i> (L.)	5	3	4
<i>Sphaerophoria rueppelli</i> (Wied.)	2	1	4
<i>Scaeva pyrastris</i> (L.)	1		3
<i>Syrphus vitripennis</i> Meig.		1	3
Parasitized larvae	4	2	5
total	54 a	37 a	50 a

Means in rows marked the same letters they are without statistical significant differences ($\alpha < 0.05$)

Conclusions

1. Intercropping of cabbage with Pot Marigold and French Marigold had a significant impact on the limiting of aphids settling *B. brassicae*. The combination with Pot Marigold was especially favourable in this respect.

2. In combinations of cabbage with Pot Marigold and French Marigold the aphid parasitizing by *D. rapae* was greater, however, the differences were not statistically significant.
3. On plots where cabbage was intercropped the number of predatory *Syrphidae* was similar to that in homogenous crop, however, the number relations of predator to prey were more favourable there. The combination with Pot Marigold turned out to be the best in this respect.
4. Among the seven confirmed species of *Syrphidae* it was *E. balteatus* that was the dominating one.

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Wpływ współrzędnej uprawy kapusty białej z nagietkiem karłowym (*Calendula officinalis* L.) i aksamitką niską pełną (*Tagetes patula nana*) na występowanie mszycy kapuścianej (*Brevicoryne brassicae* L.), jej parazytoidea *Diaeretiella rapae* M'Intosh oraz drapieżnych *Syrphidae*

Streszczenie

W latach 2003-2005 badano wpływ współrzędnej uprawy kapusty białej z nagietkiem karłowym (*Calendula officinalis* L.) 'Promyk' i aksamitką niską pełną (*Tagetes patula nana*) 'Kolombina' na występowanie mszycy kapuścianej *Brevicoryne brassicae* L., jej parazytoidea *Diaeretiella rapae* M'Intosh i drapieżnych bzygowatych *Syrphidae*. Uprawa kapusty współrzędnie z aksamitką i nagietkiem istotnie wpływała na ograniczenie zasiedlenia roślin przez *B. brassicae*. Szczególnie korzystna pod tym względem okazała się kombinacja z nagietkiem. W kombinacjach kapusty z aksamitką i nagietkiem większe było spasożytowanie mszyc przez *D. rapae*, nie były to jednak różnice statystycznie istotne. Stwierdzono występowanie siedmiu gatunków bzygowatych, z których najliczniej występował *Episyrphus balteatus* Deg.. Na poletkach kapusty w uprawie współrzędnej liczba drapieżnych *Syrphidae* była podobna jak w uprawie jednorodnej, jednak stosunki liczbowe drapieżcy do ofiary były tam korzystniejsze. Najlepsza pod tym względem okazała się kombinacja z nagietkiem.

