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# EFFECT OF INTERCROPPING WHITE CABBAGE WITH FRENCH MARIGOLD (*TAGETES PATULA NANA*) AND POT MARIGOLD (*CALENDULA OFFICINALIS*) ON DIAMONDBACK MOTH (*PLUTELLA XYLOSTELLA* L.) POPULATION DENSITY AND IT'S PARASITOID COMPLEX

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Summary

The impact of intercropping white cabbage ('Bently $F_1$') with French Marigold *Tagetes patula nana* 'Kolombina' and Pot Marigold *Calendula officinalis* 'Promyk' on the occurrence of diamondback moth (DBM) (*Plutella xylostella* L.) and its parasitoid complex was estimated in years 2003-2005. The number of DBM larvae and pupae was significantly lower on plots where cabbage was intercropped compared with the control variant (homogenous crop). The combination with Pot Marigold turned out to be the best in this respect. The DBM larvae parasitization level varied from year to year and its percentage oscillated from 65 to 88%. Eight beneficial insect species belonging to families: *Ichneumonidae* (4 species), *Braconidae* (2 species), *Pteromalidae* (1 species) and *Eulophidae* (1 species) emerged from collected DBM pupae. *Diadegma fenestralis* Holmgr. was the most abundant species among all *Plutella* parasitoids every year of observations as it constitued 65% of all of the reared wasps. No significant differences were determined between the level of parasitization in relation to the type of cultivation.

key words: *Plutella xylostella*, cabbage, intercropping, parasitoids

## INTRODUCTION

The diamondback moth (DBM), *Plutella xylostella* (L.) (*Lepidoptera*: *Plutellidae*), remains one of the most damaging insect pests of brassica plants (*Brassica* sp.) worldwide. It is particularly dangerous to vegetables belonging to *Brassicaceae* family in Poland (Jankowska 2005, 2006) and have the potential to severely reduce the marketable yield or to completely destroy the crop. Overuse of broad-spectrum insecticides for diamondback moth control is a serious problem and has obscured the contribu-

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of indigenous parasitoids. The absence of effective natural enemies, especially parasitoids is belived to be a major cause of the diamondback moth's pest status. Naturally occurring parasites are important factors regulating pest population densities (Łagowska 1981, Wiech & Jankowska 1999, Jankowska & Wiech 2006). The biodiversification of the cultivated landscape has been a research trend in many countries worldwide. Moreover there is an increased realization over the world that development of biological control including preservation or augmentation of natural enemies is the base of management programmes (Talekar & Shelton 1993, Biever *et al*. 1994). 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 of the ways to diversify the species populations in the field. The aim of this work was to determine the impact of intercropping white cabbage with Pot Marigold *Calendula officinalis* L. and French Marigold *Tagetes patula nana* of the presence of diamondback moth and its parasitoid complex.

## MATERIAL AND METHODS

Observations on the occurrence of *P. xylostella* and its parasitoids were carried out in the Plant Protection Experimental Station in Mydlniki near Krakow, on brown soil developed on loess in 2003-2005. The experiment was designed as a randomized block, in three replications on 10.8 $m^2$ plots. The combinations of the experiment included three objects: homogenous crop white cabbage crop 'Bently $F_1$', cabbage intercropped with *Tagetes patula nana* 'Kolombina' and cabbage intercropped with *Calendula officinalis* 'Promyk'. *Tagetes* and *Calendula* were sown by hand on 22 April in 2003-2004, and 24 April in 2005. Cabbage was transplanted in spacing of 67.5 × 40 cm between flower rows on 28 May in 2003-2004, and 3 June in 2005. On experimental plots no chemical treatments were applied and weeds were removed mechanically. Ten plants from each plot were selected and marked for inspections made on a weekly basis during which both diamondback moth caterpillars and pupae were counted. The collected pupae of the diamondback moth were kept separately in glass vials at the laboratory until either parasitoid or moth emerged. Results were statistically analysed using analysis of variance. The significance of differences between particular combinations was counted using Duncan test at the 5% level.

## RESULTS AND DISCUSSION

The diamondback moth was observed each year of the experiment and occurred in all combinations. The first instar larvae were leaf miners, but later instars fed on the leaf surface. Caterpillars did not feed on veins and the sign of their presence were either windows or holes in leaves. Feeding caterpillars were observed both on the upper and lower leaf surface. The biggest DBM infestation was observed in July (Fig.1). Also in the previous research Jankowska (2005) noted the biggest infestation of different cabbage vegetables by DBM larvae at the same time. The occurrence period of caterpillars was

similar on all combinations, but statistically significant differences were found between infestation in accordance to the type of cultivation. On plots where cabbage was intercropped the number of DBM larvae and pupae was significantly lower compared with control variant (homogenous crop) (Table 1). The combination with Pot Marigold turned out to be the best in this respect. Vegetational diversity in the form of intercropping can result in reduced pest densities and increases the resistance of the environment (Wiech & Kałmuk 2005, Jankowska *et al.* 2009). Andow (1991) analysed 209 studies involving 287 pest species. Compared with monocultures, the population of pest insects was lower in 52% of the studies (149 species). Meny studies reported lower abundance of *P. xylostella* in intercropping system with labiate herbs (Dover 1986), clover and french bean (Wiech & Wnuk 1991), subterranean clover (Finch & Kienegger 1997), stravbery clover (Theunissen & Schelling 1996), white clover (Dover 1986, Wiech 1993), red clover (Åsman *et al.* 2001), tomatoes, garlic, dill, or clover (Buranday & Raros 1975, Dover 1986).

Table 1. Occurrence of the diamondback moth (*Plutella xylostella* L.) larvae and pupae on the cabbage according to the type of cultivation (2003-2005)

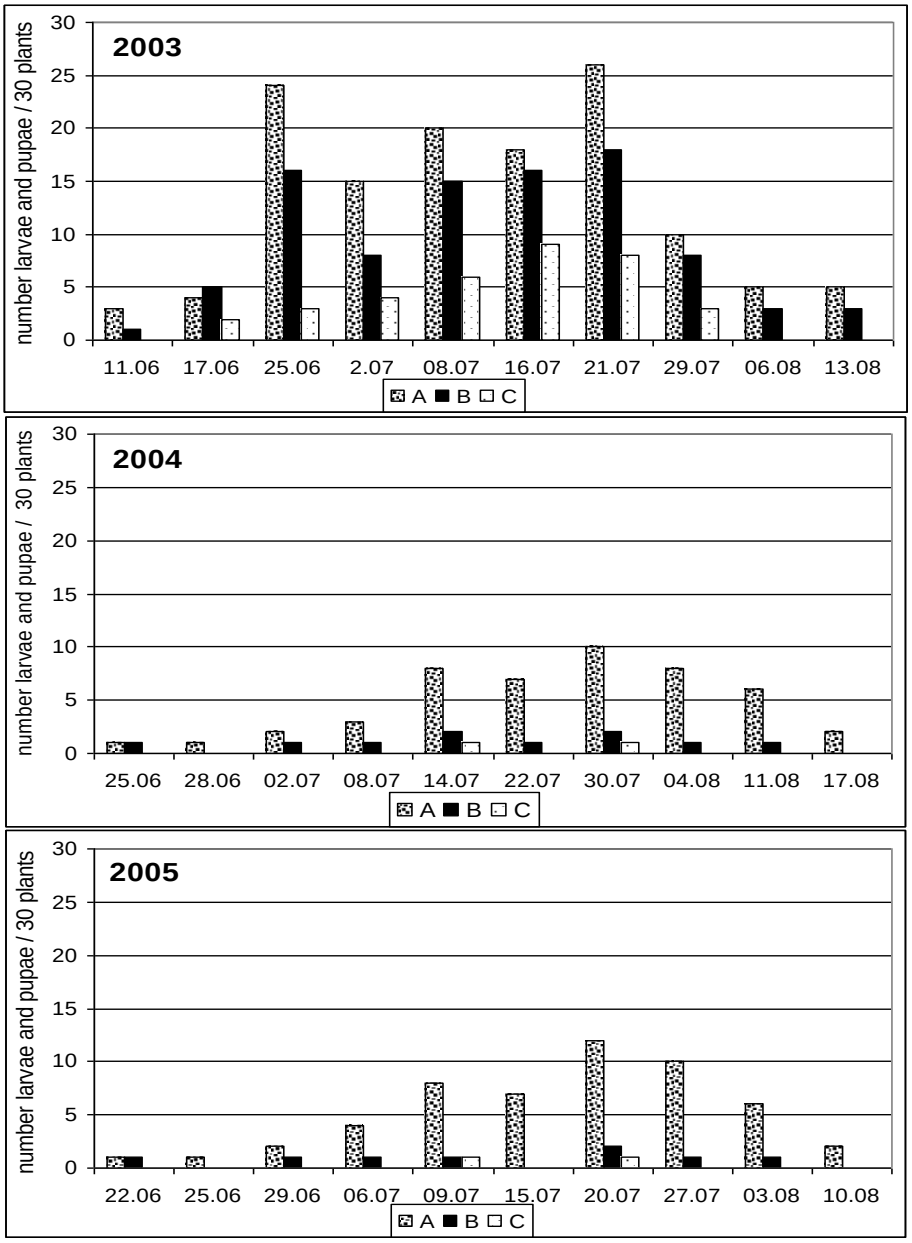
| Type of cultivation | Mean number larvae and pupae/30 plants | | |
|---|---|---|---|
| | 2003 | 2004 | 2005 |
| Cabbage (homogenous crop) | 13 b | 4.8 b | 5.3 b |
| Cabbage with *Tagetes patula* | 9.3 b | 1.0 a | 0.8 a |
| Cabbage with *Calendula officinalis* | 3.5 a | 0.2 a | 0.2 a |

Values followed by the same letter do not differ significantly at 5% level

Phytophagous insects locate plants for oviposition on the basis of scent and visual stimuli. Characteristic plant odours (volatile chemicals) are credited with the major role of guiding phytophagous insects to their host plants. Biologically active compounds called glucosinolates are feeding and oviposition stimulants for such a crucifer specialist. According to many authors (Gupta & Thorsteinson 1960, Srinivisan & Moorthy 1991, Pawar & Lawande 1995, Mitchel *et al.* 1997, Pivnick *et al.* 1990), *Plutella xylostella* is stimulated to oviposition on cabbage leaves by the secondary plant compound - allyl isothiocyanate. The proximity of plants which are not a host may mask the scent of host plant which hampers its finding (Perrin & Philips 1978).

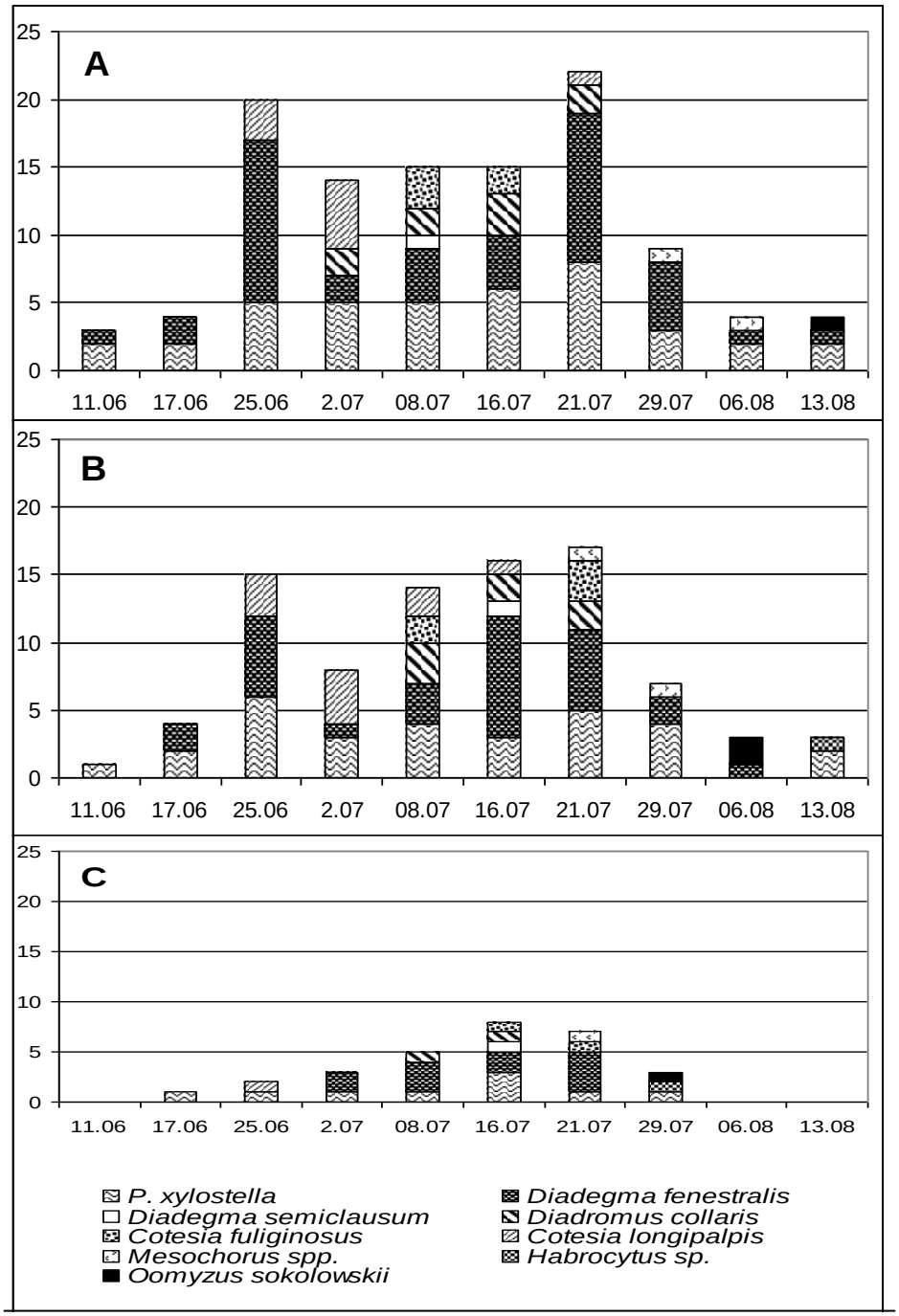
During 2003-2005 315 pupae of DBM were collected, but only 98 moths (31%) were recovered from the cocoons. The most important factor decreasing the number of DBM was parasitization (69%). The highest numbers of parasitoids were recorded in 2003 (Table 2, 3) when DBM was the most abundant. Result of rearing pupae of this pest are presented in Table 2. Total parasitization of DBM by all the parasitoids varied between the years and oscillated from 65 to 88% in the three years (Table 2). The dynamics of parasitizing was similar

irrespective of the way of cropping (Fig. 2). High rates of parasitism were recorded throughout the whole period of infestation by the DBM (Fig. 2).




A - cabbage in homogenous crop
B - cabbage intercropped with French Marigold (*Tagetes patula nana*)
C - cabbage intercropped with Pot Marigold (*Calendula officinalis*)

Fig. 1. Comparison of diamondback moth (*Plutella xylostella* L.) dynamics in relation to the cultivation method (2003-2005)




A - cabbage in homogenous crop
B - cabbage intercropped with French Marigold (*Tagetes patula nana*)
C - cabbage intercropped with Pot Marigold (*Calendula officinalis*)

Fig. 2. Number of parasitoid adults and diamondback moths obtained from the collected cocoons according to the type of cultivation on the example of year 2003

217 specimens of parasitic wasps belonging to 8 species from families: *Ichneumonidae* (4 species), *Braconidae* (2 species), *Pteromalidae* (1 species) and *Eulophidae* (1 species) emerged from the collected DBM pupae. Species composition and numbers of parasitoids are presented in Table 3.

In each year of observations the most abundant species among the *Plutella* parasitoids was *Diadegma fenestralis* Holmgr. as it constitued 65% of all of the reared wasps (Table 3). In the 2004 *D. fenestralis* was the only species (Table 3) parasitizing 88% (Table 2) of larvae. In Poland, in research of Łagowska (1981) *D. fenestralis* was the dominant species reducing 40-90% of pest population. Also observations of the dominant parasitoid species *D. fenestralis* were made by Wiech and Jankowska (1999), Wiech and Kałmuk (2002, 2003), Jankowska and Wiech (2006). This species was introduced from Europe to India where it became a natural enemy of *P. xylostella* (Devi & Raj 1995; Usha *et al*. 1997).

Table 2. Effect of rearing pupae of diamondback moth (*Plutella xylostella* L.) collected from cabbage crops

| Effect of rearing | 2003 | | 2004 | | 2005 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Number | % | Number | % | Number | % | Number | % |
| *Plutella xylostella* L. | 79 | 34.8 | 5 | 12 | 14 | 30.5 | 98 | 31 |
| Parasitoids | 148 | 65.2 | 37 | 88 | 32 | 69.5 | 217 | 69 |
| Total | 227 | 100 | 42 | 100 | 46 | 100 | 315 | 100 |

The other numerous parasitoids of *P. xylostella* caterpillars were: *Diadromus collaris* Holmgr. and *Cotesia longicauda.* Both of these species parasitized about 11.5% of DBM larvae (Table 3). *D. collaris* has been recorded in many parts of the world as an important parasitoid of the diamondback moth and introduced to Asia (Talekar 1996) and to New Zealand (Beck & Cameron 1990). In Poland it was reported by Łagowska (1981) and Miczulski (1996). *D. collaris* was described as larval-pupal (Avci & Ozbek 1990) or pupal (Okada 1991) parasitoid. Braconids belonging to genus *Cotesia* are considered as the most important representatives of this family reducing the number of DBM larvae (Łagowska 1981, Rice & Hahr 1994, Talekar 1996).

Another ichneumonid species emerging from *P. xylostella* larvae were *D. semiclausum* and *C. fuliginosus* (Table 3). Also three species of hyperparasitoids were reared: *Mesochorus spp., Habrocytus sp.* and *Oomyzus sokolowskii*. The action of the secondary parasitoids limits the efficiency of the primary parasitoids in controlling DBM populations. However, their presence is negligible and has no significant economic impact.

The attractiveness of flowers is an important characteristic that should be taken into account for the selection of flowering plants and tailoring nectar supply to the requirements of parasitoids holds potential to increase their effectiveness as biological control agents (Bianchi & Wäckers 2008).

Also Winkler *et al.* (2006) stress the importance of providing suitable nectar sources as an integral part of biological control programmes. Nawrocka (2006) noted that the number of entomophagous species (parasitoids and predators) were always higher on intercropped cabbage plants. Jankowska (2007) noted that on plots where cabbage was intercropped with Pot Marigold and French Marigold cabbage aphid parasitization by *Diaeretiella rapae* M'Intosh was greater and the percentages of predatory *Syrphidae* to prey were more favorable than on homogenous crop. However, studies conducted there were no significantly different between level of parasitization in relation to the cultivation method (Table 4). Also Wiech and Jankowska (1999) found no differences between the level of parasitism of the DBM larvae collected from the cabbage in homogenous crop and those intercropped with white clover.

Table 3. Species composition and quantities of parasitoid emerged from pupae of the diamondback moth (*Plutella xylostella* L.)

| Family /Species | 2003 | | 2004 | | 2005 | | Total | | Kind of parasitization |
|---|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % | |
| Family: *Ichneumonidae* *Diadegma semiclausum* Hellen | 3 | 2 | 0 | 0 | 0 | 0 | 3 | 1.4 | parasite of DBM larvae |
| *Diadegma fenestralis* Holmgr. | 84 | 56,8 | 37 | 100 | 20 | 62.5 | 141 | 65 | parasite of DBM larvae |
| *Diadromus collaris* Holmgr. | 18 | 12.2 | 0 | 0 | 7 | 21.9 | 25 | 11.5 | parasite of DBM pupae |
| *Mesochorus spp.* | 5 | 3.4 | 0 | 0 | 0 | 0 | 5 | 2.3 | hyperparasitoid |
| Family: *Braconidae* *Cotesia longicauda* Wesm. | 20 | 13.5 | 0 | 0 | 5 | 15.6 | 25 | 11.5 | parasite of DBM larvae |
| *Cotesia fuliginosus* Wesm. | 12 | 8.1 | 0 | 0 | 0 | 0 | 12 | 5.5 | parasite of DBM larvae |
| Family: *Pteromalidae* *Habrocytus sp.* | 2 | 1.3 | 0 | 0 | 0 | 0 | 2 | 1 | hyperparasitoid |
| Family *Eulophidae* *Oomyzus sokolowskii* Kurd. | 4 | 2.7 | 0 | 0 | 0 | 0 | 4 | 1.8 | hyperparasitoid |
| Total | 148 | 100 | 37 | 100 | 32 | 100 | 217 | 100 | |

Table 4. Comparison of the occurrence of parasitoids of diamondback moth (*Plutella xylostella* L.) in relation to the cultivation method (2003-2005)

| Species of parasitoids | Cabbage (homogenous crop) | Cabbage with *Tagetes patula* | Cabbage with *Calendula officinalis* |
|---|---|---|---|
| | **2003** | | |
| *Diadegma semiclausum Hellen* | 1 | 1 | 1 |
| *Diadegma fenestralis* Holmgr | 43 | 30 | 11 |
| *Diadromus collaris* Holmgr. | 9 | 7 | 2 |
| *Mesochorus spp.* | 2 | 2 | 1 |
| *Cotesia fuliginosus* Wesm. | 5 | 5 | 2 |
| *Cotesia longicauda* Wesm. | 9 | 10 | 1 |
| *Habrocytus sp.* | 0 | 1 | 1 |
| *Oomyzus sokolowskii* Kurd. | 1 | 2 | 1 |
| Total | 70 | 58 | 20 |
| Parasitization % | 67 a | 63 a | 65 a |
| | **2004** | | |
| *Diadegma fenestralis* Holmgr | 28 | 7 | 2 |
| Parasitization % | 74 | 90 | 100 |
| | **2005** | | |
| *Diadegma fenestralis* Holmgr. | 17 | 2 | 1 |
| *Diadromus collaris* Holmgr. | 6 | 1 | 0 |
| *Cotesia longipalpis* Reinhard | 3 | 1 | 1 |
| Total | 26 | 4 | 2 |
| Parasitization % | 54 | 54 | 100 |

## CONCLUSIONS

1. On plots where cabbage was intercropped the number of DBM larvae and pupae was significantly lower compared with control variant (homogenous crop). The combination with Pot Marigold turned out to be the best in this respect.
2. The parasitization of DBM larvae varied between the years and oscillated from 65 to 88% and was a very important factor reducing the number of emerging diamondback moths.
3. Eight species belonging to families: *Ichneumonidae* (4 species), *Braconidae* (2 species), *Pteromalidae* (1 species) and *Eulophidae* (1 species) emerged from the collected DBM pupae. In each year of observations the most abundant species among *Plutella* parasitoids was *Diadegma fenestralis* Holmgr. as it constitued 65% of all of reared wasps.
4. No differences were determined between the level of parasitization in relation to the cultivation method.

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## WPŁYW WSPÓŁRZĘDNEJ UPRAWY KAPUSTY BIAŁEJ Z NAGIETKIEM KARŁOWYM (*CALENDULA OFFICINALIS* L.) I AKSAMITKĄ NISKĄ PEŁNĄ (*TAGETES PATULA NANA*) NA WYSTĘPOWANIE TANTNISIA KRZYŻOWIACZKA *PLUTELLA XYLOSTELLA* L. I JEGO PARAZYTOIDÓW

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 tantnisia krzyżowiaczka *Plutella xylostella* L. oraz związanych z nim parazytoidów. Na poletkach, gdzie kapusta była uprawiana współrzędnie, stwierdzono istotnie mniej gąsienic i poczwarek tantnisia. Najlepsza pod tym względem okazała się kombinacja z nagietkiem. Spasożytowanie wahało się w poszczególnych latach od 65 do 85%. Nie stwierdzono istotnych różnic w spasożytowaniu w zależności od sposobu uprawy. Z zebranych poczwarek wyhodowano 8 gatunków parazytoidów z rodzin *Ichneumonidae* (4 gatunki), *Braconidae* (2 gatunki), *Pteromalidae* (1 gatunek) i *Eulophidae* (1 gatunek). We wszystkich latach gatunkiem dominującym był *Diadegma fenestralis* Holmgr.