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THE EFECT OF CRUCIFEROUS VEGETABLES ON OCCURRENCE OF *CECIDOMYIIDAE, COCCINELLIDAE* AND *CHRYSOPIDAE* PREDATORS IN COLONIES OF CABBAGE APHID (*BREVICORYNE BRASSICAE* L.)

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Abstract: In 1993–1997 the occurrence of cabbage aphid (*Brevicoryne brassicae* L.) and predators from *Cecidomyiidae, Coccinellidae* and *Chrysopidae* was observed on the nine different late cabbage vegetables; Savoy cabbage cv. 'Vertus', white cabbage cv. 'Amager', red cabbage cv. 'Langendijker', brussel sprouts cv. 'Maczuga', cauliflower cv. 'Pionier', blue kohlrabi cv. 'Masłowa', white kohlrabi cv. 'Delikates', kale cv. 'Zielony Kędzierzawy' and broccoli cv. 'Piast'. Among the examined predators only the cecidomyiid – *Aphidoletes aphidimyza* Rond. (*Cecidomyiidae*) played an important role in reducing the number of cabbage aphids. The cruciferous species had no impact on the density of *A. aphidimyza* population, and females laying eggs. The size of aphid colonies on cabbage leaves played the most important role.

Key words: *Brevicoryne brassicae* L., *Coccinellidae, Chrysopidae, Aphidoletes aphidimyza,* cabbage vegetables, predators

INTRODUCTION

Mealy cabbage aphid (*Brevicoryne brassicae* L.) is one of the three most common aphid species in Poland (Złotkowski 1988). It feeds on all cultivated and wild cruciferous plants (Szelegiewicz 1968), and is the main pest on all cabbage vegetables. Naturally occurring parasites and predators are important factors in regulating population densities of *B. brassicae*. The most important natural enemy decreasing the number of the cabbage aphid is the parasite wasp *Diaeretiella rapae* (M'Intosh) (Jankowska and Wiech 2003). Syrphids are the second group playing a major role in reducing cabbage aphid population (Jankowska 2005). This paper presents results of field studies carried out in the years 1993–1995, on the occurrence of predatory in-

sects from *Cecidomyiidae, Coccinellidae* and *Chrysopidae* and their role in reducing the *B. brassicae* population on different cruciferous vegetables.

MATERIAL AND METHODS

The experiments were carried out from 1993 till 1995 at the Agricultural Experimental Station in Mydlniki near Cracow. The following nine late cruciferous vegetables; Savoy cabbage cv. 'Vertus', white cabbage cv. 'Amager', red cabbage cv. 'Langendijker', brussels sprouts cv. 'Maczuga', cauliflower cv. 'Pionier', blue kohlrabi cv. 'Masłowa', white kohlrabi cv. 'Delikates', kale cv. 'Zielony Kędzierzawy' and broccoli cv. 'Piast' (except 1993), were grown on plots of 30 m^2 each, in four replications. No insecticide treatment was applied and the weeds were removed mechanically. Other vegetable species (broad bean, tomatoes, pepper, carrot, onion, red beet) were cultivated near the experimental plots. The observations began when the first winged forms of *B. brassicae* appeared and were continued until the population of aphids disappeared. Every 3–4 days, 12 plants from each vegetable species were inspected. Each time the number of aphids in colonies as well as the number of colonies were recorded. The different stages of predators of various groups were also counted on the tested plants. The identification of adult *Coccinellidae* was based on identification key by Bielawski (1959). The larvae of *Aphidoletes* were collected and reared in glass vials and identified using Mamajev's (1969) publication. The Duncan's multiple test ($\alpha<0.05$) was used for statistical analysis of the results.

RESULTS AND DISCUSSION

During the observations carried out in the years 1993–1995 the plants infestation by aphids differed each month. In July blue kohlrabi was the most colonised, in August brussel sprouts and in September red cabbage. The population dynamics of aphids as well as development on observed nine cabbage vegetables were presented in the previous report by Jankowska and Wiech (2004). The selected information concerning occurrence of cabbage aphid (*B. brassicae* L.) in successive years on different vegetables is presented in Table 1. Among the examined groups of predators only predatory *Cecidomyiidae* played an important role in fighting aphids.

Cecidomyiidae. In conducted field experiments the occurrence of the aphid midge (*Aphidoletes aphidimyza* Rond.) was observed. Barnes (1929) mentions ten species of predatory *Cecidomyiidae* attacking aphids. The occurrence of the larvae of *A. aphidimyza* in aphid colonies on the examined vegetables is presented in Table 2. The larvae were only registered on cruciferous plants in 1994 and 1995 growing seasons. They did not appear in 1993, which was probably due to by the fact that in 1993 aphids were present on plants only until the end of July, while according to Nawrocka (1984) they are most numerous in August and September and that affects their density in the following year. Larvae were found on all the examined vegetables except for kale and both kohlrabies. Similarly, Gadomski et al. (1998) while examining a lot of plants from the family of *Cruciferae*, found larvae of *A. aphidimyza* in colonies of cabbage aphids only on the white cabbage and cauliflowers. Furthemore, it was proven that *A. aphidimiza* exhibited a marked numerical response to

aphid density. The larvae often occurred only on single plants with abundant colonies of aphids. Thus, in 1994 in one large colony 58 larvae were found on the Savoy cabbage and in 1995 up to 66 larvae on one white cabbage. It suggests that a female of *A. aphidimiza* starts to lay eggs in a place where there is enough food for larval development. It is also confirmed by the fact that although in 1994 aphids were already feeding on plants from the end of April, larvae of aphid midge were not observed before the beginning of August, when the aphid colonies increased above 40 specimens (larvae of *Syrphidae* had already been feeding since mid-July (Jankowska 2004). Similarly in 2005 larvae of aphid midge appeared in colonies numbering over 50. The larvae of this species feed on over 60 aphid species, including cabbage aphid and only that stage is predaceous. The effectiveness of *Aphidoletes* in eliminating aphids was observed by Pollard (1969) and Raworth (1984). Females

Table 1. The density of cabbage aphid (*Brevicoryne brassicae* L.) population on some cruciferous vegetables in the 1993–1995 growing seasons

Vegetable	Savoy cabbage	White cabbage	Blue kohlrabi	Kale	Cauli-flower	Brussel sprouts	White kohlrabi	Red cabbage	Broccoli
1993									
Mean number of aphids/plant during the season	88.9 bc	114.2 c	168.9 a	53.6 a	70 ab	106.5 c	92.9 bc	60 a	X
Mean number of aphids/plant in period of max. infestation	281.9	349.4	485.4	164.3	293.6	332.4	371.8	165.2	X
Mean number of aphids/colony in period of max.infestation	111.4	127.9	117	88.2	80	50.6	130.2	103.5	X
1994									
Mean number of aphids/plant during the season	23.9 bc	20.5 ab	33.6 cd	11.8 a	24.4 bc	38.9 d	23.9 bc	43.8 d	25 bc
Mean number of aphids/plant in period of max infestation	73.8	54.2	91.7	33.7	66.8	145.5	81.6	221.2	72.3
Mean number of aphids/colony in period of max.infestation	145.3	167.9	128.3	108.4	108.4	88	108	666.2	118
1995									
Mean number of aphids/plant during the season	48.5 bc	52.6 c	85.9 e	17.1 a	40.9 bc	90.4 e	35.8 b	78.3 d	39.1 b
Mean number of aphids/plant in period of max. nfestation	100.2	89.4	180.8	49.5	102.5	165.8	82.8	135.6	106.3
Mean number of aphids/colony in period of max. infestation	156.4	158.6	187.3	101.4	107.4	94.7	68	350.1	120.3

Values followed by the same letter do not differ at 5% level of significance (Duncan's multiple test)

Table 2. The occurrence of aphid midge (*Aphidoletes aphidimyza* Rodani) larvae in cabbage aphid (*Brevicoryne brassicae* L.) colonies on various vegetable species (no. of specimens per 12 plants)

Vegetable	Savoy cabbage	White cabbage	Blue kohlrabi	Kale	Cauli-flower	Brussel sprouts	White kohlrabi	Red cabbage	Broccoli
				1994					
Number of larvae	58 a	4 a	0 a	0 a	18 a	11 a	0 a	6 a	26 a
				1995					
Number of larvae	19 a	103 a	0 a	0 a	29 a	0 a	0 a	0 a	10 a

Values followed by the same letter do not differ at 5% level of significance (Duncan's multiple test)

lay eggs on leaves close to aphid colonies (Wilbert 1972). Larvae feed on them by biting aphids in their legs and paralyzing them with a toxin before sucking out aphid body fluids. Larvae may consume 3–50 aphids per day, but if an aphid population is high, *Aphidoletes* kill many more aphids that they actually consume. *A. aphidimiza* is used successfully in biological control of aphids in greenhouses on a commercial scale, and it presents a good perspective for biological aphid control in the field, too.

Chrysopidae. Eggs of lacewings were fund on all the examined vegetables. They were laid separately, or in small groups of approximately 3–4 (max. 7). The highest numbers of eggs were found on the Savoy cabbage whose structure of leaves (very wrinkled) created favourable conditions for hiding eggs against predators. Not too many larvae of lacewings were observed (Table 3). The same observations were made by Injac and Krnjajić (1990). They found only 21 larvae of lacewing on the cabbage, despite the finding of as many as 1394 eggs. Nawrocka (1984) states that lacewings as polyphagies do not play a crucial role in fighting cabbage aphids. It is confirmed by the fact that by penetrating plants larvae of lacewing attack caterpillars of diamond back moth. In the research conducted till 1997 on insects on cab-

Table 3. The occurrence of lacewing (*Chrysopidae*) eggs and larvae in cabbage aphid (*Brevicoryne brassicae* L.) colonies on the studied cruciferous vegetables (no. of specimens per 12 plants)

Vegetable	Year						Total	
	1993		1994		1995			
	eggs	larvae	eggs	larvae	eggs	larvae	eggs	larvae
Savoy cabbage	8	0	33	0	8	0	49	0
White cabbage	7	0	18	2	2	1	27	3
Blue kohlrabi	2	0	13	0	5	0	20	0
Kale	9	0	13	0	7	0	29	0
Cauliflower	3	0	8	1	2	0	13	1
Brussel sprouts	1	0	9	0	3	0	13	0
White kohlrabi	7	0	13	1	1		21	1
Red cabbage	3	0	11	0	1	0	15	0
Broccoli	X	X	22	1	5	0	27	1
Total	40	0	140	5	34	1	214	6

Table 4. The number of sevenspotted lady beetle (*Coccinella septempunctata* L.) eggs, larvae and beetles in colonies of *Brevicoryne brassicae* L. on different cruciferous vegetables (no. of specimens per 12 plants)

Vegetable	Year												Total				
	1993				1994					1995							
	egg clusters	eggs	larvae	adults	egg clusters	eggs	larvae	pupae	adults	egg clusters	eggs	larvae	egg clusters	eggs	larvae	pupae	adults
Savoy cabbage	2 a	38 a	1 a	3 a	0 a	0 a	3 a	2 a	1 a	1 a	32 ab	2 a	3 a	70 a	6 ab	2 a	4 a
White cabbage	3 a	62 a	0 a	3 a	0 a	0 a	7 a	0 a	6 ab	1 a	40 ab	3 a	4 a	102 ab	10 b	0 a	9 ab
Blue kohlrabi	10 b	260 b	0 a	1 a	0 a	0 a	4 a	0 a	5 a	3 b	116 b	0 a	13 b	376 b	4 a	0 a	6 a
Kale	5 a	114 ab	0 a	4 a	2 a	48 b	1 a	0 a	9 b	4 b	119 b	3 a	11 b	281 b	4 a	0 a	13 b
Cauliflower	0 a	0 a	0 a	0 a	0 a	0 a	3 a	1 a	8 b	0 a	0 a	0 a	0 a	0 a	3 a	1 a	8 ab
Brussel sprouts	1 a	20 a	1 a	1 a	0 a	0 a	2 a	0 a	4 a	0 a	0 a	0 a	1 a	20 a	3 a	0 a	5 a
White kohlrabi	1 a	58 a	0 a	3 a	1 a	11 a	4 a	1 a	1 a	0 a	0 a	0 a	2 a	69 a	4 a	1 a	5 a
Red cabbage	5 a	133 ab	0 a	0 a	0 a	0 a	2 a	0 a	2 a	0 a	0 a	0 a	5 a	133 ab	3 a	0 a	2 a
Broccoli	X	X	X	X	1 a	30 b	1 a	0 a	4 a	0 a	0 a	0 a	1 a	30 a	1 a	0 a	4 a
Total	27	685	2	15	4	89	27	4	41	9	307	9	40	1081	38	4	56

Means followed by the same letter within a column are not significantly different ($\alpha<0.05$)

bage plants only few colonies of aphids on single plants were observed. Despite that, in 1997, when practically no aphids were found, one observed the highest number of eggs laid by lacewings, mainly on the Savoy cabbage. In that year caterpillars of butterflies, mainly of diamondback moth, were feeding in large numbers on plants (Jankowska 2005). So, it might be assume that they replaced aphids as a source of food for lacewings. Eigenbrode et al. (1995; 1996) point to two species of lacewings, including *Chrysoperla carnea* Steph., as predators of diamondback moth.

Coccinellidae are the best known predators of aphids. Many authors have pointed out their effectiveness in reducing the number of many species of aphids (Olszak 1978; Ciepielewska 1991; Lipok 1993; Kordian and Ciepielewska 1998; Wojciechowicz-Żytko 1999; Pobożniak and Wnuk 2003). The impact of ladybugs on reducing the number of the cabbage aphid may be significant, if they feed on some cruciferous plants, like oilseed rape crop, oilseed rape self-sown and white mustard (Gadomski et al. 1998). However their importance in reducing the number of *B. brassicae* feeding on the cruciferous vegetables is regarded as relatively insignificant (Nawrocka 1984; Gadomski et al. 1998). It is also confirmed by the conducted observations. During the research a sevenspotted lady beetle (*Coccinella septempunctata* L.) was the most dominant species. During all these years only a few twospotted lady beetles (*Adalia bipunctata* L.) were noted: in July 1993 two on the brussel sprouts and one on the Savoy cabbage in July 1994. The occurrence of eggs, larvae and adults of *Coccinella septempunctata* L. is presented in Table 4. The highest number of eggs laid by the lady beetles was observed in 1993 and in July 1994, and at that time most of the adult lady beetles were found on the kohlrabi and kale (Table 4), yet it would not result in the number of the larvae feeding on the plants. In 1993, despite the fact that 994 eggs of lady beetles (685 on plants and 309 on stakes to mark the plots) were found, at a later time there were only two feeding larvae. At the same time numerous larvae of lady beetles feeding on colonies of *Aphis fabae* Scop. on the broad beans were observed in the nearby plots (Wojciechowicz-Żytko 1998). It confirms that cabbage aphids are of little interest as food for lady beetles.

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POLISH SUMMARY

WPŁYW ROŚLIN KRZYŻOWYCH NA WYSTĘPOWANIE DRAPIEŻCÓW; *CECIDOMYIIDAE, COCCINELLIDAE* I *CHRYSOPIDAE* W KOLONIACH MSZYCY KAPUŚCIANEJ (*BREVICORYNE BRASSICAE* L.) NA RÓŻNYCH WARZYWACH KAPUSTNYCH

W latach 1993–1995 na dziewięciu późnych warzywach kapustnych obserwowano występowanie mszycy kapuścianej *Brevicoryne brassicae* L. oraz owadów drapieżnych z *Cecidomyiidae, Coccinellidae* i *Chrysopidae*. W doświadczeniu wykorzystano kapustę włoską odm. 'Vertus', kapustę głowiastą białą odm. 'Amager', kapustę czerwoną odm. 'Langendijker', kapustę brukselską odm. 'Maczuga', kalafior odm. 'Pionier', kalarepę niebieską odm. 'Masłowa', kalarepę białą odm. 'Delikates', jarmuż odm. 'Zielony Kędzierzawy' oraz brokuła włoskiego odm. 'Piast'. Z badanych drapieżców znaczenie w ograniczaniu liczebności mszycy kapuścianej miał tylko pryszczarek mszycojad *Aphidoletes aphidimyza* Rond. (*Cecidomyiidae*). Stwierdzono, że odmiana kapusty nie miała wpływu na liczebność *A. aphidimyza,* a samice składające jaja na liściach kierowały się przede wszystkim wielkością znajdujących się tam kolonii mszyc.