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Factors determining the number of aphids /Hemiptera, Aphidoidea/ in conventional and organic potato crops

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Abstract

During a three-year-long research carried out in three sites in the Lower Silesia, the number of aphids and aphids predators in conventional and organic potato crops was observed. *Myzus persicae* Sulz. was the most numerous species in both kinds of crops. Aphid density differed significantly in the research years. The lovest aphids density on potatoes was recorded in 2002. In 2003 their number was twice as high, while in 2004 three times higher. Little and evenly distributed rainfall as well as mean temperatures until the end of July not exceeding 20°C had a favourable impact on the number of aphids in both kinds of crops. Shortage of rainfall and higher temperatures limited the number of aphids. In total 22% more aphids were recorder on organic potato crops than on conventional crops and this difference was significant. This resulted from a bigger number of control treatments that were carried out on conventional crops, especially in June. Moreover, potato stalks of organic potatoes which contained more nitrogen and less phosphor than conventional crops provided better feeding conditions to aphids. A positive impact of whey used as a fertilizer in the organic crops was observed on the number of aphids. The greatest difference in aphid density between the kind of crops was recorded in the year when the pest had a low reproduction level (2002), when the number of aphids was almost twice as much. In the years which favoured aphid development this difference was the smallest (5% in 2003 and 19% in 2004).

The density of aphids predators on organic crops was about 8 times higher than on conventional crops and this difference was statistically significant. The number of aphids per one predator in organic crops was 4.3 and in conventional crops this indicator was 5 times higher. Aphids in organic crops were constantly controlled by predators. In predators group on conventional crops the ladybird adults dominated, whereas in organic crops there were more ladybird larvae. After ladybirds, chrysopa larvae were the second group in terms of their numbers, and larvae of syrphids were the least numerous. On organic crops more than 20% of predators larvae pupated and in the conventional ones – about 1%. Organic crops are thus considered to be refugia for aphids' natural enemies.

Introduction

One of the basic tasks in plant protection is to recognise environmental factors that determine the number of phytophagous organisms. This knowledge lets one relatively early foresee the intensity of the pest and the resulting threat for crops (Pruszyński & Walczak, 2006). This in particular concerns phytophags which are economically important as they feed on agricultural plants cropped in a large area. According to Nowacki (2005) potato is a plant requiring the most extended protection and so, for the purpose on average 4 kg of active substance/ha is used, while an average amount per 1 ha of all the crops amounts to 0.56 kg/ha. In production farms using potatoes for food processing this indicator rises to 14 kg. Such a high degree of chemical treatment of potato crops points out to the need to determine the conditions in which the number of pests may be reduced naturally and remain on the level below harmfulness threshold. Moreover, the most recent research claims about a growing aphid resistance to insecticides from various chemical groups. Chemical control of aphids as non-persistent potato virus vectors may also bring results opposit to the expected (Goliszewski & Zakrzyńska, 2008). Due to phytosanitary reasons the potato is considered to be the most difficult plant to be cared for in an organic system. Our research which was simultaneously carried out both in a conventional and an organic method revealed many relations between the environment, the plant and the pest.

The aim of the research was to determine to what extent abiotic factors (weather conditions and protection measures) as well as biotic ones regulate the number of aphids in conventional and organic crops of potatoes.

Material and methods

The research was carried out in 2002-2004 in six farms in the Opole district. These farms were coupled (one was conventional and one was organic) on the Śląska Lowland in Myśliborzyce near Brzeg, and Prószków near Opole as well as in the Sudety Tectonic Foreland in Ligota Bialska near Prudnik. The distance between these towns in a straight line was 70 km. The studied fields with potatoes of the 'Bryza' cultivar were always situated in an open area of a mosaic structure of the landscape surrounded by other crops. The surface of each analysed crops was 0.5 ha and they were separated from one another no more than 500 m. Organic farms, which included the researched crops, had a long history of crops in such a system. The farm in Myśliborzyce obtained a certificate of Ecoland in 1993, in Prószków in 1994, while the farm in Ligota Bialska at the time of research onset was in the second year of transformation and obtained a certificate in 2003.

Entomofaunistic observations in potato crops were carried out once a week, using the method of random analyses. For an analysis plants were selected along the diagonal of fields. Growth in the number of aphids and their natural enemies was determined in a sample of 100 leaves from 34 plants (1 composed leaf from bottom, middle and top parts of the plants from 33 plants and 1 leaf from the middle part of the 34^{th} potato plant). Wingless aphids were determined on the basis of field key published by Zeneca Crop Protection The Aphid Identification Guide (1998).

To assess the possibility of an effective control of aphid number by predators the prey predator indicator was used and, it determined the number of aphids per 1 effective stadium of predator (number of aphids / 1 predator).

The obtained data was described statistically by making a three-factor analysis of variance for a method of complete randomization. To verify the hypotheses on the lack of differentiation among the years and locations of the research, types of crops and double interactions the F (Fisher's) test was applied. Mean squares of particular sources of changeability was tested by a mean square of a triple interaction. To compare the mean numbers and to calculate the lowest significant difference (LSD) multiple test of Duncan's was applied. A statistical analysis of the results were performed using the ANOVA programme.

Characteristics of weather conditions in the years of research

Weather conditions based on climatic data from meteorological station in Łosiów (15 km from Myśliborzyce and 40 km from Prószków) and from meteorological station in Głubczyce (20 km from Ligota Bialska). Information characterizing the course of weather during the research period is presented in Fig. 1. Growth season of 2002 had the greatest amount of rainfall of all the research years. The most intensive rainfall was recorded in the first decade of June, when in both regions decade sums were above 60 mm while mean daily temperatures were 15°C. The highest daily temperature amounting to 21.5°C was registered only in the first decade of August. In 2003, after a snow-less winter, there followed a strong shortage of rainfall in both regions. In June, when the mean monthly temperature was 20°C there was no rainfall, and in July and August the highest of all the research years mean daily temperatures

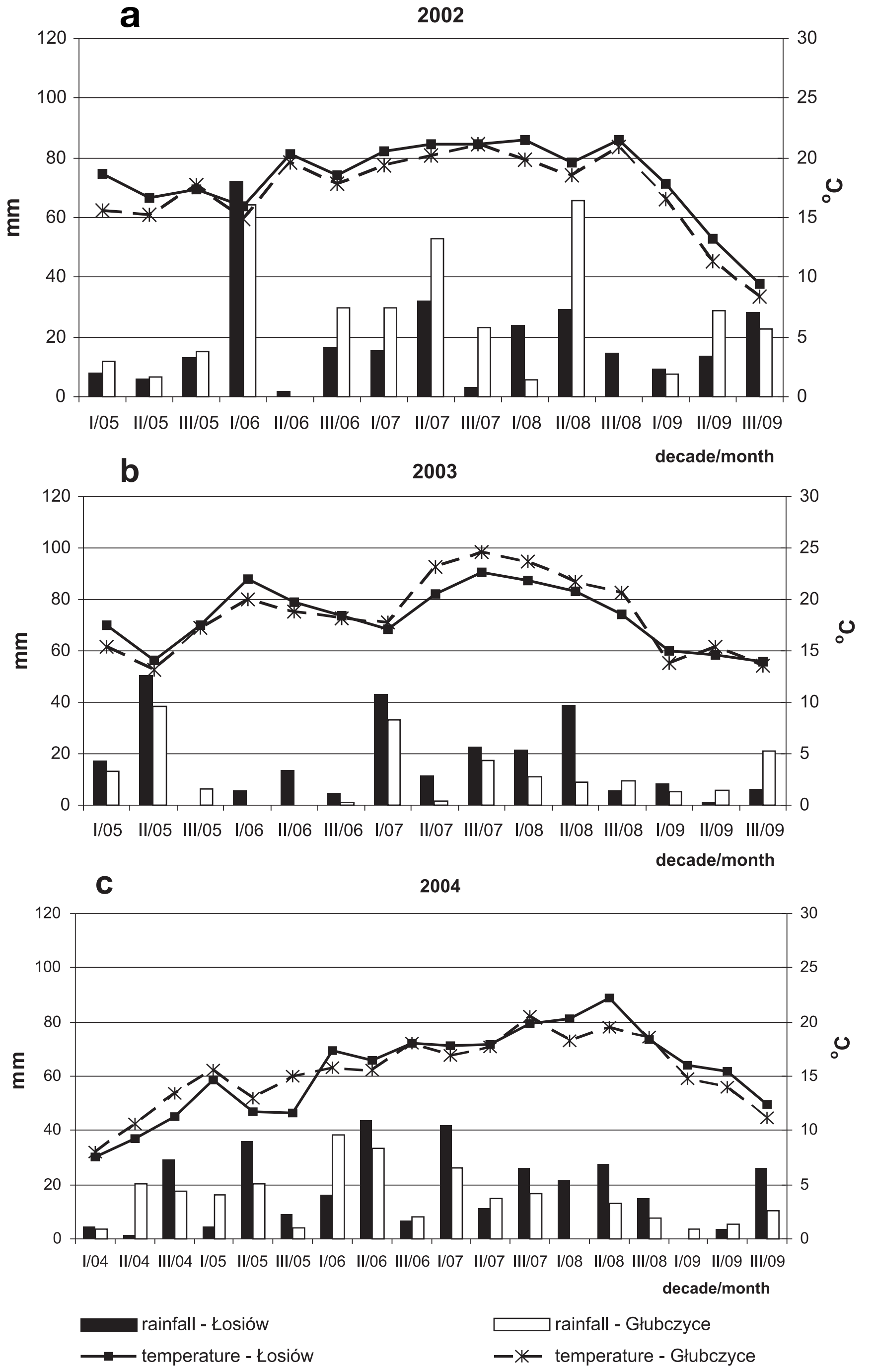

Figure 1. Decade mean temperature and sum of rainfall in Łosiów and Głubczyce; years 2002-2004

were recorded: in Głubczyce they reached 25°C. The following year of the research (2004) was a year of a mean amount of rainfall, evenly distributed throughout the entire growth season. Decade sums of rainfall during the entire growth season did not exceed 40 mm. It was quite a cold year – mean daily temperatures reached 20°C only in the second decade of August.

Table 1. Selected meteorological data characterizing the years of research (Agriculture Consulting Station, Łosiów).

L.p	Specification	2002	2003	2004
1.	Mean temperature of April	8.7	7.7	9.4
2.	Mean temperature of May	17.6	16.4	12.6
1.	Max temperature. (°C)	32.9	34.1	33.6
2.	Yearly rainfall (mm)	580	497	602
3.	Number of days with rain	135	129	144
4.	The most intensive rainfall (mm-date)	46.6 – 6.06	36.4 -1.07	27.3 – 16.10

Additional meteorological data, especially significant for an analysis of the impact of weather conditions on aphid numbers are presented in Tab. 1. From the data it follows that the first year of the research (2002) was the year that had the warmest month of May and least hot summer. The second year (2003) had the lowest amount of rain and the third year (2004) had the most abundant rainfall. In the last year of the research the month of April was unusually warm, when the mean monthly temperature exceeded by 1.2°C of the many-years mean. Information on the strongest daily rainfall seems to be significant. The highest and the earliest (in the beginning of June) daily rainfall took place in 2002. The weakest daily rainfall was recorded in 2004 and it took place in autumn.

Insecticides application on the researched plantations

The aim of all the treatments that were carried out was to fight the Colorado potato beetle. In conventional potato plantations in total during all the research years, 15 insecticide treatments were conducted, whereas on organic plantations the number of treatments that are allowed in eco-agriculture was 12. A detailed index of the applied treatments of plant protection along with the schedule is provided in Tab. 2. Fewest insecticide treatments were carried out in 2002, when only in Prószków the Regent treatment and basalt powder were applied and in Mysliborzyce – liquid manure from the nettle and hens' fertilizer. In 2003 all the conventional plantations were protected in Myśliborzyce and Ligota Bialska twice, and in Prószków four times. On organic crops one treatment was made in Myśliborzyce and Ligota Bialska and two in Prószków. In 2004 all the crops were protected twice except for the organic plantation in Ligota Bialska, where only one treatment was made.

Table 2. Plant protection treatments in conventional (C) and organic (O) potato crop

Year	Locality	Crop type	Chemical and natural substances	Date
2002	Prószków	C	Regent 200 SC	08.07
	Myśliborzyce	O	liquid manure from nettle and hens' fertilizer	10.06
	Prószków		basalt powder	30.07
2003	Myśliborzyce	C	Cyperkil 25 EC Regent 200 SC	11.07 27.07
	Prószków		Karate 025 EC Fury 100 EC Mospilan 20 SP Bancol 50 WP	20.06 27.06 11.07 27.07
	Ligota Bialska		Karate 025 EC Decis 2,5 EC	30.06 14.08
	Myśliborzyce	O	liquid manure from nettle and hens' fertilizer	30.07
	Prószków		basalt powder slaked lime	01.07 01.08
	Ligota Bialska		slaked lime	03.07
2004	Myśliborzyce	C	Mospilan 20 SP Decis 2,5 EC	01.07 26.07
	Prószków		Regent 200 SC Karate 025 EC	24.06 23.07
	Ligota Bialska		Fury 100 EC Karate 025 EC	23.06 23.07
	Myśliborzyce	O	slaked lime liquid manure from nettle and hens' fertilizer liquid manure from nettle and hens' fertilizer	18.06 09.07 30.07
	Prószków		basalt powder slaked lime	25.06 22.07
	Ligota Bialska		slaked lime	06.07

Most of the fifteen treatments on conventional crops were carried out using pyrethroids (9). Phenylopyrazoles was used three times, noenicotynoids – twice, and nereitoxyne was used only once. On organic plantations most treatments (5) were made using slaked lime. Nettle liquid manure and hens' fertilizer were used four times, while basalt powder – three times. Moreover, on conventional crops in June twice as many treatments were carried out (6) than on organic crops (3). In July and August the number of treatments in both types of crops was the same.

On organic potatoes in Prószków in order to regenerate potato leaves damaged from slaked lime usage, also treatment using whey was made. In 2003 such a treatment was made on the 5th and 9th of August and in 2004 on 31st July, and 2nd and 10th of August (Figs. 5b, 5c).

Results and discussion

Total number of aphids on researched crops

In both types of crops in all the localities and research years *M. persicae* was found to be the most numerous, as its percentage in the structure of species composition ranged from 32 to 58% in particular research years. Another numerous species was *Aphis nasturtii* (29-46%). *Macrosiphum euphorbiae* was recorded in all the researched crops in all the sites but only in 2003. *Aulacorthum solani* was present in 2004 only in Myśliborzyce in both types of crops but density only in the initial period of potato growth season.

The smallest aphid on potato crops was recorded in 2002. In 2003 their number was twice as much, while in 2004 three times as much, and these differences among research years were considered significant (Fig. 2, Tab. 3). Significant differences in aphid numbers were also recorded between conventional and organic potato crops. In organic crops the number of aphids was 27% higher (Fig. 4). No significant differences in the aphid density among particular sites was confirmed (Fig. 3, Tab. 3).

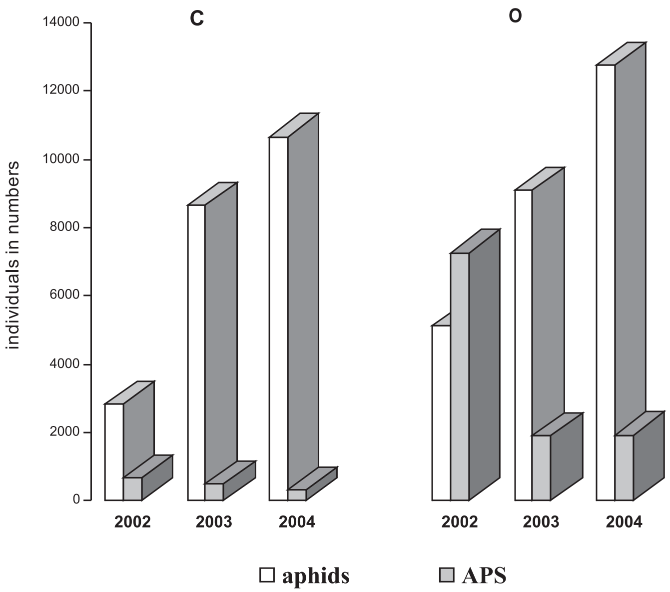

Figure 2. Number of aphids and active predatory stages (APS) in conventional (C) and organic (O) potato crops in 2002-2004

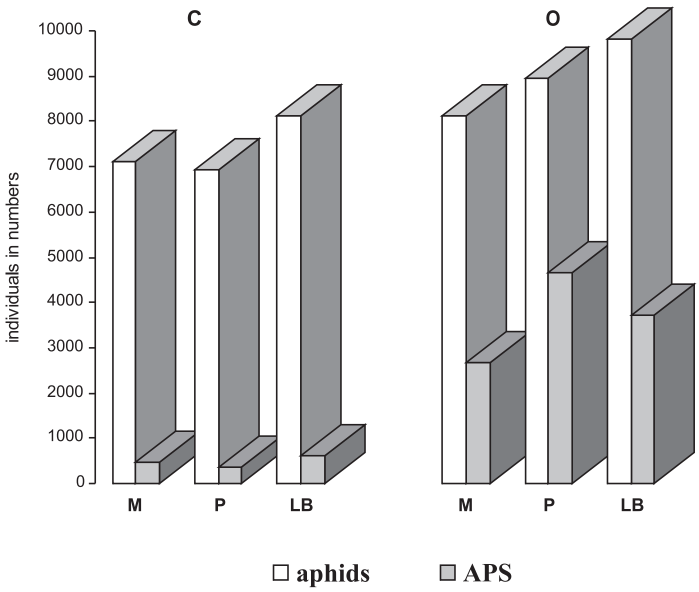

Figure 3. Number of aphids and active predatory stages (APS) in conventional (C) and organic (O) potato crops in three locations (M – Myśliborzyce; P – Prószków; LB – Ligota Bialska)

Table 3. Three-parametre variant analyse of aphid and active predatory stages on potato crops in the years (A), localities (B) and types of crops (C)

Source of changeability	Degrees of freedom	Mean square	
		aphids	active predatory stages
Years (A)	2	10249870.7**	1756478.4**
Localities (B)	2	316698.3	146189.1
Type of crop (C)	1	1301960.0*	5175616.9**
Interaction A x B	4	1687118.3*	55411.2
Interaction A x C	2	172441.0	143750.1*
Interaction B x C	2	34919.3	186792.4
Error	4	145732.3	85901.4
Means			
Years	2002	1324a	1320a
	2003	2960b	395b
	2004	3907c	371b
LSD		433	332
Localities	Myśliborzyce	2553	528
	Prószków	2648	836
	Ligota Bialska	2990	723
The smallest significant difference		unsignificant differences	unsignificant differences
Type of crop	conventional	2461	159b
	organic	2999	1232a
LSD		353.7	271.6

* – significant on level $\alpha = 0,05$
** – significant on level $\alpha = 0,01$
a, b, c – homogenous group after Duncans' multiple test

Table 3a. Mean numbers of aphids on potato crops for the following years of research (A) and locality (B) (interaction AxB)

Locality	Year		
	2002	2003	2004
Myśliborzyce	2808	6960	5550
Prószków	1990	6243	4559
Ligota Bialska	3143	4559	10237
LSD for interaction AxB	1061.27		

Table 3b. Mean number of active predator stages on potato crop for the following years of research (A) and type of crop (C)

Type of crop	Year		
	2002	2003	2004
conventional	219	156	103
organic	2421	634	649
LSD for interaction AxC	529.56		

Table 4. Date of first appearance and maximum aphid numbers of potato aphids and active predator stages (APS) in conventional (C) and organic (O) potato crops

Year	Locality	Type of crop	Date of first appearance		Maximum quantity (numbers)		Date of maximum aphid numbers	
			mszyc	APS	mszyc	APS	mszyc	APS
2002	Myśliborzyce	C	03.07	26.06	703	65	12.07	12.07
		O	03.07	26.06	845	864	19.07	19.07
	Prószków	C	04.06	28.05	32	15	16.08	07.08
		O	10.06	28.05	545	925	25.06	25.06
	Ligota Bialska	C	12.06	01.06	365	77	01.07	12.06
		O	18.06	05.06	492	429	01.07	26.06
	Mean	C			367	52		
		O			627	739		
2003	Myśliborzyce	C	09.06	09.06	2057	163	23.06	23.06
		O	09.06	09.06	447	134	16.06	23.06
	Prószków	C	11.06	11.06	1028	22	18.06	18.06
		O	11.06	11.06	1031	209	18.06	11.06
	Ligota Bialska	C	10.06	10.06	334	25	17.06	21.06
		O	10.06	10.06	696	294	21.06	21.06
	Mean	C			1140	70		
		O			725	212		
2004	Myśliborzyce	C	21.05	21.05	378	9	30.06	21.07
		O	21.05	21.05	571	50	28.07	04.08
	Prószków	C	20.05	03.06	687	26	20.07	13.07
		O	03.06	03.06	579	125	17.08	13.07
	Ligota Bialska	C	19.05	02.06	664	23	19.07	26.07
		O	03.06	19.05	579	123	26.07	09.08
	Mean	C			576	19		
		O			612	99		
Mean from years		C			694	47		
		O			655	350		

Significant differences in the number of aphids in various years of the research testify to a significant impact of weather on aphid numbers. The lowest aphid number in the year 2002 was caused by strong rainfall which reduced aphid populations in the first decade of June, i.e. in the period of initial settling of plantations (Fig. 1a). The impact of predatory aphidophags, the emergence of which on potatoes was earlier than that of aphids was also strong (Tab. 4). These predators in year 2002 were most numerous in both kinds of plantations and the difference in the predator number between conventional and organic crops was then the highest, almost eleven times more, while in the remaining research years it was only 4-5 times more (Tab. 3b). On organic potatoes the number of predators was even higher than the number of aphids (Fig. 2). Koss *et al.* (2005) similarly state that the number of aphids was the highest, just like the number of predators on potato organic crops in comparison with farms where nonselective and selective insecticides were applied.

In 2003 the number of aphids already in June was much higher than in the remaining years of the research (Fig. 5b). However, there were some factors which limited the number of aphids as soon as the beginning of July, such as the most intensive in that year control of Colorado potato beetle (Kelm & Fostiak, 2009) and July heat waves which worsened food supplies due to a long-lasting water shortage for plants (Tab. 1, Fig. 1a) caused rapid declin in aphid number at the beginning of July. The most visible was the impact of drought on the number of aphids in the region of Sudety Tectonic Foreland, where in June there was no rainfall which was confirmed in statistically significant interactions between research years and sites (Tab. 3). In the year 2003 in Ligota Bialska there were significantly fewer aphids than in Myśliborzyce and in Prószków (Tab. 3a). Koricheva *et al.* (1998), Kelm (2000), Hale *et al.* (2003) and Mc Vean & Dixon (2001) also refer to a strong inhibiting of drought on aphid number and development.

In 2004 aphids appeared on potatoes in large numbers quite early, i.e. in mid-May instead of June as it was in previous years. This was conditioned by warm temperatures in April, which were considered the highest of all the research years (Tab. 1). This led to a faster pace of aphid procreation on winter hosts and a more intense flight to potatoes. Meanwhile, moderate and evenly distributed rainfall (decade sums did not exceed 40 mm) did not threaten cleansing away of aphids from leaves, but maintained the plants' good condition. Temperature also remained at a moderate level. Mean temperatures until the end of August did not exceed 20°C (Fig. 1b). Oprychałowa *et al.* (1976) consider *Myzus persicae*, which dominates on the researched crops, to be little flexible, which favours coldness and humidity.

Wellings & Dixon (1987) in their review work on aphid gradations list a whole array of weather happenings which determine abundant procreation or strong reduction in the number of these pests.

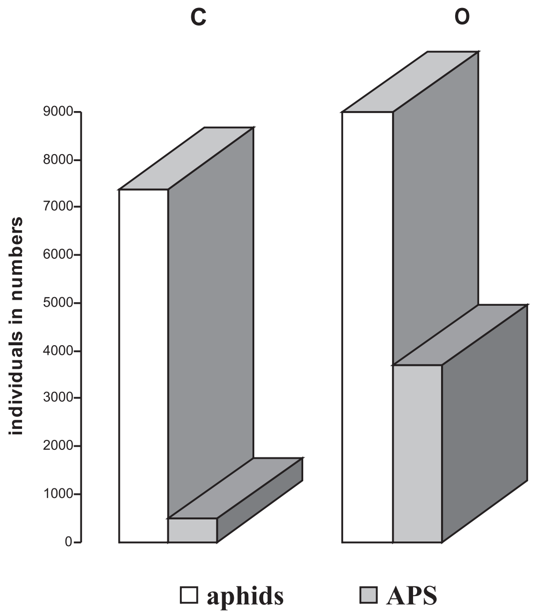

Figure 4. Aphids and active predatory stages (APS) in conventional (C) and organic (O) potato crops

Table 5. Mean values of prey/predator ratio in conventional (C) and organic (O) potato crops

Locality	Type of crop	2002	2003	2004
Myśliborzyce	C	6.4	15.7	51.0
Pruszków		2.3	25.9	29.3
Ligota Bialska		3.6	16.6	33.9
Myśliborzyce	O	0.8	7.3	8.3
Pruszków		0.5	4.1	6.0
Ligota Bialska		0.9	3.8	6.4
Mean in the years	C	4.1	19.4	38.1
	O	0.7	5.1	6.9
Total mean	C	20.5		
	O	4.3		

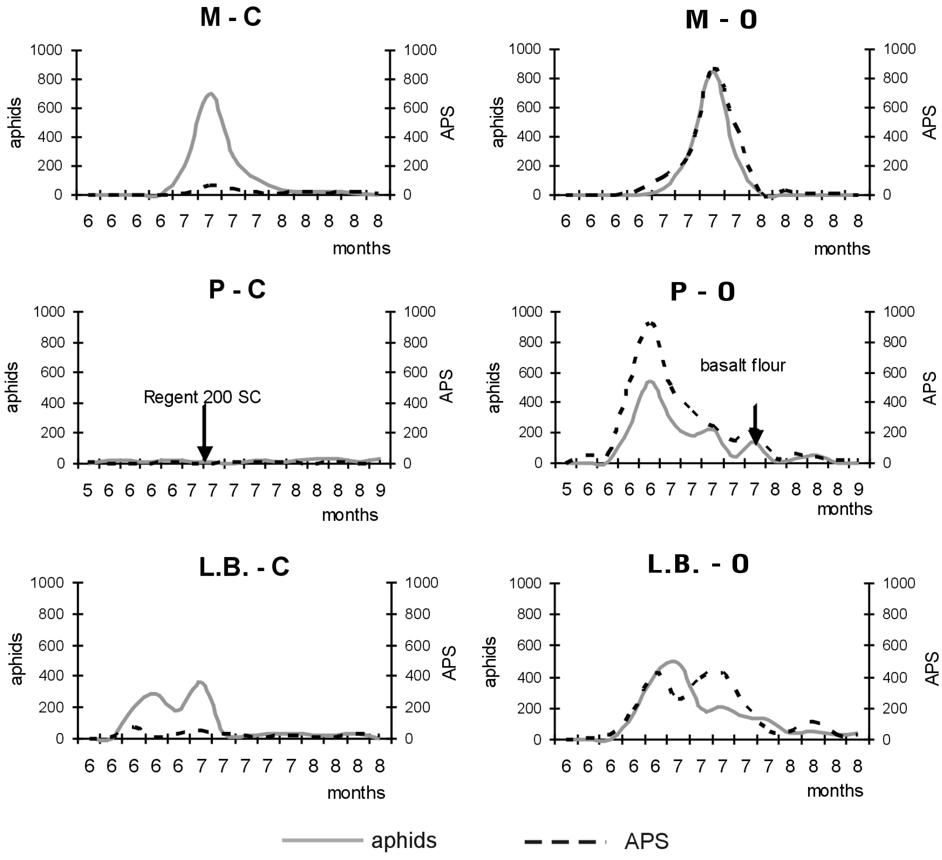

Figure 5a. Dynamics of aphid intensity (Aphidoidea) and active predatory stages (APS) and plant protection treatments on conventional (C) and organic (O) potato crops in three location (M. – Myśliborzyce, P. – Prószków, L.B. – Ligota Bialska) – year 2002

In particular research years and localities the number of aphids was always higher in organic crops (Figs. 2, 3). Romanowska (2004), who studied plants from organic crops in Myśliborzyce and Prószków, decided that potato stalks cropped on organic farms contained in their chemical composition more nitrogen, proteins and potassium and less phosphor than potato stalks of potatoes cropped conventionally. The data taken from other researchers' works show that chemical composition of plant tissues may indirectly influence aphid development. Positive impact of nitrogen on this group of insects is most often referred to (Gorczyca & Kulig, 2006; Jansson & Ekbom, 2004; Van Emden, 2006). Van Emden point out to the content of soluble nitrogen in plant tissues which may decide about plant resistance to aphids. A greater number and faster development of aphid colonies on organic crops confirms information provided by Hurej (1990), who asserts that the increase in the number of *M. persicae* offspring took place on plants along with increased portions of nitrogen and a decrease in the portions of phosphor. One can thus claim that potato stalks of organic potatoes provide better nutrient for aphids. The greatest diversity in the number of potato aphids between conventional and organic plantations was marked in 2002 which was the year of the weakest reproduction of the pest. Then the number of aphids was 80% higher in organic crops. In that year fewest protective treatments were conducted: only 1 treatment in conventional farms and 2 – in organic farms. A more similar number of aphids in both types of crops was recorded in 2003 and 2004 during their more intensive reproduction. This difference in 2003 was 5% and in 2004 – around 19%.

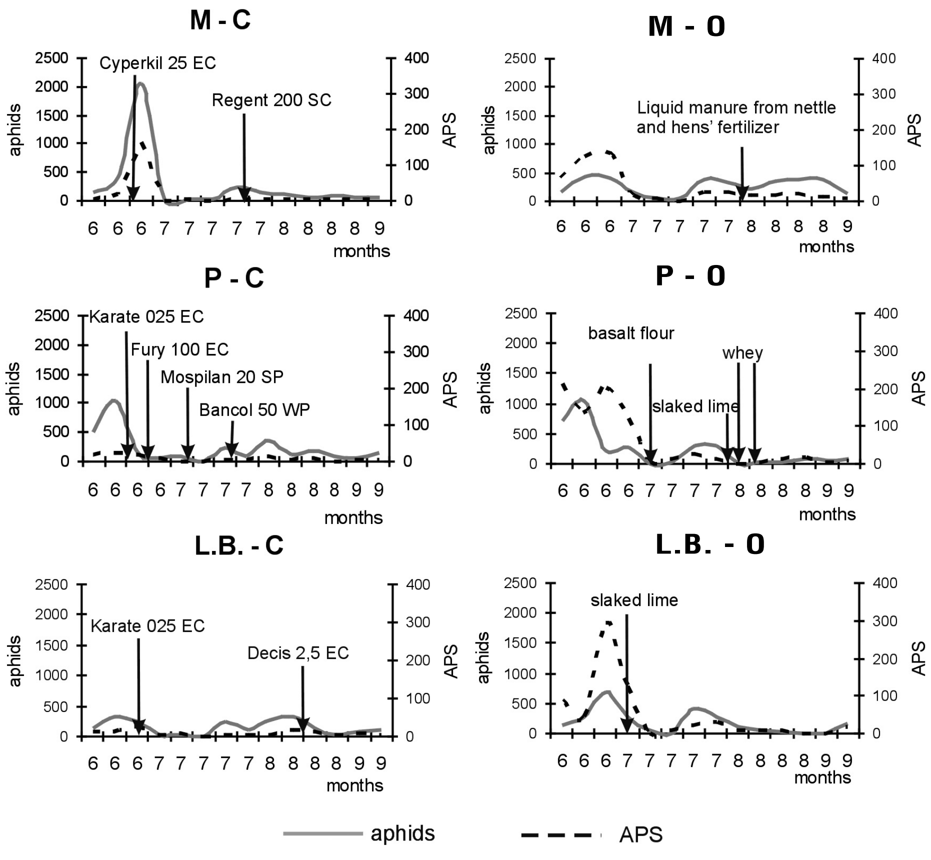

Figure 5b. Dynamics of aphid intensity (Aphidoidea) and active predatory stage (APS) and plant protection treatments on conventional (C) and organic (O) potato crops in three location (M. – Myśliborzyce, P. – Prószków, L.B. Ligota Bialska) – year 2003

The second factor which significantly diversified the number of aphids between conventional and organic crops involved a protective treatment applied on potatoes to fight the Colorado potato beetle (Tab. 2).The number of these treatments on conventional crops of potatoes was much bigger and this applies to treatments carried out in June, i.e. during the time of aphids flying on potatoes. Then on conventional crops 6 insecticide treatments were applied, while on the ecological crops only three.

A positive impact of whey on the aphid number and reproduction ability was also recorded in 2004 (Fig. 5c). Their intensive reproduction on potatoes treated with whey took place until the end of August. The effects were not visible in 2003 when it was a hot and dry weather which reduced the number of aphids.

In spite of a significantly higher number of aphids in organic crops, the calculated annual mean of aphid number maximum was 11% higher in conventional crops (Tab. 4). This can be confirmed by a factor reducing aphid procreation in colonies functioning in organic crops. One can suppose that these were predatory aphidophags, the number of which on organic crops was eight-times more than in conventional crops and the difference was statistically significant (Fig. 4, Tab. 3). In conventional crops no statistically significant differences in the number of active stadiums of predators between particular research years were recorded, whereas in organic crops in 2002 the number of predators was much higher than in the remaining years of the research (Tab. 3b). As a result, the mean number of aphids per one predator was almost 5 times higher in the conventional farms than in the organic crops in which it was 4.3 (Tab. 5). In relation to the maximum number of aphids and predators these quantitative relations were even more favourable. From the calculations of the data as provided in Tab. 4, it follows that the indicator prey/predator for organic crops was 1.8 for and 14.7 for conventional crops. Moreover, the data presented in Tab. 5 state that the lowest value of the prey/predar ratio indicator was found in potato organic crops in Prószków in 2002 (0.5), whereas the highest – in the conventional crops in Myśliborzyce in 2004 – 51.0.

In all the crops adults of ladybirds dominated. Their mean share in the structure of the predator group in conventional crops was 65% and in organic farms – 60%. In organic farms, however, the share of ladybird larvae was higher in organic farms than in the conventional ones (21%). Chrysopa larvae were the second largest group, after ladybirds, constituting 10% active predatory stages (APS) in both types of plantations. The least numerous were the syrphid larvae: only 3-4% of all the predators (Fig. 6).

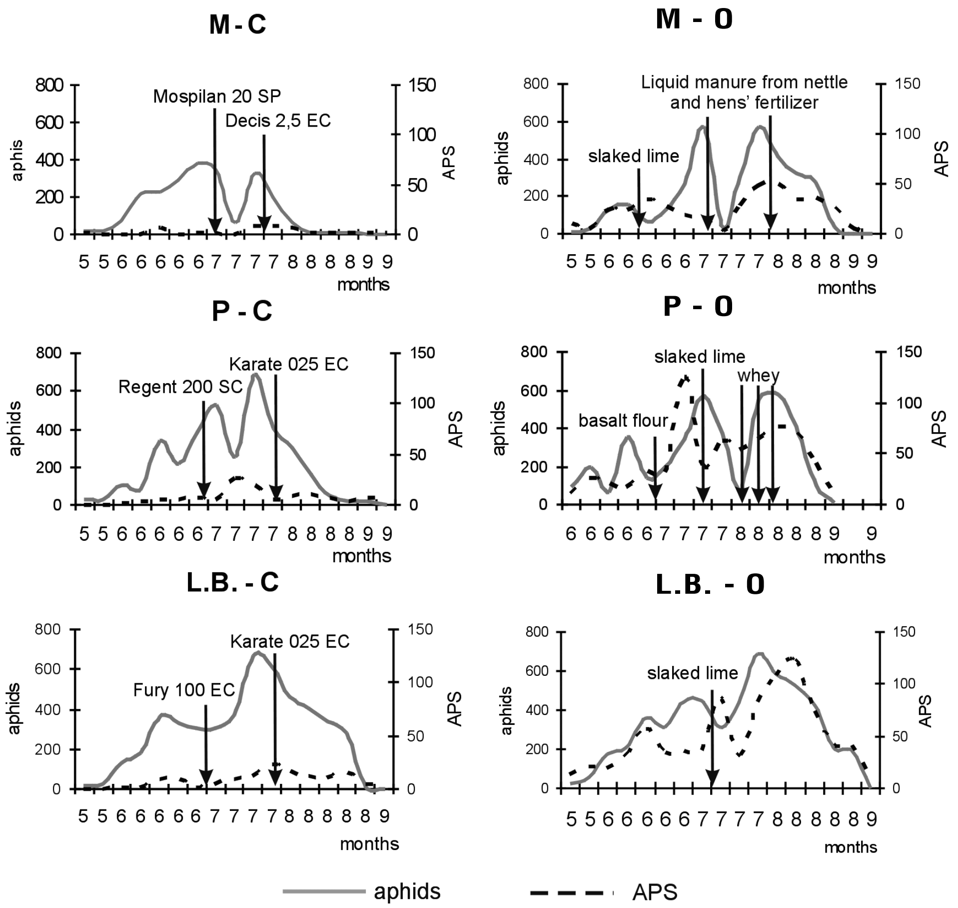

Figure 5c. Dynamics of aphid intensity (Aphidoidea) and active predatory stage (APS) and plant protection treatments on conventional (C) and organic (O) potato crops in three location (M. – Myśliborzyce, P. – Prószków, L.B. – Ligota Bialska) – year 2004

In the year of the smallest aphid reproduction level (2002) APS appeared earlier on potatoes than aphids (Tab. 4). These differences were even up to two weeks. In the year of the highest level of aphid presence (2004) the emergence of APS on conventional crop in Prószków and Ligota Bialska was two weeks later in relation to aphid emergence. In 2003 average aphid density on all the plantations, APS appeared together with aphids. In the year which was a time of scarce aphid appearance, the APS maximum was observed at the same time or earlier than the aphid maximum number. At medium aphid density one observed two cases of a later maximum of APS appearance than the maximum of aphids, and at the most intense aphid occurrence this maximum APS on four plantations took place later than aphid maximum.

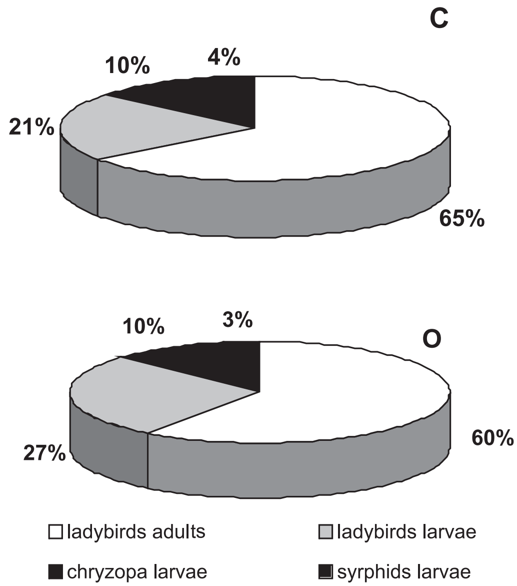

Figure 6. Structure of the group of active predatory stages (APS) in conventional (C) and organic (O) potato crop

Analysis of the impact of treatments controlling Colorado potato beetle on the number of aphids and their natural enemies in conventional and organic potato crops

Treatments applied to Colorado potato beetle control in conventional farms in 2002 and 2003 maintained aphid population on a low level. The APS number was also very low (Figs. 5a, 5b). In 2004 when aphid number was the highest, their number decreased right after the first treatment, but after 2 weeks passed there was another increase in their number which was kept under control by several treatments (Fig. 5c). The number of APS in conventional crops was also noted in subsequent analyses and was considered to be very low, not more than 10.

In organic crops nettle liquid manure and hen's fertilizer were applied 4 times. Only after the treatments in Myśliborzyce in 2004 did the number of aphids and APS clearly diminish but only for a very short period of time (10 days), after which there was another increase in the number of both groups (Fig. 5c). Slaked lime was applied 5 times. Both, the number of aphids and active stadiums of predators was becoming smaller after these treatments. The most clearly visible reduction of the studied entomofauna was registered on the crop in Ligota Bialska in 2003 (Fig. 5b). Basalt powder was applied 3 times. In 2002 it took place too late, whereas in 2003 there was a complete reduction of the populations of aphids and predators. In 2004 this decrease was short-lasting: only 1 week. Analysing the above data on the basis of weather conditions, especially in 2003, one may conclude that the primary factor which decided about the fall of aphid number were not the protective treatments but weather conditions which were unfavorable for aphids.

Additional information about the impact of Colorado potato beetle controlling treatments on APS is contained in Tab. 6, which presents indicators of pupation of predatory aphidophags larvae. On conventionally grown potatoes on average a bit more than 1% of larvae pupated. The highest indicator of pupation was found in syrphid larvae, and the highest in chrysopa larvae. On ecological potatoes the indicator of pupation of APS larvae was on average above 20% and was the lowest for ladybird larvae and the highest for syrphids.

Table 6. Ratio between numbers of predator larvae and pupae in conventional (C) and organic (O) potato crop

Crop	Ladybirds		Chrysopa		Syrphids	
	Larvae (in numbers)	Pupae (in numbers)	Larvae (in numbers)	Pupae (in numbers)	Larvae (in numbers)	Pupae (in numbers)
C	1030	18	148	3	17	2
% pupation	1.7		2.02		0.05	
mean % of pupation PAS	1.25					
O	5180	308	1511	165	394	193
% pupation	5.9		10.9		48.0	
mean % of pupation PAS	21.6					

Conclusions

1. Weather was the factor which most determined the growth of aphid number in potato crops. The number of these pests was strongly reduced by heavy rainfall in the first half of June, i.e. during the period of introductory settling of plantations.
2. Low and evenly distributed rainfall as well as medium temperatures until the end of July, not exceeding 20°C had favourable impact on aphid numbers on potato crops. Rainfall shortage and higher temperatures limited aphid numbers.

3. Aphid population on organic crops is under constant pressure of predatory insects. Predators in organic crops undergo a full developmental cycle. These crops are thus refugia for the pests' natural enemies.
4. Chemical treatment applied in conventional crops, almost entirely eliminate predatory insects living on plants from these crops. In these crops mainly adults of ladybirds which are capable of flying occur.
5. On organic plantations the application of slaked lime was the most dangerous for APS and the safest protective treatment was the usage of nettle liquid manure and hens' fertilizer.
6. During the years favouring numerous occurrence of aphids, the differences in their density between conventional and organic crops were slight. The greatest differences were recorded during years when these species were not of much economic importance.
7. Synthetic insecticides used in potato protection more effectively reduce the number of predatory aphidophags than the number of aphids.

References

GOLISZEWSKI W., ZARZYŃSKA K. 2008. Występowanie mszyc – wektorów wirusów na ekologicznej i integrowanej plantacji ziemniaków. J. Res. Appl. Agric. Engin. 53(3): 84-87.

GORCZYCA A. KULIG B. 2006. Effect of nitrogen fertilisation on harmfulness of aphids (Homoptera: Aphididae) in spring weat cultivation. Metal Ions and others Abiot Factors in the Enviroment. Chem. Inż. Ekol. 13(8): 750-757.

HALE B. K., BALE J. S., PRITCHART J., MASTERS G. J., BROWN V. K. 2003. Effect of host plant drought stress on on the bird cherry oat aphid, *Rhopalosiphum padi* (L): a mechanical analysis. Ecol. Ent. 28 (6): 666-677.

HUREJ M.1990. Wpływ nawożenia mineralnego na mszyce. Ochr. Rośl. 10: 7-10.

JANSEN J. P., WARNIER A. M. W. 2004. Aphid specific predators in potato in Belgium. Commun. Agric. Appl. Biol. Sci. 69(3) 151-156.

KELM M. 2000. Uwarunkowania występowania i szkodliwości roślinożernej entomofauny rzepaku ozimego na Dolnym Śląsku. Zesz. Nauk AR we Wrocławiu. CLVIII, 145p.

KELM M., FOSTIAK I. 2009. Analiza celowości zwalczania stonki ziemniaczanej w wybranych gospodarstwach województwa opolskiego. Prog. Plant Prot. (w druku)

KORICHEVA J., LARSON S., HAUKIOJA E.1998. Insect performance on experimentally stressed woody plants: a meta analysis. Ann. Rev. Ent. 43:195-216.

KOSS A. M., JENSEN A. S., SCHREIBER A., PIKE K. S., SNYDER W. E. 2005. Comparison of predator and pest comunities in Washington potato fields treated with broad-spectrum, selective, or organic insecticides. Envir. Ent. 34(1): 87-95.

MAC VAN R. I. K., DIXON A. F. G. 2001. The effect of plant drought stress on populations of the pea aphid *Acyrthosiphum pisum*. Ecol. Ent. 26(4): 440-443.

Nowacki W. 2005. Stopień chemizacji w technologii uprawy ziemniaka w Polsce. Prog. Plant Protec. 54(1): 317-324.

Opyrchałowa J., Drozdowska K., Goos A., Goos M. 1976. Wpływ opryskiwania przeciw stonce ziemniaczanej – *Leptinotarsa decemlineata* Say (*Col.Chrysomelidae*) na mszyce – *Aphidodea*. Pol Pismo Ent. 46(3): 579-593.

Pruszyński S., Walczak F. 2006. Rola regionalnej sygnalizacji w wyznaczaniu optymalnego terminu zwalczania agrofagów. Prog. Plant Protec. 46(1): 169-175.

Romanowska M. 2004. Skład jakościowy roślin uprawianych w gospodarstwach ekologicznych. Rozp. Dokt. AR Wrocław, 154p.

Wellings P. W., Dixon A. F. G. 1987.The role of weather and natural enemies in determining aphid outbreaks. [In:] Insect Outbreaks ed. Barbarosa and Schultz. Academic Press, Inc., 314-340.

Zeneca Crop Protection. 1998. The Aphid Identification Guide, 31p.

Czynniki warunkujące liczebność mszyc /Hemiptera, Aphidoidea/ w konwencjonalnych i ekologicznych uprawach ziemniaka

Streszczenie

W trzyletnich badaniach, w trzech miejscowościach na Dolnym Śląsku, przeprowadzono obserwacje nad liczebnością mszyc i drapieżnych afidofagów w konwencjonalnych i ekologicznych uprawach ziemniaka. Gatunkiem najliczniej występującym na obu typach plantacji była mszyca *Myzus persicae* Sulz. Nasilenie mszyc różniło się istotnie pomiędzy latami badań. W najsłabszym nasileniu mszyce na ziemniakach wystąpiły w roku 2002. W 2003 roku było ich dwukrotnie więcej, a w 2004 trzykrotnie więcej. Na liczebność mszyc w obu typach upraw korzystnie oddziaływały niskie i równomiernie rozłożone opady oraz średnie temperatury do końca lipca nie przekraczające 20°C. Deficyt opadów i wyższe temperatury ograniczały liczebność tych szkodników. Łącznie na ziemniakach ekologicznych odnotowano 22% więcej mszyc aniżeli na konwencjonalnych i różnica ta była istotna. Wynikało to z większej liczby zabiegów ochronnych wykonywanych na plantacjach ziemniaków konwencjonalnych, szczególnie w czerwcu. Poza tym łęty ziemniaków ekologicznych zawierające więcej azotu a mniej fosforu aniżeli konwencjonalne stwarzały mszycom lepsze warunki pokarmowe. Zaobserwowano także pozytywny wpływ na liczebność mszyc serwatki stosowanej w celach nawozowych w systemie ekologicznym. Największą różnicę w nasileniu mszyc pomiędzy typami upraw stwierdzono w roku najsłabszego rozmnożenia szkodnika (2002), kiedy to mszyc na plantacjach ekologicznych było prawie dwukrotnie więcej. W latach sprzyjających rozmnożeniu mszyc różnica ta była minimalna (5% w 2003 i 19% w 2004).

Nasilenie drapieżnych afidofagów na plantacjach ekologicznych było ok. 8-krotnie wyższe aniżeli na konwencjonalnych i różnica ta była istotna statystycznie. Liczba mszyc przypadająca na jednego drapieżcę w uprawach ekologicznych wynosiła 4.3, a w uprawach konwencjonalnych wskaźnik ten był 5-krotnie wyższy. Mszyce w uprawie ekologicznej znajdowały się więc pod stałą, silną presją drapieżców W zgrupowaniu drapieżców na

plantacjach konwencjonalnych dominowały imagines biedronek, a na ekologicznych większy był udział larw biedronek. Drugą po biedronkach grupą były larwy złotooków, a najmniej licznie występowały larwy bzygowatych. W uprawach ekologicznych przepoczwarczało się ponad 20% larw drapieżców, a w uprawach konwencjonalnych ok. 1%. Uprawy ekologiczne są więc refugiami dla wrogów naturalnych mszyc.