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THE EFFECT OF THE STRIP-MANAGEMENT ON REDUCTION OF *APHIS FABAE* (*HOMOPTERA: APHIDIDAE*) POPULATIONS BY PREDATORS ON SUGAR BEET CROP

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Abstract: The studies were carried out at the Agricultural Experimental Station at Pawłowice near Wrocław, Poland, in 1998-2000. The main aim of the study was to compare the natural reduction of the black bean aphid by predators in sugar-beet crop surrounded by strips of mixture of cultivated plants, weedy strips or bare soil. The lowest number of *Aphis fabae* in sugar-beet crop was observed at the plots surrounded by strips of mixture of *Sinapis alba, Phacelia tanacetifolia* and *Coriandrum sativum,* and at those surrounded by weedy strips. The greatest number of aphids was recorded on sugar-beet plots surrounded by bare soil. The relationships between the pest and its predators were the least stable in bare soil treatment. Significant pressure of predator activity in all treatments was shown in the first several days of the observation.

Key words: strip-management, mixture of cultivated plants, weeds, *Aphis fabae*, predators, sugar-beet

INTRODUCTION

Modern agriculture has often caused the simplification of biological and environmental structures in the agroecosystem mainly through intensive cropping practices (Altieri 1999). These poor habitats create unfavorable conditions for beneficial organisms. An important role in supporting biodiversity has different non-crop structures (field boundaries, tracks, watercourses, roads) (Holland et al. 2003). One of the ways to enhance populations of natural enemies is to enrich the field neighbourhood with flowering plants by using weedy strips, or strips planted with flowering plants (Altieri and Whitcomb 1979; Ruppert and Molthan 1991; Cowgill et al. 1993). This habitat can act as alternative food sources (e.g. flowers providing nectar), alternative prey or hosts, can improve microclimate and overwintering conditions (Landis et al. 2000). Simultaneously, above would be a tool for manipulations of herbivore populations.

In many regions of Poland crop fields are small (0.1–1.0 ha). Therefore, relatively long field margins occur in agricultural landscape. They are narrow and uncultivated, covered by grass and weeds. Hurej et al. (1998) suggested widening of the field margins to at least 1 m and growing of certain flowering plants as the food source for entomophagous species in low-input production system. The same authors proposed creation of strips of flowering plants within larger fields. Such strips attracted many groups of beneficial insects including syrphids, bumblebees and parasitic Hymenoptera, better than uncultivated weedy strips (Hurej et al. 1998; Hurej and Twardowski 1999; Twardowski and Hurej 1999). There are many papers describing strip-management as a tool for conservation of biological control in agroecosystems. Most of them have been focused on cereals (Lys and Nentwig 1992; Hausammann 1996; Hickman and Wratten 1996) and orchards (Wyss 1995; Wyss et al. 1995), however, no investigations were done with strip-management in sugar-beet field so far.

The main aim of this project was to study natural reduction of the black bean aphid (*Aphis fabae* Scopoli) by predators in sugar-beet crop, surrounded by strips of mixture of cultivated plants, strips of weeds and strips of bare soil. It is assumed that in this diverse habitat aphids on sugar-beet will not reach level that justify chemical control, mainly due to the action of a range of naturally occurring biological agents, including polyphagous and specialist predators.

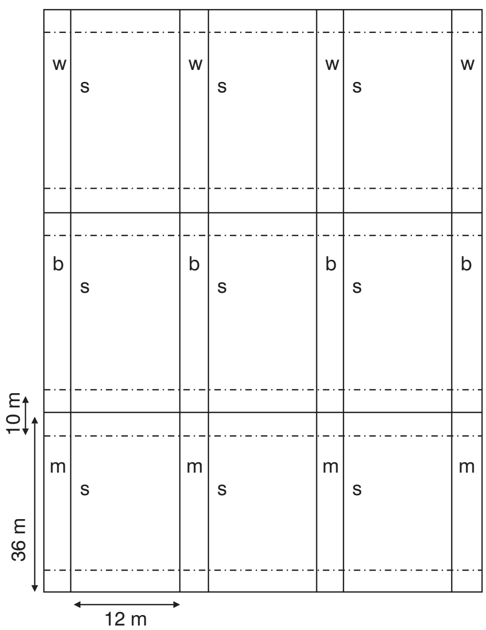


Fig. 1. Experimental design, Pawłowice 1998–2000

w – weedy strips, b – bare soil strips, m – mixture of flowering strips, s – sugar-beet (crop) plots, dotted lines indicate non-sample area

MATERIAL AND METHODS

The study was carried out at the Agricultural Experimental Station at Pawłowice near Wrocław, Lower Silesia, Poland in 1998-2000. Sugar-beet field of 0.5 ha was divided by four 1 m wide strips (Fig. 1). Each part was divided into three parts. First part was planted with a mixture of *Sinapis alba* L. (25%), *Phacelia tanacetifolia* Benth. (25%) and *Coriandrum sativum* L. (50%). Second part was herbicide treated (bare soil), and third part was uncultivated (weedy). The size of each plot was 432 m^2 and the distance between the strips was 12 m.

Black bean aphid and its predators (adults and larvae of coccinellids, larvae of chrysopids, and larvae of hoverflies) were counted twice a week on 25 sugar-beet plants (5 consecutive plants in 5 places on the one diagonal of the plot). The first and the last count were done at least 5 m from each corner to avoid of the adjacent edge effect (Fig. 1). During observations different instar of predatory larvae were not identified. The observations were conducted starting from the beginning of May to the end of July (the end of plants blooming period on mixture strips).

The basic data were analysed using ANOVA and Tukey HSD test and descriptive statistical procedures. Graphs were calculated by fits a second order polynomial function to the point in the 3D scatterplot (no. aphid; no. predator; no. days after first aphid appearance). Quadratic generalization offers an opportunity to display trend relationships between variables.

RESULTS

Each year, the lowest number of *Aphis fabae* in sugar-beet crop was recorded on plots surrounded by strips of mixture of *Sinapis alba, Phacelia tanacetifolia* and *Coriandrum sativum* (Table 1). Relatively low number of aphids was found also on plots surrounded by weeds. On those four strips the following herbaceous plants were the most abundant: *Thlaspi arvense* L., *Matricaria chamomilla* L., *Chenopodium album* L., *Amaranthus retroflexus* L., *Polygonum persicaria* L. and *Euphorbia helioscopia* L.

Black bean aphid occurred at the greatest number on sugar-beet plots surrounded by bare soil. Statistical calculation showed a variation between mixture strips and bare soil strips in 1998 and 2000 and between weedy strips and bare soil strips in 1998 only. The highest number of prey per one predator was demonstrated in bare soil treatment (Fig. 2). Among aphid predators mainly coccinellid adults and larvae were counted. Nocturnal larvae of chrysopids and syrphids were found sporadically (Table 1). In the first two years of our trials predators were most abundant on sugar-beet surrounded by bare soil. The opposite results were achieved in 2000 when the lowest number of predators was recorded in the bare soil treatment. The difference between number of aphids observed on bare soil treatment and mixture of flowering plants was the highest in 1999 (3.7 times more) and the lowest in 2000 (1.6 times more). Probably, lack of additional vegetation within sugar-beet crop facilitated finding of host plants by aphids.

Table 1. Number of *Aphis fabae* and its predators on sugar-beet plants in 1998–2000

Year	Type of habitat	Total no. of aphids	±SEM	Coccinellids		Chrysopids larvae	Hoverflies larvae	Total no. of predators	±SEM
				adults	larvae				
1998	Mixture	2143 b*	5.89	89	54	4	1	148	0.3
	Bare soil	4768 a	13.25	131	124	5	1	261	0.6
	Weeds	3240 a	9.29	106	77		1	184	0.5
1999	Mixture	1481 a	10.19	8	59	2	6	75	0.6
	Bare soil	5549 a	28.88	15	96	1		112	0.7
	Weeds	2023 a	24.14	26	41			67	0.5
2000	Mixture	4181 b	9.13	92	129	4		225	0.5
	Bare soil	6750 a	11.98	18	36	1		55	0.1
	Weeds	4607 ab	15.80	51	145	2	1	199	0.3

*different letters within a year indicate significant difference between treatments (Tukey HSD test, $p \leq 0.05$)

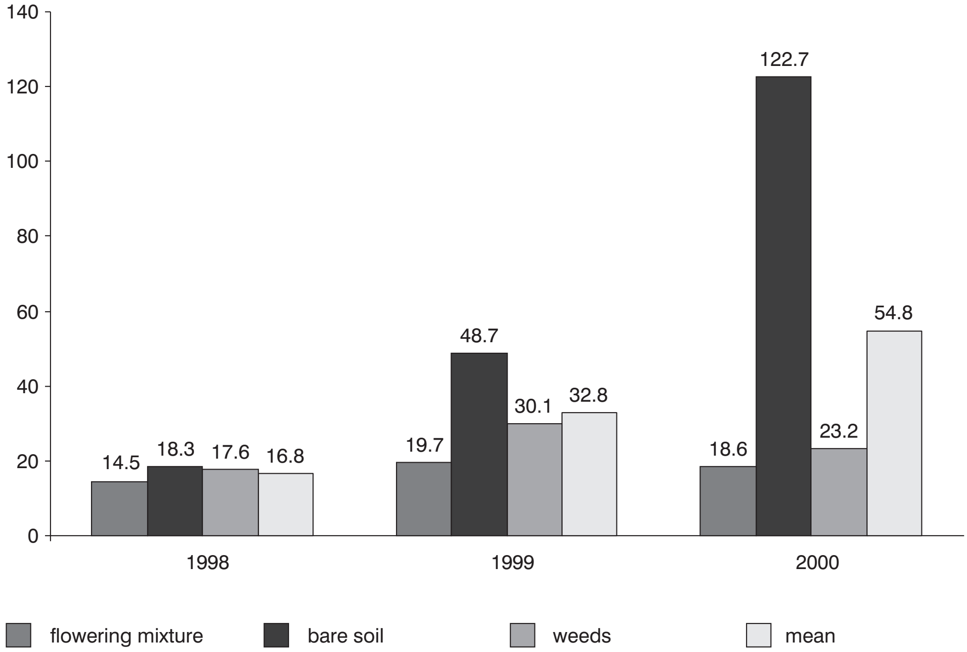
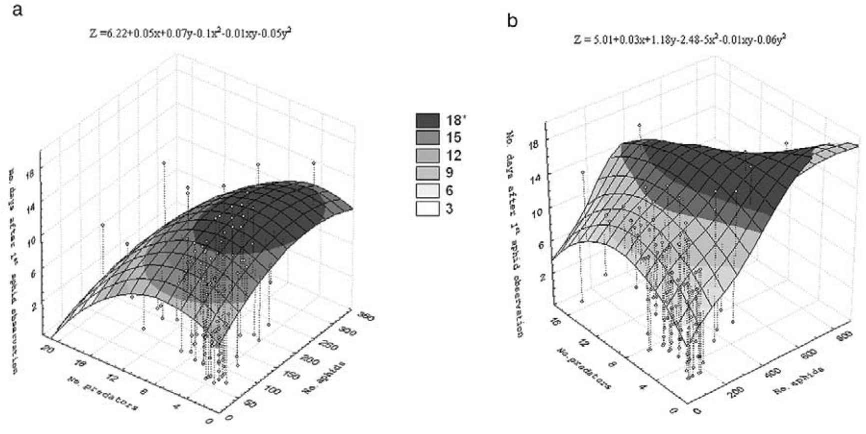


Fig. 2. Number of *Aphis fabae* per one predator in 1998–2000

The highest rate of aphid colonization was observed on sugar-beet plants surrounded by bare soil (Fig. 3). As the effect the relation of predator-prey in this treatment seems to be less stable. It is confirmed by strong, dynamic growth of the number of aphid colonies on these plots. On the other hand, the low effectiveness of predatory insects in controlling aphids feeding on sugar-beet surrounded by bare soil was probably caused by large dispersion of coccinellids. The stronger pressure of predators on herbivores was observed on plants surrounded by weeds. In this case, the dynamic aphid population growth is considerably slower. On plots surrounded by mixture of flowering plants predator-prey relationships are the most balanced. Significant pressure of predator activity in all treatments was shown in the first several days of the observation. Afterwards predator can not effectively control aphid population anymore.

DISCUSSION AND CONCLUSIONS

Flowering plants are important for the adults of many aphid antagonists in offering them pollen and nectar, which are essential for their optimal reproduction and for extending their lifespan (van Emden 1965; Altieri and Whitcomb 1979; Molthan and Ruppert 1988). The establishment of wild-flower strips around field margins affects the local abundance of syrphids, leading to increased hoverfly activity within the adjacent crop (Harwood et al. 1992). According to Hickman and Wratten (1996), the boundary strips of *Phacelia tanacetifolia* also effectively attracted hoverflies. However, though more syrphids were found in the cereal field sur-



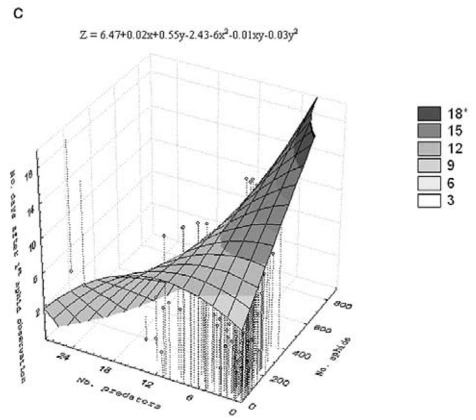


Fig. 3. Effect of the flowering mixture (a), weeds (b) and bare soil (c) on relationships between *Aphis fabae* and its predators on sugar-beet field in 1998–2000
*different hues and numbers indicate rate of changes in aphid population due to predator pressure in time (Z model)

rounded by such strips, the authors report that the aphid density in the crop was not significantly lower. Sengonca and Frings (1988) showed the reduction in *Aphis fabae* population on sugar-beet crop where *Phacelia* was sown in the field corners. Mixture of plants sown in strips in apple orchard was helpful in enhancing the beneficial fauna and for the regulation of the aphid population (Wyss 1996).

Many studies on habitat manipulation within agricultural landscape have concentrated on polyphagous predators including carabid beetles and spiders (Thomas et al. 1992; Lys and Nentwig 1992, 1994). Greater benefits for biological control in agrocenoses can be achieved by specific predators such as very effective natural enemies of aphids as coccinellids (Leather et al. 1999). Coccinellids such as *Coccinella septempunctata* and *Adalia bipunctata* are common in agricultural landscapes, but not always their suppress have eliminate aphid population to level that justify chemical control. It is proposed to use strips of flowering plants and strips of weeds, which will be designed to provide suitable hosts for beneficial insects.

The mixture of flowering plants selected and deployed in our trials attracted beneficial insects effectively and for a long time (Hurej and Twardowski 1999; Twardowski 2002). In our study predators, mainly coccinellids, successfully reduced *Aphis fabae* population on sugar-beet crop surrounded by strips of mixture of *Sinapis alba, Phacelia tanacetifolia* and *Coriandrum sativum.* Furthermore, in one of the years the aphid number was also significantly lower on plants surrounded by weedy strips than on plants surrounded by bare soil strips. In a system of reduced plant diversity a chance to obtain stability in predator-prey interaction is lower and such system is less balanced. Therefore, we recorded the highest aphid population on sugar-beet plants within the bare soil treatment.

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POLISH SUMMARY

WPŁYW PASÓW ROŚLIN NA REDUKCJĘ POPULACJI *APHIS FABAE* (*HOMOPTERA: APHIDIDAE*) PRZEZ DRAPIEŻCÓW NA PLANTACJI BURAKÓW CUKROWYCH

Badania przeprowadzono w Rolniczej Stacji Doświadczalnej w Pawłowicach koło Wrocławia w latach 1998–2000. Celem badań było porównanie stopnia redukcji populacji mszycy burakowej przez owady drapieżne na plantacji buraków cukrowych rosnących w otoczeniu: pasów mieszanki kwitnących roślin, pasów naturalnie zachwaszczonych oraz pasów ugoru.

Liczebność *Aphis fabae* na burakach była najniższa w otoczeniu pasów mieszanki: gorczycy białej, facelii błękitnej i kolendry siewnej, oraz w otoczeniu pasów chwastów. Najwięcej mszyc stwierdzono na burakach rosnących w otoczeniu ugoru. W tym wariancie doświadczenia, interakcje pomiędzy liczebnością fitofagów oraz drapieżcami były najmniej stabilne. We wszystkich kombinacjach doświadczenia istotne różnice w redukcji mszycy przez drapieżców notowano w pierwszych dniach prowadzenia obserwacji.