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RESPONSE OF *APHIS FABAE* SCOP. TO DIFFERENT BROAD BEAN CULTIVARS

Elżbieta Cichocka[1], Bogumił Leszczyński[2], Antoni P. Ciepiela[3],Wojciech Goszczyński[4]
[1]*Department of Nature Protection, Catholic University of Lublin, Poland*
[2]*Department of Biochemistry, University of Podlasie in Siedlce, Poland*
[3]*Department of Molecular Biology and Biophysics, University of Podlasie in Siedlce, Poland*
[4]*Department of Plant Protection, Catholic University of Lublin, Poland*

ABSTRACT

Based on EPG (electronic penetration graph), two broad bean cultivars of various susceptibility to aphids were selected for the research. Proteins, amino acids, sugars and phenolics in these cultivars were determined with regard to their infestation by *A. fabae* and its biology. Such records included: aphid fecundity, population dynamics, time of generation development, number of generations per season and mortality during development.

Key words: *Aphis fabae*, broad bean, harmfulness, EPG

INTRODUCTION

Black bean aphid (*Aphis fabae* Scop.) is among the most harmful pests of broad bean, causing serious yield losses in Poland. Its colonies could develop thousands of specimens in a very short time and significantly reduce crop yield and its quality. Various aspects of the aphid biology has been intensively studied [2, 7, 12]. However, little is known on relation between the broad bean chemistry and the black bean aphid performance [3, 8, 9, 10]. In the present paper we report on the effect of some content of free amino acids occurring in three selected cultivars of broad bean on feeding behaviour and bionomy of the black bean aphid.

MATERIALS AND METHODS

The experiment was carried out on three previously selected cultivars of broad bean (*Vicia fabae* L.)*:* 'Bartom', 'Hangdown White' and 'Neptun'. The bionomics and dynamics of black bean aphid on those cultivars were monitored on experimental plots of the Warsaw Agricultural University. Observations began in middle of May and were carried out until the end of June 1997-1998. Experimental plots (5×5 m) were arranged according to the Latin square layout. Field isolators of bolting cloth were used for determining aphid fecundity and the number of generations. Observations were carried out every other day for determining: maturation time, fecundity, mortality and number of generations on the broad beans. Fecundity was established for 30 females in each generation. The harmfulness of *A. fabae* was examined on 100 infested and 100 control plants, grown in plastic containers in thermally treated soil and place in the field. When the first aphid colonies appeared, all infested plants were covered with isolators. The control plants were also isolated for the protection from aphid infestation. Feeding behaviour was monitored with the help of EPG (electrical penetration graph) upon the Tjallingii [17] method. For each cultivar 8-hours EPG recordings were obtained for aphids from 10 different plants, on the top part of broad bean stem. The duration and frequency of the aphid activities such as: non-probing, penetration of peripheral plant tissues, salivation into the sieve elements, and both phloem and xylem sap ingestion were measured.

Free amino acids were extracted with 80% ethanol from lyophilizates of the studied broad beans. Amino acids were separated from carbohydrates using ion-exchange [11] and eluted from the Amberlite IR-120[H^+] – filled column (1×15 cm) with following solutions: 0.4N ammonia in 80% ethanol, 4N ammonia, and redistilled water. The final preparation containing free amino acids was dissolved in 2 ml of 0.2M citrate buffer, pH 2.2, and analysed in an amino acid analyser.

Differences in aphid performance on studied cultivars were analysed by random ANOVA and the Duncan's test.

RESULTS AND DISCUSSION

In Poland *A. fabae* flies onto field broad bean crops about mid May and feeds until late July, producing 2-4 generations, each lasting approximately 15 days. The average fecundity of wingless females fluctuated within generations from 15.3 to 59.2 larvae (fig. 1, 2). In the third generation (1997) winged specimens, which prevailed among females, left broad bean plants. This crop is usually heavily attacked by *A fabae.* The cultivar 'Bartom' showed the highest infestation rate: in late May and early June (1997) of the 100% plants were attacked, while for 'Hangdown White' and 'Neptun' it was only 81-90%. In 1997, the spring was delayed with average precipitation. On broad bean the aphids developed 3 generations and the most heavily was attacked cv 'Bartom' (fig. 3).

Fig. 1. Fecundity of *A. fabae* (wingless female) on three cultivars of broad bean

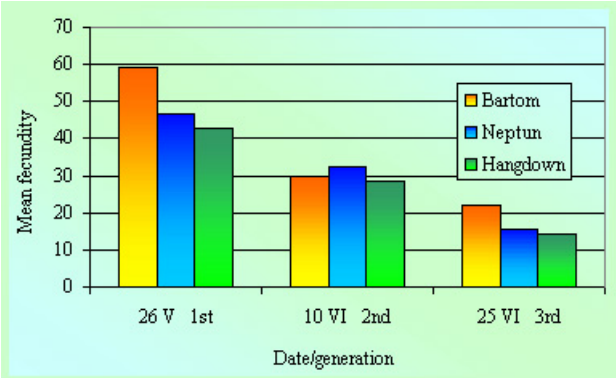


Fig. 2. Mean longevity (days) of *A. fabae* on three cultivars of broad bean

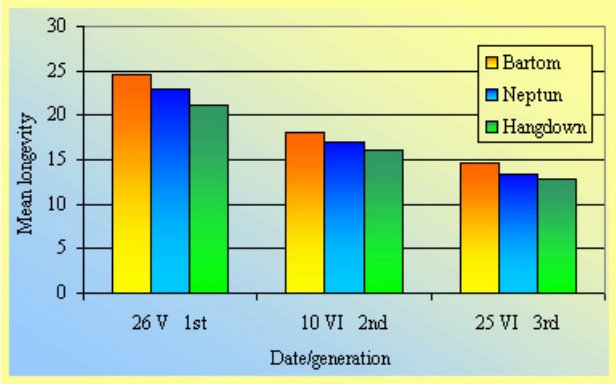
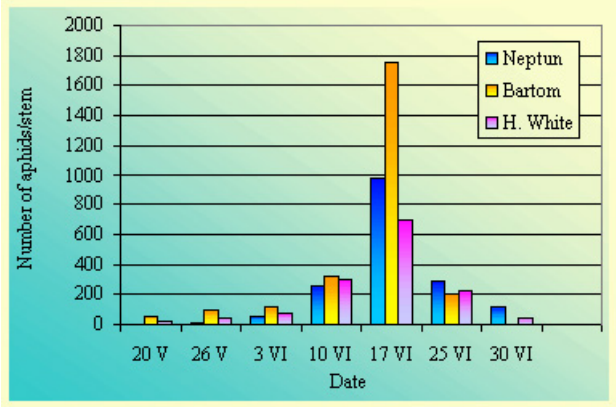
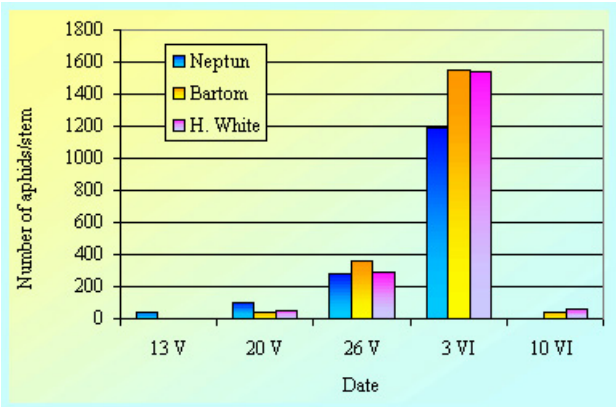


Fig. 3. Dynamics of *A. fabae* population on three cultivars of broad bean, 1977



In 1998, until late June while aphids were feeding, the spring was wet. Heavy rain washed out these insects from plants and prevented their flight. In consequence the infestation lasted only about 20 days, including 8 days with a relatively high pest quantity (fig. 4). The aphids were most numerous on cv 'Bartom', followed by 'Hangdown White' and 'Neptun'. The proportion of infested plants also varied with cultivars: 'Bartom' – 46%, 'Neptun' – 39% and 'Hangdown White' – 28%. In early June the aphids were totally suppressed by the parasitic fungus *Neozygites freseni* (Nowakowski, Remaudiere) and perished from broad bean for the rest the season.

Fig. 4. Dynamics of *A. fabae* population on three cultivars of broad bean, 1998



All the three tested cultivars responded to heavy aphid infestation by reducing the plant height and such a reaction was most pronounced for cv 'Neptun' (Table 1). In each case there was also a decline in the number of pods per stem. Infestation had no effect on the weight of single seed only in cv 'Bartom', where the number of

seeds per pod decreased. All the studied cultivars attacked by aphids reduced their seed yield as a result of limitation in pod number per plant. A similar response to *A. fabae* feeding was also observed for field bean [7]. However, a reduced of yield was additionally by a lower weight of single seed.

Table 1. Effect of infestation with *A. fabae* on plant height and seed yield, 1997

Cultivar	Plant height (cm)		Number of pods per stem		Number of seeds per pod		Single seed weight (g)		Seed weight per 100 plants (g)	
	K	A	K	A	K	A	K	A	K	A
'Neptun'	93.4	50.0**	4.0	2.3*	2.6	2.1	1.9	1.8	4958.8	1541.1**
'Bartom'	134.4	99.2*	3.5	2.0*	2.7	1.0*	2.5	2.5	5661.9	1975.6**
'Hangdown White'	108.0	83.4*	2.5	1.1*	2.6	2.2	2.4	2.4	3654.4	1436.3**

K – Control, A – Infested plants,
***significant at P = 0.05,**
****significant at P = 0.01.**

Of the three cultivars tested in the present study, 'Bartom' can be classified as the most attractive nourishment for the black bean aphid. It has been proved by the highest values of such parameters as aphid fecundity, percentage of infested plants and the duration of phloem ingestion. This polyphagous pest was also relatively abundant on the other two cultivars, but in comparison with 'Bartom', its fecundity and the proportion of affected plants were lower with prolonged feeding in tissues beyond phloem. However, a reduction of seed yield was recorded for all the tested cultivars.

The EPG recordings showed that the black bean aphid spent about 67.7% of the time ingesting the phloem sap from the susceptible Bartom cultivar, in comparison to 42.3% and 29.6% when fed on the less acceptable 'Hangdown White' and 'Neptun' broad beans respectively (Table 2). Similar trends were observed when the aphid salivation was determined into the sieve elements. However, there were no significant differences between cultivars with respect to the studied feeding activities of black bean aphid. The average duration of the phloem phase (salivation and ingestion) was clearly longer on the susceptible 'Bartom' cv as compared to the other two. Such a tendency was not observed for peripheral tissue penetration and xylem sap ingestion (Table 2). Number of the studied EPG patterns (events) was lower on the susceptible cultivar than on the other two. Generally, the aphids feeding on 'Bartom' cv spent much more time ingesting sap (feeding), while those on the less acceptable 'Hangdown White' and 'Neptun' were more active in the penetration of peripheral tissues and xylem sap ingestion.

Table 2. Feeding activities of black bean aphid on three broad bean cultivars

EPG patterns	Cultivars		
	'Hangdown White'	'Neptun'	'Bartom'
Peripheral tissue penetration – average duration (s) – number of events – duration percentage	 1532.7a 12.4a 34.2	 3254.9a 12.0a 42.4	 1854.2a 7.9a 14.3
Phloem salivation – average duration (s) – number of events – duration percentage	 111.6a 4.0a 2.5	 159.4a 5.3a 2.1	 400.5a 2.1a 3.1
Phloem ingestion – average duration(s) – number of events – duration percentage	 1894.0a 2.4a 42.3	 2277.0a 3.7a 29.6	 8743.0a 1.0a 67.7
Xylem ingestion – average duration (s) – number of events| – duration percentage	 449.2a 0.9a 10.0	 1534.9a 0.6a 20.0	 1132.0a 0.7a 8.8

Means within a now followers by the same letter are not significantly different (P = 0.05) – Duncan's test

From the analysis of top shoots of the 'Bartom' and 'Hangdown White' cultivars, it follows that the 'Bartom' – the cultivar favoured by black bean aphid is characterized by much higher content of essential and nonessential free amino acids than in the 'Hangdown White'. This was mostly resulted from threonine, valine, isoleucine, lysine, aspartic acid, serine, glutamic acid, and alanine (Table 3). Statistical analysis showed that differences between both broad bean cultivars were significant for total free amino acids, sum of essential and nonessential amino acids, as well as threonine, valine, serine, aspartic acid, alanine, glutamic acid and glycine. Similar results have bean obtained by other authors who studied the level of free amino acids in various species and cultivars of plant that were resistant to *Aphis craccivora* Koch, and *Sitobion avenae* (F.) [13, 16]. Aphids feeding on resistant pea cultivars characterized by a low concentration of free amino acids, give less progeny and excrete less honeydew then those feed on susceptible cultivars. Cell sap contains about 0.2% of free amino acids instead phloem sap is characterized by a much lower concentration of those compounds in comparison with other tissues. That is why most species of aphids which get food from phloem, equalise the deficit by getting proportionally large amounts of food, or modifying the plant metabolism towards an intensified amino acids synthesis [6].

Table 3. Content of the free amino acids (mg g^{-1} dry weight) within the studied broad bean cultivars

Cultivar	Essential amino acids								
	Thr	Val	Met	Ileu	Leu	Phe	His	Lys	Arg
'Bartom'	1.51a	0.30a	0.01a	0.18a	0.21a	0.09a	0.03a	0.08a	0.01a
'Hangdown White'	0.97b	0.20b	0.01a	0.16a	0.20a	0.09a	0.03a	0.06a	0.01a

Nonessential amino acids							
Cultivar	Asp	Ser	Glu	Pro	Gly	Ala	Tyr
'Bartom'	0.29a	1.56a	0.11a	0.01a	0.09a	0.17a	0.08a
'Hangdown White'	0.12b	1.00b	0.07b	0.01a	0.06b	0.12b	0.07a

Means within a column follows by the same letter are not significantly different (P = 0.05)

The quantitative differences in amino acids among different groups of *Cruciferous* species racemes were apparently the factors involved in determining resistance or susceptibility to aphids [1]. It appears that susceptible species, due to their high content of protein and protein amino acids, provided better nutritional conditions to the aphids for their growth and development resulting in higher rates of aphid multiplication. Similar results were obtained by Ciepiela [4] for winter wheat cultivars that differ in aphid-resistance. The flag leaves of susceptible wheat 'Liwilla' cv. contained higher concentration of protein amino acids (total, essential and nonessential) than the resistant 'Saga' cv. [5]. A remarkable example of nutrient changes affected by aphid infestation was reported by Poehling and Morvan [15] and Poehling [14]. Whereas the pattern of protein amino acids was nearly the some in susceptible and resistant broad bean before aphid infestation, asparagine, aspartic acid, methionine and some others increased in susceptible cultivar during infestation by *A. fabae*.

CONCLUSIONS

1. Broad bean crops are usually heavily attacked by *A. fabae* in Poland. In June 100% plants cv 'Bartom' (about 1000 aphids/stem) were attacked when the spring was delayed with average precipitation. When the spring was getting wet the aphids were totally suppressed by parasitic fungus *Neozygites freseni*.
2. The aphids accepted much better the 'Bartom' cv (the highest fecundity and longevity), that showed higher content of free protein amino acids (essential and nonessential) than the 'Neptun' and 'Hangdown White' ones.
3. *Aphis fabae* feeding on 'Bartom' cv spent much more time ingesting phloem sap (feeding), while those on the less acceptable 'Hangdown White' and 'Neptun' were more active in the penetration of peripheral tissues and xylem sap ingestion.
4. All the studied cultivars attacked by aphid reduced yield as a result of limitation in pod number per plant.

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Elżbieta Cichocka
Department of Nature Protection
Catholic University of Lublin
Al. Racławickie 14, 20-950 Lublin, Poland
tel. (+48 81) 445 35 29, fax. (+48 81) 445 35 36
e-mail: cichocka@kul.lublin.pl

Wojciech Goszczyński
Department of Plant Protection
Catholic University of Lublin
Al. Racławickie 14, 20-950 Lublin, Poland
tel. (+48 81) 445 35 29, fax. (+48 81) 445 35 36
e-mail: wgoszcz@kul.lublin.pl

Bogumił Leszczyński
Department of Biochemistry
University of Podlasie in Siedlce
ul. Prusa 12, 08-110 Siedlce, Poland
tel. (+ 48 25) 643 12 11, fax. (+ 48 25) 644 59 59
e-mail: leszczb@ap.siedlce.pl

Antoni Ciepiela
Department of Molecular Biology and Biophysics
University of Podlasie in Siedlce
ul. Prusa 14, 08-110 Siedlce, Poland
tel. (+ 48 25) 643 13 15, tel. (+ 48 25) 643 13 67