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BEETROOT DAMAGE DUE TO THE BLACK BEAN APHID (*APHIS FABAE* SCOP) INFESTATION

Wojciech Goszczyński[1], Elżbieta Cichocka[2], Bogumił Leszczyński[3]
[1]*Department of Plant Protection, Catholic University of Lublin, Poland*
[2]*Department of Nature Protection, Catholic University of Lublin, Poland*
[3]*Department of Biochemistry, University of Podlasie in Siedlce, Poland*

ABSTRACT

Presented data suggest that a short-term (up to 3 weeks) infestation of beetroot crop by relatively unnumerous aphids (only a few specimens per leaf) shows a stimulative effect on the growth of roots and reduces their content of nitrates.

In Poland, such low aphid populations usually occur during cold and wet spring (May, June) unfavourable for Aphis fabae, while this pest was frequently observed to be heavily infected by Neozygites freseni – a parasitic fungus effectively eliminating aphids from beetroot crop within 10 days.

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

INTRODUCTION

Black bean aphid (*Aphis fabae* Scop) is the commonly recognized pest of a number of crops in Europe. In Poland this species has been recorded as a harmful pest of broad bean, field bean and sugarbeet [1, 3]. In *Vicia faba* yield losses due to this species were found to depend on the timing and intensity of colonization [2]. Reduction in red beet yield depends upon the aphid density, time of initial feeding and sowing time [5, 6]. The present paper suggests that a short-term (up to 3 weeks) infestation of beetroot crop by relatively unnumerous aphids (only a few specimens per leaf) shows a stimulative effect on the growth of roots and reduces their contents of nitrates.

MATERIALS AND METHODS

Black bean aphid quantities and bionomics were studied on three beetroot cultivars: 'Opolski', 'Nochowski' and 'Chrobry'. The 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 generation. Observations were carried out every other day for determining: maturation time, fecundity, mortality and number of generation. Fecundity was established for 30 females in each generation. Harmfulness of *A. fabae* was examined on 300 infested and 300 control plants grown in plastic containers in thermically treated soil and placed in the field.

The aphid probing behaviour on young beetroot leaves was monitored for 4 hours (10 replications) with a continuous use of the four channel DC-EPG system [7]. Content of nitrates was analysed on fresh plant material using HPLC as described by Leszczyński [4].

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 into beetroot field usually in mid- May and feeds until late July, producing about 3 generations.

The average fecundity of wingless females fluctuated within generations and cultivars from 7.9 to 17.0 larvae/female. Black bean aphid showed a higher fertility on cv 'Opolski' as compared to 'Nochowski' and 'Chrobry'. The aphid mortality was higher on 'Nochowski' cv and 'Chrobry' than on 'Opolski', but the time of development was similar for the first generation and longer for the second generation (table 1). On field bean, instead, the average fecundity of *A. fabae* fluctuated from 19.9 to 29.0 larvae and one generation developed in approximately 15 days [1].

Table 1. Development of *Aphis fabae* on three beetroot cultivars

Cultivar	Generation	Mean fecundity larvae/female	Generation development (days)	mortality %
'Opolski'	1st 2nd	17.0 16.7	11.0 12.2	27 29
'Nochowski'	1st 2nd	12.9 11.4	10.6 13.6	33 34
'Chrobry'	1st 2nd	9.4 7.9	10.9 14.8	39 42

Beetroot was heavily attacked by *A. fabae* in 1997 (fig. 1-4). The pest infested very young plants, causing a strong malformation of their leaves. As shown in table 1, aphid mortality during development on red beet was high.

Fig. 1. Percentage of infested plants with *A. fabae* on three beetroot cultivars, 1997

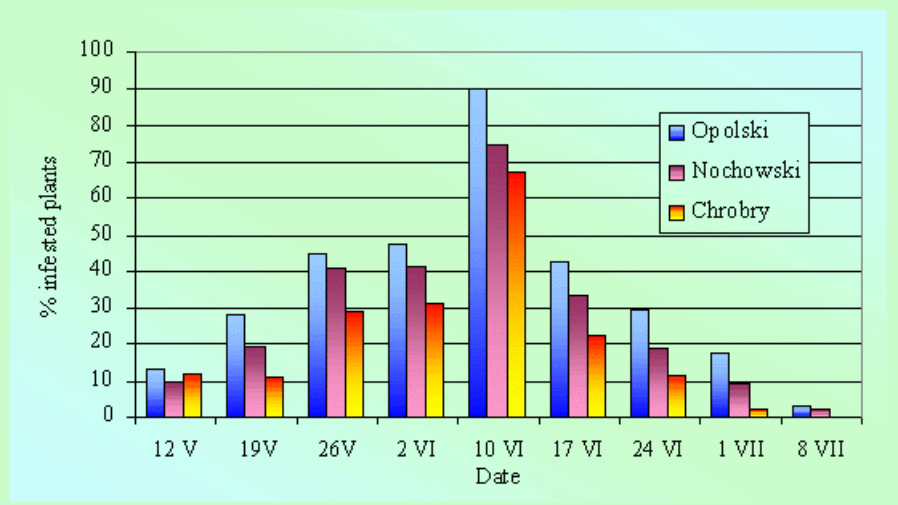


Fig. 2. Percentage of infested leaves with *A. fabae* on three beetroot cultivars, 1997

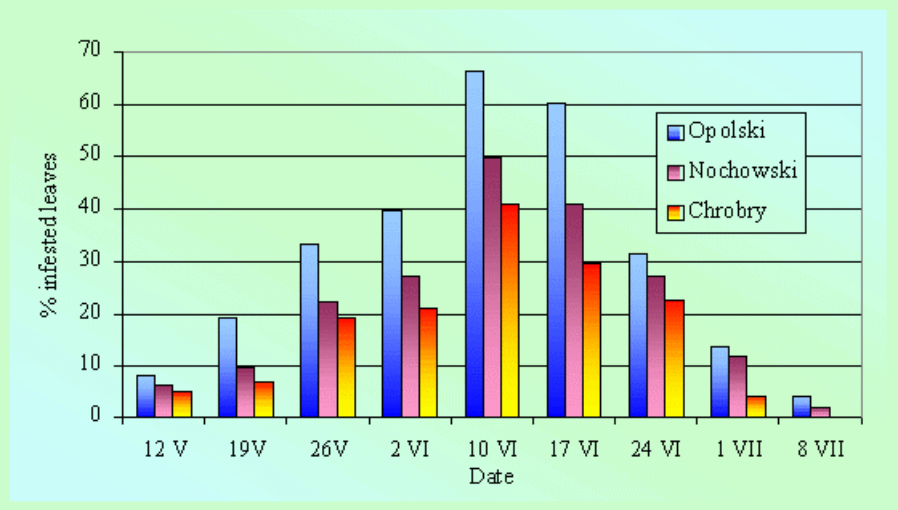


Fig. 3. Dynamics of *A. fabae* population on three cultivars of beetroot, 1997

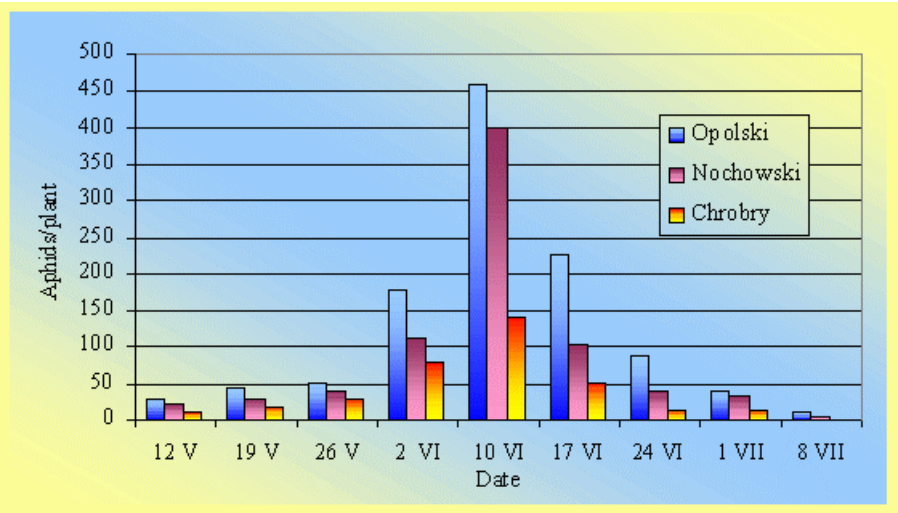
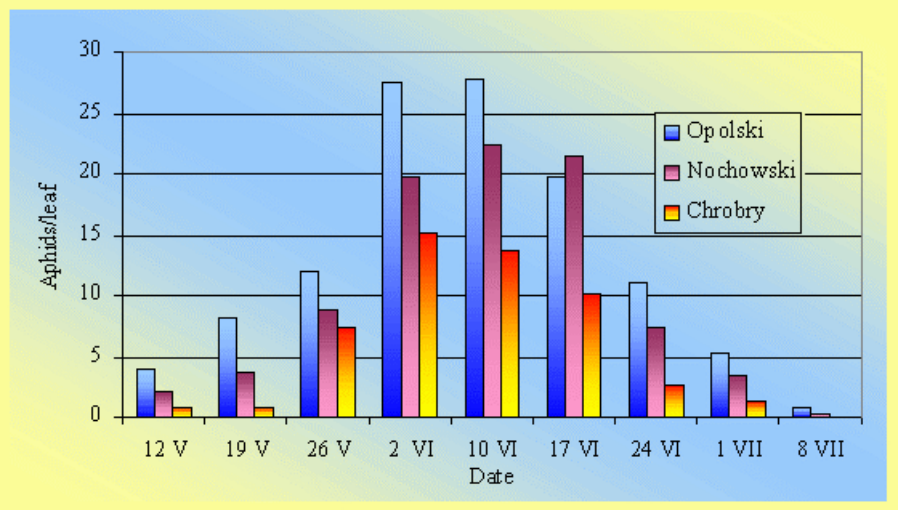


Fig. 4. Progress of infestation with *A. fabae* on three beetroot cultivars, 1997



The spring of 1997 came relatively early and was warm with average precipitation. *A. fabae* appeared on beetroot plants on May 12 and fed until early July, with its maximum quantity recorded on June 10 (fig. 1-4). The most numerous aphids (458.4 specimens per plant) and the highest proportion of infested plants (90.2%) were found on cv 'Opolski', followed by 'Nochowski'. The third cultivar, 'Chrobry' was the least affected by the pest. After July 8 the aphids left beetroot plants which started producing new leaves.

At the end of September beetroots were harvested and weighed, taking records for 300 plants of each cultivar. In relation to the control their yields were lower by 13.3, 11.4 and 10.9% for cv 'Nochowski', 'Chrobry' and 'Opolski', respectively. Although 'Opolski' cv was most heavily infested with aphids, its yield loss was relatively small, but the difference in yields of the studied cultivars were statistically insignificant.

In 1998 the spring was wet and delayed. Like the previous season, the most numerous aphids fed on cv 'Opolski', followed by 'Nochowski' and 'Chrobry'. Their maximum populations were found on June 4 when all plants of the three cultivars were affected by the pest. Moreover, in cv 'Opolski' 100% leaves were infested with aphids.

The first generation of *A. fabae* appeared as late as May 21 and fed only until June 11 (fig. 5-8). Such a short period of infestation was due to the activity of the parasitic fungus *Neozygites freseni* (Nowakowski, Remaudiere) which invaded aphid colonies on June 11 and totally eliminated them during 7 days. Up to the end of that season the pest had not returned onto the plants.

Fig. 5. Percentage of infested plants with *A. fabae* on three beetroot cultivars, 1998

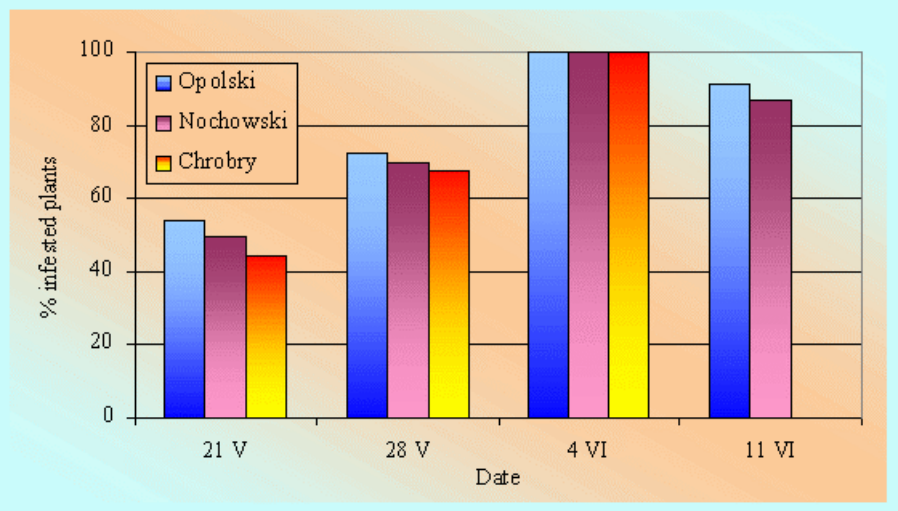


Fig. 6. Percentage of infested leaves with *A. fabae* on three beetroot cultivars, 1998

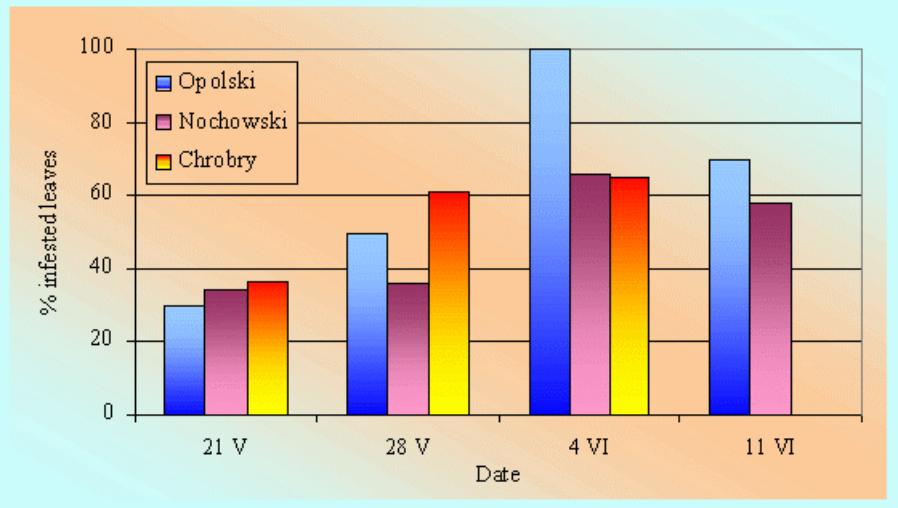


Fig. 7. Dynamics of *A. fabae* population on three cultivars of beetroot, 1998

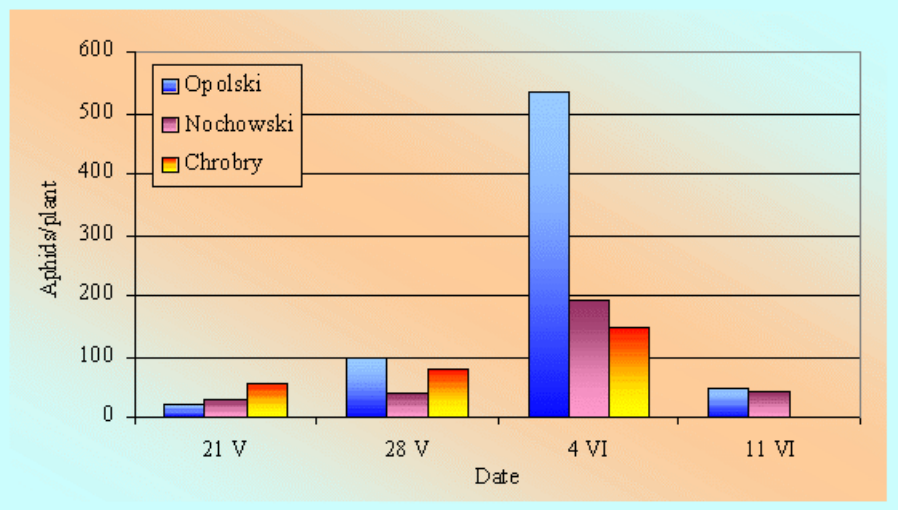
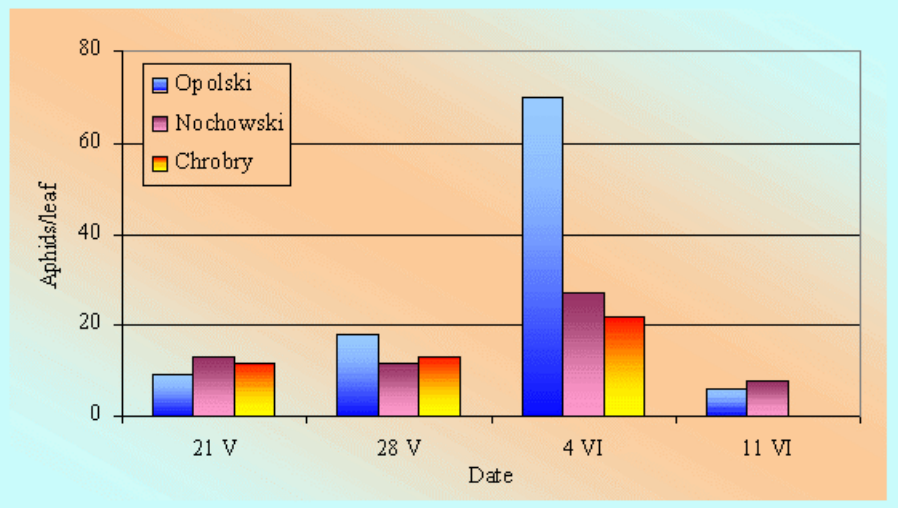


Fig. 8. Dynamics of *A. fabae* population on three cultivars of beetroot, 1998



The black bean aphid feeding behaviour varied significantly on the studied three cultivars of the beetroot (table 2). The susceptible 'Opolski' cv was much better accepted by *A. fabae* than 'Nochowski' and 'Chrobry' cultivars. The aphids fed on beetroot of 'Opolski' cv spent less time on the peripheral tissues (ABC patterns) probing, instead their activity on red beet was mostly concentrated on phloem and xylem phase. Total phloem activity (salivation into sieve elements and phloem sap ingestion; E1 and E2 patterns respectively) was twice longer than on two other studied cultivars. This was mostly due to clear difference in duration of the aphid phloem sap ingestion (table 2). Interestingly the phloem phase tendency was accompanied by xylem sap ingestion and the trends in duration of the phloem and xylem phase was positively related to number of the aphid events in the vascular tissues of the studied beetroot.

Table 2. Probing behaviour of apterous morphs of *A. fabae* on 3 cultivars beetroot during the 4-hours observation (mean per aphid)

EPG parameters min.	Cultivars		
	'Opolski'	'Nochowski'	'Chrobry'
Total penetration time (ABC+E+G)	179.62a	183.00a	177.79a
Total pathway time (ABC)	101.12b	145.05a	164.46a
Number of ABC patterns	15.20a	18.20a	18.30a
Total phloem activity time (E_1+E_2)	64.69a	33.51ab	27.49b
Total phloem sap ingestion time (E_2)	45.12a	23.80ab	11.11b
Number of E_2 patterns	6.30a	4.30ab	2.40b
Salivation into sieve elements E_1-total duration	19.57a	9.71a	16.38a
Number of E_1 patterns	8.90a	6.50ab	4.50b
Xylem sap ingestion-total duration of G-pattern	13.78a	4.45a	4.00a
Number of G patterns	0.90a	0.30a	0.20a

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

Beetroots were harvested either early, in mid-July (miniature roots for pickles) or in the autumn of 1998. After an exceptionally short time of aphid feeding there was no difference in root weight as compared with the control (table 3) and even there was a tendency of weight gain. This suggests that a low aphid infestation of red beet may have some stimulatory effect on root growth.

Table 3. Root weight (dag) of aphid- infested and control beetroot plants from summer and autumn harvests, 1998

Time of harvest	Cultivars		
	'Opolski'	'Nochowski'	'Chrobry'
15 VII – (for pickling)			
Control	4.1	4.8	3.7
Infested plants	5.7*	5.2	4.3
30 IX			
Control	21.0	16.2	20.0
Infested plants	24.0	23.5*	20.1

***significant difference at P = 0.05**

In comparison with field bean grown on the neighbouring plots, populations of *A. fabae* and its fecundity on beetroot plants were evidently smaller. It was also observed that broad bean was always preferred host plant for this pest.

In roots of red beet infested with aphids during a relatively short period (3 weeks) there was a lower content of nitrates. Such effect was recorded for all three tested cultivars, but was most pronounced for 'Nochowski' (table 4). Perhaps by utilizing nitrogen the aphids reduced the synthesis of nitrates.

Table 4. Content (p.p.m) of nitrates in roots of tested red beet cultivars, 1998

Cultivar	Control	Aphid-infested plants
'Opolski'	784.5	746.0*
'Nochowski'	1150.0	778.0**
'Chrobry'	630.0	607.5*

***significant difference at P = 0.05,**
****significant difference at P = 0.01**

In 1999 beetroots were sown twice: on April 1 (standard time) and May 1 (delayed). As the spring was wet and cool, the first singular aphids appeared as late as May 21 on plants from the early sowing while on those sown later – on June 2. In the first case the highest infestation rate reached only 55% of plants (cv 'Opolski') with aphid density not exceeding 13 specimens per leaf. Beetroots from the delayed sowing were affected by the pest: below 10% of infested plants with a maximum 3.1 specimens per leaf. In late June (2nd generation) all aphids were totally suppressed by the parasitic fungus *Neozygites freseni*.

According to Weisman & Vallo [8] *A. fabae* can significantly reduce beetroot yield, however this is determined by the density of its population and the time of pest invasion. More explicit damage can be caused to sugarbeet in which a lower root weight is accompanied by a decrease in sugar content [3]. In Poland a delayed, cold and wet spring may limit *A. fabae* populations. Heavy rainfall can wash out aphids from plants, preventing their migration. Also, a high air humidity is favourable for the development of parasitic fungi which can effectively control this pest.

CONCLUSIONS

1. Black bean aphid showed: higher fecundity, smallest mortality, most numerous aphids and highest proportion of infested plants on cv 'Opolski' as compared to 'Nochowski' and 'Chrobry'..
2. During the 4h EPG recording the beetroot 'Opolski' cv was much better accepted by *A. fabae* than 'Nochowski' and 'Chrobry'. Total phloem sap ingestion time (E_2) on 'Opolski' cv was twice longer than 'Nochowski' and fourfold than 'Chrobry'.
3. Yield losses in beetroot due to *A. fabae* have also been shown to depend on the timing and intensity of colonization. Short-term (up 3 weeks) infestation of beetroot crop by relatively low aphids numbers (few per leaf) shows a stimulative effect on the growth of roots and reduces their contents of nitrates.

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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

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

Bogumił Leszczyński
Department of Biochemistry
University of Podlasie
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

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