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Influence of Black Bean Aphid, *Aphis fabae* Scopoli. on Growth Rates of Faba Bean

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Abstract: Greenhouse experiments were conducted to determine the influence of 0, 5 and 10 initial aphid densities on the growth rate of faba bean plant, *Vicia faba major* variety, at two different growth stages over infestation periods of 14, 28 and 42 days. Data revealed that aphid feeding declined significantly the shoot fresh and dry weights, root fresh and dry weights, plant length and leaf area. In most cases, changes in theses growth parameters were proportional to the number of aphids released to each plant. When plants were infested by aphids at an early plant growth stage, 14 days post-emergence, 5 and 10 initial aphid densities caused plant to die at days 28 followed infestation. However, experimental plants infested at days 28 after emergence, survived the impact of aphid attack better than young plants. Aphid abundances derived from the low and high initial infestation levels were proportional to the number of aphids released into each plant over all infestation periods and at both infestation times. Aphid numbers developed from low infestation level were significantly less than individuals of the high initial infestation.

Key words: *Aphis faba* · faba bean · plant growth

INTRODUCTION

Black bean Aphid, *Aphis fabae* Scopoli, accounts mostly for a destructive pest attacking faba bean, *Vicia faba*, in the global [1]. In Jordan, this aphid species became a major pest of faba bean crop in most conditions, resulting on occasion in a complete weakness of crop productivity. Aphid Infestation usually influences the host plant by removal of assimilates [2]. Honeydew excretion and growth of sooty molds create also an indirect damage through impending some physiological processes in the host plant [3].

The majority of previous work on the host plant infested with aphids has been agronomic in emphasis. Nature of the relationship between aphid infestation and its effect on the growth and yield of plant has been investigated to some extent in different aphid-host plant combinations [2, 4, 5]. Various changes in plant growth rates have been ascribed to a number of herbivorous insects including aphids [2, 6-8]. However, plant response to aphid feeding has been reported to be specific to particular aphid system investigated [2]. In different aphid-plant combinations, aphid attack induced a reduction in biomass, leaf area and relative growth rate of host plant [2, 5, 6]. For the faba bean, the relation between injury caused by *A. fabae* and crop yield depends on the growth stage of host plant at the time of aphid invasion where young plants show a greater susceptibility to aphid than old ones [1, 8]. There is also evidence that the infestation of field bean by a tiny aphid population increases slightly the yield [9, 10].

Faba bean is an important agronomic crop in much of the developing world that has not received nearly as much research attention as other crops. Despite the black bean aphid is a significant faba bean pest, little systemic attention has been rewarded for *A. fabae* - *V. faba* system. A knowledge of how this aphid species affects yield forming process in this specific insect-host relationship can be of great significance to asses pest status and to devise methods of minimizing the effect of infestation on yield [11].

Therefore, the present study was performed to quantify the effect of different initial aphid densities on the growth rates of faba bean and to determine the responses of young and old plants to aphid infestation.

MATERIALS AND METHODS

Stock of *A. fabae* was collected from infested faba bean field in Jordan Valley, Jordan. Aphid culture was

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established on potted *V. faba* plant, *V. faba major* variety, in insectary at a temperature of 22±2°C, 40-80% relative humidity and 16 L:8 D light regime. To estimate the influence of *A. fabae* on some vegetative growth components of the host plant, seeds of faba bean were planted in plastic pots (20 cm diameter) filled with fine loam soil at a density of three seeds per pot, which kept at a temperature of 24±2 and 60±10% relative humidity under the greenhouse conditions. Seven days after emergence, seedlings were thinned to a single plant for each pot. Faba bean plants were watered every two days and fertilized once shortly after emergence with Diammonium phosphate (18:46:0).

Pots were divided into two experimental sets. In the first series, aphids were introduced into the plants when they reached eight true leaf stage, 14 days after seedling emergence, whereas the plants in the second experimental series were infested with the same number of aphids at 28 day post-emergence. In each set the effect of aphid feeding on host plant were assessed at initial population levels of 0, 5 and 10 aphids per plant over three periods; 14, 28 and 42 days. For all treatments, late-nymphal instars attained from synchronized aphid colony were transferred to the top of each experimental plant using a fine, moist camel-hair brush that allowed then to reproduce freely there.

Each experimental plot was divided into four blocks and each block contains 12 experimental units. Treatment combinations were randomly assigned to experimental unit within each block. After artificial infestation, each treated block including control was covered with screen organdy cloth that was mounted over the greenhouse bench in order to elude aphid contamination between treatments. During the experiment, four plants were sampled randomly from each block (total 16 plants per treatment) for each infestation level and time.

Number of aphids per plant was counted at 14 day intervals. At each sampling date, faba bean plants were removed from the pots. Water was used gently to remove the residues of soil. Plants were separated into shoots and roots and their fresh weights were separately recorded. Shoot and roots were then oven dried to a constant weight (70°C for 48 h) and afterward weighed to determine the dry weight. Plant heights were measured from the ground level to the tip of the plant using a ruler. In addition, leaf area was determined by leaf area meter (LI-3000 area meter, Li-Cor. inc., Lincoln, NE).

Data were subjected to analyses of variance (ANOVA). Collected data were analyzed using MSTATC software (Michigan State University, 1988). Means were compared using Fisher's least significant differences test at a 0.05 probability level.

RESULTS

Development of aphid population on faba bean: When plants were infested with two initial infestation levels at an early growth stage, 14 day post-emergence, aphids continued to increase in number during the first four weeks succeeding artificial infestation, reaching a peak at day 28 (Fig. 1a). Thereafter, populations of both initial aphid density decelerated their development and collapsed at the end of experimental period. However, aphid size derived from a low initial infestation level was significantly slighter than those resulting from high initial population.

The multiplication rate of aphids on older plants infested by aphids at days 28 after emergence followed a similar pattern as observed on young plants, excluding that aphid population of both infestation

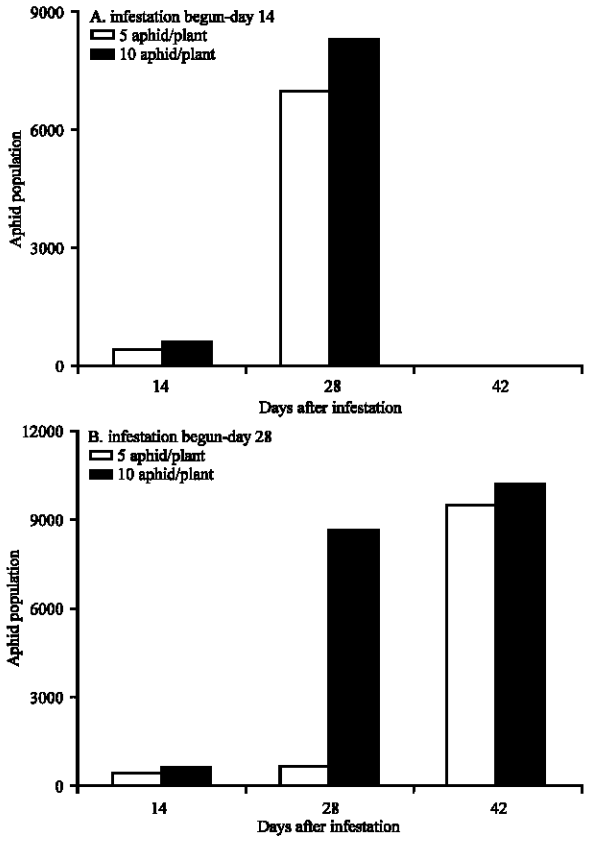

Fig. 1: Average number of *Aphis fabae* on faba bean plants infested after 14 days and 28 days (B) of emergence by two initial infestation levels of aphid for three durations under greenhouse conditions

Table 1: Average shoot fresh and dry weights (g) per plant of 14 or 28 day old faba bean plants infested by different initial infestation levels of *Aphis fabae* for different periods of time

Infestation started	Aphids/plant	Shoot fresh weight			Shoot dry weight		
		14 days	28 days	42 days	14 days	28 days	42 days
Day 14	0	19.20a (100)*	51.60a (100)	-	2.25a (100)	5.45a (100)	-
	5	17.71b (92.2)	42.16b (81.7)	-	1.66b (73.7)	3.12b (57.3)	-
	10	16.09c (83.8)	33.04c (64.0)	-	1.48b (66.0)	2.59b (47.5)	-
Day 28	0	51.16a (100)	85.62a (100)	125.00a (100)	5.72a (100)	8.34a (100)	11.15a (100)
	5	40.03b (78.2)	73.00b (85.3)	99.65b (79.7)	4.54b (79.3)	7.47b (89.6)	9.73b (87.3)
	10	38.30b (74.9)	57.63c (67.3)	73.25c (58.6)	3.80c (66.4)	6.60c (79.1)	9.06b (81.3)

Means within each column and infestation time followed by the same letter (s) are not significantly different at p = 0.05, Value between parentheses is relative to control

Table 2: Average root fresh and dry weights (g) per plant of 14 or 28 day old faba bean plants infested by different initial infestation levels of *Aphis fabae* for different periods of time

Infestation started	Aphids/plant	Root fresh weight			Root dry weight		
		14 days	28 days	42 days	14 days	28 days	42 days
Day 14	0	28.89a (100)*	40.43a (100)	-	2.50a (100)	4.17a (100)	-
	5	26.66b (92.3)	31.55b (78.0)	-	2.14b (85.3)	2.76b (66.2)	-
	10	20.37c (70.5)	25.95c (64.0)	-	1.99b (79.5)	2.56c (61.3)	-
Day 28	0	40.89a (100)	57.57a (100)	61.95a (100)	4.25a (100)	4.44a (100)	4.82a (100)
	5	32.25b (78.9)	37.00b (64.3)	51.65b (83.4)	3.16ab (74.3)	3.63b (81.8)	4.09b (84.8)
	10	28.33c (69.3)	33.40c (58.0)	44.16c (71.3)	2.55b (60.1)	3.32b (74.8)	3.81c (79.1)

Means within each column and infestation time followed by the same letter (s) are not significantly different at p = 0.05, Value between parentheses is relative to control

levels did not break down over 42 days (Fig. 1b). Also, it is evident that the increase rate of aphid population delayed in both infestation levels during the last two weeks of experiment.

Effect of *A. fabae* on shoot fresh and dry weights: Table 1 shows the impact of 5 and 10 aphids per plant over 14, 28 and 42 days when the infestation began 14 and 28 days after seedling emergence. In all cases except one, aphid feeding induced a significant decline in the shoot fresh weight. Plant infestation with 5 aphids starting on day 14, reduced the relative shoot fresh weight to 92.2, 81.7% after 14 and 28 days, respectively in comparison with the aphid-free plants. Ten aphids per plant over 14 and 28 days diminished the relative fresh weight to 83.8 and 64.0%, respectively, compared to the respective control. The effect of aphids was much similar when the infestation was initiated on day 28 (Table 1). Shoot fresh weigh was significantly reduced by plants infested with 5 and 10 aphids over 14, 28 and 42 days when compared to the relevant control. Also, significant differences in the shoot fresh weight were recorded between plants infested with 5 aphids and plants with 10 initial infestation level over 28 and 42 days.

Data revealed also that aphids were capable to trim down the shoot dry weight produced by young plants (Table 1). Within the first sampling date, a significant greater shoot dry weight was present on the control plants with respect to aphid-infested plants. Moreover, the dry weight declined as initial infestation level of aphids increased. The same trend but of greater magnitude was observed when infestation proceeded for further two weeks. Responses of old faba bean plants that were attacked by 0, 5 and 10 aphids at a little later stage of plant development, were similar to that for young plants, except that aphid feeding did not cause plant to die during the whole experimental period.

Effect of aphids infestation on root fresh and dry weights: A considerable influence on the root fresh weight was detected within each sampling date when plants were infested with 5 or 10 aphids levels on the both times of infestation (Table 2). When infestation began on 14 days, 5 aphids for each plant declined the relative fresh weight

Table 3: Average plant height (cm) of faba bean plants infested by different numbers of *Aphis fabae* for various durations beginning with 14 or 28 days after emergence

		Days after infestation		
Infestation started	Aphids/plant	14	28	42
Day 14	0	22.75a (100)	36.45a (100)	-
	5	18.75b (82.4)	28.73b (78.8)	-
	10	17.13c (75.3)	23.66c (64.9)	-
Day 28	0	41.00a (100)	58.50a (100)	73.75a (100)
	5	38.13b (93.0)	44.00b (75.2)	63.50b (86.1)
	10	30.38c (74.1)	39.00c (66.7)	51.50c (69.8)

Means within each column and infestation time followed by the same letter (s) are not significantly different at p = 0.05, Value between parentheses is relative to control

to 92.3% and 78% of that of the respective aphid-free plants at days 14 and 28, respectively. However, infestation of 14 day-old plant with 10 aphids lead to a 70.5 and 64.0% reduction in the relative root fresh weight over days 14 and 28 after initial infestation, respectively, compared to the relevant control within each sampling date. The same effect was observed when plants were infested at a progressive growth stage, 28 days after emergence. The relative fresh root weight of plants infested with 5 aphids were 78.9, 64.3 and 83.4% of the respective control by days 14, 28 and 42, in that order, whereas the reduction percent of the root weight as a result of infestation by 10 aphids ranged between 30.7-42% depending on the length of infestation period.

The influence of different *A. fabae* infestation levels on the root dry weight over three infestation periods and at two growth stages of the plant is also illustrated in Table 2. With five aphids per plant starting on day 14, root reduced in the weight to 14.7% after days 14 days and 33.8% after days 28 when compared to that of the respective aphid-free plants. Root dry weight of the plants infested with 10 aphids declined to 79.5 and 61.3% at days 14 and 28, respectively. However, there were significant differences between infested and control plants at days 14 after artificial infestation, but all treatments differed significantly among each other by days 28.

At the second infestation time, significant differences were detected between all treatments after days 42 followed aphid release. Initial density of 5 aphids per plant reduced the relative root dry weight to 74.3, 81.8, 84.8% of that of the aphid-free plants, at days 14, 28 and 42, respectively. Nevertheless, the damage was greater by plants infested with 10 aphids. The relative root dry weight decreased at high infestation level to 60.1, 74.8 and 79.1% of the control plants over the three sampling dates, in that order.

Effect of *A. fabae* infestation on the plant height: Results indicated that aphid-infested plants exhibited a significant reduction in the plant height compared to the control and the degree of these impact depends on the infestation level and intervals. At the first infestation time, significant differences were detected between initial infestation levels after 14 days following aphid introduction. The same trend, but of greater magnitude, was monitored after days 28 where initial densities of 5 and 10 aphids per plant declined the plant height to 78.8 and 64.9% of the aphid-free plants, respectively. Infestation of 28 day-old plants by *A. fabae* showed incredibly similar trend as that observed for the youngest plants. The effect of aphid infestation on plant height was highly significant and these differences were more pronounced by higher aphid density at all infestation intervals.

Effect of *A. fabae* infestation on leaf area: Leaf area produced by plant was significantly influenced by aphid feeding at both infestation times. The response of leaf area to aphid injury followed the same pattern as for the plant height. As Table 4 indicates, aphid attack declined generally the leaf area of infested plants. Significant differences in the leaf area were ascertained between all treatments when the infestation occurred on young plants. With 5 aphids per plant, leaf area decreased to 86.3 and 73.3% by days 14 and 28, respectively, compared to the respective controls. The consequence was greater when plants were occupied with 10 aphids where the relative leaf area diminished to 74.8 and 66.5% of the controls in both sampling date and was appreciably less than other treatments. A very similar fashion was observed when the two initial aphid densities were introduced into plants two weeks later. Final leaf area of aphid-infested plants was still significantly lower than that of controls. The relative leaf area of plants infested

Table 4: Mean Leaf area (cm^2) of faba bean plants infested by different numbers of *Aphis faba* for various durations beginning with 14 or 28 days after emergence

		Days after infestation		
Infestation started	Aphids/plant	14	28	42
Day 14	0	206.80a (100)	374.80a (100)	-
	5	178.40b (86.3)	274.80b (73.3)	-
	10	154.70c (74.8)	249.10c (66.5)	-
Day 28	0	376.00a (100)	646.30a (100)	886.00a (100)
	5	286.00b (76.1)	527.80b (81.7)	623.00b (70.3)
	10	273.50b (72.7)	433.00c (67.0)	552.00c (62.3)

Means within each column and infestation time followed by the same letter (s) are not significantly different at p = 0.05, Value between parentheses is relative to control

by 5 aphids was 76.1% at days 14 and a further 81.7 and 70.3% of the particular controls in the ensuring 28 and 42 days, respectively. Invasion of the plant with 10 aphids induced a greater decrease in the leaf area than those of 5 aphids. Moreover, all treatment differed significantly among each other within each sampling date.

DISCUSSION

Result of this study pronounced that aphid populations resulted from aphid infestation were proportional to the number of aphids that were initially released into each plant at both infestation times. Aphid abundance stemmed from low aphid density was less than individuals created by higher initial infestation level within each growth stage of the plant. This fact has been also reported for different aphid-plant combinations [1, 2]. However, the aphid population did not build up incessantly during this study, but a decrease in the number of aphids was observed at days 28 subsequent of older plants, at the second infestation time. The decrease in the aphid number under such crowded population conditions could be blamed on the reducing nutrient quality of phloem sap [12] and on the competition between aphid individuals on the available food source causing aphids to feed on less nutrimental plant parts, which in its turn affect detrimentally the fecundity and development rate of aphids [13]. Moreover, when plants wilt and stunt as a result of aphid attack, they turn into an interior food source for aphids and thus aphids commence to wander and nourish less leading ultimately to decelerating aphid abundance [6].

In conformity with outcomes achieved in different aphid-plant systems [2, 6, 14, 15], the growth components of *V. faba* were conspicuously reduced by aphid feeding. All tested growth parameters responded almost in a similar manner to aphid injury where the damage increased in general with the elevating infestation level. The reduction in plant growth rate is most likely caused by amputation of assimilates by aphids [16] and alteration in the sink-source ratio to the advantage of aphids [17]. Reduction in the photosynthetic leaf area recorded in this study could be also partly in charge for the decline the relative growth rate of infested plants [6]. In addition to the physical sink, aphid is competent to cause some physiological changes in infested plants as a result of vaccination of toxic saliva into the plant tissues, which eventually reduces the plant biomass [18]. Other investigators affirmed that the decrease in the plant growth could be a combined effect of saliva, translocate removal and or diminished leaf area [19, 20].

For the faba bean, the relation between injury caused by *A. fabae* and the growth rate relied on the plant developmental stage at time of aphid attack. Young plants did not show a great susceptibility to aphid feeding within days 28 after the artificial infestation, but, after a while, severe damage occurred to the plant because of the development of an enormous aphid density on the still young plants, which may exceed the carrying capacity of aphid injury. Plants infested at a later growth stage had the talent to conquer a sensitive phase at the beginning of infestation and in the further course of infestation the ratio of withdraw to fabricated assimilates is therefore most likely more profitable for plant growth [4].

Finally, this study indicated that the vegetative growth of faba been was influenced obviously by aphid feeding and the magnitude of damage was proportional to the initial aphid density. As plants advance in the growth, they become more endurable for the impact of subsequent infestation and probably compensate for damage. Also, means by which this insect pest causes injury to *V. faba* host plant are still not recognized and therefore, investigations in this regards is highly valued.

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