Differences in Growth and Yield Responses to *Aphis gossypii* Glover between Different Okra Varieties

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Abstract

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The reactions of five commercial varieties of okra, *Abelmoschus esculentus,* to *A. gossypii* were evaluated under semiarid field conditions. Each experimental plant of varieties Clemson spineless, Clemson spineless 80, Lee, Perkins dwarf, and Local was infested 60 days after emergence by three late-nymphal instars of the aphid. The results showed that aphid populations increased constantly on the varieties, except for days 42 and 49 after infestation, attaining a peak at about the end of the growing season. Differences in aphid densities were recorded between varieties. The aphids were most numerous on var. Local, while lowest in number on var. Lee. Infestation by aphids on okra varieties reduced yield by 57% on var. Perkins dwarf, 56% on var. Lee, 24% on var. Clemson spineless, 21% on var. Clemson spineless 80, and 5% on var. Local. Reduction in the number of pods produced per plant followed the same pattern as observed for total yield. Aphids had not altered significantly the vegetative plant growth at day 37 following infestation. At day 66, a substantial decrease in shoot fresh and dry weights and also leaf area was evident on var. Perkins dwarf while on var. Clemson spineless only the leaf area was significantly reduced. Moreover, aphid-free controls varied widely in their growth and productivity at the end of growing season. Varieties Clemson spineless and Clemson spineless 80 produced the highest total yield and pod numbers, var. Local the lowest. The varieties Perkins dwarf and Clemson spineless produced significantly higher shoot fresh and dry weight, as well as leaf area, than var. Lee and Local.

Keywords: *Aphis gossypii*; okra; yield; plant growth

Okra, *Abelmoschus esculentus* (L.), is cultivated to produce seed pods that are consumed fresh or dried and usually added to soup, though there are different ways of use in particular regions around the globe (Lamont 1999). In Jordan, the total area devoted to okra cultivation is estimated at 10 031.6 donums per year with a production of 5869.1 metric tons of green pods, which is still low and far less than the country's needs (Anonymous 2000). This deficiency of okra production in Jordan may be put down to unreliable rainfall, growing local cultivars with low productivity, lack of agronomic practices, and high production costs due to the labor-intensive manual picking of green pods.

The melon aphid, *Aphis gossypii* Glover, is one of the major destructive pests in most regions of okra production, particularly in tropical and subtropical regions (Kersting *et al.* 1999) where it can been seen throughout the year reproducing parthenogenetically, while the sexual part of the life cycle is omitted (Avidov & Harpaz 1969). *Aphis gossypii* attacks about 220 host plants belonging to more than 46 botanical families (Blackman & Eastop 1985). Currently, the melon aphid has become a serious pest on cotton in most cotton production regions in the world, and on vegetable crops in greenhouses, plastic tunnels and open fields (Leclant & Deguine 1994).

Like other aphid species, *A. gossypii* has the potential to build up high populations on a variety of crops (van Steenis & El-Khawass 1995) under favorable environmental conditions; on okra it usually causes a reduction in plant height, fresh weight and yield (Wanja *et al.* 2001). Heavily infested plants commonly show distorted and stunted leaves, reduced fruit set, and sometimes individual plants may be killed by direct feeding (Slosser *et al.* 1989). If the aphid is abundant early in the growing season, seedlings may be diminished in vigor, or even prematurely die (Bohmfalk *et al.* 1987), while plants at the fruiting stage are more able to withstand aphid infestation (Harris *et al.* 1992).

Treatment of crops by conventional foliar pesticides is the most widely practiced approach for aphid management to ensure satisfactory yield and quality of produce. Such intensive chemical control may in some conditions be effective, but the total reliance on pesticides is not a wise strategy. Aphid management by chemical control is often unproductive due to short-time harmful influence on aphid population and decimation of non-target insects and their benefits (Long 1994). Reliance on pesticides is also hazardous to human and animals, and adds to environmental pollution. Recently, *A. gossypii* has shown different degrees of resistance to frequently used insecticides (Chang *et al.* 1997; Herron *et al.* 2000), which could lead to increase in dosage and application frequency of a pesticide, with a rise of production costs to a level where okra cannot be grown profitably. Nowadays, the significant economical, environmental, and health costs associated with insecticide-based control programs enhance the utilisation of alternative methods for aphid management. Some researchers have recognised the potential value of plant resistance to manage *A. gossypii* and succeeded to select partial resistance in some vegetable and cotton varieties (van Edman 1978; McKinlay 1992; Weathersbee *et al.* 1994). However, the extent and biological components of plant resistance to melon aphid have not yet been fully exploited in wild relatives and cultivars of most vegetable crops, in particular okra.

Introducing tolerant or resistant crop varieties into an agro-ecosystem is meaningful because they are compatible with other control methods with minimal or no adverse side effects on the environment. Even with the importance of *A. gossypii* as agricultural pest, information on direct or indirect monetary losses from aphid damage or management costs are not available. Nor were the relationships between aphids and yield components of okra sufficiently studied. Yet knowledge of the ways by which aphids influence the yield-forming processes of a crop is desirable to appraise the impact of a pest and to create methods to minimise its impact on yield.

Therefore, the present study was to determine the effect of melon aphid infestation on fresh and dry weight of shoots, leaf area, pod numbers, and total yield of different okra varieties under semiarid field conditions.

MATERIALS AND METHODS

Stock of *A. gossypii* was collected from infested okra fields in the Irbid district, Jordan. The aphids were reared on potted okra plants of a local variety, in mesh screen cages in an insectary room at a temperature of 24 ± 3°C, 40–70% relative humidity, and 16L:8D h photoperiod regime.

Seeds of the five okra varieties Clemson spineless 80, Clemson spineless, Perkins dwarf, Lee, and Local were planted at the campus of Jordan University of Science and Technology, Irbid, on 15th April, 2002. The varieties with two infestation levels were arranged in a randomised complete block design with four replicates. Each block was divided into 10 experimental units (each 1 × 1 m) with 1 m between them as a border and a distance of 2 m between blocks. Seeds of each variety were planted in three rows per unit with inter-row spacing of 30 cm and 30 cm spacing between plants so that each unit contained six plants. Treatment combinations of five varieties and two infestation levels were randomly assigned to units within each block. The plants were fertilised and watered by drip irrigation system as usually practiced.

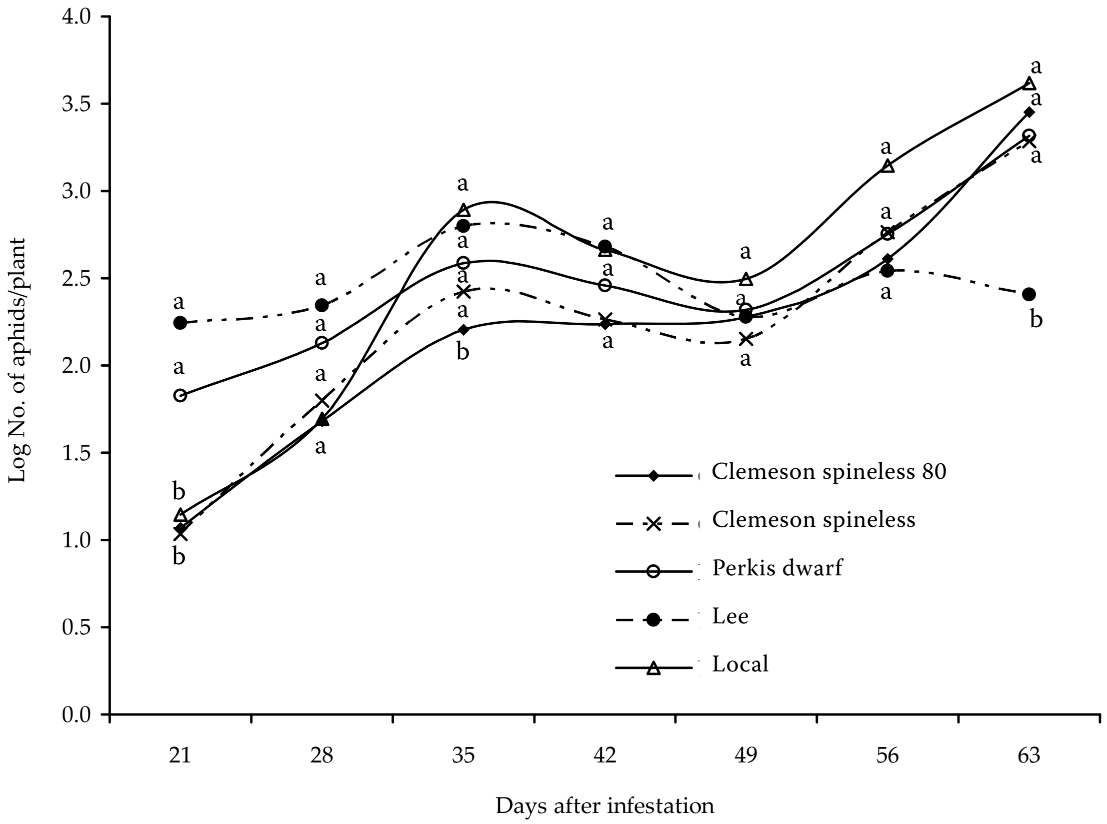
At the beginning of the flowering stage, on 20th June, 2002, each experimental plant was infested with three late-nymphal instars of *A. gossypii* acquired from synchronised colonies. Control plants remained aphid-free. Subsequent to aphid release, an organdy screen cage measuring (L × W × H) 1 × 1 × 1.5 m was erected over each experimental unit, including the aphid-free control ones, to prevent escape of released aphids and any invasion by aphids from the field. Aphid populations were then counted on three randomly selected plants from each treatment at one-week intervals. Fresh weight and number of pods produced by individual plants were determined regularly every three days. At 37 and 66 days after initial infestation, three plants from each experimental unit were sampled at random, cut direct above the ground, and weighed in the laboratory. Leaf area meter type L1-3000 (Li-Cor. Inc., Lincoln) was used to compute the leaf area after excising them.

Data on the aphid populations were transformed to logarithmic numbers to correct the standard deviations that were linearly related to the means and multiplication of the main effects. Statistical analyses were performed using MSTATC program under Windows 95 used for split-plot arrangement with randomised complete block design analysis. Significantly different means were separated by using Fisher's LSD tests at the 5% level of probability. Comparisons within each date between aphid-infested and aphid-free plants were performed by using the *t*-test.

RESULTS

Development of aphid populations on different okra varieties

The populations of melon aphid developed similarly on all tested varieties (Figure 1). Within the first 4 weeks, the number of aphids increased on var. Local, Clemson spineless 80 and Clemson spineless at a slower rate than those on var. Lee and Perkins dwarf. Aphid densities reached a first peak at 35 days after artificial infestation, with a rapid increase in aphid numbers on var. Local at the third sampling date. Afterwards, the aphid populations on all varieties dropped steadily until day 49, except on var. Clemson spineless 80. A further fast increase in aphid populations was recorded on days 56 and 63, except on var. Lee. Apart and in spite of the amazing variations in aphid quantity, no significant differences were recorded between the okra varieties at days 28, 42, 49 and 56. Up to day 21 the greatest aphid population had built up on var. Lee, but was lowest on



Means joined with the same letter within each date are not significantly different at $P \leq 0.05$

Figure 1. Population development of *Aphis gossypii* on five okra varieties under semiarid field conditions

Table 1. Average shoot fresh weight (g) of okra varieties 37 and 66 days after infestation with *Aphis gossypii*

Variety	Duration of infestation (days)					
	37			66		
	control	infested	rel. %	control	infested	rel. %
Clemson spineless 80	550.5^{a}	489.4	89	374.4^{ac}	465.1	124
Clemson spineless	661.8^{a}	563.1	85	474.3^{ab}	384.1	81
Perkins dwarf	587.1^{a}	484.1	82	585.8^{b}	370.1*	63
Lee	408.4^{a}	350.7	86	348.8^{ac}	253.5	73
Local	586.6^{a}	495.4	84	265.9^{c}	333.8	126
LSD	366.6			139.0		

Means within column followed by the same letter(s) are not significantly different at $P \leq 0.05$
Numbers joined with (*) are not significantly different from the respective control at $P \leq 0.05$

this variety on the last sampling date. Var. Local permitted aphids to develop the highest population over 35 and 63 days as compared to var. Clemson spineless 80 and Lee, respectively.

Effect of *A. gossypii* on shoot fresh and dry weights

Table 1 shows that the mean fresh weight of shoots of aphid-free varieties (control) ranged between 408.4–661.8 g at day 37 after infestation, depending on variety, but they did not differ significantly among each other. With progressive plant growth, all aphid-free varieties seem to decline in fresh weight. At day 66, var. Perkins dwarf had generated significantly greater fresh weight than other varieties, except for var. Clemson spineless, whereas var. Local had on average the lowest.

Aphid feeding had reduced shoot fresh weight by 11–17% up to day 37, but no significant differences were detected between the infested varieties (Table 1). On day 66, fresh weight had been reduced by 19%, 27% and 37% on var. Clemson spineless, Lee and Perkins dwarf, respectively. Unexpectedly, aphid-infestation had increased average fresh weight by 24% and 26% of var. Clemson spineless 80 and Local, respectively. However, infested varieties and their relevant controls did not show significant differences in all treatments, except for var. Perkins dwarf (Table 1).

The average shoot dry weight of aphid-free varieties seemed to follow the same trend as shoot fresh weight (Table 2). Varieties Lee and Local had a lower dry weight than var. Clemson spineless and Perkins dwarf on day 66. Aphid infestation had reduced shoot dry weight by 10–23%, depending

Table 2. Average shoot dry weight (g) of okra varieties 37 and 66 days after infestation with *Aphis gossypii*

Variety	Duration of infestation (days)					
	37			66		
	control	infested	rel. %	control	infested	rel. %
Clemson spineless 80	112.9^{a}	101.5	90	89.76^{ac}	114.0	127
Clemson spineless	137.5^{a}	106.4	77	122.6^{ab}	97.92	80
Perkins dwarf	112.2^{a}	91.99	82	145.6^{b}	86.59*	59
Lee	81.38^{a}	63.63	78	80.5^{c}	60.28	75
Local	132.1^{a}	101.3	77	74.75^{c}	80.80	108
LSD	74.94			38.91		

Means within column followed by the same letter(s) are not significantly different at $P \leq 0.05$
Numbers joined with (*) are not significantly different from the respective control at $P \leq 0.05$

Table 3. Mean leaf area (cm^2) of okra varieties 37 and 66 days after infestation with *Aphis gossypii*

Variety	Duration of infestation (days)					
	37			66		
	control	infested	rel. %	control	infested	rel. %
Clemson spineless 80	4026[a]	3211	80	2688[ac]	2700	101
Clemson spineless	4619[a]	4497	97	3298[ab]	2151*	65
Perkins dwarf	4190[a]	3457	82	3932[b]	2315*	59
Lee	2986[a]	2759	92	1897[c]	1420	75
Local	4178[a]	3250	78	2067[c]	1997	97
LSD	2591			972.6		

Means within column followed by the same letter(s) are not significantly different at $P \leq 0.05$
Numbers joined with (*) are not significantly different from the respective control at $P \leq 0.05$

on variety, at 37 days after artificial infestation, but without significant differences between treatments. After 66 days, a significant decrease in dry weight was only recorded between var. Perkins dwarf and its respective control (Table 2).

Influence of *A. gossypii* on leaf area

Analysis of data from the first sampling date at 37 days indicated that the leaf areas of aphid-infested and aphid-free plants of the varieties were almost equal, even though aphid-free var. Lee showed less leaf area (Table 3). It is obvious that infested var. Perkins dwarf, Local and Clemson spineless 80 varieties had a smaller leaf area than their particular controls, but they did not vary significantly among each other.

On day 66, aphid-free var. Lee and Local showed an obvious decrease in the sum of leaf area in comparison with var. Clemson spineless and Perkins dwarf. During this infestation period, aphid attack reduced significantly the leaf area of var. Clemson spineless and Perkins dwarf when compared to the controls (Table 3).

Effect of melon aphid on okra productivity

Aphid-free varieties differed considerably between each other in total pod weight (Table 4). The var. Clemson spineless and Clemson spineless 80 yielded significantly the highest amount of fresh pods, followed by var. Lee, Perkins dwarf and Local, in decreasing order. However, aphid infestation seriously impaired the productive potential of all

Table 4. Effect of *Aphis gossypii* on the productivity of five okra varieties under field conditions

Variety	Total yield (g/plant)			Pod number/plant		
	control	infested	rel. %	control	infested	rel. %
Clemson spineless 80	82.52[a]	62.72*	24	22.50[ab]	18.67*	17.0
Clemson spineless	82.40[a]	65.33*	20.7	24.28[a]	19.89*	18.0
Perkins dwarf	60.28[bc]	25.85*	57.1	17.89[cd]	7.44*	58.4
Lee	67.72[b]	29.65*	56.2	20.28[bc]	9.17*	45.2
Local	47.70[c]	45.51	4.6	16.22[d]	15.39	5.1
LSD	14.05			13.94		

Means within column followed by the same letter(s) are not significantly different at $P \leq 0.05$
Numbers joined with (*) are not significantly different from the respective control at $P \leq 0.05$

okra varieties, with the exception of var. Local. The reduction in productivity ranged between 5–56%, depending on variety (Table 4).

Furthermore, there were clear differences in the number of pods produced per plant between the aphid-free varieties of the controls (Table 4). Variety Clemson spineless had the significantly highest pod number, apart from var. Clemson spineless 80, while var. Local followed by var. Perkins dwarf had the lowest. When okra plants were infested by aphids, the mean number of pods produced on a one plant basis decreased noticeably, except for var. Local. In general, the number of pods decreased between 5% and 49%, depending on variety, with an enormous diminution on var. Lee and Perkins dwarf (Table 4).

DISCUSSION

The field experiment revealed that okra varieties differed from each other in vegetative growth and yield. Aphid-free plants of var. Clemson spineless and Clemson spineless 80 yielded the greatest total pod weight and pod number, while var. Local the lowest. The tested varieties emphasised differences in their vegetative growth just at later stages of plant development. In general, var. Perkins dwarf and Clemson spineless had the highest fresh and dry weights as well as leaf areas. This matches well with the findings of Lertrusdachakul *et al.* (1993), Suzuki *et al.* (2000) and Wanja *et al.* (2001) who had worked with an assortment of other okra cultivars. In contrast, an evaluation of several okra varieties by Shakeel *et al.* (1996) did not find noticeable differences in their productivity. These contrasting outcomes could be attributed to the diversity of the tested varieties, which could differ in genetic complements (Hopkins 1995), in addition to the environmental conditions prevailing throughout the experiment (Suzuki *et al.* 2000).

It has been reported for other crops that plants with high biomass and leaf area are able to produce the greatest yield (Silim & Saxena 1992), and that highly productive plants form the highest numbers of pods or seed (Pilbeam *et al.* 1992). This agrees to some extent with our findings. High yielding var. Clemson spineless had high pod numbers, plant weight and leaf area per plant. In contrast, var. Perkins dwarf produced plants with high weight and large leaf area, but it was low in productivity. Therefore, variations of yield between varieties could not generally be credited to the amount of dry matter produced by the plants, but they may be caused by differences in the creative potential of the plants, which probably depends on its genetic constituents (Hopkins 1995).

Aphid infestation impaired considerably the weight, leaf area and yield of okra plants with increasing infestation time. The damage levels were variable and depended on the variety. Variety Local was less vulnerable to aphid feeding, presumably due to its high compensatory growth (Dyer *et al.* 1993; Lowenberg 1994). Varieties Perkins dwarf and Lee suffered most from aphid damage, probably because aphids developed massive populations early on the still young plants where the ratio between assimilate removed by aphids to that produced by the plant is perhaps more advantageous for aphid growth (Prütter & Zebits 1991). Other tested okra varieties did not allow such exponential increase in aphid numbers at an early stage of plant growth and, therefore, they were able to endure the aphid infestation and compensate for its harm (Birch 1985). Results obtained by Roy (1990) and Jaydeb *et al.* (1999) also showed that several okra varieties other than tested in this study varied significantly among each other in their susceptibility towards *A. gossypii*.

Despite the surprising decline in the productivity of most okra varieties studied, we presume that okra plants can respond more drastically to aphid infestation, had the mean temperature not been as high as that prevailed during this experiment, when the average daily maximum exceeded 32°C over a long period. A basic life table constructed for *A. gossypii* on cucumber and cotton showed that the optimal temperature for population growth was 25°C, while temperatures above 30°C prolonged development, increased mortality of immature stages, shortened adult longevity and reduced fecundity (Kersting *et al.* 1999; Satar *et al.* 2005; Zamani *et al.* 2006). In a study conducted by Satar *et al.* (2005), the average reproductive rate of *A. gossypii* was 82.1 nymphs/female at 25°C but only 2.3 nymphs/female at 32.5°C; in addition, the highest per capita growth rate (r_m = 0.526) occurred at 25°C and the lowest at 32.5°C (r_m = 0.132). However, a constant temperature of 35°C was found to be lethal to the immature stages of *A. gossypii* (Kersting *et al.* 1999; Zamani *et al.* 2006). The high temperatures that prevailed during our study may thus have hurt aphid populations and delayed the development of high aphid populations at an early stage of plant growth (Kersting *et al.* 1999; Xia *et al.* 1999). Such high temperatures could also have been responsible for the drop in aphid densities noticed on all tested okra varieties on days 35 and 49 after artificial infestation. Similar to our results, Jaydeb *et al.* (1999) observed that the number of melon aphids hit a maximum at about the end of the okra growing season in India and, consequently, yield loss was low for some varieties. It is evident that high temperature reduces the plant's suitability for insect pests (Heinrichs 1988), presumably due to an increasing hormonal level in the plant, and thus enhancing defense mechanisms against insects (Kogan & Paxton 1983).

The aphid populations followed a similar trend on all okra varieties, but the magnitude of aphid abundances was different. This disagrees with the finding of Shakeel *et al.* (1996) who did not find significant differences in the number of *A. gossypii* on several okra varieties. Aphids were abundant on var. Lee at the beginning of growing season, but they later dropped to the lowest level in comparison with those on other varieties. This decrease could be attributed to the inherent small size (weight and leaf area) of this variety, which forces crowded aphid individuals to compete with each other for the limited food source or to feed on less nutritive plant parts, both ultimately resulting in a reduced reproductive rate (Kennedy & Stryan 1959; Wood *et al.* 1985).

In summary, this trial demonstrated significant differences in the yield components of okra varieties that were not infested by aphids. The varieties Perkins dwarf and Lee were most susceptible to aphid feeding with respect to vegetative growth and yield components. Variety Local was more tolerant among the varieties tested under such ecological conditions. Since the susceptibility of a host plant is probably influenced by age of host plant and climatic conditions, it may be worthwhile to look for aphid-induced growth changes in okra plants under field conditions by infestation of plants at different growth stages and under different environmental conditions.

References

Anonymous (2000): Statistic Yearbook. Department of Statistics, Amman, Jordan.

Avidov Z., Harpaz I. (1969): Plant Pests of Israel. Israel University Press, Jerusalem.

Birch N. (1985): Field evaluation of resistance in close relatives of faba bean, *Vicia faba*. Annals of Applied Biology, **106**: 561–569.

Blackman R.I., Eastop V.F. (1985): Aphids on the World's Crop: An Identification Guide. John Wiley and Sons. London.

Bohmfalk G.T., Frisbie R.E., Sterling W.L., Metzer R.B., Knutson A.E. (1987): Identification, biology, and sampling of cotton insects. Texas Agricultural Extension Service Publication B-933.

Chang G., Liu R., Hu M., Xue K., Xiao B., Jinag S. (1997): Comparison of the cotton aphid resistance level between Xinjiang and Shandong populations. Resistant Pest Management News Letter, **8**: 10–12.

Dyer M.I., Tuner C.L., Seastedt T.R. (1993): Herbivory and its consequences. Ecological Applications, **3**: 10–16.

Harris F.A., Andrews G.L., Caillaven D.F., Furr R.E. Jr. (1992): Cotton aphid effect on yield, quality, and economics of cotton. In: Proceedings Beltwide Cotton Production and Research Conferences. National Cotton Council of America, Memphis: 652–656.

Heinrichs E.A. (1988): Plant Stress–Insect Interactions. Wiley-Interscience Publication, John Wiley and Sons, New York: 139–160.

Herron G., Powis K., Rophail J. (2000): Baseline studies and preliminary resistance survey of Australian populations of cotton aphid, *Aphis gossypii* Glover (Homoptera: Aphididae). Australian Journal of Entomology, **39**: 33–38.

Hopkins W.G. (1995): Introduction to Plant Physiology. John Wiley and Sons, New York.

Jaydeb G., Ghosh S.K., Chatterjee H., Senapati S.K., Ghosh J. (1999): Pest constraints of okra under Terai region of West Bangal. Indian Journal of Entomology, **61**: 362–371.

Kersting U., Satar S., Uygun N. (1999): Effect of temperature on development rate and fecundity of apterous *Aphis gossypii* Glover (Hom., Aphididae) reared on *Gossypium hirsutum* L. Journal of Applied Entomology, **123**: 23–27.

Kennedy J.S., Stryan H.L.G. (1959): Biology of aphids. Annual Review of Entomology, **4**: 155–174.

Kogan, M., Paxton J. (1983): Natural inducers of plant resistance to insects. In: Hedin P.A. (ed.): Plant Resistance to Insects. ACS Symposium Series (USA), No. 208 American Chemical Society, Washington: 153–171

Lamont W.J. (1999): Okra – a versatile vegetable crop. HortTechnology, **9**: 179–184.

Leclant F., Deguine J.P. (1994): Aphids (Homoptera: Aphididae). In: Matthews G.A., Tunstall J.P. (eds):

Insect Pests of Cotton. CAB International, Wallingford: 285–323.

Lertrusdachakul B., Somboonprasert P., Jainim W. (1993): Varietal trial plot of okra in 1991. Project of research and agricultural extension varietal trial plot of okra in the central region 1990–1993: 19–39.

LONG B. (1995): Least toxic aphid management. Journal of Pesticide Reform, **14**: 38–39.

Lowenberg G.J. (1994): Effects of floral herbivory on maternal reproduction in *Sanicula arctopoides* (Apiaceae). Ecology, **75**: 359–369.

McKinlay R.G. (1992): Vegetable Crop Pests. Macmillan Press, London: 140–142.

Pilbeam B.J., Hebblethwaite P.D., Nyongesa T.E., Richetts H.E. (1992): Effect of plant population density on determinate and indeterminate forms of winter field beans (*Vicia faba* L.). 2. Growth and development. Journal of Agricultural Sciences, **116**: 385–393.

Prüter C., Zebits C.P.W. (1991): Effect of *Aphis fabae* and *Uromyces viciae-favae* on growth of susceptible and an aphid resistant cultivar of *Vicia faba*. Annals of Applied Biology, **119**: 215–226.

Roy D.K. (1990): Varietal trial of okra (*Abelmoschus esculentus*) to *Aphis gossypii* Glover population. Journal of Aphidology, **4**: 46–48.

Satar S., Kersting U., UYGUN N. (2005): Effect of temperature on development and fecundity of *Aphis gossypii* Glover (Homoptera: Aphididae) on cucumber. Journal of Pest Science, **78**: 133–137.

Shakeel M., Ahmad S., Zaman M., Karinmullah D. (1996): Infestation of aphids and jassids on different cultivars of okra at Mingora. Pakistan Entomological Society, Swat Pakistan.

Silim S.N., Saxena M.C. (1992): Comparative performance of some faba bean (*Vicia faba*) cultivars of contrasting plant types. 2. Growth and development in relation to yield. Journal of Agricultural Science, **118**: 333–342.

Slosser J.E., Pinchak W.E., Rummel D.R. (1989): A review of known and potential factors affecting the population dynamics of the cotton aphid. Southwestern Entomology, **14**: 302–312.

Suzuki S., Yoshiyasu Y., Mori S., Tsuchiya H. (2000): Comparison of the growth of *Hibiscus cannabinus* in an upland field and paddy field and the insect pests on plants in Kyoto. Scientific Reports of the Kyoto Prefectural University, Human Environment and Agriculture, **52**: 45– 53.

Van Edman H.F. (1978): Insects and secondary plant substances: an alternative viewpoint with special reference to aphids. In: Harborne J.B. (eds): Biochemical Aspects of Plant and Animal Coevolution. Academic Press, London and New York: 309–323.

Van Steenis M.J., El-Khawass K.A. (1995): Life history of *Aphis gossypii* on cucumber: influence of temperature, host plant and parasitism. Entomologia Experimentalis et Applicata, **76**: 121–131.

Wanja E.W., Hallett R.H., Sears M.K., Sithananatham S. (2001): Insect pest constraints of okra, *Abelmoschus esculentus* (L.) Moench (Malvaceae), in Kenya. In: ESA 2001 Annual Meeting – 2001: An Entomological Odyssey of ESA, San Diego.

Weathersbee A.A., Hardee D.D., Meredith W.R. (1994): Effects of cotton genotype on seasonal abundance of cotton aphid (Homoptera: Aphididae). Journal of Agricultural Entomology, **11**: 29–37.

Wood B.W., Tedders W.L., Thompson J.M. (1985): Feeding influence of three pecan aphid species on carbon exchange and phloem integrity of seedling pecan. Journal of American Society of Horticultural Sciences, **110**: 393–397.

Xia J.Y., van der Werf W., Rabbinge R. (1999): Influence of temperature on bionomics of cotton aphid, *Aphis gossypii*, on cotton. Entomologia Experimentalis et Applicata, **90**: 25–35.

Zamani A.A., Talebi A.A., Fathipour Y., Baniameri V. (2006): Effect of temperature on biology and population growth parameters of *Aphis gossypii* Glover (Hom., Aphididae) on greenhouse cucumber. Journal of Applied Entomology, **130**: 453–460.

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