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Demographic growth aspects of cowpea aphid *Aphis craccivora* (Hemiptera: Aphididae) on faba bean *Vicia faba* cultivars

Mohamed, A. A. Abdel-Rahman[1]; Enas, G. A. Elsayed[1] and Ahmed, M. A. Salman[2]

[1]*Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.*

[2]*Department of Plant Protection, Faculty of Agriculture, Sohage University.*

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Abstract:

The performance of cowpea aphid *Aphis craccivora* Koch. (Hemiptera: Aphididae), on the three faba bean *Vicia faba* L. (Fabales: Fabaceae) cultivars were evaluated. Development time, survival, and life table parameters were studied to measure the cowpea aphid performance. The time needed for the development of nymphal instars varied significantly with the cultivars. Duration of the nymphal stage lasted 8.71, 6.30 and 4.65 days when reared on the cultivars of Misr 3, Sakha 1 and Giza 843, respectively. Generation time (GT), reproductive potential (R_0), population doubling time (DT), intrinsic (r_m)) and finite rate (λ) of increase of the pest were also computed and discussed in relation to three cultivars.

Introduction

The cowpea aphid, *Aphis craccivora* Koch. (Hemiptera: Aphididae), is one of the most common and well-known insect pests throughout the world (Minks, A. K. and Harrewijn, 1987; Blackman and Eastop 2006 and Sadeghi *et al.*, 2009). Aphids are important piercing-sucking insects that during feeding cause significant loss of plant phloem saps, which is essential for plant growth (Dixon, 1998). Indirectly, cowpea aphid also disturbs the photosynthesis process by the presence of fungus on the leaves that is supported by the aphids honeydew secretion (Klingler *et al.*, 2001 and Smith and Boyko, 2007). Plant damage increases because of the aphids role as vectors of numerous plant viruses (Aldryhim and Khalil, 1993 and Smith and Boyko, 2007), such as faba bean necrotic yellow virus, and bean leaf roll virus (Weigand and Bishara, 1991).

Cowpea aphids as a pest of faba bean, *Vicia faba* L. (Fabales: Fabaceae), are increasingly more important because of their higher occurrence in the field and increased deleterious effects on plants (Weigand and Bishara, 1991). A short generation time and high fecundity of the aphid cause enormous reproductive potential during a growing season (Klingler *et al.*, 2001).

Many attempts have been made to control cowpea aphid, mostly by insecticides; however, the increasing awareness of environmental and human health hazards has led researchers to develop alternative control measures with integrated pest management (IPM) (Shannag and Ja'far, 2007; Joplin, 1974

and Schoonhoven *et al*.,1998) estimated that the use resistant plants have increased yields by 120 folds. Although partial resistance is usually possible, it is difficult to achieve complete resistance to a particular insect species. From the IPM point of view, this is an advantage because it poses weaker selection pressure on the insect population to overcome host plant resistance. Therefore, the use of plant resistance should be combined with other IPM tactics (Schoonhoven *et al*., 1998).

Resistant faba bean cultivars against aphids have been developed, such as *V. faba* Minor and *V. faba* landrace V51, which are tolerant and resistant to *Aphis fabae* and *A. craccivora*, respectively (Laamari *et al*., 2008 and Shannag and Ja'far, 2007). Because aphids can overcome resistance factors of selected cultivars, additional studies of resistant mechanisms of other faba bean cultivars are urgently needed.

In this experiment, we investigated possible resistance traits in some selected faba bean cultivars against cowpea aphid. We examined the developmental time, survival, index of efficacy and some life table parameters of *A. craccivora* reared of some faba bean cultivars.

Materials and methods

1. Plant rearing:

Three faba bean cultivars (Sakha 1, Giza 843 and Misr 3) were used for experiments. Faba bean seeds were obtained from the Ministry of Agriculture. Seeds were soaked in water for 48hrs and then germinated in a mixture of sand and peat moss (1:1) growth medium. After 1 week, To carry out the trials, seeds of three varieties of faba bean namely; Sakha 1, Giza 843 and Misr 3 were sown separately pots under laboratory conditions.

2. Aphid source:

Adults of *A. craccivora* were collected from faba bean, grown in the field. Colonies of the pest were maintained in an electrical incubator at 20±1ºC for about 10 generations.

3. Experiments:

To evaluate the effects of faba bean cultivars on biological characters and life table parameters. First instar nymphs were placed in separate Petri dish supplied with a leaf of faba bean varieties (Three varieties separately) lined with damp tissue paper. Petri dishes were placed in an incubator adjusted to 20±1ºC. Thirteen (30) nymphs were reared on each cultivar. Faba bean leaves were replaced if necessary. Nymphs are observed daily until; the appearance of adult (Aptera). Aptera was allowed to complete at the previously mentioned varieties. Aptera was inspected daily to observe and record the number of nymphs born daily.

Indices of efficiency (IE) for development of the different stages of *A. craccivora* were calculated according to the formula of Khattat and Stewart (1977):

Index of Efficiency (IE) = St/Tt, where

S, is the percentage survival, T is the time required for development in days.

Analysis of Varian's (F test) was used to compare the effect faba bean varieties on the duration of development and fecundity of the pest. Obtained results were used to calculate life table statistics. Namely:

- Net reproductive rate (R0),
- Generation time (GT),
- Population doubling time (DT),
- Intrinsic (r_m) and finite rate of increase (λ).

These parameters were calculated according to the procedures of (Birch, 1948).

Results and discussion

1. Developmental time:

The effect of three faba bean cultivars on the development should be presented in both nymphal and adult stages.

1.1. Nymphal stage:

The developmental period of the nymphal stage reared on the three varieties is presented in Table (1). A significant decrease in the duration of the three cultivars was observed. The duration of the four instars was respectively, 1.44, 1.84, 2.66 and 2.77 days; 1.35, 1.53, 1.77 and 1.65 days and third cultivar, 1.01, 1.21, 1.22 and 1.21 days on the cultivars of Misr 3, Sakha 1 and Giza 843, respectively. Nymphal duration varied significantly with three cultivars. The first nymphal duration, however, lasted for 8.71, 6.30 and 4.65 days on Misr3, Sakha 1 and Giza 843, respectively. Statistical analysis showed that the longest for nymphal development on three cultivars was recorded on Misr 3 while the shortest period was noticed on the cultivar of Giza 843. On the other hand, the time needed for the development decreased development time by about 1.24 and 1.78 times. The cultivar Giza 843 had the lowest nymphal duration (4.65 days) followed by Sakha 1., Misr 3 had the highest.

Data presented in Table (2) indicate that survival of nymphal instars and whole nymphal stage reared on three cultivars. The highest percentage of survival was observed at cultivar of Misr 3 and Sakha 1, respectively, whereas, the lowest (24%) was noticed on the cultivar of Giza 843 (Tables 2 and 3).

Using an Index of Efficiency for development of nymphal instars (Table 4), data indicate that the index values varied from cultivars. The highest index value was obtained for the cultivar of Misr 3 followed by Sakha 1. The cultivar Giza 843 had the highest Index (17.20). Based on the obtained data, it may be concluded that cultivars of Giza 843 and Sakha 1 were the most suitable for the development of the pest.

Table (1): Developmental time (In days ± SD) of *Aphis craccivora* reared on three varieties of faba bean at temperature of 20±1ºC.

Varieties	Developmental time (days ± SD)				
	1st	2nd	3rd	4th	Total
Misr 3	1.44±0.51a	1.84±0.67a	2.66± 0.74a	2.77± 0.69a	8.71±2.41a
Sakha 1	1.35±0.31b	1.53±0.39b	1.77±0.38b	1.65±0.59b	6.30±1.87b
Giza 843	1.01±0.41c	1.21±0.00c	1.22± 0.32c	1.21±0.11c	4.65±0.84c

Means followed by the same letter vertically, are not significantly different >0.05.

Table (2): Cumulative survival (Numbers) of *Aphis craccivora* reared on different varieties of faba bean at temperature of 20±1ºC.

Varieties		Cumulative survival (numbers)				
		1st	2nd	3rd	4th	Total
Giza 843	Number	30	29	28	27	30
	Alive	(29)	(28)	(27)	(26)	(26)
Sakha 1	Number	30	28	27	26	30
	Alive	(28)	(27)	(26)	(25)	(25)
Misr 3	Number	30	27	26	25	30
	Alive	(27)	(26)	(25)	(24)	(24)

Table (3): Survival (%) of *Aphis craccivora* reared on different varieties of faba bean at temperature of 20±1ºC.

Varieties	Survival (%)				
	1st	2nd	3rd	4th	Total
Giza 843	96.67	96.55	96.43	96.29	86.67
Sakha 1	93.33	96.43	96.29	96.15	83.33
Misr 3	90.00	96.29	96.15	96.00	80.00

Table (4): Index of Efficiency (IE) of *Aphis craccivora* reared on different varieties of faba bean at temperature of 20±1ºC.

Varieties	Index of Efficiency (IE)				
	1st	2nd	3rd	4th	Total
Misr 3	67.13	52.47	36.25	34.76	9.95
Sakha 1	69.13	63.02	54.40	58.27	13.22
Giza 843	89.11	79.57	78.81	79.33	17.20

1.2. Adult stage:

Data presented in Table (5) show the average length of life of the adult at the three cultivars. Adult longevity was divided into pre-reproductive, reproductive and post-reproductive periods. The results indicate that reproductive periods varied from cultivar to another. Adult apterous cowpea aphid numbers in Giza 843 were significantly higher than on Misr 3 and Sakha 1 (Table 5).

In the detached-leaf biological assay, the cultivar Giza 843 had a longer pre-reproductive, reproductive, post-reproductive, and total longevity period as compared with Misr 3 and Sakha 1, whereas the number of progenies was lower as compared with Misr 3 and Sakha 1. Generally, cowpea aphid 8performance on whole plants was different as compared with the detached leaf assay.

Demographic parameters study (Table 6) showed that cultivar Misr 3 had a significantly lower net reproduction rate (R_0) compared with Giza 843; other parameters had no clear relationship with the lesser suitability character of Sakha1 compared with Misr3.

On the detached leaf, all the demographic parameters supported that Giza 843 was less suitable for the aphid compared with Misr3, indicated by the significantly lower net reproduction rate (R_0), intrinsic rate of increase (r_m), and finite rate of increase (λ), and longer generation time (GT) and doubling time (DT). Similar to biological parameters (Table 3), cowpea aphid demographic performance on the whole plant and detached leaf was different (Table 4). Results show that Misr3, either on the detached leaf or whole plant, seems preferable to the aphid compared with Giza 843, indicated by a higher fecundity rate on Misr3.

The colony development study was conducted initially to obtain general information about the potential resistant characters that might be present among three faba bean cultivars. Studies showed that the tested cultivars differed in their suitability for the cowpea aphid development. All the parameters in colony development assay indicated that the order of cultivar resistance from the highest to the lowest was Giza 843, Sakha 1 and Misr 3.

Results obtained from the colony development assays probably reflect a similar phenomenon in the field because aphids could move freely and to feed on any part of the plant (Alvarez *et al*., 2006). Factors such as leaf surface, leaf size, or leaf color supposedly affects the results of colony development assays (Bernays and Chapman, 1994). Some differences in host plant quality among cultivars due to genetic variation or environmental factors also can determine cowpea aphid performance (Islam and Shunxiang, 2007).

It also was shown that adult numbers in Giza 843 were not significantly different as compared with Misr3 and Sakha 1, which could indicate the unsuitability of Giza 843 as host plant This may reflect that the cultivar Giza 843 exhibited higher resistance compared with Sakha 1 and Misr3. However, other parameters did not give a clear relationship to support

this conclusion. Longer total longevity and fewer progeny are essential parameters indicating the suitability of a host plant, especially for sucking insects (Awmack and Leather, 2002 and Bernardi *et al.*, 2012).

Most of the biological parameters evaluated in the detached-leaf assay showed that the cultivar Giza 843 was less suitable for cowpea aphid development compared with Misr 3 and Sakha 1, indicated by longer pre-reproductive, reproductive, post-reproductive, and total longevity periods, and fewer aphid progeny. Bernardi *et al.* (2012) reached a similar conclusion on the resistant strawberry cv. Aromas infested by green aphid *Chaetosiphon fragaefolii* (Cockerell).

Using the detached-leaf method for the biological assay is recommended by some researchers because of its efficiency (Sharma *et al*., 2005; Smith, 2005 and Michel *et al.*, 2010). We noted that the detached-leaf assay was easier to handle and provided more accurate information because all the environmental parameters were controlled. When comparing whole-plant and detached leaf methods in the biological study, results varied among cultivars for all parameters, but the progeny number parameter was significantly higher in the detached-leaf assay.

This result gave a precaution in using detached leaves in resistant screening assays for faba beans, probably because of the difference in tissue properties. However, these studies might be useful for determining the persistency of resistant characters, as shown in Michel *et al*. (2010) soybean cultivar study against soybean aphid, *Aphis glycines* (Matsumura), which concluded that the resistant character was retained in detached leaves in PI 243540' but it was lost in PI 567301B.

The net reproduction rate of whole plant faba bean cultivar Misr3 was significantly higher than Giza 843 (Table 6). If the net reproduction rate value is used as the only parameter, it can be concluded that Giza 843 was less suitable for the aphids than Misr 3 and Sakha 1. The net reproduction rate value is important in representing the host plant quality and the capacity of a female producing the progeny (Bernardi *et al.*, 2012).

It was important to note that cowpea aphid fecundity in faba bean cv. Misr3 remained high at the end of their reproductive period. This fact deviated from the general assumption that the progeny is supposed to peak at the beginning of the reproductive period (Wyatt and White, 1977).

These phenomena result in the higher value of generation time and decrease the intrinsic rate of increase value of Misr3 compared with Giza 843. The demographic parameters study gave reliable results and supported the suggested less suitability of cultivar Giza 843 compared with Misr 3 and Sakha 1, indicated by significantly lower net reproduction rate, intrinsic rate of increase, and the finite rate of increase, but longer generation time and doubling time, compared with Misr 3.

Table (5): Longevity and number of progenies of *Aphis craccivora* reared on three varieties of faba bean at temperature of 20±1ººC.

Varieties	Longevity and number of progeny / ♀				
	Longevity (in days)				Number progeny / ♀
	Pre-	Reproductive	Post-	Longevity	
Giza 843	1.22±0.47a	21.15±3.24a	7.45±3.22a	29.82±6.93	55.71±9.55a
Sakha 1	1.79±0.79b	17.77±1.56b	3.77±1.66b	23.33±4.01	38.60±8.48b
Misr 3	1.17±0.22c	13.41±2.41c	2.75±2.01c	17.33±4.64	19.66±14.91c
Total	4.18±1.48	52.33±7.72	13.97±6.89	70.48±15.58	113.97±29.68
	1.39±0.49	17.44±2.40	4.65±2.29	23.49±5.19	37.99±9.89

Means followed by the same letter vertically, are not significantly different >0.05.

Table (6): Some life table aspects of *Aphis craccivora* on reared on three varieties of faba bean at temperature of 20±1°°C.

Aspects	Faba bean varieties		
	Giza 843	**Sakha 1**	**Misr 3**
Generation time (GT)	16.46	15.34	12.81
Doubling time (DT)	4.06	3.59	3.05
Net reproductive rate (R_o)	22.64	33.68	15.85
Intrinsic rate of increase (r_m)	0.22659	0.2667	0.2294
Finite rate of increase (λ)	1.2543	1.3056	1.2578

Finally, those demographic results are important to justify resistant characters of certain cultivars, such as in strawberry cv. Aroma against green aphid (Bernardi *et al*., 2012). In addition, demographic parameters can be used to measure the suitability of a host plant for certain insects, such as in some tomato cultivars against *Bemisia tabaci* (Gennadius) (Islam and Shunxiang, 2007), the suitability of chickpea pods for *Helicoverpa armigera* (Hubner) (Dabhi and Patel, 2007), the suitability of different host plants for glassy-winged sharpshooter, *Homalodisca vitripennis* (Germar) (Chen *et al.,* 2010). Overall, these results suggested that the use of faba bean cultivar Giza 843 should decrease the cowpea aphid population. The colony development study ranked the resistance level among cultivars as Giza 843>Sakha 1 and Misr 3.

References

Aldryhim, Y. and Khalil, A. (1993): Influence of temperature and daylength on population development of *Aphis gossypii* on *Cucurbita pepo*. Entomol. Exp. Appl., 67: 167-172.

Alvarez, A.; Tjallingll, W. F.; Garzo, E.; Vleeshouwers, V.; Dicke, M. and Vosman, B. (2006): Location of resistance factors in the leaves of potato and wild tuber bearing *Solanum species* to the aphid *Myzus persicae.* Entomol. Exp. Appl., 121: 145-157.

Awmack, C. S. and Leather, S. R. (2002): Host plant quality and fecundity in herbivorous insects. Annu. Rev. Entomol., 47: 817-844.

Bernardi, D.; Garcia. M. S. ; Botton, M. and Nava, D. E. (2012): Biology and fertility life table of the green aphid *Chaetosiphon fragaefolli* on strawberry cultivars. J. Insect sci. 12:28. Available on line: www. Insect science. Org/ 12:28.

Bernays, E. A. and Chapman, R. F. (1994): Host-plant selection by phytophagous insects. Chapman and Hall.

Birch, L.L. C. (1948): The intrinsic rate of natural increase of an insect population. J. Anim. Ecol., 17 (1): 15-26.

Blackman, R. L. and Eastop, V. F. (2006): Aphids on the worlds herbaceous plants and shrubs. Volume 1: host lists and keys. Volume 2: The aphids. John Wiley, Sons.

Chen, W.; Leopold, R. A. and Boetel, M. A. (2010): Hostplant effects on development and reproduction of the glassy-winged sharpshooter, *Homolodisca Vitripennis* (Homoptera: Cicadellidae). Environ. Entomol., 39: 1545-1553.

Dabhi, M. and Patel, C. (2007): Life expectancy of *Helicoverpa armigera* on Chickpea. J. Sat Agric. Res., 5: 1-2.

Dixon, A. F. G. (1998): Aphid ecology: an optimization approach. Chapman and Hall.

Islam, M. T. and Shunxiang, R. (2007): Development and reproduction of *Bemisia tabaci* on three tomato varieties. J. Entomol., 4: 231-236.

Joplin, C. (1974): Pulse crops of the world and their important insect pests. Master Thesis, Department of Biological Science, Simon Fraser University, Burnaby, Canada.

Khattat, A. R. and Stewart, R. K. (1977): Development and survival of *Lygus lineolaris* exposed to different laboratory rearing conditions. Ann. Entomol.Soc . Amer., 70: 274-278.

Klingler, J.; Kovalski, I.; Silberstein, L.; Thompson, G. and Perl-Treves, R. (2001): Mapping of cotton-melon aphid resistance in melon. J. Am. Soc. Hortic. Sci., 126: 56-63.

Laamari, M.; Khelfa, L. ; Coeur d. and Acier, A. (2008): Resistance source to cowpea aphid (*Aphis craccivora* Koch) in broad bean (*Vicia faba* L.*)* Algerian landrace collection. Afr. J. Biotechnol., 7: 2486-2490.

Michel, A. P.; Mian, M. A. R.; Davila-olivas, N. H. and Canas, L. A. (2010): Detached leaf and whole plant assays for soybean aphid resistance: differential responses among resistance sources and biotypes. J. Econ. Entomol., 103 : 949-957.

Minks, A. K. and Harrewijn, P. (1987): Aphids. Their biology, natural enemies and control, Vol. 2A. Elsevier.

Sadeghi, A.; Van Damme, E. J. M. and Smagghe, G. (2009): Evaluation of the susceptibility of the pea aphid, *Acyrthosiphon pisum*, to a seslection of novel biorational insecticides using an artificial diet. J. Insect Sci. 9: 65. Available online: www.insecscience.org/9.65.

Schoonhoven, L. M.; Jermy, T. and Van Loon, J. J. A. (1998): Insect-plant biology: From physiology to evolution. Chapman and Hall.

Shannag, H. and Ja'far A. (2007): Biometry and responses of faba bean varieties to black bean aphid, *Aphis fabae Scopoli*. Am-Eurasia. J. Agric. Environ. Sci., 2: 328-334.

Sharma, H. C.; Pampapathy, G.; Dhillon, M. K. and Ridsdill-Smith, J. T. (2005): Detached leaf assay to screen for host plant resistance to *Helicoverpa armigera.* J. Econ. Entomol., 98: 568-576.

Smith, C. M. (2005): Plant resistance to arthropods: molecular and conventional approaches. Springer.

Smith, C. and Boyko, E. (2007): The molecular bases of plant resistance and defense responses to aphid feeding current status. Entomol. Exp. Appl. 122: 1-16.

Weigand, S. and Bishara, S. I. (1991): Status of insect pests of faba bean in the Mediterznean region and methods of control. In Cubero J.I., Saxena M.C. (edz.). Present status and future prospects of faba bean production and improvement in the Mediterranean countries.

Wyatt, I. J. and White, P. (1977): Simple estimation of intrinsic increase rates for aphids and tetranychid mites. J. Appl. Ecol. 14: 757-766.