BioOne COMPLETE

Biology and Demographic Growth Parameters of Cowpea Aphid (Aphis craccivora) on Faba Bean (Vicia faba) Cultivars

Authors: Soffan, A., and Aldawood, A. S.

Source: Journal of Insect Science, 14(120) : 1-10

Published By: Entomological Society of America

URL: https://doi.org/10.1673/031.014.120

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Downloaded From: https://bioone.org/journals/Journal-of-Insect-Science on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Journal of Insect Science
www.insectscience.org

Biology and demographic growth parameters of cowpea aphid (*Aphis craccivora*) on faba bean (*Vicia faba*) cultivars

A. Soffan[a]* and A. S. Aldawood[b]

Plant Protection Department, College of Agriculture and Food Sciences, King Saud University. Riyadh, Kingdom of Saudi Arabia

Abstract

The performance of cowpea aphid, *Aphis craccivora* Koch. (Hemiptera: Aphididae), on five faba bean, *Vicia faba* L. (Fabales: Fabaceae) cultivars was evaluated. Colony development, biology, and demographic parameters were studied to measure the cowpea aphid performance. Two methods, whole plant and detached leaf, were used in these experiments. After 14 d , the number of apterous adult, nymphs, and total cowpea aphids were significantly lower in cultivar Gazira2 and highest on cultivar Misr1. Assuming that low aphid numbers per plant represented high resistance, the order of resistant cultivars was as follows: Gazira2 > Misr > Giza3 Improved > Goff1 > Misr1. Aphid infestation significantly inhibited plant growth compared with uninfested plants, as indicated by factorial analysis using plant height (F = 41.38, P < 0.0001). The detached-leaf biological assay showed that the cultivar Gazira2 was less suitable than Misr1 because it had longer prereproductive, reproductive, and post reproductive periods, longer total longevity, and lower number of progeny. Similarly, demographic parameters also justified the suggested lower suitability of Gazira2 compared with Misr1, indicated by significantly lower net reproduction rate, intrinsic rate of increase, finite rate of increase, but longer generation time and doubling time on Gazira2. It was shown that cowpea aphid performed differently on the whole plant as compared with detached leaves. The detached-leaf biological assay is recommended for future experiments because it is more accurate and efficient and it produces reliable data.

Keywords: resistance, whole plant, detached leaf, intrinsic rate of increase, Gazira2
Correspondence: [a] alsoffan@ksu.edu.sa, [b] aldawood@ksu.edu.sa, *Corresponding author
Editor: Xinzhi Ni was editor of this paper.
Received: 9 October 2012 **Accepted:** 21 March 2013 **Published:** 1 September 2014
Copyright: This is an open access paper. We use the Creative Commons Attribution 3.0 license that permits unrestricted use, provided that the paper is properly attributed.
ISSN: 1536-2442 | Vol. 14, Number 120

Cite this paper as:
Soffan A, Aldawood AS. 2014. Biology and demographic growth parameters of cowpea aphid (*Aphis craccivora*) on faba bean (*Vicia faba*) cultivars. *Journal of Insect Science* 14(120). Available online: http://www.insectscience.org/14.120

Downloaded From: https://bioone.org/journals/Journal-of-Insect-Science on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Introduction

The cowpea aphid, *Aphis craccivora* Koch. (Hemiptera: Aphididae), is one of the most common and well-known insect pests throughout the world (Minks and Harrewijn 1987, Blackman and Eastop 2006, Sadeghi et al. 2009). Aphids are important piercing–sucking insects that during feeding cause significant loss of a plant's phloem sap, 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, Smith and Boyko 2007). Plant damage increases because of the aphids' role as vectors for numerous plant viruses (Aldryhim and Khalil 1993, Smith and Boyko 2007), such as faba bean necrotic yellow virus , broad bean yellow mosaic virus, and bean leaf roll virus (Weigand and Bishara 1991).

In the Kingdom of Saudi Arabia, cowpea aphids were first reported in 1989 (Aldryhim and Khalil 1996). They were reported to be abundant during February feeding on at least 29 host plants, most frequently species of Fabaceae (Aldryhim and Khalil 1993, 1996). The apterous or alate adult females of the cowpea aphid are readily identified (Aldryhim and Khalil 1996; Stoetzel et al. 1996).

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). An infestation rate of 71% in the field was reported in Morocco (Diekmann 1982 *in* Weigand and Bishara 1991, pp. 68). Infestations of black bean aphids, *Aphis fabae* Scopoli, stunted the growth of most faba bean cultivars, such as *V. faba* Major and Aquadulce, which led to a decrease in shoot fresh, dry weight, leaf area, and plant height. Infestation during the early stages of plant growth may kill the plant (Shannag and Ja'far 2007).

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 of resistant plants has increased yields by 120 fold. Although partial resistance is usually possible, it is difficult to achieve a 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 *A. fabae* and *A. craccivora*, respectively (Laamari et al. 2008, 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 colony development and biological–demographic parameters with two methods, whole plant and detached leaf.

Downloaded From: https://bioone.org/journals/Journal-of-Insect-Science on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Materials and Methods

This study was conducted at the Economic Entomology Research Unit Laboratory, Plant Protection Department, College of Food and Agriculture Sciences, King Saud University, Riyadh, Kingdom of Saudi Arabia. All experiments were conducted in a growth chamber maintained at 26 ± 0.1°C, 44 ± 0.1 % RH (means ± SE) with a photoperiod of 16:8 L:D h (recorded by HOBO data loggers; ONSET Co., Bourne, MA).

Plant material

Five faba bean cultivars (Misr1, Misr, Giza3 Improved, Goff1, and Gazira2) were used for the experiments. Faba bean seeds were obtained from the Legume Research Unit (LRU) Plant Production Department, College of Food and Agriculture Science, King Saud University. Seeds were soaked in water for 48 h and then germinated in a mixture of sand and peat moss (1:1) growth medium. After 1 wk, seedlings were transplanted to plastic pots (11 cm diam14 cm tall). Four granules per pot of complete fertilizer (nitrogen:12%, phosphorus:12%, potassium 17%; BASF-Asoco Agro, Limburgerhof, Germany) was applied in the growth medium once at seedling stage (19 d). The pots were drenched with 150 mL water once every 2 d.

Cowpea aphids

Experimental cowpea aphids were obtained from a colony that was collected from alfalfa plants grown in Al Amaria, Riyadh (46°31'5.5518"N and 24° 48'40.179"E). Cowpea aphid voucher specimen was deposited in King Saud Museum of Arthropods (KSMA), King Saud University. A single mother of apterous adult aphid was used to initiate cowpea aphid culture on the faba bean cv. Misr. Prior to the experiment, the cowpea aphid culture had been running for 8 mo. New faba bean seedlings were provided continuously to replace old ones for the maintenance and continuous growth of aphid cultures.

Aphid colony-development test

Two-wk-old, 6–8 cm plants were used for experimentation. Plants were acclimatized in 600 mL plastic pots. Apterous nymphs of *A. craccivora* of the same age were obtained from the aphid culture synchronization by rearing them on detached leaves of faba bean cultivars Misr. Ten 3–5-d-old nymphs were introduced on each plant and covered with clear plastic PVC tubes (30 cm high by 10 cm diam) and ventilated using muslin cloth (15 × 5 cm). The plastic tube allowed aphids to move freely to sections of the plant for feeding, while preventing escape. Uninfested plants were provided to all of the above but without aphid infestation. Ten plants were used for infested and uninfested plants. The experiments were terminated 14 d after infestation by cutting the plant from the base. Plant height and aphid numbers consisting of adults (alatae and apterae) and nymphs (alatae and apterae) were counted as parameters. Aphids were collected from the plants and preserved in 75% ethanol until the counting was ready.

Aphid biological study

Whole plants and detached leaves were distinguished in the biological study for all cultivars. The whole-plant study was conducted by using a modified clip cage (6 × 3 cm) to cover the selected leaf completely; the aphids were observed and allowed to move freely in entire leaf area.

A 4 × 2 cm muslin cloth mesh on the clip cage provided air circulation. Bamboo or metal sticks supported the clip cage on the plant. In the detached-leaf study, aphids were provided with a cut leaf. The leaf was kept fresh by capping the leaf base with moist cotton. A

Downloaded From: https://bioone.org/journals/Journal-of-Insect-Science on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

clear plastic elliptical container (215 mL) with 20 cm^2 muslin cloth for aeration was used in the detached-leaf study.

Whole-plant and detached-leaf studies were initiated by introducing a single apterous adult mother onto a single leaf of the three-leaf stage of faba bean plant. After 4–6 h, all aphids were removed with a camel hair brush (0 size), except for one newly born aphid. Nymphal developmental periods (prereproductive period, reproductive period, postreproductive period, and total longevity periods) were measured daily, and the total number of progeny was counted.

Table 1. Cowpea aphid, *Aphis craccivora*, colony-development test for 14 d on five *Vicia faba* cultivars (means ± SE).[1,2]

Parameters	No. Aphids				
	Gazira2	Misr	Giza3 Imp.	Goff1	Misr1
Nymph alatae	0.0 ± 0.0a	2.6 ± 2.4a	0.8 ± 0.8a	12.1 ± 6.7a	7.8 ± 4.4a
Nymph apterous	390.8 ± 75.9c	1034.7 ± 196.2b	1079.8 ± 211.6b	1637.5 ± 176.1a	1867.9 ± 215.3a
Adult alatae	0.7 ± 0.3ab	0.6 ± 0.3ab	0.4 ± 0.2b	3.1 ± 1.6a	1.9 ± 0.5ab
Adult apterous	44.8 ± 4.2b	108.3 ± 15.8a	107.8 ± 18.2a	144.2 ± 23.1a	127.6 ± 10.2a
Total	436.3 ± 78.8c	1146.1 ± 205.2b	1188.8 ± 218.5b	1797 ± 195.4a	2005.1 ± 223.4a

[1]Means followed by the same letter in the same row are not significantly different at LSD, α = 0.05.
[2]Parametric one-way ANOVA was performed for the above analysis.

Table 2. Plant height (cm) from the *Aphis craccivora* colony-development test on five *Vicia faba* cultivars (Means ± SE).[1,2,3]

Plant status	Plant height (cm)				
	Gazira2	Misr	Giza3 Imp.	Goff1	Misr1
Infested plant	19.4 ± 0.9b	18.6 ± 1.6b	21.6 ± 1.9ab	25.9 ± 1.9a	17.2 ± 1.4b
Uninfested plant	23 ± 3.9b	29 ± 2.2ab	30.5 ± 1.3a	29.8 ± 2.3ab	28.2 ± 1.3ab
P-value	0.35 *ns*	0.001*	0.009*	0.19 *ns*	0.0002*

[1]Means followed by the same letter in the same row are not significantly different at LSD, α = 0.05
[2]Means in the same column for each cultivar comparing infested and uninfested plant accompanied with *P*-value, asterisk (*) for significant difference, *ns* is nonsignificant at LSD, α = 0.05.
[3]Parametric one-way ANOVA was performed for the above analysis.

Experimental design and data analysis

All experiments were arranged in a complete randomized design (CRD). Ten replicates of each faba bean cultivar were used. All the data were analyzed using SAS program ver. 9.2 (2008, SAS Institute, Cary, NC). Normality distribution was tested using PROC UNIVARIATE with Shapiro-Wilk method before ANOVA analysis. Parametric one-way ANOVA test was performed for colony development study (Tables 1 and 2.) with PROC GLM, followed by multiple comparison using Least Significant Difference (LSD) test (α: 0.05). In the biological study and demographic study (Tables 3 and 4), nonparametric one-way ANOVA Kruskal-wallis was performed using PROC NPAR1WAY, because the study did not meet normal distribution conditions. Demographic parameters were calculated following Birch (1948). Proportion of individuals alive at age x (lx) and number of females progeny produced per female during age interval x (mx) were determined from daily data observation. The following demographic parameter then was calculated: (1) intrinsic rate of increase (rm) rm = (lnRo)/T; (2) net reproduction rate (Ro), Ro = Σ lxmx; (3) mean generation time (Tc), Tc = Σ(lxmx)x/Σ(lxmx); (4) finite rate of increase, λ = exp(rm); and (5) doubling time, Td = ln(2)/rm. The jackknife technique was used to estimate mean demographic parameters of lxmx of the life table and the standard errors (SE). Jackknife analysis removes one observation at a time from the original data set and recalculates the statistic of interest from the truncated data set. This method can estimate Ro, Tc, rm, λ, and Td, with their respective jackknife variances and confidence intervals (Myers et al. 2005, Chen et al. 2010).

Results

The numbers of aphids after 14 d of the colony development test varied among five faba bean cultivars (Table 1). Assuming that lower aphid numbers reflect higher level of resistance, the order of resistance levels were

Downloaded From: https://bioone.org/journals/Journal-of-Insect-Science on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Table 3. Biological study of apterous viviparous female of cowpea aphid, *Aphis craccivora*, on whole plants and detached leaves of five *Vicia faba* cultivars (means ± SE).[1,2,3]

Biological parameters	Method	Cultivars				
		Gazira2	Misr	Giza3 Imp.	Goff1	Misr1
Prereproductive period (d)	WP	6.17 ± 0.48a	7 ± 0.58a	6.6 ± 0.24a	6.6 ± 0.24a	6.83 ± 0.48a
	DL	5.7 ± 0.26ab	5.4 ± 0.24b	7 ± 0.65a	6.83 ± 0.48a	5.11 ± 0.26b
	P	0.4189 ns	0.0362*	0.9399 ns	0.5607 ns	0.0040*
Reproductive period (d)	WP	17.5 ± 1.75a	14.25 ± 1.03ab	15 ± 1.41ab	12.4 ± 1.94b	17.83 ± 1.25a
	DL	15.1 ± 1.29bc	21 ± 2.3a	16.38 ± 1.41abc	19.33 ± 1.89ab	14 ± 0.85c
	P	0.2967 ns	0.0851 ns	0.4188 ns	0.0353*	0.0244*
Postreproductive period (d)	WP	6.33 ± 2.25a	6.5 ± 1.85a	6.6 ± 2.23a	3 ± 0.55a	4.5 ± 1.2a
	DL	8.2 ± 1.33a	7.2 ± 1.39a	6.88 ± 1.09a	6.5 ± 1.26a	6.44 ± 1.19a
	P	0.2767 ns	0.6213 ns	0.4567 ns	0.0213*	0.3380 ns
Total longevity (days)	WP	29 ± 0.68a	26.75 ± 1.89a	27.2 ± 1.71a	21 ± 1.97b	27.17 ± 0.7a
	DL	28.1 ± 1.44ab	32.8 ± 2.5a	28.75 ± 1.25a	31.67 ± 1.41a	24.11 ± 1.12b
	P	0.7842 ns	0.1069 ns	0.556 ns	0.0058*	0.0473*
Progeny number produced per female	WP	37.33 ± 4.67a	38.5 ± 4.41a	34.4 ± 2.2a	31.4 ± 6.73a	45.17 ± 7.02a
	DL	58.1 ± 4.39ab	65.2 ± 6.41ab	41.75 ± 7.38b	64.67 ± 5.67a	60.56 ± 5.35ab
	P	0.0107*	0.0139*	0.4642 ns	0.0176*	0.1750 ns

[1]WP:Whole plant; DL: Detached leaves; *P*: *P*-value.
[2]Means followed by the same letter in the same row are not significantly different at LSD, α = 0.05.
[3]Means in the same column for each parameter comparing whole plant (WP) and detached leaf (DL) accompanied with *P*-value, asterisk (*) for significant difference, *ns* is non-significant at LSD, α = 0.05.
[4]Non-parametric one-way ANOVA Kruskal Wallis was performed for the above analysis.

Table 4. Demographic parameters for cowpea aphid, *Aphis craccivora*, on five *Vicia faba* cultivars (means ± SE).[1,2,3,4]

Demographic parameter	Method	Cultivars				
		Gazira2	Misr	Giza3 Imp.	Goff1	Misr1
Net reproduction rate (Ro)	WP	37.33 ± 0.26c	38.5 ± 0.33b	35.4 ± 0.25d	31.4 ± 0.33e	45.17 ± 0.25a
	DL	56.44 ± 0.35d	67.6 ± 0.64a	41.75 ± 0.3e	64.67 ± 0.34b	58.31 ± 0.51c
	P	<0.0001*	<0.0001*	<0.0001*	<0.0001*	<0.0001*
Generation time (T)	WP	11.49 ± 0.04d	12.8 ± 0.04b	12.78 ± 0.04b	12.66 ± 0.04c	13.97 ± 0.05a
	DL	11.45 ± 0.03d	14.2 ± 0.05b	12.04 ± 0.03c	14.44 ± 0.04a	10 ± 0.04e
	P	0.1092 ns	<0.0001*	<0.0001*	<0.0001*	<0.0001*
Intrinsic rate of increase (rm)	WP	0.31 ± 0.001a	0.29 ± 0.001b	0.28 ± 0.001c	0.27 ± 0.001d	0.27 ± 0.001d
	DL	0.35 ± 0.001b	0.3 ± 0.001d	0.31 ± 0.001c	0.29 ± 0.001e	0.41 ± 0.001a
	P	<0.0001*	<0.0001*	<0.0001*	<0.0001*	<0.0001*
Population Doubling time (Td)	WP	2.20 ± 0.01d	2.43 ± 0.01c	2.48 ± 0.01b	2.55 ± 0.01a	2.54 ± 0.01a
	DL	1.97 ± 0.01d	2.34 ± 0.01b	2.24 ± 0.01c	2.40 ± 0.01a	1.70 ± 0.01e
	P	<0.0001*	<0.0001*	<0.0001*	<0.0001*	<0.0001*
Finite rate of increase (l)	WP	1.37 ± 0.001a	1.33 ± 0.001b	1.32 ± 0.001c	1.31 ± 0.001d	1.31 ± 0.001d
	DL	1.42 ± 0.001b	1.35 ± 0.002d	1.36 ± 0.001c	1.33 ± 0.001e	1.50 ± 0.001a
	P	<0.0001*	<0.0001*	<0.0001*	<0.0001*	<0.0001*

[1]WP: Whole plant; DL: Detached leaves; *P*: *P*-value.
[2]Means followed by the same letter in the same row are not significantly different at LSD, α = 0.05.
[3]Means in the same column for each parameter comparing whole plant (WP) and detached leaf (DL). *P*-value with asterisk (*) for significant difference, *ns* is non-significant at LSD, α = 0.05.
[4]Non-Parametric one-way ANOVA Kruskal Wallis was performed for the above analysis.

Gazira2 > Misr > Giza3 Improved > Goff1 > Misr1. The cultivar Gazira2 had the lowest total numbers of aphids, and Misr1 had the highest. Nymph and adult apterous cowpea aphid numbers on Gazira2 were significantly lower than on Misr1; however, adult alatae numbers on Gazira2 and Misr1 were not significantly different (Table 1).

Plant response to aphid infestation was evaluated by measuring the plant height (Table 2). Misr1 exhibited the highest susceptibility to aphid infestation among cultivars, indicated by the lowest height of the infested plants, and had significant difference compared with uninfested plants ($P < 0.01$). There were no significant differences between plant heights of infested and uninfested cultivars Gazira2 and Goff1. It is interesting to note that the cul-

Downloaded From: https://bioone.org/journals/Journal-of-Insect-Science on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

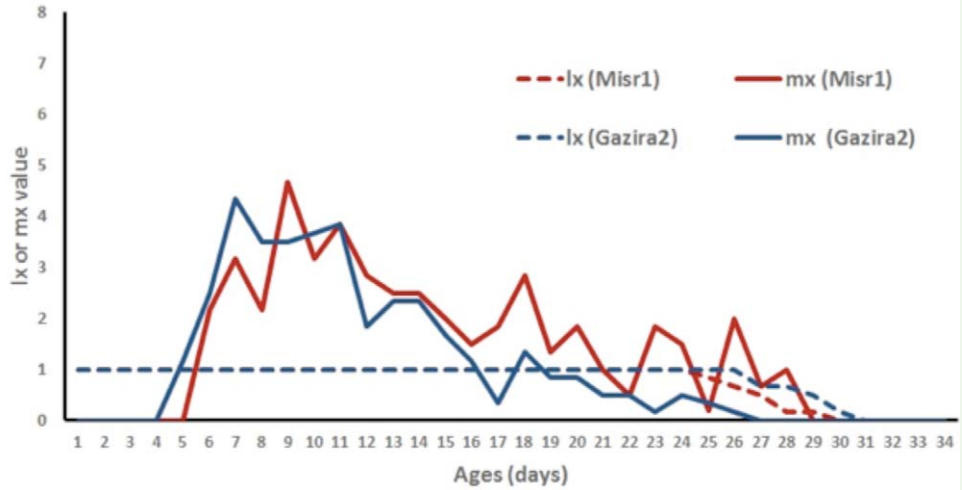


Figure 1. Survival (lx) and reproduction (mx) rate of cowpea aphid, *Aphis craccivora*, on whole plants of two cultivars of *Vicia faba*, Gazira2 and Misr1.

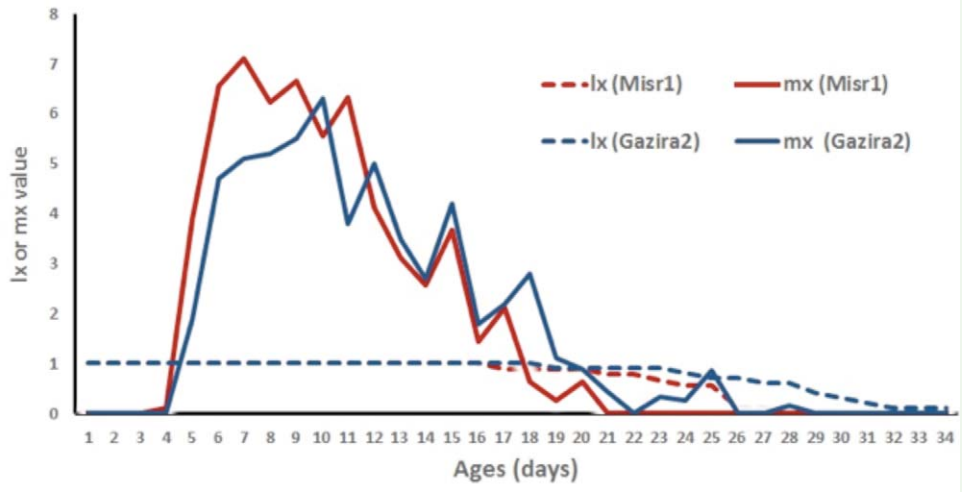


Figure 2. Survival (lx) and reproduction (mx) rate of cowpea aphid, *Aphis craccivora*, on detached leaves of two cultivars of *Vicia faba*, Gazira2 and Misr1.

tivar Goff1 supported relatively high numbers of aphid (Table 1), but the plant height was not significantly different, which indicates the possible occurrence of tolerance (Table 2).

Factorial analysis indicated that uninfested plant height as main effect had significantly higher value compared with infested plants ($F = 41.38$, $P < 0.01$). The effect of cultivar, regardless of the infestation status, showed sig-significant difference ($F = 3.28$, $P < 0.01$). Nevertheless, the interaction between the two factors (cultivars and infestation factors) was not significantly different ($F = 1.22$, $P = 0.3$).

Aphids had longer total longevity and fewer progeny in the whole-plant biological assay (Table 3) on the cultivar Gazira2 as compared with Misr1, although there was no significant difference. In the detached-leaf biological assay, the cultivar Gazira2 had a longer pre-reproductive, reproductive, post-reproductive, and total longevity period as compared with Misr1, whereas the number of progeny was lower as compared with Misr1. Generally, cowpea aphid performance on whole plants was different as compared with the detached-leaf assay.

Downloaded From: https://bioone.org/journals/Journal-of-Insect-Science on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Demographic parameters study (Table 4) on whole-plant biological assay showed that cultivar Gazira2 had a significantly lower net reproduction rate (Ro) compared with Misr1; other parameters had no clear relationship with the lesser suitability character of Gazira2 compared with Misr1. On detached leaf, all the demographic parameters supported that Gazira2 was less suitable for the aphid compared with Misr1, indicated by the significantly lower net reproduction rate (Ro), intrinsic rate of increase (rm), and finite rate of increase (λ), and longer generation time (T) and doubling time (Td). Similar to biological parameters (Table 3), cowpea aphid demographic performance on whole plant and detached leaf was different (Table 4.). Figures 1 and 2 show that Misr1, either on detached leaf or whole plant, seems preferable to the aphid compared with Gazira2, indicated by higher fecundity rate (mx) on Misr1.

Discussion

The colony development study was conducted initially to obtain general information about the potential resistant characters that might be present among five 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 Gazira2 > Misr > Giza3 Improved > Goff1 > Misr1. Results obtained from the colony development assays probably reflect a similar phenomenon in the field because aphids were allowed to move freely and to feed in any part of the plant (Alvarez et al. 2006). Factors such as plant height, leaf surface, leaf size, or leaf color supposedly affect 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 is important to note that the Gazira2 has the shortest plant height among the cultivars, which might have correlated with the aphids preferring it the least (Table 2.). It also was shown that adult alatae numbers in Gazira2 were not significantly different as compared with Misr1, which could indicate the unsuitability of Gazira2 as host plant. Cowpea aphid infestation significantly reduced plant height ($F = 41.38$, $P < 0.01$). Significant difference in height between infested and uninfested plants occurred in most cultivars, except Gazira2 and Goff1. The highest total number of aphids in Misr1 was positively correlated with the most significant difference between the height of the infested and uninfested plants.

Whole-plant biological parameters (Table 3.) indicated that aphids had longer total longevity and fewer progeny on cultivar Gazira2 compared with Misr1, although it did not differ significantly. This may reflect that the cultivar Gazira2 exhibited higher resistance compared with Misr1. However, other parameters did not give a clear relationship to support this conclusion. Longer total longevity and fewer progeny are essential parameters indicating suitability of a host plant, especially for sucking insects (Awmack and Leather 2002, Bernardi et al. 2012).

Most of the biological parameters evaluated in the detached-leaf assay (Table 3) showed that the cultivar Gazira2 was less suitable for cowpea aphid development compared with Misr1, 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* (Cock-

Downloaded From: https://bioone.org/journals/Journal-of-Insect-Science on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

erell). Using the detached-leaf method for biological assay is recommended by some researchers because of its efficiency (Sharma et al. 2005, Smith 2005, Michel et al. 2010). We noted that the detached-leaf assay was easier to handle and provided more accurate information because all of 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 leafs 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.'s (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.

Net reproduction rate of whole plant faba bean cultivar Misr1 was significantly higher than Gazira2 (Table 4). If the net reproduction rate value is used as the only parameter, it can be concluded that whole plant Gazira2 was less suitable for the aphids than Misr1. 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 whole-plant faba bean cv. Misr1 remained high at the end of their reproduction period (Fig. 1). This fact deviated from the general assumption that the progeny are supposed to peak at the beginning of the reproduction period (Wyatt and White 1977). These phenomena result in the higher value of generation time and decrease the intrinsic rate of increase value of Misr1 compared with Gazira2.

The detached-leaf demographic parameters study gave reliable results and supported the suggested less suitability of cultivar Gazira2 compared with Misr1, indicated by significantly lower net reproduction rate, intrinsic rate of increase, and finite rate of increase, but longer generation time and doubling time, compared with Misr1. 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), and for evaluating artificial diet efficiency (Wittmeyer and Coudron 2001). Cowpea aphid performance measured by demographic parameters (Table 4) has similar conclusions as the biology study (Table 3), indicating that either study can be used to generate the conclusion. Overall, those results suggested that the use of faba bean cultivar Gazira2 should decrease the cowpea aphid population.

Conclusion

The colony development study ranked the resistance level among cultivars as Gazira2 > Misr > Giza 3 improved > Goff1 > Misr1. Demographic parameters in the detached-leaf study showed that Gazira2 is less preferred than Misr1 because of lower net reproduction rate, intrinsic rate of increase, and finite rate of increase, but longer generation time and

Downloaded From: https://bioone.org/journals/Journal-of-Insect-Science on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

doubling time. The detached-leaf biological assay is preferable because it is more reliable and produced similar results as the colony development study.

Acknowledgements

We thank Salem Safer Alghamdi for his guidance and review during the experiment, and Yousif N. Aldryhim, Fahad J. Alatawi, Mohammad Aldeghairi, and Boris C. Kondratieff for their significant reviews and comments. This study was supported by student research grant (0813-11ت-ط) King Abdulaziz City for Science and Technology (KACST).

References

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

Aldryhim, Y., and A. Khalil. 1996. The Aphididae of Saudi Arabia. *Fauna of Saudi Arabia* 15: 161–195.

Alvarez, A., W. F. Tjallingii, E. Garzo, V. Vleeshouwers, M. Dicke, and B. Vosman. 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 S. R. Leather. 2002. Host plant quality and fecundity in herbivorous insects. *Annu. Rev. Entomol*. 47: 817–844.

Bernardi, D., M. S. Garcia, M. Botton, and D. E. Nava. 2012. Biology and fertility life table of the green aphid *Chaetosiphon fragaefolli* on strawberry cultivars. *J. Insect Sci.* 12:28. Available online: www.insectscience.org/12.28

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

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

Blackman, R. L., and V. F. Eastop. 2006. *Aphids on the world's herbaceous plants and shrubs. Volume 1: host lists and keys. Volume 2: The aphids*. John Wiley & Sons.

Chen, W., Leopold, R. A., and M. A. Boetel. 2010. Host plant effects on development and reproduction of the glassy-winged sharpshooter, *Homalodisca vitripennis* (Homoptera: Cicadellidae). *Environ. Entomol*. 39: 1545–1553.

Dabhi, M., and C. Patel. 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 & Hall.

Islam. M. T., and R. Shunxiang. 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.

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

Downloaded From: https://bioone.org/journals/Journal-of-Insect-Science on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Laamari, M., L. Khelfa, and A. Coeur d'Acier. 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., M. A. R. Mian, N. H. Davila-Olivas, and L. A. Cañas. 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 P. Harrewijn. 1987. *Aphids. Their biology, natural enemies and control*, vol. 2A. Elsevier.

Myers, S. W., C. Gratton, R. P. Wolkowski, D. B. Hogg, and J. L. Wedberg. 2005. Effect of soil potassium availability on soybean aphid (Hemiptera: Aphididae) population dynamics and soybean yield.). *J. Econ. Entomol*. 98: 113–120.

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

SAS Institute. 2008. *SAS/STAT 9.2 user's guide*. SAS Institute, Cary, NC.

Schoonhoven, L. M., T. Jermy, and J. J. A. Van Loon. 1998. *Insect–plant biology: From physiology to evolution*. Chapman & Hall.

Shannag, H., and A. Ja'far. 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., G. Pampapathy, M. K. Dhillon, and J. T. Ridsdill-Smith. 2005. Detached leaf assay to screen for host plant resistance to *Helicoverpa armigera*. *J. Econ. Entomol*. 98: 568–576.

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

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

Stoetzel, M. B., G. L. Miller, P. J. O'Brien, and J. Graves. 1996. Aphids (Homoptera: Aphididae) colonizing cotton in the United States. *Fla. Entomol*. 79(2): 193–205.

Weigand, S.,and S.I Bishara. 1991. Status of insect pests of faba bean in the Mediteranean 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*. Zaragoza:CIHEAM, 1991 . p. 67-74 (Options Médi terranéennes:Série A. Séminaires Méditerranéens; n.10)

Wittmeyer, J., and T. Coudron. 2001. Life table parameters, reproductive rate, intrinsic rate of increase, and estimated cost of rearing *Podisus maculiventris* (Heteroptera: Pentatomidae) on an artificial diet. *J. Econ. Entomol*. 94: 1344–1352.

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

Downloaded From: https://bioone.org/journals/Journal-of-Insect-Science on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use