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Original research

Response of certain faba bean cultivars to infestation by Aphis craccivora (Hemiptera: Aphididae) in relation to the expected yield and its components.

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Abstract:

An experiment was carried out in Egypt's Luxor Governorate, at the Agricultural Research Station El-fabaMattana's bean programme, for two seasons (2019/20 and 2020/21) to investigate the performance of six faba bean cultivars to *A. craccivora* infestation in relation to the yield. The overall average population size of *A. craccivora* was larger in the first season than in the second, according to the findings. The infestation by pest during the first season was higher than the second .The findings demonstrated that the resistance of faba bean cultivars to population density and *A. craccivora* infestation differed greatly. Concerning, the population and % infestation by pest together, the faba bean cultivar (Giza 40) was the highest population density and the highest infestation by pest, and was rated as highly susceptible (H.S.) to infestation. Followed by Giza 843, Giza 716 and Sakha 3 cultivars were appeared as susceptible (S), then by Nubaria 1 was seemed as relative resistant (RR). In contrast, Nubaria 3 cultivar had the lowest population density and the least infestation by pest and was rated as moderate resistant (MR) of pest over the entire season. Data demonstrated that raising one pest per 10 plants resulted in yield reductions of 40.54, 46.31 kg/feddan, and 40.54, 46.31 kg/feddan, respectively.0.14 and 0.30 Ardab/feddan through the two seasons, respectively. Similarly, a 1% increase in *A. craccivora* infestation would reduce faba bean yield by 20.66 and 22.39 kg/feddan, 0.13 and 0.14 Ardab/feddan, respectively, across the two seasons.

Keywords: *Aphis craccivora*, faba bean cultivars, population density, yield

1- Introduction

The faba bean *(Vicia faba L.)* is one of Egypt's most important leguminous crops, as it is consumed fresh, dried, or as a vegetable (Mohamed, 2003). The faba bean is a meat substitute (Ebadah et al., 2006) and a major source of plant protein for human use (Yassin et al., 2015). Dangerous insect pest species attack faba bean plants at various phases of development, with aphids being the most destructive, resulting in a loss in seed yield of 12.79 to 61.07 percent (El-Defrawi ; El-Harty, 2009).

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By sucking the sap with its mouth parts and then deforming it with toxic saliva, the cowpea aphid, *A. craccivora* causes direct damage to the plant. Furthermore, this pest excretes a large amount of honeydew, which coats plant leaves and attracts ants, as well as encouraging the growth of sooty mould fungus, which causes the infested plant to appear dirty black, impairing photosynthesis and respiration, as well as lowering the plant's quality, which can result in plant deformation and indirect viral disease transmission (Aly, 2014; El-Sarand et al., 2019; El-Defrawi et al., 2000 ; Khodeir et al., 2020).

Aphid infestations have a significant impact on faba bean cultivars. In addition, aphid resistance in the host plant is an important factor of IPM for aphids. (Salem, 2005; Salman et al., 2006; Hamouda, 2008; Soffan, 2012, Awadalla et al., 2013 ; Salman et al., 2015). Plants that are resistant to insect pests may have a defensive mechanism that reduces their reproduction and lengthens their development period (Legrand& Barbosa 2000). Also, Junaid et al. (2016) reported that the resistance of the host plant has been shown to be the better tool to reduction aphid losses.

Plant tolerance to insect infestation recommends using insect-resistant varieties in IPM to reduce insect pest damage. Planting pest-resistant cultivars is a plain and efficient way to limit the damage caused by pest infestations (Shahzad et al., 2019).

Because faba bean cultivars differ in their sensitivity to the aphid infestation due to genetic variation, the resistant cultivars could be utilized in integrated pest management strategies. Thus, the aim of this research was to investigate the susceptibility of six faba bean cultivars to A. craccivora infestation in relation to yield and its components, with the aim of determining the best faba bean cultivar to manage aphids infesting faba bean.

Materials and Methods:

1- Population densities of *A. craccivora* on certain faba bean cultivars:

The current research is an attempt to evaluate the differences among six cultivars in their preference by the *A. craccivora* infestation. Faba bean field trials were carried out at El-Mattana Agricultural Research Station, Luxor Governorate, over two growing seasons (2019/20 and 2020/21).was at an altitude of 99 m a.s.l., a latitude and longitude of 25.67° N and 32.71° E, respectively. Six cultivars of faba bean viz. (Giza 843, Giza 716, Giza 40, Sakha 3, Nubaria 1 and Nubaria 3).

Many authors used several insect terms to indicate the pest's population density. In this research, two insect expressions were used: insect densities and infestation incidence percentages.

1.1- Sampling method:

Three replicates for each cultivar of faba bean (replicate dimensions: 3 m × 3.5 m log ═ 10 m^2) were distributed in completely randomized block design, were planted at the most opportune time (in November, 1st every season). Throughout the trial, all agricultural methods were used with the exception of pest control. To calculate the population densities and percentages of A. craccivora infestations on different faba bean cultivars, random samples of ten plants per replicate i.e. (30 plants per each cultivar); at early morning, were picked up weekly, using 10x lenses in the field, began as soon as the plants appeared above ground and continued until the crop harvesting in each season (Mohamed, 2003 ; Awadalla et al., 2016).

According to Dewar et al., aphid samples were counted directly on the same day (1982). The Using 10x lenses in the field, the total number of alive insects (Nymphs and Apterae individuals) on faba bean plants was counted and recorded, connected to the inspection date, and reported as mean number of individuals per 10 plants standard error (SE) to express the pest population size. In addition, the percentages of A. craccivora infestation incidents were counted and recorded, together with the inspection date, and expressed as percent (percent) standard error (SE) to express the pest abundance percentages.

The population density of *A. craccivora* was estimated, and infestation incidence percentages were computed using Facylate's (1971) formula:

$$A = (n / N) \times 100.$$

Where, A = Percentage of infestation incidence.

n = Number of affected plants where the pest was found.

N = Total number of plants collected in each inspection date (uninfested + infested).

- General sampling method:

All sampling was conducted from 6120 plants on 34 dates over a 2-season period, i.e. 3 replicates × 10 plants × 6 cultivars × 34 dates.

1.2- Susceptibility degrees:

The susceptibility degrees of the examined faba bean cultivars were classified as described by (Semeada, 1985 ; Nosser, 1996) using a quantitative approach based on the following assumptions:

A- Varieties were classified into five groups: resistant (R), moderately resistant (MR), relative resistant (RR), susceptible (S), and highly susceptible (HS) (HS).

B- The overall average number of individuals

C- The range of change (RC) among the maximum and minimum mean number values for faba bean cultivars was computed using the following equation:

$$RC = MN\ max - MN\ min$$

Where,

MN max: is the maximum number of individuals/cultivars that can be used.

MN min: is the minimum number of individuals/ cultivars that can be used.

D- The amount of change in faba bean cultivars from one degree of resistance or susceptibility to the previous degree (from MR to R or from MR to RR, etc.) was called unit change in faba bean cultivars (UC).

The studied faba bean varieties could be categorised as follows using the equation described above:

1- The highly susceptible group (HS) includes faba bean cultivars with infestation levels higher than (MN+UC).

2- The group of susceptible (S) includes faba bean cultivars with infection levels ranging from MN to (MN+UC).

3- The relative resistant group (RR) includes faba bean cultivars with infestation levels ranging from MN to MN+ (MN-UC).

4- The moderate resistant group (MR): faba bean cultivars with infestation levels ranging from (MN-UC) to (MN-UC) (MN-2UC).

5- The resistant group (R) includes of faba bean cultivars with a low infestation rate (MN-2UC).

However, it is an important to point out herein that the pest mean numbers must refer to and / or agree with the resistance degree of cultivars of faba bean

1.3- Statistical analysis:

The collected data was statistically analysed using a complete randomised block design. The means were compared using Duncan's Multiple Range Test (Duncan, 1955), and the Least Significant Difference test (LSD) at the 5% level was used to determine the significance between means of faba bean varieties. The analysis was done on a computer (MSTATC Program software, 1980), and the results were graphed using Microsoft Excel 2010.

2- Effects of the cowpea aphid, *A.craccivora* (Kock.) infestation on the yield and its components:

This trial was also executed at faba bean program of El-Mattana Agricultural Research Station, Luxor Governorate during two successive growing seasons (2019/20 and 2020/21) to study the influence of population densities and the percentages of infestation incidences by *A. craccivora* on vegetative growth, yield and its components for six faba bean cultivars.

At flowering time and harvest, ten plants per replicate(30 plants per each cultivar) were selected at randomly to measure the following traits in all tested faba bean cultivars as following:

1- Height of the plant / size of the plant (cm). 2- The total number of branches on the

(Tillering) 3- The number of pods produced per plant. 4- The number of seeds per plant.

5- Pods weight / plant (g). 6- Seeds weight / plant (g).

7- Yield (Kg / feddan). 8- Yield (Ardab / feddan).

The Data collected was subjected to statistically analyzed utilizing a randomized complete block design, with three replicates for each cultivar. Means were compared using the LSD test with a P value of 0.05, which was done on a computer (MSTATC Program software 1980).

Concerning, the relationships among the [average numbers of A. craccivora individuals per 10 plants (X_1) & the percentages of infestation incidences by pest (X_2) (as the independent variables)] and the yield and its components [as the dependent variable (Y)] on certain faba bean cultivars, were determined, and assessed as mentioned previously.

As a result, the aim of this study was to see how the number of A. craccivora individuals and the percentages of infestation incidents impacted the yield and its components.

The results were analysed statistically using simple correlation, with the independent variables (X_1) representing the number of insects per 10 plants and the percentages of infestation incidences (X_2), and the dependent variable (y) representing the yield and its components for six faba bean cultivars.

According to Fisher (1950) ; Hosny et al. (1972), the simple regression was used to show the variability in the yield and its components that might be produced by the number of insect individuals or percent infestation incidences by pest during each season. The linear regression equation was calculated using the following formula:

$Y = a \pm bx$

Where:

Y= Prediction value (Dependent variable)
a = Constant (y - intercept)
b = Regression coefficient
x = Independent variable

Results and Discussion:

1- Studies on the population:

1.1- Population dynamics of *A. craccivora* on specific faba bean cultivars by season:

The total population density of *A. craccivora* during the first growing season (2019/20) was higher than the second growing season (2020/21) as shown in Table (1) and Fig. (1). The rise reached approximately 1.10 times the previous level. During the first and second growing seasons, the mean total population was 16.71 0.38 and 15.21 0.52 people per 10 tillers, respectively.

Statistical examination of the data in Table (1), demonstrated extremely significant differences in population size by *A. craccivora* between the faba bean cultivars over the two growth seasons (L.S.D values: 7.14 and 6.03).

Table (1): During the two seasons (2019/20 and 2020/21) average numbers of A. craccivora per 10 plants and susceptibility degrees of certain faba bean cultivars were measured.

Faba bean cultivars	Average no. of individuals of individuals per 10 plants ± S.E.			
	First season (2019/20)		Second season (2020/21)	
	Mean ± S.E.	Susceptibility degree	Mean ± S.E.	Susceptibility degree
Giza 843	17.54 ± 0.87 AB	S	17.28 ± 1.39 AB	S
Giza 716	17.93 ± 0.98 AB	S	15.75 ± 1.24 AB	S
Giza 40	24.23 ± 1.14 A	HS	21.76 ± 1.21 A	HS
Sakha 3	17.44 ± 0.79 AB	S	15.86 ± 1.15 AB	S
Nubaria 1	14.22 ± 0.79 BC	RR	12.76 ± 1.00 BC	RR
Nubaria 3	8.92 ± 0.48 C	MR	7.86 ± 0.58 C	MR
General average	16.71 ± 0.38		15.21 ± 0.52	
L.S.D. at 0.05 between cultivars	7.14**		6.03**	

Duncan's multiple range test finds that means in each column followed by the same letter(s) are not significantly different at the 0.05 level of probability (DRMT).

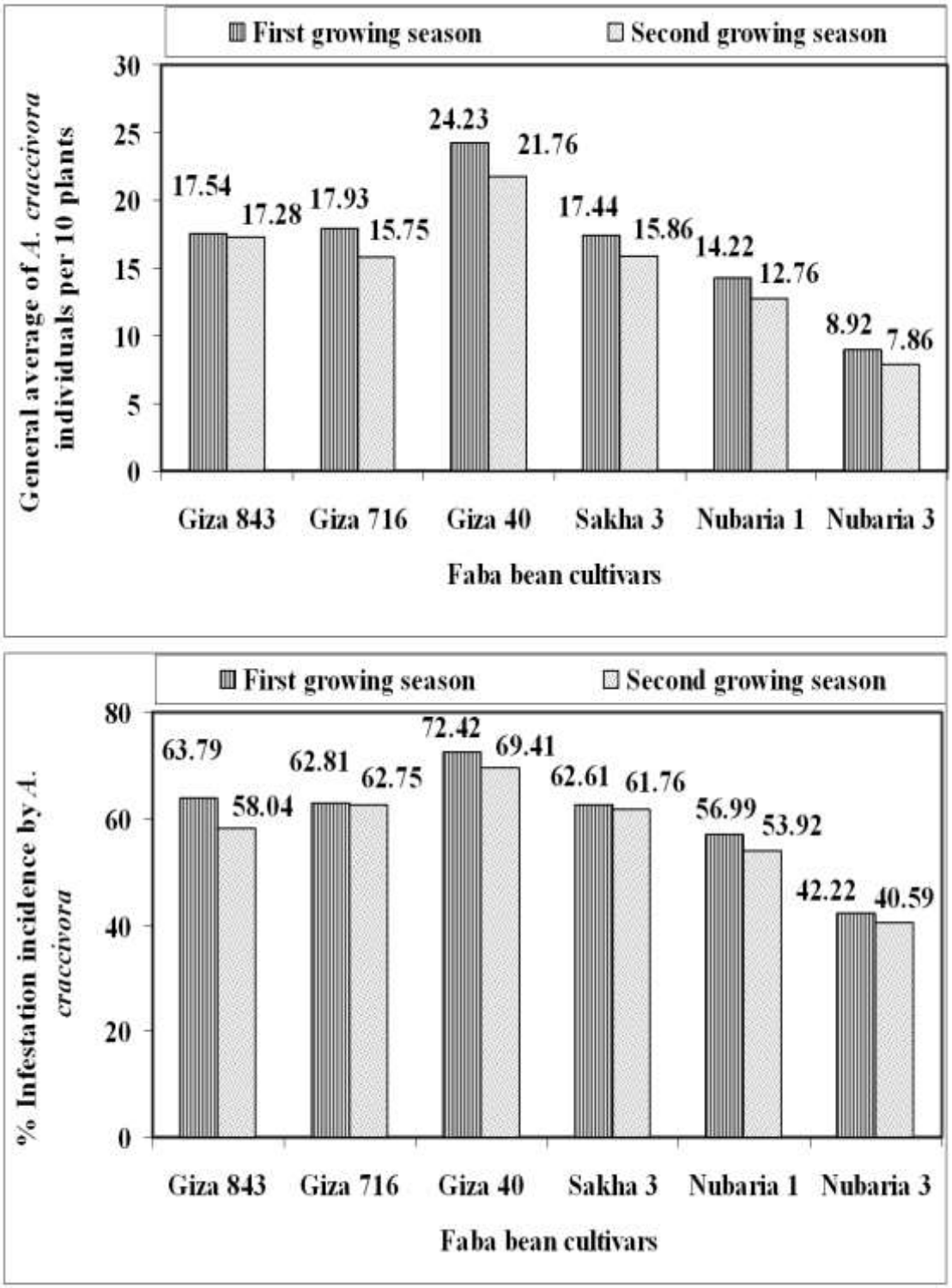

Fig. (1): Average numbers of A. craccivora per 10 plants and the infestation incidence percentages of certain faba bean cultivars through the two growing seasons (19/20 and 20/21)

When compared to the other tested faba bean cultivars, the Giza 40 cultivar had the highest number of A. craccivora individuals, with a general average of (24.23 1.14 and 21.76 1.21 individuals per 10 plants) during in the two seasons, respectively, and this cultivar was rated as highly susceptible (HS)

On contrary, Nubaria 3 cultivar demonstrated the lowest number of A. craccivora individuals on the basis of a general average of population (8.92 ± 0.48 and 7.86 ± 0.58 individuals per

10 plants) over the two growing season, respectively, and this cultivar was evaluated as moderately resistance (MR), this cultivar of faba bean plants, should be promoted in the areas of high aphid infestation.

On the other side, the general average population of A. craccivora was observed on Giza 843, Giza 716, and Sakha 3 cultivars with an average of (17.54 0.87, 17.93 0.98, and 17.44 0.79 individuals per 10 plants) during the first season and (17.28 1.39, 15.75 1.24, and 15.86 1.15 individuals per 10 plants) during in the two seasons, respectively, and these cultivars appeared to be susceptible (R). During in the two seasons, the Nubaria 1 cultivar was shown to be relatively resistant (RR), with an average population of 14.22 0.79 and 12.76 1.00 individuals per 10 plants, respectively.

.1.2- The percentages of A. craccivora infestations on several faba bean cultivars:

Table (2) and Fig. (1) show that the percentages of A. craccivora infestations were smaller in the second growing season (2020/21) than in the first (2019/20). The decrease in the percentages infestation incidences reached approximately 1.04 times. The mean infestation incidences percentages through the whole season were 60.14 ± 0.68 and 57.75 ± 1.14% respectively, during the first and second seasons.

Statistical analysis of the data revealed highly significant differences between the faba bean cultivars in terms of *A. craccivora* Infestation percentages (L.S.D values: 11.55 and 14.24) during in the two seasons, respectively.

Table (2): The infestation incidence percentages by A. craccivora and susceptibility degrees of certain faba bean cultivars through two successive growing seasons (19/20 and 20/21).

Faba bean cultivars	Average no. of individuals of individuals per 10 plants ± S.E.			
	First season (2019/20)		Second season (2020/21)	
	Mean ± S.E.	Susceptibility degree	Mean ± S.E.	Susceptibility degree
Giza 843	63.79 ± 1.70 AB	S	58.04 ± 2.00 A	S
Giza 716	62.81 ± 1.65 AB	S	62.75 ± 2.82 A	S
Giza 40	72.42 ± 1.34 A	HS	69.41 ± 2.74 A	HS
Sakha 3	62.61 ± 1.53 AB	S	61.76 ± 2.59 A	S
Nubaria 1	56.99 ± 1.47 B	RR	53.92 ± 2.75 AB	RR
Nubaria 3	42.22 ± 1.15 C	MR	40.59 ± 1.97 B	MR
General average	60.14 ± 0.68		57.75 ± 1.14	
L.S.D. at 0.05 between cultivars	11.55 **		14.24 **	

Duncan's multiple range test finds that means in each column followed by the same letter(s) are not significantly different at the 0.05 level of probability. (DRMT)

Results showed that, Nubaria 3 cultivar appeared the lowest the percentages of infestation incidences by A. craccivora as a general average of (42.22 ± 1.15 and 40.59 ± 1.97%) over the two growing season, respectively, than the others tested faba bean cultivars, as well, this cultivar was rated as moderately resistance (MR). On contrary, Giza 40 cultivar demonstrated the highest percentages of infestation incidences as a general average of (62.81 ± 1.65 and 62.75 ± 2.82%) through the two growing season, respectively, and this cultivar was evaluated as highly susceptible (HS).

However, the general average of percentages of infestation incidences by *A. craccivora* was observes on Giza 843, Giza 716 and Sakha 3 cultivars with an average of (63.79 ± 1.70, 62.81 ± 1.65 and 62.61 ± 1.53%) during the first season and it was (58.04 ± 2.00, 62.75 ± 2.82 and 61.76 ± 2.59%) through the two growing season, respectively, and these cultivars was appeared as susceptible (R). But, Nubaria 1 cultivar, was observed as relatively resistant (RR), with an average of (56.99 ± 1.47 and 53.92 ± 2.75%) the two growing season, respectively.

As a result of the previous debate, it could be concluded that the seasonal activity and % infestation incidences by pest together, the faba bean cultivar (Giza 40) was the highest population density and the highest percentages of infestation incidences by pest, and was evaluated as highly susceptible to pest (H.S.). On contrast, Nubaria 3 cultivar had the lowest population density and the least percentages of infestation incidences by pest and was rated as moderate resistant (MR) of pest over the entire season.

We found that the host plant influences pest development and that selecting the most resistant cultivar can aid to reduce pest infestation, and that this is an essential component to consider in faba bean plants integrated pest management.

Several researchers have observed differences in aphid populations among different faba bean cultivars, including (Salem, 2005; Abdel-Samad ; Ahmed, 2006; Ebadah et al., 2006; Salman et al., 2006; El-Samahy, 2008; El-Defrawi ; El-Harty (2009); Rizk, 2011; Awadalla et al., 2013; Mahmoud et al., 2015; Salman et al., 2015; Awadalla et al; 2016; Badawy, 2019).

2- Effects of the cowpea aphid *A. craccivora* , infestation on the yield and its components of different faba bean cultivars:

2.1.1- Effect on vegetative growth:

A- On the plant length:

The data represented in Table (3), cleared the relationship among the infestation by *A. craccivora* and the length of faba plants for all tested faba bean cultivars. Giza 40 cultivar was considered the greatest population density and the highest percentages of infestation incidence by A. craccivora, was exhibiting the smallest of plant length (111.00 ± 8.62 and 117.67 ± 5.36 cm) through the first and second seasons, respectively as compared with the tested faba bean cultivars. On contrary, Nubaria 3 cultivar had the lowest population density and the least percentages of infestation incidences by pest, and was exposed the higher of length (124.67 ± 2.91 and 126.33 ± 1.86 cm) through the first and second seasons, respectively. The difference in plant length among all tested faba bean cultivars was insignificantly during the first growing season and significantly (L.S.D. value was 6.42) through the second growing season

The relationship between the mean numbers of *A. craccivora* individuals as an independent factor (X1) the percentages of infestation incidents by pest (X2) and plant length of specific faba bean cultivars as a dependent factor was shown in Tables 4 and 5. (Y). Statistical analysis of simple correlation revealed highly significant negative relationships between pest population density and plant length of selected faba bean cultivars over the two experimental seasons (r values of -0.81 and -0.59). The unit effect regression coefficient (b) suggested that an increase of one individual per ten plants would result in a 1.36 cm and 0.78 cm decrease in plant length throughout the two seasons, respectively,Table (4). During the two seasons, the effect of infestation incidence percentages by pest on plant length was also highly significantly negative correlation(r values: -0.66 and -0.64). According to the estimated regression coefficient (b), an increase of 1% in pest incidence percentages would reduce plant length by 0.60 and 0.40 cm, respectively, for the two seasons, Table (5).

2- Effect on number of branches / plant (Tillering):

The effect of *A. craccivora* infestation on the number of branches per plant of several faba bean cultivars was revealed in Table (3). The Nubaria 3 cultivar had the lowest population density and the lowest percentages of pest infestations, and it was contained on the most number of branches (7.00 cm) during the entire season than the other tested cultivars.. But, Giza 40 cultivar was observed the greatest population density and the highest percentages of infestation incidence by *A. craccivora* was displaying the least of number of branches (6.00 cm) over the entire season. There were no differences in the number of branches per plant among the studied faba bean cultivars, according to statistical analysis (Table, 3).

The effect of pest population density on number of branches / plant of six faba bean cultivars was significantly negative (r values; -0.52 and -0.53) during the two seasons, according to the data in Tables 4 and 5. The estimated regression coefficient (b) showed that an increase of one individual per 10 plants would result in a 0.06 and 0.09 decrease in the number of branches per plant during the two seasons, respectively ,Table (4). Moreover, over the two seasons, the simple correlation of infestation incidence percentages by pest and number of branches per plant was significantly negative (r values -0.54 and -0.53). According to the estimated regression coefficient (b), an increase of 1% in infestation incidence percentages would reduce the number of branches per plant by 0.03 and 0.04 branches every season, respectively, Table (5).

2.1.2- Effect on resultant yield and its components:

A- Number of pods / plant:

Results depicted in Table (3) obtained that the effect the infestation by *A. craccivora* on the the number of pods produced by each plant of some faba bean cultivars. Giza 40 cultivar was recorded the highest population density and the highest percentages of infestation incidence by *A. craccivora* was appeared the least of number of pods per plant (29.00 ± 7.37 and 31.00 ± 7.09 cm) through the two seasons, respectively as compared with the tested faba bean cultivars. However, Nubaria 3 cultivar was observed the lowest population density and the least percentages of infestation incidences by pest, and was exposed the more of number of pods (50.67 ± 8.65 and 51.67 ± 6.01 pods) through the first and second seasons, respectively than the other tested cultivars (Tables, 3 and 4). There were highly significant differences (L.S.D. values; 10.57 and 8.03) in the number of pods per plant among the tested faba bean cultivars (Table, 3).

Table (3): Effect of population size and % infestation by *A. craccivora* on yield and its components of certain faba bean cultivars During the two growing seasons in the Esna area of Luxor Governorate (2019-2021).

Season	Cultivars	General average of Aphids per 10 plants ± S.E.	% Infestation incidence	Vegetative growth		Yield and its components:					
				Plant length (cm)	Tillering	No. of pods	Pods weight (g)	No. of seeds	Seeds weight (g)	Yield (Kg / /feddan)	Yield (Ardab /feddan)
2019/20	Giza 843	17.54 ± 0.87	63.79 ± 1.70	117.67 ± 6.23	6.33 ± 0.33	33.33 ± 9.21	91.97 ± 13.09	97.00 ± 18.82	61.00 ± 3.22	1711.11 ± 41.16	11.04 ± 0.27
	Giza 716	17.93 ± 0.98	62.81 ± 1.65	115.67± 5.81	5.67 ± 0.33	33.67 ± 3.18	80.17 ± 6.87	89.00 ± 3.79	61.23 ± 8.50	1288.52 ± 62.92	8.31 ± 0.41
	Giza 40	24.23 ± 1.14	72.42 ± 1.34	111.00 ± 8.62	6.00 ± 0.00	29.00 ± 7.37	79.13 ± 6.68	78.33 ± 6.17	60.87 ± 5.36	1140.74 ± 52.60	7.36 ± 0.36
	Sakha 3	17.44 ± 0.79	62.61 ± 1.53	116.00 ± 2.65	6.67 ± 0.33	44.00 ± 6.00	80.73 ± 10.29	91.00 ± 8.33	66.00 ± 10.62	1568.52 ± 56.50	10.12 ± 0.36
	Nubaria 1	14.22 ± 0.79	56.99 ± 1.47	120.67 ± 2.96	6.33 ± 0.33	35.33 ± 5.04	96.83 ± 15.60	100.67 ± 4.10	68.93 ± 8.56	1731.85 ± 28.87	11.17 ± 0.19
	Nubaria 3	8.92 ± 0.48	42.22 ± 1.15	124.67 ± 2.91	7.00 ± 0.00	50.67 ± 8.65	112.90 ± 14.37	123.00 ± 22.27	69.83 ± 3.00	1827.78 ± 72.27	11.79 ± 0.47
	Mean ± S.E.	16.71 ± 0.38	60.14 ± 0.68	117.61 ± 2.10	6.33 ± 0.14	37.67 ± 2.96	90.29 ± 4.96	96.50 ± 5.53	64.64 ± 2.62	1544.75 ± 63.28	9.97 ± 0.41
	L.S.D. at 0.05 between cultivars	7.14 **	11.55 **	N.S.	N.S.	10.57**	N.S.	N.S.	N.S.	165.80**	1.07**
2020/21	Giza 843	17.28 ± 1.39	58.04 ± 2.00	122.67 ± 3.71	6.33 ± 0.33	33.33 ± 6.01	90.20 ± 5.78	96.00 ± 14.47	66.10 ± 3.27	1727.44 ± 40.83	11.14 ± 0.26
	Giza 716	15.75 ± 1.24	62.75 ± 2.82	117.67 ± 4.33	6.00 ± 0.58	35.00 ± 2.89	84.43 ± 3.18	90.33 ± 2.60	70.36 ± 6.07	1306.59 ± 63.55	8.43 ± 0.41
	Giza 40	21.76 ± 1.21	69.41 ± 2.74	117.67 ± 5.36	6.00 ± 0.58	31.00 ± 7.09	83.57 ± 3.03	76.33 ± 4.10	65.95 ± 6.88	1157.33 ± 56.71	7.47 ± 0.37
	Sakha 3	15.86 ± 1.15	61.76 ± 2.59	117.67 ± 1.45	6.00 ± 0.58	45.00 ± 5.00	85.30 ± 6.16	86.67 ± 2.03	72.93 ± 11.62	1589.65 ± 52.80	10.26 ± 0.34
	Nubaria 1	12.76 ± 1.00	53.92 ± 2.75	122.33 ± 1.45	6.67 ± 0.33	36.00 ± 4.58	99.97 ± 15.30	93.33 ± 5.70	76.49 ± 8.86	1754.36 ± 27.72	11.32 ± 0.18
	Nubaria 3	7.86 ± 0.58	40.59 ± 1.97	126.33 ± 1.86	7.00 ± 0.00	51.67 ± 6.01	111.67 ± 10.53	96.00 ± 2.31	78.82 ± 5.04	1848.65 ± 75.50	11.93 ± 0.49
	Mean ± S.E.	15.21 ± 0.52	57.75 ± 1.14	120.72 ± 1.41	6.33 ± 7.00	38.67 ± 2.56	92.52 ± 3.83	89.78 ± 2.85	71.78 ± 2.82	1564.00 ± 63.60	10.09 ± 0.41
	L.S.D. at 0.05 between cultivars	6.031**	14.24 **	6.42 *	N.S.	8.03**	N.S.	N.S.	N.S.	165.38**	1.07 **

Table (4): Simple correlation, regression values and linear regression equation when the counts of the mean numbers of *A. craccivora* individuals were plotted versus the yield and its components of certain faba bean cultivars at Esna district, Luxor Governorate during the two growing seasons (2019-2021).

Season	Statistical analysis	Vegetative growth		Yield and its components					
		Plant length (cm)	Tillering	No. of pods	Pods weight(g)	No. of seeds	Seeds weight (g)	Yield (Kg / /feddan)	Yield (Ardab /feddan)
2019/20	r =	-0.81	-0.52	-0.73	-0.53	-0.49	-0.57	-0.80	-0.80
	b =	-1.36	-0.06	-1.73	-2.10	-2.14	-1.19	-40.54	-0.26
	Standard error	0.25	0.02	0.40	0.84	0.96	0.43	7.54	0.05
	T value	5.53 **	2.47*	4.30**	2.50*	2.22*	2.77*	5.38**	5.38**
	Probability	0.000	0.025	0.00	0.024	0.041	0.014	0.000	0.000
	Y = a ± bx	-1.36x + 140.36	-0.06x + 7.31	-1.73x + 66.62	-2.10x + 125.41	-2.14x + 132.34	-1.19x + 84.54	-40.54x + 2222.31	-0.26x + 14.34
	R^2	0.66	0.28	0.54	0.28	0.24	0.32	0.64	0.64
	E.V.%	65.64	27.52	53.59	28.08	23.60	32.39	64.34	64.34
2020/21	r =	-0.59	-0.53	-0.66	-0.58	-0.50	-0.52	-0.77	-0.77
	b =	-0.78	-0.09	-1.61	-2.08	-1.35	-1.37	-46.31	-0.30
	Standard error	0.27	0.04	0.45	0.74	0.58	0.57	9.58	0.06
	T value	2.90 **	2.49 *	3.56 **	2.82 *	2.32 *	2.41 *	4.83 **	4.83 **
	Probability	0.010	0.02	0.002	0.012	0.034	0.028	0.000	0.000
	Y = a ± bx	-0.78x + 132.64	-0.09x + 7.71	-1.61x + 63.16	-2.08x + 124.21	-1.35x + 110.34	-1.37x + 92.66	-46.31x + 2268.50	-0.30x + 14.64
	R^2	0.34	0.28	0.44	0.33	0.25	0.27	0.59	0.59
	E.V.%	34.38	27.86	44.14	33.13	25.12	26.62	59.36	59.36

Table (5): Simple correlation, regression values and linear regression equation when the counts of the percentages of infestation incidence by *A. craccivora* individuals were plotted versus the yield and its components of certain faba bean cultivars During the two seasons in the Esna area of Luxor Governorate (2019-2021).

Season	Statistical analysis	Vegetative growth		Yield and its components					
		Plant length (cm)	Tillering	No. of pods	Pods weight(g)	No. of seeds	Seeds weight (g)	Yield (Kg / /feddan)	Yield (Ardab /feddan)
2019/20	r =	-0.66	-0.54	-0.68	-0.57	-0.54	-0.48	-0.76	-0.76
	b =	-0.60	-0.03	-0.86	-1.22	-1.29	-0.54	-20.66	-0.13
	Standard error	0.17	0.01	0.24	0.44	0.50	0.25	4.44	0.03
	T value	3.49**	2.57*	3.66**	2.77*	2.57*	2.21*	4.65**	4.65**
	Probability	0.003	0.02	0.00	0.014	0.021	0.042	0.000	0.000
	Y = a ± bx	-0.60x + 153.43	-0.03x + 8.29	-0.86x + 89.45	-1.22x + 163.45	-1.29x + 173.85	-0.549x + 97.39	-20.66x + 2787.1	-0.13x + 17.98
	R^2	0.43	0.29	0.46	0.32	0.29	0.23	0.58	0.58
	E.V.%	43.25	29.20	45.58	32.41	29.24	23.34	57.51	57.51
2020/21	r =	-0.64	-0.53	-0.66	-0.63	-0.52	-0.52	-0.80	-0.80
	b =	-0.40	-0.04	-0.75	-1.07	-0.65	-0.64	-22.39	-0.14
	Standard error	0.12	0.02	0.21	0.33	0.27	0.27	4.17	0.03
	T value	3.31 **	2.49 *	3.53 **	3.28 **	2.45 *	2.42 *	5.37 **	5.37 **
	Probability	0.004	0.02	0.00	0.005	0.026	0.028	0.000	0.000
	Y = a ± bx	-0.40x + 143.58	-0.04x + 8.75	-0.66x + 81.69	-1.07x + 154.09	-0.65x + 127.56	-0.64x + 108.72	-22.39x + 2857.19	-0.14x + 18.43
	R^2	0.41	0.28	0.44	0.40	0.27	0.27	0.64	0.64
	E.V.%	40.67	27.84	43.78	40.20	27.28	26.76	64.30	64.30

Data in Tables (4 and 5) offered that, the correlation coefficient among the population density by pest on number of pods per plant of different faba bean cultivars were highly significantly negative (r values; -0.73 and -0.66) through the two seasons, respectively. The calculated regression coefficient (b) indicated that an increase of one individual per 10 plants, would decrease the number of pods produced by each plant by (1.73 and 1.61 pods) during the two seasons, respectively, are presented in Table (4). Conformable, the influence of infestation percentages by pest on number of pods per plant were highly significantly negative correlations (r values; -0.68 and -0.66) during the two seasons, respectively. The calculated regression coefficient (b) showed that an increase of 1% of infestation incidences percentages, would decrease the number of pods produced by each plant by 0.86 and 0.75 pods, for the two seasons, respectively, Table (5).

.B- Effect on pods weight / plant (g):

As shown in Table (3), showed the relationship between the infestation by *A. craccivora* and the pods weight per plant on all tested faba bean cultivars. Giza 40 cultivar was observed the highest population density and the greatest percentages of infestation incidence by *A. craccivora* was exhibiting the less weight (79.13 ± 6.68 and 83.57 ± 3.03 g) was measured during the two seasons, respectively as compared with the tested faba bean cultivars. While, Nubaria 3 cultivar was the lowest population density and the least percentages of infestation incidences by pest, and was exhibiting the greater weight with an average (112.90 ± 14.37 and 111.67 ± 10.53 g) through the two seasons, respectively. . The statistical analysis of the data showed that all faba bean varieties had minor differences in pod weight per plant.

The simple correlation among pest population density and pod weight per plant of specific faba bean cultivars, as shown in Tables 4 and 5, showed significantly negative relationships (r values of -0.53 and -0.58) over the two experimental seasons, respectively .A n increase of one individual per ten plants, according to the unit effect regression coefficient (b)., would cause 2.10 and 2.08 g decrease in the pods weight per plant during the two seasons, respectively, are presented in Table (4). Also, impact of infestation incidences percentages by pest on the pods weight per plant were negative significantly relation (r value was -0.57) through the first season and highly significantly negative correlation (r value was -0.63) through the second seasons. The estimated regression coefficient (b) suggested that an increase of 1% in pest incidence percentages would result in a drop in pod weight per plant of 1.22 and 1.07 g, respectively, for the two seasons ,Table(5).

C- Number of seeds / plant:

In relation to the information in Table (3) showed that, the impact the infestation *by A. craccivora* on the number of seeds per plant of certain faba bean cultivars. Nubaria 3 cultivar had recorded the lowest population density and the least percentages of infestation incidences by pest, and was exposed the more of number of seeds per plant (123.00 ± 22.27 and 96.00 ± 2.31 seeds) over the first and second seasons, respectively as compared the other tested cultivars (Tables, 3 and 4). While, Giza 40 cultivar was recorded the highest population density and the highest percentages of infestation by *A. craccivora*, was appeared the least of number of seeds per plant (78.33 ± 6.17 and 76.33 ± 4.10 seeds) through the two seasons, respectively as compared with the tested faba bean cultivars. Insignificant variances in the number of seeds per plant on the faba bean cultivars (Table, 3).

Results in Tables (4 and 5) showed that, the negative significantly correlations between the population density by pest on number of seeds every plant on tested faba bean cultivars (r values; -0.49 and -0.52) in both seasons, respectively. The studied regression coefficient (b) indicated that an increase of one individual each 10 plants, would decrease the number of seeds per plant by (2.14 and 1.37 seeds) in both seasons, respectively, are presented in Table (4). Corresponding, the effect of infestation incidences percentages by pest on number of seeds per plant were significantly negative correlations (r values; -0.54 and -0.52) in both season, respectively. According to the estimated regression coefficient (b), an increase of 1% in infestation incidence percentages would reduce the number of seeds per plant by 1.29 and 0.65 seeds, respectively, for the two seasons,Table (5).

D- Seeds weight / plant (g):

Data represented in Table (3), showed that, Giza 40 cultivar had observed the highest population density and the greatest percentages of infestation incidence by *A. craccivora*, was exhibiting the less seeds weight per plant (60.87 ± 5.36 and 65.95 ± 6.88 g) was measured over the two seasons, respectively than the other tested faba bean cultivars. However, Nubaria 3 cultivar was the lowest population density and the least percentages of infestation incidences by pest, and was exhibiting the greater weight with an average (69.83 ± 3.00 and 78.82 ± 5.04 g) through the two seasons, respectively. The data was statistically analysed. showed that all faba bean cultivars had minor differences in seed weight per plant.

Tables (4 and 5) reveal that the association between pest population density and seed weight per plant of different faba bean cultivars had statistically negative correlations (r values of -0.57 and -0.52, respectively) during the two study seasons Tables 4 and 5 show that during the two research seasons, the connection between pest population density and seed weight per plant of different faba bean cultivars was statistically negative correlation (r values of -0.57 and -0.52, respectively). According to the regression coefficient (b), an increase of one individual per ten plants would result in a 1.19 and 1.37 g drop in seed weight per plant for the two seasons, respectively ,Table(4). In addition, over the two seasons, the influence of infestation incidence percentages by pest on seed weight per plant was considerably negative (r value was -0.48 and -0.52, respectively). The regression coefficient (b) suggested that an increase of 1% in infestation incidence percentages would cause in a 0.54 and 0.64 g reduction in seed weight per plant for the two seasons, respectively, Table (5).

.E- Yield (Kg / feddan):

Results depicted in Table (3), revealed the relationship among the infestation by *A. craccivora* and faba bean yield (Kg / feddan) on all tested faba bean cultivars. Giza 40 cultivar had the largest population size and the highest percentages of infestation incidence by A. craccivora, although it produced less yield (1140.74 ± 52.60 and 1157.33 ± 56.71 Kg / feddan) was measured during the two seasons, respectively, than the other faba bean cultivars. During the two seasons, the Nubaria 3 cultivar had the lowest population density and the lowest percentages of pest infestation incidents, as well as the highest yield (1827.78 ± 72.27 and 11848.65 ± 75.50 Kg Per feddan, respectively). Statistical analysis of the data shoewd that there were in the extreme significant differences in faba bean yield (Kg / feddan) on all various faba bean cultivars during the two seasons (L.S.D. values: 165.80 and 165.38).

Data represented in Tables (4 and 5) indicated that the simple correlation among the population density by pest and the faba bean yield (Kg / feddan) of certain faba bean cultivars, proved significantly negative relations (r values were -0.80 and -0.77) for each of the two research seasons, . The effect regression coefficient (b) showed that an increase of one individual per 10 plants, would effect 40.54 and 46.31 (Kg per feddan) decrease in the yield weight in the both seasons, respectively, are presented in Table (4). Also, effect of infestation incidences percentages by pest on the faba bean yield (Kg per feddan) were highly negative significantly relation (r values; -0.76 and -0.80) during the two seasons, respectively. The regression coefficient (b) indicated that an increase of 1% of infestation incidences percentages, would decrease the faba bean yield weight by 20.66 and 22.39 (Kg per feddan), were measured for the two seasons, respectively, Table (5).

F- Yield (Ardab / feddan):

The results in Table (3) show a relation between *A. craccivora* infestation and faba bean yield (Ardab/feddan) on all tested faba bean varieties (3). Nubaria 3 had the lowest population density and the lowest insect infestation rate, with a high average output (11.79 0.47 and 11.93 0.49 Ardab/feddan) over two years. Throughout the two seasons, the Giza 40 cultivar, which had the highest population density and percentages of A. craccivora infection, had lower yield (7.36 0.36 and 7.47 0.37 Ardab per feddan) than the other faba bean cultivars. For both seasons, there were extremely significant differences in faba bean yield (Ardab / feddan) among the studied faba bean cultivars (L.S.D. values: 1.07 and 1.07). (Tables, 3).

Data obtained in Tables (4 and 5) indicated that the simple correlation between population density by pest and the faba bean yield of certain tested faba cultivars (Ardab/feddan) was found to be significantly negative for both of the study season (r values were -0.80 and -0.77). The effect regression coefficient (b) it was suggested an increase of one individual each 10 plants would result in yield weight decreases of 0.26 and 0.30 (Ardab per feddan) throughout the two seasons, respectively, as shown in Table (5). Also, over the two seasons, the influence of infestation incidence percentages by pest on faba bean yield (Ardab per feddan) was highly negative significantly (r values; -0.76 and -0.80), respectively. For the two seasons, the regression coefficient (b) suggested that an increase of 1% in pest incidence percentages would reduce yield weight by 0.13 and 0.14 Ardab per feddan, respectively. As cowpea aphid, transfers toxic substances by salivary secretions, The loss of phloem sap from their host plants has a significant impact on their growth. As a result, aphid infestation reduces nutrient mass flow in the primary growth zone (Pollard, 1973). Also, Hhinze and Daebeler (1982) in Germany, studied the harmful effect of A. faba on faba bean plants and found that yield losses of the variety Fribo was depending on the length of time and the intensity of aphid colonization; aphid attack beginning at the ones of flowering stage in the field caused loss in grain weight by 50%. Infestation at the time of pod setting resulted in yield reduction of up to 6%. El-Defrawi (1987) indicated that seed yield losses in faba bean cv. Giza 402 ranged between 10.97 to 100% in different treatments of aphid infestation. Salem (1998) demonstrated that yield losses in faba bean owing to *A. craccivora* are dependent on colonisation timing and severity. According to Bishara et al. (1984), faba bean yield losses are dependent on the time and degree of aphid infestation. Saxena and Stewart (1983) referred to 72.5 % loss in seed yield of 50 faba bean plants affected by aphid infestation in Egypt. El-Defrawi et al. (2000), found abnormal large colonies of cowpea aphids build up early, who caused distortion of leaves, stems and abort flowers, drop newly buds and plants may collapse. By the time such symptoms are evident, there will have been yield loss. Hossni (2004) in Egypt,

reported that the most variations in yield of faba bean cultivars were correlated to the size of *A. craccivora* infestations. El-Defrawi and El-Harty (2009) in Egypt, recorded that the yield losses caused by A. craccivora attacking ten faba bean cultivars (Sakha 1, Giza 3 improved, Giza 716, Giza 843; Misr 1, Misr 2, Giza 2 improved, Giza 40, Giza 429 and Nubaria 1). Who stated that, aphid infestation adversely affected growth parameter adopted e.g., seed yield. However, all cultivars were similarly susceptible to aphid attack, as evidenced by a loss in seed output that ranged from 12.785 to 61.072 percent among cultivars. A substantial negative linear association was also discovered between the number of aphids at the initial infection and seed yields of the 10 varieties.

Conclusions:

Carried study proved the faba bean cultivars varied significantly in their susceptibility to population size and the percentages of infestation incidence by *A. craccivora* faba bean cultivar (Giza 40) was the highest population density and the highest percentages of infestation incidences by pest, and was rated as highly susceptible (H.S.) to infestation. In contrast, Nubaria 3 cultivar had the lowest population density and the least percentages of infestation incidences by pest and was rated as moderate resistant (MR) of pest over the entire season. Increasing the number of insect individuals per ten plants reduced faba bean yield by 40.54 and 46.31 kg/feddan, and 0.14 and 0.30 Ardab/feddan, respectively, across the two seasons. As well, an increment of 1 % in the percentages of infestation incidences by *A. craccivora* would decrease the yield faba bean by 20.66 and 22.39 kg/feddan and 0.13 and 0.14 Ardab/feddan during the two seasons, respectively. This study's findings could be utilized to make an aphid IPM programme for faba bean plants.

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