INJURY LEVELS AND YIELD LOSS MODEL FOR THE COWPEA APHID *APHIS CRACCIVORA* KOCH ON *VICIA FABA* (L)

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Abstract

Two experimental techniques were conducted based on the natural infestation of faba bean local varieties (cultivars) by aphids or by infestation percentage, during 2006/07 and 2007/08 seasons at Sids ARS, Beni-Suef Governorate, Middle Egypt. Yield losses caused by the cowpea aphid A. craccivora attacking ten faba bean cultivars (Sakha 1, Giza 3 improved, Giza 716, Giza 843; Masr 1, Masr 2, Giza 2 improved, Giza 40, Giza 429 and Nubaria 1 variety) recommended for cultivation in Egypt were estimated. Results obtained showed aphid infestation adversely affected growth parameter adopted e.g., seed yield. However, all the cultivars were equally susceptible to aphid attack as manifested in terms of reduction in seed yield which varied from 12.785 to 61.072 % among different cultivars. A significant negative linear relationship between the number of aphids at the initial infestation and seed yields of the 10 cultivars was detected. Masr 1 variety exhibited the least infestation levels (1.87); while cv. Giza 40 variety scored the highest infestation index (3.28). The remaining varieties had various levels of infestation ranged between 2.08-3.07 indices

The second experiment showed that the yield obtained at various levels of infestation differed significantly from that of the untreated check during all the 2 successive years. The overall mean increase in seed yield ranged from (0.00 – 1.487 t. /fed.) and (0.108 – 1.281 t. /fed.), for Masr 1 and Giza 429 variety, respectively, and their differences were significant. The mean gain over control varied from Masr1 and Giza 429 variety at different levels of plant infestation. However, the differences in the gain from 50 to 70 per cent level of infestation were within a narrow range. Three sprays were given to maintain the 20-50 % levels of infestation is quite, and perhaps in some cases of aphid outbreaks need one spray added to keep plant full protected. The initial number of aphids which might cause detectable losses in seed yield of faba bean cv. Masr 1 and Giza 429 variety, was detected above 70 aphids per plant shoot at 5 % plant infestation. The correlation between the number of aphids per plant and yield obtained of faba bean Masr 1 and Giza 429 variety, was negative and significant (56.588 X – 1133.6 R^2 = 0.7247) and (53.167X – 2451.5, R^2 = 0.6214), respectively. The economic-injury level (EIL), i.e., the number of aphids that will cause enough economic damage identical with the cost of the

insecticidal treatment was 89.47 and 144.83 aphids per plant shoot, and the economic threshold (ET), being 48.99 and 112.75 aphids /plant shoot in cv. Masr 1 and Giza 429, respectively. The need and implementations of initiating spray operations at the lower level of aphid infestation have been discussed.

INTRODUCTION

In the last two decades in Egypt, the national production of faba bean is limited to a greater extent due to the losses caused by the cowpea aphid pest (*Aphis craccivora* Koch). It can be controlled by the application of insecticides (El-Gantiry, 1982; El-Defrawi & Abd El-Azim, 1992 and Amer *et al.*, 1995). Three sprays at 15-20 day intervals are recommended for the control of this pest in the different regions of Egypt. Thus, most farmers in the different districts of Egypt, have become familiar with a range of insecticides which they can use to increase their yields and profits. Unfortunately, the intensive use of insecticides has generated major problems with most faba bean growers in different sites of Egypt. Insecticides do not kill all of the aphids in faba bean crop. Some survive and become higher threat and resistant, that mate and breed, and within a few generations the surviving populations can become virtually immune to the insecticides. There are now many well established cases of aphids becoming resistant to insecticides that they can no longer be controlled economically (Marzouk. 1990; El-HarIry *et al.*, 1995 and 1998). Hazard uses insecticides could kill beneficial insects such as the natural enemies and bees which pollinate many of our crops (El-Heneidy *et al.*, 1991). Where insecticides have been indiscriminately used, farmers may be faced eventually with of the enormous populations of pests that are resistant to insecticides and are not checked by their natural enemies. 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 that cannot be recovered by spraying insecticides to control this aphids. Therefore, faba bean crop producers may be repeatedly treated before aphid numbers increase markedly (El-Defrawi *et al.*, 2002). The old recommendation of three sprays, therefore, needs to be revised in the light of the changed agro technology. Also most of the pesticides are lipophilic in nature. Their use on legume crops, therefore, needs to be minimized. This can be achieved through the judicious use of pesticides on the basis of population assessment (economic threshold).

A basic factor of integrated pest management to day, is the recognition of the fact that injurious pest neither can be nor have to be totally eradicated. They can be tolerated to a certain economic threshold level that has to be determined for each pest separately. This involves a judgment of the extent to which a particular pest population can be allowed to increase before a pesticide must be applied to prevent further crop loss. The concept of economic threshold implies that a pest control procedure is merited when the present costs of the procedure are equal to future benefits (David, 1987). Economic threshold actually has a variable value that may differ with, among other factors, the variety and age of the crop, its location, and previous damage received, simultaneous infestation of other pests and agronomic practices such as plant spacing, fertilizer levels and irrigation etc. Factors such as the market value of the crop, the cost of pesticide application, the expected income of growing another crop instead, and the weight of all negative health, social and environmental effects would also have to be considered (Bakhetia *et al.*, 1987).

The economic threshold of the cowpea aphid on faba bean crop has not been determined so far in major local cultivars. Studies were, therefore, carried out to develop economic threshold of the cowpea aphid on two recommended cultivars of faba beans. In addition, the present work is conducted using different models for estimating the relationship between yield loss in 10 local varieties (cultivars) and different levels of damage resulting from different population size of the cowpea aphid *A. craccivora.*

MATERIALS AND METHODS

In an attempt to determine the injury levels and yield loss due to faba bean aphid infestation, two experimental designs were conducted at Sids Agricultural Research Station, ARC, Beni-Suef Governorate, Middle Egypt, during two successive seasons of 2006/07 and 2007/08.

1- The first experimental design:

In order to quantify the relationship between yield loss and aphid infestation levels build up faba bean. Ten faba bean varieties were used, that have been recently released as commercial cultivars in Egypt namely: Sakha 1, Giza 3 improved, Giza 716, Giza 843 for cultivation in North Delta Region; Masr 1, Masr 2, Giza 2 improved, Giza 40, Giza 429 for both Upper and Middle Egypt Region; and cv. Nubaria 1 variety to plant in new reclaimed areas at Behaira Governorate. The field was divided into two equal areas of experimental plots 6 X.7 meters each, i.e. 10 rows, 6 m long, separated by 1 m wide uncultivated strips. The plots were in a

completely randomized block design with 4 replicates for each cultivar. Seeds of all cultivars were sown on the 1st. week of November in both seasons. Normal agricultural practices were done regularly in due time adopting the recommendation packages and they were the same in all treatments. One of the two areas was sprayed periodically at 2-week intervals starting on infestation build-up with Pirimicarb insecticide, *e.g.* Aphox (50 % DG), at the rate of 0.5 g /liter to keep the plants aphid-free (full protection). The other area was not sprayed with any insecticide to allow for natural aphid infestation. Aphid population in each plot was estimated weekly by counting the number of aphids on 10 shoots (main stem) selected at random from 10 plants in the medium five rows in each plot.

Aphid infestation index: Adopted (Sirohi *et al.*, 1966 and El-Defrawi & Rizk,2002), Twenty-five plants of a given tested cultivar, from each of the four replications, selected at random are to be observed and the degree of infestation level recorded and categorized as 1, 2, 3, 4 and 5 according to Visual and Inspection Counts and its symptoms given as follows (Hafez, 1964 and El-Defrawi *et al.*,1991):

Rating scale	Designation
1	up to 20 aphids /plant shoot, there is no obvious symptom of attack.
2	21-50 aphids /plant shoot, aphid colonies present on the 1/3 plant height, plant damage showing less than the untreated control.
3	51-100 aphids /plant shoot; aphids are not in recognizable colonies but diffused to infest large proportions of leaves and stems, more than one shoot infested and plants as same damage as untreated control.
4	101-500 aphids /plant shoot; present in very dense numbers, infesting all plant parts, on the 2/3 plant height and plants showing as much damage as the control.
5	> 500 aphids /plant shoot; plants showing severely infest by aphids cover nearly all plant surfaces and greater damage than the control.

The Infestation index is calculated as given below:

$$\text{Infestation index} = \frac{\text{Ixa + Iixb + IIIxc + Ivxd}}{\text{a + b + c + d}}$$

where I, II, III and IV are the grades, and

a, b, c and d are the number of plants falling in each grade.

Aphid Injury: Measure of damage caused directly by aphid infestation can be estimated in each cultivar separately based on seed yield obtained (ton /feddan) in treated plots (Unprotected) naturally infested with aphids, compared to non-infested healthy plants in sprayed plots (Protected) (El-Defrawi and Shalaby, 2002). Percentage reduction or loss in yield due to aphids was thus evaluated as follows:

Potential yield – Actual yield /Potential yield X 100

2- The second experimental design:

To determine action (A.L.) levels based on injury levels and the best timing of insecticide application for controlling cowpea aphid *A. craccivora* Koch., on the faba bean plants cultivar Giza 429 and Masr 1 variety. Percent plants naturally infested with cowpea aphid , was the criterion for recording observations. When an aphid colony is presented on the uppermost two-thirds of a faba bean plant, the plant is considered infested. A mother aphid along with at least 20 individuals on the central shoot (tiller) constituted the aphid colony. Ten levels of plant infestations (5, 10, 20, 30, 50, 60, 70, 80, 90 and 100 %), plus two checks, including infested and aphid-free treatments, comprised the experiment laid out in a randomized block design in four replications and a plot size of 6 X 7 m. The recommended agronomic practices and irrigation regimes were adopted. Plants in each plot were checked at weekly intervals. The infestation levels were maintained by spraying with the recommended insecticide Aphox (Pirimicarb) at the rate of 0.5 g / L, in the particular plots whenever the mean percent of plants infested reached or crossed the indicated level. This was continued from the seedling stage onwards. At harvest, the seed yield obtained was estimated. Also, gain per Feddan was calculated by subtracting the cost of insecticide used plus labor charges and spray operations from the cost of extra yield over the control, obtained in a particular treatment.

Data obtained were subjected to statistical analysis. The economic-injury levels (EIL), and economic threshold (ET) were finally computed according to David's (1987) formulae:

$$EIL\ t(h) = xt = \frac{C(h) - C(h^*)}{Py\,[s(h^*) - s(h)]}$$

ET is calculated from:

$$C(ht)-C(h^*t) = D\{t\,[s(ht^*)]\} - D\,\{xt\,[s(ht)]\}$$

Where:

C: Is the cost of control in LE per Feddan

P: Is constant price in LE per kilogram

D: Is the damage in LE per Feddan

x: Is a function of pest density

y: Is yield loss units in kilogram per Feddan

s: Is control-related survival

h: Is the control tactic and time and labor involved in implementation

h*: Signifies lack of control

The EIL at time "T" is the density "D" for which the cost "C" of a control tactic equals the damage prevented by implementing that tactic.

Growth Rate: The growth rate of aphid's population on cv. Masr1 and Giza 429 were calculated according to the following equation (Singh *et al.*, 1965):

$$r = P2 - P1 / P1 * 100$$

Where, r = population growth rate

$P1$ = number of aphids of the first reading

$P2$ = number of aphids of the second readings

Aphid-Day = (mean aphids /plant + mean aphids /plant
Last week this week) ÷ 2 * days between sample dates.

RESULTS AND DISCUSSION

1. Yield Loss Model For *Aphis craccivora* Koch on Faba Bean.

a. Population Abundance of Cowpea Aphid:

The data on population density of CA (*Aphis craccivora* Koch) on the ten commercial cultivars: Skha 1, Masr 1, Masr 2, Nubaria 1, Giza 2 improved, Giza 3 improved, Giza 40, Giza 429, Giza 716 and Giza 843 are given in Table 1, revealed that there was significant variation in aphid population under different treatments protected and unprotected ones. However, two cultivars Masr1 and Giza 716 harbored significantly lower aphid population than the others. Moreover, they showed good vegetative growth and nicely filled large pods compared to the adjacent varieties, which were heavily infested and seriously damaged by the aphid during the two years. There was not much difference in aphid population with the other remaining cultivars and signified as moderately to highly susceptible ones.

In general, during the whole three growth stages of plants in the ten cultivars, results exhibited that Masr 1 harbored the least aphid populations (1.87); while cv. Giza 40 scored the highest infestation index being 3.28. The remaining varieties had various levels of infestation ranged between 2.08-3.07 indices.

b. Yield Attributes and Aphid:

Measurement of damage due to aphid infestation on the ten varieties was evaluated by comparing yields of naturally infested plants (unprotected) with insect-free plants (protected) through the 2006/07 and 2007/08 growing seasons. Data presented in Table 2, showed that the yield attributes owing to aphid attack were differed and significantly influenced due to the level of aphid infestation (LSD 0.05 = 0.605) and the variation in susceptibility of the 10 cultivars to aphid attack in the two years (LSD 0.05 being 14.28 and 16.72, respectively). The loss in seed

yield in the two tested seasons 2006/07 and 2007/08 all together being Skha 1 (0.44 t./fed), Masr 1 (0.17 t./fed), Masr 2 (0.53 t./fed), Nubaria 1 (0.56 t./fed), Giza 2 improved (0.40 t./fed), Giza 3 improved (0.79 t./fed), Giza 40 (0.34 t./fed), Giza 429 (0.21 t./fed), Giza 716 (0.24 t./fed) and Giza 843 (0.83 t./fed). The annual reduce in seed yield obtained due to aphid infestation in the two years was 0.414 and 0.487 t. /fed., respectively.. Accordingly, the 10 faba bean cultivars could be arranged in a descending order based on percentages of yield loss values over the 2 successive years as follows: Giza 3 improved (62.11 %), Giza 843 (52.60 %), Nubaria1 (46.80 %), Masr 2 (33.78 %), Giza 2 improved (29.32 %), Skha 1 (28.34 %), Giza 40 (24.47 %), Giza 716 (20.40 %), Giza 429 (17.93 %) and Masr 1 (13.07 %).

The rate of decrease in seed yield was higher in 2007/08 than 2006/07, and was found 0.414 and 0.487 t. /fed. in the first and second season with R^2 values of 0.8657 and 0.9508, respectively. Annual averages in crop reduction were of 25.963 ± 4.092 % and 39.755 ± 5.755 %, respectively as shown in (Table, 2).

Table 1. Relative susceptibility of 10 faba bean varieties to *A. craccivora* infestations at three plant growth stages under field conditions at Sids, A.R.C., during 2006/07 and 2007/08 growing seasons.

v.n.	Varieties	Mean aphid infestation index during											
		2006/07				2007/08				Mean			
		S	F	P	Mean	S	F	P	Mean	S	F	P	Grand mean
1	Skha 1	1.3	2.7	3.1	2.37	1.5	3.0	3.0	2.50	1.40	2.85	3.05	2.43 ab
2	Masr 1	1.2	1.8	2.2	1.73	1.7	2.2	2.1	2.00	1.45	2.00	2.15	1.87 a
3	Masr 2	1.8	2.3	2.8	2.30	2.0	2.2	2.7	2.30	1.90	2.25	2.75	2.30 ab
4	Nubaria 1	2.3	2.8	3.1	2.73	2.5	3.0	2.9	2.80	2.40	2.90	3.00	2.77 bc
5	Giza 2 Imp.	1.4	3.0	3.2	2.53	1.6	3.6	4.1	3.10	1.50	3.30	3.65	2.82 bc
6	Giza 3 Imp.	2.6	3.4	3.3	3.10	2.4	3.3	3.4	3.03	2.50	3.35	3.35	3.07 cd
7	Giza 40	2.1	3.0	3.7	2.93	2.4	4.1	4.4	3.63	2.25	3.55	4.05	3.28 d
8	Giza 429	1.6	2.7	3.2	2.50	1.6	3.1	3.7	2.80	1.60	2.90	3.45	2.65 bc
9	Giza 716	1.7	2.1	2.6	2.13	1.9	2.0	2.2	2.03	1.80	2.05	2.40	2.08 ab
10	Giza 843	2.2	2.5	2.5	2.40	2.4	2.8	3.0	2.73	2.30	2.65	2.75	2.57 bc
L.S.D. (0.05) between verities		0.505				0.766				0.605			

* Means followed by the same letter are insignificantly different from each other at 0.05 level of probability.

S: Seedling stage 30-days

F: Flowering stage 65-days

P: Pod-setting stage 105-days

c. Avoidable Losses in Yield:

The seed yield production was drastically reduced under unprotected condition as compared to protected condition in all the 10 cultivars under investigation (Table, 2). Highest seed yield was obtained from protected cv. Skha 1, Giza 843, and Masr 2 by 1.664, 1.621 and 1.606 t. /fed., respectively. Highest seed yield of 1.220 and 1.146 t. /fed., was recorded in cv. Skha 1 and Masr 1 respectively, under unprotected fields. On the other hand, the seed yield decreased considerably in cv. Giza 843, Nubaria 1 and Giza 3 improved being 0.793, 0.682 and 0.501 t. /fed., respectively under unprotected condition in the two years.

Table 2. Estimation of seed yield losses in 10 faba bean cultivars due to aphid infestation at Sids, A. R. C, Beni Suef Governorate (2006/07 and 2007/08).

v.n.	Varieties	Seed yield (t /fed.) and Reduction (%) at respected variety						Mean seed yield (t /fed.) at field plots		Additional yield over unprot. (t /fed.)	Avoidable losses in seed yield (%)
		2006/07 season			2007/08 season						
		Prot.	Unpr..	% R	Prot.	Unpr..	% R	Prot.	Unpr..		
1	Skha 1	1.891	1.584	16.23	1.437	0.856	40.45	1.664	1.220	0.444	26.683
2	Masr 1	1.493	1.333	10.70	1.135	0.959	15.44	1.314	1.146	0.168	12.785
3	Masr 2	1.824	1.285	29.57	1.387	0.860	37.99	1.606	1.073	0.533	33.188
4	Nubaria 1	1.406	0.947	32.64	1.068	0.417	60.96	1.237	0.682	0.555	44.867
5	Giza 2 Imp.	1.612	1.274	20.96	1.226	0.764	37.67	1.419	1.019	0.400	28.189
6	Giza 3 Imp.	1.462	0.663	54.61	1.111	0.338	69.60	1.287	0.501	0.786	61.072
7	Giza 40	1.632	1.321	19.09	1.242	0.871	29.84	1.437	1.096	0.341	23.730
8	Giza 429	1.384	1.167	15.68	1.052	0.840	20.18	1.218	1.004	0.214	17.570
9	Giza 716	1.331	1.082	18.74	1.012	0.789	22.05	1.172	0.935	0.237	20.222
10	Giza 843	1.841	1.079	41.41	1.400	0.507	63.79	1.621	0.793	0.828	51.080
Mean ± s.e.		1.588 ± 0.062	1.174 ± 0.075	25.963 ± 4.092	1.207 ± 0.047	0.720 ± 0.065	39.797 ± 5.755	1.398 ± 0.054	0.947 ± 0.067	0.451 ± 0.068	31.939 ± 4.694
"T" value		4.037***			5.764***			4.942***		-	-
LSD 0.05		14.28			16.72			-	-	-	-

Prot.: Protected plants; Unpr.: plants infested naturally by aphids.

% R: Per cent reduction in seed yield = C – T / C * 100.

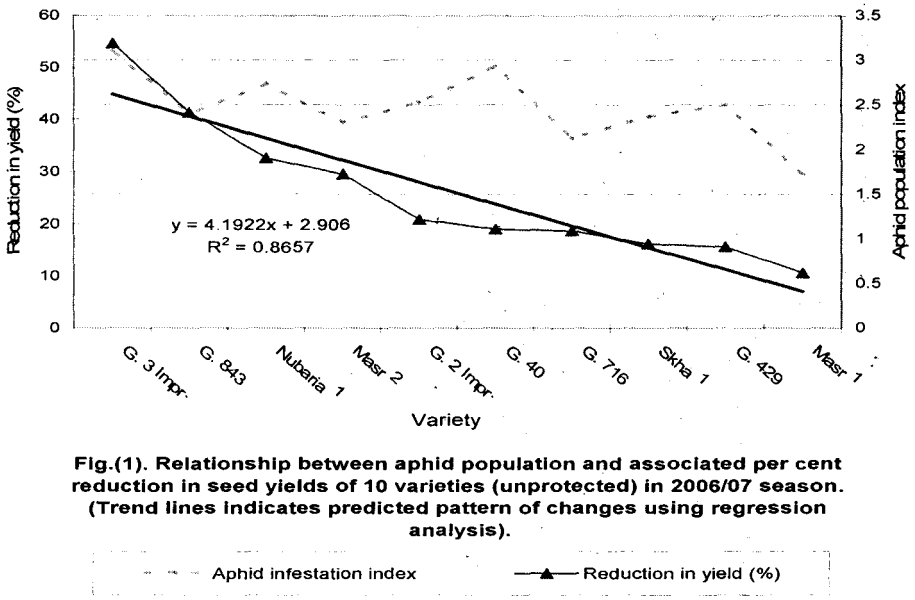

Fig.(1). Relationship between aphid population and associated per cent reduction in seed yields of 10 varieties (unprotected) in 2006/07 season. (Trend lines indicates predicted pattern of changes using regression analysis).

During all together of the two years of study the seed yield was lowest in unprotected condition. The yield loss varied from 110.70 to 54.61 % in 2006/07 and 15.44 to 69.60 % in 2007/08. Thus it was observed that there was up to 70 per cent yield loss of faba bean without proper and timely plant protection under open fields at Middle Egypt Region as the crop could not sustain the infestation and failed to survive. On an average there was 25.963 .to 39.797 per cent yield loss without plant protection. Hinz and Daebele (1984) found that the initial infestation by aphids on faba bean which started at the flowering stage caused a reduction of 52-64 % in seed yield. Also, El-Defrawi and Abd El-Azim (1992), reported the avoidable losses due to cowpea aphid up to 71.0 per cent. Similarly, El-Defrawi *et al.* (1998) observed 82.40 to 88.30 per cent yield loss due to aphid, the additional yield from protected field plot as compared to unprotected plot ranges from 0.160 to 0.799 and 0.176 to 0.773 t. /fed. In 2006/07 and 2007/08 respectively under different cultivars. Atwal *et al.*, 1971 also found the avoidable losses due to mustard aphid up to 69.6 per cent. Similarly, El-Defrawi *et al.* (1998) reported the avoidable loss in seed yield of faba bean Giza 2 varieties due to A. craccivora attack was 0.081 to 1.308 t /fed.

The influence of aphid density build up 10 faba bean cultivars during the two consecutive years of 2006/07 and 2007/08 was worked out through the regression analysis. Using the percentage of yield loss and the infestation index per plant as parameters, and the data graphically illustrated in Fig., 1 & 2, showed that an increase in aphid infestation index per plant (x) is followed by an increase in

yield loss (y) as follows: Y = 4.1922 X + 2.906 (R^2 = 0.8657) and Y = 6.1782 X + 5.8167 (R^2 = 0.9508) in the two years, respectively Thus, yield related well to estimated a regression coefficient values of aphid-days on the respected 10 cultivars and the associated per cent yield loss was exhibited highly significant relationship and represented as follows:

% Yield loss = 0.0128 X aphid-days.(r = 0.4758, *P >0.05*)

During all the two years of study the seed yield was lowest in unprotected condition and the seed yield loss varied from 12.785 to 61.072 %. Thus, it was indicated that there was more than 60 per cent yield loss of faba bean crop could be happened without proper and timely plant protection under open field sowing on 1st. week of November as the crop did not sustain the infestation and failed to survive. The additional yield from protected field plots as compared to unprotected plot ranges from 0.168 to 0.828 t. /fed.

Fig. 3, shows the correlation between the population density of *A. craccivora* and the corresponding percentage reduction in seed yield of the 10 faba bean cultivars. Combined results of two successive seasons revealed positive and statistically highly significant correlation in seed yield loss to aphid infestation indices by 93.51 % variation, in the two years. The linear relationship being (Y = 5.121 X + 4.7167). Kieckhefer and Kantack (1986), mentioned that the correlation coefficient for the relationship between mean aphid number and final yield showed close agreement between those numbers and loss in seed yield. It is worth to mention that the character of tolerance to aphid attack did not necessarily mean that the cultivar gives the highest yield, but mainly exhibited less damage throughout unsuitability for build-up of aphid population (Bond & Lowe, 1975 and El-Defrawi & Bishara, 1992). This ability is most probably due that chemical composition of plants is of fundamental significance in their acceptance orientation as food by insects. This is true with regard to selection between different plant species (Hsiao & Fraenkel, 1968) or by interfering with host-selection stimuli, such as leaf shape and colour (Klingauf, 1987). Hinz and Daebeler (1984) found that the initial infestation by aphids on faba bean which started at the flowering stage caused a reduction of 52-64 % in seed yield. Berlandier and Sweetingham (2003) found the extent of lupine damage caused by aphids (*Aphis craccivora and Acyrthosiphon kondoi*) varied greatly but it was significantly influenced by lupine cultivars, and yields for the same treatment regimes (protected and unprotected), varied between geographical locations. They also added that, a single foliar spray of the insecticide Pirimicarb controlled abundant aphids and increased yield by as much as 95 % (0.55 t. /ha) in Wodjil- Australia.

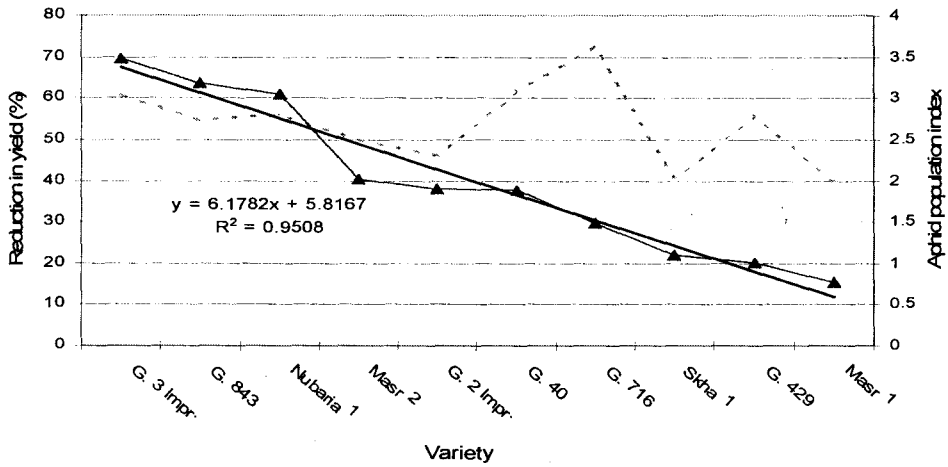

Fig.(2). Relationship between aphid population and associated per cent reduction in seed yields of 10 varieties (unprotected) in 2007/08 season. (Trend lines indicates predicted pattern of changes using regression analysis).

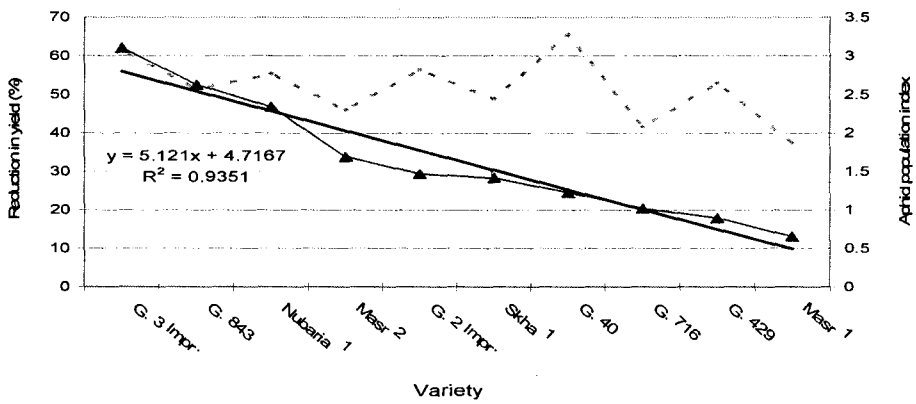

Fig.(3). Relationship between aphid population and associated per cent reduction in seed yields of 10 varieties (unprotected) average reading of (2006/07 + 2007/08).
(Trend lines indicates predicted pattern of changes using regression analysis).

2. Injury Levels For *Aphis craccivora* Koch on Faba Bean

The yield obtained in all levels of aphid infestation maintained on the faba bean fields during the 2 successive years of study for the two commercial cultivars Masr 1 and Giza 429 were equally and significantly higher than that obtained in the untreated control (A). The same trend was observed in case of increase in yield over control (Table, 3 & 4). Statistical analysis of the data revealed highly significant differences existed between the ten levels of plant infestation by aphids

(L.S.D. at 0.01 = 91.20 & 129.6, for the two cultivars, respectively. The increase in seed yield over control (0.748 and 0.747 t. /fed., and ranged between -0.01-1487 and 0.108-1.281 t. /fed., for the two cultivars Masr 1 and Giza 429, respectively. These differences may be attributed to the sensitivity levels of the cultivars Masr1 and Giza 429 and the distribution of this aphid species start in the fields. Hence, it gave equally good yields, being (1.782 and 1.630 t. /fed.), and (1.411 and 1.327 t. /fed.), when plants maintained at 5 and 10 % levels of infestations. These yields were not significantly different from the control yield of aphid-free fields (B) (1.778 and 1.446 t. /fed., for cv. Masr 1 and Giza 429 varieties, respectively).

The relationship between the reduction in seed yield and the associated levels of plant infestation was positively correlated and statistically highly significant (r =0.9556*** and 0.9736***). Also, the same factor was highly significant correlated with the mean number of aphids (r = 0.8887*** and 0.9527***), for the two cultivars Masr 1 and Giza 429, respectively.

Table 3. Economics of aphid control on faba bean variety Masr 1 on the basis of pooled yield under different number of sprays given over 2 successive seasons (2006/07-2007/08), Sids, ARC, Beni-Suef Govern., Middle Egypt.

Per cent Plant infested	Mean no. aphids /plant	Mean seed yield (t. /fed.)	Avoidable loss in seed yield (%)	Increase in seed yield over control (t. /fed.)	Price of seed yield (LE. /fed)*	Cost of chem. control** (LE. /fed)	Gain over control (LE./fed)*
5	285.6	1.782	0.00 a	1.487	5948.0	160 (4)	5788.0
10	380.8	1.630	8.32 a	1.335	5340.0	160 (4)	5180.0
20	542.8	1.272	28.46 b	0.977	3908.0	120 (3)	3788.0
30	798.4	1.128	36.56 b	0.833	3332.0	120 (3)	3212.0
50	1057.6	1.025	42.35 c	0.730	2920.0	120 (3)	2800.0
60	1340.0	0.931	47.64 c	0.636	2544.0	80 (2)	2464.0
70	1660.4	0.878	50.62 c	0.583	2332.0	80 (2)	2252.0
80	2762.4	0.782	56.02 d	0.487	1948.0	80 (2)	1868.0
90	2672.0	0.716	59.73 d	0.421	1684.0	40 (1)	1644.0
100	5292.0	0.285	83.97 e	-0.010	-40.0	40 (1)	-80.0
Check control							
A-Unsprayed	2866.7	0.295	83.41		1180.0	-	-
B-Protected (Aphid-free)	0.0	1.778	a		7112.0	-	-

* At seed price of L.E. 4000 per ton.
** At insecticide cost + labor charge operation, L.E. 40/ fed.
a, b, c, d and e are the rank for loss in seed yield.
Figures in parentheses are the number of sprays given in a particular treatment.

As regards the gain over control, it was highest (LE /fed. 5788.0 & 5180) and (LE /fed. 4964.0 & 4628.0) in 5 and 10 per cent plant infestation in the two cultivars respectively during the two years. It was also found that the gain over control closely followed by that obtained (LE /fed. 3788.0 & 3212.0) in 20 and 30 per cent plant infestation in cv. Masr1; while this value reached (LE./fed. 3812.0, 3320.0 and 3080.0), in 20, 30 and 50 per cent plant infestation was maintained in cv. Giza 429. On the other hand, the lowest gain of Masr1 and Giza 429 was obtained in case of 100 per cent plant infestation (LE. /fed. -80.0 & 392.0, respectively.). The mean gain over control varied from Masr1 and Giza 429 at different levels of plant infestation. However, the differences in the gain from 50 to 70 per cent level of infestation were within a narrow range. In general three sprays were given to maintain the 20-50 % levels of infestation is quite, and perhaps in some cases of aphid outbreaks need one spray added to keep plant full protective.

The number of sprays required to maintain the given levels of percentage of plants infested with aphids varied from 1 to 4 in different seasons. The economics of the aphid control on the basis of pooled yield obtained in different number of sprays has been summarized in Tables (3 and 4). The maximum gain over control (L.E /fed. 5788.0 & 5180.0) and (L.E /fed. 4964.0 & 4628.0) were received 4 successive sprays given to maintain plant infestation in 5-10 % levels, followed by (L.E /fed. 3788.0, 3212.0 and 2800.0) and (LE. /fed. 3812.0, 3320.0 and 3080.0) with 3 sprays to maintain 20, 30 and 50 % infestation levels in Masr1 and Giza 429, respectively. The minimum gain over control (LE /fed 1644.0 & -80.0) and (LE /fed. 1728.0 & 392.0) was from the field plots which received only one spray and the percentage of plant infestation ranged between 90-100 % over two years.

Table 4. Economics of aphid control on faba bean variety Giza 429 on the basis of pooled yield under different number of sprays given over 2 successive seasons (2006/07-2007/08), Sids, ARC, Beni-Suef Govern., Middle Egypt.

Per cent Plant infested	Mean no. aphids /plant	Mean seed yield (t. /fed.)	Avoidable loss in seed yield (%)	Increase in seed yield over control (t. /fed.)	Price of seed yield (LE. /fed)*	Cost of chem. control** (LE. /fed)	Gain over control (LE./fed)*
5	250.0	1.411	2.42 a	1.281	5124.0	160 (4)	4964.0
10	384.4	1.327	8.23 a	1.197	4788.0	160 (4)	4628.0
20	546.4	1.113	23.03 b	0.983	3932.0	120 (3)	3812.0
30	766.8	0.990	31.54 b	0.860	3440.0	120 (3)	3320.0
50	1110.8	0.930	35.68 b	0.800	3200.0	120 (3)	3080.0
60	1444.0	0.850	41.22 c	0.720	2880.0	80 (2)	2800.0
70	2162.0	0.753	47.93 c	0.623	2492.0	80 (2)	2412.0
80	2677.2	0.589	59.27 d	0.459	1836.0	80 (2)	1756.0
90	3536.4	0.572	60.44 d	0.442	1768.0	40 (1)	1728.0
100	4031.6	0.238	83.54 e	0.108	432.0	40 (1)	392.0
Check control							
A-Unsprayed	4139.3	0.130	91.01		520.0	-	-
B-Protected (Aphid-free)	0.0	1.446	a		5784.0	-	-

* At seed price of L.E. 4000 per ton.
** At insecticide cost + labor charge operation, L.E. 40/ fed.
a, b, c, d and e are the rank for loss in seed yield.
Figures in parentheses are the number of sprays given in a particular treatment.

The cowpea aphid reproduces parthenogenetically at a very fast rate of multiplication during November-December (El-Defrawi *et al.*, 2000). It has also been reported that from mid-February onward the cowpea aphid population in the field starts declining due to mortality factors like natural enemies, raise in temperature and hardiness of host tissues (Atwal *et al.*, 1971; Azza, 1980; Bakhetia *et al.*, 1987 and El-Defrawi *et al.*, 2000). It is therefore, apparent that the control of the initial build up of the aphid population is more important. The first spray should therefore be given when 5-10 per cent plants are infested with the aphid. Owing to the high susceptibility of all local cultivars to legume aphids and may be virus vectors (El-Defrawi *et al.*, 1994 and Makkouk *et al.*, 1994) and the above mentioned mortality factors, a subsequent spray should be required. However, if considered necessary, the third spray could be given any time between ranges of 10-20 per cent plant infestation without any substantial loss in yield.

Regression lines obtained from plotting the points for each level of aphid infestation and the corresponding seed yield reduction are shown in Fig. (4 & 5). By applying David's formula to calculate the economic-injury level, number of aphids that will caused enough damage equal to the cost of additional control measure was 89.47 and 144.83 aphids per plant, whereas the economic threshold calculated was 48.99 and 112.75 aphids /plant in cv. Masr 1 and Giza 429, respectively. The relationship between aphid population development and yield loss in the two faba bean tested cultivars. Our data were based on the direct effect of aphids reproductively on faba bean cv., Masr 1 and Giza 429 varieties. Table (5), clearly indicated that the growth rate of cowpea aphid populations infesting faba bean increased rapidly 14-days after the first onset of aphids. The developmental rate ranged between (51.3-2703.0) and (53.8-2016.8) or the aphid individuals could been increased through the season by 52 and 37 folds, depend on the number of aphids set up plants at the starting and differed between the two cultivars. The slope of growth rate of population was steady increase in both tested variety. Population developed to reach a maximum numbers of 5292.0 and 4031.6 on Masr 1 and Giza 429 plants firstly infested by 47.2 and 62.5 aphids /plant. The correlation between the number of aphids per plant and yield is negatively significant, (56.588 X – 1133.6 R^2 = 0.7247), and (53.167X – 2451.5, R^2 = 0.6214), when aphids set on faba bean variety Masr 1 and Giza 429, respectively (Fig. 6 & 7).

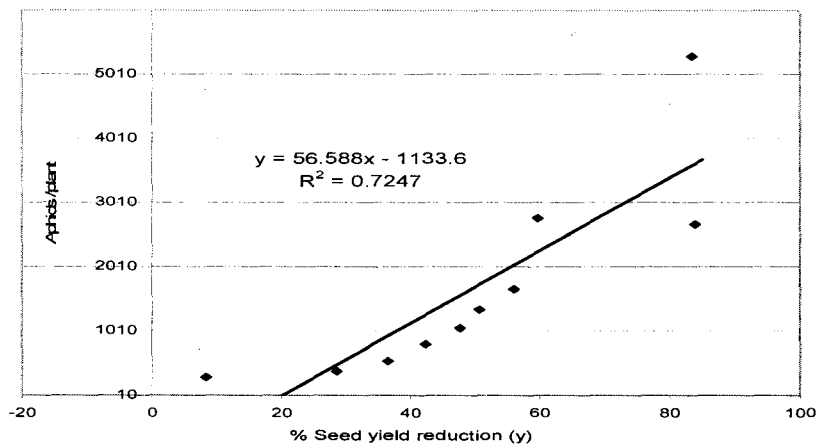

Fig. (4). Scatter diagram of various levels of cowpea aphid intensities and associated yield reduction of faba bean Masr 1 and the calculated linear regression line to represent this association.

From these results, it could be concluded that 47.2 and 62.5 aphids /plant at the first attack faba bean, did not detectable reduced yields of faba bean cv.,

Masr 1 and Giza 429, and above this numbers a sharp reduction in yield was obtained reaching a maximum reduction in yield being 83.41 and 96.07 %, when the first onset of aphids was averaged > 50 and >70 individuals /plant, left untreated.

During the present study, observations clearly indicate that the close relationship between the sizes of the initial infestation on faba bean varied from year to year and within different areas. This results agrees with those of Mathews and Tunstall (1968); Nyrop *et al.* (1986) and Bakhetia *et al.* (1987). Forecasting aphid abundance is also very important to avoid the risk of recommending no treatment which may result in monetary loss. Also, the value of area forecasts was demonstrated. Infestation varied in a particular year according to area and microclimatic conditions.

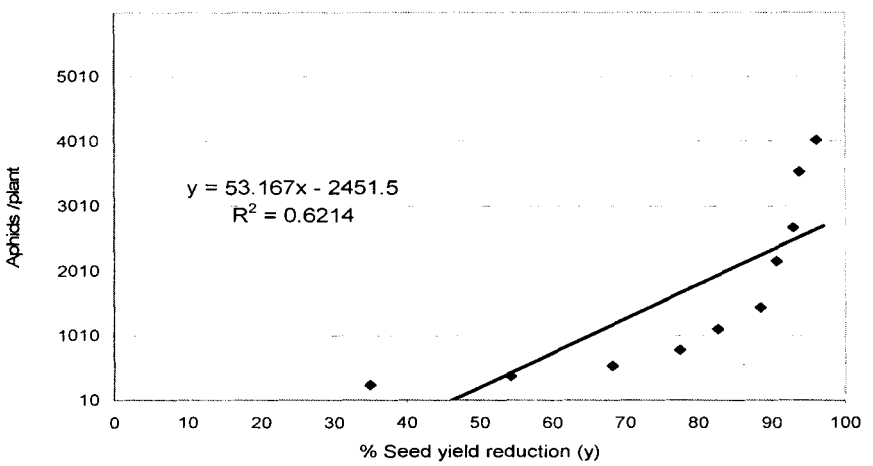

Fig. (5). Scatter diagram of various levels of cowpea aphid intensities and associated yield reduction of faba bean Giza 429 and the calculated linear regression line to represent this association.

The economic threshold for adopting chemical control measures against pests have been reported by: Matthews and Tunstall, 1968; Headly, 1972; Stern, 1973; Cammell and Way, 1977; Mumford and Norton, 1984 and Bakhetia *et al.* (1987). Most of the earlier workers based their studies on population density of the target pests. Cammell and Way, (1977) Pointed out three alternative strategies for controlling black bean aphid on faba bean; when the aphid colonies become readily visible, before aphid attacks as routine preventive treatment, and by forecasting result of *A. fabae* on the other alternate hosts colonized by primary migrants. Cuperus *et al.* (1982) stated that the economic threshold of the pea aphid,

Acyrthosiphon pisum on alfalfa crop was 114 individuals per alfalfa stem. Bishara *et al.* (1984) Mentioned that the injury threshold was 5 % of faba bean initially colonized by cowpea aphids, and that chemical treatments is justified when this level is reached Mumford and Norton (1984) resulted that the ET can be a useful operational rule for pest optimal decision making. Hermoso *et al.* (2001) found that Clementine yield loss was correlated with number of aphids per square meter of canopy.

Table 5. The relationship between the cowpea aphid intensities and associated yield reduction of the faba bean (variety Masr 1 & Giza 429) under natural field conditions at Sids ARS, Beni-Suef Governorate.

Masr 1				Giza 429			
Mean no. aphids /plant	Population growth rate	Obtained Yield (gm /plant)	% in yield loss	Mean no. aphids /plant	Population growth rate	Obtained Yield (gm /plant)	% in yield loss
285.6	51.3	15.52	8.32	250.0	53.8	12.64	34.96
380.8	101.7	12.11	28.56	384.4	118.6	10.60	54.25
542.8	187.5	10.74	36.46	546.4	214.7	9.43	68.23
798.4	322.9	9.76	42.35	786.8	344.3	8.86	77.49
1057.6	460.2	8.87	47.64	1110.8	477.6	8.10	82.69
1340.0	609.7	8.36	50.62	1444.0	764.8	7.17	88.44
1660.4	779.4	7.45	56.02	2162.0	970.9	5.61	90.66
2762.8	1363.3	6.82	59.73	2677.2	1314.6	5.45	92.93
2672.0	1315.3	2.71	83.97	3536.4	1512.6	2.27	93.80
5292.0	2703.0	2.81	83.41	4031.6	2016.8	2.64	96.07

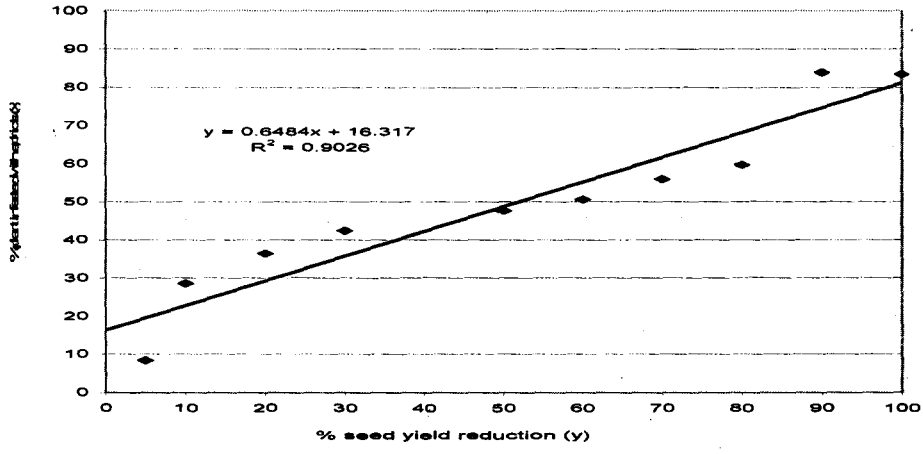

Fig. (6). Scatter diagram of various levels of per cent plants of faba bean Masr 1 infested with cowpea aphid and associated seed yield reduction and the calculated linear regression to represent this association.

Sharma and Bhatnagar (2004) found aphid infestation on barley cultivars adversely affected growth parameters such as plant height, ear head length, and number of grains per ear head and grain yield and loss in yields varied from 24.52 to 29.61 % among 8 barley cultivars. The yield losses 32.38, 42.85 and 60.00 % were recorded on barley cv. RD-387, when infested at 5, 10 and 15 aphids per plant respectively, in Rajasthan India. Way *et al.* (1954) found that the damage done by aphids reduce seed viability and food value. 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. Saxena and Stewart (1983) referred to 72.5 % loss in seed yield of 50 faba bean plants affected by aphid infestation in Egypt.

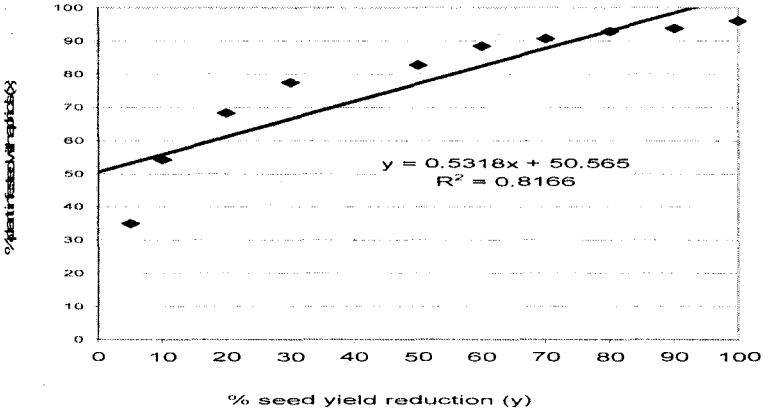

Fig. (7). Scatter diagram of various levels of per cent plants of faba bean Giza 429 infested with cowpea aphid and associated seed yield reduction and the calculated linear regression to represent this association.

From these results, it could be concluded that around 70 aphids or less /plant shoot at the start attack faba bean plant, did not cause detectable loss in seed yields of faba bean cv., Masr 1 and Giza 429, and above this numbers a sharp reduction in yield could be dramatically happened and reaching a maximum reduction in seed yield by 83.41 and 96.07 %. Aphids feeding on faba bean can cause yield loss before plant symptoms become obvious. Large colonies, with more than 70 aphids per shoot, may cause distortion of leaves, stems, flowers and plant collapsed or may be died in most. By the time such symptoms are evident, there will have been yield loss that cannot be recovered by spraying to control the aphids. The faba bean crop should be treated before aphid numbers increase markedly.

The economic loss depends on time of the cultivar infested, and on the numbers of aphids in each growing tip or buds. Yield losses are greater if virus transmission also occurs. Viruliferous aphids feeding slow growth, distort flowers, and reduce pod set and fill. FBNYV transmitted mainly by aphids (Cowpea Aphid and Pea Aphid), cause a range of symptoms, including retarded growth, stunting, and leaves thick and intervene chlorotic blotches starting from the leaf margins, young leaves remained very small and cupped upwards and take yellowing, whereas the older leaves rolled downwards and plants will be died within 5-6 weeks after inoculation. FBNYV disease can cause significant yield loss in faba bean because plant infected with FBNYV will be die within one to two month later if the infection made during seedling stage, however some are infested in the later stage, i.e., flowering; podding and premature stages the plant fall or seeds inevitability. A few aphids can carry and spread this viral disease, at population level zero that because almost all yield destruction from direct and indirect feeding. The actual losses in seed yield of faba bean due to aphid infestation varied from year to year according to the infestation rate, date, time of duration and the sensitivity of cultivars.

Economic threshold actually has a variable value that may differ with, among other factors, the variety and age of the crop, its location, previous damage received, simultaneous infestation of other pests and agronomic practices such as plant spacing, fertilizer levels and irrigation etc. Factors such as the market value of the crop, the cost of pesticide application, the expected income of growing another crop instead, and the weight of all negative health, social and environmental effects would also have to be considered. The concept of economic threshold should not be confined to assessing the need for chemical control only, as is often suggested. It is just as valid for evaluating any form of pest control, including biological and cultural control, breeding of resistant varieties and other methods which may often provide the more permanent forms of pest control. In each case, the cost of the activity needs to be weighed against the cost of the expected crop loss.

There are further complications involved in applying the economic threshold. In some instance, a low level of infestation may have a beneficial effect, because it stimulates plant growth or enables a lesser amount of plant to grow to greater size, thus avoiding the need for chemical control. Plants can compensate for dead tillers or missing plants by increased tillering and so eventually produce even higher yields. However, once damage exceeds the crop's potential for compensating losses, a further increase in the size of a pest population results in a progressive reduction of yield.

Working with economic thresholds requires a system of scouting and training on visual and inspection for the actual presence level of aphid pests in the leguminous crops and of forecasting probable population developments. Forecasting should also include the sampling of natural enemies and predicting their impact on pest development. It is clear that farmers need to be trained in recognizing pest and natural enemies and in the proper counting of pest numbers on the plants.

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مستويات الضرر الاقتصادي ونموذج الفقد في محصول الفول البلدي الناجم عن الإصابة بحشرة من اللوبيا *Aphis craccivora* Koch

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١. *قسم بحوث الحشرات الثاقبة الماصة – معهد بحوث وقاية النباتات – مركز البحوث الزراعية – الدقي – الجيزة – مصر.*
٢. *قسم بحوث المحاصيل البقولية – معهد بحوث المحاصيل الحقلية- مركز البحوث الزراعية – الجيزة – مصر.*

أجريت تجربتان حقليتان في محطة سدس للبحوث والتجارب الزراعية – محافظة بني سويف – إقليم مصر الوسطي خلال موسمي ٢٠٠٧/٢٠٠٦ و ٢٠٠٨/٢٠٠٧ بهدف دراسة مستويات الضرر الاقتصادي وعمل نموذج لحساب الفقد المتوقع في محصول الفول البلدي الناجم عن الإصابة الطبيعية بحشرة من اللوبيا *Aphis craccivora* Koch وذلك باستخدام العلاقة بين المستويات المختلفة للإصابة الطبيعية بالحشرة من اللوبيا وعلاقتها بالنقص في محصول الأصناف المتداولة حديثا والموصى بها في مصر من الفول البلدي وهى أصناف سخا ١، جيزة ٣ محسن، جيزة ٧١٦، جيزة٨٤٣، مصر١، مصر ٢، جيزة ٢ محسن، جيزة ٤٠، جيزة ٤٢٩ و نوباريا ١ بغرض عمل تقديرات تقريبية تساعد على استخدام انسب التوقيتات واتخاذ القرار المناسب لإجراء عمليات المكافحة لحشرة من اللوبيا والتوصل إلى أقل تعداد لها دون الوصول للحد الاقتصادي الحرج للإصابة.

- وقد تبين من النتائج أن حشرة من اللوبيا لها تأثير شديد وواضح على نمو نباتات الفول البلدي في مراحله المختلفة وأهمها التأثير السلبي على كمية ونوعية محصول البذرة الناتج ، هذا وقد ظهرا ذلك جليا بلا استثناء في جميع أصناف الفول البلدي العشر المختبرة ، حيث قدر النقص في الكمية المنتجة تحت تأثير الإصابة الطبيعية بحشرة من اللوبيا بصورة عامة في الأصناف العشر ما بين ١٢,٧٨٥ إلى ٦١,٠٧٢ % خلال عامي الدراسة.
- وجود علاقة ارتباط خطى سالب عالي المعنوية ما بين تعداد حشرات المن الذي يصاب به النباتات في بدايتها والنسب المؤوية للنقص في الإنتاج المحصولى للعشرة أصناف من الفول البلدي المختبرة، وبمقارنة حساسية الاصتاف العشر يمكن اعتبار أن صنف الفول البلدي مصر ١ هو أقل الأصناف المختبرة حساسية للإصابة بحشرة من اللوبيا (مستوى ١,٨٧)، بينما كان الصنف جيزة ٤٠ هو أعلى الأصناف المختبرة حساسية للإصابة (مستوى ٣,٢٨). أما باقي الأصناف المختبرة فقد تباينت درجة حساسيتها للإصابة بحشرة من اللوبيا وكانت مستوياتها ما بين ٢,٠٨ و ٣,٠٧ درجة باستخدام مقياس الإصابة من ١ إلى ٥ درجات.

في الجزء الثاني من التجارب الخاص بدراسة مستويات الضرر الاقتصادي والحد الاقتصادي الحرج للإصابة بحشرة من اللوبيا في حقول الفول البلدي صنفي مصر ١ وجيزة ٤٢٩ ومدى تأثيرها على المحصول الناتج وذلك باستخدام العلاقة بين المستويات المختلفة للإصابة بالحشرة وعلاقتها بالنقص في المحصول. وقد تبين من النتائج الاتى:

- أن أجراء عمليات المكافحة في جميع مستويات الإصابة العشر بحشرة من اللوبيا على نباتات الفول البلدي صنف مصر ١ وجيزة ٤٢٩ تحت ظروف الحقلية الثابتة قد اختلفت فيما بينها وأدت جميعها إلى زيادة في الإنتاج المحصول بصورة متفوقة عن الإنتاج في القطع المقارنة وبصورة عالية المعنوية خلال عامي الدراسة. وقد تراوحت الزيادة في أنتاج محصول البذرة ما بين (٠ – ١,٤٨٧ طن في الفدان) و (١,٠٨ – ١,٢٨١ طن في الفدان) في صنفي مصر ١ وجيزة ٤٢٩ على الترتيب.، وظلت الزيادة في الانتاج المحصولى كلما انخفضت نسب الإصابة النباتات بحشرة من اللوبيا.
- وأدت مكافحة حشرة من اللوبيا عند المستويات المختلفة إلى زيادة في الدخل، فقد أشارت النتائج إلى ارتباط الزيادة في الدخل بالتدخل بأجراء عمليات المكافحة في الوقت المناسب والمرتبط بمستوى الإصابة بحشرة من اللوبيا المتواجدة على النباتات في كل من الصنفين المختبران مصر ١ وجيزة ٤٢٩ ، بالرغم من عدم وجود جدوى اقتصادية في المستويات العليا من الإصابة ٥٠-٧٠ %.
- وأما بالنسبة لعدد مرات إجراءات عمليات المكافحة بالرش على النباتات بمبيد الافوكس (مجموعة البيريميكرب) المتخصص للمن واللازمة لخفض التعداد دون الوصول للمستوى الأعلى من الإصابة والمتسبب لضرر اقتصادي اختلف من ١ إلى ٤ رشات. هذا وقد ثبت أن ٣ رشات متتالية بالمبيد بالمعدلات الموصى بها من قبل وزارة الزراعة فى مصر كلما وصلت نسب الإصابة ٢٠-٥٠ % أنها الأنسب والإحدى اقتصاديا، بالرغم من احتمال حدوث إصابة فجائي بالحشرة بصورة عالية ولفترة طويلة غير معتادة مما يستدعى زيادة عدد مرات الرش إلى إضافة رشة واحدة أخرى بغرض التوصل إلى الابادة الكاملة للحشرة داخل الحقل خاصة في حالة الإصابة بالمسببات المرضية الفيروسية والتي قد تسبب في هلاك المحصول بكاملة فى كثير من الأحيان.
- تبين أيضا من النتائج أن بداية تأثير هذه الحشرة على المحصول تظهر عند إصابة النباتات في الحقل بمتوسط عام أعلى من ٧٠ حشرة على الفرع النباتي الواحد في الصنفين مصر ١ وجيزة ٤٢٩ أو عند وصول نسبة الإصابة بالحقل إلى ٥ % من النباتات.
- أمكن وضع صيغة رياضية للعلاقة ما بين أعداد حشرات المن على النبات (المتوسط على الفرع الواحد) وما يمكن توقعه من خفض في الإنتاج المحصولى في كل من صنفي الفول البلدي مصر ١ (٥٦,٥٨٨ مضروبه في متوسط مستوى الإصابة ومطروحا منها ثابت الصنف ١١٣٣,٦) وجيزة ٤٢٩ (٥٣,١٦٧ مضروبه في متوسط مستوى الإصابة ومطروحا منها ثابت الصنف ٢٤٥١,٥).
- قدر الحد الاقتصادي الحرج بحوالى ٨٩,٤٧ و ١٤٤,٨٣ حشرة على الفرع النباتي الواحد وان مستوى الضرر الاقتصادي كان عند متوسط ٤٨,٩٩ و ١١٢,٧٥ حشرة على الفرع النباتي الواحد لصنفي مصر ١ وجيزة ٤٢٩على التوالي.
- أن الفترة ما بين الحد الحرج للإصابة وحدود الضرر الاقتصادي هي فترة اخذ القرار بأجراء عمليات المكافحة حيث تتساوى فيها قيم المحصول الناجم عن الإصابة بالحشرة مع قيمة أجراء عمليات مكافحتها.
- هذا وقد نوقش في هذه الدراسة امكانية استخدام عمليات المكافحة عند المستويات المنخفضة من حشرات المن لتلافى الخسائر في المحصول على المستوى الاقتصادي العام.