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5. SUMMARY

Faba beans are used as a source of protein, calories, minerals and vitamins. They are considered as a major protein source especially where animal protein is expensive in developing countries.

During the last few years faba bean (*Vicia faba* L.) crop became of major importance in Egypt due to the dramatic decrease of cultivated areas. Faba bean crop is annually attacked by the most injurious insect pest *Aphis craccivora* Koch., that caused considerable damages during their different growth stages causing economic losses to their yields. To plan a control program of this pest it is necessary to investigate some ecological and biological studies.

The present study was carried out in the Experimental Farm of Agricultural Research Center, at both Beni-Suef (Sids, ARC), and Qalubya (Kahaa', ARS) Governorates throughout a period from 2008/09 to 2012/13 growing seasons. The investigation includes field and laboratory observations: survey and identify different aphid species infest faba bean plants in two different localities, obtain some ecological and biological data as well as effects of some agricultural practices on population density of the cowpea aphid, *A. craccivora*. Results obtained could be summarized as follows:

I. Survey of different aphid species infesting faba bean (*Vicia faba* L.) plants in Egypt:

Survey studies were carried out to survey and identify aphid species under two agro-ecosystems (Qalubya and Beni-Suef Governorates) infesting faba bean plants. This host plant was cultivated in the two governorates. Regular two-weekly samples were taken throughout November 2008 to April 2009. The survey was made adopting the direct method (Inverse Binomial Count Technique). Identification procedures and confirmation of identification with reference collections were carried out. Seasonal activities of surveyed species in the two localities were recorded.

Five aphid species (Homoptera: Aphididae) were surveyed on faba bean plants in Beni-Suef Governorate, while one species being

fenugreek aphid disappeared from Qalubya Governorate. The recorded species with mean numbers were: the cowpea aphid, *Aphis craccivora* Koch (695.8 & 304.7 insects /shoot); the black bean aphid, *Aphis fabae* Scopoli (208.5 & 82.7 insects /shoot); the pea aphid, *Acyrtosiphon pisum* (Harris) (141.9 & 57.0 insects /shoot); the fenugreek aphid, *Acyrtosiphon gossypii* Mordvilko (*sesbaniae* David) (10.7 & 0.0 insects /shoot) and the green peach aphid, *Myzus persicae* (Sulzer) (19.1 & 46.8 insects /shoot), in the two localities, respectively.

Cowpea aphid, *A. craccivora* was more abundant and dominant species occurred all over the whole growing season in faba bean plants in both Beni-Suef and Qalubya Governorates of Egypt.

II. Ecological Studies:

The population dynamics of the cowpea aphid, *Aphis craccivora* Koch and associated predators in faba bean fields were studied in Sids ARS., Beni-Suef Governorate, Middle Egypt. Standard weekly samples were picked at random from faba plants throughout two successive growing seasons 2009/10 and 2010/11. The occurrence and fluctuations in population density of *A. craccivora* in relation to plant growth stage was also investigated.

(i). Seasonal abundance and population density of cowpea aphid, *Aphis craccivora* Koch and associated predators on faba bean crop in Beni-Suef:

A. Spatial distribution of *A. craccivora* Koch:

The given results revealed that *A. craccivora* preferred northern, eastern and western sides of faba bean fields. The highest mean numbers of *A. craccivora* during 2009/10 and 2010/11 season was mostly accumulated at the northern side of faba bean field (594.0 and 315.4 insects /shoot, respectively). The southern side of the field received the lowest number of this aphid species (520.9 and 266.4 insects /shoot, in the two seasons respectively).

B. Aphid abundance in relation to plant growth stage:

Faba bean plants were infested with *A. craccivora* early during seedling establishments after germination in the 2nd. week of November 2009 and 2010 recorded mean numbers of 41.0 and 26.1 insects, respectively. Population density increased gradually to reach maximum during the 3rd. week of January 2010 and 2nd. week of January 2011 in coincidence with the beginning of the flowering and developing of fruit stages (1818.1 and 797.7 insects /shoot) at prevailing weather conditions of 15.4 °C & 18.9 °C and 67.4 % & 55.3 % R.H., respectively. Aphids population increased again and recorded another activity period with a maximum infestation by the 1st. week of March 2010 and 2011 (687.9 and 452.5 insects /shoot, respectively), where the prevailing weather conditions being 16.5 °C & 23.6 °C and 52.6 % & 47.3 % R.H., respectively, that faba bean plants in the 90 % pod ripening stage. As the faba bean plants reached the full ripening stage, aphids began to escape and the population tended to decline onward the end of the growing season in the last week of April in both seasons.

C. Fluctuation in the population density of *A. craccivora* Koch on faba bean plants:

The first winged individuals of *A. craccivora* landed on faba bean plants during the 2nd. week of November in both 2009/10 and 2010/11 seasons. This species was more abundant during the first season (561.74 insects /shoot) than in the second season (285.56 insects). *A. craccivora* had two main periods of seasonal activity: the first from the 2nd. week of November to the 3rd. week of February; while the second interval from the 4th. week of February to 1st. week of April in both seasons. In 2009/10 season, the maximum numbers recorded in the 3rd. week of January; while in the second interval, the maximum counts recorded in the 1st. week of March by 1818.1 and 687.9 insects /shoot, respectively. While in the second season 2010/11, the weekly mean numbers reached its first peak in the 2nd. week of January and the second peak in the 1st. week of March, being

797.7 and 452.5 individuals /plant shoot for the two intervals, respectively.

(ii). Predator species associated with *A. craccivora* Koch in faba bean field:

Four aphidophagous predators observed in faba bean field were : *Coccinella undecimpunctata* L., *C. septempunctata* L. (Coccinellidae : Coleoptera); *Chrysoperla carnea* Steph. (Chrysopidae : Neuroptera) and *Orius* spp. (Anthocoridae : Hemiptera). Such predaceous species were relatively more abundant during the first season (14.55 insects /10 plants) than in the second season (10.02 insects /10 plants). Two peaks of predator populations occurred by 2nd. week of December 2009 and 3rd. week of March 2010 (15.8 and 56.7 individuals /10 plants, respectively) and 3rd. week of December 2010 and March 2011 (25.3 and 26.1 individuals /10 plants, respectively). Both cowpea aphids and associated predators were more active during 2009/10 than on 2010/11 season and both seemed to be coinciding with each other.

**III. Effects of some ecological factors on *Aphis craccivora*
Population Density on Faba Beans:**

The simultaneous effects of four ecological factors (one biotic and 3 abiotic) on the fluctuation in population density of cowpea aphid, *Aphis craccivora* Koch on faba bean plants was determined throughout two successive seasons 2009/10 and 2010/11.

1. Effect of predators:

Statistical analysis showed that predatory complex had highly significant and negative effects on aphid population density throughout the first season; while non-significant and also negative effects in the second season. The correlation coefficient values were ("r" = -0.4339; $P = >0.01$) and (- 0.1792; $P = n.s.$) in the 1st. and 2nd. season, respectively. The slope "b" values for this association were (- 0.081; -0.013 and - 0.014) and (0.430; - 0.007 and - 0.007) for alate,

apterae and total *A. craccivora* throughout the two successive seasons, respectively.

2. Effect of temperature:

The population density of *A. craccivora* found on faba bean plants under field conditions was negatively correlated with maximum weekly mean temperature and poses significant effect ($r = -0.6173$, $P > 0.001$) in the first season 2009/10, while non-significant effect ($r = -0.2190$, P n.s.) in the second season 2010/11. The minimum temperature exhibited also negative and significant effect on the aphid population in the first ($r = -0.4496$, $P > 0.01$) and second season ($r = -0.3126$, $P > 0.05$).

The present results led to the weekly average of temperature were more pronounced negative effective on aphid population abundance in both 2009/10 and 2010/11 growing seasons, but more conspicuous in the first season ($r = -0.5789$, $P > 0.001$) than in the second season ($r = -0.2857$, P n.s.). Therefore, it could be stated that the population density of *A. craccivora* build up faba bean plants markedly varied according to temperature regime and unit of change by (- 0.002, - 0.001 and - 0.002) and (- 0.004, - 0.003 and - 0.003) individuals in 2009/10 and 2010/11, respectively, could result due to a change in the weekly mean maximum, minimum, and average temperature by 1 °C.

3. Effect of relative humidity:

Insignificant negative relationship between relative humidity percentage and *A. craccivora* on faba bean during the first season 2009/10 (" r " = -0.0395), while Insignificant but positive correlation between abiotic factor (R.H. %) and *A. craccivora* in 2010/11 (" r " = 0.0110). Therefore, it could be stated that relative humidity had insignificant effect on the population density of cowpea aphids during the two tested seasons.

4. The combined effect of plant age and the three weather conditions:

The combined effect of the plant age and the three considered climatic factors as a percentage of explained variance on cowpea aphid population (*A. craccivora*), was more pronounced in the first season than in the second one. This effect was 67.80 and 67.42 % in the first and second season, respectively. The variance ratio “F” values were 4.085 and 5.490 and both was significant at >0.01 probability in the two seasons, respectively. These results revealed that the simultaneous effects of the four selected factors had precise effects, as a group on the population density of *A. craccivora* on faba bean plants than the effects of each factor separately.

IV. Effects of some agricultural practices on *Aphis craccivora* population on faba bean crop and their yields in the field:

i. Effects of planting dates:

Four planting dates were tested i.e., early date (10 October), the normal date (25 October) and late date (10 and 25 November) on aphid infestation levels and yield components of faba bean Giza 843 variety, grown under natural infestation in fields of Sids ARS, Beni-Suef Governorate, throughout two consecutive seasons of 2009/10 and 2010/11.

Plants of faba bean Giza 843 variety varied significantly in their response to aphid infestations based on date of planting. The first date of sowing (October 10) and the fourth one (November 25) confronted higher degree of aphid infestations; meanwhile, those of the 2nd. and 3rd. date of sowing (October 25 and November 10), were encountered the lowest degree of aphid infestation levels

There were significant differences among planting dates on seed yield obtained of faba bean crop. The highest yield contributed to the 2nd. and 3rd. planting date (25 October and 10 November) and characterized by higher yield attributes than others did.

It was also observed that yield attributes and seed yield of faba bean cultivar Giza 843 variety was significantly decreased with delayed sowing even under protected conditions.

Based on the accumulated results, it could be recommended seeding of faba bean cultivar Giza 843 at a period from 25th. October to 10th. November in Beni-Suef Governorate and in the similar climatic regions.

ii. Effects of Plant Population density:

Four plant populations were tested: 8, 16, 24 and 32 plants per square meter on aphid infestation levels and yield potentiality of faba bean Giza 843 variety, grown under natural infestation in Sids ARS, Beni-Suef Governorate, throughout two consecutive seasons of 2009/10 and 2010/11. Results indicated that a greater number of cowpea aphids infested the less dense plant populations.

Insect population increased with time in all plant populations tested. Dense planting satisfactorily decreased the proportion of plants infested with cowpea aphid by 27.55 and 34.53 % in 2009/10 and 23.10 and 27.26 % during 2010/11 season at plant population of 24 and 32 plants /m².

There has been negative relation between aphid abundance and plant density per unit area observed. Also, there was a positive response of seed yield with higher plant population densities, 24 and 32 plants /m² confirmed in the two successive seasons.

The seed yield of faba bean crop cultivated at the rate of 24 and 32 plants /m² increased by (19.02 % and 20.50 %), and (14.66 and 34.02 %), over the two lower plant population densities 8 and 16 plants /m²., in the first and second season, respectively.

The overall results lead to the conclusion that yields of faba bean Giza 843 variety under environment of infestation with cowpea aphid, *A. craccivora* in middle Egypt region, could be successfully

maximized by planting the crop at 24-32 plants /m² plant density (sowing at 2 seeds /hill in double rows or one seed /hill in three rows, 20 cm hill to hill distance on ridges 60 cm apart).

iii. Effect of crop variety:

Relative susceptibility of six local faba bean varieties were carried out at Sids ARS., Beni-Suef Governorate to follow up population density of the cowpea aphid, *Aphis craccivora* Koch., throughout two winter growing seasons 2009/10 and 2010/11.

Results showed that highly significant difference between weekly mean numbers of *A. craccivora* population infesting the six varieties in the two successive seasons.

Variety Masr 1 and Giza 3 improved harbored the least aphid population (331.8 & 431.7 individuals /shoot, respectively); while Giza 429 exhibited the highest infestation levels (808.5 insects). and the remaining varieties had various levels of infestation categorized as intermediate: Giza 40 (529.8 insects), Giza 716 (549.4 insects) and Giza 843 (738.2 insects).

Yield attributes owing to aphid attack were differed and significantly influenced due to the level of aphid infestation (LSD at 0.05 = 189.91). The loss in seed yield due to aphid infestation being: Masr 1 (0.188 ton /fed), Giza 429 (0.204 ton./fed), Giza 716 (0.303 ton /fed), Giza 40 (0.323 ton /fed), Giza 843 (0.735 ton /fed), and Giza 3 improved (0.782 ton /fed).

V. Biochemical Changes in Faba Bean Plants Infested by *A. craccivora* Koch.

Plants of the six faba bean varieties screened have inherent variability for aphid susceptibility confirmed, in the previous studied and hypothesized differ in biochemical contents as affects their physiology and consequently the herbivorous insects feeding on them.

Besides, insects need considerable amounts of protein amino acids and carbohydrates in their diets.

In this study, the variation on biochemical (Protein; carbohydrates; soluble and reduce sugar contents) concentrations and in relation to cowpea aphid, *Aphis craccivora* infestations on 6 faba bean (*Vicia faba* L.) varieties: Giza 429, Masr 1, Giza 843, Giza 716, Giza 40 and Giza 3 improved, were investigated.

Results indicated that a significant variation on total protein, carbohydrate and soluble and reduce sugar contents resulted as cowpea aphid infestation affected throughout 100 days where observed among different sampling times and cultivars.

The direct and indirect effects due to aphid infestation exhibited as reduce in contents of total protein by (10.7, 3.1, 33.2, 11.6, 16.5, and 23.2 %), carbohydrate (25.7, 30.5, 32.6, 22.4, 18.0, and 19.6 %), soluble sugars (27.0, 10.0, 13.8, 16.6, 11.8, and 12.1 %) and reduce sugars (16.5, 12.6, 10.8, 4.2, 3.9, and 37.4 %), estimated on the six common varieties of faba beans, respectively throughout 100 days insect infestations.

The present data could be used as remarked in screening varietal operation for diagnostic insect preference and non- preference.

VI. Biological Studies:

Effect of Temperature on the Biology of Cowpea Aphid, *Aphis craccivora* Koch on Faba Bean

The developmental time, survival rate and reproduction of the cowpea aphid, *Aphis craccivora* (L.) (Homoptera: Aphididae), were evaluated on detached faba bean leaves (*Vicia faba* L.) at four constant temperatures (15, 20, 25 and 30 °C). Developmental periods of immature stages ranged from 10.79 days at 15 °C to 5.12 days at 30 °C. The lower developmental threshold for the cowpea aphid was estimated at 1.12 °C and it required 156.10 degree-days for a first

instar to become an adult. The average longevity of adult females was reduced from 26.12 days at 15 °C to 15.40 days at 30 °C. The average reproduction rate per female (RO) was 29.84, 59.90, 51.80 and 43.10 aphids/aphid at 15, 20, 25 and 30 °C, respectively. Mean generation time (TO) of the population ranged from 6.29 days at 30 °C to 12.59 days at 15 °C. The highest mean fecundity per reproduction day (rm) occurred between 20° and 25 °C with 4.51 to 4.13 nymphs per female and day.

It was evident that temperatures above 25/30 °C prolonged development, increased the mortality of immature stages, shortened adult longevity and reduced fecundity. The optimal range of temperature for the population growth of *A. craccivora* on faba bean was 20 to 25 °C.