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**Influence of intercropping onion, garlic and fenugreek with faba bean on yield, and on population densities of aphid and its associated predators**

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**Abstract:**

The effects of intercropping onion, garlic and fenugreek with faba bean on faba bean yield and yield attributes were investigated. In addition, influences of the abovementioned cropping systems on population densities of aphid *Aphis craccivora* Koch (Hemiptera: Aphididae) and associated natural enemies were evaluated. Yield and yield attributes of faba bean were higher in solid faba bean than in all intercropping patterns. However, numbers of faba bean branches, pods and seeds/ plant, seed weight/ plant, 100- seed weight and seed yield/ feddan were highest in the case of intercropping faba bean with onion, followed by garlic and then fenugreek. The highest seed yield (9.32 and 9.37 ardab/ fed.) was that of faba bean – onion, followed by faba bean – garlic (9.19 and 9.23) and faba bean fenugreek (9.16 and 9.19) in 2019/2020 and 2020/2021 seasons, respectively. Aphid, *Aphis fabae* Scopoli (Hemiptera: Aphididae) population density was reduced by 44.28 – 45.17% due to intercropping fenugreek with faba bean, followed by intercropping garlic with faba bean (3.20 – 16.66%). As for natural enemies, a significant positive correlation was found between aphid population density and each of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) and *Coccinella undecimpunctata* L. (Coleoptera: Coccinellidae) population densities. However, correlation coefficient values were insignificantly positive between aphid and each of *Scymnus* spp. and *Orius* spp. On the other hand, the population density of *A. craccivora* correlated negatively with each of faba bean plant height and seed protein content. The current results indicate that intercropping of garlic or fenugreek with faba bean reduces *A. craccivora* population density, meanwhile, enhancing the role of natural enemies for managing aphid populations.

**Introduction**

Intercropping is a kind of crop management to cultivate more than one crop in the same area and at the same time. This phenomenon helps in better exploitation of the sources, especially for

the small holder growers to maximize crop production and enhance their monetary return. Willey (1979) concluded that intercropping has improved the make use of water, sunlight, nutrients, and soil nitrogen by 10 – 50% over the solid crops. This

pattern of crop management is highly promising to increase the sustainability of crop production (Ghosh *et al.*, 2009).

In addition, Hamd-Allah *et al.* (2014) indicated the enhancement of soil fertility in the case of intercropping systems. Khan *et al.* (2015) reported that pepper – garlic intercropping patterns increased soil fertility by enhancing levels of nutrients, enzymatic activity, and micro-organisms populations in the soil. Mahmoud *et al.* (2018) concluded that areas of faba bean obviously increased when this legume crop was intercropped with some winter crops, such as wheat, onion, garlic, funnel, sugar beet or tomatoes. Latati *et al.* (2015) reported that intercropping, mainly in the small holder growers, increased crop production, and reduced risks, by more efficient use of lands. Mohammed (2015) and El-Shamy and Abbas (2016) obtained more yield and yield attributes of faba bean when cultivated as sole crop compared to the intercropped one.

From the pest management point of view, intercropping systems encouraged the presence of natural enemies and reduced the populations of insect pests. Ruppert and Molthan (1991) indicated that communities of parasitoids and predators were denser in intercropped faba bean compared to the sole one. Michel (2000) concluded that flowering coriander attracts hoverflies to the host crop, which manage the insect pests. Rizk (2011) suggested intercropping faba bean with coriander to inhibit population densities of *Aphis craccivora* Koch (Hemiptera: Aphididae) and meanwhile enhances the role of predators as an important biological control component. El-Shamy and Abd El-Aty (2021) reduced the population densities of some piercing and sucking insects in faba bean intercropped with garlic; *Aphis fabae* Scopoli (Hemiptera: Aphididae) by 32 – 55%, *Empoasca lybica* (De Berg.) (Hemiptera: Cicadellidae) by 35 – 54% and *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) by 35-59%.

The current investigation aimed to determine the role of intercropping aromatic plants, onion, garlic and fenugreek with faba bean on faba bean

yield and population density of *A. craccivora* and its associated predators.

### Materials and methods

#### 1. Experimental site:

Field experiments were carried during two faba bean seasons, 2019/2020 and 2020/2021 at Sakha Agricultural Research Station, Kafr El- Sheikh Governorate. The location lies at 31° 07' N latitude, and at 30° 57' longitude with a clayey soil, and PH of 0.8. The preceding crop for faba bean was sorghum in both seasons of study.

#### 2. Land preparation:

After sorghum harvest, the experimental area was ploughed. Phosphorous was distributed on the land in the form of single calcium superphosphate ( $P_2O_5$ ) at a rate of 100 Kg / feddan. In addition, potassium was broadcasted on the ploughed soil in the form of potassium sulphate ( $K_2O$ ) at the rate 50 Kg/ fed. Then, the soil was ploughed for the second time to incorporate phosphorous and potassium into the soil, and then the experimental area was harrowed. The area was divided into 63 plots, each measures 5.0 × 3.6 m, as each plot has six rows, 5m long.

#### 3. Considered crops:

Four crops, as sole or intercropped, were the target of this study. These crops are faba bean (*Vicia faba* L.), garlic (*Allium sativa* L.), onion (*Allium cepa* L.) and fenugreek (*Trigonella foenum -greacum*). Cultivars of faba were Sakha1, Nubaria 3 and Misr 1, in addition to sids-40 garlic cultivar, Giza 20 onion cultivar and Giza 2 fenugreek cultivar.

#### 4. Experimental design:

The treatments were distributed in a split-plot design, where the three faba bean cultivars were laid out in the main plots, while garlic, onion, and fenugreek either sole or intercropped were distributed in the sub plots.

**The treatments in subplots were as follows:**

- 4.1.** Faba bean + garlic., **4.2.** Faba bean + onion, **4.3.** Faba bean + fenugreek.
- 4.4.** Sole faba bean., **4.5.** Sole garlic,
- 4.6.** Sole onion, **4.7.** Sole fenugreek.

#### 5. Crop planting:

Gloves of garlic were drilled on one ridge of each row, spaced at 10 cm

apart while the other ridge had faba bean seeds on 3<sup>rd</sup> and 5<sup>th</sup> of October in 2019/20 and 2020/21 seasons, respectively. Seeds of faba bean and fenugreek were drilled and seedlings of onion were transplanted on one ridge of each row, while the other ridge had faba bean, on 13<sup>th</sup> and 14<sup>th</sup> of November, in 2019/ 20 and 2020/21 seasons, respectively. In the case of sole crops, both ridges of each row were sown with the considered crop.

#### 6. Nitrogenous fertilization:

Nitrogen fertilization at the rate of 30 Kg/ fed, in the form of ammonium nitrate (-- %), was applied. This dose was split into two halves, the first one was added just before the first irrigation, while the second half was applied just before the second irrigation. Throughout the crop season, all recommended agricultural practices were applied without any pesticide treatments.

#### 7. Data recorded:

At harvest, data of yield and yield attributes of 10 faba bean plants/plot were recorded. These attributes were plant height (cm), number of branches/plant, number of pods / plant, number of seeds/plant, seed weight/plant (g), 100 – seed weight (g), protein %, and seed yield / feddan (ardab).

#### 8. Statistical analysis:

Statistical analysis was carried out for each crop separately according to Snedecor and Cochran (1989), using MSTAT (1986) computer V4. LSD at 0.05 level of probability was used to compare between treatment means. Also, correlation coefficient values between population density of aphid and each of predatory population densities, faba bean plant height, and protein content.

#### Land Equivalent Ratio (LER)

LER was described by Willey and Osiru (1972), and was determined according to the following formula:

$$LER = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where: Yaa and Ybb were pure stands of crop a and b respectively.

Yab is the mixture yield of a and Yba is the mixture yield of b crop.

#### Monetary Advantage Index (MAI)

The economic assessment should be in terms of the value of land saved; this

could probably be most assessed on the basis of the rentable value of this land. MAI was calculated according to the following formula, as suggested by Willey (1979).

$$MAI = \frac{\text{value of combined intercrops} \times LER - 1}{LER}$$

In Egyptian pounds, faba bean price was 15 L.E. / kg in 2019/2020 and 10 L.E./kg in 2019/2020, onion was 1050 L.E./ton in 2019/2020 and 1045 L.E./ton in 2020 /2021, garlic was 20000 L.E./ton in 2019/2020 and 15000 L.E./ton in 2020 /2021 and fenugreek was 30000 L.E./ton in 2019/2020 and 30000 L.E./ton in 2020/20210 seasons (Bulletin of Agriculture Statistical Cost Production and Net Return, 2020).

#### 9. Insect data:

Data of aphid, *A. craccivora* and its associated predators were recorded on 10 faba bean plants / plot, throughout the period from 11<sup>th</sup> December up to 25<sup>th</sup> of March. nymphs, adults of *A. craccivora* and adults of predators were counted visually in a sample of 10 plants / plot.

#### Results and discussion

##### 1. Effect of onion, garlic and fenugreek, intercropped with faba bean on faba bean growth and yield attributes:

Data presented in Table (1) show the effect of intercropping some vegetable crops with faba bean on growth, yield, and yield attributes of faba bean in 2019/2020 and 2020/2021 seasons.

The crops, onion, garlic, and fenugreek, intercropped with faba bean resulted in significant differences in growth and yield parameters of faba bean. Regardless of faba bean cultivar, plant height and seed protein percentage were almost highest in faba bean + fenugreek treatment, followed by intercropping with garlic and then with onion in both seasons of study.

All other considered traits; the number of faba bean branches, pods and seeds/ plant, seed weight/ plant, 100 – seed weight, and seed yield/ fed was highest in the case of intercropping faba bean (Average of three cultivars) with onion, followed by garlic and then fenugreek. It is worth mentioning that the highest seed yield (9.32 and 9.37 ardab/ feddan) was that of faba bean + onion treatment, followed by faba bean + garlic (9.19 and 9.23) and faba

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bean + fenugreek treatment (9.16 and 9.19 ardab/ feddan) in 2019/20 and 2020/21 seasons, respectively. These findings are in

line with those of Willey (1979), Vandermeer (1989), Abou-Keriasha *et al.* (2013) and Hamd-Allah *et al.* (2014).

**Table (1): Effect of some crops intercropped with faba bean on plant height, growth and yield attributes of faba bean in 2019/2020 and 2020/2021 seasons**

Treatment	Plant height (cm)	No. of branches/plant	No. of pods/plant	No. of seeds/plant	Seed weight /plant (g)	100seed weight (g)	Protein %	Seed yield/ fed (ardab)
<b>2019/2020</b>								
Faba bean +onion	116.29	3.76	19.67	58.51	51.05	80.79	25.30	9.32
Faba bean + garlic	120.18	3.63	19.57	58.37	47.28	80.24	25.65	9.19
Faba bean +fenugreek	125.21	3.51	19.42	58.25	47.03	79.31	25.74	9.16
L.S.D. at 5% level	1.09	0.10	0.22	0.40	6.34	2.34	0.34	0.08
<b>2020/2021</b>								
Faba bean +onion	116.40	3.80	20.17	58.59	51.14	80.86	25.79	9.37
Faba bean + garlic	120.26	3.67	19.69	58.43	47.95	80.65	25.71	9.23
Faba bean +fenugreek	125.26	3.56	19.48	58.30	47.31	79.36	25.84	9.19
L.S.D. at 5% level	1.124	0.116	1.251	0.398	1.504	0.151	0.306	0.073

### 2. Comparison between intercropped and sole faba bean concerning growth and yield attributes:

Data in Table (2) compare the growth and yield attributes of intercropped faba bean with those of sole faba bean in 2019/2020 and 2020/2021 seasons. All considered parameters were usually higher in sole faba bean cultivars than in intercropped ones. In 2019/2020 season, number of faba bean branches, pods, and seeds per plant, in intercropped Sakha1, were 3.681, 21.421, and 65.362 compared to 3.750, 25.651, and 70.482 in the case of sole faba bean. The corresponding values of intercropped Nubaria3 were 3.596, 20.452, and 60.410 compared to

4.231, 24.840, and 66.426 in the case of sole Nubaria3. The abovementioned values took the same trend for Misr1 faba bean cultivar. In 2019/20 season, all other yield and yield attributes exhibited the same trend for the three considered faba bean cultivars. In the same trend, the seed yields were 9.469, 9.301, and 8.898 ardab/ feddan for the intercropped Sakha1, Nubaria3, and Misr1 compared to 11.446, 11.321, and 11.265 ardab/ feddan for the same three cultivars, in case of sole plantations, respectively. Results of the second season (2020/2021) took the trend of 2019/2020 season. Similar results were obtained by Abou-Keriasha *et al.* (2013) and Hamd-Allah *et al.* (2014).

Table (2): Growth and yield attributes of sole faba bean cultivars compared to intercropping with onion, garlic and fenugreek in 2019//2020 and 2020//2021 seasons.

Treatment	Plant height (cm)	No. of branches/plant	No. of pods/plant	No. of seeds/plant	Seed weight/plant (g)	100seed Weight (g)	Protein %	Seed yield/ Fed (ardab)
<b>2019/2020</b>								
1	115.855	3.681	21.421	65.362	58.904	88.189	25.23	9.469
2	120.437	3.596	20.452	60.410	47.669	79.190	25.281	9.301
3	125.384	3.068	16.786	49.356	38.789	72.958	26.183	8.898
L.S.D.at 5%	0.984	0.039	0.093	0.275	5.398	1.725	0.171	0.076
Sole faba bean (Sakha 1)	120.122	3.750	25.651	70.482	62.225	90.441	25.421	11.446
Sole faba bean (Nobaria 3)	125.000	4.231	24.840	66.426	50.924	82.256	25.340	11.321
Sole faba bean (Miser 1)	126.950	4.243	23.255	56.243	45.156	80.264	26.225	11.265
<b>2020/2021</b>								
1	115.961	4.276	21.999	65.431	59.202	88.259	26.238	9.513
2	120.504	3.641	20.508	60.474	47.901	79.260	25.329	9.340
3	125.463	3.112	16.837	49.411	36.306	72.351	25.277	8.941
L.S.D.at 5%	0.996	0.039	0.987	0.281	0.855	0.111	0.172	0.076
Sole faba bean (Sakha 1)	120.320	3.828	28.453	72.561	63.118	92.124	25.450	11.501
Sole faba bean (Nobaria 3)	125.215	4.322	26.233	70.220	52.305	85.113	25.368	11.438
Sole faba bean (Miser 1)	127.123	4.256	25.128	58.342	48.257	83.353	26.301	11.324

(1) Faba bean (Sakha1) + AV. of onion, garlic and fenugreek.

(2) Faba bean (Nubaria3) + AV. of onion, garlic and fenugreek.

(3) Faba bean (Misr 1) + AV. of onion, garlic and fenugreek.

### 3. Effect of intercropping interaction between faba bean and onion, garlic and fenugreek on growth and yield attributes of faba bean:

Data presented in Table (3) show the interaction effect of intercropping between some faba cultivars and some vegetable crops. There were significant effects on the

traits of faba bean in both seasons. The highest values of all studied traits were recorded for faba bean c.v Sakha 1 intercropped with onion in both seasons, whereas the lowest values were obtained for faba bean c.v Misr1 intercropped with fenugreek in both seasons.

**Table (3): Effect of interaction between crops intercropped with faba bean cultivars on growth, and yield attributes of faba bean in 2019/2020 and 2020/2021 seasons.**

Treatment		Plant height (cm)	No. of branches/plant	No .of pods/plant	No .of seeds/plant	Seed weight /plant (g)	100-seed weight (g)	Protein %	Seed yield/ardab/fed
<b>2019/2020</b>									
<b>Onion</b>	Sakha 1	120.81	4.45	21.51	65.30	59.56	89.08	26.41	9.62
	Nobaria 3	125.15	4.23	21.48	65.28	58.25	87.86	26.23	9.41
	Maser 1	130.19	4.03	21.26	65.26	58.22	87.61	25.90	9.37
<b>Garlic</b>	Sakha 1	112.05	3.72	20.49	60.44	47.97	80.11	25.35	9.40
	Nobaria 3	115.21	3.54	20.48	60.39	47.67	78.86	25.35	9.26
	Maser 1	120.31	3.51	20.36	60.30	47.38	78.53	24.94	9.24
<b>Fenugreek</b>	Sakha 1	115.99	3.10	17.00	49.42	45.50	73.30	25.40	8.95
	Nobaria 3	120.19	3.09	16.64	49.35	44.63	73.23	25.34	8.93
	Maser 1	125.10	2.99	16.37	49.06	44.23	71.77	25.04	8.80
<b>L.S.D 5%</b>		8.94	0.285	0.285	0.351	1.298	1.82	0.470	0.204
<b>2020/2021</b>									
Treatments		Plant height (cm)	No. of branches/plant	No .of pods/plant	No .of seeds/plant	Seed weight /plant (g)	100-seed weight (g)	Protein %	Seed yield/ardab/fed
<b>Onion</b>	Sakha 1	120.92	4.49	23.19	65.60	60.04	89.16	26.45	9.68
	Nobaria 3	125.22	4.26	21.47	65.34	59.25	87.95	26.30	9.44
	Maser 1	130.23	4.06	21.33	65.34	58.30	87.66	25.95	9.41
<b>Garlic</b>	Sakha 1	112.26	3.78	20.55	60.52	48.08	80.19	25.43	9.44
	Nobaria 3	115.31	3.59	20.54	60.46	48.04	78.59	25.41	9.29
	Maser 1	120.31	3.56	20.42	60.44	47.57	78.00	24.99	9.22
<b>Fenugreek</b>	Sakha 1	116.08	3.15	17.05	49.65	37.02	73.38	25.51	8.99
	Nobaria 3	120.25	3.14	16.75	49.48	36.34	71.99	25.39	8.98
	Maser 1	125.18	3.04	16.69	49.09	35.52	71.82	25.08	8.84
<b>L.S.D 5%</b>		8.874	0.292	1.21	0.376	1.35	1.63	0.485	0.221

**Yields of sole onion, garlic and fenugreek as compared with those intercropped with faba bean:** Yields of sole onion, garlic and fenugreek were, in both seasons, higher in the sole system as compared with the intercropping system (Table 4). In 2019/20 season, onion yielded 15.35 tons/ fed in the sole system compared to 8.75 tons/ fed when intercropped with

faba bean. The corresponding values of garlic were 10.13 and 6.64 and those of fenugreek were 0.676 and 0.283 ton/ fed, respectively. Data for 2020/21 took the same trend. Abou-Keriasha *et al.* (2013) estimated a reduction in onion bulb weight by 3.0 – 4.4% when intercropped with faba bean as compared to a cultivated sole onion.

**Table (4): Onion, garlic and fenugreek yields in case of sole and intercropping systems.**

Onion		Garlic		Fenugreek	
Yield (ton/fed)					
Sole	Intercrop	Sole	Intercrop	Sole	Intercrop
2019/2020					
15.35	8.75	10.13	6.64	0.676	0.283
2020/2021					
15.66	8.97	10.35	7.13	0.683	0.291

**Land Equivalent Ratio (I. E. R.):** Data in Table (5) revealed that land equivalent ratio (LER) values were greater than one, in both seasons. Thus, it could be concluded that actual productivity was higher than the expected productivity. The highest LER values (1.476, 1.509) were observed when garlic was intercropped with Sakha1 faba bean cultivar, while the lowest values (1.199, 1.206) were observed when fenugreek was intercropped with Misr1 faba bean cultivar in 2019/20 and 2020/21 seasons, respectively. Similar results in this respect were observed by Willey

(1979), Liben *et al.* (2001), Eskandari and Ghanbari (2010), and Abou-Keriasha *et al.* (2013).

**Monetary Advantage Index (MAI)** is considered an indicator of the economic feasibility of cropping systems. Results obtained in Table (5) showed that the highest MAI values (49699.11 and 40888.07) were obtained from faba bean + garlic in the first and second seasons, respectively. These MAI values were positive due to LER which was greater than one. These results are in the same line as those obtained by Abou-Keriasha *et al.* (2012) and Hamd-Allah *et al.* (2014).

**Table (5): Effect of intercropping patterns on land equivalent ratio (LER) and monetary advantage index (MAI) during 2019/2020 and 2020/2021 seasons.**

Intercrop pattern		Land equivalent ratio (LER)		Monetary advantage index (MAI)	
		2019/2020	2020/2021	2019/2021	2020/2021
Onion	Sakha 1	1.410501	1.414463	8973.246	7001.268
	Nobaria 3	1.401232	1.398116	6062.582	6701.248
	Maser 1	1.401813	1.403775	6043.048	6756.161
Garlic	Sakha 1	1.476726	1.509687	49699.11	40888.07
	Nobaria 3	1.473428	1.501094	49364.55	40353.73
	Maser 1	1.475718	1.503089	49511.85	40425.48
Fenugreek	Sakha 1	1.200572	1.207733	4782.616	3821.034
	Nobaria 3	1.207439	1.211164	4910.497	3870.525
	Maser 1	1.19982	1.206704	4711.463	3766.807

#### 4. Effect of intercropping of some vegetable plants with faba bean on *Aphis craccivora* population density:

Data presented in Table (6) show the population fluctuations of the aphid, *A. craccivora* on solid faba bean and intercropped faba bean, Sakha1 faba bean cultivar. On solid faba bean: From December 11<sup>th</sup> up to March 25<sup>th</sup>, average of *A. craccivora* of both years on solid faba bean ranged between 1.00

and 108.5 nymphs and adults/ 5 plants. Three peaks could be recorded throughout the season. The first peak (100.5 nymphs and adults/ 5 plants) was detected on December 18<sup>th</sup>, the second one (108.5) was recorded on January 1<sup>st</sup>, while the third one (104.0 nymphs and adults) occurred on January 29<sup>th</sup>. In case of intercropping between faba bean with garlic, onion or fenugreek, the population fluctuations of *A.*

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*craccivora* seemed similar to those monitored on solid faba bean.

Grand means of *A. craccivora* numbers were computed as 42.41, 50.25, 24.41 and 43.81 nymphs and adults/ 5 faba bean plants due to intercropping garlic, onion and fenugreek with faba bean, or on solid faba bean, respectively. Thus, the reductions in aphid populations were

highly obvious (- 44.28%) when fenugreek was intercropped with faba bean, but the population density of *A. craccivora* increased by +14.70 in case of intercropping onion with faba bean.

**Table (6): Population density of *Aphis craccivora* on solid faba bean and faba bean intercropped with some crops (Average of 2019/20 and 2020/21 seasons, Sakhal faba bean cultivar).**

Date of inspection	Faba bean + garlic	Faba bean + Onion	Faba bean + fenugreek	Faba bean Solid
Dec. 11	0.0	0.0	0.0	4.5
18	120.0	125.0	50.0	100.5
25	87.0	91.0	53.0	50.0
Jan. 1	85.0	162.5	35.0	108.5
8	71.0	24.0	40.5	72.5
15	21.0	18.0	17.5	36.5
22	16.5	16.5	35.0	18.0
29	94.5	122.5	61.5	104.0
Feb. 5	74.5	140.0	56.0	63.0
12	70.5	25.0	11.0	70.0
19	10.5	42.5	7.0	21.5
26	20.5	22.5	15.5	33.5
Mar. 4	1.5	6.0	1.0	7.0
11	7.5	8.5	7.5	8.0
18	0.0	0.0	0.0	2.5
25	0.0	0.0	0.0	1.0
<b>Grand mean</b>	42.41	50.25	24.41	43.81
<b>Compared to solid faba bean (+ or - %)</b>	-3.20	+14.70	-44.28	-

Data presented in Table (7) show the population fluctuations of the aphid, *Aphis craccivora* on solid faba bean and intercropped faba bean, Misr1 faba bean cultivar. On solid faba bean: From December 11<sup>th</sup> up to March 25<sup>th</sup>, the average of *A. craccivora* of both years on solid faba bean ranged between 1.00 and 127.5 nymphs and adults/ 5 plants. Three peaks could be recorded throughout the season. The first peak (127.5 nymphs and adults/ 5 plants) was detected on December, 25<sup>th</sup>, the second one (96.0) was recorded on January 15<sup>th</sup>, while the third one (25.5

nymphs and adults) occurred on February 26<sup>th</sup>.

In the case of intercropping faba bean with garlic, onion, or fenugreek, the population fluctuations of *A. craccivora* seemed similar to those monitored on solid faba bean but with lower values. Grand means of *A. craccivora* numbers were computed as 29.75, 37.56, 22.97, and 31.14 nymphs and adults/ 5 faba bean plants due to intercropping garlic, onion, and fenugreek with faba bean, or on solid faba, respectively. Thus, the reductions in aphid populations were highly obvious (-26.24%) when fenugreek was



intercropped with faba bean, but the population density of *A. craccivora*

increased by +20.62% in the case of intercropping onion with faba bean.

**Table (7): Population density of *Aphis craccivora* on solid faba bean and faba bean intercropped with some crops (Average of 2019/2020 and 2020/2021 seasons, Misr1 faba bean cultivar).**

Date of inspection	Faba bean + garlic	Faba bean + Onion	Faba bean + fenugreek	Faba bean Solid
Dec. 11	0.0	0.0	0.0	0.0
18	5.0	15.0	50.0	5.5
25	112.0	134.0	55.5	127.5
Jan. 1	79.0	92.0	68.5	22.5
8	43.0	80.0	40.5	61.0
15	83.5	85.5	39.5	96.0
22	52.5	52.5	14.5	65.5
29	45.0	86.0	6.0	47.5
Feb. 5	14.0	14.0	56.5	15.5
12	5.0	5.0	9.5	6.0
19	13.5	13.5	7.0	11.0
26	19.5	19.5	11.5	25.5
Mar. 4	1.0	1.0	1.0	5.0
11	3.0	3.0	7.5	8.0
18	0.0	0.0	0.0	1.0
25	0.0	0.0	0.0	1.0
<b>Grand mean</b>	29.75	37.56	22.97	31.14
<b>Compared to solid faba bean (+ or - %)</b>	-4.47	+20.62	-26.24	-

Data presented in Table (8) show the population fluctuations of the aphid, *Aphis craccivora* on solid faba bean and intercropped faba bean, Nubaria3 faba bean cultivar. On solid faba bean: From December 11<sup>th</sup> up to March 25<sup>th</sup>, the average of *A. craccivora* of both years on solid faba bean ranged between 1.00 and 111.0 nymphs and adults/ 5 plants. Two peaks could be recorded throughout the season. The first peak (101.0 nymphs and adults/ 5 plants) was detected on December, 25<sup>th</sup>, while the second one (111.0) was recorded on January 29<sup>th</sup>. Grand means of *A. craccivora* numbers were computed as 24.61, 29.59, 16.19, and 29.53 nymphs and adults/ 5 faba bean plants due to intercropping garlic, onion, and fenugreek with faba bean, or on solid faba, respectively. Thus, the reduction in aphid populations was -45.17% when fenugreek was intercropped with faba bean, but the

population density of *A. craccivora* increased by +0.20% in the case of intercropping onion with faba bean.

Bowie *et al.* (1995) investigated the effect of intercropping on insect infestation in the main crop plants. They found that coriander, *Coriandrum sativum* acted as an insect repellent, and concluded that coriander could be utilized in biological control programs. Afrin *et al.* (2017) concluded that garlic had a repellent effect against cabbage aphids attacking canola, which reduces the populations of the pest on canola plants. Mousa and Ueno (2020) detected *A. craccivora* as the most dominant aphid species on faba bean plants. The population of the insect pest was dense in the early growth stages of the crop. They indicated that *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) and true spiders were the most dominant predators. Mollaei *et al.* (2021) found

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that intercropping of faba bean, field pea, garlic or wheat with canola suppressed the population densities of cabbage aphid, *Brevicoryne brassicae* on canola. On the other hand, the treatment of canola/ faba bean encouraged the

occurrence of natural enemies. The authors attributed aphid reduction to the fact that the insect pest population is lowered by intercropped plants which act as barriers to the considered insect pests.

**Table (8): Population density of *Aphis craccivora* on solid faba bean and faba bean intercropped with some crops (Average of 2019/2020 and 2020/2021 seasons, Nubaria3 faba bean cultivar).**

Date of inspection	Faba bean + garlic	Faba bean + Onion	Faba bean + fenugreek	Faba bean + Solid
Dec. 11	0.0	0.0	0.0	0.0
18	20.0	20.0	3.5	17.5
25	80.0	60.0	15.5	101.0
Jan. 1	36.0	103.0	44.5	47.5
8	51.5	36.5	29.5	54.0
15	22.5	47.0	29.0	36.0
22	52.5	50.5	44.5	55.5
29	96.0	104.5	58.5	111.0
Feb. 5	20.5	33.5	17.5	21.0
12	6.5	6.5	5.5	8.0
19	5.0	7.5	3.5	9.0
26	3.5	3.5	6.5	4.5
Mar. 4	0.0	0.0	0.0	3.0
11	1.0	1.0	1.0	4.0
18	0.0	0.0	0.0	0.5
25	0.0	0.0	0.0	0.0
<b>Grand mean</b>	24.61	29.59	16.19	29.53
<b>Compared to solid faba bean (+ or - %)</b>	-16.66	+0.20	-45.17	-

### 5. Correlation coefficient values between *Aphis craccivora* population and each of natural enemies and some yield attributes:

Data presented in Table (9) show that *A. craccivora* population density correlated positively and significantly (0.5044) with the population density of *C. carnea*, and with a positive highly significant value (0.8616) with *Coccinella undecimpunctata* L. (Coleoptera: Coccinellidae). However, the correlation between aphid population density was not significant with each *Scymnus* spp (0.1574) and *Orius* spp (0.3186). Concerning some faba bean yield attributes, the population density of *A. craccivora* correlated with a highly negative significant value (-

0.9499) with plant height, and with insignificant negative value (-0.3600) with protein percentage.

Ruppert and Molthan (1991) observed that natural enemies populations were higher on flowering plants than on non-flowering ones. Accordingly, the intercropped flowering plants enhance the biological control of insects prevailing in the main crop plants. Michel (2000) reported that coriander attracts hover flies to cabbage plants which reduces some insect pests, particularly aphids. Shannag (2007) found that protein content in leaf tissues of faba bean was reduced by 7 – 33% as a result of black bean aphid, *A. fabae* infestation. The correlation between aphid infestation and protein content was positive. Severe aphid infestation

seriously damaged several chemical compositions. Rizk (2011) studied the effect of intercropping faba bean with coriander on population density of *A. craccivora* and associated predators. Intercropping enhanced the population

of predators and reduced populations of *A. craccivora* on faba bean. Meanwhile, yield of faba bean increased in intercropped plots compared to solid faba bean.

**Table (9): Pearson correlation coefficients between *Aphis craccivora* population density and natural enemies and some faba bean yield attributes, Kafr El- Sheikh region.**

Intercropping pattern	Season	Per five faba bean plants					Plant height (cm)	Protein %
		<i>Aphis craccivora</i>	<i>Chrysoperla carnea</i>	<i>Coccinella undecimpunctata</i>	<i>Scymnus spp.</i>	<i>Orius spp.</i>		
Faba bean + Garlic	2019/20	25.75	3.44	2.38	3.75	1.38	120.18	25.65
	2020/21	33.81	4.44	2.81	4.56	2.19	120.26	25.79
Faba bean + Onion	2019/20	36.06	4.43	3.06	4.94	1.88	116.29	25.30
	2020/21	38.50	3.44	3.31	3.98	2.44	116.40	25.79
Faba bean + Fenugreek	2019/20	22.25	3.25	2.06	4.31	2.56	125.21	25.74
	2020/21	23.06	3.75	2.75	5.31	1.50	125.26	25.84
(r) value			0.5044*	0.8616**	0.1574 ns	0.3186 ns	- 0.9499**	- 0.3600 ns

\*, Significant at 5% level. \*\*, Highly significant at 1% level. ns, not significant.

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