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Intercropping Influence of aromatic plants and okra on the population fluctuations of *Earias insulana* and *Helicvorpia armigera* (Lepidoptera :Noctuidae) a well as the role of intercropping on predator population and okra yield

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Abstract:

This study was conducted at El-Riad region, Kafr El-Sheikh Governorate during two successive growing seasons (2017 and 2018) to investigate the role of intercropping of okra and aromatic plants on the infestation with *Earias insulana* (Boisduval), *Helicvorpia armigera* (Hübner) (Lepidoptera :Noctuidae) and the associated predators and okra yield. The aromatic plants were catnip, spearmint, lemongrass, rosemary and lemon balm plants. Results showed that intercropping reduced the infestation percentage with *E. insulana* , *H. armigera*, especially in case of rosemary + okra, catnip + okra, respectively and increased the associated numbers of predators especially in lemon balm+ okra. Results exhibited that lemon balm intercropping with okra was highest attractive for *Coccinella* sp. (Coleoptera: Coccinellidae) and *Nesidiocoris tenuis* (Reuter) (Heteroptera: Miridae). Intercropping between spearmint and okra was highest attractive to *Chrysoperla carnea* Stephens (Neuroptera: Chrysopidae), as so catnip plants intercropping with okra plants was more attractive to *Paederus alfierii* Koch (Coleoptera:Staphylinidae) and *Scymnus* spp. (Coleoptera: Coccinellidae). The highest abundance of true spiders was found on okra plants intercropped with lemongrass, followed by okra with catnip. The highest okra yield was obtained when okra was intercropped with lemon balm.

Introduction

Vegetables consist a major part of food consumed by the Egyptian population. One of the popular important vegetable crops in Egypt is okra [(*Abelmoschus esculentus* (L.) Moench. (Malvaceae)], which is a good source of protein, vitamin and mineral elements needed for the development and maintenance of human body. The fruit also lend itself well to freezing and canning products (Dike, 1983). Foliage of okra plants are known to provide good sources of fodder for livestock (BOSADP, 1998).

Okra is a popular summer vegetable crop in Egypt. The cultivated area in Egypt for okra was nearly 17 thousand fedan (one fed. =4200m^2) and produced about 97 thousand ton in 2012 cropping season (Anonymous, 2013). Intercropping of compatible plants also encourages biodiversity, by providing a habitat for a variety of beneficial insects and soil organisms that would not be present in a single crop environment. This biodiversity can in turn help to limit outbreaks of crop pests by increasing the diversity or abundance of natural enemies, such as spiders or parasitic wasps. Increasing the complexity of the crop environment through intercropping also limits the places where pests can find optimal foraging or reproductive conditions. There are some different variants of intercropping: 1. Mixed intercropping. 2. Row intercropping 3. Relay intercropping (Infonet biovision).Okra is an annual Malvaceae crop and is susceptible to a large range of insect-pests and diseases. Various growth stages of the crops are susceptible to the different insect-pests and diseases(Baseline survey). Okra plants infested by the bollworms of *Helicvorpia armigera* (Hübner) (Lepidoptera :Noctuidae), which take it up as food. Pods and flowers are primary targets of spiny bollworm, *Earias insulana* (Boisduval) (Lepidoptera :Noctuidae), while the American bollworm caterpillar, *H. armigera* prefers the reproductive parts of the plant, including buds, flowers and fruits (Mudathir,2000). The American bollworm (*H. armigera*) caterpillars prefer the reproductive parts of the plant, including bands, flowers and fruits. Also, invade attack the ripped and pre-ripped fruits, contaminating them fraises and exposing them to fungi and bacteria (Ahmed, 2004). Planting insect pest repellent plants (PRP) as companion plants along with crops has been used as an alternative method in pest management. Many plant species have been identified to contain repellent effects on pests, such as, planting basil (*Ocimum basilicum* L.) with tomatoes repels T.tabaci. Coriander (*Coriandrum sativum* L.) repelled aphids, spider mites and potato beetles in potato. Garlic (*Allium sativum* L.) repelled aphids in roses, while mint (*Mentha cordifolia* L.) deterred white cabbage moths, ants, rodents, beetles, fleas and aphids in many crops (Anonymous, 2004a). Onion repelled cabbage lepidopterous pests in cabbage (Anonymous, 2004b). Marigolds repelled Mexican bean beetles in beans and tomato hornworms (Anonymous, 2004c) pest repellent plants may be an alternative method in controlling pests in organic agriculture as it needs to avoid the use of synthetic pesticides, growth regulators, livestock feed additives, etc. Insect predators and parasitoids were detected at variable levels, attacking mainly insect pests on okra (Barahoei *et al.*, 2012; Abdalla and Bilal, 2012; Saljoqi *et al.*, 2013; Khan *et al.*,1980 and El-Fakharany, 2016). In relay intercropping, two or more crops are grown in the same piece of land during part of the cropping season. A second crop (usually a cover crop) is planted in the same field as the first crop after the first has achieved reproductive maturity but before it has reached physiological maturity. This helps avoid competition between the main crop and the intercrop. It also uses the field for a longer time, since the cover crop usually continues to grow after the main crop is harvested.

The present investigation aimed to study the impact of intercropping of five aromatic plant species (catnip, spearmint, lemongrass, rosemary and lemon balm) with okra on the population fluctuations and abundance of *E. insulana* and *H. armigera*. In addition, the influence of intercropping on predator population and okra yield was investigated

Materials and methods

Experiments were carried out at okra field to study the impact of intercropping, between okra and aromatic plants (Table, 1) and its effect on okra infestation with *E.insulana* , *H.armigera*, predator population and okra yield.

Table (1): Aromatic plants intercropped with okra to manage the infestation with *Earias insulana* and *Helicvorpia armigera* in okra plants

Common name	Scientific name	Plant family	الاسم العربى
Catnip	*Mentha pulegium* L.	Lamiaceae	النعناع البرى
Spearmint	*Mentha viridis* L .	Lamiaceae	النعناع البلدى
Lemongrass	*Cymbopogon citratus (Dc.)*	Poaceae	حشيشة الليمون
Rosemary	*Rosmarinus officinalis L.*	Labiatae	حصالبان
Lemon balm	*Melissa officinalis* L.,	Lamiaceae	الترنجات

1. Experimental design:

The experiment was carried out during two okra growing seasons, 2017 and 2018 on pests *E. insulana and H.armigera,* in El-Raid region, Kafr El-Sheikh Governorate, Egypt. An area of one fedan was prepared (6 treatments × 4 rep.) and divided into 24 plots (each plot about 175 m2 13*13m, 10 row) separated by a border of 1 m path and 2 m between each replication .in a randomized complete block design. The seeds of okra (Ladies fingers Mansoura Red variety) were sowed (2 seeds/hole) on two sides of row with widths' of 100cm spacing 30 cm between plants during the two seasons on 20th Marsh

Seedlings of catnip, spearmint, lemongrass, rosemary and lemon balm were transplanted on 1st of April in the middle of rows at a space of 50 cm between plants and 100 cm row intercropping of each five aromatic plants sown with okra on alternating rows (1:1), (Individual terraces of the replicate. Horticultural practices were performed according to the recommendations of the Ministry of Agriculture and Land Reclamation of Egypt, but without pesticides.

2. Sampling procedure:

Weekly samples were taken randomly beginning from June 15th up to end of October . Each sample consisted of 25 plants/ replicate randomly chosen from each treatment, Population of *E. insulana* and *H. armigera* (number of larvae/25 plants) and percent shoot damage *by E. insulana* (number of bored shoots to healthy shoots in 10 plants) were observed starting from 30 days after till the end of the crop season at 7 days interval. Percent fruit damage by *E . insulana* and *H. armigera* (number of bored fruits to healthy fruits/ 25 plants) was recorded at each harvest starting from 60 days after dibbling till the end of the crop season.

3. Abundance of associated predators:

Coccinella sp. (Coleoptera: Coccinellidae) (eggs, larvae and adults), *Chrysoperla carnea* Stephens (Neuroptera: Chrysopidae) (eggs, larvae and adults), *Paederus alfierii* Koch (Coleoptera:Staphylinidae) (adults), *Scymnus* spp. (Coleoptera: Coccinellidae) (larvae and adults), spiders (spiderlings and adults) and *Nesidiocoris tenuis* (Reuter) (Heteroptera: Miridae) were counted weekly by the aid of lens on 25 plants/ replicate, repeated four times beginning from May 15th up to end of October.

4. Estimating the crop yield of different treatments:

The mean okra yield (in Kg) were estimated for each treatment per Karat or fedan; fruits of 25 plants / treatment were picked and weighed

5. Statistical Analysis:

Data were subjected to ANOVA and statistically different means were compared using Duncan Multiple Range Test **(Duncan, 1955)**.

Results and discussion

1. Effect of intercropping between okra and aromatic plants on *Earias insulana* and *Helicvorpia armigera* infestation:

1.1. Number of *Earias insulana* larvae infested shoot and fruit borers:

Data presented in Table (2) showed that the effect of intercropping between okra plants and some aromatic plants on number of *E . insulana* larvae infested on okra shoots and fruits. In 2017, okra solid plants (control) received the highest mean number of *E. insulana* larvae (78.42 /25 plants) compared to okra intercropped with aromatic plants that received ranging between 7.45 and 49.75 larvae / 25 plants. This means that intercropping between okra and aromatic plants achieved 36.56-90.50 % reduction in *E. insulana* larvae. Intercropping between okra and rosemary or lemon balm or catnip reduced larvae infested shoot and fruits borer by 90.50, 82.07 and 73.82 %, respectively. Regardless of the intercropping pattern, the highest numbers of larvae infested were those on 2nd week from August and the end sample, in first season. However, the least number of infested larvae were in 2nd week from September. In 2018 season, almost the results were the same of 2017 season.

1.2. Number of *Helicvorpia armigera* larvae infested shoot and fruit borers:

In 2017 and 2018 seasons (Table, 3)), control okra had the highest larval population; 57.95 and 62.44 larvae/ 25 okra plants, respectively. The second rank of larval population was detected in okra- catnip intercropping pattern; with values of 36.67 and 41.11larvae / 25 okra plants in the first and second seasons, respectively. The third rank of larval population was found in okra + spearmint intercropping pattern. On the other hand, the least larval population was detected in okra+ lemon balm intercropping, as this pattern achieved the highest reduction in *H. armigera* larval population; 93.39 and 91.76% reduction, in the first and second seasons, respectively. Okra- rosemary pattern occupied the second rank of efficiency in reducing larval population, while the third rank of efficiency was that of okra- Lemongrass pattern. Regardless of intercropping pattern, the highest population densities of *H. armigera* larvae were recorded on 2nd, 1st week- August, in first and second season, respectively. However, the least larval population densities occurred by late September in both seasons.

1.3. Percent fruit damage by *Earias insulana* and *Helicoverpa armigera* in intercropping system:

During 2017 season, the lowest percent fruit damage by *E. insulana* and *H. armigera* was in *A. esculentus* (2.25 %), intercropping with Lemon balm. However, the highest percent fruit damage by *E. insulana* and *H. armigera* in intercropping system was in okra control (83.56 %) (Table, 4). In 2018 season, almost the results were the same of 2017 season.

The current results showed that intercropping aromatic plants with okra plants reduced mean number of E. insulana and H. armigera larvae compared to okra sole. It was clear that aromatic plants were more attractive to predators than okra sole. The high yield of okra was in case of intercropping between okra and aromatic plants, while, the lowest yield was that of okra plants only. These results agree with those obtained by other authors who proved that intercropping has the potentiality to reduce the injuries of harmful insects and to increase the predatory populations. This finding was coinciding with Ofuya (1991) who recorded that damage by *H. armigera* was significantly higher in sole cowpea than in cowpea intercropped with tomato. Also our result was coinciding with that of Abro *et al*. (2004) who indicated that pest Infestation in mix crop was recorded two weeks later than monoculture; so, Earias sp. infestation in okra grown as mono crop remained higher than in okra grown as mix crop, recorded 24.9 and 12 %, respectively. In okra fields in Ghana, intercropping with basil caused 23% decrease in insect pests compared to pure okra stands (Amoatey and Acquah, 2010).

Table (2): Number of shoot and fruit borer, *Earias insulana* larvae/ 25 okra plants as affected by intercropping pattern.

Sampling Date	Intercropping pattern					
	Okra	**Okra+**	**Okra+**	**Okra+**	**Okra+**	**Okra+**
Mean number of larvae of *Earias insulana* / 25 plant during 2017 season						
July 1st	30.50	3.00	16.25	5.25	22.75	10.50
2nd	47.25	5.25	20.25	10.00	36.50	19.25
3rd	55.75	8.50	36.75	16.25	49.25	25.25
4th	69.00	13.75	41.50	20.75	55.75	29.75
August 1st	75.00	14.25	50.25	20.50	71.75	38.00
2nd	109.25	18.00	70.50	28.25	97.50	50.25
3rd	83.50	2.50	35.75	11.00	50.25	25.50
4th	57.75	1.75	19.50	6.00	20.00	10.25
September 1st	33.25	1.50	15.00	2.25	17.25	5.00
2nd	47.25	1.00	6.00	2.00	10.25	3.75
3rd	73.75	2.75	15.25	5.25	24.50	5.00
4th	91.00	3.50	22.50	8.00	37.75	9.25
October 1st	106.25	5.25	31.75	12.75	59.25	10.00
2nd	112.50	9.00	38.25	19.25	68.50	15.00
3rd	121.00	13.50	50.25	22.00	79.00	26.75
4th	141.75	21.00	65.75	35.50	95.75	45.00
Overall mean	78.42 f	7.45 a	33.53 d	14.06 b	49.75 e	20.53 c
Reduction %	-	90.50	57.24	82.07	36.56	73.82
Mean number of larvae of *Earias insulana* / 25 plant during 2018 season						
July 1st	40.25	5.00	17.25	6.25	24.00	10.00
2nd	49.50	7.25	23.00	10.75	30.25	15.25
3rd	61.25	9.25	27.25	13.25	43.25	20.25
4th	85.75	15.00	33.75	17.25	58.00	30.75
August 1st	111.75	17.25	58.25	24.50	76.75	46.50
2nd	92.00	3.75	33.00	10.50	60.25	17.00
3rd	86.25	2.25	18.25	5.75	36.00	10.00
4th	50.25	1.25	11.50	2.50	15.25	4.25
Septem. 1st	20.00	0.75	8.00	2.25	10.25	3.25
2nd	48.75	2.75	11.25	4.25	18.25	8.75
3rd	77.75	3.75	15.75	9.00	23.75	12.00
4th	96.00	6.00	23.25	15.25	44.25	14.00
October. 1st	98.75	5.75	43.25	21.5	65.00	28.25
2nd	133.00	10.25	60.75	29.50	97.25	33.75
3rd	143.75	20.00	84.25	35.75	113.75	54.25
4th	147.25	28.00	97.75	38.50	137.75	59.50
Overall mean	86.33	8.64	36.03	15.42	53.37	22.98
R.%.	-	89.99	58.26	82.14	38.18	73.38

Means followed by a common letter are not significantly different at the 5% level by DMRT

Table (3): Number of shoot and fruit borer, *Helicoverpa armigera* larvae/ 25 okra plants as affected by intercropping pattern.

Sampling date	Intercropping pattern					
	Okra solid	Okra+ rosemary	Okra+ lemongrass	Okra+ lemon balm	Okra+ spearmint	Okra+ catnip
Mean number of ***Helicoverpa armigera*** larvae / 25 plant during 2017 season						
July 1st	12.50	1.25	4.25	0.75	7.00	15.75
2nd	31.75	7.75	10.00	1.00	8.25	23.25
3rd	55.25	10.00	19.00	3.25	13.75	31.25
4th	124.00	15.00	25.75	11.00	30.00	37.00
August 1st	108.25	27.25	33.25	13.00	41.50	48.00
2nd	77.25	30.50	57.75	23.25	74.25	95.25
3rd	41.25	25.25	49.00	4.75	66.00	83.25
4th	85.00	20.25	40.00	2.00	51.75	63.50
September 1st	96.00	14.25	31.25	1.25	43.50	58.25
2nd	110.75	9.00	22.50	0.75	31.25	50.00
3rd	45.25	4.25	14.75	0.25	25.25	30.00
4th	31.25	2.00	8.25	0.00	15.00	20.25
October 1st	40.50	1.25	4.25	0.00	13.00	13.25
2nd	38.75	0.50	2.75	0.00	7.25	7.75
3rd	20.25	0.25	1.25	0.00	4.75	6.75
4th	9.25	0.00	0.75	0.00	2.25	3.25
Overall mean	57.95	10.55	20.30	3.83	27.17	36.67
R %	-	81.79	64.97	93.39	53.11	36.72
Mean number of ***Helicoverpa armigera*** larvae / 25 plant season 2018 season						
July 1st	16.75	2.25	6.00	0.25	10.25	17.50
2nd	33.50	8.25	15.75	6.25	20.25	25.50
3rd	41.25	11.00	21.00	10.50	25.00	35.25
4th	172.75	23.75	52.5	21.75	53.75	58.75
August 1st	118.25	47.25	68.00	31.00	84.50	96.25
2nd	72.25	39.00	58.00	15.00	74.25	80.00
3rd	7.00	31.25	50.25	6.25	66.25	76.75
4th	99.50	24.00	41.25	1.75	65.50	68.50
September 1st	109.75	15.75	33.50	1.50	44.50	59.25
2nd	133.25	9.75	25.25	0.50	33.75	45.00
3rd	89.25	5.00	15.75	0.00	22.25	34.75
4th	63.50	2.25	9.00	0.00	18.75	25.25
October 1st	55.75	1.5	4.25	0.00	10.00	14.75
2nd	43.50	0.75	2.00	0.00	4.00	10.75
3rd	27.75	0.25	1.00	0.00	3.50	6.25
4th	15.00	0.00	0.25	0.00	1.75	3.25
Overall mean	71.81	13.88	24.91	5.92	31.44	41.11
R %	-	80.67	65.31	91.76	56.22	42.75

Means followed by a common letter are not significantly different at the 5% level by DMRT

Table (4): Percent fruit damage by *Earias insulana* and *Helicoverpa armigera* / 25 okra fruit as affected by intercropping pattern.

Intercropping Pattern	Percentage fruit damage/ 25 okra fruit	
	2017 season	2018 season
Okra+ rosemary	9.33 b	10.55 b
Okra+ lemongrass	17.65 c	18.23 c
Okra+ lemon balm	2.25 a	4.33 a
Okra+ spearmint	35.55 e	36.23 e
Okra+ catnip	24.75 d	26.00 d
Okra control	83.56 f	85.55 f

Means followed by a common letter are significantly different at the 5% level by DMRT

The average population and shoot and fruit damage caused by *E. insulana* and *H. armigera* on okra were low when intercropped with cluster bean (*Cyamous tetragocalobe* L.), besides attracting comparatively high population of *Chrysoperla zastrowi sillemi* (Esben-Petersen) (Neuroptera: Chrysopidae) (Baskaran and Parthiban 2017). Khafagy (2011) reported that intercropping system of kidney bean with sweet basil, geranium, peppermint, spearmint and hot pepper showed highly reduction of *Bemisia tabaci* (Gennadius) (Hemiptera, Aleyrodidae) (eggs, nymphs and adults) compared to kidney bean solid. El-Gobary *et al*. (2014) found that okra plants intercropped with aromatic plants reduced *H. armigera* compared to control (okra solely). Khafagy (2015) reported that intercropping aromatic plants with tomato plants reduced the infestation with *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), especially on geranium + tomato and increased the numbers of predators especially on sweet basil + tomato compared with tomato solid (control). The pooled average percent fruit infestation by fruit borer was lowest in the marigold intercrop treatment (9.69) followed by coriander intercropping (12.40) on weight basis. While the sole crop (32.14) recorded the highest percent fruit infestation (Surjayanand *et al*., 2016). The data on the pod damage percent revealed that all the intercrop treatments were significantly superior over the chickpea sole crop. Among all the intercrop treatments, lowest per cent pod damage was recorded in chickpea + coriander treatment with 7.74 found among and it was followed by chickpea + lentil, chickpea + safflower, chickpea + tomato and chickpea + mustard with 9.41, 10.19, 11.81 and 12.62 per cent pod damage respectively. The highest pod damage treatments were, chickpea + wheat and chickpea sole with 14.45 and 16.08 per cent pod damage respectively and they were found high damage than other. Chickpea sole was found to be predominantly affected by highest pod damage per cent compared to other treatments with 16.08 per cent (Aditya, 2018).

2. Effect of intercropping aromatic plants between okra on predator population:

Intercropping of okra with lemongrass or catnip encouraged almost all considered predatory insects and true spiders (Table, 5). In 2017 season, the highest population densities, of *C. carnea*; 50.00 and 36.50 individuals / 25 plant were obtained with okra + peppermint and okra + Lemon balm intercropping pattern, respectively. *Coccinella* spp. population densities were highest with okra + lemon balm and okra + catnip, followed by okra +spearmint, but low in plots of okra solid and okra +lemongrass pattern. The highest densities of *P. alfierii* were detected with okra +catnip and okra + lemon balm, with value, of 50.00 and 43.75 individuals / 25 plant, respectively. The same trend was found with *Scymnus* spp. The true spider populations proved to be highest in case of intercropping between okra and lemongrass (53.25) , followed by okra+ catnip (46.50 spiderlings and adults / 25 plants) . The least densities of true spiders were found in plots with okra control, or okra intercropped with spearmint. Other intercropping patterns resulted in intermediate population densities of true spiders. The highest population density of *N.tenuis*, intercropping between okra and lemon balm or spearmint encouraged the occurrence of the predator, with values of 37.25 and 30.75 individuals / 25 plants, respectively. Predatory population densities in 2018 season took a trend very similar to that 2017 season**.**

Table (5): Effect of intercropping okra with aromatic plants on population density of predators in okra fields .

Treatment	Mean No. / 60 leaflets					
	Chrysoperla carnea (eggs, larvae , adults)	*Coccinella* spp (eggs , larvae,adults)	*Paederus alfierii* (adults)	*Scymnus* spp (larvae & adults)	True spider (spiderlings , adults)	*Nesedicoris tenuis* (nymphs & adults)
2017 season						
Okra control	7.50 e	11.00f	12.50f	17.75f	20.50f	5.00f
Okra + lemongrass	15.75 d	16.25e	19.25e	23.50e	**53.25a**	11.25e
Okra + Spearmint	**50.00 a**	28.50c	35.75c	36.00c	26.00e	30.75c
Okra + Rosemary	24.25 d	22.25d	27.50d	30.25d	39.75b	17.00d
Okra + catnip	30.25 c	53.75b	**50.00a**	**55.50a**	46.50c	25.50b
Okra+ Lemon balm	36.50 b	**59.00a**	43.75b	42.25b	32.00d	**37.25a**
2018 season						
Okra control	9.25 f	13.50f	13.50f	20.50f	19.50f	7.75f
Okra + lemongrass	18.50 e	19.75e	20.75e	25.25e	55.25a	13.50e
Okra + Spearmint	**55.00 a**	30.00c	37.00c	40.75c	28.25e	33.25c
Okra + Rosemary	27.25 d	26.00d	29.50d	33.00d	41.00b	19.50d
Okra + catnip	34.25 c	45.25b	53.25a	56.00a	48.75c	26.00b
Okra+ Lemon balm	40.50 b	**60.00a**	46.50b	43.75b	33.50d	40.75a

Means followed by a common letter are not significantly different at the 5% level by DMRT

This finding in agree with Kares *et al.* (1993) and Shalaby *et al.* (1983), who proved that cotton surrounded by maize on the periphery of the plots refuge the highest numbers of predators followed by cotton and maize in alternating rows at the ratio (2:1), then cotton and maize at the ratio (1:1). Accordingly, some environmental manipulation could affect efficiency of a natural enemy during biological control programs of *Helicoverpa* spp. (Roome, 1975) suggested that increasing plant diversity in cropping systems by intercropping crops carrying nectars could enhance effectiveness of natural enemies. When different host plants of *H .armigera* are interplant, population of *H. armigera* and its natural enemies on a crop are influenced by neighboring crops, both directly and indirectly. Direct influences include preference for one crop over the other by ovipositing moths and the movement of larvae and natural enemies between interplant crops. Indirect influences arise when *H. armigera* infestation on one crop is influenced by the population build-up or mortality level on neighboring crops (van den Berg *et al.* ,1993). Hickman and Wratten (1996) refered to increasing in population of natural enemies was attributed to supplying access of nectar-producing plants such as alyssum (*Lobularia maritima* L.). Overall, flowering companion plants have been implemented in a variety of crops including cereals, vegetable crops and fruit orchards to improve conservation biocontrol (Landis *et al.*, 2000 and Jonsson *et al.*, 2008). Flowering companion plants have been used in different cropping systems to enhance the impact of natural enemies (Begum *et al.*, 2004). In addition to food resources, companion plants can provide a shelter to pests away from predators and pesticides as well as favorable microclimates (Hossain *et al.*, 2002). A wide variety of natural enemies utilize non-prey food sources. For example, pollen and nectar have been demonstrated to be highly attractive to a variety of predators including syrphids (Diptera: Syrphidae) (Hickman and Wratten, 1996) and coccinellids (Pemberton and Vandenberg, 1993). Nectar is a source for carbohydrates and provides energy, while pollen supplies nutrients for egg production (Lee *et al*., 2004). Many natural enemies, including predators, require non-prey food items in order to develop and reproduce (Wackers *et al*., 2005).The availability of alternative prey and hosts is likely to mostly benefit generalist natural enemies. But, it has been shown that a better supply of pollen, nectar and honeydew might increase the effectiveness also of specialized predators and parasitoids. In addition, diversified communities provide better habitats for natural enemies because they have a larger variation in microclimates and microhabitats and thus provide better shelter to escape adverse condition. El-Gobary *et al*. (2014) found that okra plants intercropped with aromatic plants increased the associated numbers of predators compared to control (okra solely). Khafagy (2015) reported that intercropping aromatic plants with tomato plants increased the numbers of predators especially on sweet basil + tomato compared with tomato solid (control).

3. Intercropping between okra and aromatic plants on okra yield:

Data in Table (6) present the okra yield as affected by intercropping between okra and aromatic plants. Okra + lemon balm pattern proved to be the best combination. This combination produced 176.00 and 137.75 K.g./ Karat in 2017 and 2018 seasons, respectively. Thus, the yield advantages of okra + lemon balm were 212.89 and 227.83 % as compared to tomato solid in the first and second seasons, respectively. Okra + spearmint intercropping pattern proved to be the second best combination, followed by okra+ rosemary pattern, concerning obtained okra yield, with values of 157.75 and 155.50 and 143.50 and 139.00 K.g./ Karat .in the first and second seasons, respectively. However, the lowest tomato yields were obtained from okra+ lemongrass and okra + catnip patterns in both seasons. Mean of harvested okra pods yield in the previous cropping systems exceeded that of the control (untreated) which recorded the lowest total okra pods yield of 68.73 and 68.37 K.g. / Karat in the two regions (Mansour *et al.,* 2017). The highest tomato yield was obtained when tomato was intercropped with lemongrass than tomato plants only (Khafagy. 2018).

Table (6): Effect of intercropping okra with aromatic plants on okra yield.

Aromatic plant species intercropping+ okra	2017 season		2018 season	
	Yield production (K. g./Karat)	Increase in yield production %	Yield production (K. g./Karat)	Increase in yield production %
Okra control	56.25 f	-	53.00 f	-
lemongrass	115.50 e	105.33 e	113.75 e	114.62 e
Catnip	128.75 d	128.89 d	125.75 d	137.26 d
Rosemary	143.50 c	155.11 c	139.00 c	162.26 c
Spearmint	157.75 b	180.44 b	155.50 b	193.40 b
Lemon balm	176.00 a	212.89 a	173.75 a	227.83 a

Means followed by a common letter are not significantly different at the 5% level by DMRT

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