J. of Plant Protection and Pathology, Mansoura Univ., Vol. 11 (2):103 - 110, 2020

Journal of Plant Protection and Pathology

Journal homepage: www.jppp.mans.edu.eg
Available online at: www. jppp.journals.ekb.eg

Intercropping of some Aromatic Plants with Sugar Beet, its Effects on the Tortoise Beetle *Cassida vittata* Vill. Infestation, Appearance Predators and Sugar Beet Yield

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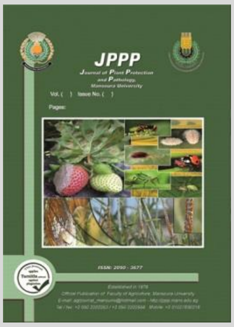

ABSTRACT

These studies were carried out at the Experimental Farm at the Sakha Agriculture Research Station, Kafr El-Sheikh Region and Egypt during the two successive growing seasons; 2017/18 and 2018/19 to investigate the role of intercropping of Sugar Beet with four aromatic plants on the infestation with *Cassida. vittata* (vill.), the appearance predators and sugar beet yield. The four aromatic plants were Fennel, Dill, Coriander and Marjoram. Results showed that intercropping pattern reduced the infestation percentage with *C. vittata (*all stages), especially in case of Coriander with Sugar beet. Results showed that intercropping pattern with sugar beet increased the appearance numbers of predators especially in case of Fennel+ sugar beet. Results exhibited that dill intercropping with Sugar beet was highest attractive for *Coccinella* sp.. Intercropping between Fennel and Sugar beet was highest attractive to *Chrysoperla carnea* Stephens, as so coriander plants intercropping with sugar beet plants was more attractive to *Paederus alfierii* Koch. Results indicated that Marjoram intercropping with sugar beet was highest attractive for *Scymnus* spp.. The highest abundance of true spiders was found on sugar beet plants intercropped with Fennel, followed by sugar beet with Marjoram. The highest sugar beet yield was obtained when sugar beet was intercropped with Fennel, followed by coriander.

Keywords: Cassida vittata, intercropping, sugar beet, aromatic plants, predators

INTRODUCTION

Sugar beet (*Beta vulgaris* L.) (Fam. Chenopodiaceae) is very important source of sugar and it is considered to be the second source of sugar after sugar cane in Egypt. (El-Khouly 1998). Sugar beet is one of the most important sugar crops in the world. It considered as an important source of feed for livestock and pectin production from the pulp of sugar beet (Fouad 2011). Several numbers of insect pests attack this crop e.g Vennila *et al.* (2014) indicated that sugar beet,., is host plant of *Phenacoccus solenopsis* Tinsley. *P. solenopsis* (Bazazo *et al.* 2017), beet fly *Pegomia mixta* (Vill.), tortoise beetle *Cassida vittata* (Vill.) and the green beach aphid *Myzus persicae* (Sulzer) caused considerable damage in yield (El-Dessouki *et al.* 2014*)*.

Population density of the predatory insects inhabiting sugar beet fields such as, *Chrysopa carnea* (Steph.), *Coccinella undecimpunctata* L, *Paederus alfierii* (Koch), *Scymnus sp* and *Cydonia vicina* isis were studied by many author (Shalaby 2001, El-Khouly 2006, El-Dessouki *et al.* 2014 and Bazazo *et al.* 2017). In order to reduce the use of pesticides, the intercropping between different crops and its effect on the occurrence of the pests is recommended in some cases as one of agricultural practices and of integrated pest management (IPM) elements. Insect predators and parasitoids exploit a variety of chemical signals from different trophic levels as kairomones and synomones to locate their herbivorous prey and hosts in tri-trophic systems (Raffa 2001, Vet and Dicke 1992, Kielty *et al.* 1996 and price 1981). These attractive chemical signals (behavioral chemicals = semiochemicals) may include pheromones of herbivores (second trophic level), host plant kairomones of herbivores (first trophic level), and herbivore-induced plant odor synomones (combination of first and second trophic levels). Behavioral responses to kairomones (positive signals) lead natural enemies to suitable breeding sites and habitats, as well as ensuring encounter with mates and availability of prey and/or hosts. The importance of these positive signals has been widely documented and accepted (Vet and Dicke M (1992), but the potential role of negative signals (behavioral inhibitors, interruptants, or repellents) from non-prey and non-host habitats has rarely been studied (Raffa 2001, price 1981 and Vet 1999).So many authors studied its positive and negative effects on infestation rates of pests. For example, Bregante and Matt (1985) studied the intercropping of Maize and *Phaseolus vulgaris*. In Egypt, the intercropping of basil with cotton significantly reduced *Pectinophora gossypiella* infestation and led to 50% reduction in abundance of the pest (Schroeder 1992) .Several studies state its qualities as repellent or companion plant to decrease aphid, thrips and hornworm attacks when intercropped in fields, particularly of tomato crops (Schader *et al*. 2005; Basedow *et al.* 2006; Sujatha *et al.* 2011; Parker *et al.* 2013). Basil (*Ocimum basilicum* L., Lamiaceae) is an aromatic herb with repellent effects on different kinds of arthropods (Bomford 2004; Del Fabbro and Nazzi 2008). Repellent plants are generally used to keep pest organisms away from the main crop (Hjalten *et al.*, 1993).Omar *et al.* (1993) in Egypt, conducted that field trails to study the effect of two intercropping systems of cotton and cowpea on

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DOI: 10.21608/jppp.2020.85987

population density of target pests, aphids, jassid, whitefly, and bollworm.

Also, Omar *et al.* (1994) reported that intercropping of cowpea with cotton as a cultural method to decrease target pests of cotton. Metwally *et al.* (2008) performed the effect of different intercropping systems between plants on pest populations and weight of yield. Plants with aromatic qualities contain volatile oils that may interfere with host plant location, feeding, distribution and mating, resulting in decreased pest abundance (Lu *et al*. 2007). Hassan (2009) found that cowpea and sorghum intercropped reduced aphid (*Aphis craccivora*) population significantly compared to sole cowpea crop in Mubi, Adamawa State, Nigeria. Khafagy (2011) found that intercropping of five aromatic plants (geranium, sweet basil, spearmint, peppermint and hot-pepper) with kidney been as cultural method to decrease whitefly stages and increase of parasitoids. The intercropping of three aromatic plants (Coriander, Carrot and Fennel) with okra plants reduced of insect pests infestation and increased its predators (Sharma *et al.* 2018). Jolliffe (1997) reported that intercrop yields averaged 13% higher with basil than in mono- cultures. This way, the banker plants enhance the efficiency of biological control because the predators are ready to attack the pests as soon as they appear on the crops in the IPM system (Cano *et al*. 2012). Conifer bark beetles not only detect and orient to their aggregation pheromone and host volatiles, but also are able to perceive and respond behaviorally to volatiles from non-host angiosperm trees (Schroeder 1992, Zhang & Schlyter 2004).

Such specific olfactory recognition and inhibitory behavioral effects on attraction of angiosperm non-host volatiles (NHV) have been reported for several other conifer bark beetle genera in both Eurasia and in North America (Zhang & Schlyter 2004 and Graves *et al* 2008). In several insects orders, the inhibitory effects of NHV at second trophic level are reported: Coleoptera (Zhang & Schlyter 2004 and Mauchline *et al*. 2005), Diptera (Linn *et al* 2004), Homoptera (Linn *et al.* 1991), and Lepidoptera (McNair *et al*. 2000).

In order to further develop the utilization of semiochemicals or mixed planting strategies in pest management, we must understand the mechanisms behind the insects' choice of habitat and host, and how biodiversity affects the insects' habitat- and host location ability.

The present investigation aimed to study the impact of intercropping of four aromatic plant species (Fennel (*Foeniculum vulgare*), Dill (*Anethum graveolens)*,Coriander (*Coriandrum sativum*),and Marjoram (*Majorana hortensis*)) with sugar beet on the population fluctuations and *C. vittata*. In addition, the influence of intercropping on predator population and sugar beet yield was investigated

MATERIALS AND METHODS

Experiments were carried out at the Experimental Farm at Sakha Agriculture Research Station, Kafr El-Sheikh Region, Egyp to study the impact of intercropping, between sugar beet and four nun host plants (Table 1), on sugar beet infestation with different stages of the sugar beet beetle *Cassida vittata* (Vill.), its appearance predators and sugar beet crop yield.

Table 1. Aromatic plants intercropped with sugar beet to manage the infestation with C.vitatta in sugar beet plants

Common name	Scientific name	Plant family
Fennel	*Foeniculum vulgare*	Umbelliferae
Dill	*Anethum graveolens*	Umbelliferae
Coriander	*Corlandrum sativum*	Umbelliferae
Marjoram	*Majorana hortensis*	Labiatae

Plants and experimental design:

The experiment was carried out during two sugar beet growing seasons; 2017/18 and 2018/19 to investigate the effect of intercropping some aromatic plants with sugar beet on different stages (eggs, larvae, pre-pupae, pupae and adults) of *C. vittata* (Vill.) at the Experimental Farm at Sakha Agriculture Research Station, Kafr El-Sheikh Region, Egypt. An area of one feddan was prepared and divided into 20 plots (each about 210 m^2) in a randomized complete block design. The seeds of sugar beet (Faten cultivar) were sowed (1seed/ hole) on two sides of row with spacing of 100 × 25 cm during the two seasons on 15th October. Seeds of Fennel, Dill, Coriander and Marjoram were sowed in the same time on (15th October) at the middle of rows at a space of 50 cm between plants and 100 cm between of rows. Normal agricultural practices were performed according to the recommendations of the Ministry of Agriculture and Land Reclamation of Egypt, but without pesticides used. Sampling of C. *vittata* Vill stages were took place at weekly intervals as soon as the time of newly vegetative growth of sugar beet was completed and just after the appearance of beetles (*C. vittata* Vill.) and since of infestation beginning from February 4th week and continued up to crop harvesting(May 4th week). Each sample consisted of 20 sugar beet plants which were chosen randomly from each replicate, repeated four times. The numbers of the different insect stages were counted on the selected standing plants in the field.

Abundance of associated predators:

Studies of *Cassida vittata* Vill. Abundance indicated that the insect attacked sugar beet plants from February to May and its population was always accompanied with presences of some natural enemies. To get more information about the relationship between four aromatic plants, *C. vittata* population, population density of the predatores *Coccinella* sp. (eggs, larvae and adults), *Chrysoperla carnea* Stephens. (eggs,and larvae),

Paederus alfierii Koch (adults), *Scymnus* spp. (larvae), spiders (spiderlings and adults) and, *Metasyrphus carollae* (larvae) were estimated in the same sugar beet fieled where *C. vittata* existing. Samples consisted of 20 sugar beet plants/ replicate were chosen randomly from each intercropping pattern, from the four field borders and the filed center (100 plants) at weekly intervals. Plants were inspected in the field and the numbers of the previous aforementioned predators stages were counted and recorded weekly by the aid of lens on 20 plants/replicate.

The study was carried out during two consecutive growing seasons, 2017/18 and 2018/19.

Effect of intercropping on sugar beet net root weight production and sucrose percentage:

Fresh weight of each intercropping pattern:

Influence of the used intercropping aromatic plants with sugar beet on the weight and sugar percentages of the final crop production (weight roots) was evaluated. Sugar beet final total yield (weight roots) was taken from one plot (1 m) and replicated 5 times for each treatment.

Estimated of sucrose percentage in roots of each intercropping pattern in laboratory of Delta Sugar Company research as follow:

- Each fresh sample grated into small pieces using stainless grater.
- 177 gm of lead acetate were added to 26 gm of the previous sample and mixed very well using an electric blender.
- The mixture filtered into filtration, and it measured by saccharometer apparatus.
- The value of measuring x 1.54 to gain sucrose percentage in bulbs.

This methods were determined as previously described by Carucarruthers& Oldfield (1960) and Darweish (1990).

Statistical Analysis:

Reduction % = infestation in control (untreated) - infestation in treatments/ infestation in control * 100.

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 sugar beet and four aromatic plants on the population abundance of *Cassida vittata* Vill:

1. Number of eggs laid on sugar beet plants:

Data presented in Table (2) show the effect of intercropping between sugar beet plants and some aromatic plants on number of *Cassida vittata* Vill eggs laid on sugar beet leaves during season 2017 /2018 .

Table 2. Effect of intercropping pattern on the average number of the sugar beet C.vittata eggs during the first season 2017 /2018 .

Sampling date	Sugar beet intercropping pattern				
	Sugar beet alone	with Coriander	with Fennel	with Dill	with Marjoram
March					
1	10.00	0.00	0.00	0.75	2.25
2	33.50	1.25	1.75	2.25	6.75
3	55.25	2.50	5.50	10.50	20.50
4	84.75	5.00	10.75	17.50	31.25
April					
1	125.50	25.50	29.25	70.00	89.25
2	105.00	20.75	20.00	24.25	40.00
3	67.50	5.50	10.50	15.25	20.25
4	85.75	10.25	20.75	22.25	28.00
May					
1	115.70	17.00	26.25	37.75	42.75
2	100.50	10.75	21.25	25.25	35.25
3	75.00	4.00	11.00	18.50	30.25
4	47.75	1.00	7.50	10.75	20.50
Total	916.20	93.50	164.46	285.00	367.00
Mean+- se	70.48 e	7.19 d	12.65 c	21.92 b	28.23 a
Reduction %	-	89.80 d	82.05 c	68.90 b	59.95

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

The highest average number of eggs laied recorded in the first week of April 2018 on sugar beet alone followed by sugar beet with Margoram ,Dill, Fennel and Coriander and represented by 125.5 , 89.3 ,70.0, 29.3 and 25,5 eggs \ 20 sugar beet plants, respectively. It can be noticed that ,the highest seasonal average number of eggs recorded on sugar beet alone (70.5),followed by suger beet with Margoram (28.2),Dill (21.9),Fennel (12.7) and with Coriander came in the last ranking (7.2 eggs).

Statistical analysis revealed that ,a highly significant effect were recorded according to intercropping pattern on the egg laying by *C. vittata* females .

Regardless of the intercropping pattern, the highest numbers of laid eggs were those on April 1st week and May 1st week, in both seasons. However, the lowest numbers of laid eggs were in March. In 2018-2019 season, almost the results were the same of 2017 -2018 season.

Table 3. Effect of intercropping pattern on the average number of the sugar beet C.vittata eggs during the first season 2018 /2019

Sampling date	Sugar beet intercropping pattern				
	Sugar beet alone	with Coriander	with Fennel	with Dill	with Marjoram
March					
1	12.25	0.00	0.00	2.00	2.50
2	36.00	0.75	2.00	3.00	7.00
3	58.75	3.25	6.25	11.25	21.00
4	88.00	5.50	11.75	19.25	33.25
April					
1	130.00	26.50	37.00	75.25	90.75
2	107.75	21.00	21.75	27.00	41.75
3	70.25	6.25	12.25	17.50	21.50
4	88.50	11.75	21.50	23.75	30.25
May					
1	118.75	19.25	35.25	40.50	44.00
2	105.00	12.00	22.75	26.75	36.25
3	77.25	5.25	13.00	19.25	31.50
4	50.00	1.50	9.25	11.50	22.00
Total	942.50	113.00	192.75	277.00	381.75
Mean+- se	72.50 e	8.69 d	14.83 c	21.31 b	29.37 a
Reduction %	-	88.01 d	79.54 c	70.61 b	59.49 a

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

2. Number of immature stages (egg, larvae and pupae):

During experimental, of 2018 and 2019 (Tables 4&5), Sugar beet alone had the highest immature population; 119.77 and 122.81 immature stages/ 20 Sugar beet plants, respectively. The second rank of larval population was detected in sugar beet+ Marjoram intercropping pattern; with values of 52.06 and 53.42 immature stages / 20 plants in the first and second seasons, respectively.

The third rank of immature stages population was found in Sugar beet with Dill intercropping pattern. On the other hand, the lowest immature stages population was detected in Sugar beet with Coriander intercropping, as this pattern achieved the highest reduction in *C. vittata* Vill immature stages population; 83.16 and 82.17% reduction, in the first and second seasons, respectively. Sugar beet with fennel pattern occupied the second rank of efficiency in reducing immature stages population, while the third rank of efficiency was that of Sugar beet with Dill pattern.

Regardless of intercropping pattern, the highest population densities of *C. vittata* Vill immature stages were recorded on 1st week- April and 1st week-May in the two seasons. However, the least immature stages population densities occurred by late May in both seasons.

Table 4. Number of *Cassida vittata* Vill Immature stage/ 20 sugar beet plans as affected by intercropping pattern 2017 /2018 season:

Sampling date	Sugar beet intercropping pattern: Sugar beet alone	with Coriander	with Fennel	with Dill	with Marjoram
March					
1	13.50	0.00	0.25	2.75	3.50
2	29.00	5.50	8.50	13.25	15.00
3	59.25	9.25	15.00	20.75	25.75
4	190.25	25.50	50.25	53.50	60.25
April					
1	215.00	76.00	100.75	123.25	140.75
2	193.50	30.50	63.50	63.00	72.50
3	160.75	10.25	15.00	24.25	40.50
4	175.25	25.50	59.25	73.00	91.50
May					
1	194.00	51.75	70.75	90.25	100.00
2	165.75	12.75	36.75	46.00	75.75
3	90.50	8.50	12.50	27.25	35.75
4	70.25	5.75	9.00	11.00	15.50
Total	1557.00	262.25	421.54	548.25	676.76
Mean+- se	119.77 e	20.17 a	32.43 b	42.17 c	52.06 d
Reduction %	-	83.16 a	72.92 b	64.78 c	56.53 d

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

Table 5. Number of *Cassida vittata* Vill Immature stage/ 20 sugar beet plans as affected by intercropping pattern 2018 /2019 season

Sampling date	Sugar beet intercropping pattern: Sugar beet alone	with Coriander	with Fennel	with Dill	with Marjoram
March					
1	15.25	0.00	0.50	3.25	4.75
2	32.25	6.25	9.25	15.00	15.25
3	62.50	11.50	17.50	22.25	27.00
4	193.75	27.75	53.25	55.50	61.75
April					
1	217.75	79.25	105.00	125.25	142.50
2	197.00	33.25	66.75	65.00	73.75
3	164.25	11.75	17.50	25.75	42.50
4	177.75	28.50	63.25	75.50	93.25
May					
1	199.00	55.00	73.50	89.25	103.25
2	169.25	14.25	39.00	66.50	77.50
3	94.25	10.00	14.25	28.75	36.25
4	73.50	7.25	11.25	13.25	16.75
Total	1596.50	284.75	471.00	585.25	694.50
Mean+- se	122.81 e	21.90 a	36.23 b	45.02 c	53.42 d
Reduction %	-	82.17 a	70.50 b	63.34 c	56.50 d

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

3. Number of *Cassida vittata* Vill adults:

All intercropping patterns reduced the numbers of *C. vittata* Vill adults sugar beet plants as compared to Sugar beet alone that suffered 95.42 and 100.13 adults / 20 plant, in two experimental of 2017 / 2018 and 2018 / 2019seasons, respectively (Table 6).

The best combination was intercropping sugar beet with Coriander as *Cassida vittata* adult were reduced by 85.15 and 84.12% in the first and second seasons, respectively (Table 7). The second rank was that of sugar beet with fennel intercropping with 75.19 and 74.93 % adults' reductions, in the first and second seasons, respectively

Table 6. Number of *Cassida vittata* Vill adult stage/ 20 sugar beet plans as affected by intercropping pattern 2017 /2018 season :

Sampling date	Sugar beet intercropping pattern: Sugar beet alone	with Coriander	with Fennel	with Dill	with Marjoram
February 4th week	3.00	0.00	0.00	0.50	1.50
March					
1st	5.50	0.00	0.00	1.25	2.00
2nd	18.75	1.25	2.25	3.50	10.50
3rd	38.50	3.50	5.75	8.25	16.25
4th	101.75	20.75	26.50	39.00	50.75
April					
1st	197.50	60.50	90.25	121.75	127.50
2nd	146.00	17.25	20.00	27.50	39.25
3rd	136.25	8.50	12.25	20.75	28.75
4th	153.75	17.00	41.75	46.50	62.25
May					
1st	163.50	40.25	61.50	70.25	79.50
2nd	151.25	13.75	32.25	41.50	53.50
3rd	73.00	8.00	10.00	16.25	27.50
4th	51.75	3.50	5.25	7.00	11.25
Total	1240.50	184.24	307.75	404.00	519.54
Mean/ 20 plant	95.42 e	14.17 a	23.67b	31.08 c	39.96 d
Reduction %	-	85.15 a	75.19 b	67.43 c	58.12 d

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

Table 7. Number of *Cassida vittata* Vill adult stage/ 20 sugar beet plans as affected by intercropping pattern 2018 /2019 season:

Sampling date	Sugar beet intercropping pattern: Sugar beet alone	with Coriander	with Fennel	with Dill	with Marjoram
February 4th week	3.50	0.00	0.00	1.00	2.25
March					
1st	6.25	0.25	0.25	1.50	3.25
2nd	20.00	1.50	2.75	4.25	12.75
3rd	40.25	3.75	6.00	10.25	19.50
4th	123.50	21.50	27.75	42.25	53.75
April					
1st	220.75	63.25	93.25	124.50	130.50
2nd	143.50	19.25	22.75	29.75	43.50
3rd	139.00	9.25	15.00	22.50	29.75
4th	155.25	17.75	43.50	49.25	65.50
May					
1st	166.25	43.50	63.25	72.25	83.50
2nd	152.75	14.50	35.00	43.50	55.75
3rd	76.50	8.50	10.75	18.50	31.00
4th	54.25	3.75	6.00	9.25	13.25
Total	1301.75	206.75	326.25	428.75	544.25
Mean/ 20 plant	100.13 e	15.90 a	25.10 b	32.98 c	41.87 d
Reduction %	-	84.12 a	74.93 b	67.06 c	85.18 d

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

2. Effect of intercropping between sugar beet and four aromatic plants on predator population:

Intercropping of sugar beet with all nun host plants encouraged almost all considered predatory insects and true spiders compared with sugar beet sole (Table 8). In 20117/18 season, the highest population densities, of *Chrysoperla carnea*; 70.00 and 57.50 individuals / 10 plants were obtained with sugar beet with Fennel and sugar beet with Dill intercropping pattern, respectively.

Coccinella spp population densities were highest with Sugar beet with Dill and Sugar beet with Fennel, followed by Sugar beet with Coriander, but low in plots of Sugar beet solid and sugar beet with Marjoram pattern. The highest densities of *Paederus alfierii* were detected with Sugar beet with Coriander and Sugar beet with Fennel, with value, of 65.75 and 50.25 individuals / 10 plants, respectively. The highest population densities, of *Scymnus* spp; 63.25 and 53.75 individuals / 10 plants were obtained with Sugar beet with Marjoram and sugar beet with Coriander intercropping pattern, respectively .The true spider populations proved to be highest in case of intercropping between Sugar beet and Fennel (65.75) , followed by sugar beet with Marjoram (57.25) spider lings and adults / 60 leaflets) . The least densities of true spiders were found in plots with Sugar beet solid, followed by sugar beet intercropped with Coriander. Other intercropping patterns resulted in intermediate population densities of true spiders.

Predatory population densities in 2018/19 season took a trend very similar to that 2017/18 season.

Table 8. Effect of intercropping sugar beet with four aromatic plants on population density of *C. vittata* predators in sugar beet plants

Intercropping pattern	*Chrysoperla carnea*	*Coccinella* spp	*Paederus alfierii*	*Scymnus* spp	True spider
Mean number during 2017 / 2018 season					
Sugar beet plant +Fennel	70.00 a	61.50 b	50.25 b	45.50 c	65.75 a
Sugar beet plant +Dill	57.25 b	79.75 a	29.25 d	22.00 d	45.25 c
Sugar beet plant +Coriander	33.50	40.00 c	65.75 a	53.75 b	30.50 d
Sugar beet plant +Marjoram	28.25 d	26.50 d	44.00 c	63.25 a	57.25 b
Control (sugar beet plant)	17.00 e	15.25 e	13.50 e	7.00 e	25.50 e
Mean number during 2018 /2019 season					
Sugar beet plant +Fennel	67.50 a	60.25 b	55.25 b	49.00 c	67.50 a
Sugar beet plant +Dill	53.75b	76.50 a	32.75 d	25.50 d	47.25 c
Sugar beet plant +Coriander	31.25 c	36.25 c	70.25 a	57.75 b	32.75 d
Sugar beet plant +Marjoram	24.5 d	24.00 d	47.25 c	65.00 a	60.00 b
Control (sugar beet plant)	15.25 e	14.00 e	15.00 e	9.50 e	29.50 e

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

3-Intercropping between sugar beet and four aromatic plants on sugar beet yield:

Data in Table (9) present the sugar beet yield as affected by intercropping between sugar beet and nun host plants. Sugar beet + Fennel pattern proved to be the best combination, as the sugar percentages were 21.70 and 21.90 % in the first and second seasons, respectively. This combination produced 39.25 and 41.00 tons / feddan in first and second seasons, respectively. Thus, the yield advantages of Sugar beet with Fennel were 44.59 and 48.78 % as compared to Sugar beet solid in the first and second seasons, respectively. Sugar beet with Dill intercropping pattern proved to be the second best combination, followed by Sugar beet with Coriander pattern, concerning obtained Sugar beet yield, with values of 34.00& 35.25 and 29.50 & 29.75 ton / fed .in the first and second seasons, respectively. However, the lowest sugar beet yields were obtained from Sugar beet plant with Marjoram patterns in both seasons.

Table 9. Effect of intercropping sugar beet with aromatic plants on sugar beet yield

Aromatic plant species	Yield production (ton/ fed.)	Increase in yield production %	Sucrose percentage
2017/18 season			
Sugar beet plant +Fennel	39.25 a	44.59 a	21.70 a
Sugar beet plant +Dill	34.00 b	36.03 b	20.50 a
Sugar beet plant +Coriander	29.50 c	26.27 c	19.25 b
Sugar beet plant +Marjoram	27.00 c	19.44 d	17.75 b
Control (sugar beet plant)	21.75 d	-	16.50 c
2018/19 season			
Sugar beet plant +Fennel	41.00 a	48.78 a	21.90 a
Sugar beet plant +Dill	35.25 b	40.43 b	20.75 a
Sugar beet plant +Coriander	29.75 c	26.32 c	19.75 b
Sugar beet plant +Marjoram	28.50 c	20.32 d	18.25 b
Control (sugar beet plant)	21.00 d	-	17.00 c

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

Discussion

The current results showed that intercropping the aromatic plants with Sugar beet plants reduced mean number of *Cassida vittata* stages compared to Sugar beet sole. It was clear that nun host plants were more attractive to predators than sugar beet sole. The high yield of Sugar beet was in cases of intercropping between Sugar beet and the aromatic plants, while, the lowest yield was that of sugar beet 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 (Khafagy, 2015).

Tomato yield intercropped with coriander herbs (*Coriandrum sativum* L.) (Apiaceae) and dier (*Galinsoga parviflora* Cav.) (Asteraceae) increased due to reducing *T. absoluta* abundance and enhancing the role of predarors, like lady bugs and spiders (Medeiros *et al*., 2009). Coriander plants have been successfully intercropped with tomatoes to manage whiteflies by reducing the number of adults (Hilje & Stansly 2008). Reductions in larvae, eggs and adults of *T. absoluta* (Meyrick) and increase in populations of insect predators were reported in coriander intercropped with tomato compared to tomato alone (Medeiros *et al*., 2009).

Khafagy (2011) reported that intercropping system of kidney bean with sweet basil, geranium, peppermint, spearmint and hot pepper showed highly reduction of *Bemisia tabaci* (Genn.) (eggs, nymphs and adults) compared to kidney bean solid. Kassem *et al.* (2012) found that intercropping between cowpea and each of citronella grass and lemon grass reduced the populations of insect pests attacking cowpea. Intercropping in general, reduced the pest complex in cowpea fields. These reductions were 94.34 – 97.78, 75.98 – 80.19 and 50.64 – 58.37% in case of intercropping of citronella grass with one, two and three rows of cowpea, respectively. El-Fakharany *et al.* (2012) reported that sugar beet plants intercropped with maize, faba bean or cabbage plants had the highest densities of *Chrysoperla carnea* Stephens, *Paederus alfierii* Koch, *Scymnus* spp. and true spiders compared to sole sugar beet. Mohamed *et al.* (2013) reported that mean numbers of the pests (*B. tabaci* Gen. and *Tetranychus urticae* Koch) in okra decreased in rosella intercropped with okra. Abou-Shanab *et al.* (2014) obtained significant differences among treatments, when intercropping of coriander with tomato concerning whitefly nymphs, *Aphis gossypii* nymphs, jassid adults, *Empoasca* spp, *Thrips tabaci* nymphs and *Tetranychus urticae* on tomato plants. El-Gobary *et al*. (2014) found that okra plants intercropped with aromatic plants increased the associated numbers of predators and reduced *Helicoverpa armigera* (HUB.) compared to control (okra solely). Khafagy (2015) reported that intercropping aromatic plants with tomato plants reduced the infestation with *T. absoluta*, especially on geranium + tomato and increased the numbers of predators especially on sweet basil + tomato compared with tomato solid (control). Intercropping eggplant (*Solanum melongena* L.) with coriander or marigold was previously reported to lead to lower numbers of *B. tabaci* on egg- plant, compared to eggplant alone (Sujayanand *et al.*, 2015). Azouz (2016) found that intercropping between tomato and garlic reduced the number of *Tuta absoluta* compared to tomato sole. (El – Ghanam 2016) reported that intercropping coriander and dill between Antsar 2 and Master B pea varieties proved to control *Liriomyza trifolii*. Stella *et al.*, (2016) reported that sweet basil intercropping between tomato plants helped to lower *B. tabaci* infestation on tomatoes compared to tomato sole. The lowest *B. tabaci* nymph and adult infestation on tomato plants was achieved through companion planting with a row of basil in between adjacent rows of tomato compared to tomato only. Hata *et al.* (2016) suggested that intercropping garlic with strawberry reduced *Tetranychus urticae* populations. Flowering companion plants have been used in different cropping systems to enhance the impact of natural enemies (Begum *et al.,* 2004 and Begum *et al.*, 2006). The increase 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 (Jonsson *et al.*, 2008) to improve conservation biocontrol. 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). In addition, flowering plants can increase the fecundity and longevity of parasitic hymenopterous (Baggen *et al.*, 1999 and Bickerton & Hamilton 2012) and predators (Begum *et al.*, 2004 and Begum et al. 2006). Because of the wide variety of herbivores that become available at different times or in different microhabitats, natural enemies can reach larger population sizes (Root 1973). Literature survey showed that 68 (53%) of total of 130 natural enemy species had higher population densities in polycultures compared to monocultures (Andow 1991). For example, adult syrphid whose larvae are voracious predators of aphids, feed on both pollen and nectar (Hickman and Wratten 1996). In addition to increasing natural enemy fitness, improved nutrition may also enhance foraging behavior (Lavandero *et al*., 2006) and increase the female-based sex ratio of parasitoid off springs (Berndt *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 (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 (Jactel *et al.*, 2005).

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تحميل بعض النباتات العطرية مع بنجر السكر وتأثيرها على الإصابة بحشرة خنفساء البنجر السلحفائية، والمفترسات المصاحبة لها و إنتاجية محصول بنجر السكر

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معهد بحوث وقاية النباتات – محطة البحوث الزراعية بسخا – كفر الشيخ – مركز البحوث الزراعية - مصر

أجريت هذه التجربة بالمزرعة البحثية لمحطة البحوث الزراعية بسخا , بمحافظة كفر الشيخ خلال موسم١٧/ ٢٠١٨ و٢٠١٩/١٨م وذلك لدراسة تأثير تحميل بعض النباتات العطرية على الإصابة بحشرة البنجر السلحفائية والمفترسات المصاحبة لها وإنتاجية محصول بنجر السكر كانت النباتات العطرية محل الدراسة هي: الشمر، الشبت ، الكزبرة والبردقوش. أوضحت النتائج انخفاض الإصابة بحشرة خنفساء البنجر السلحفائية عند تحميل النباتات محل الاختبار على بنجر السكر وبخاصة تحميل نبات الشمر على بنجر السكر يليه تحميل الشبت ثم الكزبرة، ثم البردقوش بالمقارنة بزراعة بنجر السكر منفردا . كما أظهرت الدراسة أن تحميل الشبت مع بنجر السكر كان الأكثر جذباً لمفترس أبو العيد, بينما كان تحميل الشمر أكثر جذباً لأسد المن، و كان البردقوش أكثر جذباً للمفترس الأسكمينس وكان تحميل الكزبرة اكثر جذباً لحشرة الرواغة. وكان الشمر اكثر جذباً للعناكب الحقيقية بالمقارنة بالمعاملات الاخرى . تم الحصول على اعلى محصول لبنجر السكر عند تحميلها مع الشمر يلى ذلك عند تحميل نباتات البنجر مع الكزبرة.