Nat. Volatiles & Essent. Oils, 2021; 8(6): 2245-2262

NVEO
Natural Volatiles &
Essential Oils

Effect Of Intercropping Systems On Diamondback Moth (Plutella Xylostell L.) And Turnip Aphid (Lipaphis Erysimi Ka) Infesting Cabbage, Brassica Oleracea Var. Capitate

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Abstract

A field experiment was carried out at province of Basra for conducting the study during the growing season 2020/2021. This study was conducted to evaluate the effect of intercropping of the cabbage crop on the infestation of the most important insect pests, Diamondback Moth DBM (Plutella xylostell L.) and Turnip Aphid (Lipaphis erysimi Ka). Cabbage crop was intercropped with three different intercrop configurations 'onions, alfalfa, and broad beans'. Row intercropped plots contained 4 lines of cabbage crop with 0-3 lines of companion plants. The results of the effect intercropping systems showed the population of the DBM larvae and pupae and aphids were significantly greater on cabbage monoculture compared to intercropped treatments. Cabbage intercropped with the bean plant (1 cabbage: 1 broad bean) was the best treatments. The results also showed the effectiveness of the intercropping systems of cabbage on reducing the population density of aphids. The lowest population were recorded in the treatments (3 cabbage: 1 alfalfa) and (3 cabbage: 1 broad bean), compared to the monoculture cabbage system. In conclusion, this study showed the efficiency of intercropping systems in decreasing the infestation or influencing the development of the DBM instars and turnip aphids.

Key words: Cabbage, Diamondback Moth, Intercropping, Plutella xylostell, Turnip Aphid, Lipaphis erysimi.

Introduction

Pests associated with Brassicaceae, especially cabbage crop are highly diverse, including Cabbage Aphid (Brevicoryne brassicae L.), Turnip Aphid (Lipaphis erysimi Ka., Lipaphis lepidii Ne and Lipaphis pseudobrassica Da), Green Peach Aphid (Myzus persica Su), Diamondback Moth (Plutella xylostell), whitefly (Bemisia tabaci), the Large Cabbage Butterfly (Pieris brassicae L.), the Small Cabbage Butterfly (Pieris rapae L.), the Cabbage Worm, (Trichoplusia ni Hubner), and Stink bug Bagrada hilaris (De, 2001; Alyousuf and Al-Masudey,2012). These pests cause damage to the cabbage heads, by making holes in the leaves, leads to the destruction of the developing buds, and digging tunnels in the heads of mature cabbage (Baidoo et al., 2012). Thus, it reduces productivity and decreases the marketing value of the

crop (Dobson et al., 2002). However, aphids and whiteflies reduces the photosynthesis, and transmits viruses, reflecting on the crop quantity and quality (Mochiah et al., 2011; 2013).

Diamondback moth (DBM) (P. xylostella L.) is one of the most distractive pests of brassica crops worldwide; the total cost of controlling this pest was estimated at 4-5 billion dollars annually (Zalucki et al., 2012; Furlong et al., 2013). The pest has the ability to rapidly develop resistance to the most groups of the insecticides (Shelton et al., 2000; Furlong et al., 2013). Aphids are economically important insect pests of these crops that hinder the growth of the plant leading to failure of seed formation and low level of oil in the grains (Ali et al., 2006). The high aphid's infestations leads to a severe economic loss of the crop up to 75% (Sekhon, 1999; Kift et al., 2000; Pontoppidan et al., 2003).

Although the application of chemical control methods usually use to reduce the effects of these pests (Ntow et al., 2006), but the insecticides causes many problems, including food and environmental pollution, effect on non-target organisms and beneficial insects (Timbilla and Nyarko, 2004; Ntow et al., 2006; Fening et al., 2013). As well as developing resistance in pests against chemical insecticides, making farmers use broad spectrum insecticide, to prevent these pests reaching the economic thresholds (Roush and Tabashnik, 2012).

Intercropping is an agricultural practice of integrated pest management (IPM) (Sarfraz et al., 2005), which can be defined as the cultivation of two crops of two different species at the same time closely. There are many possible farming patterns for intercropping, where different crops are grown in the same rows within the same field, or planting different crops in alternating rows (Zhang et al., 2014). Currently, multiple cropping systems represent 15-20% of the global food supply (Altieri, 1999).

Crop growers and producers have faced many environmental problems arising from reliance on homogeneous agricultural systems (monocultures), represented by increasing in the incidence of crops with agricultural pests and plant diseases, which can be severe pests when infesting a widely cultivated agricultural crop. Worldwide, about 91% of the 1.5 billion hectares of agricultural land are cultivated with crops; most of them are planted with monoculture such as, wheat, rice, corn, cotton, or soybeans (Smil, 2000). Monoculture may have temporary economic advantages for growers and producers, but it has negative effect on the long-term productivity (Robinson, 1996). However, the intercropping of diverse plant species prevents pest's population buildup in conventional agroecosystems. Moreover, the environmental benefits of intercropping, as the strategy of these types of cultivation increases the productivity and quality of crops (Xue et al., 2016). As well as optimizing the investment of the earth's resources and reducing the spread of weeds (Asman et al, 2001).

In some intercropping system, a single crop can be grown as a transforming host, protecting other crops that are more sensitive or more economically valuable from serious damage. While, crops are grown together, that improves the abundance of natural enemies, which offers biological suppression of pest populations, thus maximizing the necessity to use the highly hazardous pesticides (Landis et al., 2000; Altieri et al., 2009; Garratt et al., 2011). For example, it was found that planting onions with cabbage decreased the population densities of pests (Baidoo et al., 2012). Intercropping of lemongrass (Cymbopogon citratus)

provided better protection for cabbage crop than monoculture system; as well as the density of the striped beetle (Leptinotarsa decemlineata) was significantly reduced on cabbage (Han et al., 2015). The objective of this study was to determine the effects of intercropping on cabbage pests populations.

Materials and Methods

Two Experimental sites were selected in province of Basra for conducting the study during the growing season 2020/2021. The experiments were carried out in private field at Al-Zubair region; the second field was chosen in the Agricultural Research Station of the College of Agriculture, University of Basrah at Karmat-Ali region. The physical and chemical properties of the soil of the fields were analyzed before conducting the experiments (Table 1).

Table (1) The physical and chemical properties of the soil at Al-Zubair and Karma Ali field, Basra, 2020/2021.

Soil properties	Al-Zubair	Karma Ali
EC (dS m^{-1})	3.14	5.71
Soil pH	7.58	7.61
Available Nitrogen (g k^{-1})	154	196.0
Available phosphorous (g k^{-1})	61.38	38.04
Available Potassium (g k^{-1})	110	243
Organic matter (%)	0.68	0.89
Soil type		
Sand	803.98	627.66
Silt	78.41	208.60
Clay	117.61	163.74
Soil texture	Sandy	Loamy sand

The intercropping of cabbage plant treatments:

Each field (350 m^2) was divided into three blocks; each block was divided into ten experimental units, which were 30 m^2 (12x2.5 m), with 1 m. alleys, arranged in a randomized complete block design with 3 replicates.

Cabbage crop were intercropped with onions, alfalfa, and broad beans (Table 2). Row intercropped plots contained 4 lines of cabbage crop with 0-3 lines of companion plants (Table 3). At each experimental unit, the distance between every two lines of cabbage crop was 75 cm. At each line, 10 cabbage plants were grown, and the spacing between each 2 plants, and between the cabbage plant and the companion plants were 30 cm, and 35 cm respectively (Figure 1). Alfalfa and broad beans were planted in the field directly on 10/12/2020 and 9/30/2020 at Al-Zubair and Karmat-Ali regions respectively; whereas, the companion plant 'onion' were transplanted to the fields on 10/31/2020 and 1/11/2020 at Al-Zubair and Karmat-Ali regions respectively. However, cabbage plants were transplanted to the fields on 10/24/2020 at Al-Zubair, and Karmat-Ali regions. All agricultural operations were applied such as weed control.

Table (2) The plant cultivars of the main degraded plant and the plants intertwined with it were used.

The plant	The scientific name	variety	Source
Cabbage	Brassica oleracea var	Dala F1	New Zealand
Onions	Allium cepa	Sturon	Dutch
Alfalfa	Madicago sativa L.	local	
broad Bean	Vicia faba	local	

Table (3) Models of intercropping of cabbage crop used in the study.

Model	companion plant	Number of lines (cabbage: companion plant)	Intercropping Systems
First	Onions	3: 1	3 cabbage+ 1 onion
Second		2: 1	2 cabbage + 1 onion
Third		1: 1	1 cabbage + 1 onion
Forth	Alfalfa	3: 1	3 cabbage + 1 alfalfa
Fifth		2: 1	2 cabbage + 1 alfalfa
Sixth		1: 1	1 cabbage + 1 alfalfa
Seventh	Beans	3: 1	3 cabbage + 1 broad bean
Eighth		2: 1	2 cabbage + 1 broad bean
Ninth		1: 1	1 cabbage + 1 broad bean
Tenth		4: 0	cabbage only

The effect of intercropping of the cabbage plant on the infestation of the most important insect pests:

The population densities of most important insect pests were studied. Randomly, samples were taken weekly from three cabbage plants intercropped with companion plants in each treatment starting 14/11/2020, till 3/4/2021 at Karmat-Ali field, and from 15/11/2020 until 7/4/2021 at Al-Zubair field.

Diamondback moth population:

The population density of larvae and pupae of the DBM were estimated; the first appearance of the insect was recorded on 19/12/2020, and 15/12/2020, at in Al-Zubair and Karmat-Ali fields respectively. The insect was diagnosed by Assistant Professor Dr. Hana Al-Saffar (Natural History Research Center and Museum / University of Baghdad).

Turnip Aphids population:

The population density of turnip aphids Lipaphis erysimi (Hemiptera: Aphididae) was determined at each experimental units. The first appearance in the field was reported on 10/2/2021 and 25/11/2020 at Al-Zubair and Karmat Ali study sites. The number of insects was calculated on three cabbage plants, randomly selected from the middle of each experimental unit for each intercropping system. Insects were identified using taxonomic key of Blackman and Eastop (1984).

Data analysis

Treatment effects for DBM and aphids count data were determined by ANOVA using Genstat (3). Treatment effects were considered significant at $P \leq 0.05$.

Results and Discussion

The effect of intercropping of cabbage on the infestation of insect pests:

DiamondBack Moth P. xylostella L.

DBM was observed on cabbage at seventh week after transplanting at Al-Zubair site, with average of 0.01 larvae/ plant; the density increased to the highest density 3.21 larvae/ plant at the first week of March (4/3/2021) (Table 4).

The results of the effect intercropping and the different plant densities (planting lines) of the cabbage crop on the population density of DBM larvae showed in the above table. The intercropping systems had a significant negative effect on population density of DBM larvae compared to monoculture. Cabbage intercropped with the bean plant (1 cabbage: 1 broad bean) was the best treatments, with the lowest average of density of 0.30 larvae/ plant, which did not differ significantly from the treatment (3 cabbage: 1 bean; 0.62 larvae/ plant). However, the average of densities of larvae ranged from 0.49 larvae/plant on (1 cabbage: 1 onion) to 0.06 larvae/plant on (2 cabbage: 1 onion), compared to 1.08 larvae/plant in the treatment (3 cabbage: 1 onion). Intercropping cabbage with alfalfa (1 cabbage: 1 alfalfa) affected the larval population with an average of 0.61 larvae/plant, followed by treatments (2 cabbage: 1 alfalfa) and (3 cabbage: 1 alfalfa), which had 0.79 and 1.03 larva/plant, respectively compared with the highest larval density of 1.21 larvae/plant on cabbage planted in monoculture system in the control treatment.
The results of the statistical analysis also showed that there was no significant interaction between treatments, cultivation systems, different plant densities, and sampling periods.

Table (4) The effect of intercropping systems on the population density of DBM larvae in Al-Zubair region during the growing season 2020-2021.

Intercropping System	Larvae population density (larva/plant)											Means
	19/12/2020	26/12/2020	2/1/2021	14/1/2021	30/1/2021	10/2/2021	17/2/2021	25/2/2021	4/3/2021	20/3/2021	7/4/2021	
3 cabbage + 1 onion	0.0	0.0	0.0	0.1	1.2	0.6	0.3	0.2	4.2	5.1	0.1	1.08
2 cabbage + 1 onion	0.0	0.0	0.0	0.1	0.2	0.0	0.1	0.8	2.9	2.4	0.0	0.60
1 cabbage + 1 onion	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.3	1.7	2.4	0.2	0.49
3 cabbage + 1 alfalfa	0.0	0.0	0.2	0.3	1.8	0.0	0.3	1.2	5.4	2.0	0.0	1.03

2 cabbage + 1 alfalfa	0.0	0.2	0.0	0.1	1.9	0.3	0.2	0.6	3.3	2.1	0.0	0.79
1 cabbage + 1 alfalfa	0.0	0.0	0.3	0.0	0.7	0.1	0.0	0.0	3.3	2.3	0.0	0.61
3 cabbage + 1 broad bean	0.1	0.0	0.6	0.0	0.6	0.0	0.2	0.6	3.4	1.4	0.0	0.62
2 cabbage + 1 broad bean	0.0	0.0	0.1	0.0	1.3	0.2	0.2	0.1	2.4	3.8	0.2	0.76
1 cabbage + 1 broad bean	0.0	0.0	0.0	0.0	0.2	0.0	0.3	0.4	0.6	1.7	0.1	0.30
cabbage only	0.0	0.6	0.0	0.0	1.0	0.8	0.9	0.3	4.8	5.0	0.0	1.21
Mean	0.01	0.08	0.12	0.07	0.92	0.23	0.27	0.45	3.21	2.83	0.07	
L.S.D	0.47											0.45

L.S.D interaction; N.S

The effect of intercropping on the population density of DBM pupae was also observed (Table 5); the lowest population density of 0.03 pupae /plant was recorded in the third and fourth week of December, respectively, while the highest rate of population density was 3.28 pupae/plant in the first week of April on 7/4/2021.

Cabbage intercropped with broad bean (1:1) was recorded as the best treatment, with the lowest average of 0.47 pupae /plant, which did not differ significantly from the two treatments of cabbage (2 lines and 3 lines: 1 broad bean), with an average of 0.74 and 0.79 pupae/plant, respectively.

Also, the population of the DBM pupae was significantly greater on cabbage monoculture compared to intercropped treatments; Intercropping cultivations with onions, (2 cabbage: 1 onion; 1 cabbage: 1 onion) recorded an average population density of 0.65 and 0.70 pupae /plant, compared to 1.35 pupae/plant of (3 cabbage: 1 onion), which did not differ from the monoculture treatment, which recorded the highest average population density of pupae was 1.46 pupae /plant.

It was also noted that there was no difference in the effect of the cabbage monoculture systems and the intercropping with the alfalfa plant, depending on the number of cabbage lines (1, 2 and 3 cabbage lines: 1 alfalfa), average densities of 1.30, 1.06 and 1.07 pupae /plant.

The lowest densities of pupae were 1.55 pupae/plant on cabbage planted in the intercropping system, treated with (1 cabbage: 1 broad bean) in the first week of April, whereas, the highest number density of 5.44 pupae /plant was recorded for treatment (3 cabbage: 1 onion), compared to monoculture systems, 6.44 pupae/plant in the same week above.

Table (5) The effect of intercropping systems on the population density of DBM pupae in Al-Zubair region during the growing season 2020-2021.

Intercropping System	Pupae population density (pupae/plant)											Means
	19/12/2020	26/12/2020	2/1/2021	14/1/2021	30/1/2021	10/2/2021	17/2/2021	25/2/2021	4/3/2021	20/3/2021	7/4/2021	
3 cabbage + 1 onion	0.0	0.11	0.0	0.0	0.11	1.66	0.0	0.55	1.55	5.44	5.44	1.35
2 cabbage + 1 onion	0.0	0.0	0.0	0.22	0.33	0.44	0.22	0.77	0.11	3.11	2.0	0.65
1 cabbage + 1 onion	0.0	0.0	0.0	0.0	1.11	0.44	0.66	0.11	0.66	2.66	2.11	0.70
3 cabbage + 1 alfalfa	0.0	0.0	0.11	0.11	0.88	0.0	0.88	2.22	0.77	3.55	3.22	1.07
2 cabbage + 1 alfalfa	0.33	0.11	0.0	0.33	0.88	0.11	0.55	1.0	4.11	2.55	1.66	1.06
1 cabbage + 1 alfalfa	0.0	0.11	0.0	0.11	0.33	0.66	1.77	0.88	2.22	2.88	5.33	1.30
3 cabbage + 1 broad bean	0.0	0.0	0.0	0.66	0.22	0.11	1.0	0.33	1.0	3.11	2.33	0.79
2 cabbage + 1 broad bean	0.0	0.0	0.33	0.0	1.0	0.44	0.44	0.22	0.55	2.55	2.66	0.74
1 cabbage + 1 broad bean	0.0	0.0	0.0	0.0	0.0	0.11	0.55	0.66	0.66	1.66	1.55	0.47
cabbage only	0.0	0.0	0.0	0.0	0.33	1.33	2.0	2.44	0.33	3.22	6.44	1.46
Mean	0.03	0.03	0.04	0.14	0.52	0.53	0.81	0.92	0.21	3.07	3.28	
L.S.D	0.49											0.47

L.S.D interaction; 1.57

At Karmat-Ali region, the first appearance of larvae of the DBM P. xylostella was recorded on the cabbage crop in the seventh week after transplanting (15/12/2020) (Table 6), with an average of 0.05 larvae/plant, the highest rate of population density of 0.41 larvae/plant was recorded in the fourth week of December on (24/12/2020).

There is no significant difference between the intercropped treatments and monoculture in Karmat-Ali. However, intercropping treatments of (2 cabbage: 1 onion), (1 cabbage: 1 onion), (3 cabbage: 1 alfalfa), (1 cabbage: 1 alfalfa), (2 cabbage: 1 broad bean) and (1 cabbage: 1 broad beans), were represented by the minimum number of larvae density 0.0 larvae/plant in the second week of February, compared to 0.4 larva/plant on monoculture in the same week.

Table (6) The effect of intercropping systems on the population density of DBM larvae in Karmat-Ali region during the growing season 2020-2021.

Intercropping System	Larvae population density (larva/plant)										Means
	15/12/2020	24/12/2020	6/1/2021	13/1/2021	2/9/2021	16/2/2021	23/2/2021	9/3/2021	27/3/2021	3/4/2021	
3 cabbage + 1 onion	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.03
2 cabbage + 1 onion	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.06
1 cabbage + 1 onion	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.10
3 cabbage + 1 alfalfa	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.1	0.07
2 cabbage + 1 alfalfa	0.0	0.2	0.0	0.0	0.5	0.0	0.0	0.1	0.0	0.0	0.08
1 cabbage + 1 alfalfa	0.22	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.05
3 cabbage + 1 broad bean	0.2	1.7	0.0	0.0	0.0	0.0	0.0	0.11	0.0	0.11	0.22
2 cabbage + 1 broad bean	0.11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.03
1 cabbage + 1 broad bean	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.3	0.05
cabbage only	0.0	0.1	0.3	0.0	0.4	0.0	0.0	0.1	0.0	0.0	0.10
Mean	0.05	0.41	0.03	0.0	0.11	0.0	0.0	0.13	0.0	0.08	
L.S.D	0.14										N.S

L.S.D interaction; 0.46

The results shown (Table 7) showed the effect of the intercropping system on the pupae of the DBM in the Karmat-Ali site; the highest rate of population density reached 1.50 pupae /plant in the second week of March on 9/3/2021.

Cabbage intercropped with faba beans prevented increasing of the pupae population. The population was significantly lower in the treatment (1 cabbage: 1 broad bean), with an average of 0.08 pupae /plant; this intercropping system did not differ significantly from the treatments (2 cabbage: 1 broad bean) and (3 cabbage: 1 broad bean), which had a densities of 0.15 and 0.30 pupae /plant, respectively.

It was also proved the efficiency of the companion plant 'onion'; pupae density of 0.22 pupae /plant was recorded from the treatment (2 cabbage: 1 onion), which did not differ significantly from the two treatments (3 cabbage: 1 onion) and (1 cabbage: 1 onion); the population density of pupae reached 0.24 and 0.35 pupae/plant, respectively.

The two treatments (1 cabbage: 1 alfalfa) and (3 cabbage: 1 alfalfa) were superior in reducing the density to 0.30 and 0.41 pupae /plant, compared with the highest mean density of pupae at 0.52 pupae/plant in treatment (2 cabbage: 1 alfalfa) and cabbage monoculture (0.46 pupae /plant).

It was observed that the highest number of pupae on cabbage planted in monoculture was 1.8 pupae/plant in the first week of April; However, the two treatments (3 cabbage: 1 alfalfa) and (1 cabbage: 1 broad bean) did not record any population density of 0.0 pupae /plant in the same week.

Table (5) The effect of intercropping systems on the population density of DBM pupae in Karmat-Ali region during the growing season 2020-2021.

Intercropping System	Pupae population density (pupae/plant)										Means
	15/12/2020	24/12/2020	6/1/2021	13/1/2021	2/9/2021	16/2/2021	23/2/2021	9/3/2021	27/3/2021	3/4/2021	
3 cabbage + 1 onion	0.0	0.1	0.0	0.0	0.3	0.0	0.0	1.8	0.0	0.1	0.24
2 cabbage + 1 onion	0.0	0.7	0.0	0.0	0.2	0.0	0.0	0.8	0.0	0.3	0.22
1 cabbage + 1 onion	0.0	0.2	0.0	0.0	0.2	0.0	0.0	1.4	0.0	1.6	0.35
3 cabbage + 1 alfalfa	0.11	0.0	0.4	0.0	0.5	0.0	0.0	3.0	0.0	0.0	0.41
2 cabbage + 1 alfalfa	0.33	0.0	0.1	0.0	2.2	0.0	0.0	2.1	0.0	0.4	0.52
1 cabbage + 1 alfalfa	0.11	0.0	0.0	0.0	0.1	0.0	0.0	2.6	0.0	0.1	0.30
3 cabbage + 1 broad bean	0.0	0.0	1.0	0.0	0.4	0.0	0.0	0.7	0.0	0.1	0.30
2 cabbage + 1 broad bean	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.4	0.0	0.4	0.15
1 cabbage + 1 broad bean	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.7	0.0	0.0	0.08
cabbage only	0.0	0.1	0.1	0.0	1.0	0.0	0.0	1.0	0.0	1.8	0.46
Mean	0.05	0.12	0.22	0.0	0.58	0.0	0.0	1.50	0.0	0.51	
L.S.D	0.25										0.25

L.S.D interaction; 0.79

The results of the current study proved the efficiency of intercropping systems in decreasing the infestation / or not favoring / or influencing the development of the DBM instars. Many studies have indicated the efficiency of intercropping on the pest management. El-Fakharany et al. (2012) revealed to efficiency of the intercropping system of Sugar Beet Beta vulgaris with broad beans (Vicia faba), cabbage and maize in reduction of the population density of adult and immature instars, for some pests of the Sugar Beet, including Cassida vittata, Pegomyia mixta, Bemisia tabaci and Aphis spp. Tajmiri et al. (2017) found that the Brassica napus L. (Brassicacae) intercropped with Trifolium alexandrinum, significantly reduced egg density of DBM (P. xylostella L.), however, the intercropping with alfalfa was significantly minimized the density of larvae and pupae, compared to monoculture. Laxman et al. (2019) evaluated the effect of intercropping cabbage with three companion plants (fenugreek, alfalfa and turnip) with two planting patterns (lines and plots) on incidence of insect pests and population of the natural enemies; it was noticed that the cabbage plots intercropped with alfalfa was the most effective intercropping system in reducing the population density

of P. xylostella larvae, Pieris brassicae and aphids. As well as the attraction of biological enemies as pollinators to flowering plants of companion plants that reducing the population density of pests.

Reduced pest populations of DBM in diversified crops maybe attributed to several reasons, which affects the field environment and makes it unsuitable for pests; such as the disturbance of the ability of the insect pest to locate the host plant (Altieri et al., 2009; Asare-Bediako, 2010). Insect pests in intercropping systems will have more difficulties in finding host plants, compared to crops in monoculture (Vandermeer, 1989), due to the complex visible or tangible signals, which confused the selection of insects to their hosts (Eigenbrode et al., 2016). In the case of intercropping with beans, the companion plants impede the movement of pests or act as a barrier that obscures the host plant (Sullivan, 2003). Also, several studies have shown that volatile organic compounds from different types of plants has a repellent effect on many insect pests (Kellouche et al., 2010; Pugazhvendan et al., 2012; Inbaneson et al., 2012; Akono Ntonga et al., 2014).
It may also be recognized to the enhancement of the presence of natural enemies, which contribute to reduction the population of pests (Amin, 2016). Laxman et al. (2019) indicated to efficiency of natural enemies of Brassica oleracea var Capitata L., intercropped with turnip by increasing the densities of predators (Syrphids fly, ladybirds) and parasitized P. xylostella and P. brassicae. Saeed et al. (2016) noted the abundance of natural enemies, especially the Coccinelids beetle, the Syrphid fly and the green lacewing (Chrysoperla carnea), on wheat crop from February to April (pollen and nectar availability), when planting with intercrops (rapa, alfalfa and garlic).

Fening et al. (2020) indicated that the intercropping system between cabbage and onion crops, led to an increase in the natural enemies of predators such as the Paragus borbonicus fly and Cheilomenes spp., and the number of Araneae spiders increased significantly during the growing seasons, led to a reduction in the densities of aphids, cabbage moths and DBM. However, the reason may be due to the production of companion plants many volatile substances. Onion plants produce the compound Allicin, which is an organosulfur compound; that have a defense mechanism against insect pests (Moran, 1992).

The reason for the variation and increase in the numbers of larvae and pupae of the DBM during the growing season at the two sites (Al-Zubair and Karmat-Ali) may be due to the effect of different environmental conditions such as temperatures, relative humidity, wind, rain and others on the DBM P. xylostella (Sahu and Pachori, 2020); or it may be due to the plant size, which increases through the season; the preference of P. xylostella to lay eggs increases on the large plant (Badene and Perezet, 2005).

The results of this study revealed also to the low population density of DBM at Karmat-Ali site compared to Al-Zubair. The cabbage head were characterized by the large size at the Al-Zubair compared to Karmat-Ali field. That is attributed to the effect of high soil salinity on cabbage production and head size in the Karmat-Ali site, where the salinity level (EC) was high (5.71 dS m^{-1}), compared to the salinity content (3.14 dS m^{-1}) in Al-Zubair site. However, cabbage is classified as moderately sensitive to salinity, and the highest yield can be obtained when the salinity was 1.2 dS m^{-1} (Gaballah and Gomaa, 2004).

Turnip aphids:

The first appearance of turnip aphid on cabbage crop was recorded at in Al-Zubair site in the fifteenth week after transplanting (10/2/2021). The highest peak of the population reached on 20/3/2021, with an average of 3.61 insects/ plant (Table 8).

The results showed the effectiveness of the intercropping systems of cabbage on reducing the population density of aphids. The lowest population were recorded in the treatments (3 cabbage: 1 alfalfa) and (3 cabbage: 1 beans) with a population density of 0.0 and 0.37 insects/ plant, respectively, compared to the monoculture cabbage system with the highest average density of 4.00 insects/ plant.

The highest density of aphids on cabbage monoculture (11.11 insects/ plant) in the third week of March, which differed significantly from all treatments of intercropping of cabbage systems. The lowest densities of 0.0 aphids/ plant were represented in the treatments (1 cabbage: 1 beans), (1 cabbage: 1 onion), (3 cabbage: 1 broad bean) and (3 cabbage: 1 alfalfa) in the same week.

Table (8) The effect of the intercropping system on the population density of turnip aphids in the Al-Zubair site during the year 2020-2021.

Intercropping system	Population density of aphids (insect/plant)						Means
	10/2/2021	17/2/2021	25/2/2021	4/3/2021	20/3/2021	7/4/2021	
3 cabbage + 1 onion	0.0	0.0	0.0	2.2	5.5	0.0	1.30
2 cabbage + 1 onion	1.1	0.0	0.0	0.0	6.1	0.0	1.20
1 cabbage + 1 onion	0.0	0.0	0.0	3.1	0.0	0.0	0.52
3 cabbage + 1 alfalfa	0.0	0.0	0.0	0.0	0.0	0.0	0.00
2 cabbage + 1 alfalfa	1.1	0.0	0.0	1.6	2.7	0.0	0.93
1 cabbage + 1 alfalfa	0.0	0.0	0.0	1.1	7.2	0.0	1.39
3 cabbage + 1 broad bean	0.0	0.0	0.0	2.2	0.0	0.0	0.37
2 cabbage + 1 broad bean	1.6	0.0	0.0	0.0	3.3	0.0	0.83
1 cabbage + 1 broad bean	0.0	0.0	0.0	1.1	0.0	0.0	0.81
cabbage only	5.5	0.0	3.4	3.8	11.1	0.0	4.00
Mean	0.94	0.00	0.72	1.53	3.61	0.00	
L.S.D	1.38						1.74

L.S.D interaction; N.S

At Karmat-Ali site, the first appearance of turnip aphids on the cabbage crop was recorded in the fifth week after transplanting (25/11/2021), the highest rate of population density was 10.39 insects/ plant on 23/2/2021 (Table 9).

All treatments of intercropping systems were distinguished for their superiority in reducing the infestation of turnip aphid on cabbage plants. The lowest average number of densities was 1.65 insects/plant in the two treatments (2 cabbage: 1 onion) and (1 cabbage: 1 onion),

compared with the control treatment (cabbage monoculture), which reached the highest insect densities of 6.87 insects/ plant.

Table (8) The effect of the intercropping system on the population density of turnip aphids in the Karmat-Ali site during the year 2020-2021.

Intercropping system	Population density of aphids (insect/plant)												Means
	25/11/2020	6/12/2020	15/12/2020	24/12/2020	6/1/2021	13/1/2021	9/2/2021	16/2/2021	23/2/2021	9/3/2021	27/3/2021	3/4/2021	
3 cabbage + 1 onion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	4.4	3.3	10.5	2.36
2 cabbage + 1 onion	0.0	0.0	0.0	0.0	0.0	1.6	0.0	2.2	10.5	0.0	1.6	3.6	1.65
1 cabbage + 1 onion	1.4	1.1	0.0	0.0	0.0	0.0	1.6	0.0	5.5	1.6	1.1	7.2	1.65
3 cabbage + 1 alfalfa	0.0	0.0	0.0	0.0	1.6	7.7	2.7	1.6	12.2	5.5	1.6	7.7	3.43
2 cabbage + 1 alfalfa	0.0	0.0	0.0	0.0	5.0	3.3	0.0	5.5	8.8	5.0	6.1	8.7	3.56
1 cabbage + 1 alfalfa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	4.4	0.0	0.0	16.1	1.81
3 cabbage + 1 broad bean	0.5	1.6	0.0	0.0	0.0	0.0	3.8	0.0	13.3	6.6	11.0	6.6	3.65
2 cabbage + 1 broad bean	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	10.5	5.5	12.2	3.3	2.82
1 cabbage + 1 broad bean	2.2	0.0	0.0	0.0	0.0	0.0	4.4	0.0	6.6	0.0	1.1	5.5	1.67
cabbage only	0.0	0.0	0.0	0.0	0.0	2.2	8.3	7.7	21.6	11.5	14.7	16.1	6.87
Mean	0.42	0.28	0.00	0.00	0.67	1.50	2.33	1.83	10.3	4.04	5.30	8.58	
L.S.D	1.93												1.76

L.S.D interaction; 6.10

Several studies have indicated the importance of intercropping in reducing the population density of aphid species; Muthukumar and Sharma (2009) reported the reduction of aphids on the intercropped Medicago sativa L. and Brassica oleracea var. botrytis L., with companion plants, sunflower plant Helianthus annuus L., Tagetes erecta L., tomato, Lycopersicon esculentum L., alfalfa Trifolium alexandrinum L. Saeed et al. (2016) demonstrated reducing the rate of infestation of the aphid (Brevicoryne brassicae) on the M. sativa, Brassica napus, Trifolium alexandrinum, garlic Allium sativum intercropped with wheat crop, compared to monoculture.

Debra and Misheck, (2014) show that intercropping of cabbage with onions and garlic reduced the rate of infestation of Brevicoryne brassicae L. and Bemisia tabaci and aphids; thus, the yield increased compared to the cabbage monoculture. Sankar et al. (2007) concluded that the intercropping of cabbage with of onions, garlic, and mustard reduced the incidence of whitefly, thus improving yields (Debra and Misheck, 2014). Tiroesele (2015) also indicated that population of aphid B. brassicae was reduced on the cabbage intercropped with Allium spp., Ocimum basilicum and T. patula flowers.

The reason for decreasing of density of aphids on the intercropping cabbage with the onion plant may be returned also to volatile compounds emitted from companion 'onions' that confusing olfactory of aphids; that reduced their capacity for finding the host and increased the dispersal (Blackman and Eastop, 2000). As well as to the attraction of some pollinators, which their immatures feed on aphids; such as flower flies (Root, 2001; Burgess et al., 2004). Entwistle and Dixon (1989) and Blatch (1999) reported that the larvae of flower flies considered one of the important predators in reducing the population density of aphids.

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