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Influence of Fertilization and Plant Density on Population of some Maize Insect Pests and Yield

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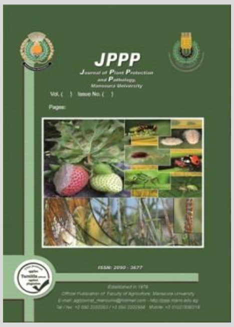

ABSTRACT

Maize considered one of most important cereals in Egypt that used in consumed directly by humans. It is attacking by different insect pests and most important of these insects, aphids, thrips and corn borer that was influence yield size and quality. Field experiments were planted in early June 2019-2020 seasons at Assiut Governorate. Current study, effects of three fertilizers systems (synthetic, organic and mixture between synthetic and organic fertilizers) and three planting densities (5, 10 and 15 plant/Linear meter) on the population of insects and yield were investigated. Results indicated that mixture fertilizers had lowest mean number and infestation percentage of three tested insects at two seasons. Infestation% was higher in 1st than 2nd season. Mean numbers of thrips at mixture fertilizers were a highly significant than both synthetic and organic fertilizers. Addition that, highest yield of maize was recorded in mixture fertilizer at the two seasons (3783 and 3948 kg/feddan, respectively). Results showed that, mean numbers of three insect pests were increased with increasing plant density/Linear meter at the two seasons. Thrips population and aphids were significantly differences in three plant densities (5, 10 and 15 plants/Linear meter) at the two seasons. The highest yield of maize in medium plant density (10 plant/Linear meter) recorded 3655 and 3768 kg/fed., at 2019-2020 season respectively. It is concluded that mixture fertilizer and plant density was 10 plants/Linear meter recorded lowest population of three tested insects and high yield of maize at the two successive seasons.

Keywords: Maize, Synthetic fertilizers, Organic fertilizers**,** Insect population, Plant density, Yield.

INTRODUCTION

Maize (*Zea mays* L.) is the third most important cereal crop after wheat and rice in the world in terms of area and production (Ray et al 2012 and Toungos, 2019). In Egypt, the maize was cultivated in about 2.5 million Feddans during 2018 season (Agricultural Statistics, 2019 and Khaffagy et al. 2020). However, maize yields across the country remain low when compared to acreage of land under production with a decreasing trend over several years. The maize considered one of the most important cereals in Egypt that used in consumed directly by humans. In addition to, maize is also used for corn ethanol, animal feed and other maize products, such as corn starch and corn syrup (Foley, 2019). Maize is utilized as human food (25%) as well as in different industries (29%) (Hussain, et al 2006 and Khan et al., 2015).

Insect pests of maize that was influence the size and the quality of the yield. The most important of these insects, the maize aphids and thrips (Obrist *et al*., 2005; Khan *et al*., 2006; Kucharczyk *et al*., 2011; Nelson *et al*., 2011 and Mahmoud *et al.* 2021).

The corn thrips, *Limothrips cerealium* (Hal.) (Thysanoptera) caused great economic importance such as damages on leaves, fruity, feed on flowers and pollen (Deligeorgidis *et al.* 2011). Thrips feeding on plants usually do not have a direct significant effect on corn yield, but their indirect harmfulness is considerably greater because the infested plants are more susceptible to pathogens infections, (Parsons and Munkvold, 2010 and Bereś, et al., 2013).

Corn leaf aphid, *Rhopalosiphum maidis* (Fitch) (Aphididae) attack more than 30 genera of the Gramineae and can cause serious yield losses through feeding damage, tassel cover by honeydew and viral infection (Kuo *et al.* 2006). Also, the corn borer, *Sesamia cretica* (Lederer) (Noctuidae) is considered the most lepidopterus insects that attack corn seedling and causing dead-heart and longitudinal tunnels when feeding on older plants (Ezzeldin *et al.* 2009).

Fertilization is a major input for increased agricultural productivity and changes the physiological condition of the plant. The Nitrogen (N) fertilizers on agricultural fields decreased despite a 2% increase in land under maize production (FAO, 2017). The form of these fertilizers can influence pest populations in various ways in agro ecosystems, depending on the kind of fertilizer used, the crop grown and the insect species present (Kalule and Wright, 2002). Chemical fertilizers cause environmental hazards, such pollution by nitrate leaching and might increase pest populations (Conway and Pretty 1991; Khidr, 2019).

There is some evidence that synthetic fertilizers reduce plant resistance to insect pests (Herms, 2002), tend to enhance insect pest populations and can increase the need for insecticide applications (Edwards and Stinner 1990). For instance, synthetic nitrogen fertilization increased aphid infestations on winter wheat and *Aphis fabae* (Scopoli) in faba (Hasken and Poehling 1995).

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Excessive and/or inappropriate use of synthetic fertilizers can cause nutrient imbalances and lower pest resistance (Altieri & Nicholls, 2003; Marazzi et al., 2004). Hence, fertilizer application for crop yield can have decisive but variable effects on the complex of associated pest and beneficial insects, necessitating at times a compromise between maximum crop yield and the susceptibility of the fertilised crop to insect pests (Facknath & Lalljee 2005). In recent years, organic farming has received great attention as promising alternative to chemical fertilizers. Organic matter has a high nutritional value, cheap, readily available, biodegradable products, less insect and disease infection and can encourage the presence of beneficial microorganisms which contribute to soil fertility restoration (Rahman, 2004 and Khidr, 2019). Currently, several countries are working to reduce the use of agrochemicals using environmentally friendly strategies such as the application of organic fertilizers from plant and animal waste based on plant extracts and microbials (Durán-lara, 2020).

Plant density and arrangement of plants in a unit area greatly determine resource utilization (light, nutrients and water), the rate and extent of vegetative growth and development of crops (Jettner et al 1998). Plant density is one of the most important cultural practices determining grain yield, as well as other important agronomic attributes of maize. Moreover, grain yield of maize is more affected by variations in plant density than of other members of the grass family because of its low tailoring ability (Sangoi, et al 2002, Abuzar et al 2011). Hence, optimum plant density of maize will lead to effective utilization of soil moisture, nutrients, and sunlight resulting in high yield (Liu et al, 2004 and Sibonginkosi, et al 2019). Its yield is very low partly due to use of non-optimum plant density for different maturity group maize varieties (Sibonginkosi, et al 2019).

The infestation by corn borer to maize was in relation to plant density. Only in one heavily infested maize field did the injury per plant increase slightly with the N-treatment (Parisi et al. 1973). The maize borers may react to phenotypical changes in the plant by modifying its oviposition behavior (Van Huis, 1981). The aim of the present study was to effect of different types of fertilization system and plant densities on the important insect pests in maize fields under climatic changes conditions and yields.

MATERIALS AND METHODS

Experimental design:

Two field experiments were conducted in farmers' fields of Assiut Governorate during the 2019 and 2020 growing seasons. Each of the experiment was performed with a randomized complete block design. All normal agricultural practices were performed without the use of insecticide treatments. The white maize variety "single cross 10" was planted on planted in early of June. An area of approximately 1/6 feddan was divided into 3 treatments long (240 m2) [12 wide×20m.) × 4 plots (replicates) each measuring (60 m2) [3× 20m.]. Each plot consisted of five rows that were 20 m in length and spaced 70 cm apart.

The first experiment (Fertilization treatments):

The maize plants were distributed in the sub-plot treatments and two plants were grown per hill at a distance of 20cm. apart on the one sides of the row. Three Fertilization systems are used to determine the effect of these fertilizers on the population of insects. These systems as follows:

1- Synthetic fertilizers: The different fertilizers were applied twice, added during the service in two doses using 40 Kg NPK of 10:20:10
2- Organic fertilizers using 30 cubic meter /fed. of animal dung which added before the land plowed.
3- Mixture between synthetic and organic fertilizers: using half dose of NPK (20 Kg) and half dose of organic fertilizers (15 m3) which added at the above mention treatments.

The second experiment (plant density treatments):

The experiment was laid out to investigate the effect of three planting densities, as follows:

- The first plant density (low) was 5 plant / Linear meter (The distance between the plants = 20cm approximately)
-The second plant density (medium) was 10 plant / Linear meter (The distance between the plants = 10cm approximately)
-The third plant density (high) was 15 plant / Linear meter (The distance between the plants = 7cm approximately)

Plant samples

Plant samples were taken out from June, 18 to Sept. 3 in the first season and June, 22 to Sept. 7 in the second season. Ten plants were sampled from each experimental unit using a random procedure. Visual count of the insect pests was continued until virtually vanished from the field. At all samples, the plants in each plot were examined and count the following:

The population of thrips and aphids

To record the population of maize thrips, L. cerealium and corn aphid, R. maidis were calculated by counting individual nymphs and adults on each flag leaf of a plant in each sample.

The population of pink stems borers, *Sesamia cretica*

The plants were cut at ground level and samples were subsequently taken to the laboratory for dissection and extraction of stem borer larvae. Abundance of stem borer larvae in the field was expressed as density of larvae per plant. Also, the numbers of the damaged leaves and the dead hearts of examined plants were recorded to determine the infestation percentage.

Statistical analyses:

Data were statistically analyzed by one-way analysis of variance as described by Snedecor & Cochran (1967). Mean values were tested for differences using Tukey's test with $P \leq 0.05$ as the significance level for each season to relationship between the three major pests infesting the maize plants during three fertilization treatments and three plant density treatments.

RESULTS AND DISCUSSION

Effect of fertilization on the population density

Three fertilizers, synthetic, organic and mixture between synthetic and organic fertilizers were applied during the two successive maize growing seasons of (2019 – 2020) to evaluate fertilizers type on the population density of corn thrips, aphids and pink stem borer.

The corn thrips, *L. cerealium*

Data presented in Table (1) indicated that, during the two seasons, the different fertilizer treatments resulted to significantly different in the population of the *L. cerealium*. The high population of this insect was appeared in the first week and decreased at the later week in different fertilizers.

In the first season, the organic fertilizer had the highest mean number of *L. cerealium* population (139.1insects/10 plants) followed the synthetic fertilizer (129.7 insects/10 plants) then the mixture between synthetic and organic fertilizers (112.4 insects/10 plants). The mean numbers of thrips at the mixture fertilizer were a highly significant than both synthetic and organic fertilizers which were insignificant between them. During the second season, results took the same trend as obtained in the first season. The organic fertilizers had the highest number (122.2 insects/10 plants) flowed by the synthetic fertilizers (113.1 insect/10 plant) then the mixture fertilization (94.91 insects/10 plants) and it was a significant difference between the mean numbers at the three fertilizations.

Table 1. Effect of synthetic, organic and their mixture fertilizers on the population density of the corn thrips, *Limothrips cerealium* of maize plants during 2019 and 2020 seasons.

	First season			Second season		
	Synthetic	Organic	Mixture	Synthetic	Organic	Mixture
1	206.7 ±3.53b	160.3 ± 5.2e	149.3 ±5.81d	74.0 ± 3.1k	143.0 ± 3.8f	123.3 ±3.6b
2	121.0 ±2.65c	230.3 ±5.0a	215.7 ± 4.1b	101.7 ± 4.4f	201.3 ±4.4a	115.3±2.6c
3	194.3 ± 2.3d	207.6 ±6.2c	255.3 ± 3.2a	151.0 ± 4.6g	134.3 ± 2.8f	214.3±2.9a
4	106.3 ±2.1f	146.3 ± 1.45f	157.0 ±3.8e	117.3 ±4.7e	156.6 ± 4.4ec	124.6± 3.1b
5	92.0 ± 1.15g	130.0 ±5.5g	50.0 ±3.21g	109.0 ±5.2ef	221.0 ± 4.6b	75.3±3.2e
6	245.3± 2.9a	214.0 ±3.2b	87.3 ±1.45h	166.0 ± 3.2b	168.6 ±3.2c	129.6±3.5b
7	192.7 ± 2.3d	170.7 ± 5.8h	195.0 ± 2.8c	204.3±3.0a	117.3± 7.5d	89.3±3.4d
8	184.3 ± 3.0e	122.3 ±4.3i	132.7 ± 2.9f	176.7 ± 4.4c	152.0 ±4.0e	112.3±4.0c
9	67.3 ±4.1gh	118.7 ±4.9i	33.6 ±2.3i	113.0 ±5.8d	157.6 ±3.7ec	65.0±2.8f
10	69.0 ± 2.1g	68.7 ±3.2j	25.0 ± 2.8j	60.3 ± 2.6l	35.3 ± 6.4g	43.3 ±3.5g
11	61.3 ± 4.2h	55.3 ± 3.0k	35.0 ± 2.5i	32.3 ±1.2m	23.3 ±3.5h	35.3±3.2g
12	15.7 ± 3.2i	44.6 ±5.5l	13.3 ± 3.5k	7.67 ± 1.76n	0.00 ± 0.0i	11.0± 1.7h
LSD 5%	7.559	5.223	6.258	9.280	11.705	7.828
F value	800.077	1,213.878	1,534.239	354.666	313.420	419.376
P value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mean	129.7 ±11.7A	139.1 ±10.1A	112.4±13.5B	113.1±9.24A	122.2 ± 11.8A	94.91±8.8B
F value		4.431			4.199	
P value		0.01542			0.01896	

Means followed by the same letters are not significantly different; small letters represent differences between data in columns based on least significant difference tests at the 5% level (LSD 5%), whereas capital letters represent differences between rows based on Tukey's multiple range test at P ≤ 0.05.

Generally, the infestation percentages of *L. cerealium* were higher in the first season than in the second season at all different fertilizations. At two seasons, the lowest infestation percentage was recorded in the mixture fertilizer with 7.25 and 6 %, respectively (Fig. 1).

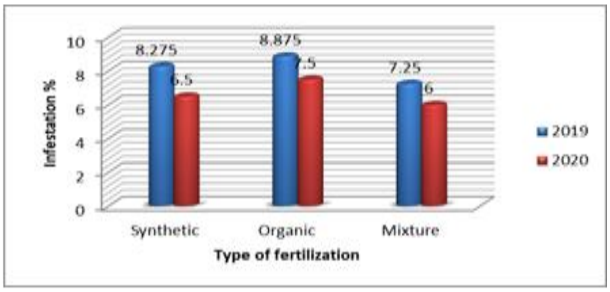

Fig. 1. Effect of synthetic, organic, and their mixture fertilizers on the infestation percentage of the corn thrips, *Limothrips cerealium* during 2019 and 2020 seasons.

Experiments. Lowering fertilization rate from 100% to 33% of the recommended level reduced mean *F. occidentalis* abundance on cut roses.

Our finding was similarity with Chow *et al*, 2012 who recommended the lowering synthetic fertilization rate from 100% to 33% reduced means the western flower thrips , *Frankliniella occidentalis* abundance on rose. The results were disagreement with Khidr (2019) who mentioned that the organic fertilizer was significant effects on reducing the population density of *Haplothrips tritici* in comparison with inorganic practices which recorded highest numbers (2.84 thrips/spike). Thrips, Frankliniella occidentalis Pergande (Thysanoptera: Thripidae), to experiments. Lowering fertilization rate from 100% to 33% of the recommended level reduced mean F. occidentalis abundance on cut roses by experiments. Lowering fertilization rate from 100% to 33% of the recommended level reduced mean F. occidentalis abundance on cut roses by

The corn aphids, *R. maidis*

The results in Table (2) revealed that, the mean number of aphids was significantly difference between the three fertilizers during the first season but insignificantly at the second season. At two seasons, the mixture fertilizer had the lowest mean number of *R. maidis* (13.1 and 19.4 individuals /10 plants, respectively) followed by organic fertilizer (33.3 and 26.8 individuals /10 plants, respectively) then synthetic fertilizer (48.4 and 33.9 individuals /10 plants, respectively).

Data illustrated in Figure (2) showed that the higher infestation percentage of *R. maidis* was recorded the in the first season than the second seasons at the different fertilizers. At the two seasons, the lowest infestation percentage recorded in the mixture fertilization (1.5 and 0.87 %, respectively) while the highest percentage of infestation recorded at the synthetic fertilizer (3.5 and 1.93%, respectively).

The present results agree with those of Phelan *et al.*, 1995 who found that organic fertilizer significantly reduced in the aphid populations on plants than the full-rate of synthetic fertilizers. Furthermore, Yardlm and Edwards 2003 found the application of synthetic fertilizers influence abundance of insect herbivores and crop damage in tomato. The population of aphids on tomatoes grown with the organic fertilizer was lower than on those grown with the synthetic fertilizers. The populations of aphid were the lowest on tomato plants in organic fertilizers may be the potential to reduce pest attacks in the long term.

Moreover, Khidr, (2019) who evaluate the addition of organic fertilizers into the soil to the wheat and their susceptibility to attack by corn leaf aphid, *R. maidis*. There were significant effects of organic fertilizers on reducing the population density of aphid in comparison with synthetic fertilizer (NPK).

Table 2. Effect of synthetic, organic and their mixture fertilizers on the population density of the corn aphids, *Rhopalosiphum maidis* of maize plants during 2019 and 2020 seasons.

	First season			Second season		
	Synthetic	Organic	Mixture	Synthetic	Organic	Mixture
1	0.00 ± 0.0f	0.00 ± 0.0g	0.00 ± 0.0f	0.00 ± 0.0g	0.00 ± 0.0f	0.00 ± 0.0e
2	0.00 ± 0.0f	0.00 ± 0.0g	0.00 ± 0.0f	0.00 ± 0.0g	0.00 ± 0.0f	0.00 ± 0.0e
3	0.00 ± 0.0f	2.7 ± 1.5fg	0.00 ± 0.0f	2.6 ±1.5 g	0.00 ± 0.0f	0.00 ± 0.0e
4	0.00 ± 0.0f	7.0 ±1.7f	0.00 ± 0.0f	9.7 ± 2.9fg	25.0 ±2.9d	0.00 ± 0.0e
5	3.7± 2.3f	5.3 ±1.4f	15.7 ± 3.5d	15.0 ±2.6ef	65.3 ±3.0a	32.6±4.3 b
6	9.7 ± 0.8ef	22.7 ± 2.9e	10.3 ± 2.0e	16.3 ± 1.8ef	44.0± 3.1c	25.0± 2.8c
7	18.3 ± 1.0e	38.0 ±4.3d	40.7 ± 2.2b	19.7 ± 2.7e	25.0 ± 2.6d	11.6±2.0d
8	3.0 ± 1.15f	45.0 ±2.9c	55.3 ± 3.2a	31.6±4.4d	47.6±4.33b	46.7± 2.2a
9	39.0 ± 2.6d	19.0 ±5.2e	22.3 ± 2.6c	44.3±2.9c	24.0±3.05 d	41.8±4.0a
10	110.7± 2.1b	87.7 ± 1.4b	13.3 ±2.0d	93.0± 3.6a	29.6 ± 2.9d	35.0±2.5b
11	301.7 ± 10.1a	95.0 ± 2.8a	0.00 ± 0.0f	99.7±5.8 a	44.0± 3.2c	29.3± 3.0c
12	95.3 ±2.9c	77.3 ±2.6b	0.00 ± 0.0f	75.0±2.8b	17.6±4.0 e	11.0 ±2.1d
LSD 5%	10.123	6.771	4.968	7.948	8.116	7.329
F value	665.862	238.566	117.878	159.053	55.793	89.990
P value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mean	48.4±14.3A	33.3 ±5.8AB	13.1± 3.0B	33.9±10.5	26.8±6.0	19.4±5.1
F value		4.982			1.545	
P value		0.00949			0.23552	

Means followed by the same letters are not significantly different; small letters represent differences between data in columns based on least significant difference tests at the 5% level (LSD 5%), whereas capital letters represent differences between rows based on Tukey's multiple range test at P ≤ 0.05.

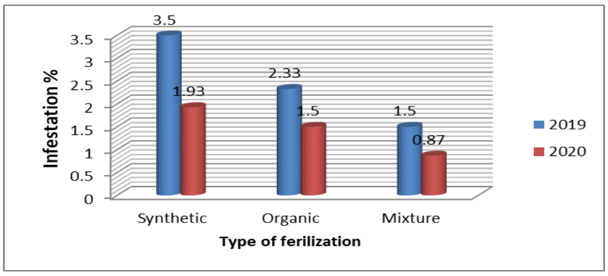

Fig. 2. Effect of synthetic, organic and their mixture fertilizers on the infestation percentage of *Rhopalosiphum maidis* during 2019 and 2020 seasons.

The pink stem borer, *S. cretica*

The results obtained in Table 3 showed that, the weekly population size of *S. cretica* larvae infesting corn plants. During the two seasons, for all fertilizers, there was a highly significant difference between the weekly population sizes of pink stem borer. The infestation of *S. cretica* larvae was appeared in the first week of investigation with organic and synthetic fertilizers but appeared in the second week with mixture fertilizer. The population of *S. cretica* was the highest mean number in organic fertilizer (5.3 larvae/10 plants in first season and 3.6 larvae/10 plants in the second season).

Table 3. Effect of synthetic, organic and their mixture fertilizers on the population density of the *Sesamia cretica* of maize plants during 2019 and 2020 seasons.

	First season			Second season		
	Synthetic	Organic	Mixture	Synthetic	Organic	Mixture
1	0.67 ± 0.33c	3.0 ± 1.2c	0.00± 0.0b	0.0±0.0c	1.7 ± 0.9c	0.00± 0.0c
2	5.0 ± 1.7ab	5.0 ± 1.2c	5.3 ± 1.45a	3.3 ±1.7ab	9.3 ±0.8 a	2.7 ±1.5 c
3	6.67 ±2.1a	9.3 ± 2.1ab	3.7 ± 2.1ab	5.7 ± 1.4a	7.3 ±1.4 a	8.0 ±1.5 a
4	7.0 ± 2.0a	12.0± 2.1a	2.7 ± 1.5ab	6.0 ± 1.7a	5.3 ± 0.3b	4.6 ± 1.3b
5	6.3 ± 2.0a	8.3 ± 1.4ab	5.0 ± 1.7a	3.7 ± 1.5ab	6.7 ± 1.8b	3.6 ± 1.2b
6	4.7 ±1.8ab	10.3±1.5a	4.3 ± 1.5a	3.7 ± 1.5ab	5.0 ± 1.2b	3.6 ± 1.2b
7	3.0 ± 1.8b	7.7 ± 2.1bc	4.0 ± 2.3a	2.7 ± 1.5bc	2.3 ± 1.2c	3.3 ± 2.0b
8	3.7 ± 1.2b	4.7 ± 1.2c	3.0 ± 1.2ab	2.0 ± 1.2bc	2.0 ± 1.2c	4.0 ± 1.2b
9	2.0 ± 1.2bc	1.7 ± 0.9c	3.7 ± 1.2ab	2.0 ± 1.2bc	1.0 ± 0.6c	2.0± 1.3c
10	1.7 ± 1.1bc	1.0 ± 0.6c	1.0 ± 0.6b	0.0± 0.0c	2.0 ± 1.2c	1.3 ± 0.8c
11	1.3 ± 0.8bc	1.0 ±0.6c	1.3 ± 0.9b	0.0± 0.0c	0.0± 0.0c	1.3 ± 0.8c
12	0.00 ± 0.0c	0.0±0.0d	0.0±0.0b	0.0±0.0c	0.0± 0.0c	0.0± 0.0c
LSD 5%	3.553	4.027	3.501	3.682	2.871	3.887
F value	3.925	9.053	2.434	2.989	10.021	2.847
P value	0.00308	<0.001	0.03642	0.01387	<0.001	0.01767
Mean	3.5 ± 0.5B	5.3 ± 0.7A	2.8 ± 0.5B	2.4 ±0.4 B	3.6 ± 0.6A	2.9± 0.5B
F value		12.558			3.168	
P value		<0.001			<0.001	

Means followed by the same letters are not significantly different; small letters represent differences between data in columns based on least significant difference tests at the 5% level (LSD 5%), whereas capital letters represent differences between rows based on Tukey's multiple range test at P ≤ 0.05.

The mean number of *S. cretica* in organic fertilizer was significantly higher than the mean number at both the synthetic and mixture fertilizers in the two seasons.

The infestation percentage of *S. cretica* recorded the highest rate in the first season than the second seasons at all fertilizers. At the two successive seasons, the mixture fertilizer had the lowest percentage of infestation (0.2% & 0.15%, respectively) while the organic fertilizer had the highest percentage of infestation (0.35% &0.22%, respectively) as shown in Figure (3).

Vanhuis, 1981 shows that fertilizing changes the physiological condition of the maize plant, the physiologically various plants will probably exert an effect on the development of the larvae. Larvae of *Ostrinia nubilalis,* which were fed on its leaves containing a relatively high protein and little sugar, had a high survival rate and a low weight.

The present results disagree with those of Phelan et al 1995 and Yardlm & Edwards 2003 demonstrated that oviposition levels of *O. nubilali* in synthetic fertilizer were significantly higher than in organic fertilizer on maize.

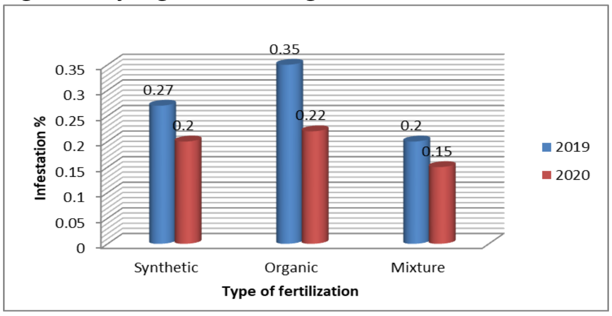

Fig. 3. Effect of synthetic, organic and their mixture fertilizers on the infestation percentage of *Sesamia cretica* during 2019 and 2020. seasons

Effect of type of fertilization on maize yield

Results in Fig. (4), showed that different fertilizers (synthetic, organic and mixture fertilizer) effect on the maize yield. At the both seasons, the highest yield of maize was recorded in mixture fertilizer (3783&3948 kg/fed., respectively) while the lowest yield had in synthetic fertilizer (3295&3379 kg/fed, respectively). So can be used the integration of synthetic fertilizers alongside organic manures with optimum rates to improve crop productivity on sustainable basis.

The result was agree with Hasid et al. 2021 who reported that the yields of sweet corn plants from plots applied with mixture fertilizer (organic and synthetic fertilizers) were significantly higher than the yields from sole synthetic fertilizer application. Morever, Abd El-Gawad and Morsy, 2017 indicated that the integration of organic and synthetic fertilizers was better than using organic or synthetic fertilizer separately. The results were similarity with Mahmood et al 2017 found that growth and yield of maize were improved by synthetic fertilizer application addition with organic increase the maize yield than applied synthetic or organic fertilizer alone. But Khidr (2019) evaluate the organic and synthetic fertilizers (NPK) were applied into the soil on wheat yield. The field trial indicated that organic treatments were effective as synthetic fertilizer and therefore similar biological and grain yields and that differ from untreated control.

Our results disagreement with Toungos, 2019 who studied the efficacy of organic and synthetic fertilizers on the growth and yield parameter of maize found that the synthetic fertilizers (NPK) gave significantly higher yield and grain weight than plants that were supplied with organic or their combined.

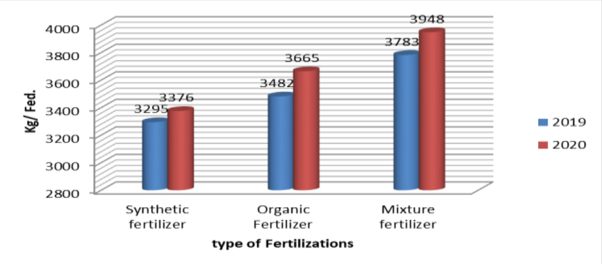

Fig. 4. Effect of synthetic, organic, and their mixture fertilizers on yield (kg /fed.) of maize during 2019 and 2020 seasons.

Effect of plant density on the population

Three plant densities, 5, 10 and 15 plants/Linear meter were applied during the two seasons to evaluate their effect on the population of corn thrips, aphids and pink stem borer.

The corn thrips, *L. cerealium*

During the two seasons, data indicated that the population of *L. cerealium* was appeared high in the first week and gradually decreased during investigation times in the three plant densities. The mean number of *L. cerealium* was highly significant difference between the weekly populations in the three plant densities.

In Table (4), the highest mean number of *L. cerealium* was recorded in the highest plant density during the two seasons (168.7&127.0 insects/10plants, respectively). The population decreased as decreasing plant density. So the lowest mean number of thrips was 91.75 & 81.7 insects/10 plants in low plant density (5 plants/Linear meter) at two seasons, respectively.

Our results agree with those of Ali et al 2016 showed that thrips population, plant heights and final yield of onion bulb were greater due to medium planting density when plants were spaced at 6 inches as compared to less or more planting density (4 or 9 inches distance between plants).

The corn aphids, *R. maidis*

Results in Table (5) revealed that the population density of aphids in three plant densities, (5, 10 and 15 plants/ Linear meter) was significantly difference in the two seasons. Also, the data showed a positive relationship between aphid populations and plant density. The lowest mean numbers of *R. maidis* were 10.1 insect/10 plants in 2019 season and 12.9 insect/10 plants in 2020 season in the low plant density. Results of this study agree with those of Sarwar (2008) who reported significantly differences in mustard aphid, *Lipaphis erysimi* (Kalt.) populations on canola sown at 20, 30 and 40cm in Sindh Province of Pakistan.

The result was agree with Abd El-Hafez *et al*., 2012 who reported that aphid (*Aphis craccivora* Koch) infestation rate and plant height (cm) were progressively increased with increasing plant density from 22 to 33 plants/m2 .

Table 4. Population density of *L. cerealium* (mean ± SE) on maize plants at different planting densities during the 2019 and 2020 seasons in Assiut Governorate.

	First season			Second season		
	5 plants/m	**10 plants/m**	**15 plants/m**	**5 plants/m**	**10 plants/m**	**15 plants/m**
1	167.7 ± 4.3a	208.3 ± 5.5b	297.0 ±4.3b	116.7 ± 3.5b	73.3 ± 3.5h	198.3± 6.0b
2	117.3 ± 4.6c	120.3 ± 4.3e	317.7 ± 4.3a	127.0 ±3.8a	101.7 ± 4.4g	187.0 ± 4.0c
3	124.3 ± 2.6b	195.0 ± 2.9c	267.0 ± 4.0c	95.0 ±2.9d	149.0 ± 3.2d	209.3 ± 3.1a
4	122.5 ±4.5b	106.0 ± 3.5f	244.0 ± 3.2d	87.7 ±3.5f	118.6 ± 6.0f	167.0 ± 4.3e
5	87.3 ± 4.5e	92.0 ± 2.3g	216.0 ±3.5e	111.0 ±2.9c	111.7 ± 4.2f	137.3 ± 4.3f
6	86.0 ± 3.6e	247.0 ± 4.3a	169.0 ± 5.2g	97.6 ± 3.0d	167.3 ± 4.3c	86.7 ± 2.3h
7	95.0 ± 2.9d	192.3 ± 2.6c	187.7 ± 4.3f	88.3 ± 2.0f	204.3± 3.0a	177.6 ± 3.8d
8	114.0 ± 2.6c	183.7 ±2.3d	147.7 ± 3.2h	124.0 ± 2.3a	176.0 ±2.0b	139.6 ± 4.4f
9	65.0 ± 2.9f	68.3 ±4.9h	97.3 ± 4.0i	67.7 ± 3.2j	113.6 ± 2.3f	100.0 ± 5.3j
10	40.0 ± 4.0g	71.7 ± 2.6i	77.0 ± 3.8k	53.7 ± 2.3k	61.7 ± 4.4j	77.6 ±4.8 k
11	12.7 ± 1.7h	60.7 ± 3.0j	65.0 ± 2.9l	11.3 ± 2.0l	34.3 ± 3.0k	20.3 ± 3.9l
12	0.00± 0.00i	16.7 ± 3.0k	38.0 ±4.3m	0.00± 0.0m	7.7 ± 2.3l	23.3 ± 3.5l
LSD 5%	7.381	8.649	2.238	3.087	3.433	3.262
F value	387.362	611.851	15,424.720	1,583.261	2,560.665	3,484.55
P value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mean	91.75 ±8.3C	132.6 ±12.4B	168.7 ±15.6A	81.7 ±6.C	109.9 ± 9.6B	127.0 ± 10.6A
F value		18.165			17.687	
P value		<0.001			<0.001	

Means followed by the same letters are not significantly different; small letters represent differences between data in columns based on least significant difference tests at the 5% level (LSD 5%), whereas capital letters represent differences between rows based on Tukey's multiple range test at P ≤ 0.05.

Table 5. The population density of *R. maidis* (mean ± SE) on maize plants at different plant densities during the 2019 and 2020 seasons in Assiut Governorate.

	First season			Second season		
	5 plants/m	**10 plants/m**	**15 plants/m**	**5 plants/m**	**10 plants/m**	**15 plants/m**
1	0.00 ± 0.0f	0.00 ± 0.0h	0.00 ± 0.0k	0.00 ± 0.0e	0.00 ± 0.0g	0.00 ± 0.0k
2	0.00 ± 0.0f	0.00 ± 0.0h	0.00 ± 0.0k	0.00 ± 0.0e	0.00 ± 0.0g	0.00 ± 0.0k
3	0.00 ± 0.0f	0.00 ± 0.0h	0.00 ± 0.0k	0.00 ± 0.0e	3.3 ± 2.0fg	0.00 ± 0.0k
4	0.00 ± 0.0f	0.00 ± 0.0h	20.3 ± 4.7f	0.00 ± 0.0e	9.0 ± 1.7f	43.6 ± 2.3f
5	0.00 ± 0.0f	3.0 ± 2.0g	17.7 ± 3.8g	10.3 ± 2.1d	13.3 ± 2.3e	33.6 ± 2.3g
6	0.00 ± 0.0f	11.0 ± 2.3f	8.7 ± 3.8h	13.0 ± 2.9cd	14.7 ± 3.2e	52.6 ± 3.0d
7	7.0 ± 2.0e	21.7 ± 2.0e	34.3 ± 3.0e	22.0 ± 2.3b	18.7± 2.3e	19.7 ± 2.8f
8	5.0 ± 2.0e	3.0 ± 1.7g	14.3 ± 3.0g	47.6 ± 3.8a	30.0 ± 2.9d	32.0 ± 1.7g
9	18.7 ± 3.7c	38.7 ± 3.5d	49.3 ± 3.2d	0.00 ± 0.0e	43.7 ± 2.9c	66.0 ± 2.3c
10	33.3 ± 2.0b	111.0 ± 2.3a	147.3 ± 5.0b	0.00 ± 0.0e	90.0 ± 2.6b	78.7 ± 3.5b
11	12.3 ± 3.2d	87.7 ± 3.8b	301.7 ± 4.4a	45.0 ± 2.3a	99.0± 3.6a	118.6± 3.7a
12	45.0 3.0a	65.3 ± 3.0c	97.3 ± 4.4c	17.3 ± 3.0c	43.6 ± 2.3c	44.3±2.6 f
LSD 5%	4.283	5.968	5.662	4.423	6.884	7.363
F value	107.259	370.736	2,149.925	135.596	206.031	202.564
P value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mean	10.1 ± 2.5B	28.4 ± 6.3B	57.6 ± 14.4A	12.9 ± 2.8C	30.4 ±5.4 B	40.8 ±5.7 A
F value	11.658			19.365		
P value	<0.001			<0.001		

Means followed by the same letters are not significantly different; small letters represent differences between data in columns based on least significant difference tests at the 5% level (LSD 5%), whereas capital letters represent differences between rows based on Tukey's multiple range test at P ≤ 0.05.

Our results disagree with those of Razaq et al (2012) that populations of Cabbage aphid, *Brevicoryne brassicae* L. and mustard aphid, *Lipaphis erysimi* (Kalt.) were non-significantly different in all three spacing (10, 20 and 30 cm plant spacing) of plants, *Brassica napus*.

The pink stem borer, *S. cretica*

Results in Table (6) revealed that, in the two seasons, the population of *S. cretica* was recorded the lowest mean number (1.69 & 1.08 larvae/10 plants, respectively) in low plant density (5 plant/ Linear meter) but the population of this insect recorded highest mean number (2.83 & 3.19 larvae/10 plants) in high plant density (15 plant/ Linear meter). There are highly significantly between the population of *S. cretica* larvae in low plant density and other plant density during the two successive seasons.

The results are agreement with Van Huis, 1981 which reported that the number of eggs and larvae of *O. nubilalis* increased with increasing plant density. It may be that a higher oviposition occurred at a higher plant density or that the colonization of plants by a certain number of young larvae was more efficient.

Furthermore, Scott *et al.* (1965) mentioned that the high plant density was increased larval survival of *O. nubilalis* and a greater infestation. The maximum loss of yield in maize was when maize grown under competition stress. On the other hand, Harding et al. (1971) mentioned that the control of the first and second generation *O. nubilalis* were insignificantly influenced by row spacing of maize plants. Zepp and Keaster (1977) reported that the percentage of plants infested by the second generation of *Diatraea grandiosella* was not influenced by densities between 16,500 and 91,500 plants per hectare.

Table 6. The population density of *S. cretica* larvae (mean ± SE) on maize plants at different planting densities during the 2019 and 2020 seasons in Assiut Governorate.

	First season			Second season		
	5 plants/m	**10 plants/m**	**15 plants/m**	**5 plants/m**	**10 plants/m**	**15 plants/m**
1	0.00 ± 0.0b	1.33 ± 0.9bc	4.0 ± 1.7ab	0.00 ± 0.0c	0.00 ± 0.0b	3.3 ±0.9b
2	3.0 ± 1.73a	5.0 ± 1.2ab	6.0 ±1.7 a	4.0 ± 1.2a	4.0 ± 1.5a	2.0 ±1.15cb
3	5.3 ± 1.45a	7.3 ± 1.5a	3.33 ±1.5b	2.0 ± 1.3bc	5.7 ± 1.8a	6.3 ±2.0a
4	2.3 ± 1.45b	7.6 ± 1.7a	5.0 ±1.7 a	2.0 ± 1.2bc	5.0 ±1.7a	4.7 ±1.5 b
5	2.7 ± 1.2b	6.0 ± 1.7a	3.0 ±0.6 b	1.0 ± 0.0c	4.7 ±1.7a	2.7 ±1.5 c
6	4.3 ± 1.86a	4.3 ± 1.5ab	2.0 ± 1.2b	3.0 ± 1.4a	4.3 ± 1.5a	5.0 ±1.7a
7	1.7 ± 1.2b	3.7 ± 1.2b	4.7 ± 1.2a	0.0 ± 0.0c	3.0 ± 1.2ab	4.3± 1.5b
8	1.0 ± 0.0b	3.0 ± 1.2bc	1.3 ±0.9 cb	1.0 ± 0.0c	2.7 ± 1.2ab	3.3 ± 1.4b
9	0.00 ± 0.0b	2.0 ± 1.2bc	1.3 ± 0.9cb	0.00 ± 0.0c	2.3 ± 1.5ab	2.0 ± 1.2cb
10	0.00 ± 0.0b	1.0 ± 0.6bc	2.0 ± 1.2c	0.00 ± 0.0c	0.00 ± 0.0b	1.00 ± 0.0c
11	0.00 ± 0.0b	1.0 ± 0.0bc	0.00 ± 0.0c	0.00 ± 0.0c	0.00 ± 0.0b	1.3 ± 0.8c
12	0.00 ± 0.0b	0.00 ± 0.0c	0.00 ± 0.0c	0.00 ± 0.0c	0.00 ± 0.0b	2.3 ± 1.5cb
LSD 5%	2.809	3.608	3.584	1.968	3.590	1.560
F value	3.824	4.455	2.561	4.278	3.175	9.358
P value	0.00359	0.00141	0.02909	0.00182	0.01014	<0.001
Mean	1.69 ±0.39 B	3.53 ± 0.5A	2.83 ± 0.42A	1.083 ±0.27 B	2.64 ±0.46 A	3.19 ±0.42A
F value		8.315			13.900	
P value		<0.001			<0.001	

Means followed by the same letters are not significantly different; small letters represent differences between data in columns based on least significant difference tests at the 5% level (LSD 5%), whereas capital letters represent differences between rows based on Tukey's multiple range test at P ≤ 0.05.

Effect of plant densities on maize yield

The results in Fig. 5 showed that the different plant densities affected on the maize yield. The highest yield of maize had in the medium plant density (10 plant/ Linear meter) that was 3655 kg/fed in the first season and 3768 kg/fed in the second season. The results are similarity with Sibonginkosi et al.; 2019 who mentioned the increase plant density from 44444 to 57143 plants/ha decrease the grain yield in maize.

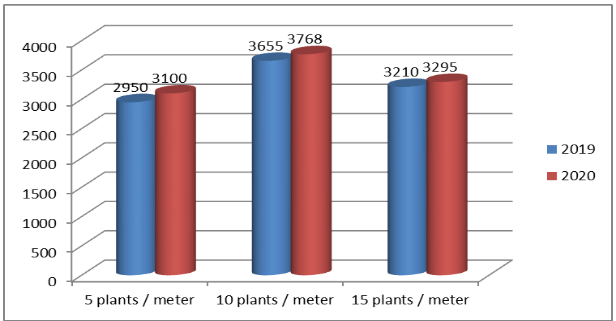

Fig. 5. Effect of three plant densities on the yield maize plants (kg / fed) on during 2019 and 2020 seasons.

Morever, Khan, et al 2017 indicated that the moderately density (9 maize plants/ m^2) can be recommended for better suppression of barnyard grass and higher yields of maize. The result was similarity with Abd El-Hafez et al., 2012 who reported that the yield (g) per plant (faba bean) was decreased with increasing plant density (22, 27 and 33 plants/m^2), it could be concluded that Giza 843 with 27 plants/m^2 and sowing at November 5^{th} was high productivity, decreases aphid. Furthermore, El-Deeb, et al (2006) demonstrated that planting 1706B/87/1999 genotype at 33 plants/m^2 on Mid-October resulted in the highest faba bean yields. Also Hussein, et al (1999) mentioned that planting Giza 429 or Giza 674 with 27 plants/m^2 gave the higher seed yield (3.67 and 3.62 tons/ha. respectively).

Our results disagree with those of Razaq et al (2012) that plants, *Brassica napus* grown on all three spacing (10, 20 and 30 cm plant spacing) were non-significantly different in the yield components.

CONCLUSION

Generally, it is concluded from the aforementioned results that the thrips were the most abundant insects on corn plants, followed by aphids, while the stem borers were present at low numbers throughout fertilizer treatments and three plant densities. The mixture fertilizer recorded the lowest percentage of population and infestation of three insects, also it is caused high yield of maize, at the two successive seasons. Furthermore, the best plant density is 10 plants/Linear meter that gave high yield of maize. It is concluded that the three insects had highly significant correlation with all treatments and its can minimizing the insect populations in the maize ecosystem.

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تأثير التسميد وكثافة النباتات على تجمعات بعض الآفات الحشرية للذرة الشامية والمحصول

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اجريت هذة الدراسة بمحافظة أسيوط في صعيد مصر خلال موسمي ٢٠١٩ و ٢٠٢٠ م، حيث زرعت الذرة الشامية فى بداية شهر يونية لدراسة تأثير ثلاثة أنظمة تسميدية مختلفة (تركيبية ، عضوية ومخلوطة بين الأسمدة الاصطناعية والعضوية) وكذلك ثلاثة كثافات زراعية متباينة (٥ ، ١٠ ، ١٥ نبات / المتر الطولى) على الكثافة العددية ومعدل الإصابة بكل من تربس الذرة ومن أوراق الذرة ودودة القصب الكبيرة بالاضافة الى تحديد تأثير المعاملات على المحصول. أشارت النتائج المتحصل عليها بان تعداد الآفات محل الدراسة يتأثر بشكل كبير بنوع الأسمدة المضافة للنباتات حيث وجد ان الخلط بين الأسمدة العضوية والمعدنية أدت الى خفض متوسط أعداد ونسبة الإصابة بالحشرات الثلاثة المختبرة في الموسمين بالمقارنة بين الأسمدة المعدنية أو العضوية على حدة. كما تبين أن نسب الإصابة بالافات الثلاثة كانت أعلى في الموسم الأول عنها في الموسم الثاني. وكانت الفروق عالية المعنوية بين متوسط أعداد التربس في خليط الأسمدة مقارنة بالأسمدة المعدنية أوالعضوية. كما سجلت النتائج أعلى محصول للذرة عند المعاملة بمخلوط الاسمدة في الموسمين (٣٧٨٣ و ٣٩٤٨ كجم / فدان على التوالي). ومن ناحية أخرى أظهرت النتائج زيادة متوسط أعداد الآفات الثلاثة المختبرة بزيادة الكثافة النباتية للذرة الشامية فى المتر الطولى خلال موسمى الدراسة، حيث كانت الفروق معنوية بين أعداد كل من تربس الذرة ومن أوراق الذرة فى الثلاثة كثافات المختبرة (٥ ، ١٠ ، ١٥ نبات / المتر الطولى) في الموسمين. وسجل أعلى محصول للذرة (٣٦٥٥ و ٣٧٦٨ كجم / فدان) في الكثافة النباتية المتوسطة (١٠ نبات / المتر الطولى) في الموسمين على التوالي. ومن النتائج المتحصل عليها يمكن ان نستنتج أن تسميد نباتات الذرة الشامية بخليط من الأسمدة المعدنية والعضوية وبكثافة نباتية ١٠ نباتات / المتر الطولى تؤدى الى خفض تعداد الآفات الحشرية مع زيادة إنتاجية المحصول.