Correlation Between Different Levels of NPK Fertilization and Population Dynamics of Cotton Aphid (*Aphis gossypii*), Whitefly (*Bemisia. tabaci*) and Spiny Bollworm (*Earias insulana*) in Cotton Crop

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ABSTRACT

Three levels form each NPK fertilizer plus the recommended level were applied to study the efficiency of different levels on cotton aphid, *Aphis gossypii,* ،whitefly *Bemisia tabaci* and spiny bollworm, *Earias insulana* population dynamics , and its reflect on the cotton yield in El-Noubaria district, Behaira Governorate, Egypt. Consequently, the highest mean number of aphid, whitefly and spiny bollworm population in both seasons were obtained from plots applied with 250 kg nitrogen, and it gave the least cotton yield. On the other hand, there was a decrease in the mean numbers of aphid, whitefly and spiny bollworm with decreasing level of nitrogen applied at 100 kg, but it increasing cotton yield.While the increase in potassium fertilizer caused a decrease in the population density of aphid, whitefly and spiny bollworm. For phosphorus fertilization, non significant correlation was observed among different levels of phosphorus fertilizer and the population densities of those tested pests. Finally, it could be assumed that nitrogen was the most fertilizer that had an effect on infestation rates, all levels of it led to a high significant increase in the number of tested pests compared with other fertilization.

Keywords: NPK levels, cotton, Aphis *gossypii*, *Bemisia tabaci, Earias insulana*, cotton yield

INTRODUCTION

Cotton, one of the world's leading agricultural crops, is abundant and economically produced. The occurrence of cotton pests such as sucking insects and bollworms has always been an important factor affecting the total cotton production (Xiao *et al*., 2019). Year after year, the infestation of sucking pests has increased, and these pests have became one of the dangerous pests of cotton and many other crops in tropical and subtropical regions of the world (Jyothi *et al*., 2019). It also, caused huge losses in cotton crop. In addition, the spiny bollworm, *Earias insulana* (Boisd.) is one of the most dangerous pests that attack cotton in Egypt, and its larvae cause damage to cotton buds early in the growing season and squares, and bolls at the end of the season (El-Aswad &Abou-Taleb,2008 ; Younis *et al*., 2007). Some cultural practices such as early planting, crop rotation, use of resistant cultivars, plant spacing and applied of fertilizers can be used as one of the effective control methods (Matthews and Tunstall, 1994). Cotton is highly dependent on fertilization as it grows and is the most responsive crop to fertilizer.

Therefore, the main factors such as nitrogen, phosphorus and potassium fertilizers that govern the different vegetative and fruiting stages of the cotton plants must be weighed. Whereas, random fertilization increases the number of nutrients that the plant dose not need, which affects its components and the quality properties. Moreover, improper fertilization leads to economic losses due to increasing insect population density and reduced productivity along with environmental risks (Rajan *et al*., 2005). Also, Fertilization levels for ornamental crops may influence the dynamics of pest numbers, crop quality, and pest management strategy (Chau *et al.,* 2005).

So, this field study was conducted to evaluate the best level of NPK fertilization and its association with the population dynamics of cotton aphids, *A. gossypii* (Glover) (Hemiptera: Aphididae) and whitefly, *B. tabaci* (Gennadius) (Hemiptera: Aleyrodidae) and spiny bollworm, *E. insulana* (Boisd) (Lepidoptera: Noctuidae) as one of the control options to suppress the spread of these pests in Integrated Pest Management (IPM) programmes.

MATERIAL AND METHODS

Experimental design and sowing.

Experiments were conducted in a private cotton field at El- 10000 Feddan Village, Noubaria district، Behera Governorate, Egypt during two growing seasons, 2018 and 2019. Cotton variety "Giza 88" was sown on 17th of May in 0.25 feddan (1050 m^2). The experimental area was divided into 12 plots. Each plot was divided into four replicates (4 sub plots). Cotton seeds were sown according to the recommended rates of cotton sowing and all agricultural practices were applied as usual as recommended by the Egyptian Ministry of Agriculture; this area was remained free of pesticides spraying. The design was completely randomised block (RCBD).

Four levels of each fertilizer were tested including recommended fertilization dose to compare as shown in Table (1).

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Table 1. Treatments and their rate of application during the growing seasons of 2018&2019

Fertilizer	Type of NPK	Rate of application/ feedan
Nitrogen	(N) Complex of NPK 31/5/0 * (Vermix)®	N1 : 100 kg N2 : 150 kg N3: 200 kg N4: 250 kg
Phosphorus	(P) Super Phosphate * 15% P_2O_5	P1: 75 kg P2: 100 kg P3: 150 kg P4: 200 kg
Potassium	(K) Potassium Sulphate * 48 % K_2O	K1: 50 kg K2: 75 kg K3: 100 kg K4: 150 kg

*Vermix® produced by Abu-Qir Fertilizers Company. The main components are: N: P: K (31:5:0), 31% nitrogen, 5% fifth Potassium oxide.
* 15% P_2O_5 produced by Ferchem Masr Fertilizers & chemicals.
* 48 % K_2O produced by Al Menofia for Fertilizers & Chemicals.

Application of NPK fertilizers.

(Vermix) ® Complex of NPK 31/5/0 as source of nitrogen (N) was applied to the soil on two batches (2/3 recommended dose "100 kg/feedan ") with the first irrigation (after thinning) and (1/3 recommended dose "50 kg/feedan") with the second irrigation, Super phosphate 15% P_2O_5 as (P) before sowing with soil service, after the second plow and potassium sulphate 48 % K_2O as (K) after thning. The total doses of Phosphorus and potassium fertilizers were added before sowing with soil preparation.

Sample of sucking pests.

Weekly, 60 leaves (15 leaves × 4 replicates for each treatment) were randomly selected early in the morning from each replicate for 15 weeks out of three weeks after sowing. Samples were taken from three selected leaves randomly (top, middle and bottom). The upper and lower surfaces of randomly selected leaves were examined to count whitefly adults and nymphs. Also, all stages of aphids were counted using a hand lens (5xs), and then all observations were averaged and expressed as mean population.

Cotton boll sampling technique.

60 green bolls (15 bolls × 4 replicates / treatment) were sampled weekly at random. The level of spiny bollworm infestation was weekly estimated for 8 weeks from 3rd week of August till 1st week of October during the growing seasons of 2018 & 2019, respectively. In each sample taken, the bolls were examined externally before dissection and internal examination, was also done. The recorded infestation was based on the existence of injury symptoms regardless the presence of the larvae.

cotton yield.

In each treatment, ripened open bolls from twenty-five cotton plants were collected to determine the rate of cotton yield / plant, from which, the total yield /feddan was relatively calculated as follows:

$$\text{Yield} = \frac{\text{plant yield (g)} \times \text{No.of plants per fed (45000)}}{\text{Kg/fed ==Ken. /fed}} = \frac{1000}{157.5}$$

Statistical analysis.

All sampling data were compared with analysis of variance (ANOVA). Duncan's multiple range test (Duncan, 1955) was used to determine significant differences ($p \leq 0.05$) between mean of numbers of each pest for each NPK fertilization treatment. Computer program COSTAT (Costat Statistical Software, 1990) according to the method of Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

RESULTS

Influence of different levels NPK fertilizers on *Aphis gossypii* & *Bemisia tabaci*.

The data illustrated in Table (2) showed the mean numbers of *A. gossypii* and *B. tabaci* as affected with different levels of NPK fertilizers during the all experimental periods of both seasons 2018 &2019.

A. gossypii

The obtained results indicated that the highest fertilization level at 250 Kg (N4) increased significantly the mean population number of aphids 108.45 and 121.43 individuals /60 leaves for the first and second seasons, respectively, while the level of 100 Kg (N1) was the least one showing a seasonal mean count of 67.43and 85.03 individuals /60 cotton leaves during the both seasons, respectively, compared with the recommended level (N2) at 150 Kg which gave mean 81.38 and 101.28 individuals /60 cotton leaves for both seasons, respectively (Table 2). It is clear that, aphid population densities were affected positively with fertilization levels of nitrogen.

On the contrary, the data of Potassium effect (Table 2) were proved that the mean population number of aphids decreased when the potassium level was increased. It was found that the highest level of K4 application 150 Kg was the lowest mean population number of aphids 63.8 and 82.05 individuals / 60 leaves

for the first and second seasons, respectively, while the recommended level (K3) (100 Kg) was gave 67.33 and 88.91 individuals / 60 leaves, respectively for both seasons, but it still significant differences among the tested Potassium levels K1, K2, K3 and K4. On the other hand, non significance difference among the counts of this pest on the different phosphorous fertilization levels were found in both seasons 2018&2019 (Table 2).

It could be noticed that nitrogen is the most positive fertilizers impact on increase or reduce on the population densities of aphids. Whenever the nitrogen level increased, the infestation rate was increased.

B. tabaci

From data shown in Table (2). Statistical analysis showed highly significant differences between the population densities of *B. tabaci* for the different levels of fertilizers treatments in both seasons, 2018 and 2019.

The estimated population clarified that the higher number of whitefly (19.95 and 18.5 individuals / 60 leaves) for both seasons, respectively was recorded on the cotton fertilized with the highest level (N4) at 250 kg .Also, the recommended level (N2) at 150 kg was statistically significant effective with highest number (14.06 and 13.76 individuals / 60 leaves), in both seasons. But, the fertilization level (N1) at 100 kg proved to be the best where it decreased the number of whitefly (11.88 and 9.75 individuals / 60 leaves) in both seasons, respectively (Table 2).

The data represented in (Table 2) revealed that the whitefly population decreased significantly with increasing the level of Potassium fertilizer. Meanwhile, the maximum population of whitefly was recorded (14.43 and 13.75 individuals / 60 leaves) from those plots that had lower Potassium fertilizer 50Kg (K1) in two seasons, respectively. In connection with phosphorus fertilization, non significant difference among the population densities of this pest and different phosphoric fertilization levels in both seasons. Also, the obtained results proved highly significant differences among two means of infestation with aphids and whitefly in both seasons of study.

Table 2. Influence of different NPK fertilizers levels on population of *A. gossypii*, and *B. tabaci* on cotton plants during the growing seasons of 2018 & 2019

Treatments	Mean No. of *A. gossypii, B. tabaci* / 60 cotton leaves			
	Season of 2018		Season of 2019	
	Aphids	White fly	Aphids	White fly
N1 (100Kg)	67.43^{f}	11.88^{f}	85.03^{ef}	9.75^{fg}
N2 (150Kg) (Recommended)	81.38^{c}	14.06^{d}	101.28^{bc}	13.76^{c}
N3 (200Kg)	88.41^{b}	16.38^{b}	105.21^{b}	15.01^{b}
N4 (250Kg)	108.45^{a}	19.95^{a}	121.43^{a}	18.5^{a}
P1 (75Kg)	64.4^{gh}	10.5^{h}	80.93^{fg}	9.33^{g}
P2 (100Kg)	64.21^{gh}	10.36^{h}	80.56^{fg}	9.3^{g}
P3 (150Kg) (Recommended)	63.1^{h}	9.58^{i}	79.18^{g}	8.86^{h}
P4 (200Kg)	65.7^{fg}	11.13^{g}	$82.23f^{g}$	9.83^{f}
K1 (50Kg)	75.55^{d}	14.43^{c}	97.5^{cd}	13.75^{c}
K2 (75Kg)	70.76^{e}	12.51^{e}	93.6^{d}	12.16^{d}
K3 (100Kg) (Recommended)	67.33^{f}	11.46^{g}	88.91^{e}	11.03^{e}
K4 (150Kg)	63.8^{gh}	9.98^{i}	82.05^{fg}	9.58^{fg}
$LSD_{.05}$	2.17	0.35	4.22	0.42
P	$< 0.0001^{***}$	0.0001^{***}	0.0001^{***}	0.0001^{***}

Numbers in the same column followed by the same latter (s) are not significantly different.
***means highly Significant (0.001).

Influence of different levels of NPK fertilizers on the spiny bollworm, *E. insulana* infestation during the cotton growing seasons of 2018 & 2019.

Data in Table (3) illustrate the efficiency of different rates of NPK fertilizers against *E. insulana* and yield during 2018 and 2019 seasons. Statistically, all treatments induced significant effect on the larval population of the spiny bollworm expressed as average number of larvae /60 bolls compared with the recommended level.

It is explicated that the lowest infestation rate by the spiny bollworm with averages (5.00 and 5.15 larvae/60 bolls) in 2018& 2019 seasons was recorded in treatment treated with low N fertilizer (N1) at 100 kg while highest number of the spiny bollworm larvae (6.68 and 7.21 larvae/ 60 bolls) was observed on cotton plants treated with the highest fertilization level (N4) at 250 Kg compared to the recommended level (N2) at 150 kg which recorded average number of the spiny bollworm larvae (5.50 and 5.75 larvae/60 bolls) in respect, for the first and second seasons (Table 3).

The various levels of phosphorus showed non-significant effect on the spiny bollworm larvae population (5.09 & 5.12 larvae/60 bolls at (P1) 75Kg, 5.18 & 5.15 at (P2) 100Kg, 4.96 & 4.75 at (P3) 150Kg and 5.53 & 5.40 at (P4) 200Kg for the 2018 and 2019 cotton seasons, respectively (Table 3). The lowest Potassium fertilizer levels (K1) at 50Kg significantly increased the number of the spiny bollworm larvae (5.90 and 6.12 larvae/60 inspected bolls), in respect, during the cotton seasons of 2018 & 2019. Comparatively the recommended level (K3) at 100 kg which reduced the number to 5.37and 5.31 larvae/60 bolls in both seasons, in respect. The highest potassium level at 150 kg (K4) recorded lower the spiny bollworm larvae number 4.81and 4.75 larvae/60 bolls, for two seasons, respectively.

Influence of different levels of NPK fertilizers on cotton yield during the growing cotton seasons of 2018 & 2019.

Data shown in Table (3) exhibit the effect of each tested fertilizers on cotton seed yield. Logically, there is a positive correlation between the total cotton seed yield and infestation rate. It could be concluded that the treatment of (N1) 100Kg recorded the highest cotton seed yield (1228.5 & 1102.5 kg. /fed) followed by the recommended level (N2) at 150 kg (1165.5 & 1023.75 kg. /fed) in 2018 and 2019 seasons. The fertilizer level (N4) 250 Kg gave the lowest cotton seed yield (756 & 677.25 kg. /fed) in both seasons, in respect.

Table 3. Influence of different levels of NPK fertilizer applied on the spiny bollworm *E. insulana* infestation and cotton yield during the growing cotton seasons of 2018 & 2019

Treatments	Season of 2018		Season of 2019	
	Mean No. of larvae / 60 bolls	Yield (Kg. /fed.)	Mean No. of larvae / 60 bolls	Yield (Kg. /fed.)
N1 (100Kg)	5^{def}	1228.5	$5.15f^{g}$	1102.5
N2 (150Kg) (Recommended)	5.5^{bcd}	1165.5	5.75^{cd}	1023.75
N3 (200Kg)	5.93^{b}	945.0	6.18^{b}	913.5
N4 (250Kg)	6.68^{a}	756.0	7.21^{a}	677.25
P1 (75Kg)	5.09^{cdef}	1023.75	5.12^{fg}	960.75
P2 (100Kg)	5.18^{cdef}	1023.75	5.15^{fg}	945.0
P3 (150Kg) (Recommended)	4.96^{ef}	992.25	4.75^{g}	897.75
P4 (200Kg)	5.53^{bc}	1008.0	5.40^{def}	929.25
K1 (50Kg)	5.90^{b}	1039.5	6.12^{bc}	945.0
K2 (75Kg)	5.59^{bc}	1071.0	5.65^{de}	992.25
K3 (100Kg) (Recommended)	5.37^{cde}	1086.75	5.31^{ef}	1039.5
K4 (150Kg)	4.81^{f}	1149.75	4.75^{g}	1086.75
$LSD_{.05}$	0.44	--	0.37	--
P	$< 0.0001^{***}$	--	0.0001^{***}	--

Numbers in the same column followed by the same latter (s) are not significantly different.
***means highly Significant (0.001).

On the contrary, the application of different phosphorus levels were showed a slightly effective on the cotton seed yield. Moreover, other potassium fertilizer gave cotton seed yield ranged from (1039.5 and 945 kg. /fed) for (K1) 50Kg to 1149.75 & 1086.75 kg. /fed for (K4) 150Kg for both seasons 2018& 2019, in respect (Table 3).

DISCUSSION

Among the cultural control methods to be used for pests control are appropriate inorganic fertilization types and rates. Nitrogen, Phosphorus and Potassium are the more effective fertilizers on cotton growth through growing stages (Ai *et al*., 2011), especially Nitrogin is crucial nutrient element which affected signifiactly on all plant parts and has a positive effecton plant infestation degree with many insects (Setyaningrum *et al*., 2018) . Therefore, excessive nitrogen fertilization causes an activity in the vegetative growth of cotton plants, and the leaves grow and become juicy and wide, therefore more susceptible to severe infestation, especially piercing sucking pests. Also, the increase in nitrogen fertilizer led to more abundant vegetative growth of plants, which provided a favorable environment for the survival, reproduction of bollworms and delays ripening of bolls, which expose it to infestation by bollworms, and causing great losses in the crop yield.

Our data indicated that significant variations between NPK fertilizations levels and infestation rates by aphids and whitefly. Also, the highest nitrogen fertilization level increased significantly the mean population of aphids and whitefly because reducing nitrogen fertilization and increasing potassium led to strengthens cell walls and hinders the feeding process of insects. Our results in the same line with Setyaningrum *et al*. (2018) who reported that the infestation with *A. gossypii* caused the plant to wilt and inhibit its growth, and this infestation rate was increased with the nitrogen level increased. Also, Bi *et al.* (2021) who reported that the numbers of both adult and immature whiteflies were increased through population peaks with increasing rates of nitrogen. Anusha *et al.* (2017) showed there was a significant positive relation between aphid population and nitrogen levels. The current results indicated that increase the potassium level has been shove to reduce the mean population of aphids and whitefly decreased. In the present investigation, phosphorus levels had showed non significant effect against aphids and whitefly. These findings are in conformity with (Jyothi *et al.,* 2019) found that a significant effect on jassids and shoot weevil population when applied various levels of phosphorus fertilizer, and using NP in combination showed high significant effect on aphids and thrips population. And El-Zahi *et al.* (2012) mentioned that the phosphorus fertilizer was proved effective in reducing the population of *B. tabaci* , whereas it was increased the density of *Impoasca* spp significantly.

On the other hand, a study reported that a high significant variation among different levels of NPK in relation to infestation rate by spiny bollworm infestation and their cotton yield. Also, the lowest nitrogen fertilization level was the most effective treatment since it reduced the number of the spiny bollworm larvae and it gave the highest cotton seed yield but in the case of potassium fertilizer levels, the highest potassium level recorded least spiny bollworm larvae number and high cotton seed yield. Furthermore, various levels of phosphorus showed low significant difference among the larval population of the spiny bollworm and cotton yield. The presented results are in agreement with those found by Abd El-Wahab (2005) who found that the fertilization rate (NPK) at 150 Kg gave the lowest average percentage of infestation by spiny bollworm and caused the highest cotton yield. Taneja and Dhindwal (1982) stated that nitrogen uses causes a higher infestation of bollworms, while plant population levels do not affect the occurrence of bollworms. Hwang *et al*. (2008) reported that lepidopteran larvae, when fed on plants that had a high nutrient content, showed increased growth rates and developed faster than those fed on low nutrient plants.

Rustamani *et al.* (1999) cleared that cotton plants which applied with recommended levels of nitrogen combined with high levels of phosphorus fertilizer gave cotton seed yield much higher than levels of other fertilizer. Also, Anusha *et al.* (2017) observed that the highest increase in cotton yield 7.2% recorded at 150 kg N ha^{-1} (1967 kg ha^{-1}) over recommended level of 120 kg N ha^{-1} (1826 kg ha^{-1}) whereas, without nitrogen treatment was the lowest cotton yield of 1440 kg ha^{-1}. The use of nitrogen fertilizers should be optimized to maintain optimum plant physiology and reduce pest growth (Huang *et al*., 2002).

CONCLUSION

In nutshell, the various levels of NPK fertilization had a positive correlation with the population dynamics of aphids, whitefly and spiny bollworm. The nitrogen fertilizer which was applied with lower level recorded lower infestation and higher cotton yield compared to other nitrogen levels. Whereas, the applied potassium fertilizer applied with the highest level recorded the lower infestation and highest cotton yield, in the case of phosphorus fertilizer, the recommended level was the best one among another levels. Thus, it is concluded

that the use of different types and levels of fertilization can be one of the control methods of cotton pests.

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الملخص العربي

العلاقة بين المستويات المختلفة لاسمدة NPK والكثافة العددية لحشرات من القطن و الذبابة البيضاء و دودة اللوز الشوكية فى محصول القطن

عبير شعبان عوض

تم تطبيق ثلاث مستويات مختلفة من كل سماد (نيتروجين – فوسفور– بوتاسيوم) بالإضافة الى المستوى الموصى به لدراسة تأثيرها على الكثافة العددية لحشرات من القطن والذبابة البيضاء و دودة اللوز الشوكية وكذلك إنتاجية محصول القطن، أظهرت النتائج أن تطبيق سماد النيتروجين بمعدل ٢٥٠ كجم / الفدان سجل أعلى متوسط لتعداد حشرات المن والذبابة البيضاء ودودة اللوز الشوكية وأعطى أقل إنتاجية للفدان، بينما عند تطبيق سماد النيتروجين بمعدل ١٠٠ كجم / الفدان سجل أقل متوسط لتعداد حشرات المن والذبابة البيضاء ودودة اللوز الشوكية وأعلى إنتاجية للفدان فى كلا الموسمين، كما أدت الزيادة في سماد البوتاسيوم إلى إنخفاض متوسط تعداد حشرات المن والذبابة البيضاء ودودة اللوز الشوكية وإرتفاع إنتاجية الفدان. كذلك لوحظ عدم وجود معنوية بين الكثافة العددية لحشرات المن والذبابة البيضاء ودودة اللوز الشوكية وإنتاجية الفدان من القطن و المستويات المختلفة من الأسمدة الفوسفورية.

وعلى ذلك يمكن الاستنتاج أن سماد النيتروجين هو السماد الأكثر تأثيرا على معدلات الإصابة، حيث أدت المستويات المرتفعة منه إلى زيادة معنوية عالية في عدد الآفات مقارنة بالتسميد الآخر.

الكلمات المفتاحية: تسميد NPK، حشرة المن ، الذبابة البيضاء، دودة اللوز الشوكية ، محصول القطن.