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Bemisia tabaci (Hemiptera: Aleyrodidae) infestation and yield cantaloupe production in relation to inorganic fertilization

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Abstract:

Plant nutrition has a great impact on the susceptibility of host plants to herbivores pests. Fertilization affects herbivores especially hemipteran insects to large extent. The physiological, physical, and mechanical defense traits in plants can be enhanced by fertilizers. Fertilization concerns the chemicals required by theorganism for its growth, tissue maintenance, and reproduction, and are necessary to maintain these functions. Many organic and inorganic compounds affect plant health but two of them; nitrogen and potassium play an important role in plant growth and theplant-pest relationship. In this study, the two inorganic fertilizers; nitrogen and potassium were used at three units (40, 50, and 60 units/fed.) as soil treatments for cantaloupe (*Cucumis melo* L.) in summer plantation of two growing seasons. Nitrogen was applied in the form of ammonium sulphate (20.6% N_2) and potassium in the form of potassium sulphate (48% K_2O) on *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) nymphal infestation. Different nine rates of nitrogen and potassium in combination were applied. Application of a high level of N_2 mixed to the lowest level of K_2O (60 N_2+40 K_2O units) remarkably resulted in high infestation (15.5 nymphs/leaf) in the two seasons of study. The population decreased at levels of N_2 and K_2O as follows (40 N_2 + 40 K_2O, 40 N_2 + 50 K_2O, and 40 N_2 + 60 K_2O units) with nymphal infestation 3.95, 3.46, and 2.8 nymphs/leaf, respectively over the two studied seasons. Moreover, the application of a lower level of N_2 mixed with higher levels of K_2O led to a higher cantaloupe yield of 4.01 kg/plot (i.e., 3.97 m^2). So, the best treatment that could be recommended to fertile the soil of cantaloupe plants is the rate containing low N_2 and high K_2O (40 N_2 + 60 K_2O units).

Introduction

Integrated pest management in agro horticultural ecosystems needs the priority use of some unconventional methods including adequate inorganic fertilization (El-Zahi *et al*., 2012). Fertilization practices may also affect crop tolerance pests by affecting the growth pattern, the anatomy and morphology, and particularly the chemical composition (Michaud and Charbonneau, 1993). Many species of plant feeding Hemiptera are considered serious agricultural and horticultural pests, whose feeding leads to wilting, distortion, or stunting of shoots. Apart from feeding, some also transmit plant viruses and other diseases and their sugary excreta (Honeydew) leads to the formation of black sooty moulds, which spoil leaves and fruits and can impair photosynthesis (Singh and Sood, 2017). To govern and reduce the severity of damage of *Bemisia tabaci* (Gennadius) (Hemiptera : Aleyrodidae) in the field, there is an enormous demand to use safe and alternative strategies to chemical control (Abd Allah *et al*., 2018). Sucking insects show a much stronger response to crop fertilization (Butler *et al*., 2012). Increasing the number of whitefly nymphs in melon fields seriously hampers weight and number of boxes harvested, reduces product and quality due to sooty mold fungus, and decreases fruit size and total soluble solids content (Riley and Palumbo, 1995).

Plants, which are supplied with all necessary nutrients in a balanced manner, are shown to be more resistant to insect pests. This lowers the need for particular pest control measures and also can be integrated with insect-pest management programs (Singh and Sood, 2017). Understanding the relationship between plant nutrition and pest reproductive potential is necessary for pest management in modern agro-ecosystems (Zarasvanda *et al.*, 2013).

The current investigation is aimed at studying the influence of different rates of nitrogen and potassium in combination on *B. tabaci* nymphal infestation on cantaloupe plants and the resultant yield in order to reach the best treatment with lower infestation and high yield.

Materials and methods

The experiments were carried out in the Experimental Farm of Plant Protection Research Institute in Qaha region, southwest of Qalyubiya Governorate in Egypt over two successive growing seasons; 2015 and 2017 in summer plantation. Each plot is represented by $3.97 m^2$. Cantaloupe seeds (cv. Darvina) were sown directly in successive single rows on the southern edges. Rows are designed as 7 plants per row spaced $0.30 m^2$ apart.

All the recommended practices for cantaloupe cultivation in Egypt were completely adopted without the application of chemical pest control measures during the whole period of study in summer (Starting in Mar. until Jul.). The natural infestation of whiteflies was evaluated in the experiments.

In order to evaluate the effect of nitrogen/potassium mixture (NK) on the infestation rates by *B. tabaci* nymphs, the nine ratios of nitrogen (Ammonium sulphate 20.6%N_2) and potassium (Potassium sulphate 48% K_2O) fertilizers were used as follow:

- Recommended rate 150 kg fed^{-1} which is represented by 50 unit /fed.) (feddan= 4200 m^2).
- Sub recommended rate 120 kg fed^{-1} which is represented by 40 unit/fed.
- Over recommended rate 180 kg fed^{-1} which is represented by 60 unit/fed.

In this trial seeds of cantaloupe were sown on Mar. 19th and Mar. 31st in 2015 and 2017, respectively. The experiment in 2016 was repeated 2017 because the cantaloupe plants in this experiment didn't grow in a good way in 2016.

1. Experimental design and cultivation method:

The different nine rates of nitrogen (N_2) were applied in the form of ammonium sulphate (20.6 %N_2) and potassium (K) which were added as potassium sulphate (48% K_2O) 40, 50, and 60 units/fed. Nitrogen and potassium were mixed together and applied to the soil cultivated with cantaloupe after complete germination and during the flowering and fruiting stages.

However, calcium superphosphate (15.5% P_2O_5) was added at the recommended rate only in agricultural practices during the preparation of the experiment for agriculture. An area of about 350 m^2 was chosen to carry out the experiment. The nine rates of the mixture of inorganic fertilizers (40, 50, and 60 units/fed.) were replicated three times as well as the control (Check) which was without fertilization. The experiment design was a Complete Randomized Block (CBRD). When cantaloupe fruits grew and reached the time to be harvested, the yield was picked out and weighted for estimation of yield during 2015 only.

2. Data analysis:

All the obtained data during the trials over the two growing seasons were subjected to analysis by using SAS **(SAS Institute, 1988)** program. Duncan's multiple range test was used to obtain the mean separation and arrange fertilization rates according to their degree of infestation by *B. tabaci* eggs and nymphs at the level of 5 % of probability.

Results and discussion

In the current study ammonium sulphate (20.6% N_2) and potassium sulphate (48% K_2O) were tested on the nymphal infestation. The two fertilizers were used at three units (40, 50, and 60 units/fed.) as a soil treatment.

1. Effect of different inorganic fertilization rates on nymphal infestation:

The data graphically illustrated in Figure (1) reveals that the population density of *B. tabaci* nymphs/cantaloupe leaf was significantly affected by the different rates of inorganic fertilization and control throughout the two studied seasons (2015 and 2017). In 2015, the lowest infestation rate of *B. tabaci* nymphs was estimated in the control experiment (Free from any fertilizer treatment 1.75 nymphs/leaf). The highest density of nymphs (21.8 nymphs/leaf) was recorded in leaves that received a high level of N_2 mixed with the lowest level of K_2O (60 N_2+40 K_2O units). By decreasing N_2 to 50 units mixed to the lowest level of K_2O (40 units) giving decreased infestation (12.8 nymphs /leaf), the highest level of N_2 mixed to moderate level of K_2O (60 + 50 units, respectively) resulted in infestation with *B. tabaci* nymphs as 12 nymphs /leaf. The highest rate (60 N_2+60 K_2O units) led to infestation with *B. tabaci* as 11.3 nymphs/leaf. On the other hand, the recommended rate contains moderate levels of two fertilizers (50 N_2 + 50 K_2O), and the rate which had a moderate level of N_2 mixed with the highest level of K_2O (50 N_2+60 K_2O) remarkably resulted in a moderate infestation of nymphs of 8.9 and 8.6 nymphs /leaf, respectively. On the other extreme, application lowest level of N_2 (40 units) mixed with 40, 50, and 60 units of K_2O led to lower infestation means of nymphs as 4.99, 4.4, and 3.8 nymphs/leaf, respectively.

In 2017, the data illustrated in Figure (2) showed that increasing in infestation rates with *B. tabaci* nymphs (9.2 nymphs/leaf) was recorded by increasing the levels of N_2 and decreasing K_2O (60 N_2 + 40 K_2O units) followed by a moderate level of N_2 and the lowest level of K_2O (50 N_2 + 40 K_2O units) as the population density was 5.5 nymphs /leaf and (60 N_2 + 50 K_2O units) with infestation rate of 5.2 nymphs /leaf. The moderate infestation rate was recorded by applying 50 N_2 + 50 K_2O and 60 N_2 + 60 K_2O units which led to infestation rates of 4.01 and 3.69 nymphs/leaf, respectively. On the other hand, decreasing N_2 to the lowest level and increasing K_2O gradually led to decreasing nymphs' infestation as K_2O increased i.e. 40 N_2 + 40 K_2O, 40 N_2 + 50 K_2O, and 40 N_2 + 60 K_2O decreased the infestation to 2.9, 2.5 and 1.8 nymphs/leaf, respectively, which didn't differ significantly from the control which had infestation rate as 1.75 nymphs/leaf.

As for the calculated means of the 2015 and 2017 cantaloupe seasons altogether, the results were in harmony with the trend as that obtained in each of the two seasons, as the plants harbored the highest infestation received the NK containing the highest level of N_2 (60 units). The highest infestation rate in cantaloupe was recorded (15.5 nymphs/leaf) at the highest level of N_2 mixed to the lowest level of K_2O (60 N_2 +40 K_2O). The opposite extreme was observed in the soil kept free from any fertilizers in the control which led to the lowest mean population density in the two years as 1.5 nymphs/leaf. Higher rates of *B. tabaci* nymphs were also detected when the highest levels of N_2 mixed with the lowest level of K_2O and the highest level of N_2 mixed with a moderate level of K_2O and the highest levels of N_2 mixed with K_2O (50 N_2 + 40 K_2O, 60 N_2 + 50 K_2O and 60 N_2+ 60 K_2O units) as 9.15, 8.6 and 7.6 nymphs/leaf, respectively. Moreover, the fertilization rates of moderate levels of N_2 mixed with moderate and highest levels of K_2O (50 N_2 + 50 K_2O and 50 N_2 + 60 K_2O units) resulted in infestation rates of 6.3 and 5.9 nymphs/leaf, respectively (Figure 2).

The lower infestation rates with *B. tabaci* nymphs which didn't significantly differ from the check or control at LSD= 3.84 in leaves received the lowest levels of N_2 and the population decreased as K_2O increased as follows (40 N_2 + 40 K_2O, 40 N_2 + 50 K_2O and 40 N_2 + 60 K_2O units) with the infestation of nymph counts as 3.95, 3.46 and 2.8 nymphs/leaf, respectively.

From the above mentioned results, it can be concluded that the highest levels of N_2 led to the higher infestation rates with nymphs of *B. tabaci* (Linear relationship, Figure 1). So, the best treatment that could be recommended to fertile the soil of cantaloupe plants was the rate containing low N_2 and high K_2O (40 N_2 + 60 K_2O units).

2. Effect of the combination of inorganic fertilizer rates on cantaloupe yield:

The obtained results in Figure (3) revealed that applying the combination of inorganic fertilizers NK led in most instances to an increase in the cantaloupe yield. Generally, the application of N_2 at a high level (60 units) mixed with moderate (50 units) 60 N_2 + 50 K_2O or highest (60 units) 60 N_2 + 60 K_2O led to the highest weight of cantaloupe 4.16 and 4.05 Kg/plot (This means by application this rate to fertile cantaloupe soil, cantaloupe may give about 4.4 and 4.3 tons/fed., respectively). Application of 40 N_2 + 60 K_2O and intermediate rate 50 N_2 + 40 K_2O yielded cantaloupe being 4.01 and 3.9 Kg/plot [LSD= 1.24]. While, fertilizers applied at the rate of 40 N_2 +40 K_2O and fertilizers as 50 N_2 +50 K_2O and 50 N_2+ 60 K_2O yielded moderate cantaloupe weight yield as 2.82, 2.87, 3.04 Kg/plot. These weights didn't differ significantly from the control (2.74 Kg/plot). On the contrary, the lower mean of weight 2.16 kg/plot resulted from applying 60 N_2 + 40 K_2O but it didn't significantly differ from the lowest weight in this season (1.99 kg/plot) which resulted from applying 40 N_2 + 50 K_2O.

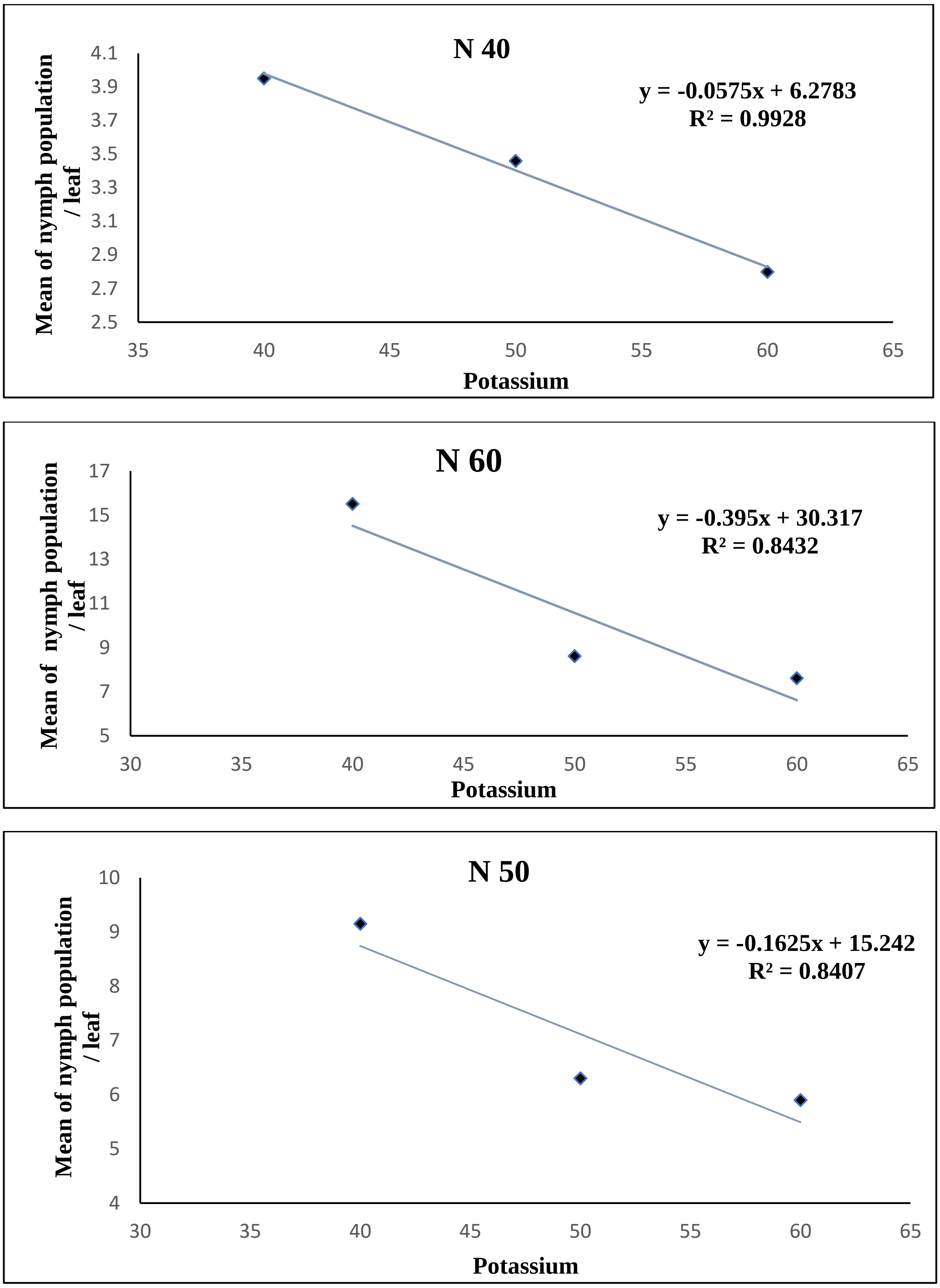

Figure (1): *Bemisia tabaci* infestation in relation to nine rates of NK in combination (40, 50, and 60 units).

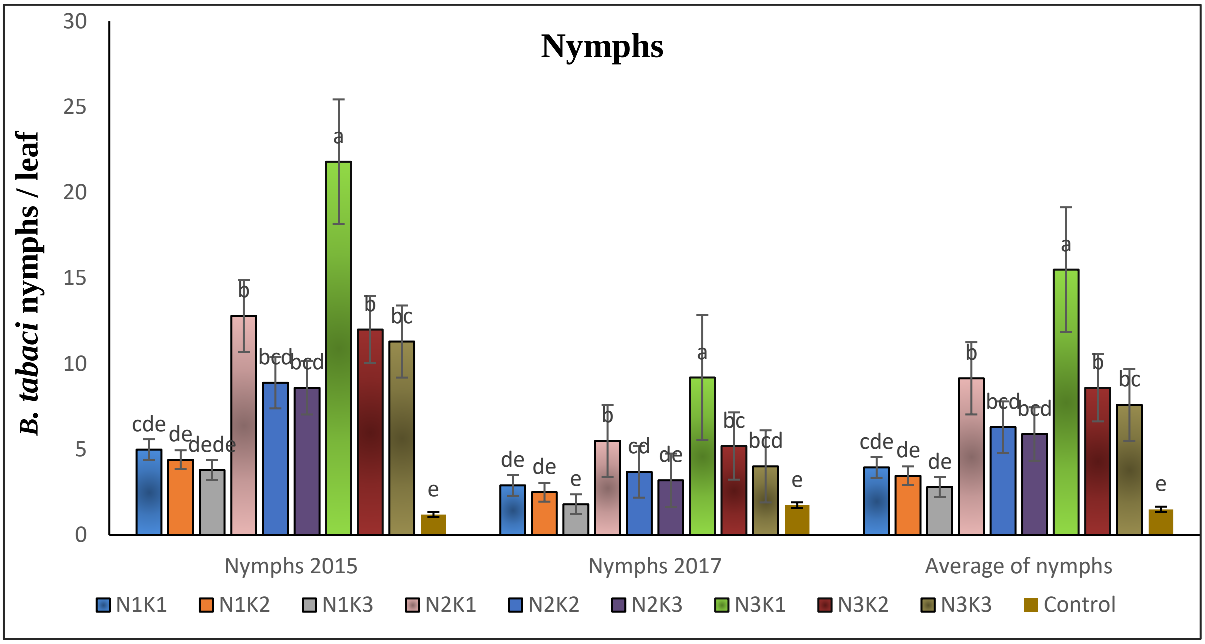

Figure (2): Mean population of *Bemisia tabaci* nymphs/leaf on cantaloupe under nine rates of NK fertilizer combinations and control over 2015 and 2017 summer plantations and an average of the two years. Bars topped with different letters are significantly different by Duncan's multiple range test ($P < 0.05$).

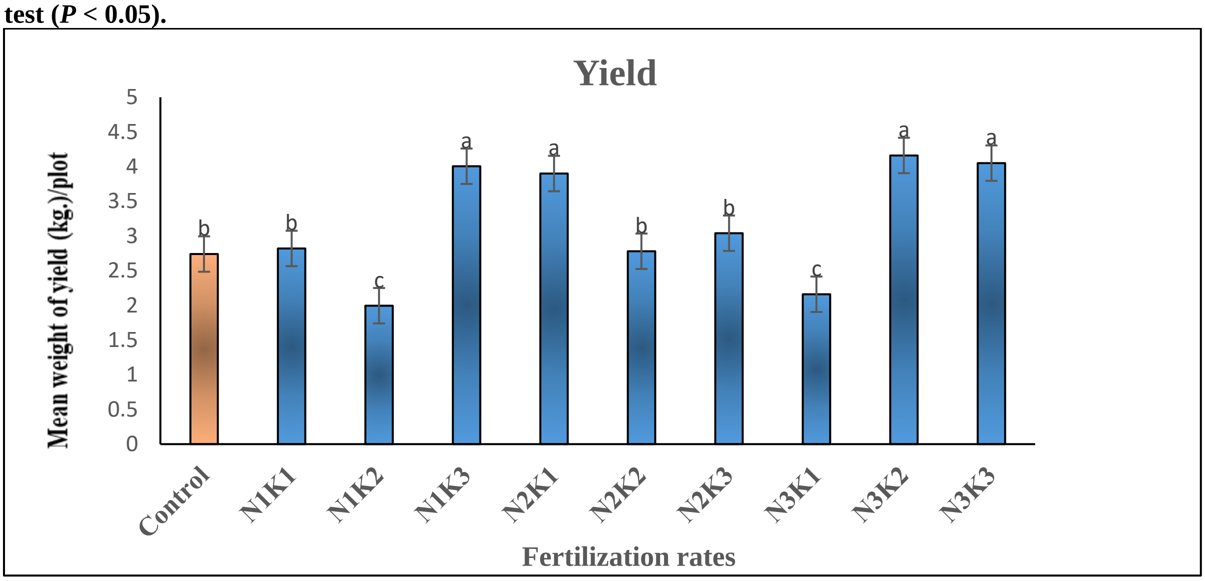

Figure (3): Mean counts of *Bemisia tabaci* nymphs/leaf of cantaloupe plants which received different rates of NK fertilizers in combination over 2015 and 2017 summer plantations. Bars topped with different letters are significantly different by Duncan's test ($P < 0.05$).

Plant pest defense mechanisms such as biochemical, physical, and mechanical properties can be enhanced by balanced fertilization with plant nutrients. Nitrogen and potassium affect plant health (Singh and Sood, 2017). Sucking insects have a much stronger response to crop fertilization (Balakrishnan *et al.*, 2007). The relationship between plant nutrition and pest reproductive potential is important for pest management in modern agro-ecosystems (Zarasvanda *et al.*, 2013). Fluctuation in the nitrate (NO_3) led to increased susceptibility of plants to insects as its excessive use decreases lignin concentration, which is a substance used by plants as a physical defense against various pests (Torres-Olivar *et al.*, 2014).

In the present investigation of inorganic fertilizers, N and K in combination in the soil the populations of *B. tabaci* were largely affected. In general, the highest infestation rate of *B. tabaci* population was recorded in treatments with high nitrogen and lower potassium content. The highest infestation in leaves was recorded in case of high N_2 and low K_2O (60 $N_{2\,+}$ 40 K_2O units) followed by (50 $N_{2\,+}$ 40 K_2O units). However, the moderate fertilization rate (50 $N_{2\,+}$ 50 K_2O) led to moderate infestation. Application of a lower level of N_2 (40 units) mixed with either 40, 50, or 60 units of K_2O led to a lower infestation of nymphs. The treatments with high potassium and low nitrogen level lowered the infestation. The current investigation revealed that higher levels of nitrogen led to a higher infestation rate of *B. tabaci*. This result was obtained by many investigators Bi *et al.* (2001), Zurina *et al.* (2010), Draz *et al.* (2013) and Islam *et al.* (2017) recorded that increasing amount of nitrogen led to the increasing population of whitefly. However, an adequate supply of nitrogen is associated with high photosynthetic activity, vigorous vegetative growth, and the dark green color of the leaves (Zafar *et al.*, 2010). Application of nitrogenous fertilizer can alter the nutritional levels in the plant tissues and reduce plant resistance against herbivores, consequently feeding preference of herbivore, food consumption, survival, growth, reproduction, and population density will increase (Cipollini *et al*., 2002; Prudic *et al*., 2005; Ortega-Arenas *et al*., 2006 and Zhong-xian *et al*., 2007). Excessive use of nitrate (NO_3^-) can increase the susceptibility of plants to insect pests by decreasing lignin concentration, which is a substance used by plants as a physical defense against various pests (Torres - Olivar *et al*., 2014).

Moreover, an excessive N supply with unbalanced fertilization requires carbon (C) to metabolize it and these leaves have little C from the Kreb's cycle for the synthesis of secondary compounds, such as phenols and quinones. Also, phenolic compounds play an important role in the host/pest relationship, being the basis for many defense mechanisms. They act as phytoalexins or as precursors of lignin and suberin, which act as mechanical barriers in leaves and stems against insect-pest attacks (Imas, 2013). Potassium plays an important physiological role building up resistance to insect pests. Adequate amounts of K have been reported to decrease the incidence of insect damage. Plants excessively supplied with N and little K have soft tissue with little resistance to sucking and chewing insects. The yellowish discoloration of plants suffering from K deficiency acts as a signal to attract aphids (Liu *et al*., 2013).

The high levels of potassium can enhance secondary compound metabolism, reduce carbohydrate accumulation, eliminate some amino acids, and increase the silica content of leaves and plant damage from insect-pests (Krauss, 2001 and Facknath and Lalljee, 2005). Biswas *et al.* (2009) recorded the highest number of *B. tabaci*, per leaf at a higher dose of nitrogen and found a positive correlation between whitefly abundance level and nitrogen dose. Ahmed *et al.* (2007) found highest N rate resulted in the highest mean population of *B. tabaci* being 0.44; 1.49, 1.43, and 1.62 per leaf at 50, 100, 150, and 200 kg N/ha, respectively.

Concerning the yield, it was noticed that the application of a low rate of nitrogen in combination with a high rate of potassium (40 N_2 + 60 K_2O units), moderate rate of nitrogen in combination with the lowest rate of potassium (50 N_2 + 40 K_2O units) and the highest rate of nitrogen in combination with a moderate rate of potassium or highest rate of potassium (60 N_2 + 50 or 60 K_2O units, respectively) led to the high weight of cantaloupe. This means that the high infestation of nymphs resulting from high nitrogen levels didn't affect the cantaloupe weight. Our results were in harmony with El-Rafie (1999) evaluated three major phytonutrients (N, P, and K) in the infestation of tomatoes with *B. tabaci* in Egypt, his results revealed that plants treated with high levels of N resulted in anincreased number of *B. tabaci* and decreased yields. These results didn't be the same as those obtained by Feltrin *et al.* (2002) they evaluated the infestation of *B. tabaci* on tomato plants fertilized with different sources of potassium KCl + K_2SO_4 + K_2SiO_3; KCl + K_2SO_4; K_2SO_4 + KC1. These different sources of potassium neither affect the *B. tabaci* infestation, nor the fruit yield and quality of the tomato fruits.

Agricultural practices like excessive and massive use of fertilizers can result in nutrient imbalance and finally into the increased attack of insects. Our findings concluded that application of the lowest rate of nitrogen (40) mixed with the highest rate of potassium (60) to cantaloupe soils could be successfully recommended in IPM program as lower infestation with high yield fruits.

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