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# Impact of the thrips-borne tomato spotted wilt virus infestation on some cucurbitaceous plant yield, Egypt

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**Abstract:**

In Egypt, two cultivated cucurbitaceous vegetable crops, (Cucumber, *Cucumis sativa* L. (Cultivar: Beta Alfa) and squash, *Cucumis pepo* L. (Cultivar: Eskandarani)) were used to define the thrips-borne tomato spotted wilt virus (TSWV) species attack them, during two successive seasons, 2010 and 2011, for summer and nili plantation in Giza Governorate. These species were, onion thrips *Thrips tabaci* Lindeman, palm thrips *Thrips palmi* Karny, western flower thrips *Frankliniella occidentalis* (Pergande), and grass thrips *Chirothrips texanus* (Andre). With note, the data of *C. texanus* recorded for the first time in Egypt. The occurrence and seasonal abundance of each thrips species of both plants were determined and thrips species numbers were direct counted and recorded. Either in cucumber or squash fields, the population of each thrips species expressed a higher total number in the nili plantation than the summer plantation with significant difference in both plantation in the same growing season, but not between the growing seasons based on the mean of collected thrips numbers. The correlation between climatic factors and thrips population was also performed and found that, thrips population was affected by both temperature and relative humidity. Otherwise, pathological symptoms of TSWV infection on the two plant crops were categorized according to the visual syndromes, and the highest rate of infection was observed. The effect of the natural infection of thrips on reduction of leaves number, loss of fruit weight, and the percentage of yield loss due to thrips-borne TSWV infection, in relation to the average yield of the healthy plant was determined and observed significant differences among the nili and the summer plantations in the same growing season, but not between the growing seasons, either in cucumber or squash plants.

## Introduction

Cucurbitaceous (Cucurbit) plants, especially squash and cucumber, are important vegetable crops in Egypt, they are ranked fourth after potato, tomato and onion (Mohamed *et al*., 2003). In Egypt,

cucurbitaceous crops are attacked by many insect pests and viral diseases. Piercing sap sucking insect pests such as whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae), onion thrips *Thrips tabaci* (Linderman) (Thysanoptera: Thripidae) , cotton aphid *Aphis gossypii* Glover (Hemiptera: Aphididae) and leafhoppers *Empoasca decipiens* Paoli (Hemiptera: Cicadellidae) causing serious damage to the host plants either directly by feeding on plant sap or indirectly through transmitting the causative agents of various diseases especially those belong to viral diseases (Abd El-Salam *et al*., 2008 and Ghallab *et al*. , 2011). The common diseases on cucurbit crops are varying causes approximately 16% decrease in yield crop. Several viral diseases infect cucurbits as tomato spotted wilt virus (TSWV) and zucchini yellow mosaic virus (ZYMV), previously known as a muskmelon yellow stunt virus in melon, squash, watermelon, field cucumber, greenhouse cucumber, zucchini and some wild cucurbit hosts is considered important viral diseases.

Worldwide, fourteen thrips species have shown to be vectors of plant viruses among 5500 described thrips species (Hassani-Mehraban *et al*., 2010 and Nakahara and Foottit, 2012). Until now, only eight thrips species are known as vectors of tospoviruses and they are members of the genera *Thrips* Linnaeus and *Frankliniella* Karny (Thysanoptera) within the family Thripidae (Nagata and Peters, 2001). Biological insect transmission test indicated that four different thrips species were tested as vectors of tospovirus (Salah, 2016).

The present study aimed to study the impact of the thrips-borne tomato spotted wilt virus infestation on some cucurbitaceous plant yield, Giza, Egypt.

**Materials and methods**

**1. Location of field study:**

Two cultivated cucurbitaceous vegetable crops, (Cucumber, *Cucumis sativa* L. (Cultivar: Beta Alfa) and squash, *Cucumis pepo* L. (Cultivar: Eskandarani)) were used in the present study to define the thrips species attack them by direct plant inspection. During two successive seasons, 2010 and 2011, the field study was conducted at the Experimental Station, Faculty of Agriculture, Cairo University, Giza, Egypt. The field area was approximately 1/3 feddan (1400 $m^2$), prepared and cultivated 700 $m^2$ per each crop, and seeds were sown directly in the field during April for summer plantation and during July for nili plantation in each season. All the agricultural practices were done, and no insecticides were used in pest control and squash.

**2. Seasonal abundance and inspected of thrips species:**

Two successive growing seasons of 2010 and 2011 to define the thrips species attack cucumber and squash fields by direct plant inspection. Four thrips-borne TSWV species were inspected in the present study are belonging to order Thysanoptera and family Thripidae. These species were, onion thrips *T. tabaci*, palm thrips *Thrips palmi* Karny, western flower thrips *Frankliniella occidentalis* (Pergande), and grass thrips *Chirothrips texanus* (Andre). Monitoring and direct count of thrips species on the host plants, sampling was started as soon as the plants appeared above the ground. Samples were taken at each of the four cardinal directions of the field. Also, samples were collected weekly; 15 leaves (3 leaves/plant) from each plant species and dusted on a white paper sheet and collected thrips species numbers were counted and recorded.

**3. Field monitoring of tomato spotted wilt virus (TSWV) viral syndromes:**

Pathological symptoms of TSWV infection on cucumber and squash plants were diagnosed through signs of yellowing, stunning, crinkled, vein banding, mottling and local lesions on leaves. During the survey of thrips species on the plants in the

field, parallel observations were made to detect the appearance of any viral symptoms. Natural infection of cucumber and squash plants shown viral symptoms were labelled, weekly observed and categorized into groups according to the visual syndromes.

**4. Assessment of crop yield:**

Both the infected plants and the healthy plants were labelled. The weight of the fruit yield of each group was recorded at the end of the season by using the digital balance (Brother, Capacity 40Kg, China). The percentage of yield loss due to thrips-borne TSWV infection was determined, in relation to the average yield of the healthy plant, according to the following formula described by Dereje (1993).

$$\text{Yield loss, YL (\%)} = \frac{YH - YD}{YH} \times 100$$

Where, YL= Yield loss. YH= Yield of the healthy plant. YD= Yield of the diseased plant.

**5. Statistical analysis:**

Analysis of variance test was conducted for the different seasons, plantations, thrips species and the effect of the virus infection on the different plant parameters by using SPSS program (Levesque, 2013). L.S.D was conducted using Fisher's test in SPSS program. The correlation between temperature, relative humidity and thrips population was performed.

**Results and discussion**

**1. Population density of different thrips species on cucumber plants:**

The occurrence and seasonal abundance of each thrips species of the cucumber plants was determined and thrips species numbers were counted and recorded (Figure 1).

**1.1. *Thrips tabaci* :**

Population in cucumber fields expressed a higher total number in the nili plantation during the two growing seasons (58.53 and 53.20 individuals per leaf), respectively, than the population in the summer plantation (53.27 and 45.40 individuals/leaf), respectively. This result agrees with that found by Abd El Kareem *et al*. (1984) and El-Dabi (1999).

**1.2. *Thrips palmi* :**

Population expressed a relatively lower total number in case of the nili plantations than the first season with an average of (37.47 and 38.67 individuals/leaf), respectively. The total thrips number per leaf was more than the summer ones (36.33 and 33.00 individuals/leaf) in each season, respectively. These results agree with that found by Kawai (1983).

**1.3. *Chirothrips texanus* :**

The data of *Chirothrips texanus* Andre population showed that the total number in the nili plantation (4.80 and 3.67 individuals/ leaf) respectively, were more than in the summer ones (5.07 and 4.00 individuals/ leaf) respectively. These data were recorded for the first time in Egypt based on the published literatures by Zur Strassen (1960) and Nagata and Peters, (2001).

**1.4. *Frankliniella occidentalis*:**

Population occurred the total number in both nili plantations (45.80 and 44.87 individuals/ leaf) respectively, which were more (Higher) than in the summer ones (41.80 and 37.73 individuals/leaf) respectively, which agree with what recorded by EPPO/CABI (1996).

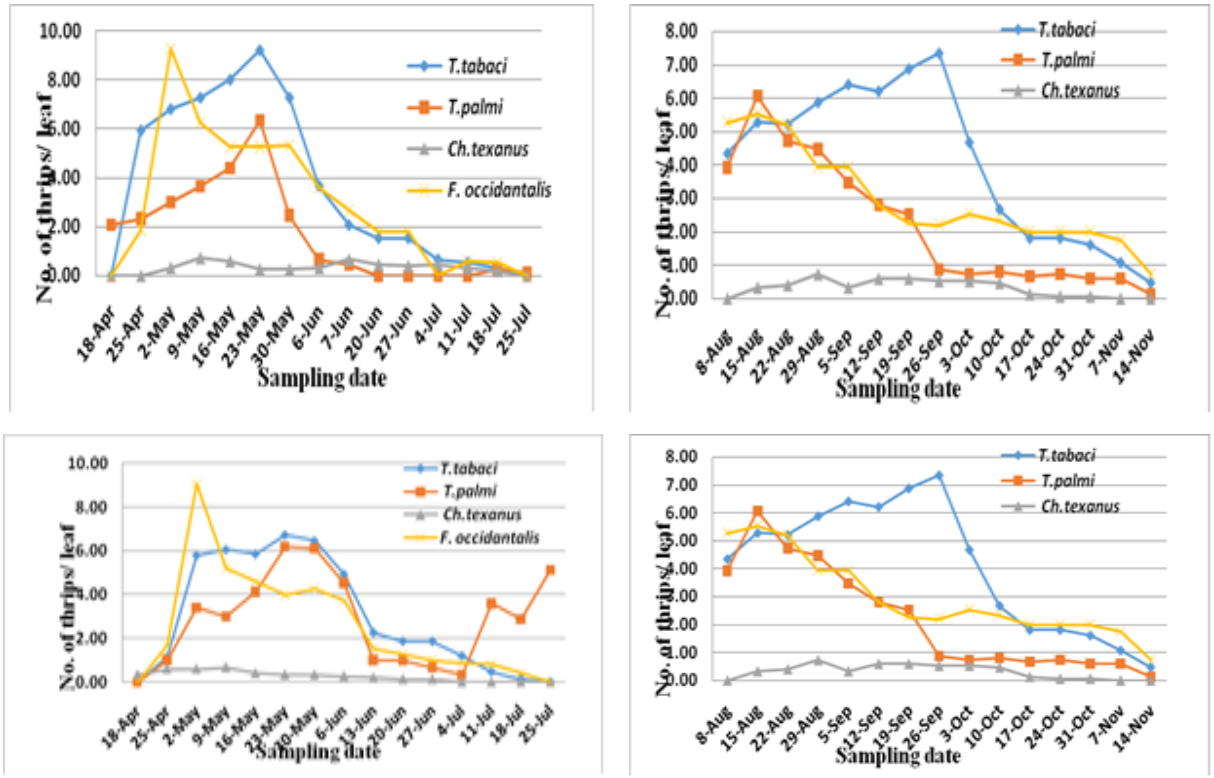


**Figure (1): Mean numbers of thrips species in cucumber fields recorded weekly during the (a,c) summer plantation, (b,d) nili plantation at Giza region, 2010/2011, respectively.**

## 2. Population density of different thrips species on squash plants:

The occurrence and seasonal abundance of each thrips species of the squash plants was determined and thrips species numbers were counted and recorded (Figure 2).

### 2.1. *Thrips tabaci* :

In the summer plantation of the growing seasons 2010 and 2011, *T. tabaci* occurred on squash plants in the field from mid April to early November. The average number of thrips increased gradually with the growing of the seedling and reached the maximum in late May (6.73 and 6.73 individuals/leaf), in each season, respectively.

This result on contrast with what found by El-Dabi (1999) in Egypt and agree with Abd El Kareem *et al*. (1984). In the case of the nili plantation, the average number of thrips increased gradually with the seedling age and reached its maximum in mid October (7.53 and 7.67 individuals/leaf), in each season respectively.

This result agrees with Abd El Kareem *et al*. (1984) and El-Dabi (1999). The thrips population in a squash field expressed as the total number in both nili plantation in each season (63.80 and 55.67 individuals/leaf) respectively, which were higher than in the summer ones (42.40 and 51.67 individuals/ plant), respectively.

### 2.2. *Thrips palmi* :

*T. palmi* occurred also from mid April to early November in each season 2010 and 2011. In the summer plantation, the average number of thrips increased gradually with seedlings growing and reached its maximum in late May (6.20 and 6.20 individuals/leaf) in each season respectively. This result is recorded for the first time in Egypt. The nili plantation, the number of thrips increased gradually and reached its maximum in early September (6.07 and 6.20 individuals/leaf) at early October in each season, respectively.

This result agrees with that found by Kawai (1983) . The thrips population expressed as the total number in both nili plantations (34.80 and 35.67 individuals/leaf) respectively, which were higher than the summer ones (34.73 individuals/leaf), in each season, respectively.

**2.3. *Chirothrips texanus* :**

*Ch. texanus* occurred on squash seedlings grown in the field also from mid April to early November in both season 2010 and 2011. In the summer plantation of the first growing season 2010 the average number increased gradually with seedlings and reached its maximum in early June (0.80 individuals/leaf).

However, during the second growing season 2011, *Ch.texanus* occurred their maximum in early May (0.87 individuals/leaf). This result is recorded for the first time in Egypt based on the published literatures by Zur Strassen (1960) and Nagata and Peters (2001). The nili plantation of the first growing season 2010, the number of thrips increased gradually with seedlings and reached its maximum in late September (0.87 individuals/leaf). While their maximum reached on at late August (0.67 individuals/leaf) during the second growing season 2011.

The thrips population expressed as the total number in both nili plantations (5.73 and 4.73 individuals/ leaf), in each season respectively, which were higher than in the summer ones (4.53 and 4.87 individuals/ leaf) respectively.

**2.4. *Frankliniella occidentalis*:**

*F. occidentalis* occurred on squash seedlings grown in the field also from mid April to early November during 2010 and 2011. In the summer plantation, the average number of thrips increased gradually and reached its maximum in early May (9.07 and 8.93 individuals/leaf) in each season respectively.

In the nili plantation, the average number of thrips increased gradually with the seedling age and reached its maximum in early September (5.53 individuals/leaf). But *F. occidentalis* occurred their maximum in mid September (9.07 individuals/ leaf), which agree with what recorded by EPPO/CABI (1996). The thrips population in the squash field expressed as the total number in both nili plantation (45.87 and 44.67 individuals/leaf), which were higher than in the summer ones (38.80 and 38.67 individuals/ leaf) in each season, respectively.

With both plants, statistical analysis showed a significant difference among the nili and the summer plantations in the same growing season, but not between the growing seasons. Also, there was a significant difference between the thrips species population in both plantations based on the mean of collecting thrips numbers.

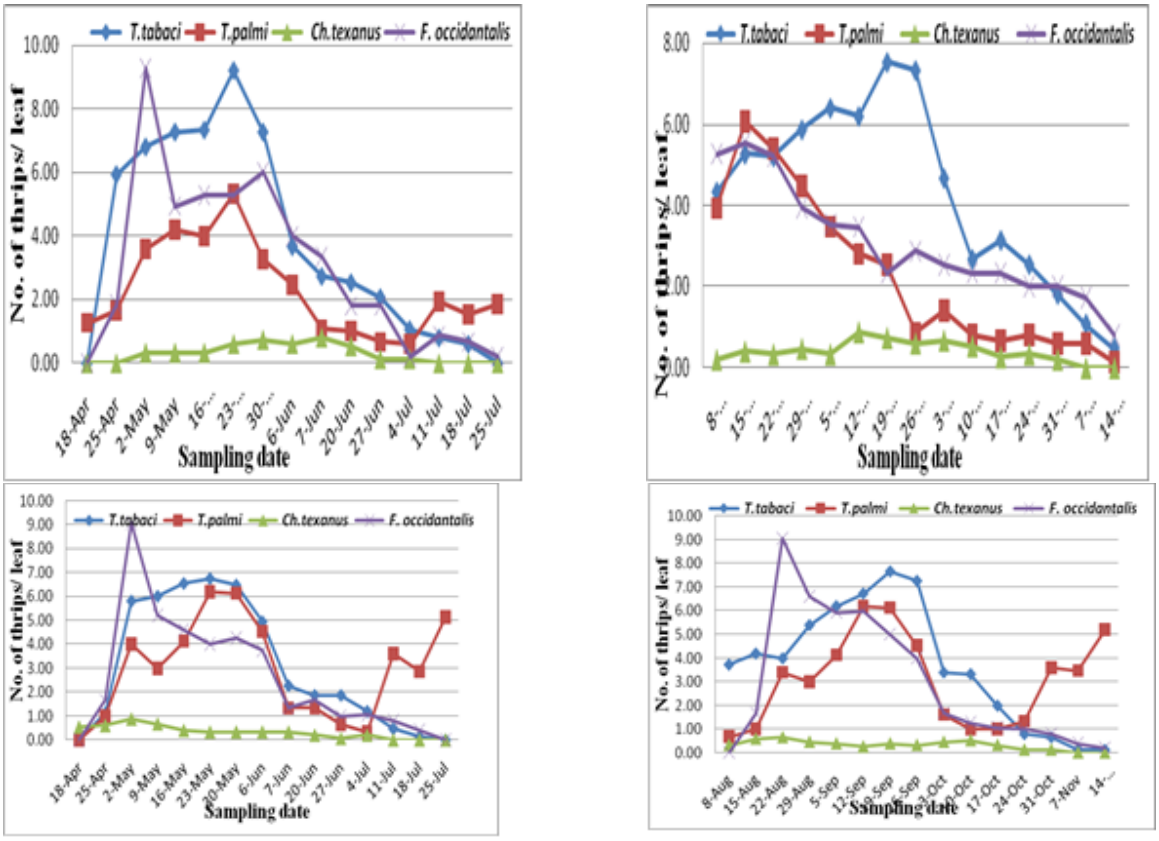


**Figure (2): Mean numbers of thrips species on squash fields recorded weekly during the (a,c) summer plantation, (b,d) nili plantation at Giza region, 2010/2011, respectively.**

### 3. Correlation values between population of thrips species and the climatic factors:

Based on the meteorological data regarding the mean daily temperature and relative humidity obtained by recording them daily, thrips population was affected by both temperature and relative humidity. In cucumber fields, there was a significant positive correlation between the temperature and the average numbers of thrips and a negative correlation between the relative humidity and the average number of thrips, referring that with the gradual increasing with the temperature degrees. This result is applicable to both plantations in each season. In squash fields, in the summer plantation in each season, the correlation values showed a significant positive correlation between the temperature and the average numbers of thrips, while, a negative correlation was found between the relative humidity and the average number of thrips. But, in the nili plantation, in each season a significant negative correlation was found between the temperature and the average numbers of thrips, while, a positive correlation between the relative humidity and the average number of thrips was found.

### 4. Determination of reduction in cucumber leaves number and loss of fruit weight:

The obtained data indicated the effect of the natural infection on the yield of cucumber. In the first growing season 2010, a remarkable reduction in all tested parameters was recorded compared with the healthy plants. The infection resulted in (12.1%) reduction in the cucumber leaves and (29.7%) reduction in the fruit weight compared to the healthy plants yield (Figure 3). The estimated average number of leaves/ healthy plant (19.96 leaves) was reduced to

(17.56) leaves/infected plant (Table 1) as showed in Figure (5). However, the estimated average weight of 10 fruits/healthy plant was 866 gm reduced to 608.72 gm in case of un-healthy plants (Table 2). In case of nili plantation, the natural infection on the yield of the nili plantation 2010, on a cucumber field in the first growing season 2010, caused a remarkable reduction in leave numbers and fruit weight compared with the healthy plants. The infection resulted in a 14.6% reduction in the cucumber leaves and 30.3% reduction in the fruit weight in comparison with the healthy plant, (Figure 3). The estimated average number of leaves/healthy plant was 19.72 leaves reduced to 16.84 leaves/infected plant (Table 1). However, the estimated average weight of 10 fruits in case of the healthy plant was 876.8 gm reduced to 611.52 gm in case of infected plants (Table 2).

In the second cucumber growing season (2011), the data indicated also a remarkable reduction in both leave the numbers and fruit weight during the summer plantation 2011, compared with the healthy plants. The infection resulted in a 11.9 % reduction in the cucumber leaves and 23 % reduction in fruit weight compared with the healthy plant (Figure 3). The counted average number of leaves of the healthy plants (20.08 leaves) was reduced to (17.68 leaves) in case of the infected plant (Table 1). Also, the estimated average weight of 10 fruits for healthy plant was (890.8 gm) reduced to (686 gm) in case of infected plants (Table 2). The obtained results in Figure (3) indicated that, the natural infection on the yield of the nili plantation in the second growing season 2011, with TSWV caused a remarkable reduction in all tested parameters compared with the healthy plants, the infection resulted in (12.4 %) reduction in the cucumber leaves and (27.9 %) reduction in the fruits weight in comparison with the healthy plant. The estimated average number of leaves/healthy plant (20 leaves) was reduced to (17.52 leaves) in case of the infected plant (Table 1). However, the estimated average weight of 10 fruits for healthy plant was (900.4 gm) reduced to (649.2 gm) in case of infected plants (Table 2).

Although the statistical analysis presented in Table (1) showed significant differences in the cucumber leaves numbers among the nili and the summer plantations in the same growing season, but not between the growing seasons. Also, the results in Table (2) showed a significant difference in the cucumber fruit weight among the nili and the summer plantations in the same growing season, but not between the growing seasons. These results partially agree with that found by Abd El-Salam *et al*. (2008), Farrag and Fatouh (2010) and Ghallab *et al*. (2011) .

**5. Determination of reduction in squash leaves number and loss of fruit weight :**

Two parameters were estimated to study the effect of thrips population on the squash yield. The obtained data in Figure (4) indicated a remarkable reduction in all tested parameters compared with the healthy squash plants cultivated in the summer plantation 2010. The infestation resulted in 11.7 % reduction in the squash leaves and 28 % reduction in the fruits weight in comparison with the healthy plant. The estimated average number of leaves/ healthy plant was 20.96 leaves reduced to 18.52 leaves in case of infected plants, (Table 3) as showed in (Figure 5) . However, the estimated average weight of 10 fruits for healthy plant was 894.4 gm reduced to 643.96 gm in case of infested plants (Table 4). The obtained data presented in Figure (4) showed the effect of the natural infection on squash yield of nili plantation 2010, in the first growing season 2010. The TSWV caused a remarkable reduction in all tested parameters compared with the healthy plants. The infection resulted in (22.1 %) reduction in the squash leaves and (30 %) reduction in the fruits weight in

comparison with the healthy plant, The estimated average number of leaves/healthy plant (20.96 leaves) was reduced to (16.32 leaves) in the case of infected plant (Table 3). However, the estimated average weight of 10 fruits for healthy plant (912 gm) was reduced to (637.96 gm) in the case of infected plants, (Table 4).

The presented data in Figure (4) showed the effect of the natural infection on squash yield of the summer plantation in the second growing season 2011, The TSWV caused a remarkable reduction in all tested parameters compared with the healthy plants. The infection resulted in (10 %) reduction in the squash leaves and (25 %) reduction in the fruits weight in comparison with the healthy plant. The estimated average number of leaves for the healthy plant (21.16 leaves) was reduced to (19.04 leaves) for the infected plant (Table 3). However, the estimated average weight of 10 fruits of the healthy plant (900.4 gm) was reduced to (675.96 gm) in case of the infected plants (Table 4). The obtained data illustrated in Figure (4) showed the effect of the natural infestation of thrips on squash yield of the nili plantation in the second growing season 2011,Thrips species transmit TSWV caused a remarkable reduction in all tested parameters compared with the healthy plants, The thrips infestation resulted in 9 % reduction in squash leaves and 27.8 % reduction in the fruits weight compared to the healthy plant. The estimated average number of leaves for healthy plant was 21.32 leaves reduced to 19.36 leaves for the infested plant (Table 3). However, the estimated average weight of 10 squash fruits of the healthy plant was 898 gm reduced to 647.6 gm in case of infested plants (Table 4).

The statistical analysis presented in Table (3) showed significant differences in the squash leaves numbers between the nili and the summer plantations in the same growing season, but not between the growing seasons. In Table (4) a significant difference in the squash fruits weight among the nili and the summer plantations in the same growing season was recorded, but not between the growing seasons. These results partially agree with that found by Abd El-Salam *et al*. (2008) , Hassani-Mehraban *et al*. (2010) and Ciuffo *et al*. (2010) .

The infected cucumber and squash fruits were showed obviously infection symptoms compared with the healthy ones as shown in Figures (5 and 6).

**Table (1): Effect of natural infection with TSWV on number of cucumber leaves during 2010/ 2011 seasons.**

| | **The first season (2010)** | | **The second season (2011)** | |
|---|---|---|---|---|
| | **Summer plantation** | **Nili plantation** | **Summer plantation** | **Nili plantation** |
| **Healthy** | 19.96 | 19.72 | 20.08 | 20.0 |
| **Infected** | 17.56 | 16.84 | 17.68 | 17.52 |
| **LSD 0.05** | 2.33 | 2.53 | 2.24 | 2.03 |
| **Seasons** | NS | **Seasons * plantation** | | NS |
| **Plantation** | Sig. | **Seasons * infection** | | NS |
| **Infection effect** | Sig. | **Plantation * infection** | | Sig. |
| | | **Seasons * plantation* infection** | | NS |

**Tab le (2): Effect of natural infection with TSWV on fruit weight of cucumber during 2010/ 2011 seasons.**

| | The first season (2010) | | The second season (2011) | |
|---|---|---|---|---|
| | Summer plantation | Nili plantation | Summer plantation | Nili plantation |
| **Healthy** | 866.0 | 876.80 | 890.80 | 900.40 |
| **Infected** | 608.72 | 611.52 | 686.0 | 649.20 |
| **LSD 0.05** | 69.13 | 70.31 | 79.43 | 79.22 |
| **Seasons** | NS | **Seasons * plantation** | | NS |
| **Plantation** | Sig. | **Seasons * infection** | | NS |
| **Infection effect** | Sig. | **Plantation * infection** | | Sig. |
| | | **Seasons * plantation* infection** | | NS |

**Table (3): Effect of natural infection with TSWV on number of squash leaves during 2010/ 2011 seasons.**

| | The first season (2010) | | The second season (2011) | |
|---|---|---|---|---|
| | Summer plantation | Nili plantation | Summer plantation | Nili plantation |
| **Healthy** | 20.96 | 20.96 | 21.16 | 21.32 |
| **Infected** | 18.52 | 16.32 | 19.04 | 19.36 |
| **LSD 0.05** | 1.89 | 1.72 | 1.63 | 1.98 |
| **Seasons** | NS | **Seasons * plantation** | | NS |
| **Plantation** | Sig. | **Seasons * infection** | | NS |
| **Infection** | Sig. | **Plantation * infection** | | Sig. |
| | | **Seasons * plantation* infection** | | NS |

**Table (4): Effect of natural infection with TSWV on fruit weight of squash during 2010/ 2011 seasons.**

| | The first season (2010) | | The second season (2011) | |
|---|---|---|---|---|
| | Summer plantation | Nili plantation | Summer plantation | Nili plantation |
| **Healthy** | 894.40 | 912.0 | 900.40 | 898.0 |
| **Infected** | 643.96 | 637.96 | 675.96 | 647.60 |
| **LSD 0.05** | 72.54 | 69.67 | 72.59 | 78.68 |
| **Seasons** | NS | **Seasons * plantation** | | NS |
| **Plantation** | Sig. | **Seasons * infection** | | NS |
| **Infection** | Sig. | **Plantation * infection** | | Sig. |
| | | **Seasons * plantation* infection** | | NS |

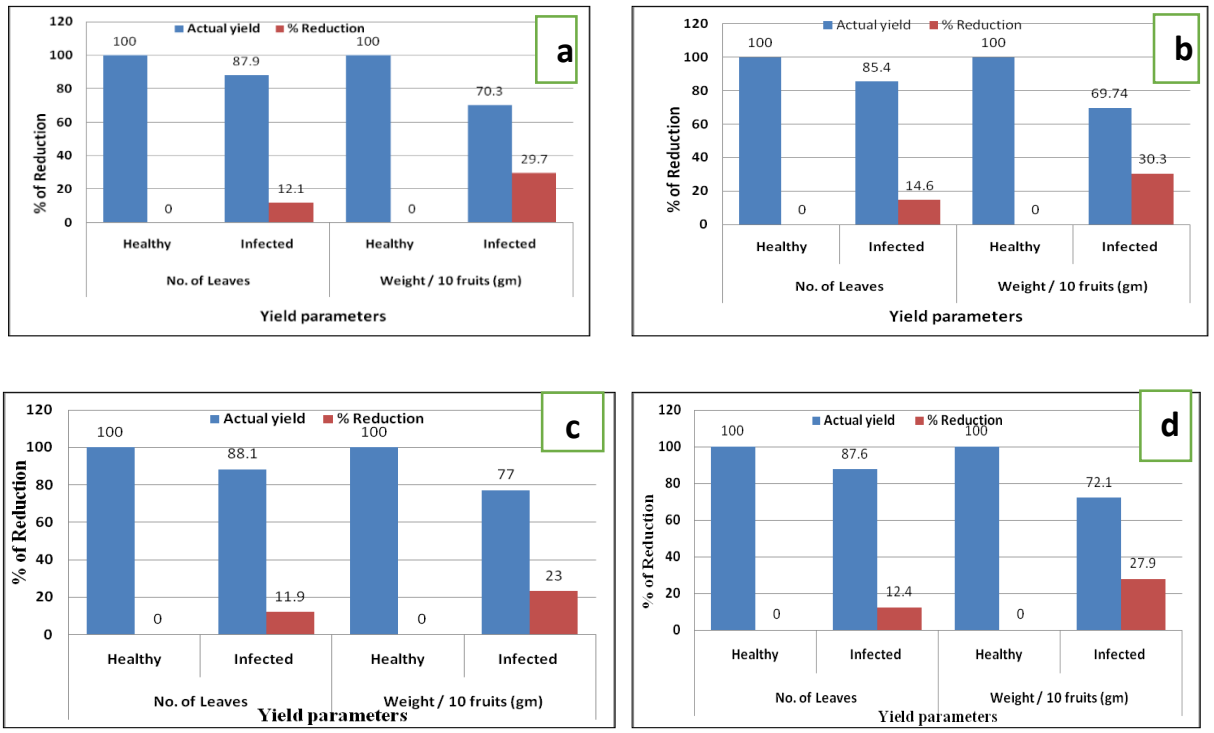


**Figure (3): Reduction percentage in leaves number and fruit weight of cucumber plant due to natural infection with TSWV during a,c) the summer plantation and b,d) nili plantation, Giza region, 2010/2011, respectively.**

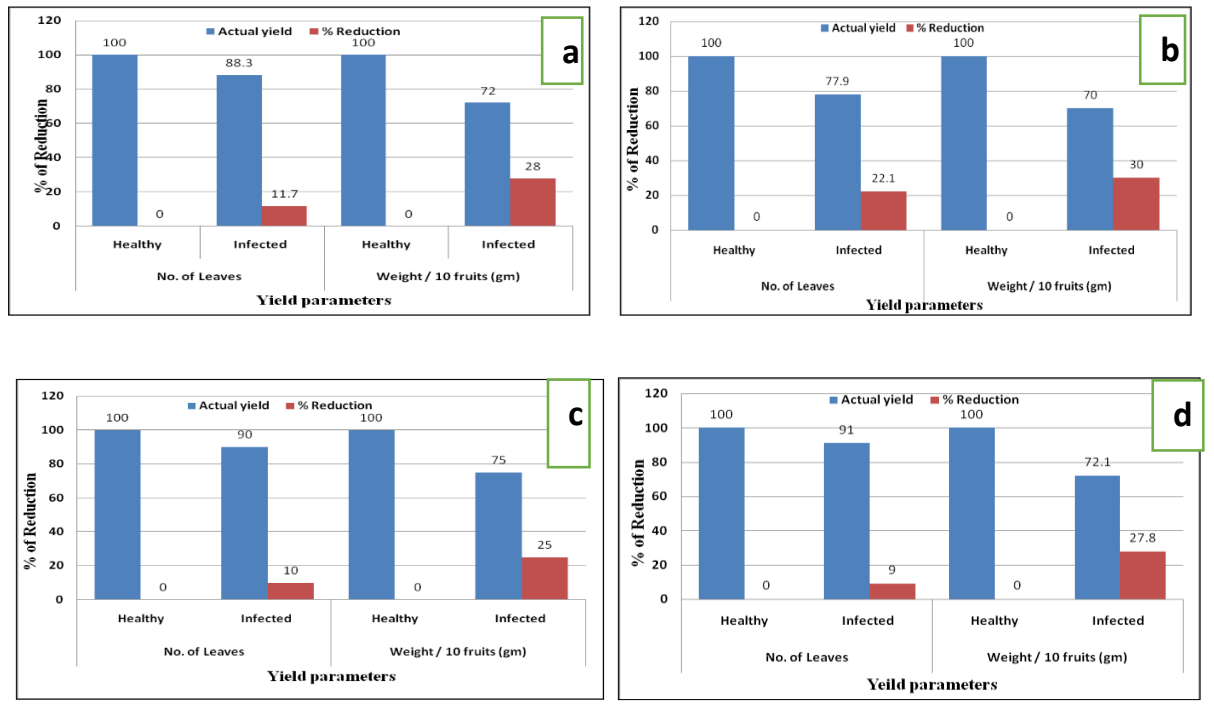


**Figure (4): Reduction percentage in leaves number and fruit weight of squash plant due to natural infection with TSWV during a,c) the summer plantation and b,d) nili plantation, Giza region, 2010/2011, respectively.**

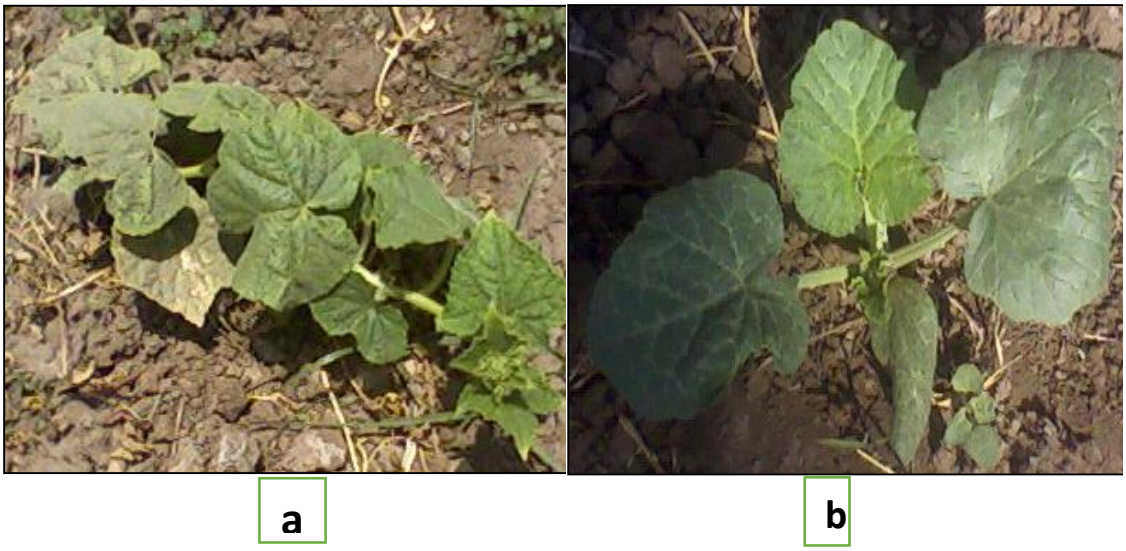


**Figure (5): Visible symptoms of TSWV, a) On cucumber plant, b) On squash plant**

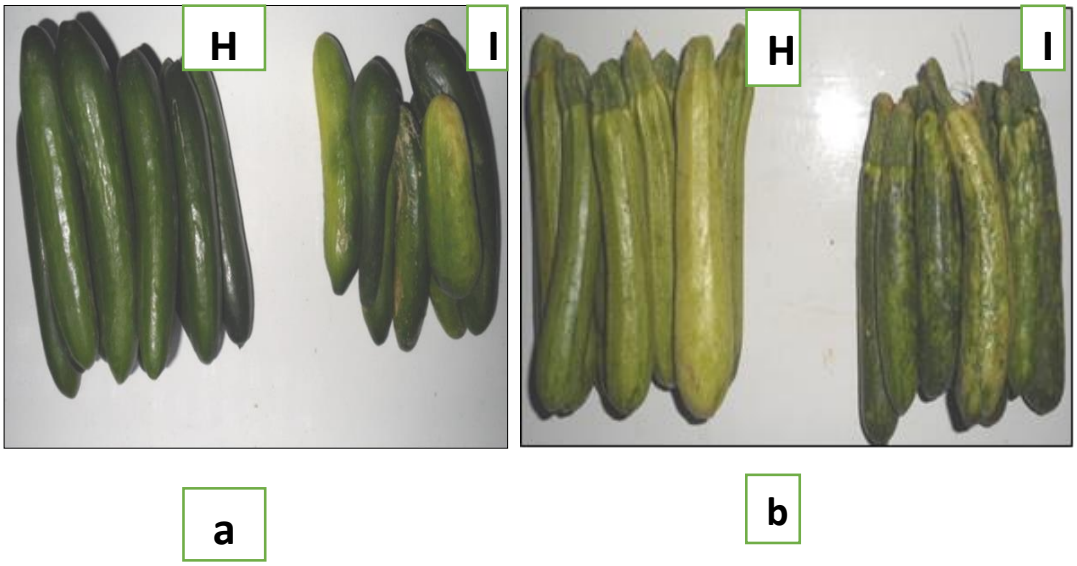


**Figure (6): Symptoms appeared on a) Cucumber fruits b) Squash fruits due to natural infection with TSWV. (H) Healthy fruit, (I) Infected fruits.**

## References

**Abd El Kareem, A.I.: Shanab, L.M. and Abou El Naga, A.M. (1984):** The fluctuation in the activity of *Thrips tabaci* Lind. On squash throughout the hours of the day (Egypt). J. of Agri. Sci. Mansoura. Egypt, 4:88-95.

**Abd El-Salam, A.M.; Assemand, M.A. and Ragab, F.Y. (2008):** Chemical control of some squash pests in Egypt. Ang. Entomo., 70: 169- 174.

**Ciuffo, M.; Mautino, G. C.; Bosco, L.; Turina, M. and Tavella, L. (2010):** Identification of Dictyothripsbetae as the vector of Polygonum ring spot virus. Annals of Applied Biology 157: 299–307.

**Dereje, G. (1993):** Yield loss of faba bean caused by foot rot *Fusarium avenaceaum*. FABIS Newsletter, 33: 24-27.

**El-Dabi, R.M.A. (1999):** Population and control studies on three sap sucking insects on different plantations of squash and cucumber in Giza governorate. M.Sc. Thesis, Fac. Agri., Cairo University.

**EPPO/CABI (1996):** *Frankliniella occidentalis* (Pergande) in quarantine pests for Europe. 2nd edition (Ed. By Smith, I.M.; McNamara, D.G.; Scott, P.R.; Holderness, M.). CAB INTERNATIONAL., Wallingford, UK.

**Farrag, E.S.H. and Fatouh, Y.O. (2010):** Solarization as a method for producing fungal-free container soil and controlling wilt and root-rot diseases on cucumber plants under greenhouse conditions. Arch. Phytopathol. and Plant Prot., 43(6):519-526.

**Ghallab, M.M.; Habashi, N.H.; Iskandarand, A.K. F. and Rizk, M.A. (2011):** Sensitivity of four cucumber cultivars to some piercing sap sucking pests infestation and their impact on yield. Egypt. J. Agric. Res., 89 (4):1363-1373.

**Hassani-Mehraban, A.; Botermans, M.; Verhoeven, J.T.J.; Meekes, E.; Saaijer, J.; Peters, D.; Goldbach, R. and Kormelink, R. (2010):** A distinct Tospovirus causing necrotic streak on Alstroemeriasp in Colombia. Archives of Virology 155: 423–428.

**Kawai, A. (1983):** Studies on population ecology of *Thrips pulmi* Karny. I. Population growth and distribution pattern on cucumber in greenhouse. Jpn. J. Appl. Entomol. Zool., 27:261-264.

**Levesque, R. (2013):** SPSS Programming and Data Management: A Guide for SPSS and SAS Users (4th ed.). Chicago, Illinois: SPSS Inc. ISBN, 1-56827-390-8.

**Mohamed, M.F.; Refaeiand, E.F.S.; Shalaby, G.I. (2003):** Growth and yield of inbred zucchini squash (Cucurbitapepo L.) lines developed under adverse climatic conditions. Ass. Univ. Bull. Environ. Res., 6 (1):1-13.

**Nagata, T. and Peters, D. (2001):** An anatomical perspective of Tospovirus transmission. In: Harris KF, Smith OP, Duffus JE (eds) Virus–insect–plant interactions, Academic Press, New York, 51–67.

**Nakahara, S. and Foottit, R.G. (2012):** Review of *Chirothrips* and related genera (Thysanoptera: Thripidae) of the Americas, with descriptions of one new genus and four new species. Zootaxa, 3251:1-29.

**Salah, S. (2016):** Studies on thrips species (Order: Thysanoptera: Family: Thripidae) and their relation in tospovirus transmission to some cucurbitaceous crops in Giza, Egypt. M.Sc. Thesis, Fac. Agri., Cairo University.

**Zur Strassen, R. (1960):** Key to and catalogue of the known species of *Chirothrips Haliday*, 1836 (Thysanoptera:Thripidae). Journal of the Entomological Society of South Africa, 23(1): 144-176.