Susceptibility Assessment of Two Tomato Hybrids Against *Tuta absoluta* Infestation Under Greenhouse Conditions

Atef S. Abdel-Razek[1], Nesreen M. Abd El-Ghany[1*], Mohamed A. Gesraha[1], Tarek A. Elewa[2] and Abdelhameed Moussa[1]

(1) Pests and Plant Protection Department, Agricultural & Biological Research Institute, National Research Centre, 33 El-Buhouth St., Dokki, Giza, Postal Code 12622, Egypt; (2) Field Crops Research Department, Agriculture and Biological Institute, National Research Centre, 33 El-Buhouth St., Dokki, Giza, Postal Code 12622, Egypt. *Email of corresponding author: nesreennrc@gmail.com

Abstract

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Tuta absoluta is a major insect pest which attack tomato plant varieties in Egypt. Several control attempts were carried out to avoid major crop losses by heavy application of chemical insecticides. The aim of the present study is to assess the susceptibility of infestation of *T. absoluta* of two tomato varieties (Shifa and Savera F1 hybrids) under greenhouse conditions. The tomato varieties were planted in two plantation periods at the district of Kom Hamada, El-Nubaria province, El-Behira Governorate. The susceptibility tests were done by random counting of leaf samples for the presence of *T. absoluta* mines and larvae. Both tomato varieties showed almost the same *T. absoluta* infestation level. Moreover, yield assessment was carried out for the two plantation periods by taking the average fruit weight yield (Kg/acre). The tomato yield results showed that Savera F1 hybrid tomato had higher yield compared to Shifa F1 hybrid variety, but such difference was not significant, However, the yield difference of both vireties between the two planting dates was significant.

Keywords: Tomato, *Tuta absoluta*, susceptibility, leaf-mine, larvae, yield.

Introduction

Tomato (*Lycopersicon esculentym* Mill.) is one of the most popular vegetable crops in the world. It belongs to family Solanaceae, genus Solanum grown in temperate, sub-tropical and tropical areas of the world, which includes seven species of other wild types. There are more than 700 varieties of tomatoes in the world that could be distinguished from each other based on several characteristics including: (i) leaf form and size, (ii) fruit size and color, (iii) biological length of growth cycle, yield and (iv) resistance to different biotic and abiotic conditions. The top tomato producers in the Mediterranean countries are Turkey, Egypt, Italy, Spain, Tunisia, Portugal and Morocco (FAOSTAT, 2014). In Egypt, tomato is considered one of the most important vegetable crops for fresh consumption and processing. The Arab Republic of Egypt government is encouraging growers to increase tomato production to cover the increasing demand of human populations and to increase export. In 2014, the total cultivated area, and productivity of tomato in Egypt, was estimated by 513,638.4 feddan/acre (~215,728.15 ha), yielding 8,288,043 ton with an average of 15 ton/feddan (Anonymous, 2014).

Tomato plants are very susceptible to attack by many insects and diseases in the field, greenhouse and storage. The most important insect pest attacking tomatoes are tomato white fly, *Bemisia tabaci* (Gennadius), aphids, green stink bug, *Nezara viridula* (L.), American tomato budworm, *Helicoverpa armigera* (Hubner), potato tuberworm, *Phthorimaea operculella* (Zeller), tomato leafminer, *T. absoluta* (Meyrick), mole-cricket, *Gryllotalpa gryllotalpa* (L.), the white grubs, *Pentodon bispinosus* (Kuster), the black cutworm, *Agrotis ipsilon* (Hüfnagel), cotton leafworm, *Spodoptera littoralis* (Boisduval) and mealy bugs, *Phenacoccus solenopsis* (Tinsley) (Abd El-Ghany *et al.,* 2018; Abdel-Razek *et al*., 2017; Ibrahim *et al*., 2015). Tomato leafminer, *T. absoluta* represents a major problem for the tomato crops, not only due to the intensity of its attack, but also due to its occurrence during all the crop cycles (Oliveira *et al.,* 2008). The larvae of *T. absoluta* mine the leaves producing large galleries and burrow into the fruit, causing a substantial loss ranging from 60 to 100% of tomato yield in protected and open filed cultivations (Abd El-Ghany *et al.*, 2018). In addition to the loss in yield, economic loss is also derived from the unmarketability of the infested fruits (Abd El-Ghany *et al.,* 2016a, 2016b). Susceptibility test of tomato cultivars exploited in this study as a prophylactic measure to identify naturally occurring resistance in the tested tomato genotypes against the target insect pest (Broekgaarden *et al.,* 2011). Moreover, selection, fertilization, irrigation and spacing can play an additional role in reducing *T. absoluta* infestation.

The present research focus on the prophylactic considerations against *T. absoluta* infestation for optimum tomato production under greenhouse conditions. In this context, the susceptibility of two different tomato F1 hybrid varieties to attack by *T. absoluta* infestation under

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greenhouse conditions were evaluated in Egypt.

Materials and Methods

Tomato varieties used and experimental design

Two different F1 Hybrid tomato varieties,Shifa and Savera, were provided by the Agriculture Research Center, Egypt (Shifa was imported from Thailand and Savera from China) and seeds were sown at two different dates, August 20th and December 15th, 2014, at the horticulture nursery of the National Research Centre (NRC). The two different hybrid seeds were sown for 30 days in a nursery before transplanting the seedlings to the the greenhouse. Tomato seedlings were transplanted on the 15th of September, 2014 in the first greenhouse and on 15th of January, 2015 in the second greenhouse.

A split plot design was used in the experimental greenhouse to compare between thw two tomato varities. The experimental greenhouse was divided into into three blocks representing replications. Each of these blocks was then divided into two main plots to be allocated to varieties, namely, Shifa and Savera. Each main plot consisted of 3 double rows with a total of 6 rows for each variety. The space between double rows was 60–65 cm, whereas the space between single rows ranged from 80 to100 cm. The inter-row space was 50 cm as determined by the drippers in the drip irrigation pipes. Each double row consisted of 40 transplants (20 plants per single row).

Greenhouse growing conditions

The work was carried out in the greenhouse unit of the National Research Centre farm at Kom Hamada district, El-Nubaria province, El-Behira Governorate, about 160 Km north from Cairo. The experimental greenhouse altitude was 27-29 m above sea level. The average annual temperature of the location is about 21.2±2°C, relative humidity of 57% and annual rainfall of 11.6±4.5 ml. The soil had sandy texture, deep, non-saline or slightly saline (EC-values ranged between 0.2 and 0.5 dS/m). Field capacity and wilting point are low (8-9 and 2-3% of soil moisture content, respectively). Soil fertility was characterized by light content of macro- and micro-nutrients and organic matter. Drip irrigation system was used. The principal source of irrigation water for the whole area is the Nile Nubaria canal. The greenhouse was oriented to the north-south, covered with polyethylene plastic. The total area of the greenhouse was 480 m^2 (60 m long and 8 m wide). The soil was mixed with poultry manure and tilled 3 times, one time per week to increase fertility and reduce the viability of weed seeds and other possible pests. A drip irrigation system was used with a distance of 50 cm between dripers to ensure homogenious distribution of water. The water source for the irrigation system was solely based on waste water supplied by the organic fish farm. Plant growth was observed weekly during the growing season. Poultry manure compost and organic fish farm water was sufficient enough to ensure proper plant growth. Hand picking of emerged weeds was carried out in the experimental greenhouse to prevent the competition between weeds and cultivated tomatoes.

Susceptibility assessment for the two tomato hybrids to infestation with *T. absoluta*

The purpose of these experiments were to evaluate the susceptibility differences between the two tomato varieties under investigation to the infestation of *T. absoluta* as a prophylactic measure. Sampling of *T. absoluta* were carried out after the early detection by a total of 4 pheromone traps on early November, 2014 to mid-January, 2015 for first greenhouse grown tomatoes and early March to mid-May, 2015 for the second greenhouse grown tomatoes(7-10 males/trap). For the evaluation of infestation susceptibility, a total of 60 plant leaves per week (30 leaves/tomato hybrid) were collected from the two tomato hybrids for a total period of 11 weeks in the 1st and 2nd greenhouse-grown tomatoes with a total of 3 replicate per tomato hybrid. The plant samples were collected in a paper bags and transferred to the Microbial Control of Insect Pests Laboratory at Pests and Plant Protection Department, NRC, Egypt, for the observation of *T. absoluta* larvae and their mines, a random of twenty infested leaflets from each variety was collected weekly and the collected samples were examined in the laboratory under stereomicroscope (Optika). Larvae and number of mines for *T. absoluta* were counted for both tomato varieties (Cherif *et al.,* 2013).

Yield assessment

For this experiment, three random full maturity tomato plants from each tomato variety were removed from the soil with a total of three replicates per tomato hybrid in order to calculate the total fruits yield. The fruits were harvested and weighted in order to calculate the yield in kg/m^2 and per feddan/acre (Poate, 1988).

Statistical analysis

A student test (Independent t-test) was carried out to find the significant differences between Shifa and Savera F1 Hybrid tomato varieties in terms of their ability to resist *T. absoluta* infestation, based on the number of feeding larvae using SPSS program Version 16 (SPSS-Inc. 2005). Assessment of the difference in yield between the two planting dates was carried out by testing the normality followed by t-test using “dplyr” package in R studio (Wickham & Wickham, 2020).

Results

Insect infestation susceptibility of the two tomato varieties

The results of t-test showed that there is no significant difference between the two tomato varieties in terms of the infestation level of *T. absoluta* in the two greenhouse grown tomatoes. In the 1st greenhouse grown tomatoes, the mean number of mines for Shifa F1 hybrid tomato variety were between 5.20±0.38 to 6.85±0.33 and the number of larvae were between 3.50±0.26 to 4.40±0.20. Whereas, the infestation in Savera F1 hybrid the mean number of *T. absoluta* mines were between 5.25±0.42 to 6.70±0.34 and mean number of larvae were between 3.50±0.26 to 4.40±0.20 (Table 1). Data indicated that the first increase in infestation began on the 1st week of December.

In the second greenhouse grown tomatoes, the mean number of larvae for Shifa F1 Hybrid tomato variety was between 4.07±0.33 to 19.80±1.26 and the mean number of larvae was between 3.27±0.30 to 16.80±0.86, whereas for Savera F1 Hybrid tomato variety the mean number of mines was between 3.80±0.37 to 17.40±1.13 and the mean number of larvae was between 3.13±0.31 to 14.53±1.04 (Table 2). The first increase of infestation began on the 23rd of April, 2015.

Yield assessment

Results obtained showed that there was no significant difference in the total yield of tomato produce between Shifa and Savera varieties in the first greenhouse grown tomatoes (t=102.3, p-value = 0.008278) and in the second greenhouse grown tomatoes (t =117.89, p-value = 0.4373). In the first greenhouse grown tomatoes, the average yield was 12,985 Kg/acre (~31,164 Kg/ha) for Savera variety and 11,025(~26460 Kg/ha) for Shifa variety. In the second greenhouse grown tomatoes, the average yield was 23,907 Kg/acre (~57,376 Kg/ha) for Savera variety and 22,462 Kg/acre (~53,908 Kg/ha) for Shifa variety (Figure 1).

Table 1. Infestation with *T. absoluta* of Shifa and Savera tomato varieties under greenhouse conditions during the first planting period.

No. Weeks	Mean number of leaf-mines (± SE)				Mean number of larvae (± SE)			
	Variety				Variety			
	Shifa	Savera	T-value	*P*-value	Shifa	Savera	T-value	*P*-value
1	2.70±0.35	2.90±0.37	0.394 NS	0.696	2.30±0.30	2.75±0.25	1.152 NS	0.256
2	4.25±0.34	3.25±0.34	2.084*	0.044	3.35±0.29	2.45±0.23	2.399*	0.021
3	1.85±0.33	3.10±0.30	0.113 NS	0.911	1.85±0.33	2.45±0.35	1.458 NS	0.150
4	3.80±0.51	3.85±0.25	0.088 NS	0.930	2.90±0.30	3.35±0.23	1.190 NS	0.241
5	5.20±0.38	5.25±0.42	0.089 NS	0.930	3.60±0.27	3.50±0.26	0.271 NS	0.788
6	6.50±0.47	6.80±0.41	0.477 NS	0.636	4.55±0.28	4.40±0.28	0.372 NS	0.712
7	6.30±0.32	5.90±0.40	0.772 NS	0.445	4.10±0.28	4.00±0.251	0.266 NS	0.792
8	6.85±0.33	6.70±0.34	0.318 NS	0.753 ns	4.30±0.26	4.40±0.20	0.304 NS	0.762
9	6.85±0.33	6.70±0.34	0.318 NS	0.753 ns	2.95±0.30	3.05±0.30	0.237 NS	0.817
10	6.00±0.50	6.30±0.49	0.429 NS	0.617 ns	3.85±0.39	3.80±0.35	0.095 NS	0.925
11	6.30±0.42	6.05±0.36	0.454 NS	0.652 ns	3.95±0.35	3.80±0.35	0.301 NS	0.765

*=Significant, NS= not significant at P= 0.05.

Table 2. Susceptibility of Shifa and Savera tomato varieties to infestation with *T. absoluta* under greenhouse conditions during the 2nd plantation period.

No. Weeks	Mean number of mines (± SE)				Mean number of larvae (± SE)			
	Variety				Variety			
	Shifa	Savera	T-value	*P*-value	Shifa	Savera	T-value	*P*-value
1	4.07±0.33	3.80±0.37	0.539 NS	0.594	3.27±0.30	3.13±0.31	0.311 NS	0.758
2	5.27±0.32	4.93±0.39	0.392 NS	0.698	4.33±0.25	4.33±0.39	0.000 NS	1.000
3	5.87±0.34	6.93±0.32	2.313*	0.028	5.73±0.30	5.67±0.36	0.142 NS	0.888
4	6.53±0.38	7.33±0.36	1.535 NS	0.136	6.07±0.42	6.40±0.33	0.621 NS	0.540
5	7.47±0.86	8.27±0.45	0.823 NS	0.418	6.80±0.76	7.20±0.44	0.457 NS	0.651
6	6.87±1.44	6.27±1.03	0.339 NS	0.737	4.60±0.56	4.47±0.88	0.128 NS	0.899
7	8.53±0.94	8.73±1.45	0.115 NS	0.909	6.80±0.85	6.67±1.13	0.094 NS	0.926
8	11.20±1.42	9.07±0.98	1.232 NS	0.228	7.53±0.95	7.80±0.91	0.203 NS	0.841
9	12.07±1.42	12.00±1.24	0.035 NS	0.972	9.80±1.10	10.47±1.41	0.373 NS	0.712
10	14.20±1.15	13.73±0.49	0.259 NS	0.798	11.27±1.25	10.80±1.15	0.075 NS	0.785
11	19.80±1.26	17.40±1.13	1.414 NS	0.168	16.80±0.86	14.53±1.04	1.680 NS	0.104

*=Significant, NS= not significant at P= 0.05.

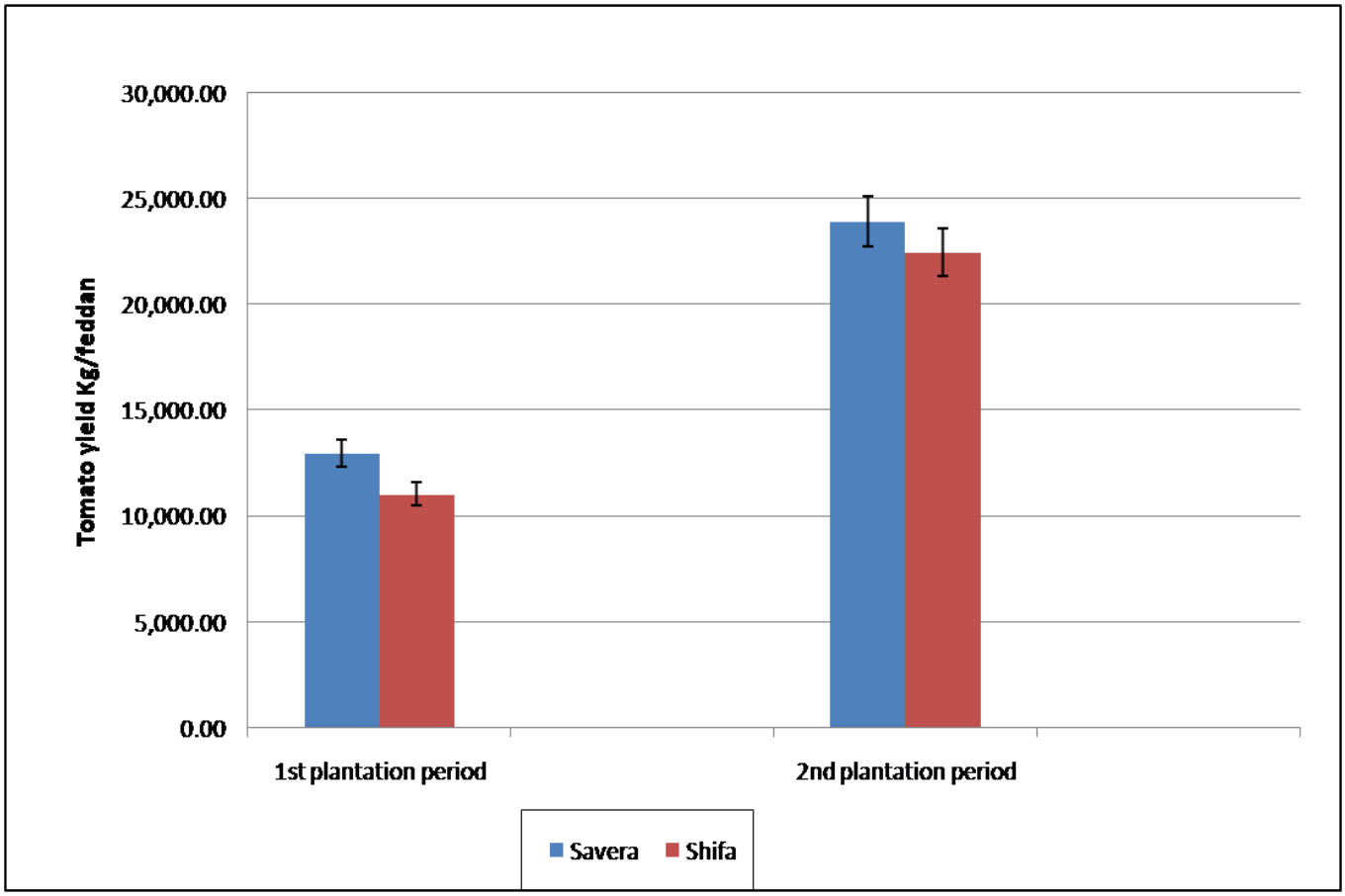

Figure 1. Fruit yield (Kg/feddan) for Shifa and Savera tomato varieties of the 1st and 2nd planting periods.

Furthermore, results of Shapiro-Wilk normality test showed that yield data between the 1st and 2nd growing dates was normally distributed (W = 0.96832, p-value = 0.00626). Results of t-test showed that there was a significant difference in tomato yiled between the two growing dates (t = 11.293, p-value < 2.2e-16). The average tomatoe yield in the first plantation date was 12,000 Kg/acre (24,000 Kg/ha), whereas in the second plantation data the average tomato yield was 23,400 Kg/acre (56,160 Kg/ha) (Figure 1).

Discussion

The results obtained were in agreement with those reported by Cherif *et al.* (2013) in Tunisia, which showed that the highest *T. absoluta* population during four months was between mid-January to early May. The results of this study revealed the occurrence of three insect population peaks. The first peak of infestation was recorded on January 20th, the second peak was observed on March 24th, whereas the third peak was recorded on late April. In Turkey, Öztemiz (2013) reported more-or-less similar results. Cocco *et al.* (2015) Studied the population dynamics of *T. absoluta*, where the active infestation level was less than 1.0 leaf-mine with alive larvae/leaf in winter (December-March), and rose progressively in spring to reach 3.4 mines with alive larvae/leaf in June.

During the winter in this study, the number of mines with alive larvae and the total mines per leaf were low, indicating a slow development of immature stages. Whereas under spring favorable climatic conditions, the total number of mines increased with many abandoned mines due to a faster development rate of *T. absoluta*. The infestation of fruits was observed from May onwards, when the leaf infestation exceeded 1 mine with alive larvae/leaf, and resulted in a mean infestation of 2.3% during the harvest period. Harbi *et al.* (2012) stated that the population density of *T. absoluta* in the surveyed protected tomato crop was low in winter and showed a sharp increase towards the end of the season, which is similar to population dynamics observed in other winter-spring protected tomato crops in the Mediterranean region. Lee *et al.* (2014) mentioned that larvae developed on leaves for most of the growing season and infested fruits in spring as a consequence of increased population density. Adults and immature stages were simultaneously present during the entire cultivation period, indicating overlapping of generations caused by the long oviposition period of females (up to 24 days), and to variable developmental time of individuals due to different microclimatic conditions in the unheated greenhouse. Cocco *et al.* (2013) showed that male captures in pheromone traps fluctuated during the growing season with no distinct generation peaks and increased

consistently in May-June, as the temperature rose favouring *T. absoluta* development. The data presented indicated that both tomato hybrids evaluated were susceptible to *T. absoluta* infestation, but whether or not the infestation level observed lead to yield loss require further investigation.

For yield assessment, the results obtained showed that there was a minor yield difference between both varieties in the first greenhouse grown tomatoes (Figure 1). On the other hand, Savera variety tended to have a slightly higher (~5%) yield than Shifa variety in the second greenhouse grown tomatoes. Also, there was a visible increase in total tomato yield in the second greenhouse grown tomatoes compared with the first greenhouse grown tomatoes because of higher temperature. Previous studies demonstrated that tomato fruit setting is usually poor, when the temperature is either very low or very high (Hussain *et al.*, 2001).

الملخص

عبد الرازق، عاطف، نسرين عبد الغني، محمد جسرها، طارق عليوه وعبد الحميد موسى. 2021. تقدير حساسية إثنين من هجن البندورة/الطماطم بحشرة حافرة أوراق البندورة/الطماطم (*Tuta absoluta*) تحت ظروف البيئة المحمية. مجلة وقاية النبات العربية، 39(4): 317−322.
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تعتبر حافرة أوراق البندورة/الطماطم (*Tuta absoluta*) من الآفات الحشرية الرئيسية التي تصيب أصناف نباتات البندورة/الطماطم في مصر. ويعاني منتجي الطماطم من هذه الآفة الضارة. ولقد تم إجراء العديد من محاولات المكافحة لتجنب الخسائر الفادحة في المحاصيل عن طريق الاستخدام المكثف للمبيدات الحشرية الكيميائية. تهدف الدراسة الحالية لتقيدير مدي حساسة صنفين من البندورة/الطماطم شيفا (Shifa) وسفيرا (Savera) للإصابة بحشرة حافرة أوراق البندورة/الطماطم تحت ظروف الدفيئات/الصوب الزجاجية كإجراء وقائي. تم زراعة أصناف البندورة/الطماطم على فترتين زراعتين بمركز كوم حمادة بالنوبارية بمحافظة البحيرة. وتم إجراء اختبارات الحساسية عن طريق العد العشوائي لعينات الأوراق لوجود أنفاق ويرقات حافرة أوراق البندورة/الطماطم. أظهرت النتائج أن كلا الصنفيين من البندورة/الطماطم أعطت مستويات قريبة من مستويات الإصابة بحشرة حافرة أوراق البندورة/الطماطم. علاوة على ذلك تم إجراء تقييم الإنتاجية لفترتي الزراعة بأخذ متوسط وزن المنتج بالكيلو غرام/الفدان. أظهرت نتائج الإنتاجية لصنفيين الطماطم أولوية لصنف سفيرا، نظراً لإمكاناته الإنتاجية العالية خاصة في ظروف الدفئ والمناسبة لانتاج مستويات مناسبة من الثمار.

كلمات مفتاحية: البندورة/الطماطم، حافرة أوراق البندورة/الطماطم، حساسية الاصابة، الأنفاق، اليرقات، الإنتاجية.

عناوين الباحثين: عاطف عبد الرازق[1]، نسرين عبد الغني[1*]، محمد جسرها[1]، طارق عليوه[2] وعبد الحميد موسى[1]. (1) قسم الآفات ووقاية النبات، دائرة البحوث الزراعية والحيوية، المركز القومي للبحوث، الدقي، الجيزة، الرمز البريدي 12622، مصر؛ (2) قسم بحوث المحاصيل الحقلية، دائرة البحوث الزراعية والحيوية، المركز القومي للبحوث، الدقي، الجيزة، الرمز البريدي 12622، مصر. *البريد الإلكتروني للباحث المراسل: nesreennrc@gmail.com

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