Minufiya J. Agric. Res. Vol.39 No. 3(2):1109-1129 (2014) **"http://www.mujar.net"**

GRAFTING CUCUMBER ONTO SOME ROOTSTOCKS FOR CONTROLLING ROOT- KNOT NEMATODES

A. A. S. El-Eslamboly[1] and A. A. A. Deabes[2]

[1] Protected Cultivation Dept., Horticulture Research Institute, Agriculture, Research Center, Egypt

[2] Fungicides, Bactericides and Nematicides Dept., Central Agricultural Pesticides Lab., ARC, Egypt

(Received: Apr. 16, 2014)

ABSTRACT: *This study was conducted during the seasons of 2011 and 2012 at a Private Farm in infested area with root-knot nematodes M. incognita in El-Katta village, Giza, Egypt. Using eleven grafting treatments in addition to non grafting cucumber (control) in a randomized complete blocks design experiment with three replicates. Cucumber Lama hybrid was grafted onto rootstocks namely i.e., Bottle gourd, Calabash gourd, Emphasis (Lagenaria siceraria), the Cucurbita rootstocks pumpkin (Cucurbita moschata), fig leaf gourd (Cucurbita ficifolia Bouché), the interspicific hybrids rootstocks Shintosa, Ercole Nun 6001, Ferro RZ F1, Super Shintosa (Cucurbita maxima × Cucurbita moschata), Balsam pear Momordica charantia and Horned cucumber (Cucumis metuliferus) by using tongue approach grafting method.*

The obtained results showed that, all rootstocks showed high compatibility with cucumber. All grafting treatments had a significant increment in yield and vegetative growth compared with the control. Horned cucumber (Cucumis metuliferus) rootstocks only can be considered as resistant rootstocks, nevertheless, this rootstock gave lower yield when compared with the other studied rootstocks. Other rootstocks under study may be considered tolerant to nematodes. Lagenaria rootstocks had a significant increment in plant length, internodes length, mean fruit weight and total yield but gave less marketable yield than interspicific hybrids Super Shintosa rootstock in the first season. In both seasons, Lagenaria rootstocks led to a shortage of dry matter and the content of total soluble solids and decreasing the number of branches and early yield compared with other rootstocks. All interspicific hybrids (Cucurbita maxima × Cucurbita moschata) gave a significant increment in vegetative growth, marketable yield and fruit characteristics especially Super Shintosa followed by Ercole Nun 6001. Cucurbita moschata may be arranged in moderate level for tolerance to nematode and compatibility with cucumber and their effect on vegetative growth, yield and fruit characteristics. Momordica charantia gave lower survival rate compared with all rootstocks under study. Grafting cucumber Lama hybrid had lower values in most vegetative growth and yield characteristics.

The grafted cucumber onto fig leaf gourd (Cucurbita ficifolia Bouché) rootstock showed a significant increment in most characteristics such as vegetative growth, early and total yield, fruit characteristics as compared with nongrafted cucumber (control).

Key words: *Cucumber, Grafting, Rootstocks, Nematode, Resistant, Tolerant, Yield, Fruit Quality.*

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is an important vegetable crop, it's highly susceptible to root-knot nematodes (Fernández, *et al.* 1998). Root-knot nematodes, *Meloidogyne spp.* cause high levels of economic loss in a multitude of agricultural crops worldwide (Sigüenza *et al.*, 2005). Root-knot is predominantly caused by four *Meloidogyne* species i.e *M. incognita, M. arenaria, M. javanica, and M. hapla* (Fassuliotis, 1982). Resistant cucumber cultivars are not available. Root-knot nematodes is the most economically cucumber disease which causes an average annual yield loss of about 11 % (St. Amand and Wehner, 1991).

Grafting is an easier and faster approach than plant breeding to take advantage of both existing resistant plants, especially wild cultivars, and high-bred cultivars (Khah *et al* 2011). Grafting of resistant rootstocks to susceptible scions has been used for management of root-knot nematodes on annual crops.

Grafting is an alternative technique often recommended for the cucumber crop in root-knot nematodes infested areas (Wilcken, *et al.,* 2010). Grafting on resistant rootstock is an often recommended technique for cucumber culture in areas infested with root-knot nematodes (Salata, *et al*., 2012). In China ZhenDe, *et al* (2012) found that, grafting cucumber on rootstock had significant effects on controlling southern root-knot nematode, with 67.8%-79.7% effect higher in spring and 12.7%-44.7% effect higher in autumn.

Rootstocks of *Cucurbita maxima*× *Cucurbita moschata* have become the most used hybrids for several watermelon, melon and cucumber cultivars, because of their properties related to the resistance or high tolerance to *F. oxysporum* f. sp. melonis*, F. oxysporum* f. sp. niveum, *Phomopsis sp*., *M. cannonballus, Verticillium dahliae*, MNSV and Nematodes (Tello and Camacho, 2010).

Bur cucumber and the African horned cucumber have the best nematode tolerance using for cucurbit grafting (Lee and Oda, 2003). Cantaloupes (*Cucumis melo* L.) grafted on *C. moschata* reduced Root-knot nematodes (*M incognita* race 3) galling incidence but did not limit final nematode populations in the soil, whereas *Cucumis metuliferus* rootstocks offered similar benefits and reduced nematode levels observed at harvest. The later rootstock allowed egg production and was therefore considered moderately resistant (Sigüenza *et al*., 2005). Bur cucumber is also effective for RKN management in cucumber and offers resistance to fusarium wilt but is susceptible to damping off (Sakata *et al*., 2008).

In Asia, Europe and the Middle East, bottle gourd (*Lagenaria siceraria*) and hybrid squash (*Cucurbita moschata* x *C. maxima*) were widely used as rootstocks in watermelon production due to their resistance to fusarium wilt (Cohen *et al*., 2007). However, the fusarium-wilt resistant rootstocks were highly susceptible to *M. incognita* (Thies *et al*., 2010).

Despite the presence of nematodes of the genus *Meloidogyne* in the soil, the yield of plants grafted onto ‘Shintoza’ was the same in fumigated and non-fumigated soils This agrees with the results of Miguel and Maroto (1996), who reported higher yields of the ‘Queen’ cultivar grafted onto ‘Shintoza’ and grown in nematode-infested soils than for non-grafted plants grown in fumigated soils.

Granges and Leger (1996) showed that when susceptible tomato were grafted on to rootstocks having resistance to species of *Meloidogyne* and various root pathogens, yield increased 50 and 30% at the beginning and end of harvest when compared with the non-grafted plants, respectively.

Grafting susceptible melons on *C. metuliferus* rootstocks also reduced levels of root galling, prevented shoot weight losses, and resulted in significantly lower nematode levels at harvest. Thus*, C. metuliferus* may be used as a rootstock for melon to prevent both growth reduction and a strong nematode buildup in *M. incognita*-infested soil (Sigüenza *et al* 2005).

The aim of the present study is to evaluate eleven commercial and local rootstocks to resistance to (*M. incognita*) nematodes and these rootstocks compatibility with cucumber (scion) under natural infection conditions in infested soil.

MATERIALS AND METHODS

The present study was carried out during the two seasons of 2011 and 2012 at highly nematode infested Farm at El-Katta, Giza, Egypt to evaluate the compatibility of some commercial and local rootstocks with cucumber (scion), also for screening and determining the resistant or tolerant rootstocks to root-knot nematodes *(M. incognita*) under natural infection condition in infested soil. The nematode initial population was 99400 second stage juveniles/250gm soil.

Plant materials

a. Cucumber hybrid
   Cucumber, Lama hybrid from Seminis seed company was used as a scion.
b. Eleven commercial and local rootstocks were also used in this study (Table a).

Nursery of scions and rootstocks

Cucumber Lama hybrid was grafted on to these eleven rootstocks by tongue approach method. Cucumber seeds (scions) were sown in the nursery greenhouse at Experimental Farm of Kaha, Kalubia Governorate on 28th of February in 2011, in the first season and 9th of March in 2012 in the second season. After five days from seed sowing of the cucumber scions, the seeds of different rootstock i.e, Bottle gourd, Calabash gourd, Emphasis (*Lagenaria siceraria*) and the Cucurbita rootstocks Pumpkin (*Cucurbita moschata*), Fig leaf gourd (*Cucurbita ficifolia* Bouché) and the interspicific rootstocks Shintosa, Ercole Nun 6001, Ferro RZ F1 and Super Shintosa (*Cucurbita maxima* × *Cucurbita moschata*) were sown in speedling trays with 84 cells filled with a mixture of peat-moss and vermiculite at the ratio of 1:1 (v/v). Three hundred grams of ammonium sulphate, 400 g calcium superphosphate, 150 g potassium sulphate, 50 ml. nutrient solution and 50 gm of a fungicide were added for each 50 kg of the peat-moss. After seven days, all seedlings of rootstocks and cucumber (scions) were transformed onto plastic pots of 8 cm diameter, filled with the same previously culture mixture (one seedling of the rootstocks with one seedling of cucumber (scions) in the same pot). While the Bitter melon Balsam pear (*Momordica charantia*) and Horned cucumber (*Cucumis metuliferus*) rootstocks were sown at the same time with the cucumber seeds. The grafting was performed in all rootstocks and cucumber (scions) when the stem diameter reached about 4mm. Before grafting, the scions and rootstocks were irradiated by the sunlight for 2-3 days and the soil was kept dry to avoid spindly growth as recorded by Oda (1999).

The tongue approach grafting

The tongue approach grafting method which is called approach graft (TAG), is relatively simple and is the oldest grafting style. This method is preferred by inexperienced growers because of its high success rate, and low care requirement. This method originated in the Netherlands (Ishibashi, 1965), and is now widespread in Japan, Spain, France, and Italy (Lee and Oda, 2003). It is easy to use, has a high success rate, and the grafted seedlings have a uniform growth rate (Davis *et al* 2008).

Table a : The commercial and local rootstocks used in this study.

Rootstocks	Source
Bottle gourd *(Lagenaria siceraria)*, PI 534556 01 SD	USDA gene bank
Calabash gourd *(Lagenaria siceraria)*	Local variety
Emphasis hybrid *(Lagenaria siceraria)*	Syngenta Seed Company
Fig leaf gourd (*Cucurbita ficifolia* Bouché) PI 512680 02 SD	USDA gene bank
Pumpkin (*Cucurbita moschata*) PI 525174 01 SD	USDA gene bank
Shintosa F1 hybrid (*Cucurbita maxima* × *C. moschata*)	Sakata Seed Company
Ercole F1 hybrid (*C. maxima* × *C,moschata*) Nun 6001F_1	Nunhems Seed Company
Ferro RZ F1 hybrid (*C. maxima* × *C. moschata*)	Rijk Zwaan Seed Company
Super Shintosa F1 hybrid (*C. maxima* × *C. moschata*)	G.S.I. Seed Company
Bitter melon (Balsam pear) *Momordica charantia*	Local variety
Horned cucumber *Cucumis metuliferus* PI 482454	USDA gene bank

Grafting steps

The scions and rootstocks should be approximately the same diameter in the TAG method. Therefore, the cucumber seeds were planted seven days before the rootstock seeds. At the first true leaf stage, the cut was made by using a sharp blade, in both stems of the cucumber and rootstocks. The rootstock was cut through the hypocotyl at a 35◦ to 45◦ angle. The scions were cut from bottom to the top, while the rootstocks were cut from top to bottom. This is usually the case after the rootstock has fully developed cotyledons and the scion has cotyledons and the first true leaf. Each slit was like a tongue, and were fitted together and sealed with an aluminum wrap and grafting clips to allow healing to take place .

Healing was begun after five days and the rootstock stem was removed. Ten days after grafting the cucumber root was cut. The metal strips were remained on the plant once the plant has healed, while the grafting clips were removed 15–20 days after grafting .

Grafted seedlings were removed after grafting immediately into shaded plastic low tunnel for healing and hardening. A polyethylene sheet was laid on the floor of low tunnels and covered with a shallow layer of water. Grafted seedlings were placed above speedling trays which placed on bricks to support the plants above the water layer. The plastic tunnel was closed to achieve a temperature 25-32 °C and (>85% RH) humidity. Four to five days after grafting, the hardening process began by peeling away the top layer of shade net. The water was drained out of the floor pan. Meanwhile, the plastic covered was gradually removed for four to five days.

Grafted plants were moved out of the tunnel and placed into a screen house, twelve days after grafting until ready for transplanting. The plants were stayed in the screen house for seven to eight days after removing the scion roots for further development and hardening. The entire process took 30 to 35 days from transplanting.

Grafted cucumber seedlings were transplanted in April 13th, 2011 and 22nd of April, 2012 for the first and the second seasons, respectively. Grafted plants were transplanted in rows 10 meter in length and 1.2 meter in width. The space between plants was 0.5m. at a density of 7000 plants per feddan. Each single treatment contained 20 plants in one row.

The graft union of grafted seedlings was kept above the soil line, to avoid development of adventitious roots from the scion that penetrate the soil and cause disease bypassing of resistant rootstock that may lead to infection and death of the entire plant. The conventional agricultural practices *i.e.,* irrigation, fertilization, and weeding and pest control followed standard commercial practices, were done as recommended by the Ministry of the Agriculture in Egypt, for cucumber production. Plots were first harvested after 35 days from transplanting then every two days interval. Fruits were graded, counted and weight. Fruits (of about 12-15 cm in length) having a regular shape were classified as marketable fruits, while the diseased and malformed fruits were considered as unmarketable. At the end of each season, the following data were calculated.

Meloidogyne incognita, Nematodes

After 75 days from planting, three plants from each plot were uprooted from the field carefully and washed. The root system of each plant was submerged in a 15% solution of McCormick's red food color (Thies *et al*., 2002) for 15 to 20 min to stain the egg masses. The root system was carefully rinsed under running tap water and evaluated for number of galls and egg mass production. Then approximately, the total root weight was recorded and root-knot nematode eggs were extracted from the root sample using 1.0% (NaOCl) sodium hypochlorite solution (Hussey and Barker, 1973). The average number of eggs per ten egg masses was counted using a stereomicroscope. The initial number of nematode's population density in the infested field was estimated by modified sieving and Bearman's plats technique (Viglierchio and Schmitt, 1983). The root systems were carefully washed under running tap water.

Root gall index for *M. incognita* was estimated by counting the gall or egg-masses on the root system, and calculated according to the scale given by Taylor and Sasser (1978) as follows: 0= no galls or egg-masses, 1=1-2 galls or egg- masses, 2=3-10 galls or egg-masses, 3=11-30 galls or egg-masses, 4=31-100 galls or egg-masses, 5= more than 100 galls and egg-masses. Category of host was measured by gall index (G.I.) and egg-mass index (E.I.) according to Hadisoeganda and Sasser (1982) as follows: (G.I.) or (E.I.) range of 0.0-1.0= highly resistant (HR), 1.1-3.0= very resistant (VR), 3.1-3.5= moderately resistant (MR), 3.6-4.0= slightly resistant (SR) and 4.1-5= susceptible (S).

Studied characteristics

1. Survival rates:

Survival rates were measured after 12 days from the grafting by counting the survive seedlings and divided on the total number of the grafted seedlings.

The following data were recorded during growth period until the end of harvesting.

2. Vegetative growth characteristics

Vegetative growth characters, were recorded after 75 days from transplanting of three plants randomly chosen from each plot as follows

a. Plant length (cm)
b. Average internodes length (cm)
c. Leaf area (cm^2): It was expressed as the mean leaf area in cm^2 using the fresh weight method. The leaves were cleaned from dust and then weight to nearest 0.001 g. Therefore 20 disks of known area were separated as weight.

$$leaf\ area\ cm^2 = \frac{fresh\ weight\ of\ one\ leaf\ No.10}{fresh\ weight\ of\ 20\ disks} \times 20 \times \text{area of disk}$$

Where, the area of a disk is about 1.0 cm

d. Number of leaves per plant
e. Stem diameter (cm)
f. Number of branches/plant
g. Plant fresh weight (g)
h. Plant dry weight (g): It was measured as the weight of the same plants used for plant fresh weight after being dried out in an oven with driven hot air at 70 °C until a constant weight.
i. Plant dry matter percentage: It was measured by this equation

$$\text{Plant dry matter\%} = \frac{\text{Plant dry weight(g)}}{\text{Plant fresh weight(g)}} \times 100$$

3. Yield and its components

a. Total weight of fruits /plant
b. Total number of fruits/plant
c. Early yield (ton/feddan)
d. Early yield (number/feddan)
e. Total yield (ton/feddan)
f. Total number of fruits/feddan
g. Marketable yield
h. Percentage of decreasing yield

4. Fruit characteristics

a. Fruit length (cm)
b. Fruit diameter (cm)
c. Fruit shape index: It was calculated by dividing fruit length on fruit diameter.
d. Average fruit weight (g)
e. Total soluble solids (T.S.S. %): They were measured in fruit juice by using a hand refractometer. Five fruits were taken at random from each treatment for this test. This was estimated according to the methods of A.O.A.C. (1975).
f. Fruit dry matter %: It was determined by allowing 100 g of fruit fresh weight to dry in an oven at 70°C till a constant weight.
g. Determination of leaf pigments: Green color reading: It was determined by using a SPAD 501 leaf chlorophyll meter (for using the greenness measurements) for fully expanded leaves (the fifth leaf from the shoots growing tip without destroying them) (Yadava, 1986).

Experimental design and statistical analysis

The experiment was layout as randomized complete blocks design with three replications. Data were statistically analyzed using analyses of variance by the technique of analysis of variance (ANOVA) with the Stat soft statistical package (MSTATC) software program (Michigan State University,. East Lansing, MI, USA). Probabilities of significance among treatments and means were compared with least significant difference L.S.D. ($P \leq 0.05$) were used to compare means within and among treatments according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1. Survival rates

Data in Table (1) indicate that *Momordica charantia* had lower values of survival rate which were (77.38 and 79.76%) in the first and the second seasons respectively. These results may be due to the partial incompatibility with cucumber. The highest survival rate was obtained when cucumber plants were grafted onto Super Shintosa followed by grafted cucumber on both Calabash gourd, *Cucurbita ficifolia* Bouché, Shintosa, Ercole Nun 6001 and Ferro RZ F1, in the first season while, in the second season Calabash gourd, Emphasis, *Cucurbita ficifolia* Bouché, Shintosa, Ercole Nun 6001, Ferro RZ F1 and Super Shintosa gave the same values (95.24%).

Grafted cucumber on horned cucumber (*Cucumis metuliferus*) had (92.86 and 94.05%) in the first and the second seasons respectively. The Bottle gourd rootstock gave 94.05% in both seasons. While (*Cucurbita moschata*) gave (92.86 and 94.05%) in the first and the second seasons respectively. These results agree with that of Al-Debei *et al*., (2012) who found that, cucumber cultivar Zezia grafted on Strongtosa, Shintosa supreme and Tetsukabuto by tongue approach or by top grafting (hole-insertion) methods had 100% survival rate as compared to non-grafted plants. On the other hand, graft success rate was 100% from plants grafted on Shintosa supreme and Strongtosa whereas, it was 76.66% for plants grafted on Tetsukabuto once top-grafting method was used.

Table 1. Effect of grafting cucumber Lama hybrid onto eleven rootstocks on survival rate percentage of seedlings, in 2011 and 2013 seasons.

Treatments		2011			2012		
		Number of grafted plant	No. of survive	Survival %	Number of grafted plant	No. of survive	Survival %
Control		84	82	97.62	84	82	97.62
Lagenaria	Bottle gourd	84	79	94.05	84	79	94.05
	Calabash gourd	84	80	95.24	84	80	95.24
	Emphasis	84	79	94.05	84	80	95.24
Cucurbita	Moschata	84	78	92.86	84	79	94.05
	Ficifolia Bouché	84	80	95.24	84	80	95.24
	Shintosa	84	80	95.24	84	80	95.24
	Ercole Nun 6001	84	80	95.24	84	80	95.24
	Ferro RZ F1	84	80	95.24	84	80	95.24
	Super Shintosa	84	81	96.43	84	80	95.24
Momordica charantia		84	65	77.38	84	67	79.76
Cucumis metuliferus		84	78	92.86	84	79	94.05

Data in Table (2) indicate that, there were significant increment in plant vigor of grafted plants compared to ungrafted (control) of the cucumber Lama hybrid under the nematode infested soil in both seasons. This was shown in plant length (cm), stem diameter, mean internodes length (cm), leaf area (cm^2) and number of branches and leaves per plant. Grafting cucumber on *Lagenaria* rootstocks (Emphasis, Bottle and Calabash gourd) gave a significant increment in plant length and internodes length, in both seasons. While grafting cucumber on interspecific hybrid rootstocks (*Cucurbita maxima* × *Cucurbita moschata)* rootstocks such as Shintosa, Super Shintosa, Ercole and Ferro RZ F1 gave a significant increment in stem diameter, leaf area, number of branches and leaves number followed by grafting on *Cucurbita pepo*, *Cucurbita Ficifolia* Bouché, followed by *Cucumis metuliferus and Momordica charantia,* in both seasons.

Cultivation grafting cucumber in an infested field with nematode showed good vegetative growth compared with ungrafted plants. This agrees with that of Salam *et al.* (2002) in watermelon, they reported that, both length of vine and number of lateral branches produced in the grafted plants were higher than those of the ungrafts. Differential hormone synthesis (cytokinins, abscisic acid, ethylene, gibberellins, auxins) controlled by root systems could lead to variations in growth and root to shoot ratios (Zijlstra *et al.,* 1994).

Zhang *et al* (2006) found that, the values of plant height, leaf area, number of leaves, stem diameter and number of nodes were intermediate in cucumber plants grafted on bur cucumber compared with those grafted on black seed pumpkin and self-rooted plants. They added that cold resistance and photosynthetic rate as well as yield, fusarium wilt resistance and root-knot nematode resistance were highest in plants grafted on bur cucumber.

Data in Table (3) indicate that, in infested soil with root knot nematode (*Meloidogyne spp*), grafting cucumber on all rootstocks had a significant increment in both fresh and dry weights compared with the control plants in both seasons. The dry matter percentage had a significant decrease when grafting cucumber on *Lagenaria* rootstocks (Bottle gourd, Calabash gourd and Emphasis) compared with control plants, at the same time the cucumber plants grafted on interspecific hybrid rootstocks (Shintosa, Ercole Nun 6001, RZ and Super Shintosa) gave a significant increment in dry matter percentage when compared with the control in the first season. While in the second season, no significant differences were obtained from grafting cucumber on interspecific hybrids (Shintosa, Ercole Nun 6001, RZ and Super Shintosa), and on *Cucurbita moschata*, *Cucurbita ficifolia, Momordica charantia and Cucumis metuliferus* compared with control. Grafting cucumber on pumpkin, fig leaf gourd (*Cucurbita ficifolia* Bouché) balsam pear (*Momordica charantia)* and *Cucumis metuliferus* did not have any significant differences compared with ungrafted cucumber, in the first season.

In the second season, grafting cucumber on *Lagenaria* rootstocks gave a significant decrease in dry matter percentage when compared with grafting cucumber on other rootstocks and control plants. These results agree with that of Huang *et al*. (2009), they showed that reduction of cucumber (*Cucumis sativus* L.) shoot dry weight can be alleviated by grafting onto bottle gourd rootstock i.e, 'Chaofeng 8848 (*L. siceraria* Standl). Grafted cucumber Zezia cultivar on two rootstocks Strongtosa, Shintosa supreme resulted in more vigorous cucumber plants. For instance, the total dry weight of vegetative parts was 112-123% higher than non-grafted plants in the first season and 131-152% in the second season (Al-Debei *et al*., 2012).

Data in the same table illustrate that, the total chlorophyll content as (SPAD value) showed significant differences between grafted and ungrafted cucumber, in both seasons. Grafting cucumber on interspecific hybrid rootstocks showed highest values, in both seasons followed by the cucumber plants which were grafted on *Momordica charantia* and *Cucumis metuliferus* followed

Table 2

Table 3. Effect of grafting cucumber Lama hybrid on eleven rootstocks on plant fresh and dry weights and dry matter percentage under infested soil with root knot nematodes, in 2011 and 2012 seasons.

Treatments		2011				2012			
		Plant (gm)		Dry matter %	Spad Index	Plant (gm)		Dry matter %	Spad index
		Fresh	Dry			Fresh	Dry		
Control		546.0	56.11	10.28	34.81	556. 7	56.60	10.18	37.48
Lagenaria	Bottle gourd	814.0	78.37	9.63	45.98	820. 3	77.12	9.40	45.14
	Calabash gourd	818.0	78.25	9.56	46.35	831. 3	80.08	9.63	44.66
	Emphasis	829.7	80.35	9.69	46.31	827. 3	78.87	9.53	45.86
Cucurbita	Moschata	873.7	89.60	10.26	49.57	860. 7	85.00	9.88	48.95
	Ficifolia Bouché	930.0	97.23	10.45	51.27	902. 7	91.13	10.10	52.18
	Shintosa	986.0	107.13	10.86	54.52	919. 7	93.07	10.12	54.28
	Ercole Nun 6001	983.0	108.33	11.02	52.48	946.0	95.98	10.15	53.96
	RZ	1005.3	110.47	10.98	54.03	955.7	96.67	10.11	54.00
	Super Shintosa	1015.3	114.30	11.25	53.77	976.0	100.37	10.28	54.23
Momordica charantia		817.0	80.70	9.87	50.47	798.0	79.53	9.97	49.34
Cucumis metuliferus		818.7	82.73	10.11	49.92	816.3	82.57	10.10	49.35
LSD at $t_{0.05}$		32.55	6.59	0.45	2.82	32.36	3.42	0.23	2.99

by the grafted cucumber on *Lagenaria* rootstocks, while the control plants had the lowest values, in the first and the second seasons. SPAD values have been shown to have a strong correlation with leaf chlorophyll content (Yadava, 1986).

FengMing *et al.* (2002) studied the effect of grafting of some species of watermelon on three different rootstocks . The results showed that there was no difference in the chlorophyll content. Huang *et al*. (2009 and 2010) showed that reduction of cucumber (*Cucumis sativus* L.) shoot dry weight can be alleviated by grafting onto bottle gourd rootstock 'Chaofeng 8848 *(L. siceraria* Standl.).

Results in Table (4) show that there were significant differences between the grafted and ungrafted plants in early, total yield as a weight and number of fruits per plant or per feddan as well as marketable yield. The fruit yield was significantly higher in the grafted plants than the ungrafted plants. Early yield from all grafting treatments showed a significant earliness compared with the control plants which gave 0.23 and 0.26 kilogram per plant in the first and the second seasons respectively. Grafting cucumber on *Lagenaria* rootstocks (Bottle and Balabash gourd or Emphasis) gave a significant increment in total yield as weight and marketable yield.

Unmarketable yield when grafting cucumber on *Lagenaria* rootstocks significantly increased compared to all grafted cucumber on other rootstocks and control. The number of fruits per plant or per feddan yielded from grafting cucumber on *Lagenaria* rootstocks (Bottle gourd, Calabash gourd and Emphasis) showed lower values compared with cucumber grafted on other rootstocks, *Cucurbita moschata*, *Cucurbita ficifolia* rootstocks and all interspecific hybrids (*Cucurbita maxima*×*Cucurbita moschata), Momordica*

Table 4

charantia and *Cucumis metuliferus*. These results may be due to the effect of *Lagenaria* rootstocks on vegetative growth as these rootstocks gave a lower number of branches than all other rootstocks but gave a highest value on plant length. The increase in total yield when using *Lagenaria* rootstocks may be due to the increase in fruit weight; length and diameter as a result of grafting on *Lagenaria* rootstocks (Bottle gourd, Calabash gourd and Emphasis). Grafting cucumber on interspecific hybrid rootstocks (Shintosa, Ercole Nun 6001, RZ and Super Shintosa) gave significant increment on yield characters except the total yield as a weight.

The lowest percentage of unmarketable yield was produced from cucumber plants which grafted on the interspecific hybrid rootstocks (*Cucurbita maxima*× *Cucurbita moschata)*, specially by grafting cucumber on RZ and super shintosa it gave (4.44 and 4.57) in the first season and (4.1 and 4.0) in the second season respectively. These results agree with that of Al-Debei *et al.* (2012) who found that when grafted cucumber cultivar Zezia on (Strongtosa, Shintosa supreme and Tetsukabuto) by tongue approach or by top grafting (hole-insertion) methods, grafting cucumber on two rootstocks resulted in more vigorous cucumber plants.

For instance, the total dry weight of vegetative parts was 112-123% higher than non-grafted plants in the first season and 131-152% in the second season. The more vigorous growth resulted in higher marketable yield ranging from 37% to 134% of that of non-grafted plants. In addition, both rootstocks showed a significant increase in fruit yield when compared to plants grafted on the Tetsukabuto rootstock. However, Tetsukabuto rootstock showed a higher marketable yield which ranged from 22% to 85% than that of non-grafted plants. All plants were severely infested with nematodes with no significant differences in galling index, even though Strongtosa had the lowest galling index and showed enhanced resistance against the root knot nematode. Therefore, it is recommended to use Strongtosa and Shintosa supreme as rootstocks for 'Zezia' cucumber that improves plant vigor and yield, which confer tolerance to root knot nematode.

The obtained results are in agreement with those of some researchers.

In Turkey, Özarslandan *et al.* (2011) found that all bottle gourds genotypes were susceptible to root-knot nematodes. Watermelon plants which grafted onto bottle gourd rootstocks showed better plant growth performance and produced higher yield than ungrafted watermelon plants in field contaminated with root-knot nematodes. It was concluded that bottle gourd rootstocks were not directly resistant to nematodes but they can tolerate nematodes with their rapid growth, at low soil temperature nematodes are multiplication is reduced.

Cansev and Ozgur, (2010) reported that, in general, the yield and growth of non-grafted plants were significantly reduced, compared with grafted plants. Earliness and total yield were increased in grafted cucumber cultivars (by 53-120% and 87-209%, respectively, in cv. Marathon F_1 and by 20-100% and 54-154%, respectively, in cv. Assos F_1), compared with control plants. Likewise, plant-growth and development parameters were improved in grafted plants, compared with controls. These results suggest that grafted plants prevent the reduction in cucumber yield caused by continuous cropping due to soil-borne pathogens. Grafting on resistant rootstock is a technique often recommended for cucumber crop in root-knot nematodes infested areas. Higher fruit yield was obtained in cucumber grafted on 'Shelper', for both nematode species, while cucumber grafted on 'Excitte Ikki' did not differ from non grafted plants for total fruit weight. Both nematode species reduced fruit yield, which was more evident when *M. javanica* was inoculated. Grafted and non grafted plants were susceptible, because they enabled the multiplication of nematodes, with a reproduction factor, at 72 days after inoculation, ranging from 3.57 to 15.04, with the highest value in cucumber nongrafted inoculated with *M. javanica* (Salata, *et al.*, 2012). The highest numbers of early yield were produced from the cucumber plants grafted on interspecific hybrid rootstocks while the lowest value of early yield was produced from control. In this respect (Walters and Wehner, 1997) reported that, root knot nematodes are a major problem of cucumber production in north Carolina, as well as in other southern states. *Meloidogyne spp.* can cause yield losses of over 30% in various vegetable crops (Netscher and Sikora, 1990).

Zhang, *et al.* (2006) found that cucumber plants grafted on bur cucumber rootstock *(Sicyos angulatus*) showed earlier first female flowering and first harvesting date than those grafted on black seed pumpkin rootstock (*Cucurbita ficifolia*) and self-rooted plants. Higher fruit yield was obtained in cucumber grafted on squash hybrid Shelper, for both nematode species, while cucumber grafted on squash hybrid Excitte Ikki did not differ from non grafted plants for total fruit weight (Salata, *et al*., 2012).

In China ZhenDe, *et al.* (2012) reported that generally speaking, cucumber grafted with 'Xindongli' and 'Huangzhen No.3' rootstocks has higher yield, better quality and good control effect of southern root-knot nematode. In Georgia, RKN significantly reduced fruit yield of ‘Cooperstown’ seedless watermelon grown in non-treated soil beds compared to that grown in methyl bromide treated soil beds (Davis, 2007). Root knot nematodes can cause substantial damage to cucurbits. All cucurbits are susceptible to root knot nematodes. Damage is typically greatest in warm regions with light, sandy soils. Nematode-infested plants may have reduced growth, lower yield and fruit quality, and tend to wilt earlier under moisture stress. *Meloidogyne spp.* can cause yield losses of over 30% in various vegetable crops (Netscher and Sikora, 1990). This agrees with the results of Miguel and Maroto (1996) who reported higher yields of the watermelon hybrid ‘Queen’ cultivar grafted onto ‘Shintoza’ rootstocks and grown in nematode-infested soils than for non-grafted plants grown in fumigated soils. The main advantages of ‘Shintoza’ as a rootstock have been reported by Lee and Oda (2003).

Data in Table (5) indicate that, in infested soil, grafting cucumber on *Lagenaria* rootstocks had the highest values of mean fruit weight , fruit length and fruit diameter, while the lowest values were detected with ungrafting (control) followed by grafting cucumber hybrid on *Cucumis metuliferus* and *Momordica charantia* rootstocks. Data in the same table indicate that there were significant differences between different grafting treatments and control in average fruit weight, length and diameter, total soluble solids and fruit dry matter percentage, while, no significant differences were detected in fruit shape index between the grafting treatments on other rootstocks and the nongrafted cucumber (control). That significant difference in fruit weight, length and diameter showed insignificant differences between all treatments in fruit shape index in both seasons. Grafting cucumber on Bottle gourd, Calabash gourd and Emphasis had a significant decrease in total soluble solids (TSS) which had (3.33, 3.53 and 3.47) in the first season and (3.17, 3.30 and 3.17) in the second season, respectively. Similar results were detected in fruit dry matter percentage by grafting on *Lagenaria* rootstocks, in both seasons. Grafting cucumber on all rootstocks under study expect the *Lagenaria* rootstocks had great fruit dry matter percentage when compared with the control plants, while *Lagenaria* rootstocks gave the lowest value in fruit dry matter percentage compared with other rootstocks and the control. The use of rootstocks could increase the fruit yield of cucumber (Zhu *et al*., 2008), and our previous studies suggested that grafting (rootstock) has no significant effect on fruit dry matter and soluble sugar content of cucumber under unstressed conditions (Zhong and Bie, 2007). Both nematode species (*Meloidogyne javanica* or *M. incognita* race 2) reduced fruit yield, which was more evident when *M. javanica* was inoculated. Grafted and non grafted plants were susceptible, because they enabled the multiplication of nematodes, with a reproduction factor, at 72 days after inoculation, ranging from 3.57 to 15.04, with the highest value in cucumber nongrafted inoculated with *M. javanica* (Salata, *et. al.,* 2012).

Table 5

Grafted watermelon plants flowered about 10 days earlier and showed more vigorous vegetative growth than the control plants. Grafted plants had up to 148% higher fresh weights than control plants. Similarly, grafted plants showed 42–180% higher dry weight, 58–100% more leaves and larger leaf area as compared with the control. In total yield, *Lagenaria* type rootstocks produced a higher yield. While control plants gave a lower yield, *Lagenaria* type rootstocks produced 27–106% higher yield than the control (Yetisir and Sari 2003).

Data in Table (6) indicate that, all rootstocks except *Cucumis metuliferus* were susceptible to root-knot nematodes, (*M. incognita*) that were obvious in nematode characters under study such as numbers of galls, egg-masses and eggs per root system and gall index or egg masses index that were detected in both seasons. Where, it was very resistant and highly resistant in the first season and very resistant in the second one according to gall index and egg masses index parameters, respectively. Generally, data show that, grafting can improve tolerance to root-knot nematodes, it has been demonstrated that many common rootstocks (both *Lagenaria* gourds, *Cucurbita moschata*, *Cucurbita ficifolia* interspecific Cucurbita hybrids and *Momordica charatia*) are completely susceptible, but provide tolerance by having an extensive root system as recorded by (Giannakou and Karpouzas, 2003). Such tolerance should be used with caution since these rootstocks may allow a buildup of nematodes that could potentially infect succeeding crops. However, there is evidence that some rootstocks have genetic resistance that can be utilized to improve rootstock nematode resistance (Davis, *et al*., 2008).

Grafting susceptible melons on *C. metuliferus* rootstocks also reduced levels of root galling, prevented shoot weight losses, and resulted in significantly lower nematode levels at harvest. Thus, *C. metuliferus* may be used as a rootstock for melon to prevent both growth reduction and a strong nematode build-up in *M. incognita-* infesting soil (Sigüenza *et al*., 2005).

The African horned cucumber is highly resistant to root-knot nematodes. Norton and Granberry (1980) reported that *C. metuliferus* was highly resistant to the root-knot nematodes (*M. incognita, M. arenaria*, and *M. javanica*). Wehner *et al.* (1991) found that, *C. sativus*'Sumter' was more susceptible than *C. metuliferus* to *M. incognita*, *M. arenaria*، and *M. javanica*. Other Cucumis species, including *C. anguria* L., *C.ficifolius* A. Rich., *C. longipes* Hook., and *C. heptadactylus* Naud،. are resistant to M*eloidgyne spp.* (Fassuliotis, 1967). Resistance to root-knot nematodes was found in *C. metuliferus*, but attempts to incorporate this resistance into *C. melo* have not been successful (Granberry and Norton 1980). *Cucumis metuliferus* and hybrids of *C. melo* and *C. metuliferus* have proven to be good candidates for root-knot nematode resistant rootstocks suitable for grafting onto commercial muskmelon cultivars (Sigũenza *et al*., 2005). Attempts to incorporate this nematode resistance into *C. melo* using traditional plant breeding approaches have not been successful (Chen and Adelberg, 2000). Kokalis-Burelle and Rosskopf (2011) recorded that, in muskmelon trials, only *C. metuliferus* rootstock reduced galling in nematode infested soil. Under cold stress conditions in 2009, inoculation with nematodes negatively impacted almost all growth and disease parameters measured, increasing disease and reducing plant growth. Tetsukabuto (*Cucurbita maxima* × *C. moschata*) did not reduce numbers of second stage juveniles of *M. incognita* either soil or roots in either year of the study, and should not be considered as a good rootstock for fields infested with *M. incognita*. *C. metuliferus* provided a higher level of resistance to nematode population development and galling than the other tested rootstocks. Finding alternative rootstocks for nematode control is an important area of research and burr and African horned cucumbers (*Cucumis metuliferus* E. Meyer ex Naudin) are considered promising (Igarashi *et al*., 1987). Grafting reduced nematode gall formation in cucumber (Giannakou and Karpouzas,

Table 6

2003), watermelon (Miguel *et al.*, 2004), and melon fields (Sigüenza *et al.*, 2005). In some cases, the rootstocks appear to provide tolerance by providing extensive root area and vigor (Miguel *et al.*, 2004), but some rootstocks have genetic resistance that is exhibited in the grafted plants (Sigüenza *et al.*, 2005).

Rootstocks of *C. maxima* × *C. moschata* have become the most used hybrids for several watermelon, melon and cucumber cultivars, because of their properties related to the resistance or high tolerance to *F. oxysporum* f. sp. melonis, *F. oxysporum* f. sp. niveum, *Phomopsis* sp., *M. cannonballus*, *Verticillium dahliae*, MNSV and Nematodes (Tello and Camacho, 2010). *Cucumis metuliferus* is highly resistant to *M. hapla*, *M. incognita*, *M. javanica* and *M. arenaria,* but the development of hybrids with *Cucumis* spp has failed. Resistance to *M. incognita* and *M. arenaria* was identified in *Cucumis anguria* and others wild cucurbits (Galatti, *et al.,* 2013).

The mechanism of resistance in *Cucumis metuliferus* PI 482454 to root-knot nematode may be due to reducing the development into later stage (J3s and J4s) of nematode life cycle, whereas in *C. metuliferus* PI 482454, high numbers of J2s for all root-knot nematodes were observed with few developing into later stages (J3s or J4s). The reasons for the reduced detection of J3 or J4 stages could be J2 death or emigration from roots. Although giant cells develop after root-knot nematode penetration in resistant *C. metuliferus* roots, resistance is most likely associated with feeding site development as the giant cells in resistant roots tended to be elongated in shape. These sites probably result in abnormal nematode development as these parasites depend on the nutrient supply from fully developed giant cells to complete their life cycle (Walters *et al.*, 2006).

Conclusion

From the mentioned results it can be concluded that:

1. Grafting is a good method for reducing the great losses causes by soil born disease especially root knot nematode in cucumber.
2. For managing root knot nematode, it is necessary for this aim, to select the wild material followed by evaluating it and breeding the immunity, resistant or tolerant rootstocks
3. There is no resistant varieties for nematodes and fumigation by methyl bromide and different nematicides are expensive, change the soil environment and unfriendly with sustainable agriculture in addition to the dangerous effects on the environment, animal and human. So grafting is one of the best methods to control diseases.
4. Eleven evaluated rootstocks showed different degrees of tolerant to nematodes, some of these rootstocks are local varieties.
5. Horned cucumber *Cucumis metuliferus* was highly resistant for nematode than other rootstocks under study and it must be used as a rootstock with highly infested soil for reducing the number of initial population, whereas *C. metuliferus* reduced the life cycle development however it gave a lower yield compared with the other rootstocks under study.
6. Grafted cucumber gave higher, vegetative growth, early yield, total yield, and marketable yield than ungrafted plants.
7. The studies recommend grafting cucumber that will be grown in highly infested soils with root knot nematode (*M. incognita*) soil.

REFERENCES

Al-Debei, H. S., I. Makhadmeh, I. Abu-Al-Ruz, A. M. Al-Abdallat, J. Y. Ayad and N. Al-Amin (2012). Influence of different rootstocks on growth and yield of cucumber (*Cucumis sativus* L.) under the impact of soil-borne pathogens in Jordan. Journal of Food, Agriculture and Environment. 10(2): 1: 343-349

Association of Official Analytical Chemists (1975). Official Methods of Analysis of the Association of Official Agriculture Chemists. 12^{th} Ed. Published By the

A.O.A.C., Washington, D.C., U.S.A, 870pp.

Cansev, A. and M. Ozgur (2010). Grafting cucumber seedlings on *Cucurbita spp.*: Comparison of different grafting methods, scions and their performance. J. Food, Agriculture and Environment, 8 (3/4) – 2: 804-809.

Chen, J. F. and J. Adelberg (2000). Interspecific hybridization in Cucumis-progress, problems, and perspectives. HortScience 35:11-15

Cohen, R., Y. Burger, C. Horev, A. Koren and M. Edelstein (2007). Introducing grafted cucurbits to modern agriculture. The Israeli experience. Plant Disease 91: 916-923

Davis, R.F. (2007). Effect of *Meloidogyne incognita* on watermelon yield. Nematropica 37: 287-293.

Eisenback, J. D. and D.J. Hunt (2009). General Morphology. pp 18- 55. In Root-knot Nematodes (Eds R.N. Perry, M. Moens and J.L. Starr). ISBN-13: 978 1 84593 492 7. Pp 531

Fassuliotis, G. (1967). Species of Cucumis resistant to the root-knot nematode, *Meloidogyne incognita* acrita. Plant Disease Report. 51:720-723.

Fassuliotis, G. (1982). Plant resistance to root-knot nematodes, p. 31-49. In: R.D. Riggs (Ed.(. Nematology in the southern region of the United States. Arkansas Agr. Expt. Sta., Fayetteville، South. Coop. Serv. Bul. 276.

FengMing, Y., Y. LiYing, L. YuYan and L. YanChun (2002). The physiological influence on grafted watermelon of different stocks. Journal of Hebei Vocation Technical Teachers College 16(4): 34-36. Cited from CAB Abstract, International Standard Serial Number: (462-0316).

Galatti, F. de S., A. J. Franco, L. A. Ito, H. de O. Charlo, L. A. Gaion and L. T. Braz (2013). Rootstocks resistant to *Meloidogyne incognita* and compatibility of grafting in net melon. Revista Ceres. 60 (3): 432-436.

Giannakou, I.O. and D.G. Karpouzas (2003). Evaluation of chemical and integrated strategies as alternatives to methyl bromide for the control of root-knot nematodes in Greece. Pest Management Science 59: 883-892.

Gomez, K.A. and A.A. Gomez (1984). Statistical Procedures for Agricultural Research, p: 680. Wiley, New York, USA

Granberry, D. M. and J. D. Norton (1980). Response of progeny from interspecific cross of *Cucumis melo x C. metuliferus* to *Meloidogyne incognita* acrita. J. the American Society for Horticultural Science. 105 (2): 180-183.

Granges, A. and A. Leger (1996). Essai comparatif de plants de tomates greffes a une ou deux tetes et de desinfection du sol a la vapeur en serre. Revue Suisse de Viticulture, d'Arboriculture et d'Horticulture 28: 389–392,(C.F. Luc, M. Sikora R.A. and Bridge J. (2005)).

Hadisoeganda, W.W. and J.N. Sasser (1982). Resistance of tomato, bean, southern pea and garden pea cultivars to root-knot nematodes based on host suitability. Plant Disease. 66 (2):145-150.

Huang, Y., Z.L. Bie, S.P. He, B. Hua, A. Zhen and Z.X. Liu (2010). Improving cucumber tolerance to major nutrients induced salinity by grafting onto *Cucurbita ficifolia*. Environ. Journal of Experimental Botany. 69:32–38.

Huang, Y., Z.L. Bie, Z.X. Liu, A. Zhen and W.J. Wang (2009). Protective role of proline against salt stress is partially related to the improvement of water status and peroxidase enzyme activity in cucumber. Soil Science and Plant Nutrition. 55: 698–704.

Hussey, R.S. and K.R. Barker (1973). A comparison of methods of collecting inocula of *Meloidogyne* species, including a new technique. Plant Disease Reporter 42: 865-872.

Igarashi, I., T. Kano and T. Kawabe (1987). Disease and pest resistance of wild Cucumis species and their compatibility as rootstock for melon, cucumber and watermelon. Bull. Natl. Res. Inst. Veg. Ornam. Plants and Tea Japan. A1: 173–185. (Cited in Kubota, *et al.*, 2008).

Ishibashi, K. (1965). Tongue-approach grafting in cucurbits. Agr. Hort. 40: 1899–1902. (In Japanese)(C.F. Davis *et al.*, 2008)

Khah, E. M., N. Katsoulas, M. Tchamitchian and C. Kittas (2011). Effect of grafting on eggplant leaf gas exchanges under Mediterranean greenhouse conditions. International Journal of Plant Production. 5(2): 121-134

King, S. R., A. R. Davis, B. LaMolinare, D.W. Liu and A. Levi (2008). Grafting for Disease resistance. Hort Science. 43(6):1673-1376.

Kofoid, C.A. and W.A. White (1919). A new nematode infection of man. Journal of the American Medical Association 72, 567–569,(C.F. Perry, R. N., Moens, M. and Starr, J. L.(2009) pp531. ISBN-13: 978 1 84593 492 7).

Kokalis-Burelle, N. and E. N. Rosskopf (2011). Microplot Evaluation of Rootstocks for Control of *Meloidogyne incognita* on Grafted Tomato, Muskmelon, and Watermelon. J. Nematology 43(3–4):166–171.

Kubota, C., M. A. McClure, N. Kokalis-Burelle, M. G. Bausher and E. N. Rosskopf (2008). Vegetable grafting: History, use and current technology status in North America. HortScience 43(6): 1664-1669.

Lee, J.M. and M. Oda (2003). Grafting of herbaceous vegetable and ornamental crops. Horticultural Reviews. John Wiley and Sons, New York, NY. 28, 61–124.

Luc, M., R.A. Sikora and J. Bridge (2005). Plant Parasitic Nematodes in Subtropical and Tropical Agriculture, 2nd Edition, CAB International. ISBN 0 85199 727 9.

Miguel, A. and J. V. Maroto (1996). El injerto herba´ceo en la sand´ıa (*Citrullus lanatus*) como alternativa a la desinfeccio´ n qu´ımica del suelo. Investigacio´ n Agraria. Produccio´ n y Proteccio´ n Vegetales 11: 239–253 (C.F. Miguel *et al*., 2004).

Miguel, A., J. V. Maroto, A. San Bautista, C. Baixauli, V. Cebolla, B. Pascual, S. Lo´pez-Galarza and J. L. Guardiola (2004). The grafting of triploid watermelon is an advantageous alternative to soil fumigation by methyl bromide for control of fusarium wilt. Scientia Horticulturae,103 (1): 9-17.

Nagakura, K. (1930). Über den Bau und die lebensgeschichte der Heterodera radicicola (Greeff) Müller. Japanese Journal of Zoology 3, 95–160,(C.F. Perry, R. N., Moens, M. and Starr, J. L.(2009) pp531. ISBN-13: 978 1 84593 492 7).

Neal, J.C. (1889). The Root-knot Disease of the Peach, Orange and Other Plants in Florida, Due to the Work of Anguillula. Bulletin 20, Division of Entomology, US Department of Agriculture,(C.F. Perry, R. N., Moens, M. and Starr, J. L.(2009)).

Norton, J. D. and D. M. Granberry (1980). Characteristics of progeny from an interspecific cross *of Cucumis melo* with *C. metuliferus*. Journal of the American Society for Horticultural Science 105:174.–180.

Netscher, C. and R.A. Sikora (1990). Nematode parasites of vegetables. In: Luc, M., Sikora, R.A. and Bridge, J .(2005). Plant Parasitic Nematodes in Subtropical and Tropical Agriculture. CAB International, Wallingford, UK، pp. 237–283.

Oda, M. (1999). Grafting of vegetables to improve greenhouse production. Extension Bulletin Food and Fertilizer Technology Center No. 480, 11pp.

Özarslandan, A., M. A. Söğüt, H. Yetişir and İ. H. Elekcioğlu (2011). Screening of bottle gourds (*Lagenaria siceraria* (Molina) Standley) genotypes with rootstock potential for watermelon production for resistance against *Meloidogyne incognita* (Kofoid & White, 1919) Chitwood and *Meloidogyne javanica* (Treub, 1885) Chitwood. Türkiye Entomoloji Dergisi. 35 (4): 687-697.

Perry, R. N., M. Moens and J. L. Starr (2009). Root-knot Nematodes. CAB International. ISBN-13: 978 1 84593 492 7. 531p

Ricàrdez-Salinas, M., M.V. Huitr n-Ramírez, J.C. Tello-Marquinac and F. Camacho-Ferrec (2010). Planting density for grafted melon as an alternative to methyl bromide use in Mexico. Scientia Horticulturae 126:2 236–241.

Sakata, Y., T. Ohara and M. Sugiyama (2008). The history of melon and cucumber grafting in Japan. Acta Horticulturae. 767:217–228.

Salam, M. A., A. S. M. H. Masum, S. S. Chowdhury, M. Dhar, M. A. Saddeque and M. R. Islam (2002). Growth and yield of watermelon as influenced by grafting. OnLine J. Biological Sciences, 2 (5): 298-299.

Salata, A. C., E. V. Bertolini, F. O. Magro, A. Cardoso and S. R. S. Wilcken (2012). Effect of grafting on cucumber production and reproduction of *Meloidogyne javanica* and *M. incognita*. Horticultura Brasileira. 30(4):590-594. ISSN 0102-0536.

Sigüenza, C., M. Schochow, T. Turini and A. Ploeg (2005) . Use of *Cucumis metuliferus* as a rootstock for melon to manage *Meloidogyne incognita*. Journal of Nematology 37: 276–280.

St. Amand, P.C. and T.C. Wehner (1991). Crop loss to 14 diseases in cucumber in North Carolina for 1983 to 1988. Cucurbit Genetics Cooperative Report. 14:15-17.

Taylor, A.L. and J.N. Sasser (1978). Biology, identification andcontrol of root-knot nematodes (*Meloidogyne* ssp.) international *Meloidogyne* project Publication, North Carolina State Univ., Raleigh, 111pp

Tello, J.C. and F. Camacho (2010). Organismos para el control de patógenos en los cultivos protegidos, practicas culturales para una agricultura sostenible. Fundación Cajamar, Almeria, Spain (C.F. Ricàrdez-Salinas, *et al.,* 2010)

Thies, J. A. and R. L. Fery (2002). Host plant resistance as an alternative to methyl bromide for managing *Meloidogyne incognita* in pepper. Journal of Nematology 34:374–377.

Thies, J. A., J.J. Ariss, R.L. Hassell, C. S. Kousik, S. Olson and A. Levi (2010). Grafting for Managing Southern Root-Knot Nematode, *Meloidogyne incognita*, in Watermelon. Plant Disease 94:1195–1199.

Treub, M. (1885). Onderzoekingen over Sereh-Ziek Suikkeriet gedaan in s Lands Plantentium te Buitenzorg. Mededeelingen uit's Lands Plantentium, Batavia, 2, 1–39,(C.F. Perry, R. N., Moens, M. and Starr, J. L.(2009) pp531. ISBN-13: 978 1 84593 492 7.).

Viglierchio, D. R. and R. V. Schmitt (1983). On the Methodology of Nematode Extraction from Field Samples: Baermann Funnel Modifications. Journal of Nematology 15(3):438-444.

Walters, S. A. and T. C. Wehner (1997). 'Lucia', 'Manteo', and 'Shelby' root-knot nematode-resistant cucumber inbred lines. HortScience 32: 1301-1303.

Walters, S. A., T. C. Wehner, M. E. Daykin and K. R. Barker (2006). Penetration rates of root-knot nematodes into *Cucumis sativus* and *C. metuliferus* roots and subsequent histological changes. Nematropica 36:231-242.

Wehner, T.C., S.A. Walters and K.R. Barker (1991). Resistance to root-knot nematode in cucumber and homed cucumber. Supplement to Journal of Nematology., 23 (4S):611-614.

Wilcken, S. R. S., J. M. O. Rosa, A. R. O. Higuti, M. J. de M. Garcia and A. I. I. Cardoso (2010). Reproduction of *Meloidogyne spp.* in rootstocks and cucumber hybrids. Horticultura Brasileira. 28 (1): 120-123. ISSN 0102-0536.

Yadava, I.L. (1986). A rapid and nondestructive method to determine chlorophyll in intact leaves. HortScience, 21: 1449.

Yetisir, H. and N. Sari (2003). Effect of different rootstock on plant growth, yield and quality of watermelon. Australian Journal of Experimental Agriculture, 43:1269-1274.

Zhang ShengPing, Gu XingFang and Wang Ye (2006). Effect of bur cucumber (*Sicyos angulatus* L.) as rootstock on growth physiology and stress resistance of cucumber plants. Acta Horticulturae Sinica . 33 (6): 1231-1236.

ZhenDe, C., W. PeiSheng, Z. Ying, J. YuLing, W. ZongJun and L. Ping (2012). Effects of rootstock grafting on yield, quality and control of *Meloidogyne incognita* of cucumber (*Cucumis sativus* L.). China Vegetables, 8: 57-62.

Zhong, Y.Q. and Z.L. Bie (2007). Effects of grafting on the growth and quality of cucumber fruits. Acta Horticulturae. 761, 341–347.

Zhu, J., Z.L. Bie, Y. Huang and X.X. Han (2008). Effect of grafting on the growth and ion concentrations of cucumber seedlings under NaCl stress. Soil Science and Plant Nutrition. 54, 895–902.

Zijlstra, S., S. P. C. Groot and J. Jansen (1994). Genotypic variation of rootstocks for growth and production in cucumber: possibilities for improving the root system by plant breeding. Scientia Horticulturae, 56: 185-196.

تطعيم الخيار على بعض الاصول لمكافحة نيماتودا تعقد الجذور

أحمد عبد الهادي سيد عبد الوهاب الاسلامبولي(١) ، أحمد عبد المحسن احمد دعبس(٢)

(١) قسم بحوث انتاج الخضر تحت ظروف جوية معدلة– معهد بحوث البساتين–مركز البحوث الزراعية

(٢) قسم بحوث المبيدات الفطرية والبكتيرية و النيماتودية– المعمل المركزي للمبيدات– مركز البحوث الزراعية

الملخص العربي

الخيار (*Cucumis sativus* L) هو واحد من محاصيل الخضر الهامة التي تزرع في مصر . الخيار حساس جدا للاصابة بنيماتودا تعقد الجذور . نيماتودا تعقد الجذور (*Meloidogyne spp.*) تسبب خسائر اقتصادية عالية في العديد من المحاصيل الزراعية في جميع أنحاء العالم . النيماتودا تسبب أضرارا بالغة علي نباتات الخيار، لا يوجد اصناف خيار مقاومة لنيماتودا تعقد الجذور. التطعيم واحد من التقنيات الفعالة والمبتكرة للسيطرة على نيماتودا تعقد الجذور. النباتات المطعومة علي اصول مقاومة للنيماتودا والامراض ذات قيمة تجارية عالية. تطعيم الخضر على اصول مقاومة أو ليست عائل مفضل للنيماتودا والمسببات المرضية تحد من الضرر الناجم عن الأمراض التي تنتقل عن طريق التربة وهو وسيلة فعالة للغاية. ولذلك هدفت تلك الدراسة الي تقييم ١١ تركيب وراثي للمقاومة لنيماتودا تعقد الجذور والتوافق مع الخيار. أجريت هذه الدراسة خلال الموسمين ٢٠١١ و ٢٠١٢ في مزرعة خاصة بمنطقة موبؤة بنيماتودا تعقد الجذور في قرية القطا بمحافظة الجيزة، مصر. أحدي عشر معاملة تطعيم بالاضافة الى الكنترول (الخيار الغير مطعوم) في تصميم القطاعات كاملة العشوائية في ثلاث مكررات. تم تطعيم هجين الخيار لاما على ثلاثة اصول من اليقطين (Lagenaria siceraria) وهي Bottle gourd و Calabash gourdو الهجينEmphasis والقرع العسلي (*Cucurbita moschata*) و الفسيفوليا *Cucurbita ficifolia* (Bouché)، واربعة من الهجن النوعية (*Cucurbita maxima × Cucurbita moschata*) وهي شينتوزا و سوبر شينتوزا و إركولي ٦٠٠١ و فيرو RZ F1 و بلسم الكمثرى (*Momordica charantia*) والخيار الافريقي (*Cucumis metuliferus*) باستخدام طريقة التطعيم اللساني.

أظهرت النتائج أن جميع الاصول أظهرت مستويات عالية من التوافق مع الخيار. كل معاملات التطعيم اعطت زيادة كبيرة في النمو الخضري والمحصول بالمقارنة مع الكنترول. اصل الخيار الافريقي(*Cucumis metuliferus*) فقط يمكن اعتباره مقاوما للنيماتودا، مع ذلك، أعطى التطعيم علي هذا الاصل محصول اقل مقارنة مع باقي الاصول تحت الدراسة. ويمكن اعتبار باقي الاصول تحت الدراسة اصول متحملة لنيماتودا تعقد الجذور. ادي التطعيم علي اصول Lagenaria الي زيادة كبيرة في طول النبات و طول السلاميات ووزن الثمرة و المحصول الكلي ولكن المحصول التسويقي كان اقل عن المحصول التسويقي الناتج عن التطعيم علي الاصول التابعة للهجين النوعي (*Cucurbita maxima × Cucurbita moschata*) في الموسم الأول. في كلا الموسمين أدى التطعيم علي اصول Lagenaria إلى نقص في المادة الجافة ومحتوى المواد الصلبة الذائبة الكلية و تقليل عدد الفروع و المحصول المبكر مقارنة مع الاصول الاخرى المختبرة. أعطى التطعيم علي الهجن النوعية

زيادة كبيرة في النمو الخضري والمحصول وصفات جودة الثمار و المحصول التسويقي بالاخص الخيار المطعوم علي اصل سوبر شينتوزا ويليها المطعوم علي الاصل إركولي ٦٠٠١.

القرع العسلي *Cucurbita moschata* يمكن اعتباره متوسط التحمل لنيماتودا تعقد الجذور وكذا التوافق مع الخيار ومن ناحية تأثيرها على النمو الخضري والمحصول و صفات الجودة للثمار . أعطى التطعيم علي اصل البلسم انخفاض في معدل البقاء بالمقارنة مع جميع الاصول قيد الدراسة . اعطي الكنترول هجين الخيار لاما بدون تطعيم القيم الأدنى في معظم الصفات من نمو خضري وانتاجية وخصائص الثمار.

اعطي الخيار المطعوم علي اصل الفسيفوليا (*Cucurbita ficifolia* Bouché) زيادة كبيرة في معظم صفات النمو الخضري و المحصول المبكر و الكلي و صفات جودة الثمار بالمقارنة مع الخيار غير المطعوم(الكنترول).

Table 2. Effect of grafting cucumber Lama hybrid on eleven rootstocks on vegetative growth under infested soil with root knot nematodes, in 2011 and 2012 seasons.

Treatments		2011						2012					
		Plant length Cm	Number		Stem diameter mm	Internodes length Cm	Leaf area cm^2	Plant length cm	Number		Stem diameter mm	Internodes length cm	Leaf area cm^2
			Branch	Leaves					Branch	Leaves			
Control		124.00	5.00	64.33	17.00	7.50	177.33	129.00	5.87	69.33	16.67	9.67	164.00
Lagenaria	Bottle gourd	202.33	7.42	130.00	22.33	15.33	221.33	209.33	7.70	143.67	22.33	16.00	206.67
	Calabash gourd	205.33	7.45	128.33	22.33	15.67	224.33	217.67	7.38	134.67	22.33	15.00	209.33
	Emphasis	195.67	7.33	131.67	21.67	15.67	224.33	211.00	7.63	134.33	22.00	15.67	211.33
Cucurbita	Moschata	155.33	8.87	126.00	26.33	11.67	254.00	161.33	8.62	127.33	25.67	11.67	223.00
	Ficifolia Bouché	171.00	8.33	136.33	26.33	12.67	265.67	168.67	9.45	132.00	26.00	12.00	234.00
	Shintosa	163.00	12.03	166.00	29.33	13.00	281.33	172.00	12.13	175.00	29.67	13.00	263.00
	Ercole Nun 6001	166.00	12.17	165.00	30.67	11.67	272.67	176.00	12.27	178.00	27.33	10.33	265.67
	Ferro RZ F1	163.33	12.63	168.67	30.67	11.67	275.67	171.00	12.47	172.33	28.67	10.67	263.67
	Super Shintosa	166.33	12.43	166.33	31.00	12.00	274.00	169.00	12.63	173.33	28.33	12.00	270.67
Momordica charantia		163.33	7.67	119.67	22.33	9.83	198.00	159.33	8.10	116.33	23.00	10.83	199.00
Cucumis metuliferus		168.67	8.10	126.67	24.67	10.00	207.00	165.67	8.17	131.00	23.00	10.40	202.67
LSD at $t_{0.05}$		11.22	0.48	5.8٩	2.68	1.56	15.9٥	13.64	0.45	9.02	2.72	1.62	10.08

Table 4. Effect of grafting cucumber Lama hybrid on eleven rootstocks on yield characters under infested soil with root knot nematodes in 2011 and 2012 seasons.

	Treatments	2011								2012							
		Number of fruit		Total yield		Early yield/plant		Marketable yield ton/feddan	Unmarketable yield %	Number of fruit		Total yield		Early yield/plant		Marketable yield ton/feddan	Unmarketable yield %
		Plant	Feddan	Plant Kg	Feddan ton	Number	Weight Kg			Plant	Feddan	Plant kg	Feddan ton	Number	Weight kg		
Control		11.68	81746	1.062	7.44	2.57	0.23	7.04	5.38	12.02	84149	1.090	7.63	2.87	0.26	7.20	5.64
Lagenaria	Bottle gourd	14.73	103119	1.689	11.83	3.20	0.37	11.08	6.34	15.04	105247	1.734	12.14	3.70	0.43	11.44	5.77
	Calabash gourd	14.70	102872	1.704	11.93	3.33	0.39	11.17	6.37	14.97	104790	1.712	11.98	3.83	0.44	11.28	5.84
	Emphasis	14.84	103857	1.740	12.19	3.13	0.37	11.38	6.64	15.42	107931	1.778	12.45	3.83	0.44	11.57	7.07
Cucurbita	Moschata	16.49	115416	1.538	10.77	4.33	0.41	10.19	5.39	16.16	113101	1.540	10.78	4.43	0.42	10.21	5.29
	Ficifolia Bouché	16.99	118907	1.711	11.98	4.37	0.44	11.43	4.59	17.43	122043	1.708	11.96	4.43	0.43	11.42	4.52
	Shintosa	17.36	121543	1.659	11.62	4.57	0.44	11.07	4.73	17.32	121221	1.610	11.27	5.10	0.48	10.82	4.00
	Ercole Nun 6001	18.15	127045	1.717	12.02	5.13	0.48	11.43	4.91	18.40	128800	1.729	12.10	5.73	0.54	11.58	4.30
	RZ	18.16	127092	1.707	11.95	5.17	0.49	11.42	4.44	18.22	127531	1.706	11.95	6.00	0.56	11.46	4.10
	Super Shintosa	18.42	128945	1.718	12.03	5.43	0.51	11.52	4.24	18.33	128303	1.766	12.36	5.70	0.55	11.82	4.37
Momordica charantia		15.62	109368	1.438	10.07	4.03	0.37	9.61	4.57	15.75	110283	1.460	10.22	4.57	0.42	9.75	4.60
Cucumis metuliferus		15.71	110003	1.471	10.30	3.97	0.37	9.82	4.66	16.06	112373	1.477	10.34	5.07	0.47	9.89	4.35
LSD at $t_{0.05}$		0.993	6956	0.112	0.786	0.43	0.05	0.75	0.60	0.580	4070	0.076	0.535	0.43	0.05	0.54	0.55

Table 5. Effect of grafting cucumber Lama hybrid on eleven rootstocks on fruit characters under infested soil with root knot nematodes in 2011 and 2012 seasons.

Treatments		2011						2012					
		Fruit weight	Fruit		Fruit shape index	TSS	Fruit dry matter %	Fruit weight	Fruit		Fruit shape index	TSS	Fruit dry matter %
			Length	Diameter					Length	Diameter			
	Control	91.00	14.10	2.63	5.36	4.37	4.30	90.67	14.30	2.60	5.50	4.23	4.50
Lagenaria	Bottle gourd	114.67	15.90	3.33	4.78	3.20	3.90	115.33	15.33	3.37	4.56	3.17	3.70
	Calabash gourd	116.00	15.47	3.53	4.39	3.30	3.70	114.33	15.23	3.43	4.44	3.30	3.70
	Emphasis	117.33	15.73	3.47	4.55	3.17	3.60	115.33	14.70	3.50	4.20	3.17	3.50
Cucurbita	Moschata	93.33	13.73	1.93	5.28	4.63	4.20	95.33	15.17	2.60	5.84	4.40	4.20
	Ficifolia Bouché	100.67	13.77	2.93	4.70	4.57	4.40	98.00	14.93	2.80	5.37	4.87	4.40
	Shintosa	95.67	14.20	2.87	5.03	4.73	4.50	93.00	15.43	2.47	6.26	4.77	4.70
	Ercole Nun 6001	94.67	13.60	2.57	5.30	5.00	4.60	94.00	14.53	2.70	5.39	4.77	4.70
	RZ	94.00	13.80	2.60	5.32	4.73	4.60	93.67	14.60	2.53	5.79	5.00	4.6
	Super Shintosa	93.33	13.63	2.47	5.53	5.07	4.50	96.33	14.53	2.80	5.21	4.97	4.60
Momordica charantia		92.00	13.50	2.63	5.08	4.23	4.30	92.67	14.27	2.57	5.56	4.17	4.40
Cucumis metuliferus		93.67	13.20	2.53	5.22	4.20	4.50	92.00	14.50	2.40	6.05	4.23	4.40
LSD at $t_{0.05}$		3.68	0.67	0.52	NS	0.37	0. 17	3.18	0.6٩	0.18	NS	0.25	0.22

Table 6. Effect of grafting cucumber Lama hybrid on eleven rootstocks on number of nematode galls, egg masses, eggs and number of eggs per root system under infested soil with root- knot nematodes in 2011 and 2012 seasons.

Treatments		2011						2012					
		Galls/ Root system	No. Egg masse/ Root system	Average Number of Eggs/An eggmass	Eggs/ Root system	G.I./E.I.	Host category	Galls/ Root system	No. Egg masse Root system	Average Number of Eggs/An eggmass	Eggs/ Root system	G.I./E.I.	Host category
Control		363	221	401	88621	5/5	S/S	389	237	387	91719	5/5	S/S
Lagenaria	Bottle	218	138	367	50646	5/5	S/S	258	166	375	62250	5/5	S/S
	Calabash	238	154	362	55748	5/5	S/S	244	184	367	67528	5/5	S/S
	Emphasis	211	131	371	48601	5/5	S/S	236	173	397	68681	5/5	S/S
Cucurbita	Moschata	312	244	418	101992	5/5	S/S	338	252	421	106092	5/5	S/S
	Ficifolia	278	236	411	96996	5/5	S/S	299	229	398	91142	5/5	S/S
	Shintosa	286	252	431	108612	5/5	S/S	332	238	418	99484	5/5	S/S
	Nun 6001	265	222	394	87468	5/5	S/S	276	234	387	90558	5/5	S/S
	Ferro RZ F1	278	212	398	84376	5/5	S/S	288	229	412	94348	5/5	S/S
	S. Shintosa	238	165	389	64185	5/5	S/S	263	177	398	70446	5/5	S/S
Momordica charantia		245	167	383	63961	5/5	S/S	252	189	393	74277	5/5	S/S
Cucumis metuliferus		8	0.0	0.0	0.0	0/0	VR/HR	0.0	0.0	0.0	0	0/0	HR/HR
LSD at $t_{0.05}$		43.5	17.9	11.4	1121.8	-	-	58	26	14.5	1143.9	-	-