EFFECT OF GRAFTING CUCUMBER ONTO DIFFERENT ROOTSTOCKS ON VEGETATIVE GROWTH AND YIELD UNDER PLASTIC TUNNELS

Etman A.*; F. El-Aidy*; N. Hassan*; H. El-Dowany and Manal A. Abd-Alla****

*Dept. of Hort., Faculty of Agriculture, Tanta Univ., Kafr El-Sheikh
**Hort. Res. Institute, Ministry of Agriculture, Cairo

ABSTRACT

Grafting has become popular especially in fruit bearing vegetables grown in greenhouses. Grafted seedlings are used commonly in commercial vegetable culture in many countries.

The experiment was conducted in the experimental farm of the Faculty of Agriculture, Kafr El-Sheikh, during the winter seasons of 1998/1999 and 1999/2000, on cucumber plants cv "Nile F1". Seedlings were grafted onto Squash, Pumpkin 1, Pumpkin 2, Bottel gourd, Fig leaf gourd, NCSU cucumber sumter rootstocks, and without grafting as control, under plastic tunnels.

The results indicated that grafting cucumber onto Fig leaf gourd (*Cucurbita ficifolia*) mostly increased vegetative growth and growth attribute values.

The highest values in early and total fruit yield/m^2 were obtained from Fig leaf gourd as rootstock. The increment in the total fruit yield varied between 86-102% than the control.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is a favorite vegetable crop in Egypt. It is used as a salad and pickle. It occupied about 4931 and 4886 hectare in winter season of 1999 and 2000, which yielded 97232 and 76968 tons, respectively.

Within the last years, cucumber has become the main crop in greenhouses in Egypt, due to the higher production and monetary returns. Cucumber is a warm season vegetable. The best growth is obtained at temperatures between 18^0C and 24^0C. The faster growth and higher yield are resulted during the spring, compared to those plants sown during the cold months (Benzioni et al., 1991). In Egypt, cucumber production under such conditions is usually low, hence, more expensive.

There are some problems which may face cucumber production in plastic greenhouses such as soil borne diseases, soil salinity, and excessive low temperature in winter even under plastic cover.

Grafting has many benefits to plants grown in greenhouses, such as increasing tolerance to low temperature (Liebig, 1984), tolerance to soil salinity (Matsubara, 1989), and resistance to soil borne diseases (Oda, 1995). Grafted seedlings therefore, are used commonly in commercial vegetable culture in some countries such as Korea and Japan, both in outdoor and in greenhouses, (Kurata, 1994).

MATERALS AND METHODS

The experiment was carried out in the Experimental Farm of the Faculty of Agriculture, Kafr EL-Sheikh, Tanta university, using cucumber (*Cucumis sativus* L.), cv Nile hybrid plants, during the winter seasons of 1998/1999 and 1999/2000.

Tongue approach grafting method was used according to Wittwer and Honma (1979) and Yamakawa (1982) as follows:

Day(1): Hybrid cucumber seeds were sown into seedling trays under plastic.

Day(7): Rootstock seeds were sown into seedling trays under plastic.

Day(14-16): Grafting was performed. Rootstock and scion seedlings were taken off from the seedling trays. Downward (rootstock) and upward (scion) incision was made with a razor blade. The lips of the incision were placed into each other and clipped. After grafting, the plants were potted together under plastic and shade netting.

Day(16-20): Plastic cover was displaced daily for some hours, but the shade net was kept over the plants.

Day(21) : The top of the rootstock was cut.

Day(28:(Seedlings of grafted plants were transplanted under plastic.

Day(35:(Plants were vertically fixed with a robe to the horizontal wires. Then, the lower part of cucumber hybrid plant (scion) was cut below grafting position .

Treatments used

The experiment included 7 treatments. Cucumber, cv Nile hybrid, seedlings were grafted onto different rootstocks. They could be illustrated as follows:

- Cucumber onto Squash.....(*Cucurbita pepo*)
- Cucumber onto Pumpkin 1.....(*Cucurbita moschata*)
- Cucumber onto Pumpkin 2.....(*Cucurbita maxima*)

- Cucumber onto Bottle gourd.....(*Lagenaria siceraria*)
- Cucumber onto Fig leaf gourd.....(*Cucurbita ficifolia*)
- Cucumber onto NCSU cucumber sumter
- Cucumber seedling without grafting.(Control)

Cucumber, Nile hybrid, seeds were sown on October 13th in the first season and October 3rd in the second one. Seedlings were transplanted under plastic on November 10th (first season) and November 2nd (second season).

Data recorded

Vegetative growth characters were recorded at 45, 60, and 75 days after transplanting. Samples of 5 plants were randomly chosen from each experimental unit to determine the following characters: stem length (cm), plant leaf area (cm^2) and fresh weight of leaves.

Growth attribute characters as Crop Growth Rate (CGR), Relative Growth Rate (RGR) and Net Assimilation Rate (NAR) were determined using the dry weight of the shoot and leaf area per plant. They were determined in samples of 2 plants randomly chosen from each plot at the given dates.

Growth attributes were computed at two stages (6-8 and 8-10 weeks after transplanting) according to Watson (1952), Watson (1958), and Radford (1967).

Crop Growth Rate (CGR) was determined by the equation

$$CGR = W2\text{-}W_1/T_2\text{-}T_1$$

Relative Growth Rate (RGR) was determined by the equation

$$RGR = Log_e W_2 - Log_e W_1 / T2 - T1$$

Net Assimilation Rate (NAR) was determined by the equation

$$NAR = (W_2\text{-}W_1)(Log_e A_2 - Log_e A_1)/(A_2 - A_1)(T_2 - T_1)$$

Where: W1, A_1 and W_2, A_2 refer to dry weight and leaf area at the time T_1 and T_2 in weeks, respectively.

Data of fruit yield included early and total yield. Early fruit yield was determined as weight (Kg) and number of fruits per square meter. It was determined on base of yield of the first 4 pickings. Total fruit yield was determined as weight (Kg) and number of fruits per square meter of all pickings.

Fruit characteristics included average of fruit weight (g), length (cm), and total soluble solids percentage. Total soluble solids (TSS %) were determined in fruit juice by a hand refractometer according to A.O.A.C. (1965).

Fruit characteristics were determined in fruits picked in the same day (which its flowers were previously labeled at the same opening day).

Dry matter samples of the fifth leaf from the plant growing tip were dried at 70 °C. The crude dry materials were wet digested with sulphoric acid and hydrogen peroxide mixture as described by Koch and Mc Meeking (1924) to determine the following constituents:

-Total nitrogen: was determined in the digestion product using the micro Kjeldahl method (Piper, 1947).

-Total phosphorus: was colourimetrically estimated using a spectrophotometer at 650 µm (Murphy and Riely, 1962).

-Total potassium: was determined using a flame photometer as described by Jackson (1967).

Experimental design and statistical analysis:

The treatments were arranged in complete randomize block design with 3 replications. Data were tested by analysis of variance (Little and Hills, 1972). Duncan's multiple range test (DMRT) was used for the comparisons among treatments means (Duncan, 1955).

RESULTS AND DISCUSSION

The results are introduced to clarify the effect of grafting cucumber plants, onto 6 different rootstocks, in comparison with control (non-grafted cucumber).

Vegetative growth

Data on vegetative growth parameters are presented in Table (1) and Fig. (1). Concerning stem length, data show that plants grafted onto fig leaf gourd (*C. ficifolia*) and bottle gourd (*Lagenaria siceraria*) rootstocks had, in general, the highest values at the different growth stages (45, 60, and 75 days after transplanting) compared with the other rootstocks. On the other hand, cucumber plants without grafting (control) had the lowest values.

Concerning plant leaf area and leaves fresh weight, data indicate that plants grafted onto fig leaf gourd had the highest values at all growth stages in both seasons, followed by those grafted onto bottle gourd and NCSU cucumber sumter, while the lowest values were obtained from non-grafted cucumber (control).

It is clear from the above mentioned data that plants grafted onto all rootstocks had higher values for all vegetative growth parameters compared to control. This may be due to that grafted plants can absorb more water and nutrients than non-grafted plants (Masuda and Gomi, 1984). Also grafted plants

Table 1. Effect of grafting cucumber plants, onto different rootstocks, on vegetative growth parameters in 1998/1999 and 1999/2000 seasons.

Treatments (Rootstocks)	Stem length (cm)			Plant leaf area (cm^2)			Leaves fresh wt./plant (g)		
	Stages (days after transplanting)								
	45	60	75	45	60	75	45	60	75
	1998/1999 season								
- Squash	92.8 c	149.5 c	160.3 e	2393 d	2721 d	3033 d	79.4 c	112.4 e	119.8 d
- Pumpkin 1 (*C. moschata*)	95.3 c	151.0 c	161.8de	2232 f	2563 f	2893 f	78.3 cd	114.9 d	117.4 e
- Pumpkin 2 (*C. maxima*)	97.0 b	145.0 c	162.7 d	2339 e	2575 e	2900 e	76.5 d	112.1 e	114.7 f
-Bottle gourd	97.2 b	170.8 a	185.5 b	2658 b	2913 c	3710 b	86.5 b	134.0 b	150.7 b
-Fig leaf gourd	99.7 a	165.2 b	192.9 a	2780 a	3001 a	3970 a	88.9 a	138.5 a	163.7 a
-NCSU cucumber sumter	94.0 c	123.7 d	168.1 c	2503 c	2956 b	3572 c	86.2 b	129.9 c	145.9 c
-Non-grafted cucumber (control)	86.0 d	121.7 d	145.7 f	2011 g	2305 g	2588 g	67.2 e	96.4 f	104.8 g
	1999/2000 season								
- Squash	90.9 e	158.7 bc	165.7 d	2468 d	2693 d	3141 d	75.3 c	115.1 d	121.6 c
- Pumpkin 1 (*C. moschata*)	95.7 d	145.0 d	154.7 f	2070 f	2132 f	2658 f	72.7 c	105.1 f	111.6 e
- Pumpkin 2 (*C. maxima*)	98.7 c	155.7 c	160.5 e	2368 e	2467 e	3038 e	74.6 c	112.5 e	118.6 d
-Bottle gourd	97.7 c	173.3 a	187.7 a	2550 c	2881 c	4042 b	90.6 b	131.1 c	156.4 b
-Fig leaf gourd	104.3 b	162.7 b	180.0 b	2806 b	3055 b	4189 a	95.7 a	135.8 a	167.2 a
- NCSU cucumber sumter	106.8 a	137.9 e	179.4 c	2854 a	3472 a	3903 c	91.1 b	134.4 b	156.2 b
-Non-grafted cucumber (control)	82.3 f	131.7 f	149.8 g	1979 g	2099 g	2415 g	68.3 d	93.9 g	103.0 f

Means separation within columns and seasons by DMRT test. $P< 0.05$.

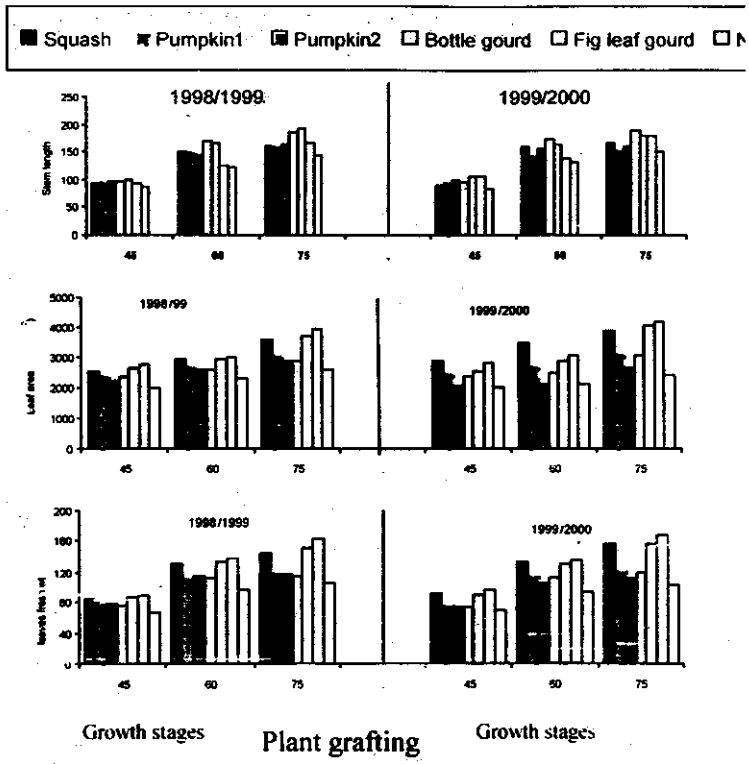

Fig. 1. Vegetative growth parameters of cucumber plants at different growth stages (45, 60 and 75 days after transplanting), as affected by plant grafting in 1998/1999 and 1999/2000

can grow better than non-grafted plants under high soil salinity (Matsubara, 1989), low soil temperature (Nijs et al., 1983) or soil borne disease existence (Lee, 1989). It is obvious from the data (Table 1) that fig leaf gourd (*C. ficifolia*) rootstock surpassed all other rootstocks in stimulating vegetative growth. This result coincided with that previously reported by Nijs (1980). Early work indicated that flow velocity of water transport per leaf area of grafted plants onto *C. ficifolia* was twice as high as that of non-grafted plants, indicating a higher activity of root system of the rootstock (Nijs et al., 1983 and Itai and Birnbaum, 1991).

Growth attributes

Data on growth attributes presented in Table (2) show that grafted plants onto fig leaf gourd had significantly the highest CGR compared to the other treatments at the two growth stages (6-8 and 8-10 weeks after transplanting) in both seasons. The lowest CGR values were obtained from grafted plants onto bottle gourd at the first stage in the first season and from the control treatment at the second stage in the first season and both stages in the second season.

Table 2. Effect of grafting cucumber plants, onto different rootstocks, on growth attributes at 2 stages[@] of vegetative growth in 1998/1999 and 1999/2000 seasons.

Treatments (Rootstocks)	Crop growth rate (g/m^2/week)		Relative growth rate (g/g/week)		Net assimilation rate (g/m^2/week)	
	Stage (week)					
	6-8	8-10	6-8	8-10	6-8	8-10
	1998/1999 season					
- Squash	5.36 b	10.63 e	0.150 bc	0.207 f	8.36 bc	14.81 f
- Pumpkin 1 (*C. moschata*)	4.13 d	10.86 e	0.117 d	0.129 e	6.83 d	16.10 e
- Pumpkin 2 (*C. maxima*)	3.88 e	15.34 d	0.111 d	0.291 c	6.22 d	22.48 c
-Bottle gourd	2.63 f	22.83 b	0.059 e	0.339 a	3.76 e	20.12 d
-Fig leaf gourd	8.75 a	26.57 a	0.172 a	0.317 b	12.13 a	30.70 a
- NCSU cucumber sumter	5.32 b	20.68 c	0.143 c	0.338 a	8.76 b	29.10 b
-Non-grafted cucumber (control)	4.26 c	9.38 e	0.155 b	0.231 d	7.84 c	15.38 f
	1999/2000 season					
- Squash	6.28 bc	16.60 c	0.158 c	0.270 c	9.88 c	22.77 c
- Pumpkin 1 (*C. moschata*)	5.18 d	8.95 e	0.155 c	0.190 d	9.65 cd	15.12 d
- Pumpkin 2 (*C. maxima*)	6.71 b	10.51 d	0.184 b	0.197 d	11.15 b	15.34 d
-Bottle gourd	6.02 c	25.66 a	0.138 d	0.353 a	8.82 d	29.85 a
-Fig leaf gourd	9.61 a	25.83 a	0.202 a	0.316 b	13.15 a	28.36 b
- NCSU cucumber sumter	6.30 bc	18.45 b	0.174 b	0.307 b	9.05 cd	23.01 c
-Non-grafted cucumber (control)	3.26 e	6.90 f	0.108 e	0.171 e	6.36 e	12.28 e

[@] Stages are defined as 2 successive periods of 2 weeks (as weeks after transplanting).
Means separation within columns and seasons by DMRT test, $p< 0.05$

Concerning, RGR and NAR, data show that, at the first stage of vegetative growth, grafted plants onto fig leaf gourd had the highest values compared to other treatments in both seasons. The lowest values were obtained from those grafted onto bottle gourd at the first season and non-grafted plants (control) in the second one. At the second stage, grafted plants onto fig leaf gourd and bottle gourd had the highest values compared to other treatments, while the lowest values were obtained from grafted plants onto squash rootstocks in the first season and non-grafted plants (control) in the second one. The differences were significant in most cases.

It is clear from the data that grafting cucumber onto fig leaf gourd mostly increased growth attributes values. This may be attributed to the increases in leaf area and leaves dry weight per plant at both growth stages. This response may also be due to that fig leaf gourd roots can absorb water and nutrients more efficiently than cucumber roots (Nijs et al., 1983 and Masuda and Gomi, 1984). This increase in absorption was correlated with the increased cytochrome respiration rate coupled with oxidative phosphorylation in the cytochrome system (Lee, 1994) and that positively affected the growth attributes.

Fruit yield

Data in Table (3) and Fig. (2) indicate that early fruit yield as weight and number of fruits per m^2 was significantly affected by grafting onto

different rootstocks. The highest values were obtained from grafted plants onto fig leaf gourd, followed mostly by those grafted onto NCSU cucumber sumter. On the other hand, the lowest values were obtained from control (non-grafted plants).

Table 3. Effect of grafting cucumber plants, onto different rootstocks, on fruit yield in 1998/1999 and 1999/2000 seasons.

Treatments (Rootstocks)	Early fruit yield		Total fruit yield	
	Wt. of fruit (Kg)	No. of Fruits	Wt. of fruit (Kg)	No. of Fruits
	1998/1999			
- Squash	0.569 c	6.38 c	3.77 c	41.83 c
- Pumpkin 1 (*C. moschata*)	0.312 de	3.57 f	3.25 de	36.08 d
- Pumpkin 2 (*C. maxima*)	0.377 d	4.40 e	3.66 cd	40.58 c
-Bottle gourd	0.512 c	5.44 d	4.79 b	47.92 b
-Fig leaf gourd	1.059 a	11.32 a	5.44 a	54.42 a
- NCSU cucumber sumter	0.70 b	9.3 b	2.78 f	34.8 d
-Non-grafted cucumber (control)	0.237 e	2.80 g	2.91 ef	33.56 d
	1999/2000			
- Squash	0.596 b	6.88 c	3.54 c	39.46 c
- Pumpkin 1 (*C. moschata*)	0.378 d	4.38 de	3.34 c	37.04 d
- Pumpkin 2 (*C. maxima*)	0.369 d	4.15 e	3.36 c	37.33 d
-Bottle gourd	0.464 c	4.88 d	4.69 b	46.80 b
-Fig leaf gourd	0.975 a	10.20 a	5.27 a	50.13 a
- NCSU cucumber sumter	0.579 a	7.60 b	2.81 d	34.20 e
-Non-grafted cucumber (control)	0.284 e	3.35 f	2.60 d	32.58 f

Means separation within columns and seasons by DMRT test, $p< 0.05$.

The increase in early fruit yield of grafted plants onto fig leaf gourd compared with other treatments may be attributed to the higher vegetative growth parameters (Table 1, Fig. 1) induced by such treatment.

Data in Table (3) and Fig. (3) show that total fruit yield as weight and number of fruits per m^2 was significantly affected by grafting onto different rootstocks. Grafted plants onto fig leaf gourd had the highest values in all cases. Grafted plants onto bottle gourd came in the second array among other treatments, while control (non-grafted cucumber) had mostly the lowest values in both seasons.

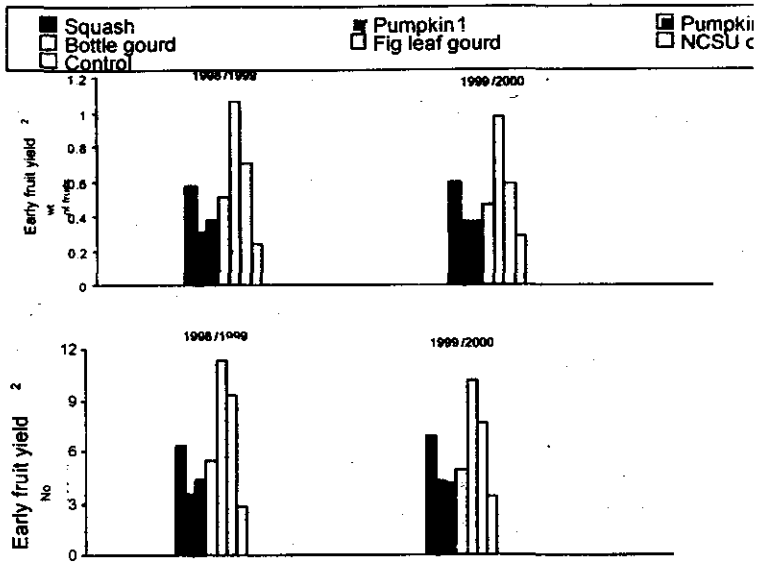

Fig. 2. Early fruit yield of cucumber plants as affected by grafting cucumber (onto different rootstocks) in 1998/1999 and 1999/2000 seasons.

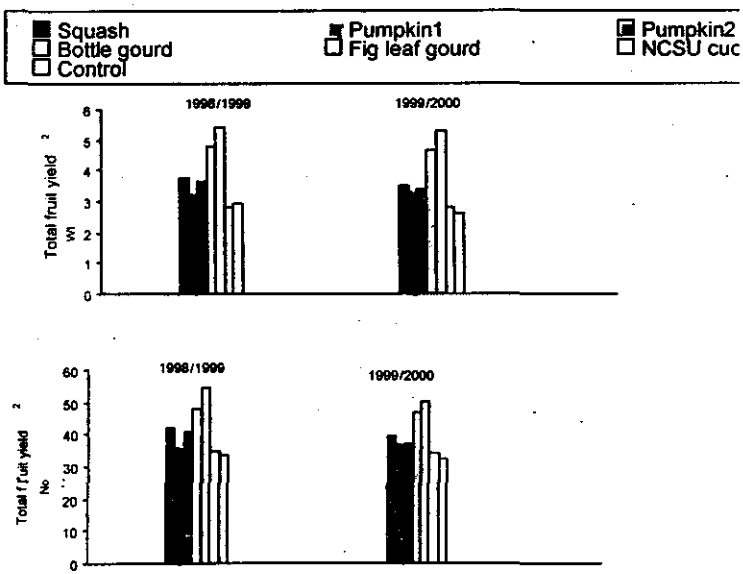

Fig. 3. Total fruit yield of cucumber plants as affected by grafting cucumber (onto different rootstocks) in 1998/1999 and 1999/2000 seasons.

Fruit characteristics

The increase in total yield in grafted cucumber plants onto fig leaf gourd is mainly due to the consequent higher vegetative growth (Table 1); also the increase of net assimilation rate (NAR) values which was a limiting factor to the yield (Watson, 1958). On the other hand, root death in cucumber at the onset of harvesting caused by competition for assimilates between fruits and roots could be prevented by grafting cucumber onto fig leaf gourd (Vlugt, 1986).

Data on fruit weight show that grafted plants onto bottle gourd had the highest values, followed by those grafted onto fig leaf gourd, while the lowest values were obtained from grafted plants onto NCSU cucumber sumter.

Concerning fruit length, grafted plants onto bottle gourd had significantly the highest values, followed by those grafted onto fig leaf gourd, while grafted plants onto pumpkin 1 (*C. moschata*) had the lowest values.

Table 4. Effect of grafting cucumber plants, onto different rootstocks, on fruit characteristics in1998/1999 and 1999/2000 seasons.

Treatments	Fruit characteristics			Some leaf chemical contents		
	Fruit weight (g)	Fruit Length (cm)	T.S.S (%)	N%	P%	K%
	1998/1999					
- Squash	88.7 c	12.3 bcd	7.5 a	3.56 cd	0.47 d	4.2 b
- Pumpkin 1 (*C. moschata*)	90.0 b	11.3 d	5.9 bc	3.40 e	0.53 c	5.2 a
- Pumpkin 2 (*C. maxima*)	88.6 c	12.7 abc	5.9 bc	3.45 de	0.55 c	3.5 c
-Bottle gourd	98.5 a	13.5 a	5.8 bc	3.78 b	0.68 a	4.3 b
-Fig leaf gourd	97.7 a	13.3 ab	6.0 b	4.17 a	0.63 b	5.7 a
- NCSU cucumber sumter	79.1 e	12.7 abc	4.7 d	3.60 c	0.61 b	5.6 a
-Non-grafted cucumber (control)	83.5 d	12.0 cd	5.7 c	3.33 e	0.43 e	4.5 b
	1999/2000					
- Squash	89.4 d	12.4 c	7.3 a	3.50 a	0.39 c	6.7 ab
- Pumpkin 1 (*C. moschata*)	90.8 c	11.3 e	5.8 bc	3.36 a	0.39 c	6.8 a
- Pumpkin 2 (*C. maxima*)	90.1 cd	12.7 bc	5.8 bc	3.50 b	0.38 c	5.5 d
-Bottle gourd	99.2 a	13.4 a	5.8 bc	3.70 ab	0.70 a	5.4 d
-Fig leaf gourd	97.3 b	13.2 ab	6.0 b	4.10 a	0.63 ab	6.2 c
- NCSU cucumber sumter	81.7 f	11.8 de	4.5 d	3.20 b	0.60 b	6.4 bc
-Non-grafted cucumber (control)	84.1 e	12.2 cd	5.8 c	3.40 b	0.35 c	4.0 e

Means separation within columns and seasons by DMRT test, $p< 0.05$.

Data on TSS% indicate that grafted plants onto squash had significantly the highest TSS% compared with other treatments, followed by those grafted onto fig leaf gourd. While the lowest values were obtained from grafted plants onto NCSU cucumber sumter.

The enhancement in fruit characteristics with different rootstocks may be due to the differences in the effectiveness of their root systems, or in the interaction between root and shoot (Nijs, 1980; Zijlstra et al., 1994); hence, that may lead to variable ability of mineral uptake.

Chemical analysis

Chemical analysis comprises the contents of nitrogen (N), phosphorus (P) and potassium (K) as percentage of leaves dry weight. Data are presented in Table (46).

Cucumber plants grafted onto fig leaf gourd had higher N% values followed by grafted plants onto bottle gourd. However the differences were not statistically significant in the second season.

Data on P indicate that plants grafted onto bottle gourd rootstock had significantly higher P content compared to the other treatments in both seasons. It was followed by those grafted onto fig leaf gourd, while non-grafted plants (control) had the lowest P content.

Concerning K%, data show that it was significantly affected by the rootstock treatments in both seasons, but no constant responses were found in the 2 seasons.

The higher values of mineral contents in grafted plants onto different rootstocks may be attributed to the vigorous root system of rootstocks which is often capable of absorbing water and nutrients such as N, P, K, Mg, Mn, and Cu more efficiently than cucumber roots (Nijs. 1984; Masuda and Gomi, 1984; Kim and Lee, 1989).

REFERENCES

A.O.A.C. 1965.Official methods of analysis, the association of official agricultural chemists. Washington D. C., 10 th ed U.S.A.

Benzioni, A., S. Mendlinger, M. Ventura, and S. Huyskens. 1991. Effect of sowing dates temperatures on germination, flowering and yield of *Cucumis metuliferus*. HortScience 26: 1051-1053.

Duncan, B.D. 1955. Multiple range and multiple F test. Biometrics 11:1-42

Itai, C. and H. Birnbaum. 1991. Synthesis of plant growth regulators by roots. In Y. waisel, A. Eshel, and U. Kafkati (Eds), Plant roots, The Hidden Healf. Marcel Dekker, New york, pp.163-178.

Jackson, M. L. 1967. Soil chemical analysis. Prentice Hall of India private Limited, New Delhi, P. 115.

Kim, SE. and JM. Lee. 1989. The effect of grafting and fertilizers on growth and mineral contents of leaves of cucumber (*Cucumis sativus* L.) Korean Soc. Hort., Sci. 7 : 46-47. [C.F. Hort. Abst. : 59-7413].

Koch F. C. and T. L. Mc Meeking .1924. The chemical analysis of food and food products. J. Amer. Chem. Soc., 46: 2066.

Kurata, K. 1994. Cultivation of grafted vegetables. II. Development of grafting robots in Japan. HortScience 29 (4):240-244.

Lee, J.M. 1989. On the cultivation of grafted plants of cucurbitaceous vegetables. J. Korean Soc. Hort. Sci., 30 (3):169-179.

Lee, J.M. 1994. Cultivation of grafted vegetables I. Current status, grafting methods, and benefits. HortScience 29 (4):235-239.

Liebig, H.P. 1984. Model of cucumber growth and yield I. Raising the crop under low temperature regimes. Acta Hort. 156:127-137.

Little, T. A. and F. J. Hills. 1972. Statistical methods in agriculture research. Univ. of Calif. Davis., p. 242.

Masuda, M. and K. Gomi. 1984. Mineral absorption and oxygen consumption in grafted and non-grafted cucumbers. J. Jap. Soc. Hort. Sci. 52 (4):414-419 [C.F. Hort. Abst. 55 : 06095].

Matsubara, S. 1989. Studies on salt tolerance of vegetables. III. Salt tolerance of rootstocks. Scientific Reports of Faculty of Agriculture, Okayama Univ. 73 : 17-25.

Murphy, J and J. P. Riely, 1962. A modified single solution method for determination of phosphate in natural waters. Anal. Chem. Acta. 27: 31-36.

Nijs, A. P. M. Den, 1980. The effect of grafting on growth and early production of cucumbers at low temperature. Acta. Hort. 118, : 57-63.

Nijs, A. P. M. Den. 1984. Rootstock scion interaction in the cucumber: Implications for cultivation and breeding. Acta. Hort.156:53-60.

Nijs, A. P. M. Den; A. S. H. Van, and J. E. A. Reinders. 1983. Water transport in cucumber plants measured by nuclear magnetic response. In efficiency in plant breeding. Proceeding of the 10th Congress of the European Association for Research on plant Breeding, Egucarpia, Wageningen, the Netherland, 19-24 June. [C.F. Pl. Breeding. Abst. 55 : 4881].

Oda, M. 1995. New grafting methods for fruit-bearing vegetables in Japan. Jap. Agric., Res. Quarterly, JARQ 29 : 187-194.

Piper, C. S. 1947. Soil and plant analysis. The university of Adelaide (Australia). Pp. 59-74.

Radford, P. J. 1967. Growth analysis formulae their use and abuse. Crop sci, 7:171-175.

Vlugt, J. 1986 . Root death in cucumber under different competitive conditions of the roots. Acta Hort. 178 : 121-127.

Watson, D. J. 1952. The physiological basis of variation in yield. Adv. Agron. 4:101-145.

Watson, D. J. 1958. The dependence of net assimilation rate on leaf area index. Annals of Botany, N. S. 22 : 37-54.

Wittwer, S. H. and S. Honma. 1979. Greenhouse tomatoes, lettuce and cucumbers. Michigan state Univ. press. Pp. 204-223.

Yamakawa, K. 1982. Use of rootstocks in solanaceous fruit-Vegetable production in Japan. Jap. Agric., Res. Quarterly, JARQ 15 (3) : 175-179.

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 Hort., 56 : 185-196.

الملخص العربي

أصبح إستخدام التطعيم شائعاً خاصة للخضر الثمريه الناميه تحت ظروف الزراعه المحميه ، و كما أصبح إستخدام الشتلات المطعمه شائع على النطاق التجارى فى عديد من البلاد.

أجريت تجربه على نباتات الخيار -صنف هجين نيل- خلال موسم الشتاء تحت الصوب البلاستيكية لموسمي ١٩٩٨/١٩٩٩و ١٩٩٩/٢٠٠٠ في مزرعة التجارب بكلية الزراعة بكفر الشيخ جامعة طنطا .

تم التطعيم على ٦ أصول لتطعيم الخيار وهي الكوسة، و قرع عسلي ١(C. moscata) ، و قرع عسلي٢ (C.maxima) ، و اليقطين و الفسفوليا وخيارNCSU ، مقارنة بالخيار بدون تطعيم (كنترول).

أدى التطعيم على اصل الفسيفوليا إلى زيادة النمو الخضرى والحصول على أعلى قيمة لكل الصفات المرتبطة بالنمو.

أنتجت النباتات المطعمة على الأصل فسيفوليا أعلى محصول مبكر و كلى للمتر المربع (مقدار بعدد و وزن الثمار). كما أدى لزياده المحصول الكلى زياده تتراوح بين ٨٦-١٠٢% مقارنة بالنباتات الغير مطعمه.