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THE ROLE OF GRAFTING IN IMPROVING THE PRODUCTIVITY OF CUCUMBER UNDER SALINE STRESS CONDITIONS

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ABSTRACT: A greenhouse experiment was carried out during 2017 and 2018 summer seasons at Desert Research Center farm, Ras Sudr, South Sinai. The aim of the experiments was to investigate the effect of different rootstocks and citric acid foliar spray on growth, yield and its components and net income as well as net income diffraction percentage and mineral composition of cucumber plant Safi (F1) hybrid. The foliar spray of citric acid was four concentrations (0, 200, 300 and 400 ppm) and the grafting treatments were check nongrafted, Safi (F1) grafted onto Shentoza or on Coplt rootstocks (*Cucurbita moschata* Duch.). Strip plot design was used where main plots were assigned for foliar spray and sub plots for grafting. Results showed that grafting increased plant growth, yield and its components, marketable yield, net income and net income diffraction percentage. The increasing was differing according to rootstock source. Grafting, also, increased leaf chlorophyll and fruit potassium and calcium content while sodium content was decreased. The highest values of all measured parameters were obtained, in general, with cucumber plants grafted onto Shentoza rootstock. As for citric acid effects, results indicated that its application increased all parameters except sodium content; the highest values were obtained with cucumber plants sprayed with citric acid at rate 400 ppm. As for the combination between grafting technic and citric acid concentration, the best growth and highest yield and its components were obtained with the cucumber plants grafted onto Shentoza rootstock combined with the highest concentration of citric acid. Also, leaf chlorophyll and potassium of fruits recorded the highest increases, whereas fruit calcium and sodium were not significantly affected.

Key words: Cucumber, grafting, citric acid, growth, yield, net income, net income diffraction %.

INTRODUCTION

Ras Sudr is one of the Egyptian cities located 29.5912^0 N 32.7184^0 E on Coast Suez Gulf at the South Sinai Governorate. It is a model of saline-affected land. Salinity is one of the constraints of producing vegetable crops. Greenhouse production is facing many challenges in these areas, especially cucumber crop with salinity in the soil or irrigation water.

Grafting of cucumber plants on desirable rootstocks is an effective method to decrease the harmful effects of biotic and abiotic stresses as well as improve vegetative growth, yield and fruit quality of cucumber **(Miao *et al.*, 2019)**. There are many researches showed that the grafting on varieties, strains, lines or hybrids rootstocks of *C. maxima*, *C. moschata*, *C. pepo*, *Lagenaria siceraria*, significantly increased cucumber growth characteristics, *i.e.* shoot length, number of leaves and branches per plant, leaf area and fresh and dry weight, as well as fruit yield and its components **(Heidari *et al.*, 2010; Marsic and Jakse, 2010; Moradipour *et al.*, 2010; Colla *et al.*, 2012; Liu *et al.*, 2012; Farhadi and Rezaie, 2014; Farhadia and Malek, 2015; Farhadi *et al.*, 2016; Velkov and Pevicharova, 2016 and Khodadadi and Aghabeigi 2017)**. Also, under saline conditions, **Huang *et al.*, (2011), Huang *et al.* (2013), Rouphael *et al.*, (2012), Suleiman *et al.* (2016), Xu *et al.* (2017), Soubeih *et al.* (2018) and Usanmaz and Abak, (2018)**, found that the use of salt tolerant pumpkin (*Cucurbita moschata Duch*.) rootstock can improve cucumber adaptation to salt stress leading to increase plant shoot dry mass, leaf area, number of secondary branches, number of female flowers, net photosynthetic rate and stomata conductance as well as number of fruits and total production compared to non-grafted plants. Moreover, grafting had a positive effect on yield and its components

through increasing salt tolerance and reducing sodium toxicity. Also, the grafting significantly increased net income and net income diffraction percent compared with non-grafting of cucumber plants under saline conditions **(Soubeih *et al.*, 2018).**

Citric acid plays an important role in plant metabolism and stress tolerance of crop plants which help plants to ameliorate the bad effect of stress **(Singh *et al*., 2010);** it is considered to be the most powerful organic anion to mobilize phosphorous in the soil **(Bolan *et al.*, 1994)** and protecting plant from injury which could result in prolonging the shelf life of plant cells and improving growth characters **(Rao *et al*., 2000).**

In wheat crop, citric or oxalic acid foliar sprays at rates of 0, 100 and 200 mg/l showed marked increases in growth parameters and improved grain nutritional values of the yielded grains. In addition to increasing the amount of IAA, GA_3 and cytokinins, DNA and RNA with decreases in ABA contents, MDA and H_2O_2 contents compared with untreated plants **(MervatSh and Orab, 2015). Jafari and Hadavi (2012)** revealed that plant vegetative parameters as well as tolerance to powdery mildew were improved by the combination of 0.3% citric acid and 0.1% malic acid. **El-Tohamy *et al*. (2013)** reported that foliar spray with citric acid reduced the harmful effect of drought in bean. As well as, foliar fertilization of two levels of citric acid (100 or 300 mg L-1) was investigated on flower, stem length, plant height, flower performance and yield indices of *Gazania*; plant height and peduncle length were significantly increased in all applied levels of citric acid compared to control treatment **(Talebi *et al.*, 2014)**. In Red globe grapevines, **Mohamed (2018)** showed that foliar application of citric acid (1000 ppm), macro-elements (0.5%) and micro-elements (0.1%) either alone or in combination among them had the best results in comparison with control.

The aim of this study was to use citric acid foliar spray to increase the tolerance of plants to salinity and improve growth characters and yield in grafted or non-grafted cucumber plants under saline stress conditions at Ras Sudr region.

MATERIALS AND METHODS

A greenhouse trial was conducted during the summer seasons of 2017 and 2018 at Ras Sudr Experiment Station of Desert Research Center, South Sinai Governorate, Egypt to study the effect of citric acid foliar spraying at four concentrations (0, 200, 300 and 400 ppm) on cucumber plants Safi (F1) hybrid as it is or as grafted on two pumpkin (*Cucurbita moschata Duch*.) rootstocks, the first was Shentoza, while the second was Coplt (F1) on vegetative growth, yield, fruit quality and mineral content under saline stress, the rootstock descripting is shown in Table (D). The grafting process was carried out on cucumber plants in a private nursery for vegetables by Techno Green Company in Berqash area, Giza governorate, by using tongue approach grafting method. This method was characterized by a uniform growth and higher success of grafted transplants **(El-Kersh *et al*., 2016).**

White thiram greenhouse (360 m^2, 9 m width and 40 m long) with 63% shading was prepared with soil tilling after sheep dung application (realized from Ras Sudr animals Farm Station) at rate of 2 m^3/greenhouse plus 20 Kg calcium super phosphate 15.5 P_2O_5 and 10 kg crude agricultural sulfur then irrigated two weeks before transplanting. After grafting success, the seedlings were transplanted on July 18th in the first and second seasons. The experimental area was 10.0 m^2 contained one row of 10.0 m length and 1.0 m width and the distance between transplants was 25 cm apart. Citric acid concentrations were prepared in laboratory by solving in ethyl alcohol then diluted by distilled water to the studied concentration. After seedling stand up (15 days from transplanting) citric acid was sprayed four times with 10 days interval.

The NPK fertilizers (20 Kg calcium super phosphate 15.5 P_2O_5 + 25 Kg ammonium sulfate 20.5% N +25 Kg potassium sulfate 48% K_2O) were divided to equal parts, every one was applied daily during the growing season through fertigation system started after two weeks of transplanting until the end plant life signs appeared. All agricultural practices including plant protection against weeds, diseases and pests were performed as recommended by the Ministry of Agriculture in Egypt for cucumber production. Random soil samples were taken at depth from 0 – 60 cm before planting for mechanical and chemical analysis according to **Piper (1950)** and the obtained data are presented in Tables (A and B). Well irrigation water was analyzed according to **Jackson (1973)**, its analysis is shown in Table (C).

Table A. Mechanical properties of the experimental soil at Ras Sudr station

Character	$CaCO_3$ %	Coarse sand (0.5- 1mm)	Fine sand (0.1– 0.25 mm)	Silt (0.002 - 0.05mm)	Total sand (0.1-1mm)	Clay < (0.002mm)	Class texture
	57.99	38.98	42.51	9.77	81.53	8.70	Sandy loam

Table B. Chemical analyses of the experimental soil at Ras Sudr station

Depth	pH	E.C(dS/m)	Cations				Anions			Available nutrients (mg Kg. $^{-1}$)			
			Ca^{++}	Mg^{++}	Na^{+}	CO_3	HCO_3^-	Cl^-	SO_4^-	N	P	K	Fe
0-30	7.8	8.82	25.2	5.7	57.8	0.0	6.2	61.9	26.4	26.2	5.2	51.5	4.3
30-60	7.9	7.50	17.3	4.2	42.9	0.0	3.8	50.2	23.7	18.6	3.6	35.4	3.6

Table C. Chemical analyses of average irrigation water at Ras Sudr Station

pH	EC (dS/m)	Total soluble salts (ppm)	Soluble Cations in mmoLcL-1				Soluble Anions in mmoLcL-1			
			K^+	Na^+	Mg^{++}	Ca^{++}	So_4^{--}	Cl^-	HCO_3^-	CO_3^{--}
8.10	7.03	4540	0.56	35.42	18.34	18.08	4.35	57.43	1.75	-

Table D. Rootstock description

Description	Rootstock	
	Coplt (F1) (64-19)	**Shintosa (F1)**
Classification	(*Cucurbita maxima* × *C. moschata*)	(*Cucurbita maxima* × *C. moschata*)
Source	Rijk Zwaan Seed Company	Sakata Seed Company
Tolerant	Dry climate zones	Both heat and cold
Tolerant to plant disease	---	Fusarium
Fruit quality	Good and earliness	Good and earliness

Data recorded during the two tested seasons

Stand percentage

After 15 days from transplanting, the remaining plants are counted in each treatment.

Vegetative growth measurements

Five plants were randomly taken from each experimental plot, after 60 days from transplanting., to estimate growth parameters, *i.e.* shoot length, number of leaves per plant, upper fourth leaf area fresh and dry weight were recorded.

Flowering and productivity period

Also, random five plants in every plot were marked to count number of female flowers per plant (No. ♀ FP^{-1}), fruit set percentage, number of days to first flower (NDFF), number of days to last flower (NDLF) and productivity period (Pp).

$$\text{Fruit set (\%)} = \frac{\text{Number of fruit/ plant}}{\text{Number of female flower/ plant}} \times 100$$

Pp = NDLF - NDFF

Fruit yield characteristics

Fresh fruit yield were harvested every three days to determine the following characters:

a. Number of fruits plant
b. Average fruit weight
c. Total yield
d. Marketable yield
e. Net income
f. Net income diffraction

Chemical analyzes

- Chlorophyll reading of fresh leaves at 60 days from transplanting was determined in upper fourth leaf using Minolta Chlorophyll Meter SPAD-502.
- Random five fruits from each experimental plot were taken and dried in oven at 70 ºC until stable weight then grinded to fine particles and potassium, calcium and sodium were measured using flame photometer according to **Hemingway (1956) and Irri (1976).**

Statistical Analysis

The experiment included two factors which were arranged in strip plot design with three replicates, foliar spray treatments were randomly distributed to occupy the main plots, while grafting treatments were within the sub plots. The results of both investigated seasons were tested for homogeneity for applying combined analysis. Statistical analyses of the obtained data which were analyzed according to **Thomas and Hills (1975)**.

RESULTS AND DISCUSSIONS

Growth characteristics

Data recorded in Table 1 indicated that stand percentage increased with using cucumber Safi (F1) grafted onto Shentoza rootstock when compared with their grafting onto Coplt or nongrafting plants. These results may be due to Shentoza rootstock is more tolerant to saline in soil or irrigation water at Ras Sudr region. These findings agree with those obtained by **Heidari *et al*. (2010), Marsic and Jakse, (2010), Moradipour *et al*. (2010), Huang *et al*. (2011) and Colla *et al*. (2012).**

Table 1. Effect of grafting on stand percent of cucumber transplants in 2017 and 2018 seasons

Transplants	First season	Second season
Safi/ Shentoza	98.042	96.49
Safi/ Coplt	92.875	91.18
Safi	88.325	86.03

Data presented in Table 2 showed that growth characteristics (shoot length, number of leaves, leaf area, fresh and dry weight) were significantly increased by using Shentoza rootstock and /or foliar spraying by citric acid at concentration of 400 ppm whether individual or in combination. As regard to grafting, Safi (F1) plants grafted onto Shentoza rootstock gave the highest value of growth characters compared to those non-grafted or grafted onto Coplt rootstock which recorded the lowest value. These results are in line with those **of Huang *et al.* (2011), Huang *et al.* (2013), Rouphael *et al.* (2012), Suleiman *et al.* (2016), Xu *et al.* (2017), Soubeih *et al.* (2018), Usanmaz, and Abak (2018) and Miao *et al.* (2019).** These results may be due to the Safi (F1) onto Shentoza rootstock is an effective method to decrease the harmful effects of biotic and abiotic stresses as well as improve vegetative growth of cucumber.

As for the foliar spraying by citric acid, the concentration of 400 ppm led to the highest significant increase in all tested growth parameters compared to other treatments. These results are in line with those of **Singh *et al*. (2010) and MervatSh and Orab (2015).**These results may be due to the role of citric acid in plant metabolism and stress tolerance which helps plants to ameliorate the bad effect of stress.

The combination between the studied factors indicated that Safi (F1) grafted onto Shentoza rootstock and sprayed with citric acid at rate 400 ppm produced the highest growth parameter values compared to other treatments. These results are agree with those found by **Heidari *et al.* (2010), Marsic and Jakse, (2010), Moradipour *et al.* (2010), Huang *et al.* (2011), Colla *et al.* (2012), Liu *et al.* (2012), Soubeih *et al*. (2018) and Miao *et al.* (2019).** These results may be due to the pumpkin is classified as moderate tolerant plants to salinity and their root biomass increase more than sensitive plants under these conditions. Also, its root have the ability to select the needed nutrients to absorb or may be the vacuole juice osmotic potential in root is more higher than the soil solution for this more beneficial nutrients is uptaken and in turn increased the metabolism through large leaf area.

It could be concluded that under Ras Sudr conditions (high calcium carbonate and salinity Table A and B) spraying citric acid at a concentration of 400 ppm and grafting on resistant rootstocks reduced the harmful effects of salinity on plant growth of cucumber plants**.**

Flowering and productivity period

Illustrated data in Table 3 showed that fruit set percentage, productivity period and their components (No. ♀ FP^{-1}, NDFF and NDLF) were significantly affected with the studied factors whether separate or in combination. The fruit set percentage was increased due to using grafting technic, where cucumber plants which were grafted onto Shentoza rootstock increased fruit set with 24.48 and 28.76% more than those grafted onto Coplt rootstock and control treatments, respectively. Also, it increased productivity period more than the same treatments with 21.71 and 86.39%, respectively. Our findings are in agreement with those of **Soubeih *et al*. (2018) and Miao *et al.* (2019).** These results may be due to the grafting technique can improve cucumber adaptation to salt stress which leading to increase number of female flowers, net photosynthetic rate and stomatal conductance as well as number of fruits and total production compared to non-grafted plants.

Table 2. Effect of grafting and citric acid foliar spraying on growth characters of cucumber plants (Combined analysis for 2017 and 2018 season)

Treatments		Shoot length (cm)	leaf Number plant^{-1}	Leaf area (cm^2)	Fresh weight g plant^{-1}	Dry weight g plant^{-1}
Effect of rootstock						
Safi		71.8	11.1	58.8	303.3	31.8
Safi/Shentoza		121.7	20.4	100.0	675.5	83.7
Safi/Coplt		100.9	16.2	82.7	493.4	53.5
LSD at 0.05		3.162	0.534	2.589	3.893	0.799
Effect of citric acid (ppm)						
0		85.7	14.1	71.1	475.2	51.7
200		90.7	14.7	75.2	483.8	53.5
300		102.8	16.5	83.8	495.4	58.1
400		113.3	18.4	91.8	508.6	62.0
LSD at 0.05		2.652	0.431	2.225	5.471	1.011
Effect of interactions						
Safi	**0**	63.2	10.2	52.4	292.7	28.7
	200	71.8	10.5	59.6	299.8	30.7
	300	74.7	10.9	61.1	308.1	33.3
	400	77.3	13.1	61.9	312.7	34.4
Safi/ Shentoza	**0**	110.8	18.6	91.9	653.6	77.2
	200	114.0	19.8	94.6	664.1	80.1
	300	122.1	20.7	97.7	683.6	86.3
	400	139.8	22.5	115.9	700.9	91.5
Safi/ Coplt	**0**	83.0	13.4	68.9	479.3	49.2
	200	86.3	13.9	71.5	487.5	49.8
	300	111.6	18.0	92.6	494.6	54.6
	400	122.7	19.7	97.7	512.2	60.2
LSD at 0.05		4.593	0.747	3.853	9.477	1.751

Table 3. Effect of grafting and citric acid foliar spraying on flowering and productivity period of cucumber plants (Combined analysis for 2017 and 2018 season)

Treatment		No. ♀ FP^{-1}	Fruit set %	NDFF	NDLF	Productivity period (Pp)
Effect of rootstock						
Safi		26.6	23.3	8.2	46.4	38.2
Safi/Shentoza		54.2	30.0	14.0	85.2	71.2
Safi/Coplt		57.0	24.1	11.6	70.1	58.5
LSD at 0.05		1.6	1.8	0.4	2.8	2.4
Effect of citric acid (ppm)						
0		36.6	24.2	9.9	58.6	48.7
200		41.2	25.3	10.5	62.7	52.2
300		49.2	26.5	11.7	71.5	59.8
400		56.7	27.3	12.8	76.1	63.3
LSD at 0.05		1.3	1.2	0.3	2.4	2.1
Effect of interactions						
Safi	**0**	21.7	21.6	7.3	39.9	32.6
	200	24.7	23.2	8.3	46.8	38.5
	300	26.7	24.2	8.5	49.3	40.8
	400	33.3	24.3	8.7	49.5	40.8
Safi/ Shentoza	**0**	46.4	28.0	12.9	79.6	66.7
	200	51.4	28.5	13.2	82.1	68.9
	300	55.4	30.8	13.7	85.1	71.4
	400	63.6	32.8	16.2	93.7	77.5
Safi/ Coplt	**0**	41.7	23.0	9.6	56.3	46.7
	200	47.5	24.1	10.0	59.0	49
	300	65.6	24.4	12.9	80.0	67.1
	400	73.2	24.8	13.7	85.2	71.5
LSD at 0.05		2.3	2.3	0.5	3.6	3.1

In this context, the foliar spraying of citric acid concentrations increased fruit set percentage, productivity period and their components gradually up to spraying with 400 ppm. The maximum values of fruit set percent and productivity period were 12.81 and 30.0 % over control treatments. Our results are in conformity with that obtained by **Jafari and Hadavi (2012) and MervatSh and Orab (2015).** These results may be due to the citric acid at the rate 400 ppm increases amount of IAA, GA_3 and cytokinins, DNA and RNA with decreases in ABA contents.

The combination treatments resulted in that the highest values of fruit set percnt productivity period and their components were produced from citric acid at concentration of 400 ppm when sprayed on cucumber Safi (F1) plants grafted onto Shentoza rootstock. These results agree with those reported by **Huang *et al.* (2011), Huang *et al.* (2013), Rouphael *et al.* (2012) and Suleiman *et al.* (2016).** These results may be due to that grafting technic reduced salinity harmful effect through reducing the accumulation of Na^+ catin in shoot (Table 5) in turn enhanced plant vital and increased flowers and fruit set.

Yield and its components

Data presented in Table 4 indicated that the grafting onto different types of rootstocks significantly increased number of fruits per plant, average fruit weight total as well as marketable yield and net income percentage. Grafting onto Shentoza rootstock was the best except the heaviest fruit weight was achieved from cucumber grafted onto Coplt rootstock. The maximum total and marketable yield increases were 156.4 and 150.0 %, respectively, above the values had gotten from non-grafted cucumber plants, while the increases were 48.04 and 87.7 % more than plants grafted on Coplt rootstock. Economically, the highest net income values were achieved from grafted plants compared with non-grafted plants. These results agree with those **Huang *et al.* (2011), Huang *et al.* (2013), Rouphael *et al.* (2012), Suleiman *et al.* (2016), Xu *et al.* (2017), Soubeih *et al.* (2018) and Usanmaz and Abak (2018)** who indicated that the use of salt tolerant pumpkin (*Cucurbita moschata Duch*.) rootstock can improve cucumber adaptation to salt stress leading to increase number of female flowers, net photosynthetic rate and stomatal conductance as well as number of fruits and total production compared to non-grafted plants.

Citric acid foliar spray plays an important role on yield, fruit quality, marketable yield and net income of cucumber by improving plant resistance to biotic and abiotic stresses. Foliar spray with citric acid the rate 400 ppm gave the highest total yield, marketable yield and net income compared to other treatment. **El-Tohamy *et al*. (2013)** reported similar results for yield and its components.

As for, the effect of the interaction treatments of grafting technic and the foliar spraying concentrations of citric acid the highest values of total yield, marketable yield, net income and net income diffraction percentage (Fig. 1) were obtained, generally, from cucumber plants grafted on Shentoza rootstock and sprayed with citric acid at the concentration of 400 ppm. The increases in such parameters were 283.6, 285.8, 283.8 and 286.5 %, respectively, than control treatment followed, in decreasing order, by plants grafted on the same rootstock and sprayed with acid at the concentration of 300 ppm. These finding may be due to enhancing growth (Table 2), chlorophyll of leaves (Table 5) and flower (Table 3) parameters which in turn increased yield and its components as well as marketable yield and net income and net income diffraction percentages. These results are in agree to those reported by **Jafari and Hadavi (2012), Suleiman *et al.* (2016), Xu *et al.* (2017), Soubeih *et al.* (2018) and Usanmaz and Abak (2018).**

Mineral content

Data reported in Table (5) indicated that there were significant positive effects for grafting treatments on total leaf chlorophyll, and fruit potassium, calcium and decreased sodium accumulation in cucumber fruit. The highest leaf total chlorophyll, potassium and calcium content, and the lowest sodium in fruits were obtained with the application of grafting cucumber plants onto Shentoza rootstock. These results were true in the two growing experimental seasons.

With respect to the effect of citric acid foliar spraying, data in Table (5) showed that the application of citric acid decreased Na accumulation and increased total leaf chlorophyll, as well as potassium and calcium contents of fruits.

The interaction between grafting treatments and citric acid concentrations indicated that the highest contents of total leaf chlorophyll and potassium in fruits were recorded from cucumber plants grafted on Shentoza rootstock and sprayed with citric acid at concentration of 400 ppm compared with control treatment. However, Ca and Na percents were not statistically affected, indicating that the two tested factors acted independendently on calcium and sodium values.

It can be concluded that cucumber productivity under saline condition could be improved by grafting technic using combatable tolerant rootstock and spraying with citric acid at concentration of 400 ppm.

Table 4. Effect of grafting and citric acid foliar spraying on yield and fruit quality of cucumber plant (Combined analysis for 2017 and 2018 season)

Treatment		Number of fruits plant	Average of fruit weight (g)	Total yield kg / m²	Marketable yield kg/m²	Net income £/ m²
Effect of rootstock						
Safi		2.7	46.0	2.58	2.32	9.3
Safi/Shentoza		5.4	58.2	6.41	5.80	23.1
Safi/Coplt		3.3	61.5	4.33	3.09	15.6
LSD at 0.05		0.1	1.0	0.07	0.06	0.2
Effect of citric acid (ppm)						
0		3.2	37.4	3.76	3.39	13.5
200		3.5	50.7	4.26	3.84	15.3
300		4.0	61.4	4.59	4.14	16.5
400		4.6	71.4	5.14	4.63	18.5
LSD at 0.05		0.1	1.3	0.08	0.07	0.3
Effect of interactions						
Safi	**0**	2.6	31.9	1.89	1.69	6.8
	200	2.7	46.9	2.52	2.27	9.1
	300	2.7	49.5	2.72	2.45	9.8
	400	2.9	55.7	3.18	2.86	11.5
Safi /Shentoza	**0**	4.0	34.3	5.71	5.14	20.6
	200	4.4	47.5	6.19	5.57	22.3
	300	5.9	66.6	6.49	5.84	23.4
	400	7.4	84.5	7.25	6.52	26.1
Safi/Coplt	**0**	3.1	46.0	3.70	3.33	13.3
	200	3.3	57.8	4.07	3.67	14.7
	300	3.3	68.0	4.57	4.11	16.4
	400	3.6	74.1	5.00	4.50	18.0
LSD at 0.05		0.2	2.2	0.14	0.13	0.5

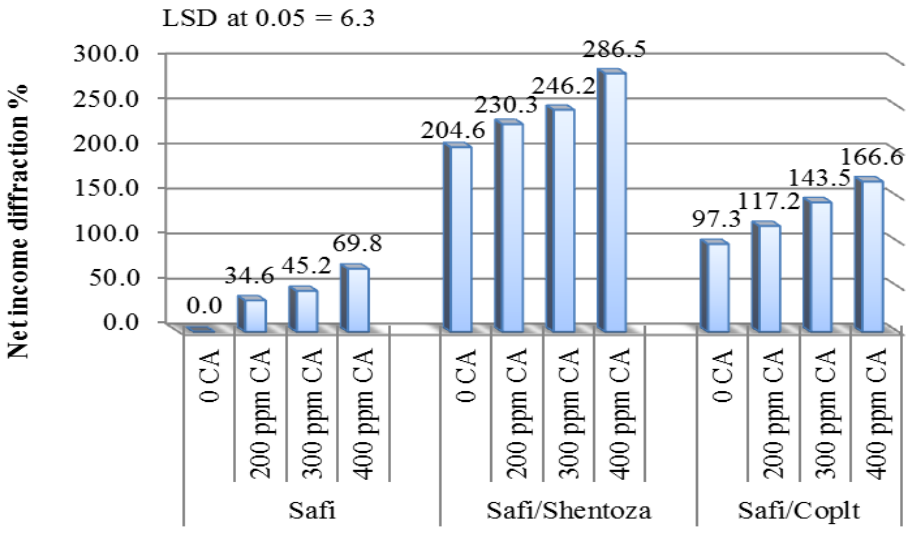

Fig. 1. Effect of grafting and citric acid foliar spraying on net income diffraction (%) of cucumber plant.

Table 5. Effect of grafting and citric acid foliar spray on total leaf chlorophyll, K, Ca and Na contents in fruits of cucumber plant (Combined analysis for 2017 and 2018 season)

Treatment		Total Chlorophyll mg/100g	%		
			K^+	Ca^{++}	Na^+
Effect of rootstock					
Safi		31.8	1.7	1.9	3.6
Safi/Shentoza		50.6	2.2	2.5	2.8
Safi/Coplt		44.1	2.4	2.2	3.4
LSD at 0.05		1.2	0.2	0.1	0.2
Effect of citric acid (ppm)					
0		37.7	2.1	1.9	3.4
200		40.2	2.0	2.1	3.3
300		43.5	2.1	2.3	3.2
400		47.3	2.2	2.5	3.1
LSD at 0.05		1.6	0.1	0.1	0.1
Effect of interactions					
Safi	**0**	29.9	1.5	1.7	3.7
	200	31.3	1.6	1.8	3.6
	300	32.6	1.7	1.9	3.5
	400	33.6	1.9	2.1	3.4
Safi /Shentoza	**0**	43.3	2.1	2.1	3.1
	200	46.7	2.0	2.5	2.9
	300	53.3	2.3	2.7	2.7
	400	58.9	2.6	2.8	2.6
Safi/Coplt	**0**	39.8	2.6	1.9	3.5
	200	42.7	2.4	2.1	3.4
	300	44.6	2.3	2.4	3.3
	400	49.3	2.2	2.6	3.2
LSD at 0.05		0.2	0.2	NS	NS

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