Zagazig J. Agric. Res., Vol. 51 No. (2) 2024 213-223

Plant Production Science

Available online at http://zjar.journals.ekb.eg
http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

UTILIZING OF DIFFERENT CUCURBIT ROOTSTOCKS AS A SUSTAINABLE ALTERNATIVE TO ENHANCE GROWTH, PRODUCTIVITY AND FRUIT QUALITY OF CUCUMBER

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Received: 31/03/2024; Accepted: 28/04/2024

ABSTRACT: Grafting is an effective and environmentally friendly method for combating the negative impacts of biotic and abiotic stressful conditions and increasing the productivity of vegetable crops. Our experiment was conducted for two seasons in net greenhouse during summer seasons of 2020 and 2021 at Vegetable Crops Department Farm, Faculty of Agriculture, Cairo University, Egypt. In our study, we investigated the effect of grafting cucumber onto eight rootstocks, which belong to four different species of cucurbits on plant growth, productivity and fruit quality characters. The experiment was performed using a randomized complete block design. The rootstocks included three accessions of squash (PEP 1635, PEP 1636 and PEP 1666), two accessions of pumpkin (PI526246 and PI599586), two accessions of bottle gourd (PI491347 and PI534556) and local cultivar of Luffa and compered with non-grafted cucumber (Hesham F_1). The performance of grafted cucumber scions varied according to the used rootstocks. Grafting process was applied by slant cut method which commercially used in cucurbits grafting, the highest survival rate was found for grafting onto bottle gourd rootstock PI491347 in both seasons (67.9% and 69.23%, respectively) while the lowest survival rate value was observed for grafting on squash rootstock PEP1636 in both seasons (37.5% and 31.21%, respectively). Comparing with performance of non-grafted plants, grafting on squash rootstocks PEP 1635, PEP 1636 and PEP 1661 and pumpkin rootstock PI599586 caused a significant enhancement in all most plant growth parameter (plant length, leaf area, internode length and SPAD value), fruit quality (average fruit weight, fruit length and fruit diameter), early and total fruit yield. Pumpkin rootstocks significantly decreased Leaf diffusion resistance and increased Transpiration ratio. Pumpkin PI599586 increased the macro elements (N, P, K, Ca, Mg) in scion leaves. Grafting hybrid cucumber (Hesham F_1) on squash rootstocks (PEP1635 and PEP1666) caused a significant enhancement in total yield/m^2.

Key words: Cucumber; fruit characters; rootstock; scion grafting and yield.

INTRODUCTION

Egypt is among the top twenty cucumbers and gherkins producers' countries, which globally ranked eleventh. Egypt produced 484424.68 tons, with gross production value about 181233000 USD (**FAOSTAT, 2024**). Cucumber (*Cucumis sativus* L.) is one of cucurbitaceous plants, which is affected by different abiotic factors such as soil salinity, water deficiency, and cold stress that negatively effect on the optimal growth conditions, in addition to numerous biotic agents *i.e.* fungus, nematode, bacteria and virus. Both biotic and abiotic stressful conditions cause severe yield loss and reduce quality of fruits (**Das *et al.*, 2022**). Cucumber plant is sensitive to diverse biotic stresses like powdery mildew, downy mildew, different viruses and soil-borne disease, which lead to huge economic losses (**Kaur and Sharma, 2022**). Cucumber is reported as salt sensitive plant, which can tolerate salinity level

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about 2.5 dS m^{-1}, but its productivity reduces by 13% as a result for each increased unit of electrical conductivity over the threshold value (**Chen *et al.*, 2018; Al-Momany and Abu-Romman, 2023**). Significantly reduction in stomatal conductance, transpiration, photosynthesis, intercellular CO_2 concentration, and leaf area in irrigation levels 60% ETc (crop evapotranspiration) and 40% ETc, with significant increment in relative leaf temperature compared to irrigation level 100% ETc (**Parkash *et al.*, 2021**). Grafting is an effective and environmentally friendly method for combating the negative impacts of climate changes and increasing the productivity of vegetable crops (**Khalid *et al.*, 2023**). Concerning biotic stresses, **Shalaby *et al.* (2022)** reported that using VSS-61 F_1 as rootstock enhanced the cucumber plant resistance for fusarium wilt and increased the total yield, **Hernández *et al.* (2021)** found that utilizing Forticuke F_1 and Lag 53 rootstocks which belongs to *Lagenaria siceraria* improved growth parameters i.e. plant length, number of leaves in addition to leaf area, also increased fruit firmness and fruit weight under infestation with *Meloidogyne incognita*. **Kousik *et al.* (2018)** confirmed that level of powdery mildew resistance in susceptible watermelon cultivar was clearly provided by using USVL482-PMR and USVL351-PMR which classified as bottle gourd rootstocks. Regarding abiotic stress, **Guo *et al.* (2023)** used Luffa rootstock to alleviate the negative effects for salinity on cucumber plants, which produced higher fresh weight associated with reduction in Na+ accumulation and enhanced potassium accumulation in shoots of cucumber seedlings, which grafted onto Luffa rootstock. Also, **Amerian *et al.* (2024)** confirmed that grafting cucumber onto pumpkin led to enhancement in salinity tolerance by decreasing sodium uptake and translocation to shoots. **El-Shraiy and Mostafa (2016)** used Shintosa supreme pumpkin rootstock to alleviate salt stress effects on cucumber plants cv. Falcon, which significantly enhanced plant vigor and productivity in addition to antioxidant enzymes activity, leaf pigments and proline. **Shehata *et al.* (2022)** enhanced cucumber tolerance to drought stress by using five tolerant rootstocks including two genotypes of squash Super Green and Just, two accessions of bottle gourd PI 491365 and PI 491352, in addition to watermelon cv. Colocynthoides, which significantly improved the agronomical traits and cucumber productivity. In relation to cucumber productivity and fruit quality improvement, **El-Sayed *et al.* (2021)** found that grafting cucumber cv. Vivasun onto squash 13 and squash 6 rootstocks led to clear increment in both early and total yield, in addition to fruit diameter. **Noor *et al.* (2021)** reported that using four cucurbit rootstocks included local cultivars of ridge gourd, bitter gourd, pumpkin and bottle gourd increased yield in cucumber plants cv. Kalaam F_1 and enhanced the fruit quality especially mineral contents in fruits i.e. N, P, K, Ca and Mg. Our study was carried out to investigate the effect of grafting cucumber onto eight rootstocks, which belong to four different species of cucurbits on growth, productivity and fruit quality characters.

MATERIALS AND METHODS

Location, Plant Materials and Growth Conditions

The experiment was conducted for two successive seasons in net greenhouse during summer seasons of 2020 and 2021 at Vegetable Crops Department Farm, Faculty of Agriculture, Cairo University, Egypt. Eight genotypes belong to four different species of cucurbits were used as rootstocks to study the influence of these rootstocks on cucumber growth, productivity and fruit quality characters and compered with "control" non-grafted cucumber.

The evaluated rootstocks included three accessions of *Cucurbita pepo* L (PEP 1635, PEP 1636 and PEP 1666), two accessions of *Cucurbita maxima (*PI526246 and PI599586), two accessions of *Legenaria siceraria* (PI491347 and PI534556) and local cultivar *of* Luffa (*Luffa aegyptiaca*). All genotypes except Luffa were self-propagated during the period from 15th September 2019 to the end of January 2020 in plastic greenhouse. Luffa was separately self-propagated before. The hybrid cucumber (Hesham F_1) was used as the scion. Seeds of all PIs accessions were kindly supported by the USDA, but the seeds of PEPs accessions were kindly supported by IPK-Gatersleben gene bank, Germany, while the local cultivar of Luffa provided by local source.

Grafting process was performed in private nursery under plastic greenhouse conditions. The compatibility test between rootstocks and the commercial cucumber cv. Hesham was carried out in first half of February. the seeds of rootstocks were sown during third week of February using (84 cells) Foam seedling-trays. Seeds of the commercial cucumber cultivar were sown week after the sowing date of rootstock seeds. Grafting process was performed manually during second week of March, slant cut grafting method was used at first true-leaf stage. Survival grafted cucumber plants, in addition to non-grafted cucumber were sown in net greenhouse in rows at a distance of 50cm between plants. Drip irrigation system was used. A completely randomized block design with 3 replicates was used. This experiment included 9 treatments. The experimental plot area was 5 m^2 (5 x 1m^2). Each plot contained 10 plants. The common agricultural practices were applied according to the Egyptian agricultural ministry.

Determination of Plant Growth, Yield and Fruit Quality Traits

Plant growth characters such as plant height and inter-node length were measured at 60 days after transplanting. The 6th leaf from meristem tip was used to determine the following traits. chlorophyll index was assessed by SPAD meter (SPAD 502 Minolta Co, Osaka, Japan), and leaf area was determined using leaf area meter (Biovis Leaf Av., Expert Vision Labs Pvt. Ltd., India), Leaf gas exchange characters such as leaf diffusion resistance and transpiration rate were determined in sun-exposed leaves by a portable photosynthesis system (Steady State Porometer, LI1600, LI-COR, Inc., Lincoln, Nebraska, USA). The weight of fruits in the first three pickings was estimated as early yield (kg/m^2), while total yield (kg/m^2) was assessed as total weight of fruits during the harvesting season. The fifth harvest was used to recorded fruit quality parameters such as weight, length, diameter and TSS% (by Zeiss laboratory refractometer).

Determination of Chemical Constituents

The modified "Micro Kjeldahl" apparatus of Parnas and Wagner was used to assess nitrogen content as method described by **Pregl (1945)**. Phosphorus was estimated using spectrophotometer by stannous chloride according to **AOAC (1975)**. Potassium was measured according to **Brown and Lilliland (1964)** using flame photometer. Atomic Absorption Spectrophotometer (Pye Unicam, model SP-1900, Cambridge, UK) was used to assess calcium (Ca) and magnesium according to according to **Helrich (1990)**. Fruit dry matter % was determined by drying 100 g of cucumber fruits in an oven at 70°C until constant weigh. Total sugars in cucumber fruits were measured according to **AOAC (1975)**.

Statistical Analysis

MSTAT-C v.2.1 software (Michigan State University, Michigan, USA) was used to perform the statistical analysis. Duncan's multiple range test was used to compare the means at the 0.05 level of probability (**Gomez and Gomez, 1984**).

RESULTS AND DISCUSSION

Effect of Grafting Process on Survival Plants

The results of survival rate between plants of cucumber cv. Hesham grafted onto different cucurbit rootstocks were presented in Table 1. Generally, the highest survival rate was found for grafting onto bottle gourd rootstock PI491347 in both seasons (67.9% and 69.23%, respectively) while the lowest survival rate value was recorded for grafting on squash rootstock PEP1636 in both season (37.5% and 31.21%, respectively). Bottle gourd rootstock PI534556 ranked second in both seasons, followed by Luffa in 2020 and pumpkin rootstock PI599586 in 2021. All squash rootstocks had the lowest survival rate.

The differences among the evaluated rootstocks in survival rate may be due to compatibility between cells of scion and cells of rootstocks. Suitable environmental condition should be provided to enhance callus formation at wounded place to increase grafting compatibility **(Lee *et al.*, 2010**). The compatibility between tissue of scion and tissue of rootstocks attributed to ability to vascular regeneration between them (**Tamilselvi and Pugalendhi, 2017**). The huge

Table 1. The effect of combinations between scion and rootstocks on survival plants rate during summer seasons of 2020 and 2021

Rootstock	No. of grafted plants	No. of survival plants	Survival plants %	No. of grafted plants	No. of survival plants	Survival plants %
	2020 season			2021 season		
PEP1635	78	31	39.74	118	44	37.28
PEP1636	80	30	37.5	112	35	31.25
PEP1666	82	33	40.24	115	41	35.65
PI526246	78	40	51.28	108	58	53.7
PI599586	81	49	60.49	113	73	64.6
Luffa	79	48	60.75	115	68	59.13
PI491347	81	55	67.9	117	81	69.23
PI534556	79	51	64.55	112	76	67.85

reduction in survival plant rate in squash rootstocks group may be due to the used grafting technique. splice technique increased survival plant rate for squash rootstock (*Cucurbita pepo* L.) than tongue, single cotyledon and hole insertion grafting techniques (**Noor *et al.*, 2019**). Similar results about compatibility between cucumber plant cv. Vivasun as scion and different cucurbit rootstocks. Squash rootstocks gave the lowest survival plant rate, while bottle gourd rootstocks had high survival plant rate (**El-Sayed *et al.*, 2021)**.

Effect of Grafting Process on Agronomic Traits

Data in Table 2 demonstrated the effects of different cucurbit rootstocks on agronomic parameters. Concerning plant height, squash rootstocks PEP1635 and PEP1666, pumpkin rootstock PI599586, and bottle gourd rootstock PI534556 showed had the highest significant plant height in 2020, while Luffa rootstock exhibited significant reduction in plant height than non-grafted cucumber plants in 2021. Regarding to internode length, pumpkin rootstock PI526246 in both seasons, in addition to pumpkin rootstock PI599586 and bottle gourd rootstock PI534556 in 2020 had the longest significant internodes. Concerning Leaf area, squash rootstock PEP1666, pumpkin rootstocks PI526246 and Luffa rootstock in both seasons, in addition to squash rootstocks PEP1635, PEP1636 and pumpkin rootstock PI599586 in second season had the largest Leaf area.

Enhanced plant vigor may be due to the strength roots of almost rootstocks. Similar results were recorded by **El-Sayed *et al.* (2014)** who tested 4 rootstocks included bottle Gourd, Supper Shintosa, Squash 3 and interspecific hybrid rootstock called Ferro' (*C. maxima* × *C. moschata*) compared with non-grafted cucumber in winter and found that significant increase in plant height over non-grafted control for all tested rootstocks. Similar results were founded by **Noor *et al.* (2019**) who compared between four cucurbit belongs to different cucurbitaceous species: *Luffa operculate* Cogn. (ridge gourd), *Momordica charantia* L. (bitter gourd), *Cucurbita pepo* L. (squash) and *Lagenaria siceraria* (bottle gourd) using four grafting techniques and compared with non-grafted cucumber plants. Rootstocks enhanced cucumber plant growth compared to non-grafted plants. Leaf area was significantly maximum when grafted onto *Lagenaria siceraria* rootstock followed by *Luffa operculate* Cogn., *Momordica charantia* L. and, *Cucurbita pepo* L. rootstock. **El-Sayed *et al.* (2021)** evaluated eight local hybrid rootstocks belongs to four different cucurbit species, and confirmed that grafting

Table 2. The effect of combinations between scion and rootstocks on plant growth traits at 60 days after transplanting during summer seasons of 2020 and 2021

Rootstocks	Plant height (cm)		Internodes length (cm)		Leaf area (cm^2)	
	2020	2021	2020	2021	2020	2021
PEP1635	182.9 ab	171.2 bc	6.7 bc	6.1 cd	31.66 cd	32.36 a
PEP1636	177.8 bc	190.3 a	6.8 bc	6.9 a-c	31.02 d	32.67 a
PEP1666	189.4 a	182.3 ab	6.2 cd	5.9 d	33.13 a-c	33.52 a
PI526246	172.7 cd	190.8 a	7.4 a	7.6 a	33.65 a	34.00 a
PI599586	188.1 a	176.2 bc	7.6 a	7.2 ab	31.88 b-d	32.55 a
Luffa	143.7 e	168.4 c	6.4 cd	7.3 ab	33.23 ab	34.55 a
PI491347	175.7 bc	190.4 a	6.2 cd	6.9 a-c	28.47 e	29.25 b
PI534556	180.6 a-c	193.1 a	7.3 ab	7.2 ab	27.00 f	28.38 b
Non-grafted	164.7 d	183.3 ab	6.0 d	6.5 b-d	24.21 g	24.80 c

[z]Mean values followed by a letter in common were not significantly different according to Duncan's multiple range test ($p < 0.05$).

onto two hybrids, namely squash 6 and squash 13 caused a significant increment in all characters of the plant growth such as plant height, length of inter-node and leaf area. Former studies interpreted the improvement of vegetative growth such as **Schwarz *et al.* (2010)** who explained that the enhanced vegetative growth is due to hormonal signals effects from the rootstock. Also, **Ceylan *et al.* (2018)** reported that micro and micro elements uptake were increased as grafting effects.

Effect of Different Rootstocks on SPAD Value and Some Physiological Characters

The present data in Table 3 clearly indicated that squash rootstocks PEP1666 in both seasons and PEP1635 in second season only had the highest SPAD value. All squash rootstocks significantly enhanced the SPAD vale in both years except PEP1636 in second year only, while there were not significant differences between non-grafted cucumber plants and other cucurbit rootstocks. Cucumber plants grafted onto pumpkin rootstocks PI599586 in both seasons and PI526246 in second season only recorded significant reduction in Leaf diffusion resistance. Pumpkin rootstocks PI599586 in both seasons and pumpkin rootstocks PI526246 in second season recorded the highest significant transpiration ratio, while other rootstocks did not significantly differ than non-grafted plants. Similar results were recorded by **El-Sayed *et al.* (2021)** who reported stomatal conductance value, respiration and photosynthesis in non-grafted cucumber plants were similar to those grafted onto *Legenaria siceraria* (Gourd 8), *Cucurbita maxima* (winter Squash 7) and *Cucumis zambianus* (wild cucumber). Also, **Hmmam *et al.* (2023)** found that the increment of leaf diffusion resistance led to the reduction in stomatal conductance and transpiration rate due to the nocturnal chilling periods and reduction in chlorophyll concentration due to the increment in leaf diffusion resistance, in addition to ROS accumulation in leaf, which cause degradation for chlorophyll.

Effect of Different Rootstocks on Nutrients in Cucumber Leaves

Data in Table 4 indicated that leaves of non-grafted cucumber and leaves of scion grafted onto pumpkin rootstocks PI526246 showed the lowest concentrations of N, K and Ca. Leaves of cucumber scion grafted onto squash rootstock PEP1636 in 2020, in addition to all squash rootstocks in 2021 recorded the highest value of N%. Leaves of cucumber scion grafted onto squash rootstock PEP1666 and pumpkin rootstocks PI599586 in both seasons, in addition to bottle gourd PI534556 in first season had the

Table 3. The effect of combinations between scion and rootstocks on SPAD value and some physiological characters at 60 days after transplanting during summer seasons of 2020 and 2021

Rootstocks	SPAD value		Leaf diffusion resistance ($s\ cm^{-1}$)		Transpiration ratio ($mmol\ H_2O\ m^{-2}\ S^{-1}$)	
	2020	2021	2020	2021	2020	2021
PEP1635	49.90 b	50.73 ab	4.57 a-c	4.54 a-d	4.51 b	4.40 b
PEP1636	48.10 bc	45.30 cd	4.86 a-c	4.44 a-d	4.34 b	4.32 b
PEP1666	57.40 a	52.80 a	4.65 a-c	6.70 a	4.46 b	3.12 b
PI526246	44.20 cd	44.57 cd	4.59 a-c	2.68 cd	4.36 b	7.91 a
PI599586	47.20 b-d	46.07 b-d	2.56 c	2.23 d	8.23 a	8.55 a
Luffa	45.90 b-d	46.93 b-d	3.89 bc	5.08 a-c	5.81 ab	4.25 b
PI491347	42.83 d	46.83 b-d	6.82 a	6.26 ab	2.95 b	3.30 b
PI534556	47.57 b-d	48.07 bc	4.60 a-c	3.99 b-d	4.51 b	4.99 b
Non-grafted plants	42.87 d	42.60 d	5.89 ab	5.52 ab	3.58 b	4.45 b

[z]Mean values followed by a letter in common were not significantly different according to Duncan's multiple range test ($p < 0.05$).

Table 4. The effect of combinations between scion and rootstocks on nutrients content in cucumber leaves at 60 days after transplanting during summer seasons of 2020 and 2021

Rootstocks	N%		P %		K %		Ca %		Mg %	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
PEP1635	4.18 b	4.27 a	0.27 d	0.29 c	3.72 a	3.76 a	2.43 d	2.45 cd	0.61 b	0.62 b
PEP1636	4.26 a	4.29 a	0.31 bc	0.34 bc	3.55 b	3.62 b	2.51 c	2.52 bc	0.63 b	0.64 b
PEP1666	4.11 c	4.24 a	0.38 a	0.39 ab	3.49 c	3.45 c	2.55 bc	2.61 ab	0.63 b	0.61 b
PI526246	3.27 g	3.31 d	0.32 b	0.29 c	3.24 e	3.26 de	2.25 e	2.28 e	0.61 b	0.62 b
PI599586	3.87 d	4.05 b	0.37 a	0.41 a	3.67 a	3.71 ab	2.51 c	2.53 bc	0.71 a	0.69 a
Luffa	3.55 e	3.63 c	0.28 cd	0.31 c	3.31 d	3.35 cd	2.64 a	2.63 a	0.53 c	0.52 c
PI491347	3.41 f	3.64 c	0.29 b-d	0.32 c	3.70 a	3.72 b	2.42 d	2.38 d	0.60 b	0.59 b
PI534556	3.42 f	3.48 cd	0.36 a	0.35 bc	3.35 d	3.39 c	2.61 ab	2.59 ab	0.54 c	0.52 c
Non-grafted plants	3.29 g	3.41 d	0.28 cd	0.32 c	3.19 f	3.22 e	2.18 f	2.22 e	0.49 c	0.51 c

[z]Mean values followed by a letter in common were not significantly different according to Duncan's multiple range test ($p < 0.05$).

highest value of P%, while non-grafted plants and other rootstocks exhibited the lowest concentration without significant differences among them. Concerning K%, Leaves of cucumber scion grafted onto squash rootstock PEP1635, pumpkin rootstocks PI599586 in both seasons and bottle gourd rootstock PI491347 in first season showed the highest value without significant differences among them. Regarding Ca%, Leaves of cucumber scion grafted onto bottle gourd rootstock PI534556 and Luffa had the highest value in both seasons, in addition to squash rootstock PEP1666 in 2021 only without significant differences among them. Leaves of scion grafted onto pumpkin rootstock PI599586 showed the highest concentration of Mg%, while non-grafted plants, Luffa and bottle gourd rootstock PI534556 exhibited the lowest concentration without significant differences among them. Our results indicated that the interpretation for increment in plant vigor of almost evaluated rootstocks due to of the uptake of the nutrients. The present results agree with that of **El-Sayed *et al.* (2014 and 2021)** who reported improvement of plant growth parameters due to enhancement micro and micro elements uptake in grafted plants over non-grafted plants. Also, **Shehata *et al.* (2022)** reported that leaves of grafted plants accumulated high minerals concentration than non-grafted cucumber under normal and drought stress conditions. While, **Huang *et al.* (2016)** suggested that strong root system for rootstocks enhanced water and elements absorption which exhibited the positive effect in plant growth parameters in grafted watermelon.

Effect of Different Rootstocks on Fruit Quality Traits

Data in Table 5 showed that grafting process onto different cucurbit rootstocks significantly effected on fruit characters. Squash rootstocks PEP1635 and bottle gourd rootstock PI491347 in both years, in addition to squash rootstocks PEP1636 and bottle gourd rootstock PI534556 in second year showed the highest value of average fruit weight. Bottle gourd rootstock PI491347 in both season and squash rootstocks PEP1636 in first year recorded the tallest fruit length. All rootstocks led to increase fruit diameter, especially all squash and bottle gourd and luffa rootstocks had the highest value of fruit diameter. Grafting onto bottle gourd, luffa and squash rootstocks except the accession PEP1635 caused significant reduction in TSS%. Pumpkin rootstock PI599586 in both years exhibited the highest significant TSS%. Several former studies recorded increment in average fruit weight trait (**El-Sayed *et al.*, 2014 and 2015; Velkov and Pevicharova, 2016; Zaki *et al.*, 2018; Noor *et al.*, 2019; El-Sayed *et al.*, 2021**), reduction in TSS % in fruits of the grafted plants than non-grafted plants (**El-Sayed *et al.*, 2021**), rapid development in diameter and length of fruits in grafted plants than non-grafted plants (**Noor *et al.*, 2019**). On the contrary, **Noor *et al.* (2019)** recorded increment in TSS % in grafted plants over non-grafted cucumber, and **Zaki *et al.* (2018)** reported that no effect for grafting on fruit length and fruit diameter.

Effect of Different Rootstocks on Cucumber Productivity

Data in Table 6 indicated that squash rootstock PEP1666 in both seasons and squash rootstocks PEP1635 and PEP1636 and pumpkin rootstock PI526246 in first season displayed the highest content of dry matter in fruits. No significant differences were found among rootstocks in total sugars content in fruits. All rootstocks significantly increased the early yield except pumpkin rootstocks compared with non-grafted plants. Squash rootstocks PEP1635 and PEP1636, in addition to bottle gourd rootstock PI491347 recorded the highest significant early yield over non-grafted plants. Regarding total yield, in 2020 all squash rootstocks exhibited the highest value of total yield, while luffa and bottle gourd rootstock PI491347 ranked second, but in 2021, squash rootstock PEP1635 and bottle gourd rootstock PI491347 recorded the highest significant total yield. The high yielding ability of squash rootstock PEP1635 and bottle gourd rootstock PI491347 were due to their high average fruit weight, high values of fruit length and fruit diameter. Concerning dry matter and total sugars in cucumber fruits, our results agree with those by **El-Sayed *et al.* (2014)** who reported that using Squash 3 (*Cucurbita pepo* L.) as rootstock caused significant increment in dry matter content in fruits during winter season, while all rootstocks had no effect on total sugars in fruits

Table 5. The effect of combinations between scion and rootstocks on fruit quality traits during summer seasons of 2020 and 2021

Rootstocks	Fruit weight (g)		Fruit length (cm)		Fruit diameter (cm)		TSS (%)	
	2020	2021	2020	2021	2020	2021	2020	2021
PEP1635	97.29 a	95.39 a	13.89 bc	13.95 b	3.63 ab	3.76 a	4.31 b	4.59 ab
PEP1636	88.62 bc	86.59 a	14.56 a	14.30 ab	3.55 b	3.69 a	3.80 d	3.75 c
PEP1666	71.26 d	70.31 bc	13.84 c	13.97 b	3.69 a	3.66 ab	3.75 d	3.73 c
PI526246	73.09 d	70.03 bc	14.08 bc	14.01 b	3.38 c	3.41 c	4.25 bc	4.30 b
PI599586	72.53 d	71.92 bc	14.30 ab	14.18 ab	3.53 b	3.48 bc	4.85 a	4.68 a
Luffa	75.63 d	71.90 bc	12.76 d	13.03 c	3.53 b	3.62 ab	3.30 e	3.34 d
PI491347	92.63 ab	91.22 a	14.71 a	14.60 a	3.63 ab	3.65ab	3.31 e	3.40 d
PI534556	84.36 c	83.06 ab	13.88 bc	14.15 ab	3.52 b	3.57 a-c	3.25 e	3.33 d
Non-grafted plants	70.44 d	62.70 c	13.94 bc	13.86 b	3.28 c	3.18 d	4.11 c	4.35 b

[z]Mean values followed by a letter in common were not significantly different according to Duncan's multiple range test ($p < 0.05$).

Table 6. The effect of combinations between scion and rootstocks on fruit dry matter, total sugars, early and total yield during summer seasons of 2020 and 2021

Rootstock	Fruit dry matter (%)		Total sugars (%)		Early yield /m^2 (kg)		Total yield/m^2 (kg)	
	2020	2021	2020	2021	2020	2021	2020	2021
PEP1635	8.24 a	7.71 b	4.40 a	4.32 a	2.53 a	2.75 a	7.21 a	7.83 a
PEP1636	8.15 a	7.55 b	4.23 a	4.07 a	2.52 a	2.47 bc	6.85 a	6.24 bc
PEP1666	8.11 a	8.36 a	4.54 a	4.23 a	2.23 b	2.35 c	7.02 a	6.26 bc
PI526246	7.95 a	7.62 b	4.48 a	4.16 a	1.01 d	0.93 e	2.30 f	2.89 d
PI599586	7.52 b	6.69 c	4.50 a	4.31 a	0.97 d	0.95 e	2.81 e	3.59 d
Luffa	7.33 bc	6.90 c	4.76 a	4.24 a	1.54 c	1.61 d	6.04 b	5.52 c
PI491347	6.78 d	6.47 c	4.50 a	3.97 a	2.68 a	2.59 ab	6.29 b	6.97 ab
PI534556	6.97 cd	6.86 c	4.63 a	4.31 a	1.46 c	1.64 d	3.68 d	3.25 d
Non-grafted plants	7.11 b-d	7.76 b	4.60 a	4.48 a	1.12 d	1.15 e	4.85 c	5.42 c

[z]Mean values followed by a letter in common were not significantly different according to Duncan's multiple range test ($p < 0.05$).

during summer season. **Noor *et al.* (2019)** found that significant differences between rootstocks in dry mater and total sugar in cucumber fruits, but *Cucurbita pepo* L rootstock caused a reduction in dry matter content in fruits, while it did not differ in sugar content than non-grafted plants. Many former studies support the improvement of productivity with utilizing grafting technology due to grafting cucumber onto squash and bottle gourd rootstocks such as **El-Sayed *et al.* (2014)** found that Squash 3 rootstock improved the total yield of cucumber significantly. **Velkov and Pevicharova (2016)** reported that grafting two different cultivars as scions onto *Legenaria siceraria* produced the highest significant early and total yield value. **Alaaeldin *et al.* (2019)** reported significant enhancement in early and total cucumber productivity by grafting on hybrid rootstocks belong to different cucurbit and found also clear effect for the different rootstocks on dry mater and total sugars in cucumber fruits. **El-Sayed *et al.* (2021)** confirmed that grafting cucumber cv. Vivasun onto Squash 6 (*Cucurbita pepo* cv. Coby X *C. pepo* cv. Eskandarani) and Gourd 1 rootstock (*Legenaria siceraria* PI Local X PI 53455501) exhibited the highest total productivity. **Taha *et al.* (2022)** found that grafting cucumber onto bottle gourd produced significant yield increment in both normal and drought conditions, while squash rootstock significantly improved the total yield in second season under normal conditions.

Conclusion

Grafting is an effective and environmentally friendly method for combating the negative impacts of biotic and abiotic stressful conditions and increasing the productivity of cucumber, but the grafting effect is clearly dependent on the choice of the rootstock. The compatibility between cells of rootstocks and scions is the main criteria. Generally, the suitable rootstocks that enhance the plant vigor characters and produce a high yield with high macro and micro elements content, in addition to high fruit quality. Grafting hybrid cucumber (Hesham F_1) on squash rootstocks (PEP1635 and PEP1666) caused a significant enhancement in total yield/ m^2.

Acknowledgements

The authors thank their colleague Dr. Haytham Hashem for his help in the statistical analysis for this research.

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استغلال أصول قرعيات مختلفة كبديل مستدام لتحفيز نمو وإنتاجية وصفات جودة ثمار الخيار

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يعد التطعيم طريقة فعالة وصديقة للبيئة لمواجهة الأثار السلبية للإجهادات الحيوية وغير الحيوية ولزيادة إنتاجية محاصيل الخضر. أجريت التجربة تحت ظروف صوبة التظليل خلال فصل الصيف لعامي 2021/2020 في مزرعة قسم الخضر بكلية الزراعة جامعة القاهرة بمصر. كان الهدف من التجربة دراسة تأثير تطعيم الخيار باستخدام ثمانية أصول تابعة لأربعة أنواع مختلفة من القرعيات على النمو والإنتاجية وصفات جودة الثمار. التجربة تمت باستخدام تصميم قطاعات تامة العشوائية. الأصول المستخدمة تضم ثلاثة سلالات من الكوسة (PEP 1635 و PEP 1636 و PEP 1666) و سلالتين من القرع العسلي (PI526246 و PI599586) و سلالتين من اليقطين (PI491347 و PI534556) وسلالة محلية من اللوف وتم مقارنتها مع نباتات الخيار الغير مطعومة من صنف هشام. أداء النباتات المطعومة اختلف وفقا للأصل المستخدم. عملية التطعيم أجريت بطريقة القطع المائل المستخدمة بشكل تجاري. أعلى نسبة لنجاح التطعيم كانت في السلالة التابعة لليقطين PI491347 حيث كانت النسبة في الموسمين 67.9 % و 69.23 % على التوالي بينما سجلت اقل نسبة نجاح للتطعيم في سلالة الكوسة PEP1636 حيث كانت النسبة في الموسمين 37.5 % و 31.21 % على التوالي. بالمقارنة مع أداء نباتات الخيار غير المطعومة حقق التطعيم على أصول الكوسة الثلاثة (PEP 1635 و PEP 1636 و PEP 1666) وكذلك التطعيم على أصل القرع العسلي PI599586 تحسن معنوي في معظم الصفات الخضرية (طول النبات ومساحة الورقة و طول السلمية و قيمة SPAD) وجودة الثمار (متوسط وزن الثمرة وطول وقطر الثمرة) والمحصول المبكر والكلي. أصول القرع العسلي قللت بشكل معنوي المقاومة الثغرية وزادت من معدل النتح. أصل القرع العسلي PI599586 أدى الى زيادة محتوي أوراق الخيار من العناصر الكبرى. أدى تطعيم هجين الخيار هشام على اصول قرع الكوسة (PEP1635 و PEP1666) الى زيادة محصول ثمار المتر المربع.

الكلمات الإسترشادية: الخيار، صفات الجودة، أصول، طعم التطعيم، المحصول.

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