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Original Article

Production Capacity of Seeds Affected by Green Fruit Pickings in Six Varieties of Okra (*Abelmoschus esculentus* L.)

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Abstract

Successful seed production depends on the variety, the environment, and the agricultural practices. Limited information is available on the effects of green pod-picking treatments on the production of seeds. Therefore, two-season field experiments were conducted in 2019 and 2020 to study the effects of four green fruit picking treatments (no green fruit picking 'T1', first two pickings 'T2', first 4 pickings 'T3', and first 6 pickings 'T4') and six varieties (Pusa Sawani 'V1', Emerald 'V2', Eskandarany 'V3', Baladi Assiut 'V4', Beghera Iraqi 'V5', and NOKH-1002 "F1 hybrid okra 'V6') on okra growth and seed yield and quality. The results of the experiment showed that okra plants of T1, followed by those treated with T2 had higher number of dry pods/plant, weight of pods/plant, and seed weight (kg/feddan), seed vitamin C, and pH in both seasons. Plants of T3 were significantly taller than T1 in both seasons. There were differential responses of the studied varieties to the picking treatments. Plants of 'Eskandarany' with no pickings, followed by 'Emerald' with two pickings always had higher number of dry pods, weight of pods/plant, and seed weight (kg/feddan). We can conclude that okra plants with no green fruit picking, as compared to two, four, and six fruit pickings, can be the best option for seed production due to the observed higher number of dry pods, weight of pods/plant, seed yield and quality.

Keywords: *Abelmoschus esculentus L., Fruit pickings, Varieties, Seed yield, Vitamin C, Total phenols*

Introduction

Okra (*Abelmoschus esculentus* L.) is an important vegetable crop of the most commonly known species of the Malvaceae family. It is grown in tropical and subtropical areas of the world (Gemede *et al.*, 2014). Worldwide, the harvested area of okra has reached about 2 million hectares including 4.6 ha in Egypt with a global total yield of approximately 10 million tons including 55609 tons in Egypt (FAOSTAT 2018).

In Egypt, immature fruits of okra are very popular in consumer's dietary (El-Shaikh *et al.*, 2019). Fresh, canned, frozen, or dried okra are used in soups and stews (Gemede *et al.*, 2014; El-Shaikh *et al.*, 2019). Okra is very rich in valuable

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nutrients, soluble fibers, carbohydrates, minerals, vitamins, phenolic compounds, and flavonol derivatives. Okra is also known for its high antioxidants activity (Gemede *et al.*, 2014). Okra seeds are a source of oil, protein, linoleic acid, and vitamins such as vitamin C (Adetuyi and Komolafe, 2011; Gemede *et al.*, 2014). Okra seeds are known to be rich in phenolic compounds (Gemede *et al.*, 2014) which are good resources for natural antioxidants (Khomsug *et al.*, 2010).

In general, seeds are very crucial for the production system of agricultural crops (Kumar *et al.*, 2021) and thus, seeds production is considered a profitable enterprise (Kumar *et al.*, 2021). Seed is the main factor that controls the quantitative and qualitative crop characteristics (Mohamed *et al*., 2016), hence, the significance of focusing on increasing seed yield and quality (Mohamed *et al*., 2016).

Similar to many other vegetables, success in okra seed production is based on certain agricultural practices such as sowing date, harvest date (Mohamed *et al*., 2016), fertilization (Moniruzzaman and Quamruzzaman, 2009) and picking of green fruits (Sanganagoud *et al*., 2014). During fruiting of okra, the vegetative and reproductive sinks occur in a gentle balance. Manipulation of the reproductive sink results in a change in the partitioning of the dry matter in okra plants (Bahat and Rao, 1997). It is known that okra plants develop single flower and fruit at each node after the 5th to the 8th leaf. Leaving immature fruits at one node inhibits the development of another fruit at the next node (Bahat and Rao, 1997). If fruits are not harvested every 2-3 days at the immature stage, fruit production will be affected and yield will be reduced (Mohammadi *et al.*, 2015).

Regular harvesting appears to enhance the activity of photoassimilate source, delays leaf senescence, boosts photassimilation, and consequently increases the total number of pods (Bahat and Rao, 1997). Hence, fruit pickings influence plant productivity as picking frequency has a significant effect on seed yield (Singh *et al.*, 2012; El-Shaikh *et al*., 2019) and quality of okra seeds (Singh *et al.*, 2012). However, little information is known about the effects of different fruit picking numbers on seed yield and quality in okra plants.

Unfortunately, limited research is done about increasing seed production of okra in Egypt. Knowledge of genetic resources might also help identifying desirable cultivars for commercial cultivation for seed production. Therefore, the aims of the experiment are to: study the effects of different picking numbers (no picking, 2, 4, and 6 pickings) on some growth characteristics (plant height and number of branches) and seed yield and quality (vitamin C, total phenols, and pH) and to evaluate seed yield and quality of six different varieties of okra.

Material and Methods

Experiment conditions and statistical design

This experiment was carried out during the two consecutive growing summer seasons of 2019 and 2020 at the Experimental Farm of Vegetable Crops Department, Faculty of Agriculture, Assiut University, Assiut, Egypt. Seeds were sown on 22nd of April in the first season and on the 8th of April in the second season.

The investigational location was situated at 54 meters above sea level (27°11'09.3"N latitude; 31°09'36.9"E longitude). The soil texture was clay (53.23% clay, 28.35% silt and 18.42% sand), with pH of 8.01 and field capacity of 45.7%. The plant spacing pattern was set to 70 cm among the rows and 50 cm among plants in the same row. Seeds were sown on the northern side of each row. The experiment was conducted as a split plot in a randomized complete block design with three replicates. Six varieties occupied the main plots, and four picking treatments of okra were randomly distributed in the sub-plots. The normal agricultural practices of the irrigation, fertilization, weed, and pest control were followed in this study as recommended for okra production under Assiut governorate growing conditions.

Plant material

Seeds of the six okra varieties were studied in the present experiment. Five varieties (V1 'Pusa Sawani', V2 'Emerald', V3 'Eskandarany', V4 'Baladi Assiut', V5 'Beghera Iraqi') were obtained from Horticulture Research Institute, Giza, Egypt while the 6th variety (V6 'NOKH-1002' "F1 hybrid okra) was provided by Nuziveedu Seeds Limited, Gundlapochampally Village, Medchal Mandal, Ranga Reddy District, Telangana-501 401. All seeds were soaked in water overnight one day before planting in order to enhance germination of the seeds.

Picking treatments

Four different picking treatments of green okra fruits/pods were studied as follow: no picking (Control, T1), first two pickings (T2), first four pickings (T3), and first six pickings (T4). Regular harvesting (every 2 days) was conducted on every plant in each treatment until number of pickings of each treatment was reached. In all the studied verities, pods started to appear after an average of 60-70 days from planting, except for V5 which was a late-fruiting variety that started to show its pods after an average of 70-80 days from planting in both seasons. After completion of all picking treatments, fruits were allowed to reach maturity until the end of the harvest season for seed yield measurements.

Measurements

Measurements on the plants were as follow:

1. Green immature pods measurements (in all treatments except the control)

Number of green pods/plant was counted and average weight (g) of the green pod was measured. Pod length (cm) and diameter (cm) were measured in all treatments with the use of Vernier caliper.

2. Vegetative growth measurement

Plant height (cm) was measured from the soil surface to the highest leaf tip with the use of a measuring tape. Number of branches/plant was recorded at harvest time of dry pods in each season.

3. Dry pods and seed yield measurements

Total number of pods/plant, weight of pods/plant (g), and seed weight (g) were measured. Weights in Kg/feddan were calculated for total seed yield measurement.

4. Seed quality measurements

Seed vitamin C content (g/100g), seed pH, and seed total phenols content (mg/100g) were measured in the seed flour of the different okra varieties in the different picking treatments. Seed total phenols were measured according to the method of Wolfe *et al*., 1984. Vitamin C was measured in the flour of okra seeds according to (Kapur *et al.*, 2012). Seed pH was measured in okra seed flour with the use of a pH meter (Hanna Instruments, Padova, Italy). Measurements were conducted at the Central laboratories, Faculty of Agriculture, Assiut University, Assiut, Egypt.

Statistical analysis

Analysis of variance was carried out on data and comparisons among data were done using Duncan's Multiple Range Test according (Gomez and Gomez, 1984). All data were statistically analyzed using 1998-2004 CoHort Software, CoStat Software, version 6.303 (798 Lighthouse Ave. PMB 320, Monterey, CA, 93940, USA).

Results

1. Green okra pods characteristics

Green okra pods measurements were taken from the collected fruits to compare fruit characteristics among the different varieties and to assess the effects of different picking treatments on fruit characteristics of the following picking.

Table 1. Average green pod weight (g) from six okra varieties in different green pod pickings

S1				
Variety	**Treatment**			**Mean Variety**
	T2	**T3**	**T4**	
V1	5.02 a	5.14 a	5.40 a	5.18 A
V2	5.21 a	5.54 a	5.78 a	5.51 A
V3	5.50 a	5.12 a	5.11 a	5.24 A
V4	5.59 a	5.43 a	5.49 a	5.50 A
V5	5.05 a	4.75 a	5.15 a	4.98 A
V6	5.11 a	4.98 a	5.30 a	5.13 A
Mean Treatment	5.25 **A**	5.16 **A**	5.37 **A**	
S2				
Variety	**Treatment**			**Mean Variety**
	T2	**T3**	**T4**	
V1	5.31 abc	5.14 abc	5.01 abc	5.15 A
V2	5.75 a	5.59 ab	5.45 ab	5.60 A
V3	5.51 ab	5.14 abc	4.71 abc	5.12 A
V4	5.24 abc	5.30 abc	5.01 abc	5.18 A
V5	4.30 c	4.21 c	4.61 bc	4.37 B
V6	5.52 ab	5.41 ab	5.08 abc	5.34 A
Mean Treatment	5.27 **A**	5.13 **A**	4.98 **A**	

Differences in mean values within rows/columns followed by at least one letter in common are not significant according to Duncan's multiple range test at $p \leq 0.05$.

Regarding the treatment effect and the variety effect on average green pod weight (g), there were no significant differences in the average green pod weight among different picking treatments or the different varieties in both seasons (Table 1). Average green pod weight was not significantly affected by the interaction between picking number and varieties in most of the combinations, except for V5T2 and V5T3 in the second season. In general, V5T3 had the lowest average green pod weight in both seasons (Table 1).

Table 2. Number of green pods/plant collected from six okra varieties in different green pod pickings

S1				
Variety	**Treatment**			**Mean Variety**
	T2	**T3**	**T4**	
V1	3.19 g	9.56 de	16.02 a	9.59 A
V2	3.58 g	8.00 ef	12.45 bc	8.01 BC
V3	3.53 g	7.50 ef	11.11 cd	7.38 C
V4	4.07 g	6.86 f	11.02 cd	7.31 C
V5	3.50 g	7.06 ef	11.21 cd	7.25 C
V6	3.28 g	8.93 def	14.22 ab	8.81 AB
Mean Treatment	3.53 **C**	7.99 **B**	12.67 **A**	
S2				
Variety	**Treatment**			**Mean Variety**
	T2	**T3**	**T4**	
V1	4.00 ef	12.04 b	16.67 a	10.90 A
V2	3.58 ef	8.05 cd	11.33 bc	7.65 B
V3	4.35 ef	8.05 cd	12.22 b	8.21 B
V4	3.83 ef	7.07 de	11.79 b	7.56 B
V5	2.97 f	6.22 def	11.17 bc	6.79 B
V6	4.39 ef	11.50 bc	15.67 a	10.52 A
Mean Treatment	3.85 **C**	8.82 **B**	13.14 **A**	

Differences in mean values within rows/columns followed by at least one letter in common are not significant according to Duncan's multiple range test at $p \leq 0.05$.

Regarding the number of green pods/plant, V1 significantly had the highest average number of pods/plant followed by V6 in both seasons (Table 2). Treatment effect showed that T4 significantly had the highest number of green pods/plant in both seasons (Table 2). The interaction effect showed that V1T4 had the highest number of green pods/plant, followed by V6T4, in both seasons (Table 2).

As for green pod diameter, V2 and V4 significantly had the widest diameters among all treatments in the two seasons (Table 3). Picking treatment did not affect pod diameter in both seasons except for T2 in the first season which had significantly wider pods than T3 and T4 (Table 3). No significant differences were found among the different treatments within each variety (Table 3).

Table 3. Diameter of green pods (cm) collected from six okra varieties in different green pod pickings

S1				
Variety	**Treatment**			**Mean Variety**
	T2	**T3**	**T4**	
V1	1.26 cdef	1.20 ef	1.17 f	1.21 C
V2	1.65 a	1.52 ab	1.62 a	1.60 A
V3	1.54 ab	1.42 a-e	1.44 abcd	1.47 B
V4	1.64 a	1.60 a	1.59 a	1.61 A
V5	1.46 abc	1.48 abc	1.46 abc	1.47 B
V6	1.35 b-f	1.23 def	1.22 def	1.27 C
Mean Treatment	1.48 **A**	1.41 **B**	1.42 **B**	
S2				
Variety	**Treatment**			**Mean Variety**
	T2	**T3**	**T4**	
V1	1.42 cde	1.32 def	1.27 ef	1.34 C
V2	1.58 ab	1.60 a	1.57 ab	1.58 A
V3	1.45 bcd	1.41 cde	1.30 ef	1.39 C
V4	1.51 abc	1.49 abc	1.50 abc	1.50 B
V5	1.29 ef	1.31 def	1.35 def	1.32 C
V6	1.20 f	1.24 f	1.21 f	1.22 D
Mean Treatment	1.41 **A**	1.40 **A**	1.37 **A**	

Differences in mean values within rows/columns followed by at least one letter in common are not significant according to Duncan's multiple range test at $p \leq 0.05$.

Table 4. Length of green pods (cm) collected from six okra varieties in different green pod pickings

S1				
Variety	**Treatment**			**Mean Variety**
	T2	**T3**	**T4**	
V1	5.46 a	5.59 a	5.24 ab	5.43 A
V2	3.51 de	3.23 e	3.38 de	3.37 C
V3	4.43 bcd	4.12 cde	4.11 cde	4.22 B
V4	3.51 de	3.26 e	3.47 de	3.41 C
V5	3.66 de	3.96 de	4.24 cde	3.95 B
V6	5.50 a	5.02 abc	5.26 ab	5.26 A
Mean Treatment	4.35 **A**	4.20 **A**	4.28 **A**	
S2				
Variety	**Treatment**			**Mean Variety**
	T2	**T3**	**T4**	
V1	6.22 a	5.73 ab	5.14 b	5.70 A
V2	3.18 e	3.00 e	2.99 e	3.06 C
V3	4.44 c	3.98 cd	4.04 cd	4.15 B
V4	3.39 de	3.22 e	3.05 e	3.22 C
V5	3.13 e	3.13 e	3.44 de	3.23 C
V6	5.77 ab	5.78 ab	5.33 b	5.63 A
Mean Treatment	4.36 **A**	4.14 **A**	4.00 **A**	

Differences in mean values within rows/columns followed by at least one letter in common are not significant according to Duncan's multiple range test at $p \leq 0.05$.

For the variety effect, V1, followed by V6, significantly had the longest green pods among the studied varieties (Table 4). For the treatment effect, there were no significant differences in green pod length among the different treatments (Table 4).

Table 5. Plant height (cm) of six varieties of okra as affected by different green pod pickings

S1					
Variety	**Treatment**				**Mean Variety**
	T1	**T2**	**T3**	**T4**	
V1	75.88 hij	78.97 ghij	101.97 fghi	106.70 fg	90.88 CD
V2	163.66 bcde	168.67 abcde	180.43 ab	181.43 ab	173.55 A
V3	98.27 fghi	103.00 fgh	102.87 fgh	110.00 f	103.53 C
V4	175.20 abcd	170.20 abcde	178.63 abc	196.22 a	180.06 A
V5	148.27 de	150.17 cde	142.18 e	147.80 de	147.11 B
V6	69.11 j	73.25 ij	97.94 fghi	88.00 fghij	82.08 D
Mean Treatment	121.73 **B**	124.04 **B**	134.00 **A**	138.36 **A**	
S2					
Variety	**Treatment**				**Mean Variety**
	T1	**T2**	**T3**	**T4**	
V1	90.53 f	99.80 ef	113.73 de	124.20 d	107.06 D
V2	184.83 bc	183.88 bc	187.92 bc	177.50 c	183.53 B
V3	119.00 de	130.83 d	130.66 d	132.00 d	128.12 C
V4	210.66 a	200.66 ab	212.66 a	218.83 a	210.70 A
V5	176.00 c	172.00 c	179.66 bc	170.00 c	174.42 B
V6	66.50 g	102.44 ef	112.50 de	86.00 f	91.86 E
Mean Treatment	141.25 **B**	148.27 **AB**	156.19 **A**	151.42 **AB**	

Differences in mean values within rows/columns followed by at least one letter in common are not significant according to Duncan's multiple range test at $p \leq 0.05$.

2. Effect of picking treatments on plant height and number of branches

Among all studied varieties, plants of V4, followed by V2, were significantly the highest plants whereas V6 plants were significantly the shortest (Table 5). As for treatment effect on plant height, T3 plants were significantly taller than T1 in both seasons (Table 5). Within each variety, there were no significant differences in plant height among all picking treatments, except for V1T4 that was significantly higher than V1T1 in the two seasons of the study (Table 5). In general, the tallest plants of the study were V4T4 in the two seasons (Table 5).

As regard to the average number of branches/plant, picking treatment did not show any effects except for T1 in the second season (Table 6). As for the variety effect, significant differences were noted among the studied varieties (Table 6) with V5 having the highest numbers in both seasons (Table 6). As for the interaction effect, no significant differences were found within each treatment of each variety (Table 6).

Table 6. Number of branches/plant of six varieties of okra as affected by different green pod pickings

S1					
Variety	**Treatment**				**Mean Variety**
	T1	**T2**	**T3**	**T4**	
V1	2.66 ef	2.55 ef	2.47 f	3.17 ef	2.71 D
V2	4.97 abcd	6.60 a	5.08 abcd	5.57 abc	5.56 B
V3	5.20 abcd	6.07 ab	6.33 a	5.67 abc	5.82 AB
V4	4.30 bcde	3.90 cdef	4.33 bcde	5.04 abcd	4.39 C
V5	6.40 a	6.25 a	6.48 a	6.47 a	6.40 A
V6	2.67 ef	2.89 ef	3.17 ef	3.50 def	3.06 D
Mean Treatment	4.37 **A**	4.71 **A**	4.64 **A**	4.90 **A**	
S2					
Variety	**Treatment**				**Mean Variety**
	T1	**T2**	**T3**	**T4**	
V1	1.87 g	2.60 fg	2.67 fg	2.80 fg	2.49 A
V2	6.37 abc	6.51 abc	6.83 ab	6.38 abc	6.52 A
V3	5.00 cd	4.80 de	4.83 de	5.33 bcd	4.99 B
V4	5.80 abcd	5.80 abcd	6.13 abcd	6.80 ab	6.13 A
V5	6.27 abcd	6.93 a	6.80 ab	6.07 abcd	6.52 A
V6	1.75 g	2.89 fg	3.00 fg	3.50 ef	2.79 C
Mean Treatment	4.51 **B**	4.92 **A**	5.04 **A**	5.15 **A**	

Differences in mean values within rows/columns followed by at least one letter in common are not significant according to Duncan's multiple range test at $p \leq 0.05$.

3. Effect of picking treatments on number and weight of dry okra pods/plant and seed yield

Irrespective of the picking treatment, V3 significantly had the highest number of dry pods/plant, followed by V2 in both seasons (Table 7). As for the treatment effect, plants treated with T1 had the highest number of dry pods/plant, which was significantly higher than T4 in the two seasons (Table 7). As for the interaction effect of treatment and variety, there were no significant differences within each variety among treatments except for V3T1 and V5T1 that were significantly higher than most of other treatments within each of the varieties (Table 7). In both seasons, V3T1 had the highest significant number of dry pods/plant, followed by V3T3 (Table 7). The lowest number of dry pods/plant was obtained from V6T4 in both seasons (Table 7).

As for the weight of dry pods/plant, plants treated with T1 had the highest weight of dry pods/plant which was significantly higher than T4 in the first season and higher than all other picking treatments in the second season (Table 8). As for variety effect, V3, followed by V2, had significantly higher weights of dry pods/plant than other cultivars (Table 8). The interaction effect of variety and treatment showed that V3T1 and V6T4 significantly had the highest and lowest weight of dry pods/plant in both seasons, respectively (Table 8).

Table 7. Number of dry pods/plant collected from six okra varieties as affected by different green pickings

S1					
Variety	**Treatment**				**Mean Variety**
	T1	**T2**	**T3**	**T4**	
V1	12.45 ghi	14.77 fghi	14.11 fghi	13.91 fghi	13.81 C
V2	20.49 bcde	21.64 bcd	16.64 defg	18.86 cdef	19.41 B
V3	28.93 a	22.93 bc	25.57 ab	18.73 cdef	24.04 A
V4	19.40 cdef	15.95 efgh	19.37 cdef	16.40 defg	17.78 B
V5	22.87 bc	17.73 c-g	14.73 fghi	15.93 efgh	17.82 B
V6	9.89 ij	10.78 hi	10.00 ij	5.00 j	8.92 D
Mean Treatment	19.01 **A**	17.30 **AB**	16.74 **AB**	14.81 **B**	
S2					
Variety	**Treatment**				**Mean Variety**
	T1	**T2**	**T3**	**T4**	
V1	15.73 efg	15.60 efgh	13.46 ghi	15.27 fghi	15.02 B
V2	19.66 cde	24.00 ab	20.09 bcd	20.33 bcd	21.02 A
V3	26.80 a	19.60 cde	23.27 abc	18.87 def	22.14 A
V4	18.80 def	13.07 ghi	15.09 fghi	13.88 ghi	15.21 B
V5	19.13 cdef	13.07 ghi	15.18 fghi	12.04 ghij	14.86 B
V6	8.78 j	11.33 hij	11.25 ij	8.25 j	9.90 C
Mean Treatment	18.15 **A**	16.11 **B**	16.39 **AB**	14.77 **B**	

Differences in mean values within rows/columns followed by at least one letter in common are not significant according to Duncan's multiple range test at $p \leq 0.05$.

Table 8. Weight of dry pods (g) /plant collected from six okra varieties as affected by different green pod pickings

S1					
Variety	**Treatment**				**Mean Variety**
	T1	**T2**	**T3**	**T4**	
V1	51.15 ij	66.17 hij	55.49 hij	60.60 hij	58.35 E
V2	148.47 bc	148.56 bc	116.53 cdef	133.58 bcde	136.79 B
V3	197.93 a	146.80 bc	159.07 b	113.60 def	154.35 A
V4	135.87 bcd	101.63 efg	128.60 bcde	109.67 defg	118.94 C
V5	120.27 cde	85.87 fgh	78.23 ghi	85.73 fgh	92.53 D
V6	45.11 j	64.89 hij	42.83 j	11.75 k	41.15 F
Mean Treatment	116.47 **A**	102.32 **AB**	96.79 **AB**	85.82 **B**	
S2					
Variety	**Treatment**				**Mean Variety**
	T1	**T2**	**T3**	**T4**	
V1	67.13 hi	75.47 gh	66.68 hi	71.30 gh	70.15 D
V2	145.85 bc	164.22 b	144.69 bc	129.21 cd	145.99 A
V3	197.60 a	131.20 cd	149.40 bc	118.47 de	149.17 A
V4	142.00 bc	93.33 fg	114.53 def	105.30 ef	113.79 B
V5	118.33 de	71.08 gh	80.03 gh	66.25 hi	83.92 C
V6	45.11 ij	64.00 hi	58.75 hi	34.25 j	50.53 E
Mean Treatment	119.34 **A**	99.88 **B**	102.35 **B**	87.46 **C**	

Differences in mean values within rows/columns followed by at least one letter in common are not significant according to Duncan's multiple range test at $p \leq 0.05$.

As for the seed yield, the highest significant seed yield was obtained from T1 plants whereas the lowest was in T4 in the two seasons (Table 9). For the variety effect, V3 significantly had the highest seed yield, followed by V2 while V6 gave significantly the lowest seed yield (Table 9). The interaction effect in the two seasons of the study showed that V3T1 significantly had the highest seed yield while V6T4 gave the lowest seed yield (Table 9). Plants of T1 consistently had the highest seed yields in V3, V4, and V5 but T2 plants consistently had the highest seed yields in V1, V2, and V6 in the two seasons (Table 9).

Table 9. Seed weight (Kg/feddan) collected from six okra varieties as affected by different green pod pickings

S1					
Variety	**Treatment**				**Mean Variety**
	T1	**T2**	**T3**	**T4**	
V1	761.00 efg	800.40 ef	626.43 f-i	657.56 e-i	711.35 C
V2	1431.47 b	1443.20 b	1060.00 c	1012.00 cd	1236.67 A
V3	1774.40 a	1099.20 c	1203.60 c	1008.00 cd	1271.30 A
V4	1182.40 c	719.60 efg	852.00 de	750.40 efg	876.10 B
V5	798.40 ef	603.20 f-i	570.40 ghi	591.20 f-i	640.80 C
V6	466.67 hi	666.66 efgh	448.00 i	186.00 j	441.83 D
Mean Treatment	1069.06 **A**	888.71 **B**	793.41 **BC**	700.86 **C**	
S2					
Variety	**Treatment**				**Mean Variety**
	T1	**T2**	**T3**	**T4**	
V1	835.20 fgh	870.80 efgh	755.73 ghi	776.15 fghi	809.47 D
V2	1416.80 b	1432.00 b	1171.73 cd	1022.00 de	1260.63 B
V3	2028.80 a	1292.80 bc	1441.60 b	1116.80 d	1470.00 A
V4	1334.40 bc	822.40 fgh	921.07 efg	726.40 hij	951.07 C
V5	939.20 ef	514.00 k	632.93 ijk	557.00 k	660.78 E
V6	522.67 k	733.33 hi	564.00 jk	270.00 l	522.50 F
Mean Treatment	1179.51 **A**	944.22 **B**	914.51 **B**	744.73 **C**	

Differences in mean values within rows/columns followed by at least one letter in common are not significant according to Duncan's multiple range test at $p \leq 0.05$.

4. Effect of picking treatments on okra seed quality

For the cultivar effect, all cultivars had comparable seed vitamin C content (g/100g) except for V2 which had the lowest content among the studied cultivars (Table 10). For the treatment effect, no significant differences were found in seed vitamin C content among the different treatments with fairly higher vitamin C contents in T1, followed by T2, than the other treatments (Table 10). As for the interaction effect, there were no significant differences in seed vitamin C in most of the treatments within each cultivar. However, V4T1 consistently had significantly higher vitamin C content than V4T4 in both seasons (Table 10).

Concerning the seed phenols content, okra seeds treated with T4 had higher contents than other treatments but it was not significantly different from T1 in both seasons (Table 11). For the variety effect, V5 had the highest total phenol content in the study but it was not significantly different from V1, V2, or V3 (Table 11).

Table 10. Seed vitamin C content (g/100g of seed flour) of six okra varieties as affected by different green pod pickings

S1					
Variety	**Treatment**				**Mean**
	T1	**T2**	**T3**	**T4**	**Variety**
V1	0.411 bc	0.432 b	0.437 b	0.413 bc	0.423 A
V2	0.411 bc	0.341 cd	0.304 d	0.360 bcd	0.354 B
V3	0.373 bcd	0.413 bc	0.341 cd	0.512 a	0.410 A
V4	0.506 a	0.418 bc	0.394 bc	0.341 cd	0.415 A
V5	0.418 bc	0.424 b	0.413 bc	0.413 bc	0.417 A
V6	0.418 bc	0.418 bc	0.413 bc	0.376 bcd	0.406 A
Mean Treatment	0.423 **A**	0.408 **A**	0.384 **B**	0.403 **AB**	
S2					
Variety	**Treatment**				**Mean**
	T1	**T2**	**T3**	**T4**	**Variety**
V1	0.413 bc	0.403 bc	0.397 bc	0.410 bc	0.406 A
V2	0.413 bc	0.339 cde	0.301 e	0.312 de	0.341 B
V3	0.379 bcd	0.410 bc	0.339 cde	0.424 b	0.388 A
V4	0.496 a	0.419 b	0.363 bcde	0.339 cde	0.404 A
V5	0.419 b	0.424 b	0.411 bc	0.411 bc	0.416 A
V6	0.419 b	0.413 bc	0.501 a	0.357 bcde	0.423 A
Mean Treatment	0.423 **A**	0.401 **AB**	0.385 **AB**	0.376 **B**	

Differences in mean values within rows/columns followed by at least one letter in common are not significant according to Duncan's multiple range test at $p \leq 0.05$.

Table 11. Seed total phenols content (mg/100 g) of six okra cultivars collected at different green pod pickings

S1					
Variety	**Treatment**				**Mean**
	T1	**T2**	**T3**	**T4**	**Variety**
V1	472.37 abc	364.27 bcdef	260.91 d-i	141.41 ghi	309.74 AB
V2	408.26 abcd	311.07 c-h	137.00 hi	390.27 bcde	311.65 AB
V3	401.74 abcd	197.62 d-i	237.56 d-i	535.48 ab	343.10 AB
V4	99.87 i	296.77 c-i	259.85 d-i	353.95 b-g	252.61 B
V5	594.46 a	184.17 efghi	348.80 b-h	474.61 abc	400.51 A
V6	156.68 fghi	335.79 b-h	163.30 fghi	498.29 abc	288.52 B
Mean Treatment	355.56 **AB**	281.62 **BC**	234.57 **C**	399.00 **A**	
S2					
Variety	**Treatment**				**Mean**
	T1	**T2**	**T3**	**T4**	**Variety**
V1	440.61 ab	428.06 abc	221.29 c-h	140.20 fgh	307.54 AB
V2	395.85 abcd	324.34 bcdef	98.50 gh	364.89 abcde	295.89 AB
V3	387.04 abcd	177.42 efgh	197.79 defgh	416.83 abc	294.77 AB
V4	78.72 h	276.84 b-h	177.27 efgh	308.62 b-g	210.36 B
V5	551.35 a	161.99 efgh	290.82 b-g	422.40 abc	356.64 A
V6	154.52 fgh	295.44 b-g	127.42 fgh	447.64 ab	256.26 B
Mean Treatment	334.68 **A**	277.35 **A**	185.52 **B**	350.09 **A**	

Differences in mean values within rows/columns followed by at least one letter in common are not significant according to Duncan's multiple range test at $p \leq 0.05$.

The interaction effect showed differential responses of cultivars to different treatments regarding total phenols content of seeds (Table 11). For example, seeds of V3T4, V4T4, and V1T1 consistently had the highest total phenols content

within V3, V4, and V1, respectively (Table 11). In general, the significantly highest total phenols contents were recorded in V5T1 in the two seasons (Table 11).

As regard to seed pH, T2 seeds had significantly the highest pH in both seasons (Table 12). The interaction effect however showed differential responses of varieties to the picking treatments. For instance, seeds of V1T2 and V3T2 had significantly higher pH than the other treatments within each variety in the two seasons (Table 12). Also, seeds of V4T1 had significantly higher seed pH than in V4T3 and V4T4 in the two seasons (Table 12).

Table 12. Seed pH of six okra varieties collected at different green pod pickings

S1					
Variety	**Treatment**				**Mean Variety**
	T1	**T2**	**T3**	**T4**	
V1	7.300 h	7.520 a	7.460 bcd	7.463 bc	7.436 A
V2	7.326 gh	7.516 a	7.240 i	7.413 de	7.374 B
V3	7.420 cde	7.496 ab	7.390 ef	7.423 cde	7.433 A
V4	7.436 cde	7.426 cde	7.026 l	7.106 k	7.249 C
V5	7.053 l	7.350 fg	7.446 cd	7.150 j	7.249 C
V6	7.523 a	7.513 a	7.290 h	7.430 cde	7.439 A
Mean Treatment	7.343 **B**	7.470 **A**	7.309 **C**	7.331 **BC**	
S2					
Variety	**Treatment**				**Mean Variety**
	T1	**T2**	**T3**	**T4**	
V1	7.450 c	7.523 b	7.613 a	7.420 cd	7.502 A
V2	7.390 def	7.400 cde	7.390 def	7.350 efg	7.383 C
V3	7.330 g	7.530 b	7.420 cd	7.410 cd	7.423 B
V4	7.450 c	7.350 efg	7.040 j	7.010 j	7.213 F
V5	7.323 g	7.346 efg	7.246 h	7.226 hi	7.286 E
V6	7.376 defg	7.533 b	7.183 i	7.336 fg	7.357 D
Mean Treatment	7.387 **B**	7.447 **A**	7.316 **C**	7.292 **D**	

Differences in mean values within rows/columns followed by at least one letter in common are not significant according to Duncan's multiple range test at $p \leq 0.05$.

Discussion

As a vegetable crop, picking frequency of okra will affect its green fruit yield (Maury *et al.,* 2013), and will consequently influence its seed yield and quality. Therefore, we studied four picking treatments of green okra pods of six varieties to determine their effects on the seed yield and some of their quality (vitamin C, total phenols, and pH).

In our study, picking treatments did not affect average weight of green pod, length of green pods, or the diameter of green pods (except for T2 in season 1) as pods were regularly picked every 2 days. As expected, the number of green pods was the highest in T4 since it had the highest number of pickings in the experiment with the highest numbers in V1T4, followed by V6T4. Similar observation by El-Shaikh *et al*., 2019 showed that increasing pickings frequency (from 3 pickings to full pickings) significantly increased number of fresh fruits/plant, but the fresh fruit yield/plant was also increased in their experiment.

Regardless the picking treatment, the highest number and longest green pods in our experiment were consistently noted in 'Pusa Sawani' followed by hybrid 'Nokh', while 'Emerald' and 'Baladi Assiut' varieties always had the widest pods. This observation shows that genotypic variations among the studied okra varieties have a vital effect on the average weight, number, diameter, and length of the collected green pods. This comes in agreement with the information that fruit diameter and length characteristics are mostly genetically determined (Sobrado and Turner, 1986), and should not be affected by fruit load on plant (Muhammadi *et al.*, 2015).

In the present experiment, plants of 'Emerald' followed by 'Baladi Assiut' were significantly the tallest plants, whereas the number of branches was consistently the highest in 'Beghera Iraqi' in both seasons. Regarding the picking treatment, plants of T3 in the present study were significantly and consistently taller than T1 in both seasons. The picking treatment, however, did not affect number of branches/plant (except for T1 in season 2). In accordance with our results, 3, 5, and full picking treatments of okra fruits gave the tallest plants, whereas the shortest plants were recorded with no fruit picking treatment (El-Shaikh *et al.*, 2019). Other study showed inconsistent effect of fruit load on okra plants height with clear variability among the different cultivars in terms of plant height (Mohammadi *et al.*, 2015). Regarding the number of branches, observations reported by El-Shaikh *et al*., 2019 were contradictory to our findings as full fruit pickings in their experiment resulted in the highest number of branches/plant while no fruit pickings resulted in the lowest number of branches/plant.

The present study showed that 'Eskandarany', followed by 'Emerald', always had higher number of dry pods, weight of pods/plant, and seed weight (kg/feddan). As for the treatment effect, plants of T1 always had higher number of dry pods, weight of pods/plant, and seed weight (kg/feddan). That was followed by T2 for the weight of dry pods/plant and for the seed yield (kg/feddan). Our results confirm that no picking treatment (followed by two picking treatment) were the best options for seed production. Talukder *et al.*, (2003) found that okra yield was gradually reduced with higher number of picking intervals. This happens because short picking intervals stimulate the plant to produce higher number of fruits per plant while long picking intervals increase the fruit weight and size which results in higher fruit yields (Talukder *et al.*, 2003). However, retention of the pods on plants until maturation was found to reduce pod set in okra (Muhammadi *et al.*, 2015). In contrary to our results, Singh *et al*., 2012, found that number of fruits/plant and seed yield of okra was the maximum in the three picking treatments, whereas the lowest seed yield was obtained in the one picking treatment (Singh *et al.*, 2012).

In a study on okra by Sanganagoud *et al.*, 2014, the authors found that the number of pickings (zero, one, two, three pickings) significantly affected seed yield per hectare (Sanganagoud *et al.*, 2014). Their highest values for the number of dry fruits/plant, seed yield/plant, and seed yield/hectare was recorded in the two picking treatment, whereas the lowest was in the three picking treatment (Sanganagoud *et al.*, 2014). However, in a study by Moniruzzaman and

Quamruzzaman, 2009 where six green fruit picking treatments were used (no picking, first two, first four, first six, first eight, and first ten picking), picking of first 4 green fruits treatment resulted in the highest seed yield (Moniruzzaman and Quamruzzaman, 2009).

Little information is available regarding the effect of pickings green pods on seed quality of okra such as its phenolic and vitamin C contents, and seed pH. In a study by Mohammadi *et al.*, (2015), the authors concluded that seed quality (seed moisture content and seed germination) was not affected by fruit load in okra plants (Mohammadi *et al.*, 2015). In our study, all varieties had comparable seed vitamin C content, except for 'Emerald' which had the lowest seed vitamin C content. Also, T1 followed by T2 had higher seed vitamin C than other treatments.

As for the treatment effect on phenolic contents, okra seeds of T4, followed by T1 had higher total phenols. For the variety effect,'Beghera Iraqi' had the highest total phenolic content in the study. In the present study, values of total phenolic content in okra seed extracts are in the range reported in other studies 142.8-2810 mg GAE /100g extract (Khomsug *et al.*, 2010; Hu *et al.*, 2014). Other reports attributed the differences in phenolic content in okra to the genotype and the growing conditions (Petropoulos *et al.*, 2017). Our findings suggest that the picking treatment may also have an effect on the total phenolic contents of okra seeds.

Results of our experiment show that seeds of T1 and T2 had higher vitamin C content, pH value, whereas, T1 and T4 had higher total phenols. However, seed quality is affected by genotypic variation and by the different treatment X pickings combinations.

Conclusions

From the observations of the present study, we can conclude that okra plants with no green fruit picking, as compared to two, four, and six fruit pickings, can be the best option for seed production due to the observed higher number of dry pods, weight of pods/plant, seed yield and quality. The combination of 'Eskandarany' variety with no picking treatment followed by the combination of 'Emerald' variety with no or two pickings provided the highest seed yielding potential among all studied treatment and variety combinations.

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تأثر قدرة إنتاج البذور بقطف القرون الخضراء في ستة أصناف من البامية

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الملخص

نجاح إنتاج البذور يعتمد على الصـــنف المنزرع والظروف البيئية وعلى الممارســـات الزراعية. هناك معلومات ضـــئيلة متاحة عن تأثير معاملات قطف القرون الخضـــراء على إنتاج البذور في البامية. في هذه التجربة تمت الزراعة في موسمين زراعيين في 2019 2020 لدراسة تأثير معاملات قطف القرون الخضـراء (عدم جمع أي قرون'T1' ، أول جمعتين 'T2'، أول أربع جمعات T3'، وأول 6 جمعات 'T4' من القرون الخضراء) في 6 اصناف من البامية بوذا صواني 'V1'و اميرالد 'V2' وإسـكندراني 'V3' و بلدي أسـيوط 'V4' و باغيرا عراقي 'V5' و نوخ-1002 'V6' على نمو نباتات البامية و كمية و جودة المحصول البذري.

نتائج التجربة اثبتت أن النباتات التي لم يتم جمع أي قرون خضـراء بها كانت بها عدد أكبر من القرون الجافة وكان وزن القرون الجافة والوزن الكلي للبذور (كيلو جرام للفدان) أعلى عن باقي المعاملات وكان محتوى البذورمن فيتامين ســـي أكبر وأيضـــاً درجة الحموضـــة بها أعلى. وكانت معاملة قطف أول جمعتين من القرون الخضـــراء من البامية هي ثاني أفضـــل معاملة في التجربة. كما أن النباتات التي تم جمع أول ثلاث جمعات منها كانت أطول من التي لم يجمع منها أي قرون.

وجد اختلافات بالنسبة لتأثير معاملات القطف على الأصناف. نباتات صنف الاسكندراني التي لم يتم قطف منها أي قرون خضـــراء بالإضـــافة إلى نباتات صـــنف اميرالد التي تم أخذ منها جمعتين من القرون كانوا أفضـــل من حيث عدد القرون الجافة على النبات ووزن القرون الجافة على النبات ووزن البذورالكلي. يمكن من النتائج الســـابقة تلخيص أن معاملة عدم جمع أي قرون خضـــراء من نباتات البامية كانت الأفضـــل لإنتاج قرون جافة وإنتاج البذور وكذلك تحســـين جودة البذور.