Zagazig J. Agric. Res., Vol. 43 No. (6A) 2016

http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

GROWTH AND GREEN PODS YIELD OF OKRA PLANTS AS INFLUENCED BY PLANT SPACING AND APICAL BUD PINCHING

Abd El-Rahman M. Abd El-Hameed, Dalia A.S. Nawar, A.A. Gad and A. Bardisi*

Hort. Dept., Fac. Agric., Zagazig Univ., Egypt

ABSTRACT

The present work was carried out in Vegetable Private Farm at Al-Mothalath Village, Abou-Hamad Distrect, Sharkia Governorate during two successive summer seasons of 2014 and 2015, to study the effect of plant spacing (20, 30, 40 and 50 cm) and apical bud pinching (ABP) stages (ABP at the 4th node, the 6th node, 8th node and without ABP) on growth and productivity of okra cv Balady Ahmar under sand loam soil conditions and using surface irrigation system. Obtained results could be summarized as follow: Plant height and total green pods yield/fad., increased with the closest plant spacing (20 cm), whereas number of branches/ plant and leaf area, dry weight of leaves and total dry weight/plant, number of green pods/plant and green pod yield/ plant were increased with the widest plant spacing (50 cm). Number of leaves/ plant was increased with 40 cm plant spacing. The longest plants were recorded with the control treatment (without ABP), whereas ABP at the 4th node increased number of leaves/plant, dry weight of leaves and total dry weight/ plant and ABP at the 8th node increased number of branches/plant. On the other side, apical bud pinching at the 6th node (ABP at 35 days after seed sowing) increased number of green pods yield/plant, green pod yield/plant and total green pod yield/faddan. The interaction between plant spacing at 30 cm and ABP at the 6th node, increased number of leaves/plant, whereas the interaction between plant spacing at 50 cm and ABP at the 6th node increased number of branches / plant, dry weight of leaves and total dry weight/ plant, number of green pods / plant, green pod yield / plant in both seasons. The narrow plant spacing (20 cm) and ABP at the 6th node increased total green pod yield/faddan.

Key words: Okra, plant spacing, apical bud pinching, growth, branching, yield.

INTRODUCTION

Okra (*Abelmoschus esculentus* (L; Moench), is an important fruit vegetable crop of the tropical and subtropical regions of the world. In Egypt, it is one of the most popular vegetables and considered a valuable source of calcium, iron and vitamins. It has been grown for its edible green pods which can be used as fresh, canned, frozen, or dried food.

With respect to plant spacing, okra plants grown under wider spacing received more nutrients, light and moisture around each plant surrounding compared to plants of closer spacing. Which is probably the cause of better performance and yield of individual okra in wider spacing. Whereas, the plants grown under the closest spacing gave maximum yield of okra due to presence of more number of plants resulting in the highest total yield.

Plant density is one of the most important agronomic practices that affect okra seed production, it has been found to have an enhancing influence on growth characters, yielding ability and quality of seed (Khan and Jaiswal, 1998; Feleafel and Ghoneim, 2005).

Suitable plant spacing can lead to optimum yield, but incorrect plant spacing (too high or low plant spacing) could result in relatively low yield and poor quality fruits (Moniruzzaman *et al.*, 2007). So, optimum plant spacing can lead to optimum seed yield (Bin-Ishaq, 2009).

*** Corresponding author: Tel. :** +201271887153
E-mail address: aabdallabardisi@yahoo.com

Dense plant populations may result in groups growth, poor quality fruits and low yield due to intra specific competition (Talukder *et al.*, 2003).

Respecting apical bud pinching (ABP), pinching is the removal of apical tip of plant and is a very common practice in some of vegetables like okra for inhibiting terminal growth and promoting lateral growth that increases the potential poding area (Gujar and Srivastava, 1972).

Apical dominance is a used to describe the mechanism by which the apex of a shoot inhibits the outgrowth of secondary of lateral shoots (Cline, 1997). It has been suggested that the phytohormone auxin is involved in the process. This is supported by findings that high levels of the bioactivate form, indole 3- acetic acid (IAA), are produced in the apex and transported basipetally along the stem, where the lateral shoots buds reside. Decapitation removes the apical source of IAA and stimulates lateral bud outgrowth (Dun *et al*., 2006).

Okra plants are stopped by pinching, *i.e.*, removing the apical buds at six weeks after seed sowing .This results in the outgrowth of lateral shoots that grow upwards to replace the main shoots. Each shoot thus produces flowers and later fruits in the axils of the leaves. This technique of pruning therefore results in increased yields (Norman, 1992). A wider spacing may have to be used if the plants are pruned promoted which results in cell division, enabling the bud or branch to continue outward growth (Cline, 1994).

Growth, productivity, and seed quality of okra are increased with pinching at early compared to later stages of growth, providing sufficient time for regeneration of vegetative parts, enhancing production of branches, and also resulting in increased photosynthetic activity, accumulation of more photosynthates, and ultimately resulting in increased seed size and yield (Patil *et al.*, 2012).

Therefore, the aim of this study was to determine the suitable plant spacing and apical bud pinching stages to obtain maximum green pod yield with good quality and seed yield of okra grown under sand loam soil conditions using surface irrigation system.

MATERIALS AND METHODS

The present work was carried out in Vegetable Private Farm at Al-Mothalath Village, Abou-Hamad Distrect, Sharkia Governorate during two successive summer seasons of 2014 and 2015, to study the effect of plant spacing (20, 30, 40 and 50 cm) and apical bud pinching (ABP) stages (ABP at the 4^{th} node, the 6^{th} node, 8^{th} node and without ABP) on growth and productivity of okra cv Balady Ahmar under sandy loam soil conditions and using surface irrigation system.

The soil was sandy loam in texture, it comprised of 29.95 clay, 60.6% sand and 9.25% silt (average of two seasons).

This experiment included 16 treatments which were the combinations between four plant spacings (20, 30, 40 and 50 cm) and four ABP stages (without ABP, ABP at the 4^{th} node, ABP at the 6^{th} node, and. ABP at the 8^{th} node). These treatments were arranged in a split plot in a complete randomized block design with three replicates. Plant spacings were randomly arranged in the main plots and ABP stages were randomly distributed in the sub plots.

Okra plants were pinched manually by removing the apical shoots at 30, 35 and 40 days after seed sowing for leaving 4, 6 and 8 nodes, respectively.

The experimental unit area was 10.5 m^2. It contains three ridges with 5m length and 70 cm distance between each two ridges. One ridge was used to measure the morphological traits and the other two ridges were used for yield determinations (one ridge for green pods yield determination and the other for seed yield determination).

The seeds of okra cv. Balady (Ahmar) were sown on 27^{th} March in the 1^{st} season and 1^{st} March in the 2^{nd} season. Seeds were sown on north side of the ridge.

The source of cv. Balady (Ahmar) was Mecca Trade co., Cairo, Egypt). The source of nitrogen, potassium and phosphorus fertilizers were ammonium sulphate (20.5% N) at 200 kg/fad., potassium sulphate (48% K_2O) at 150 kg/fad., and calcium superphosphate (15.5% P_2O_5) at 300 kg/fad., respectively.

All plants were fertilized with ammonium sulphate and potassium sulphate as soil application at 30 and 45 days after seed sowing. All experimental units received equal amounts of FYM at 20 m^3/fad., and calcium superphosphate during soil preparation.

The other agricultural practices for okra production were used according to the instruction laid down by the Ministry of Agriculture, Egypt.

Data Recorded

Plant growth

A sample of two plants from each experimental unit were randomly taken at 120 days after seed sowing and the following data were recorded: Plant height, No. of leaves/plant, No. of branches/plant, relative branching (%) and leaf area /plant.

The different plant parts; *i.e.,* leaves and branches were oven dried at 70°C till constant weight and the following data were recorded: Dry weight of branches/ plant, dry weight of leaves / plant, total dry weight / plant (leaves+ branches) and, relative total dry weight.

Green pods yield

Green pods of okra were picked at two days intervals beginning of 27th May till 2nd Sep. in the 1st season and beginning of 2nd May till 29th July in the 2nd season, counted and weighed. Also, green pods on lateral branches which formed on bottom of the main stem in the end of the season were picked beginning of 15th August in the 1st season and beginning of 3rd July in the 2nd season, counted and weighed. The following data were recorded: No. of green pods/ plant, average green pod weight, green pods yield/plant, total green pods yield/fad., and relative green pods yield.

Statistical Analysis

Statistical analysis was conducted for all collected data. The analysis of variance was (ANOVA) calculated according to Snedecor and Cochran (1980), means separation was done according to LSD at 0.05 level.

RESULTS AND DISCUSSION

Plant Growth

Morphological characters

Effect of plant spacing

Presented data in Table 1 show that plant spacings (20,30,40 and 50 cm) had significant effect on plant height, number of both leaves and branches/ plant and leaf area/plant, in both season except plant height in the 1st season, which was not significantly affected. Sowing seeds of okra at 20 and 30 cm (narrow spacing) gave the longest plants in both seasons without significant differences between them. Sowing at 40 cm gave the highest values of number of leaves/ plant with no significant differences with narrow spacing (20 cm), whereas sowing seeds at 50 cm (the widest plant spacing) increased number of branches / plant and leaf area in both seasons. Number of branches / plant was increased with increasing plant spacing up to 50 cm. the increases in number of branches / plant were about 40.73 and 45.35% for widest plant spacing (50 cm) over the narrow spacing (20 cm) in the 1st and 2nd seasons, respectively.

From the foregoing results, it could be concluded that, plant height increased with closet plant spacing (20 cm), whereas number of branches / plant and leaf area / plant were increased with widest plant spacing (50 cm). Number of leaves / plant was increased with plant spacing at 40 cm. Obtained results are in harmony with those reported by Maurya *et al.* (2013), Baw (2014), El-Waraky (2014), Mushayabasa *et al.* (2014) and Aliyu and Ajala (2016). They found that wider spacing increased number of leaves, leaf area and number of branches / okra plant.

Effect of ABP

Apical bud pinching (ABP) of okra main stem at different stages reflect a significant effect on plant height, number of both leaves and branches/plant, and leaf area (Table 1). Without ABP recorded the longest plants in both seasons, whereas, ABP at the 4th node (ABP at 30 days after seed sowing) increased number of leaves/plant during both seasons and leaf area in the 1st season and ABP at the 8th node (ABP at 40 days after seed sowing) increased number of branches/plant in both seasons.

Table 1. Effect of plant spacing and apical bud pinching stages on morphological characters of okra plants at 120 days after seed sowing during summer seasons of 2014 and 2015

Character	Plant height (cm)		Number of leaves/ plant		Number of branches / plant		Leaf area/ plant (m^2)		Relative branching (%)	
Treatment	**2014 season**	**2015 season**	**2014 season**	**2015 season**	**2014 season**	**2015 season**	**2014 season**	**2015 season**	**2014 season**	**2015 season**
					Effect of plant spacings (cm)					
20 cm	181.75	192.75	63.41	60.75	4.91	4.41	1.004	0.943	100.0	100.0
30 cm	178.66	199.16	51.41	45.00	5.16	4.66	0.981	1.102	125.45	105.61
40 cm	175.33	183.50	66.00	69.66	6.33	5.08	1.045	1.096	128.92	115.19
50 cm	183.08	179.16	62.91	51.91	6.91	6.41	1.365	1.077	140.73	145.35
LSD at 0.05 level	NS	14.02	8.45	9.18	1.14	1.23	0.088	0.078	--	--
					Effect of apical bud pinching stages					
Without ABP	192.16	210.16	52.33	48.66	3.83	2.75	0.988	1.172	100.0	100.0
ABP at the 4th node	173.50	170.58	72.25	79.16	6.16	5.58	1.177	0.973	160.83	202.90
ABP at the 6th node	179.08	172.50	67.41	47.50	5.91	3.91	1.135	1.143	154.30	142.16
ABP at the 8th node	174.08	210.33	51.75	52.00	7.41	8.33	1.095	0.931	193.74	302.90
LSD at 0.05 level	11.46	7.35	6.91	7.55	1.49	1.04	0.036	0.028	--	--

ABP: apical bud pinching

Number of branches/plant increased with ABP at different stages compared to the control. The increases in number of branches/plant were about 93.47 and 202.90% for ABP at the 8th node (ABP at 40 days after seed swing) over the control (without ABP) in the 1st and 2nd seasons, respectively.

From the foregoing results, it could be concluded that, without ABP recorded the longest plants, whereas ABP at the 4th node increased number of leaves and ABP at the 8th node increased number of branches in both seasons.

Effect of the interaction between plant spacing and ABP

The interaction between plant spacings and ABP had significant effect on plant height, number of leaves/ plant, number of branches/ plant, and leaf area (Table 2). In general, ABP at different stages increased number of branches/ plant under different plant spacings (20,30, 40 and 50 cm) compared to the control (without ABP) under the same plant spacings, whereas, ABP at different stages decreased plant height under different plant spacings (20, 30, 40 and 50 cm) compared to the control (without ABP) under the same plant spacings.

The interaction between plant spacings at 30 cm and ABP at the 6th node increased number of leaves/plant in the second season and the interaction between plant spacing at 50 cm and ABP at the 6th and at the 8th node increased number of branches/plant, whereas, the interaction between plant spacing at 40 cm and ABP at the 8th node increased leaf area with no significant differences with the most treatments.

The increases in number of branches/ plant were about 211 and 200% for the interaction between plant spacing at 50 cm and ABP at the 6th node over the plant spacing at 20 cm and without ABP (control) in 1st and 2nd seasons, respectively.

Table 2. Effect of the interaction between plant spacing and apical bud pinching stages on morphological characters of okra plants at 120 days after seed sowing during summer seasons of 2014 and 2015

Treatment	Character	Plant height (cm)		Number of leaves/ plant		Number of branches/ plant		Leaf area/ plant (m^2)		Relative branching (%)	
Spacing	Pinching	2014 season	2015 season	2014 season	2015 season	2014 season	2015 season	2014 season	2015 season	2014 season	2015 season
20 cm	Without ABP	191.00	208.00	62.66	57.00	3.00	3.00	0.833	1.037	100.0	100.0
	ABP at the 4th node	189.00	221.33	34.33	35.00	1.66	1.66	1.056	1.365	55.33	55.33
	ABP at the 6th node	190.33	210.00	67.33	62.33	4.33	2.66	0.944	1.238	144.33	88.66
	ABP at the 8th node	198.33	201.33	45.00	40.33	6.33	3.66	1.117	1.163	211.00	122.00
30 cm	Without ABP	182.66	184.00	85.00	83.33	1.66	3.66	1.741	0.929	55.33	122.00
	ABP at the 4th node	181.66	190.33	63.33	59.00	6.33	5.00	1.014	0.935	211.00	166.66
	ABP at the 6th node	160.00	156.33	73.66	105.33	6.66	5.66	1.031	1.135	222.00	188.86
	ABP at the 8th node	169.66	151.66	67.00	69.00	7.00	8.00	0.923	0.891	233.33	266.66
40 cm	Without ABP	170.66	180.00	69.00	48.33	4.66	3.66	0.730	1.035	155.33	122.00
	ABP at the 4th node	178.33	183.66	56.33	45.00	4.66	4.33	0.989	1.187	222.00	144.33
	ABP at the 6th node	177.00	163.66	57.66	52.00	5.00	3.00	0.670	1.048	16666	100.00
	ABP at the 8th node	190.33	162.66	56.66	44.66	9.33	4.66	2.149	1.300	311.00	155.33
50 cm	Without ABP	182.66	199.00	37.00	54.33	7.33	7.33	0.713	0.770	244.33	244.33
	ABP at the 4th node	165.66	201.33	51.66	41.00	8.00	7.66	0.863	0.921	266.66	255.33
	ABP at the 6th node	174.00	204.00	65.33	59.00	9.33	9.00	1.535	1.079	311.00	300.00
	ABP at the 8th node	174.00	201.00	53.00	53.66	5.00	9.33	1.271	0.954	166.66	311.00
LSD at 0.05 level		22.92	14.70	13.82	15.1	2.98	2.08	0.072	0.056	--	--

ABP: apical bud pinching

Dry weight

Effect of plant spacing

Plant spacings (20, 30, 40 and 50 cm) had significant effect on dry weight of branches, leaves and total dry weight/plant, except dry weight of branches in the 1st season (Table 3). In the 1st season, plant spacing at 50 cm tended to decrease dry weight of branches/plant, but it increased the total dry weight/ plant, whereas in the 2nd season, plant spacing at 40 cm increased dry weight of leaves and total dry weight/ plant. Total dry weight/plant was increased with increasing plant spacings.

From these results, it could be concluded that plant spacing at 40 and 50 cm increased dry weight of leaves and total dry weight/ plant.

The stumulative effect of plant spacings at 40 and 50 cm on total dry weight may be due to that plant spacing at 40 cm increased number of leaves / plant and plant spacing at 50 cm increased number of branches/plant (Table 1).

Effect of ABP

Apical bud pinching (ABP) at different stages had significant effect on dry weight of branches, leaves and total dry weight/ plant, during the two seasons of study (Table 3), except dry weight of branches in the 1st season.

In the 1st season, ABP at the 4th node (ABP at 30 days after seed sowing) increased dry weight of leaves and total dry weight/ plant, whereas, in the second season ABP at the 6th node increased dry weight of, leaves and total dry weight/ plant.

From these results, it could be concluded that ABP at the 4th node or at the 6th node increased dry weight of leaves and total dry weight/ plant, with no significant differences in the ABP at the 8th node (ABP at 40 days after seed sowing)

The stumulative effect of ABP at the 4th node on dry weight of levaes and total dry weight / plant may be due to that ABP at the 4th node increased number of leaves /plant (Table 1).

In this regard, Patil *et al*. (2012) indicated that growth of okra was increased with pinching at early compared to later stages of growth, providing sufficient time for regeneration of vegetative parts, enhancing production of branches.

These results agree with Abduljabbar *et al*. (2007) they found that apical bud topping (pinching) of okra cv. Karkukllia exerted a significant effect on fresh, dry weight/plant and number of branches/ plant only, but the effect on the plant height, plant dry weight and stem diameter was insignificant. Also, Ahmad *et al.* (2016) studied the effect of three pinching types (no pinching, single pinching at 45 days after seed sowing and double pinching of okra), they found that single pinched plants were recorded with larger canopy spread. Whereas the maximum number of primary branches/plant and secondary branches/plant were recorded with double pinching.

Effect of interaction between plant spacing and ABP

The interaction between plant spacings and ABP had significant effect on dry weight of branches, leaves and total dry weight/ plant in both seasons (Table 4).

The interaction between plant spacings at 50 cm and ABP at the 6th node increased dry weight of leaves and total dry weight/ plant with no significant differences with the interaction between plant spacings at 40 cm and ABP at the 6th node and with the interaction between plant spacings at 30 cm and without ABP (control) in the 2nd season.

The increases in total dry weight/plant were about 29.3 and 15.9% for the interaction between plant spacing at 50 cm and ABP at the 6th node over the plant spacing at 20 cm and without ABP (control) in 1st and 2nd seasons, respectively.

The stumulative effect of the interaction between plant spacings at 50 cm and ABP at the 6th node on dry weight of branches/plant may be due to that this interaction increased number of branches/plant (Table 2).

Green Pods Yield

Effect of plant spacing

The obtained results in Table 5 show that plant spacings (20, 30, 40 and 50 cm) had significant effect on number of green pods/plant, green pods yield/plant and total green pods/fad., in both seasons, and had no significant effect on average green pod weight in both seasons.

Number of green pods/ plant and green pods yield/plant were increased with increasing plant spacing. These means that the widest plant spacing (50 cm) recorded the maximum values of number of green pods/ plant and green pods yield/ plant, whereas, the closest plant spacing (20 cm) recorded maximum values of total green pods yield/faddan.

The widest plant spacing (50 cm) increased green pods yield/ plant may be due to that plant spacing at 50 cm increased number of branches/ plant (Table 1), dry weight of leaves and total dry weight/ plant (Table 3) and number of green pods/plant (Table 5), whereas the closest plant spacing increased total green pods yield/fad., may be due to that increased number of plants/ faddan.

The increases in green pods yield/plant were about 148.5 and 153.03% for plant spacing at 50 cm over the narrow plant spacing (20 cm) in 1st and 2nd seasons, respectively, whereas, the increases

Table 3. Effect of plant spacing and apical bud pinching stages on dry weight of okra plants at 120 days after seed sowing during summer seasons of 2014 and 2015

Character / Treatment	Dry weight of branches (g/ plant)		Dry weight of leaves (g/plant)		Total dry weight (g/ plant)		Relative total dry weight (%)	
	2014 season	2015 season	2014 season	2015 season	2014 season	2015 season	2014 season	2015 season
Effect of plant spacings (cm)								
20 cm	24.74	20.64	48.12	56.84	72.86	77.48	100.0	100.0
30 cm	24.08	25.18	54.37	63.05	78.45	88.24	107.7	113.9
40 cm	24.14	25.10	57.86	66.55	82.00	91.65	112.5	118.3
50 cm	23.77	24.17	64.52	63.50	88.30	87.67	121.2	113.2
LSD at 0.05 level	NS	1.71	2.78	2.45	3.51	2.48	--	--
Effect of apical bud pinching stages								
Without ABP	23.57	26.05	55.00	67.82	78.58	93.88	100.0	100.0
ABP at the 4th node	24.17	21.55	60.07	58.98	84.25	80.53	107.2	85.8
ABP at the 6th node	24.28	25.75	52.59	69.55	76.87	95.30	97.8	101.5
ABP at the 8th node	24.70	21.74	57.21	53.60	81.92	75.34	104.3	80.3
LSD at 0.05 level	1.06	0.90	1.82	1.55	1.92	1.69	--	--

ABP: apical bud pinching

Table 4. Effect of the interaction between plant spacing and apical bud pinching stages on dry weight of okra plants at 120 days after seed sowing during summer seasons of 2014 and 2015

Treatment / Character		Dry weight of branches (g/plant)		Dry weight of leaves (g/plant)		Total dry weight (g/plant)		Relative total dry weight (%)	
Spacing	**Pinching**	**2014 season**	**2015 season**	**2014 season**	**2015 season**	**2014 season**	**2015 season**	**2014 season**	**2015 season**
20 cm	**Without ABP**	24.00	20.90	53.70	63.03	77.7	83.93	100.0	100.0
	ABP at the 4th node	26.30	19.23	64.43	50.46	90.7	69.70	116.7	83.0
	ABP at the 6th node	23.23	21.06	33.33	64.36	56.5	85.43	72.7	101.8
	ABP at the 8th node	25.43	21.36	41.03	49.50	66.4	70.87	85.5	84.4
30 cm	**Without ABP**	22.60	29.10	53.10	70.80	75.7	99.90	97.4	119.0
	ABP at the 4th node	22.83	21.00	58.60	57.53	81.4	78.53	104.8	93.6
	ABP at the 6th node	27.20	27.40	57.83	71.03	85.0	98.43	109.4	117.3
	ABP at the 8th node	23.70	23.23	47.96	52.86	71.6	76.10	92.1	90.7
40 cm	**Without ABP**	25.83	27.86	55.13	68.90	80.9	96.77	104.1	115.3
	ABP at the 4th node	24.00	22.86	61.86	69.43	85.8	92.30	110.4	110.0
	ABP at the 6th node	22.16	27.96	43.16	72.10	65.3	100.07	84.0	119.2
	ABP at the 8th node	24.56	21.70	71.30	55.80	95.8	77.50	123.3	92.3
50 cm	**Without ABP**	21.86	26.36	58.10	68.56	79.9	94.93	102.8	113.1
	ABP at the 4th node	23.56	23.10	55.40	58.50	78.9	81.60	101.5	97.2
	ABP at the 6th node	24.53	26.56	76.03	70.70	100.5	97.27	129.3	115.9
	ABP at the 8th node	25.13	20.66	68.56	56.23	93.7	76.90	120.6	91.6
LSD at 0.05 level		2.12	1.80	3.64	3.10	3.84	3.38	--	--

ABP: apical bud pinching

Table 5. Effect of plant spacing and apical bud pinching stages on green pods yield and its components of okra plants during summer seasons of 2014 and 2015

Character / Treatment	Number of green pods/ plant		Average green pod weight (g)		Green pods yield/ plant (kg)		Total green pods yield/fad. (ton)		Relative total green pods yield (%)	
	2014 season	2015 season	2014 season	2015 season	2014 season	2015 season	2014 season	2015 season	2014 season	2015 season
Effect of plant spacings (cm)										
20 cm	85.32	102.35	5.11	4.99	0.435	0.511	12.43	14.60	100.0	100.0
30 cm	112.85	141.04	5.14	5.01	0.580	0.706	11.06	13.45	89.0	92.1
40 cm	140.42	179.32	5.22	5.02	0.733	0.900	10.47	12.86	84.2	88.1
50 cm	212.62	258.95	5.09	4.99	1.081	1.293	10.30	12.31	82.9	84.3
LSD at 0.05 level	3.34	5.75	NS	NS	0.018	0.013	0.23	0.20	--	--
Effect of apical bud pinching stages										
Without ABP	130.71	172.22	5.17	4.97	0.678	0.857	10.60	13.59	100.0	100.0
ABP at the 4th node	140.78	169.84	5.04	5.01	0.706	0.851	11.05	13.23	104.2	97.4
ABP at the 6th node	148.37	177.05	5.09	4.99	0.755	0.885	11.92	13.83	112.5	101.8
ABP at the 8th node	131.36	162.55	5.26	5.03	0.689	0.816	10.68	12.57	100.8	92.5
LSD at 0.05 level	2.55	2.94	0.10	NS	0.015	0.013	0.21	0.20	--	--

ABP: apical bud pinching

in total green pods yield/fad., were about 18.0 and 15.7% for narrow plant spacing (20 cm) over the widest plant spacing (50 cm) in 1st and 2nd seasons, respectively.

Okra plants grown under wider spacing received more nutrients, light and moisture around each plant surrounding compared to plants of closer spacing. Which is probably the cause of better performance and yield of individual okra in wider spacing. Whereas, the plants grown under the closest spacing gave maximum yield of okra due to presence of more number of plants resulting in the highest total yield.

Singh and Singh (2000) stated that, the establishment of optimum population per unit area of the field is essential to get maximum yield. Under conditions of sufficient soil moisture and nutrients, higher population is necessary to utilize all growth factors efficiently. The level of plant population should be such that maximum solar radiation is utilized. The full yield potential of an individual plant is fully exploited when sown at wider spacing. Yield per plant decreases gradually as plant population per unit area increases. However, the yield per unit area is increased due to efficient utilization of growth factors. High plant density brings out certain modifications in the growth of the plants for example, increase in plant height, reduction in leaf thickness, alteration in leaf orientation, and leaves become erect, narrow and are arranged at longer vertical intervals to intercept more sunlight.

Feleafel and Ghoneim (2005), Firoz *et al.* (2007), Moniruzzaman *et al*. (2007), Paththinige *et al*. (2008), Bin-Ishaq (2009), Ijoyah *et al.* (2010), Renato (2011), Ekwu and Nwokwu (2012) and Okunowo (2012) all came to similar results on okra.

In this regard, Zibelo *et al.* (2016) studied the effect of inter-row spacing (30, 45, 60 and 75

cm) and intra-row spacinng (15, 20, 25 and 30 cm) on growth and yield of okra. They showed that, days to pod setting, green pod length, diameter and weight were significantly affected by the main effects of inter-and intra-row spacing. Similarly, significant interaction effects of inter-and intra-row spacing were recorded for pods per plant, length of pod bearing zone, and green pod yield/ plant and/ ha. The highest green pod yield/ha was obtained from a spacing combination of 45 cm × 25 cm, being not significant from 45 cm × 30 cm spacing. Therefore, it can be concluded that okra could be planted at inter row spacing of 45 cm and intra row spacing of 25-30 cm in Humera area to maximize green pod yield.

Effect of ABP

Apical bud pinching at different stages had significant effect on number of green pods / plant, green pod yields / plant and total green pods / fad., in both seasons, and had no significant effect on average green pod weight in the second season only (Table 5)

Apical bud pinching at the 6th node (ABP at 35 days after seed sowing) increased number of green pods / plant, green pods yield / plant and total green pods/fad., in both seasons.

The increases in green pods yield/plant were about 12.5 and 1.8% for ABP at the 6th node over the control (without ABP) in 1st and 2nd seasons, respectively.

Apical bud pinching at the 6th node increased total green pods yield/fad., may be due to that ABP at 6th node increased dry weight of branches / plant and total dry weight / plant (Table 3) and increased number of green pods / plant (Table 5).

Okra plants are stopped by pinching, *i.e.*, removing the apical buds at six weeks after seed sowing. This caused in the outgrowth of lateral shoots that grow upwards to replace the main shoots. Each shoot thus produces flowers and later fruits in the axils of the leaves. This technique of pruning therefore results in increased yields (Norman, 1992)

Wenyonu *et al.* (2012) studied the effect of different stages of pruning (pruning at 35, 40 and 45 days after germination and no pruning) on yield and yield components of okra cv. Legon fingers and Legon Spineless. They indicated that the control plants produced the heaviest individual pods and the longest pods. Mean pod weight and length were reduced with subsequent pruning's. Pruning at 35 days after germination produced the highest number and weight of pods/plant and highest total yield.

Effect of the interaction between plant spacing and ABP

The interaction between plant spacings (20, 30, 40 and 50 cm) and ABP at different stages had significant effect on number of green pods/ plant, green pods yield / plant and total green pods/fad., except average green pod weight in second seasons only (Table 6).

The interaction between the widest plant spacings at 50 cm and ABP at the 6th node increased number of green pods / plant, green pod yields / plant in both seasons, whereas the interaction between the narrow plant spacing (20 cm) and ABP at the 6th node increased total green pods yield/fad., in both seasons.

The increases in total green pods/fad., were about 20.5 and 2.3% for the interaction between narrow plant spacing (20 cm) and ABP at the 6th node over the plant spacing at 20 cm and without ABP (control) in 1st and 2nd seasons, respectively.

The stumulative effect of the interaction between plant spacings at 50 cm and ABP at the 6th node on number of green pods / plant and green yield / plant may be due to that this interaction increased number of branches / plant (Table 1) and dry weight of leaves and total dry weight / plant (Table 4).

These results are in agreement with those obtained by Wenyonu *et al.* (2012). They found that plants grown at close spacing and subjected to pruning at 35 days after germination gave higher total yields and higher marketable yields than those grown at wide spacing and subjected to pruning.

Table 6. Effect of the interaction between plant spacing and apical bud pinching stages on green pods yield and its components of okra plants during summer seasons of 2014 and 2015

Treatment	Character	Number of green pods/ plant		Average green pod weight (g)		Green pods yield/plant (kg)		Total green pods yield/ fad. (ton)		Relative total green pods yield (%)	
Spacing	**Pinching**	**2014 season**	**2015 season**	**2014 season**	**2015 season**	**2014 season**	**2015 season**	**2014 season**	**2015 season**	**2014 season**	**2015 season**
20 cm	**Without ABP**	79.53	107.89	5.15	4.97	0.409	0.536	11.71	15.32	100.0	100.0
	ABP at the 4th node	85.34	100.02	5.10	5.00	0.435	0.500	12.43	14.30	106.1	93.3
	ABP at the 6th node	99.38	110.09	4.97	4.98	0.494	0.548	14.11	15.66	120.5	102.2
	ABP at the 8th node	77.02	91.42	5.22	5.02	0.402	0.459	11.49	13.12	98.1	85.6
30 cm	**Without ABP**	112.33	151.63	5.02	4.95	0.564	0.750	10.74	14.29	91.7	93.3
	ABP at the 4th node	111.50	137.23	5.08	5.00	0.567	0.686	10.79	13.07	92.1	85.3
	ABP at the 6th node	119.40	145.70	5.17	4.96	0.618	0.723	11.78	13.77	100.6	89.9
	ABP at the 8th node	108.17	129.60	5.30	5.13	0.573	0.665	10.92	12.66	93.3	82.6
40 cm	**Without ABP**	135.56	183.29	5.25	4.98	0.712	0.912	10.17	13.04	86.8	85.1
	ABP at the 4th node	149.20	183.91	5.09	5.05	0.759	0.929	10.85	13.27	92.7	86.6
	ABP at the 6th node	146.62	178.22	5.18	5.04	0.760	0.898	10.86	12.83	92.7	83.7
	ABP at the 8th node	130.31	171.86	5.37	5.01	0.700	0.862	10.00	12.31	85.4	80.4
50 cm	**Without ABP**	195.40	246.07	5.25	5.00	1.027	1.231	9.78	11.73	83.5	76.6
	ABP at the 4th node	217.07	258.20	4.91	4.99	1.065	1.289	10.14	12.28	86.6	80.2
	ABP at the 6th node	228.07	274.20	5.04	5.01	1.150	1.373	10.95	13.08	93.5	85.4
	ABP at the 8th node	209.93	257.33	5.16	4.97	1.082	1.278	10.31	12.17	88.0	79.4
LSD at 0.05 level		5.11	5.89	0.20	NS	0.031	0.026	0.42	0.40	--	--

ABP: apical bud pinching

REFERENCES

Abduljabbar, I.M., A. Ihsan and S. Salih (2007). Effect of sowing date, topping and some growth regulators on growth, pod and seeds yield of Okra (*Abelmoschus esculentus* L. Moench). Afr. Crop Sci. Conf. Proc., 8 : 473-478.

Ahmad, N., A. Rab, M. Sajid, Z. Ali and K. Ali (2016). Influence of pinching intensity and incremental nitrogen application on growth and yield of okra (*Abelmoschus esculentus* L. Moench). Int. J. Agric. Environ. Res., 2(1): 89-97.

Aliyu, U.1. and A.A. Ajala (2016). Effect of variety and plant density on growth and yield of okra (*Abelmoschus esculentus* L.) Moench). IOSR J. Agric. and Vet. Sci. (IOSR-JAVS), 9 (2): 38-42.

Baw, A.O. (2014). Effects of plant population and nitrogen rates on growth and yield of okra (*Abelmoscus esculentus* L. Moench) in gambella region, Western Ethiopia. M.Sc. Thesis, Haramaya Univ.

Bin-Ishaq, M.S. (2009). Effect of plant density and nitrogen fetilization on vegetative growth, seed yield and quality of okra plants.

Dep. Far. Sys. Technol. Fac. Appl. Sci., Seiyun Hadramout Univ. Sci. and Technol., YEMEN, 2 : 4.

Cline, M. (1994). The role of hormones in apical dominance. New approaches to an old problem in plant development. Physiologia Plantarum., 90: 230–237.

Cline, M.G. (1997). Concepts and terminology of apical dominance. Am. J. Bot., 84 : 1064–1069

Dun, E.A., F.B. James and B.C. Anne (2006). Apical dominance and shoot branching. divergent opinions or divergent mechanisms? Plant Physiol., 142 (3): 812–819.

Ekwu, L.G. and G.N. Nwokwu (2012). Effect of plant spacing and planting date on the growth and yield of okra (*Abelmoschus esculentus* L. Moench) in Abakaliki. Int. J. Agric. Rural Dev., 15 (2):1041-1048.

El-Waraky, Y.B. (2014). Effect of sowing date, plant density and phosphorus fertilization on seed yield of okra. Alex. J. Agric. Res., 59 (1) : 27-41.

Feleafel, M.N. and I.M. Ghoneim (2005). Effect of plant density and nitrogen fertilizing on vegetative growth, seed yield and quality of okra plants. J. Agric. and Env. Sci. Alex. Univ., Egypt, 4 (2): 24-36.

Firoz, Z.A., M.A. Islam, M. Mohiuddin and M. M. Rahman (2007). Yield and yield attributes of okra as influenced by lanting time and plant spacing in hill slope condition. Progress. Agric., 18 (2) : 67-73.

Gujar, K.D. and V.K. Srivastava (1972). Effect of maleic hydrazide and apical nipping on okra. Ind. J. Hort., 29 (1): 86-88.

Ijoyah, M.O., P.O. Unah and F.T. Fanen (2010). Response of okra (*Abelmoschus esculentus* L. Moench) to intra-row spacing in Makurdi, Nigeria. Agric. Biol. J. N. Am., 1 (6) : 1328-1332

Khan, A.R. and R.C. Jaiswal (1998). Effect of nitrogen, plant spacing and green fruit pickings in the seed production of okra (*Abelmoschus esculentus* L. Moench). Veg. Sci., 15 (1): 8 –14.

Maurya, R.P., J.A. Bailey and J.S.A. Chandler (2013). Impact of plant spacing and picking interval on the growth, fruit quality and yield of okra (*Abelmoschus esculentus* L. Moench). Am. J. Agric. and For., 1 (4): 48-54

Moniruzzaman, M., M.Z. Uddin and A.K. Choudhury (2007). Response of okra seed crop to sowing time and plant spacing in South Eastern hilly region of Bangladesh. Bangladesh J. Agri. Res., 32 (3): 393–402.

Mushayabasa, T., D. Kona and R. Gama (2014). Yield and fruit quality of okra (*Abelmoschus esculentus* L. Moench) in response to plant density. Int. J. Biosci., 5 (1): 449-454.

Norman, J.C. (1992). Tropical vegetables crops. Arthur H. Stockwell Ltd. Elms Court. Litracombe Devon.

Okunowo, B. (2012). Effects of Spacing on Growth and Yield of Nhae47-4 Okra Variety (*Abelmoscus esculentus* L. Moench). Federal Agric. Univ., Abeokuta.

Paththinige, S.S., P.S.G. Upashantha, R.M. Ranaweera and R.M. Fonseka (2008). Effect of plant spacing on yield and fruit characteristics of okra (*Abelmoschus esculentus* L. Moench). Tropical Agric. Res., 20: 336-342.

Patil, S.W., B.M. Aher, A.A. Sakure and A.B. Dahake (2012). Apical Bud Pinching in Okra (*Abelmoschus esculentus* L. Moench): A Rev. Seed Technol., 34 (1): 139-144.

Renato, F.M. (2011). Evaluation of Varieties and Cultural Practices of Okra (*Abelmoschus esculentus* L. Moench) for Prod. in Massachusetts.

Singh, N.P. and R.A. Singh (2000). Scientific crop production. Dehli-28.1st Ed., India, 170.

Snedecor, G.W. and W.C. Cochran (1980). Statistical Methods. Oxford and JBH Publishing Com. 7th Ed. 431.

Talukder, M.A.H., M.A. Munnaf, M.K. Alam, M.A. Salam and M.M.U. Amin (2003). Influence of sowing time, plant spacing and picking interval on the growth and the yield of okra. Pak. J. Biol. Sci., 6 (18): 1626-1630.

Wenyonu, D.K. J.C. Norman and N. Amissah (2012). Yield and yield components of okra (*Abelmoschus esculentus* L. Moench) as influenced by heading back and Intra-row spacing. Ghana J. Hort., 1013-26.

Zibelo, H., K.W. Tsadik and J.J. Sharma (2016). Effect of inter-and intra-row spacing on growth and yield of okra (*Abelmoschus esculentus* L. Moench) at Humera, Northern Ethiopia. J. Biol., Agric. and Health., 6 (3): 92-108.

تأثير مسافة الزراعة وتطويش البرعم الطرفى على نمو ومحصول القرون الخضراء لنباتات البامية

عبدالرحمن محمد عبدالحميد - داليا أحمد سامى نوار - عبدالمنعم عامر جاد - عبدالله برديسى

قسم البساتين - كلية الزراعة- جامعة الزقازيق - مصر

أجرى هذا العمل فى مزرعة خضر خاصة بقرية المثلث التابعة لمركز أبو حماد- محافظة الشرقية خلال الموسمين المتعاقبين لصيفي ٢٠١٤، ٢٠١٥ وذلك لدراسة تأثير مسافات زراعة (٢٠ ، ٣٠ ، ٤٠ و٥٠ سم)، ومراحل تطويش البرعم الطرفى وتطويش البرعم الطرفى عند العقدة الرابعة، عند العقدة السادسة، وعند العقدة الثامنة وبدون تطويش على النمو والانتاجية للباميا الصنف بلدى أحمر تحت ظروف الأرض الرملية الطميية واستخدام نظام الرى السطحى ويمكن تلخيص أهم النتائج كالتالى: إزداد كل من ارتفاع النبات ومحصول القرون الخضراء للفدان مع مسافة الزراعة الضيقة (٢٠ سم)، بينما ازداد كل من عدد الأفرع للنبات، ومساحة أوراق النبات ، الوزن الجاف للأوراق والوزن الجاف الكلى للنبات، عدد القرون الخضراء على النبات، ومحصول النبات مع مسافة الزراعة الواسعة (٥٠ سم)، كما ازدادت عدد الأوراق/ نبات مع مسافة الزراعة ٤٠ سم، سجلت أطول النباتات مع معاملة الكنترول (بدون تطويش للبرعم الطرفى)، بينما ازداد عدد الأوراق/ نبات، الوزن الجاف للأوراق والوزن الجاف الكلى للنبات بتطويش البرعم الطرفي عند العقدة الرابعة ، كما ازداد عدد الأفرع للنبات بالتطويش عند العقدة الثامنة، على الجانب الآخر فقد ازداد عدد القرون الخضراء على النبات، ومحصول القرون الخضراء النبات ومحصول القرون الخضراء/ الفدان بتطويش البرعم الطرفي عند العقدة السادسة، أدى التفاعل بين مسافة الزراعة ٣٠ سم وتطويش البرعم الطرفى عند العقدة السادسة إلى زيادة في عدد الأوراق/ نبات، وكذلك أدى التفاعل بين مسافة الزراعة ٥٠ سم وتطويش البرعم الطرفى عند العقدة السادسة إلى زيادة عدد الأفرع للنبات، الوزن الجاف للأوراق والوزن الجاف الكلى للنبات، عدد القرون الخضراء على النبات، ومحصول النبات، بينما أدى التفاعل بين مسافة الزراعة الضيقة (٢٠ سم)، وتطويش البرعم الطرفى عند العقدة السادسة إلى زيادة محصول الفدان من القرون الخضراء.

المحكمـــــون:

١- أ.د. فتحي أبو النصر أبو سديرة أستاذ الخضر المتفرغ – كلية الزراعة بمشتهر – جامعة بنها.

٢- د. هاني السيد محمد علي الدوة أستاذ الخضر المساعد – كلية الزراعة – جامعة الزقازيق.