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GROWTH AND PRODUCTIVITY OF SOME EGGPLANT CULTIVARS AS AFFECTED BY DIFFERENT PLANT SPACINGS

Doaa R. Abou Al-Azm*, A.A. Gad, H.G. Zyada and H.E.M.A. Ismail

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

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ABSTRACT: This work was carried out at Vegetable Private Farm at Bani Amer Village, Zagazig Distract, Sharkia Governorate, Egypt during the two successive summer seasons of 2017 and 2018, to study the performance of ten eggplant genotypes; *i.e*., Little Fingers (L.F.), Ping Tung (P.T.), Antigua (An.), Aswad (As.), Japanese White Egg (J.W.E.), Apple Green (A.G.), Rotonda Bianca Stumata di Rosa (R.B.S.), Korean Red (K.R.), Black Oblong (B.O.) and Black very Long (B.V.L.); under three intra- row plant spacings, (30, 45 and 60 cm). The ten cultivars were evaluate in clay soil and surface irrigation. The ten cultivars were evaluated transplanting R.B.S. and B.V.L. *cvs.* at 45 cm gave the tallest plants. Transplanting A.G. and K.R. *cvs.* at 60 cm increased number of branches and number of leaves/ plant without significant differences between each other the case of number of branches/ plant in both seasons. Transplanting K.R. and B.O. *cvs.* at 60 cm increased leaf area and dry weight of leaves, respectively. However, transplanting R.B.S. *cv.* at 60 cm increased both chlorophyll a, b and total chlorophyll (a+b) in leaf tissues, While the interaction between transplanting K.R. *cv.* on spacing at 30 cm gave the lowest concentration of chlorophyll a, b, total (a+b) and carotenoids in leaf tissues of eggplant in 2018 season. With respect yield and its components, planting P.T. *cv.* at 60 cm and B.O. *cv.* at 45 increased number of fruits/plant, yield/plant, respectively. While planting As. *cv.* at 30 cm increased average fruit weight and total yield /fad. In the 2nd season, planting K.R. *cv.* at 60 cm, B.O. *cv.* at 45 cm, B.O. *cv.* at 60 cm and B.O. *cv.* at 30 cm increased number of fruits/ plant, average fruit weight, yield/ plant and total yield/ fad., respectively.

Key words: Eggplant (*Solanum melongena* L.), *cvs*, intra row plant spacings.

INTRODUCTION

Solanum melongena L. (2n=24), commonly known as aubergine or eggplant, is an economically important vegetable crop of tropical and temperate parts of the world. It is a good source of vitamins and minerals (particularly iron). It has been used in traditional medicines for example, tissue extracts have been used for treatment of asthma, bronchitis, cholera and dysuria's; fruits are beneficial in lowering blood cholesterol (**Kashyap *et al*., 2003**).

Plant spacing for various cultivars is a major problem faced by farmers in their production under different soil textures. The use of appro priate spacing in crop production is very important and good because it reduces competition between plants and weeds. When adequate spacing is done in plant production, crop growth and yield increases.

Competition for water and nutrients in dense plant stands might be responsible for the decrease in plant growth and yield. One of the most important factors in flourishing plant productivity is correct spacing, because it allows plant to develop their full potential above and underneath the ground. Adequate space ensures less competition for sunlight, water and fertilizer as well as prevents the spread of pests and diseases from one plant to another.

There are many cultivars of eggplant that are grown commercially in Egypt. These cultivars

* **Corresponding author: Tel. :**+201125037135
E-mail address: doaaaboalazm55@gmail.com

have wide range of variability in their needs for appropriate planting distances, depending on the nature of the growth of each cultivar and its general characteristics. Therefore, determining the appropriate cultivation distance for each cultivar leads to achieving the appropriate productivity and the desired quality. Some authors studied the effect of plant spacing on growth. leaf pigments and productivity of eggplant such as: (**Sultana, 2006; Baloch *et al.*, 2012; Abu and Odo, 2017**), leaf pigments (**Aminifard *et al.*, 2012**; **Rasheed and Shareef, 2019),** and productivity (**Silva and Silva, 2005**; **Kogbe, 2006; Ikissan, 2007; Degri, 2014; Kaur *et al.*, 2017; Hassan *et al.*, 2018; Liaqat *et al.*, 2019)**.

There were significant differences among cultivars and genotypes regarding plant growth (**Hussein *et al.*, 2010; Zakari *et al.*, 2017; Al-Zubaidi, 2018; Iwuagwu *et al.*, 2019**) photosynthetic pigments **(Zakari *et al.*, 2017**; **Rasheed and Shareef, 2019)** yield (**Msogoya *et al.*, 2014; Nandwani *et al.*, 2015; Arguedas and Monge, 2017; Hassan *et al.*, 2018; Parmar *et al.* (2018)**.

The main objective of this work as study the general performance of ten cultivars of eggplant under different three intra-row plant spacing to determine the best eggplant cultivar and an optimum intra- row plant spacings which achievement high growth and best productivity under clay soil conditions and surface irrigation conditions.

MATERIALS AND METHODS

The present work was carried out at Vegetable Private Farm at Bani Amer Village, Zagazig Distract, Sharkia Governorate during the two summer seasons of 2017 and 2018, to study the performance of some eggplant genotypes, i.e., Little Fingers (L.F.), Ping Tung (P.T.), Antigua (An.), Aswad (As.), Japanese White Egg (J.W.E.), Apple Green (A.G.), Rotonda Bianca Stumata di Rosa (R.B.S.), Korean Red (K.R.), Black Oblong (B.O.) and Black Very Long (B.V.L.) and evaluate them under different plant spacings, (30, 45 and 60 cm) on growth, yield and its components and fruit quality under clay soil. The cultivars were varied for general characteristics as shown in Table 1.

The experimental units consisted of 30 treatments (three plant spacings and ten cultivars). The experimental layout was split-plot in randomized complete blocks design with three replicates. Plant spacing's were randomly arranged in the main plots and genotypes were randomly distributed in the sub plots.

Seeds of all eggplant cultivars were sown in speedling trays (209 sells) under plastic house as a nursery in 1st Feb. in both of the two seasons 2017 and 2018. The transplanting at different spacing's on one side of the ridge in 10th March in both seasons. All experimental units' area was 7.2 m^2 and it contained three ridges with 3 m long and 80 cm wide. The entries in each experimental unit consisted of 30 plants, planted at a spacing of 30 x 80 *cm* ; 20 plants, planted at a spacing of 45 x 80 *cm* ; 15 plants, planted at a spacing of 60 x 80 *cm*. The cultural practices; i.e., irrigation, fertilization and the pest and weed control were applied as recommended for eggplant.

Data Recorded

Plant growth characters:

A random sample of four plants from each experimental unit was randomly taken at the end of growing seasons to determine plant height, number of branches/plant as well as dry weight of leaves/plant (g)., Whereas, number of leaves and leaf area/plant were determined at flowering stage in both seasons.

Photosynthetic pigments

Ten discs samples from the fourth upper leaf of the plant tip from every experimental unit were randomly taken at flowering stage in the 2nd season, to determine chlorophyll a, b and total chlorophylls as well as carotenoids content, according to the method described by **Wettestein (1957)**.

Yield traits

At harvest stage, the mature fruits of eggplant for each plot were collected (twice every week). Total picked fruits/plot during the whole harvesting season were weighed, and counted to determine and the total yield per plant and per fad. A average fruit weight were calculated as total weight of all harvested fruits per plant divided by their number.

Table1. Variability among the cultivars under study and their sources

	Cultivars	Abbriv.	Fruit Shape	Fruit Colour	Source
1	Little Fingers	L.F.	Long	Purple Black	Baker Greek[1]
2	Ping Tung	P.T.	Long	Purple Rose	Baker Greek[1]
3	Antigua	An.	Long	White Purple with Strips	Baker Greek[1]
4	Black Very Long	B.V.L.	Long	Dark Black	E. I. Metwally[2]
5	Aswad	As.	Like a squat teardrop	Black Purple	Baker Greek[1]
6	Japanese White Egg	J.W.E.	Oval	Snow White	Baker Greek[1]
7	Apple Green	A.G.	Oval	Light Green	Baker Greek[1]
8	.Rotonda Bianca Stumata di Rosa	R.B.S.	Round	White - Rose - Pink	Baker Greek[1]
9	Korean Red	K.R.	Round	Red - Orange	Baker Greek[1]
10	Black Oblong	B.O.	Oval	Black	E. I. Metwally[2]

1: Baker Greek Heiriool Seed Company, 2278 Baker Greek Road Mansfield, MO-65704
World Wide Web: *RareSeeds.com*
2: Prof. Dr.E. I. Metwally, Fac, Agric,Kafr El-Sheikh Univ. Kafr El-Sheikh Governorate Egypt

Statistical Analysis

Collected data were subjected to proper statistical analysis of variance according to **Snedecor and Cochran (1980)** and the differences among treatments were compared using Duncans' multiple range test (**Duncan, 1958**).

RESULTS AND DISCUSSION

Plant Growth Characters

Effect of plant spacing

Data in Table 2 show that there were significant effects of plant spacing (30, 45 and 60 cm) on plant height, number of branches, number of leaves/plant, leaf area and dry weight of leaves at the end of growing season in both seasons.

Transplanting of eggplants at 30 cm (narrow spacing) gave the tallest plant in both seasons. However, transplanting of eggplants at 60 cm (wide spacing) increased number of branches/ plant, number of leaves/ plant and dry weight of leaves. Plant spacing at 45 cm increased leaf area/ plant.

This increase in plant height in closer spacing can be explained from the fact that in case of higher population density, penetration of light was decreased which might have led to increase the endogenous auxins formation and enhanced the growth of the buds which due to competition tended to grow faster in order to outperform the next plant (**Maya *et al*. 1997**).

These results are harmony with those reported by **Sultana (2006), Baloch *et al.*, (2012) and Abu and Odo (2017)** on eggplants.

Response of cultivars to plant spacing

There were significant differences among eggplant cultivars in plant growth at the end of growing season (Table 3). Rotonda Bianca di Rosa (R.B.S.) and Black very long (B.V.L.) cultivars recorded the tallest plants, whereas Apple green (A.G.) recorded the shortest plants in both seasons. Korean Red (K.R.) cultivar gave the highest values of number of branches / plant and leaf area/ plant, whereas Black oblong (B.O.) cultivar gave the highest values of dry weight of leaves / plant in both seasons.

Table 2. Effect of plant spacings on plant growth traits at the end of growing season of eggplant for plant height and branch No./ plant and at flowering stage for anther traits of eggplant during 2017 and 2018 summer seasons

Treatments	At the end of season		At flowering stage		
	Plant height (cm)	Number of branches/ plant	Number of leaves / plant	Leaf area (cm^2)	dry weight of leaves (g)
			1st season		
30 cm	83.45 a	5.28 b	76.19 c	45.81 b	69.08 c
45 cm	81.07 b	5.25 b	90.59 b	47.62 a	79.69 b
60 cm	79.88 c	6.21 a	109.59 a	42.69 c	92.07 a
			2nd season		
30 cm	91.96 a	5.81 b	83.93 c	48.21 b	80.01 c
45 cm	88.95 b	5.82 b	98.28 b	50.01 a	91.80 b
60 cm	87.80 c	6.64 a	120.03 a	44.24 c	106.77 a

Table 3. Effect of cultivars on plant growth tratis at the end of growing season of eggplant for plant height and branch No./ plant and at flowering stage for anther traits of eggplant during 2017 and 2018 summer seasons

Cultivars	At the end of season		At flowering stage		
	Plant height (cm)	Number of branches/ plant	Number of leaves / plant	Leaf area (cm^2)	Dry weight of leaves (g)
			1st season		
Little Fingers (L.F)	82.73 bc	5.77 bc	58.42 i	47.76 c	57.57 h
Ping Tung (P.T)	78.05 e	5.19 f	84.25 f	42.42 d	86.64 d
Antigua (An)	84.83 b	5.44 e	97.47 d	37.68 ef	72.28 g
Aswad (As)	79.55 de	5.41 e	74.11 h	52.55 b	79.90 f
Japanese White Egg (J.W.E)	74.19 f	5.88 b	120.58 a	42.16 d	93.63 b
Apple Green (A.G)	65.16 g	5.75 c	101.94 c	38.72 e	71.20 g
Rotonda Bianca Stumata di Rosa (R.B.S)	91.44 a	5.16 f	79.58 g	47.51 c	70.08 g
Korean Red (K.R)	84.97 b	6.30 a	95.38 d	60.18 a	84.09 e
Black Oblong (B.O)	80.88 cd	5.58 d	92.22 e	48.33 c	96.62 a
Black Very Long (B.V.L)	92.86 a	5.33 e	117.28 b	36.46 f	90.81 c
			2nd season		
Little Fingers (L.F)	91.75 b	6.27 bc	64.25 i	50.98 c	66.67 h
Ping Tung (P.T)	85.75 c	5.69 d	92.53 f	44.66 d	101.31 d
Antigua (An)	93.17 b	5.97 bcd	106.25 d	38.55 e	83.40 g
Aswad (As)	87.33 c	5.88 cd	81.44 h	54.97 b	92.47 f
Japanese White Egg (J.W.E)	81.56 d	6.38 ab	132.42 a	43.27 d	108.67 b
Apple Green (A.G)	71.67 e	6.08 bcd	111.19 c	39.65 e	81.61 g
Rotonda Bianca Stumata di Rosa (R.B.S)	100.69 a	5.86 cd	87.44 g	50.00 c	81.33 g
Korean Red (K.R)	93.39 b	6.75 a	104.86 d	63.53 a	97.22 e
Black Oblong (B.O)	88.44 c	6.05 bcd	101.44 e	50.88 c	111.95 a
Black Very Long (B.V.L)	101.97 a	5.97 bcd	125.64 b	38.38 e	103.97 c

The differences among the tested cultivars and genotypes in growth characters could be due to the genetic factors. These results agree with the findings of **Hussein *et al*. (2010), Zakari *et al*. (2017), Al-Zubaidi (2018)** and **Iwuagwu *et al.* (2019)** all on eggplants.

Effect of interaction

The interaction between plant spacing and cultivars had significant effect on plant growth of eggplant at the end of growing seasons (Tables 4 and 5)

Transplanting R.B.S. and B.V.L. cultivars at 45 cm gave the tallest plants. Transplanting (A.G.) cultivar at 60 cm increased number of branches and number of leaves/plant with no significant differences with K.R. cultivar at 60 cm with respect to number of branches/ plant in both seasons. Transplanting K.R. and B.O. cultivars at 60 cm increased leaf area and dry weight of leaves, respectively.

These results coincide with those reported by **Hassan *et al*. (2018).** They showed that the interaction between transplanting Wizo cultivar on spacing at 50 cm recorded the tallest plant and highest value of number of leaves / plant, while black beauty cultivar at the same spacing gave the highest of number of branches/ plant. Also, **Iwuagwu *et al*. (2019)** indicated that the interaction between eggplant cultivars and plant spacing had significant effect on leaf area/ plant at three and six weeks after transplanting, however transplanting white garden eggplant cultivar at 60cm x 40cm gave the best results, while the interaction between transplanting green garden egg plant cultivar at the same spacing gave the highest root length than other interaction treatments. **Rasheed and Shareef (2019)** showed that plant spacing at level (60 cm) and Kyme cultivar significantly improved leaf area/ plant than other interaction treatments.

Photosynthetic Pigments

Effect of plant spacing

The concentration of chlorophyll a, b, total (a+b) and carotenoides in leaf tissues were increased with increasing plant spacing at 60 cm (wide spacing) followed by plant spacing at 45 cm, while plant spacing at 30 cm recorded the lowest concentration of all leaf pigments of eggplant in 2018 summer season (Table 6).

The stimulative effect of low plant density (wide spacing) on leaf pigments may be due to the more exposing to solar radiation, that is necessary for photosynthetic activity and photosynthetic apparatus. The reduction of leaf chlorophyll content due to high plant density (narrow spacing) could be explained partially by the effects of shading of the lower canopy, causing poor canopy interception of the photosynthetically active radiation (**Brahim *et al*., 1998).**

Theses results are harmony with those reported by **Aminifard *et al*. (2012)** and **Rasheed and Shareef (2019)** on eggplant**.**

Response of cultivars to plant spacing

There were significant effect among eggplant cultivars in chlorophyll a, b, total (a+b) and carotenoides in leaf tissues (Table 6). R.B.S. cultivar gave the highest concentration of chlorophyll a, b and total (a+b) in leaf tissues, whereas Ping Tung (P.T.) cultivar gave the highest concentration of carotenoides in leaf tissues.

The obtained results are in conformity with those reported by **Zakari *et al*. (2017) and Rasheed and Shareef (2019)**. They found that there were significant differences between hybrids cultivars regarding chlorophyll a, b and total chlorophyll of eggplants.

Effect of the interaction

Transplanting R.B.S. cultivar at 60 cm increased chlorophyll a, b and total (a+b) in leaf tissues, whereas planting P.T cultivar at 30 cm increased the concentration of carotenoides in leaf tissues (Table 7). While the interaction between transplanting KR cultivar on spacing at 30 cm gave the lowest concentration of chlorophyll a, b, total (a+b) and carotenoides in leaf tissues of eggplant in 2018 season.

The obtained results are in accordance with those reported by **Rasheed and Shareef (2019)**. They showed that the interaction between Kyme cultivar and planting on 60 cm gave the highest concentration chlorophyll content in leave than other interaction treatments**.**

Table 4. Effect of the interaction treatments between plant spacing and cultivars on plant growth characters at the end of growing season of eggplant for plant height and branch No./ plant and at flowering stage for anther traits of eggplant during 2017 summer season

Treatments		At the end of season		At flowering stage		
Spacing	CVS	Plant height (cm)	Number of branches/ plant	Number of leaves / plant	Leaf area (cm^2)	Dry weight of leaves (g)
30 cm	**Little Fingers (L.F)**	86.75 ef	5.75 f	55.33 p	47.99 f	61.88 l
	Ping Tung (P.T)	79.75 hij	5.16 hi	65.83 n	39.19 klm	67.99 k
	Antigua (An)	88.66 de	5.16 hi	84.17 jk	37.43 mno	59.89 lm
	Aswad (As)	80.83 ghi	5.50 g	68.58 n	51.71 e	76.61 ij
	Japanese White Egg (J.W.E)	78.83 hij	6.08 de	116.17 d	53.39 cde	109.88 b
	Apple Green (A.G)	62.00 n	4.50 k	68.25 n	32.04 q	46.28 o
	Rotonda Bianca Stumata di Rosa (R.B.S)	92.33 bcd	4.25 l	65.42 n	44.09 hij	48.53 no
	Korean Red (K.R)	93.00 abc	5.83 f	85.33 j	60.66 b	77.18 ij
	Black Oblong (B.O)	80.50 ghi	5.08 i	80.00 l	52.25 de	85.32 fg
	Black Very Long (B.V.L)	91.91 bcd	5.50 g	72.83 m	39.34 klm	57.27 m
45 cm	**Little Fingers (L.F)**	84.25 fg	6.25 d	59.75 o	47.92 f	58.94 lm
	Ping Tung (P.T)	78.08 hij	4.58 k	80.83 kl	43.92 hij	88.99 e
	Antigua (An)	79.41 hij	4.50 k	96.50 h	41.53 jkl	74.66 j
	Aswad (As)	77.66 ij	4.83 j	67.00 n	60.99 b	79.04 hi
	Japanese White Egg (J.W.E)	72.75 kl	5.50 g	118.33 d	38.57 lmn	87.89 ef
	Apple Green (A.G)	64.83 mn	5.50 g	90.17 i	46.24 fgh	69.71 k
	Rotonda Bianca Stumata di Rosa (R.B.S)	94.33 ab	5.33 gh	73.58 m	56.44 c	79.21 hi
	Korean Red (K.R)	82.16 gh	6.08 de	97.42 h	54.97 cd	69.58 k
	Black Oblong (B.O)	80.25 g-j	5.41 g	77.83 l	51.53 e	85.10 fg
	Black Very Long (B.V.L)	97.00 a	4.58 k	144.50 a	34.13 pq	103.85 c
60 cm	**Little Fingers (L.F)**	77.21 ij	5.33 gh	60.17 o	47.37 fg	51.89 n
	Ping Tung (P.T)	76.33 jk	5.83 f	106.08 f	44.15 g-j	102.96 c
	Antigua (An)	86.41 ef	6.66 c	111.75 e	34.07 pq	82.30 gh
	Aswad (As)	80.16 g-j	5.91 ef	86.75 ij	44.95 f-i	84.05 g
	Japanese White Egg (J.W.E)	71.00 l	6.08 de	127.25 c	34.51 opq	83.15 g
	Apple Green (A.G)	68.66 lm	7.25 a	147.42 a	37.87 mn	97.61 d
	Rotonda Bianca Stumata di Rosa (R.B.S)	87.66 ef	5.91 ef	99.75 gh	42.01 ijk	82.52 gh
	Korean Red (K.R)	79.75 hij	7.00 b	103.40 fg	64.90 a	105.52 c
	Black Oblong (B.O)	81.91 gh	6.25 d	118.83 d	41.21 jkl	119.46 a
	Black Very Long (B.V.L)	89.66 cde	5.91 ef	134.50 b	35.91 nop	111.33 b

Table 5. Effect of the interaction treatments between plant spacing and cultivars on plant growth characters at the end of growing season of eggplant for plant height and branch No./ plant and at flowering stage for anther traits of eggplant during 2018 summer season

Treatments		At the end of season		At flowering stage		
Spacing	CVS	Plant height (cm)	Number of branches/ plant	Number of leaves / plant	Leaf area (cm^2)	Dry weight of leaves (g)
30 cm	Little Fingers (L.F)	97.75 c-f	6.25 c-f	60.92 o	53.67 fg	71.72 o
	Ping Tung (P.T)	87.67 jkl	5.66 e-i	72.33 m	41.26 jk	78.68 n
	Antigua (An)	97.42 def	5.75 e-i	92.58 j	36.07 mn	69.37 op
	Aswad (As)	88.50 ijk	5.91 d-g	75.33 m	54.44 ef	88.60 kl
	Japanese White Egg (J.W.E)	86.75 jkl	6.41 b-e	127.75 d	56.21 def	127.28 b
	Apple Green (A.G)	68.25 p	5.00 i	75.75 m	33.74 mn	54.10 r
	Rotonda Bianca Stumata di Rosa (R.B.S)	101.50 bcd	5.33 ghi	72.00 m	46.41 hi	56.28 qr
	Korean Red (K.R)	102.25 abc	6.33 cde	93.83 j	63.86 b	88.95 k
	Black Oblong (B.O)	88.50 ijk	5.50 f-i	88.00 k	55.01 ef	98.85 gh
	Black Very Long (B.V.L)	101.08 b-e	6.00 c-g	80.83 l	41.41 jk	66.29 p
45 cm	Little Fingers (L.F)	92.50 ghi	6.75 abc	65.67 n	49.74 gh	68.18 op
	Ping Tung (P.T)	85.75 jkl	5.08 hi	88.75 k	46.24 hi	103.30 f
	Antigua (An)	87.33 jkl	5.00 i	103.42 h	43.73 ij	84.28 lm
	Aswad (As)	85.42 kl	5.33 ghi	73.67 m	63.15 bc	91.55 jk
	Japanese White Egg (J.W.E)	79.92 mn	6.00 c-g	129.92 d	40.61 jkl	101.30 fg
	Apple Green (A.G)	71.33 op	6.00 c-g	99.08 i	48.68 h	80.71 mn
	Rotonda Bianca Stumata di Rosa (R.B.S)	103.75 ab	5.83 d-h	80.83 l	59.41 cd	92.30 ijk
	Korean Red (K.R)	90.25 hij	6.58 a-d	107.08gh	58.39 de	80.53 mn
	Black Oblong (B.O)	86.75 jkl	5.91 d-g	85.67 k	54.25 ef	98.65 gh
	Black Very Long (B.V.L)	106.50 a	5.75 e-i	148.67 b	35.93 mn	117.21 d
60 cm	Little Fingers (L.F)	85.00 kl	5.83 d-h	66.17 n	49.51 gh	60.09 q
	Ping Tung (P.T)	83.83 lm	6.33 cde	116.50 f	46.48 hi	121.95 c
	Antigua (An)	94.75 fgh	7.16 ab	122.75 e	35.87 mn	96.55 hi
	Aswad (As)	88.08 i-l	6.41 b-e	95.33 j	47.32 hi	97.26 gh
	Japanese White Egg (J.W.E)	78.00 n	6.75 abc	139.58 c	33.00 n	97.43 gh
	Apple Green (A.G)	75.42 no	7.25 a	158.75 a	36.54 lmn	110.02 e
	Rotonda Bianca Stumata di Rosa (R.B.S)	96.83 efg	6.41 b-e	109.50 g	44.16 ij	95.42 hij
	Korean Red (K.R)	87.67 jkl	7.33 a	113.67 f	68.33 a	122.19 c
	Black Oblong (B.O)	90.08 hij	6.75 abc	130.67 d	43.38 ij	138.36 a
	Black Very Long (B.V.L)	98.33 c-f	6.16 c-f	147.42 b	37.80 klm	128.42 b

Table 6. Effect of plant spacing and cultivars on leaf pigments (mg/g DW) at flowering stage of eggplant during 2018 summer seasons

Treatments	Chlorophyll a	Chlorophyll b	Total chlorophyll (a+b)	Carotenoides
		Effect of plant spacing		
30 cm	2.928 b	1.435 b	4.364 b	1.156 b
45 cm	2.928 b	1.408 b	4.337 b	1.115 c
60 cm	3.197 a	1.497 a	4.695 a	1.244 a
		Effect of cultivars		
Little Fingers (L.F)	2.553 f	1.288 f	3.841 f	1.011 g
Ping Tung (P.T)	3.720 b	1.711 b	5.431 b	1.585 a
Antigua (An)	2.279 g	1.140 g	3.419 g	0.975 h
Aswad (As)	2.867 e	1.396 e	4.263 e	1.074 f
Japanese White Egg (J.W.E)	3.221 c	1.499 d	4.720 c	1.289 c
Apple Green (A.G)	3.151 cd	1.557 c	4.708 cd	1.136 e
Rotonda Bianca Stumata di Rosa (R.B.S)	4.005 a	1.782 a	5.788 a	1.507 b
Korean Red (K.R)	2.128 h	1.092 g	3.221 h	0.800 i
Black Oblong (B.O)	3.182 cd	1.505 d	4.687 cd	1.258 d
Black Very Long (B.V.L)	3.075 d	1.500 d	4.575 d	1.080 f

Table 7. Effect of the interaction treatments between spacing and cultivars on leaf pigments (mg/g DW) at flowering stage of eggplant during 2018 summer seasons

Treatments		Chlorophyll a	Chlorophyll b	Total chlorophyll (a+b)	Carotenoides
Spacing	**CVS**				
30 cm	**Little Fingers (L.F)**	2.808 lmn	1.288 f	4.212 ij	1.043 n
	Ping Tung (P.T)	3.850 b	1.711 b	5.596 b	1.809 a
	Antigua (An)	2.341 p	1.140 g	3.512 l	1.021 o
	Aswad (As)	2.952 jkl	1.396 e	4.394 hi	1.143 hi
	Japanese White Egg (J.W.E)	2.962 jkl	1.499 d	4.410 hi	1.155 h
	Apple Green (A.G)	3.344 efg	1.557 c	4.996 e	1.120 j
	Rotonda Bianca Stumata di Rosa (R.B.S)	3.520 de	1.782 a	5.253 d	1.454 e
	Korean Red (K.R)	1.928 r	1.092 g	2.952 n	0.649 t
	Black Oblong (B.O)	2.674 no	1.505 d	4.002 jk	1.116 jk
	Black Very Long (B.V.L)	2.906 klm	1.500 d	4.313 hi	1.050 n
45 cm	**Little Fingers (L.F)**	2.256 pq	1.288 f	3.417 lm	0.949 q
	Ping Tung (P.T)	3.666 bcd	1.711 b	5.400 bcd	1.209 g
	Antigua (An)	2.133 q	1.140 g	3.210 m	0.990 p
	Aswad (As)	2.706 mno	1.396 e	4.040 jk	1.010 o
	Japanese White Egg (J.W.E)	3.410 ef	1.499 d	4.882 ef	1.448 e
	Apple Green (A.G)	2.896 klm	1.557 c	4.310 hi	1.074 m
	Rotonda Bianca Stumata di Rosa (R.B.S)	3.752 bc	1.782 a	5.494 bc	1.527 d
	Korean Red (K.R)	2.240 pq	1.092 g	3.360 lm	0.706 s
	Black Oblong (B.O)	3.048 ijk	1.505 d	4.525 gh	1.140 i
	Black Very Long (B.V.L)	3.178 ghi	1.500 d	4.734 fg	1.103 k
60 cm	**Little Fingers (L.F)**	2.597 o	1.288 f	3.896 k	1.043 n
	Ping Tung (P.T)	3.642 cd	1.711 b	5.297 cd	1.739 b
	Antigua (An)	2.362 p	1.140 g	3.537 l	0.914 r
	Aswad (As)	2.944 kl	1.396 e	4.356 hi	1.071 m
	Japanese White Egg (J.W.E)	3.290 fgh	1.499 d	4.869 ef	1.266 f
	Apple Green (A.G)	3.213 fghi	1.557 c	4.820 ef	1.214 g
	Rotonda Bianca Stumata di Rosa (R.B.S)	4.744 a	1.782 a	6.616 a	1.541 c
	Korean Red (K.R)	2.218 pq	1.092 g	3.351 lm	1.045 n
	Black Oblong (B.O)	3.824 bc	1.505 d	5.536 b	1.518 d
	Black Very Long (B.V.L)	3.141 hij	1.500 d	4.678 fg	1.089 l

Yield and its Components

Effect of plant spacing

Plant spacing had significant effect on number of fruits/plant, yield/plant and total yield /fad. in both seasons and average fruit weight in the 2nd season (Table 8). Number of fruits/ plant and yield/plant increased with increasing plant spacing at 60 cm, whereas total yield/fad. increased with decreasing plant spacing at 30 cm in both seasons.

Dense spacing designs may increase competition for water and fertilizers, which results in inadequate vegetative growth and low yields (**Knavel, 1988**). At low plant density, greater nutrients uptake and improved light environment and water at lower plant population, hence the competition was low which would increase branching, flowers and fruit yield/ plant.

Also, reduced number of fruits under wider spacing undergone less inter or intra plant competition which caused an increased number of fruits per plant. Plants tended to have higher photosynthetic potential as in-row spacing increased due to excess light source for photosynthesis within the canopy. This could however only improved the individual performance but could not compensate for the low leaf area per unit area of land as a result of the sparse population density **(Mishriky and Alphonse 1994)**.

The obtained results are in conformity with those reported by **Silva and Silva (2005)**, **Kogbe (2006)**, **Ikissan (2007), Degri (2014), Kaur *et al*., (2017), Hassan *et al*. (2018) and Liaqat *et al*. (2019)** all on eggplants.

Response of cultivars to plant spacing

There were significant differences among eggplant cultivars in number of fruits/plant, average fruit weight, yield / plant and total yield /fad. in both seasons (Table 9).

Black Oblong cultivar recorded maximum value of average fruit weight in the 2nd season and yield/plant and total yield/fad., in both seasons. As for number of fruits/plant P.T and K.R cultivars increased number of fruits/ plant in the 1st and 2nd seasons, respectively. Aswad cultivar gave the maximum average fruit weight in the 2nd season.

Significant differences between cultivars and genotypes regarding yield and its components of eggplants were reported by many others such as. **Msogoya *et al*. (2014)**, **Nandwani *et al*. (2015)**, **Arguedas and Monge (2017), Hassan *et al*. (2018)** and **Parmar *et al*. (2018)**

Effect of the interaction

The interaction between plant spacing and cultivars had significant effect on number of fruits/plant, average fruit weight, yield/plant and total yield/fad. In both seasons (Tables 10 and 11). In the 1st season, planting P.T. at 60 cm and B.O. cultivar at 45 increased number of fruits/ plant, yield/plant respectively, while planting As. cultivar at 30 cm increased average fruit weight and total yield/fad. In the 2nd season, planting K.R. at 60 cm, B.O. cultivar at 45 cm, B.O. cultivar at 60 cm and B.O. cultivar at 30 cm increased number of fruits/plant, average fruit weight, yield/plant and total yield/ fad., respectively.

These results are harmony with those reported with **Paturde *et al.* (2002)** conducted an experiment for the performance of *Arka mahima* (Tetraploid) against *Arka sanjeevini* (Diploid) varieties of wild brinjal under different plant spacing 60 x 30 or 30 x 30 cm. *Arka sanjeevini* recorded significantly more dry berry yield than *Arka mahima*. Also, **Arguedas and Monge (2017)** showed that the interaction between genotype JMX-1099 at a planting density of 1.30 plants/m^2 gave the highest marketable yield was (18.90 fruits/m^2 and 6.21 kg/m^2) than other interaction treatments of eggplant. However, **Hassan *et al*. (2018)** found that the interaction between Wizo cultivar and plant spacing at 50 cm gave the best results for increasing number of fruits/plant, average fruit weight, fruit length, while black beauty cultivar and the same spacing gave the maximum fruit diameter. In addition, **Rasheed and Shareef (2019)** showed that the interaction between Kyme cultivar and plant spacing at 60 cm had significantly enhanced average fruit weight, plant yield (Kg.plant^{-1}) and total yield (ton.ha^{-1}).

From the forgoing results, it could be concluded that, planting B.O. cultivar at 45, 60 and 30 cm increased average fruit weight, yield / plant and total yield/fad., respectively.

Table 8. Effect of plant spacing on yield and its components of eggplant during 2017 and 2018 summer seasons

Treatments	Number of fruits/ plant	Average fruit weight (g)	Yield / plant (g)	Yield /fad. (ton)
		2017 season		
30 cm	13.52 c	142.87 a	1558.6 c	27.276 a
45 cm	18.76 b	141.33 a	2043.8 b	26.824 b
60 cm	20.98 a	141.39 a	2282.1 a	19.969 c
		2018 season		
30 cm	14.13 c	133.47 a	1487.8 c	26.036 a
45 cm	15.71 b	133.19 a	1645.6 b	21.599 b
60 cm	21.09 a	129.08 b	2209.8 a	19.336 c

Table 9. Effect of cultivars on yield and its components of eggplant during 2017 and 2018 summer seasons

Treatments	Number of fruits/ plant	Average fruit weight (g)	Yield / plant (g)	Yield /fad. (ton)
		2017 season		
Little Fingers (L.F)	19.08 f	63.08 g	1200.8 f	15.214 gh
Ping Tung (P.T)	26.52 a	72.15 f	1919.8 d	23.667 e
Antigua (An)	20.14 e	77.83 e	1572.8 e	19.082 f
Aswad (As)	7.93 i	332.08 a	2632.1 b	35.350 b
Japanese White Egg (J.W.E)	22.91 c	105.71 d	2426.7 c	29.696 d
Apple Green (A.G)	24.30 b	106.90 d	2592.4 b	31.475 c
Rotonda Bianca Stumata di Rosa (R.B.S)	7.14 j	268.57 b	1919.7 d	24.072 e
Korean Red (K.R)	21.52 d	55.39 h	1194.1 f	14.892 h
Black Oblong (B.O)	11.22 h	263.68 c	2943.2 a	37.802 a
Black Very Long (B.V.L)	16.80 g	73.26 f	1213.5 f	15.646 g
		2018 season		
Little Fingers (L.F)	20.84 b	56.51 h	1487.8 c	14.618 i
Ping Tung (P.T)	15.10 f	63.99 g	1645.6 b	12.040 j
Antigua (An)	18.78 c	71.65 f	2209.8 a	16.769 h
Aswad (As)	8.30 i	265.30 b	1487.8 c	26.975 c
Japanese White Egg (J.W.E)	19.35 c	107.31 d	1645.6 b	25.886 d
Apple Green (A.G)	17.41 d	107.26 d	2209.8 a	23.099 e
Rotonda Bianca Stumata di Rosa (R.B.S)	9.70 h	238.91 c	1487.8 c	28.989 b
Korean Red (K.R)	32.98 a	48.72 i	1645.6 b	20.641 f
Black Oblong (B.O)	10.62 g	276.87 a	2209.8 a	36.445 a
Black Very Long (B.V.L)	16.69 e	82.60 e	1487.8 c	17.775 g

Table 10. Effect of the interaction treatment between plant spacing and cultivars on yield and its components of eggplant during 2017 summer seasons

Treatments		Number of fruits/ plant	Average fruit weight (g)	Yield / plant (g)	Total yield (ton/fad.)
Spacing	CVS				
30 cm	Little Fingers (L.F)	18.33 g	57.29 no	1049.8 lm	18.371 n
	Ping Tung (P.T)	20.58 f	70.25 jkl	1444.8 j	25.285 j
	Antigua (An)	12.54 k	75.59 ij	946.9 no	16.570 o
	Aswad (As)	8.28 no	359.57 a	2976.9 c	52.096 a
	Japanese White Egg (J.W.E)	15.67 i	103.35 g	1618.2 i	28.318 h
	Apple Green (A.G)	17.49 gh	104.80 fg	1834.7 h	32.107 ef
	Rotonda Bianca Stumata di Rosa (R.B.S)	6.53 p	249.41 e	1623.7 i	28.414 h
	Korean Red (K.R)	17.03 h	53.20 op	906.7 op	15.867 o
	Black Oblong (B.O)	8.58 no	273.74 c	2349.5 f	41.116 c
	Black Very Long (B.V.L)	10.25 m	81.52 hi	835.2 p	14.617 p
45 cm	Little Fingers (L.F)	16.45 hi	68.61 klm	1128.4 l	14.810 p
	Ping Tung (P.T)	25.40 c	71.76 jkl	1820.3 h	23.891 k
	Antigua (An)	23.30 e	75.81 hij	1754.5 h	23.027 kl
	Aswad (As)	7.86 no	318.33 b	2493.2 de	32.723 de
	Japanese White Egg (J.W.E)	24.48 cd	105.48 fg	2566.8 d	33.688 d
	Apple Green (A.G)	21.26 f	110.96 f	2359.5 f	30.968 g
	Rotonda Bianca Stumata di Rosa (R.B.S)	6.23 p	279.98 c	1740.9 h	22.849 l
	Korean Red (K.R)	24.37 d	50.71 p	1233.6 k	16.192 o
	Black Oblong (B.O)	13.76 j	259.13 d	3563.4 a	46.769 b
	Black Very Long (B.V.L)	24.50 cd	72.53 jk	1777.1 h	23.324 kl
60 cm	Little Fingers (L.F)	22.48 e	63.35 mn	1424.2 j	12.462 q
	Ping Tung (P.T)	33.58 a	74.42 jk	2494.4 de	21.826 m
	Antigua (An)	24.58 cd	82.09 h	2017.1 g	17.649 n
	Aswad (As)	7.66 o	318.35 b	2426.3 ef	21.231 m
	Japanese White Egg (J.W.E)	28.58 b	108.31 fg	3095.0 b	27.081 i
	Apple Green (A.G)	34.16 a	104.92 fg	3583.0 a	31.351 fg
	Rotonda Bianca Stumata di Rosa (R.B.S)	8.66 n	276.33 c	2394.5 f	20.952 m
	Korean Red (K.R)	23.16 e	62.25 mn	1441.9 j	12.617 q
	Black Oblong (B.O)	11.33 l	258.18 d	2916.7 c	25.521 j
	Black Very Long (B.V.L)	15.66 i	65.73 lm	1028.2 mn	8.997 r

Table 11. Effect of the interaction treatments between plant spacing and cultivars on yield and its components of eggplant during 2018 summer seasons

Treatments		Number of fruits/ plant	Average fruit weight (g)	Yield/ plant (g)	Total yield (ton/fad.)
Spacing	**CVS**				
30	**Little Fingers (L.F)**	18.62 f	56.11 l	1044.5 l	18.279 k
	Ping Tung (P.T)	11.20 l	55.00 l	616.8 n	11.128 p
	Antigua (An)	15.85 hi	73.83 ij	1168.2 k	20.110 j
	Aswad (As)	6.87 n	282.91 ab	1930.7 f	33.787 bc
	Japanese White Egg (J.W.E)	14.87 ij	106.41 f	1579.4 h	27.639 ef
	Apple Green (A.G)	13.33 k	107.79 f	1436.6 i	25.141 g
	Rotonda Bianca Stumata di Rosa (R.B.S)	7.50 n	249.89 d	1872.4 f	32.768 c
	Korean Red (K.R)	28.45 c	53.78 l	1528.1 hi	26.741 f
	Black Oblong (B.O)	9.04 m	264.31 c	2379.5 d	41.642 a
	Black Very Long (B.V.L)	15.62 hi	84.63 g	1321.6 j	23.128 hi
45 cm	**Little Fingers (L.F)**	15.33 i	56.63 l	867.6 m	11.387 p
	Ping Tung (P.T)	15.60 hi	66.90 jk	1043.3 l	13.694 o
	Antigua (An)	17.08 g	66.17 k	1130.5 kl	14.837 mn
	Aswad (As)	6.36 n	276.78 b	1755.5 g	23.042 hi
	Japanese White Egg (J.W.E)	19.94 e	106.79 f	2128.9 e	27.942 e
	Apple Green (A.G)	16.58 gh	106.52 f	1766.5 g	23.186 h
	Rotonda Bianca Stumata di Rosa (R.B.S)	9.87 m	234.56 e	2315.7 d	30.393 d
	Korean Red (K.R)	31.66 b	50.47 l	1597.0 h	20.961 j
	Black Oblong (B.O)	9.00 m	285.15 a	2566.4 c	33.684 bc
	Black Very Long (B.V.L)	15.70 hi	81.88 gh	1284.6 j	16.860 l
60 cm	**Little Fingers (L.F)**	28.58 c	56.77 l	1621.3 h	14.186 no
	Ping Tung (P.T)	18.50 f	70.06 ijk	1291.3 j	11.299 p
	Antigua (An)	23.41 d	74.95 hi	1755.4 g	15.360 m
	Aswad (As)	11.66 l	236.20 e	2753.8 b	24.096 gh
	Japanese White Egg (J.W.E)	23.25 d	108.73 f	2522.9 c	22.076 i
	Apple Green (A.G)	22.33 d	107.48 f	2396.6 d	20.971 j
	Rotonda Bianca Stumata di Rosa (R.B.S)	11.75 l	232.28 e	2720.5 b	23.804 h
	Korean Red (K.R)	38.83 a	41.91 m	1625.1 h	14.220 no
	Black Oblong (B.O)	13.83 jk	281.14 ab	3886.7 a	34.009 b
	Black Very Long (B.V.L)	18.75 ef	81.29 gh	1524.2 hi	13.336 o

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تأثيـــر مســـافات الـــزراعـــة المختلفـــة علـــى نمـــو وإنتـاجيـة بعض أصنـاف الباذنجـــان

دعاء رمضان ابوالعزم - عبدالمنعم عامر جاد - هاني جمال زيادة - هاني السيد محمد علي

قسم البساتين – كلية الزراعة – جامعة الزقازيق – مصر

تـم اجـراء هـذا العمـل فـي مزرعـة خضـر خاصـة فـي قريـة بنـي عـامر، مركـز الزقـازيق، محافظـة الشـرقية، مصـر أثنـاء الموسـميين الصـيفيين المتتـاليين 2017و2018، لدراسـة سـلوك عشـرة أصـناف باذنجـان هـي ليتيـل فينجـرز (.L.F)، بيـنج تـونج (.P.T)، أنتيجـوا(.An)،بـلاك فـري لـونج (.B.V.L)، أسـود (.As)،جابـانيز وايـت ايـج (.J.W.E)،ابـل جـرين(.A.G)، روتونـدا بيانكـا سـتوماتا دي روزا (.R.S.B)، كـورين ريـد(.K.R) وبـلاك اوبلـنج (.B.O) تحـت ثلاثـة مسـافات بـين النباتـات داخـل الخـط 30، 45و 60 سـم فـي التربـة الطينيـة والـري بـالغمر. وقـد أوضـحت النتـائج أن شـكل الصـنفان .R.S.B و .B.V.L علـي مسـافة 45 سـم أعطـي أطـول نباتـات. وشـكل .A.G علـي مسـافة 60 سـم زاد مـن عـدد الافـرع وعـدد الاوراق لكـل نبـات بـدون فـروق معنويـة مـع صـنف.K.R علـي مسـافة 60 سـم بالنسـبة لعـدد الافـرع فـي كـلا الموسـمين. أن زراعـة شـتلات الصـنفان .K.R و.B.O علـي مسـافة 60 سـم أدت لزيـادة مسـاحة الورقـة والـوزن الجـاف لـلاوراق علـي التـوالي. زراعـة الصـنف .R.S.B علـي مسـافة 60 سـم أدت الـي زيـادة محتـوي الكلوروفيـل أ و ب والكلـي مـن أ+ب فـي أنسـجة الورقـة، بينمـا التفاعـل بـين شـتل K.R علـي مسـافة 30 سـم أعطـي أقـل تركيـز مـن كلوروفيـل أ و ب والكلـي مـن أ+ب والكاروتينيـدات فـي أنسـجة أوراق الباذنجـان فـي موسـم 2018 . بالنسـبة للمحصـول ومكوناتـة وجـد أن زراعـة الصـنف .P.T علـي مسـافة 60 سـم و الصـنف .B.O علـي مسـافة 45 سـم أدت لزيـادة عـدد الثمـار لكـل نبـات والمحصـول الكلـي لكـل نبـات علـي التـوالي، بينمـا زراعـة الصـنف .As علـي مسـافة 30 سـم أدي لزيـادة متوسـط وزن الثمـرة والمحصـول الكلـي للفـدان. فـي موسـم النمـو الثـاني وجـد أن زراعـة الصـنف .K.R علـي مسـلفة 60 سـم أدت لزيـادة عـد الثمـار، الصـنف .B.O علـي مسـافة 45 سـم زادت مـن متوسـط وزن الثمـرة، .B.O علـي مسـافة 60 سـم زادت مـن محصول النبات و .B.O علي مسافة 30 سم زادت من المحصول الكلي علي التوالي .

المحكمـــون :

1 - أ.د. محمود عبادي وهب الله أستاذ الخضر – كلية الزراعة- الشاطبي- جامعة الإسكندرية.

2- أ.د. عبدالله برديســـي أحمد أستاذ الخضر المتفرغ – كلية الزراعة – جامعة الزقازيق.