Impact of Plant Spacing on Growth and Yield of Two Sweet Pepper Cultivars

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Abstract: A field experiment was carried out during two summer seasons of 2014 and 2015 at El-Khattara Experimental Farm, Fac. Agric., Zagazig University, Sharkia Governorate, Egypt, to study the effect of plant spacing (20, 30, 40 and 50 cm) on growth, yield and fruit quality for two sweet pepper cultivars (Primo and Mohannad 4010). The results showed that, Primo cultivar gave the highest values of plant height, total dry weight per plant, leaf area/ plant (LA), leaf area index (LAI), leaf area ratio (LAR), specific leaf area (SLA), absolute growth rate (AGR), average fruit weight, fruit yield/plant, total yield (ton/feddan) and K (%) in fruits. While, Mohannad 4010 cultivar showed higher values of number of fruits per plant and vitamin C content in fruits. In addition, total dry weight per plant, LA, LAR, AGR, average fruit weight, number of fruits per plant, fruit yield per plant and vitamin C content in fruits increased with increasing plant spacing up to 50 cm spacing. Furthermore, plant spacing at 40 or 50 cm between plants recorded the highest values of plant height, number of both leaves and branches per plant with no significant differences between them. While, plant spacing at 20 cm between plants recorded higher values of LAI, SLA and total yield. The interaction treatments between Primo cultivar and plant spacing at 50 cm had significant effect on LA, AGR and fruit yield/plant. While, Primo cultivar with plant spacing at 40 or 50 cm gave the highest values of plant height, total dry weight per plant and average fruit weight. On the other hand, Primo cultivar with plant spacing at 20 cm was the best interaction treatment in respect to LAI, SLA and total yield in the two studied seasons.

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1. Introduction

Sweet pepper (*Capsicum annuum* L.) belongs to the family Solanaceae and it is one of the most important vegetable crops which grown in Egypt and many countries around the world, for local consumption and exportation. Also, fruits of sweet pepper has high nutritional values and it contains an excellent source of antioxidant compounds which important for human health.

Selection of the suitable cultivar is important practices which had effect on quality and yield of plant **(Amanullah *et al.*, 2002)**. Many researchers found that there were significant differences showed among cultivars (**Bergefurd *et al.*, 2011**) regarding plant growth, **(Gheeth *et al.*, 2013)** regarding yield of peas. In addition**, Koner *et al.* (2015)** found that Mekong cultivar emerged as superior in terms of number of fruits, fruit weight and yield, while California Wonder cultivar recorded maximum values of vitamin C.

The productivity of the crop has influenced by different factors. Plant density is one of the important agronomic practices that can affect the growth and yield development of many vegetable crops. The optimum plant density ensures the plants to grow uniformly through efficient utilization of moisture, light, nutrients and thus causes to produce maximum yield of crop and economic use of land **(Nasto *et al.*, 2009).**

The widest plant spacing enhanced plant growth of different vegetable crops **(Viloria *et al.*, 2002; Aminifard *et al.*, 2012)** regarding plant height, **(Maurya *et al.*, 2013 on okra)** respecting number of branches per plant, **(Alabi *et al.*, 2014)** regarding plant height, number of branches and number of leaves, **(Ibrahem *et al.*, 2015** on peas) regarding the dry weight per plant. In addition, **Islam *et al.* (2011)** found that number of both branches and of leaves per plant were significantly increased with the increasing of plant spacing.

Alabi *et al.*(2014) found that the leaf area per plant and leaf area ratio increased with in-row spacing and **Amer (2004**) on eggplant, recorded that, leaf area was increased with increasing plant spacing. On the other hand, total yield of different plants increased with decreasing planting spacing till a certain limit **(Dobromilska, 2000, Islam *et al.*, 2011 and Aminifard *et al.*, 2012).**

The main objective of this study is evaluation the effect of plant spacing on two sweet pepper cultivars to which may help to improve the practices of sweet pepper production and obtain high yield under sandy soil conditions.

2. Materials and Methods

This investigation was conducted during the two summer seasons of and 2014 and 2015 at El-Khattara Experimental Farm, Fac. Agric., Zagazig Univ., Sharkia Governorate, Egypt, to study the impact of different plant spacing on growth, yield and fruit quality of two sweet pepper cultivars grown in sandy soil conditions under drip irrigation system.

This experiment included eight treatments which were the combinations between two cultivars of sweet pepper (Primo and Mohannad 4010) and four planting spacing (20, 30, 40 and 50 cm). These treatments were arranged in a split plot design system with three replications. The cultivars were randomly arranged in the main plots, while the plant spacing were randomly distributed in the sub plots. Sweet pepper transplants were transplanted in the open field on 25 June in both seasons of the study. The area of the experimental unit was 11.2m^2. It contained four dripper lines each of 4 m length and 0.70 m width.

All experimental units received equal amounts of botanical compost at 30m^3/fed. during soil preparation. The recommended amounts of mineral N, P and K fertilizers (133kgN/fed., 46.5kg P_2O_5/fed. and 120 kg K_2O/fed.) were added to all experimental units into eight equal doses every 15 days intervals beginning of 15 days from transplanting. Ammonium sulphate (20.5%N) and potassium sulphate (48% K_2O) were used as a source of N and K, respectively and were added as soil application while, phosphoric acid (52 – 54% P_2O_5) was used as a source of P and was added as fertigation. The normal agricultural practices necessary for plant growth were carried out during the growing season as recommended.

Data recorded:

1. Plant growth measurements: Five plants from each plot were randomly taken at 90 days after transplanting for measuring the vegetative growth parameters; i.e., plant height, number of leaves and number of branches per plant. After that, the plants from each experimental unit were dried at 70°C till constant weight, then total dry weight/plant (g.) was recorded.

2. Growth analysis: At 90 days after transplanting, dry weights of roots, leaves, branches, fruits and total dry weight whole plant(gm.) were used to calculate (LA, LAI, LAR and SLA) and at 60 and 90 days for to calculate AGR.

The growth analysis parameters were calculated by using the following formulas **(Radford, 1967):**

2.1. Leaf area per plant (LA) = Leaves dry weight per plant (g.) X disk area (cm^2) /Disk dry weight (g.).

2.2. Leaf area index (LAI) = Leaf area per plant (cm^2) / Land area per plant (cm^2)

2.3. Leaf area ratio (LAR) = Leaf area per plant (cm^2) / Dry weight per plant (g.)

2.4. Specific leaf area (SLA) = Leaf area per plant (cm^2) / Leaves dry weight per plant (g.)

2.5 Absolute growth rate (AGR) = $W_2 - W_1 / T_2 - T_1$.

Where W_1 and W_2 are total plant dry weights at time T_1 (60) and T_2 (90) days after transplanting, respectively.

3. Yield and its components:

At the harvest stage, the fruits were counted and weighted and the following data were recorded: Average fruit weight, number of fruits per plant, fruit yield per plant and total yield (ton/feddan).

4. Fruit quality:

Fruit samples were randomly taken at harvesting time and the following measurements were recorded:

4.1 Dry matter (D.M.%): It was determined by allowing 100gm fresh fruits to dry in a hot air oven at 105°C till constant weight and the DM% was determined.

4.2 Total soluble solids percentage (T.S.S. %): It was determined in fruit Juice by Carle Zeis Refractometer.

4.3 Vitamin C. content in the fruit as mg/100gm fresh weight was measured according to the method described by A.O.A.C. (1990).

4.4 Fruit firmness: It was determined on five fruits from each sample; the measurements were taken from each fruit using a Push Pull dynamometer (Model FD 101).

4.5 Minerals content: The content of nitrogen, phosphorus and potassium were determined according to the methods described by **Bremner and Mulvaney (1982)**, **Olsen and Sommers (1982) and Jackson (1970)**, respectively.

Statistical analysis:

All the obtained data were statistically analysis using the COSTAT program and means separation were done by least significant value (L.S.D) at 0.05 level of probability according to **Snedecor and Cochran (1980)**.

3. Results and Discussion

Plant Growth

a. Effect of cultivars

Data in Table 1 showed the effect of cultivars on the growth of sweet pepper plants. It is evident from such data that, cv. Primo gave the highest values of plant height and total dry weight per plant compared with Mohannad 4010 cultivar. On the other hand, there were no significant differences between the two cultivars on number of both leaves and branches per plant in the two studied seasons. The differences among sweet pepper cultivars in different traits could be attributed to the genetic differences between

cultivars, the growth habits and their ability for utilizing the environmental sources. These results are in agreement with those reported by **Bergefurd *et al.* (2011)** and **Alabi *et al.* (2014).**

b. Effect of plant spacing

In the current experiment, plant spacing had significant effect on the growth of sweet pepper plants. Moreover, data in Table1showed that plant height, number of both leaves and branches per plant and total dry weight per plant increased with increasing plant spacing up to 50 cm.

It was clear from the current results that the widest plant spacing (50 cm) had significant effect on total dry weight per plant. Furthermore, plant spacing at 40 or 50 cm between plants recorded the highest values of plant height, number of leaves and branches per plant with no significant differences between them. On the other hand, the the narrow plant spacing (20 cm) gave the lowest values in this respect. The significant effect of plant spacing on plant growth may be due to different factors. The plants of wider spacing could receive more light, nutrients and other resources better than the plants with narrow spacing **(Islam *et al.*, 2011)**. This could be attributed to the competition between plants for available water, mineral nutrients from the soil and photosynthetically active radiation in closer plant spacing **(Alabi *et al.*, 2014).**

The obtained results were confirmed with the results of **(Viloria *et al.*, 2002 and Aminifard *et al.*, 2012)** regarding plant height. **Maurya *et al.* (2013)** indicated that the wider spacing between okra plants enhanced number of branches per plant, **Islam *et al.* (2011)** found that the number of branches per plant and number of leaves per plant were significantly increased with the increasing of plant spacing. Also, **Ibrahem *et al.* (2015)** reported that the low plant density encouraged plant growth, and consequently an increase in the dry weight of pea plant. In addition**, Alabi *et al.* (2014)** reported that plant height, number of branches and number of leaves were significantly increased as the plant density was decreased.

c. Effect of the interaction between cultivars and plant spacing

Results in Table 2 illustrate the effect of interaction between cultivars and plant spacing treatments on growth characters. It is clear that, the interaction treatments reflected a significant effect on plant growth. The interaction treatments between Primo cultivar and plant spacing at 40 or 50 cm recorded the highest values of plant height and total dry weight per plant without significant differences between them in the two seasons of the study.

The current results suggested that, in both Primo and Mohannad cultivars, using plant spacing at 40 or 50 cm gave the highest number of branches per plant. Furthermore, using the two tested cultivars with plant spacing at 50 cm recorded the greatest number of leaves per plant in the two studied seasons. Similar results were obtained by **Choudhary *et al.* (2014)** who found that the minimum plant height and number of branches per plant were recorded with the treatment combinations between variety Doctor and the narrow plant spacing (45x30).

Table 1: Effect of cultivars and plant spacing on growth characters of sweet pepper plants during seasons of 2014 and 2015

Treatments	First season				Second season			
	Plant height(cm)	Number of leaves / plant	Number of branches/ plant	Total dry weight/ plant (g)	Plant height(cm)	Number of leaves/ plant	Number of branches/ plant	Total dry weight/ plant (g)
Cultivars								
Mohannad 4010	43.06 b	218.03 a	4.50 a	54.06 b	41.97 b	209.72 a	4.29 a	51.41 b
Primo	50.25 a	229.14 a	5.10 a	62.34 a	47.44 a	221.22 a	4.95 a	58.39 a
Plant spacing (cm)								
20	43.83 c	193.91 c	3.50 c	53.46 c	41.63 b	188.25 b	3.33 b	47.55 d
30	45.08 bc	207.18 bc	4.37 b	54.65 c	43.65 b	198.83 b	4.08 b	53.29 c
40	47.87 ab	238.25 ab	5.29 a	61.03 b	46.25 a	228.91 a	5.25 a	56.32 b
50	49.83 a	255.00 a	6.04 a	63.64 a	47.30 a	245.91 a	5.83 a	62.47 a

Values having the same alphabetical letter(s) in each column did not significantly different according to L.S.D at 0.05 of probability

Table 2: Effect of interaction between cultivars and plant spacing on growth characters of sweet pepper plants during seasons of 2014 and 2015

Treatments		First season				Second season			
		Plant height(cm)	Number of leaves/ plant	Number of branches/ plant	Total dry weight / plant (g)	Plant height(cm)	Number of leaves/ plant	Number of branches/ plant	Total dry weight / plant (g)
Cultivars	**Plant spacing (cm)**								
Mohannad 4010	20	41.00 d	187.50 d	3.00 d	50.78 c	39.16 f	181.50 e	2.83 d	45.55 e
	30	42.00 d	204.37 cd	4.00 cd	51.39 c	41.15 ef	190.00 de	3.50 cd	49.84 d
	40	41.75 d	230.25 abcd	5.25 ab	55.77 b	42.20 def	226.91 abcd	5.16 ab	50.16 d
	50	47.50 c	250.00 ab	5.75 ab	58.30 b	45.40 cd	240.50 ab	5.66 ab	60.11 bc
Primo	20	46.66 c	200.33 d	4.00 cd	56.14 b	44.10 cde	195.00 cde	3.83 cd	49.55 d
	30	48.16 bc	210.00 bcd	4.75 bc	57.91 b	46.16 bc	207.66 bcde	4.66 bc	56.74 c
	40	54.00 a	246.25 abc	5.33 ab	66.30 a	50.30 a	230.91 abc	5.33 ab	62.48 ab
	50	52.16 ab	260.00 a	6.33 a	68.99 a	49.20 ab	251.33 a	6.00 a	64.82 a

Values having the same alphabetical letter(s) in each column did not significantly different according to L.S.D at 0.05 of probability

Growth Analysis

a. Effect of cultivars

Results listed in Table 3 showed the effect of cultivars on recorded of sweet pepper plants. The current results indicated that there were significant differences between the two tested cultivars among growth characters. Primo cultivar gave higher growth analysis compared to Mohannad 4010 cultivar in the both seasons of the study. The variability among sweet pepper cultivars in growth analysis could be attributed to the heredity differences.

b. Effect of plant spacing

It is obvious from Table 3 that, the widest plant spacing (50 cm) between plants recorded the highest values of LA, LAR and AGR characters. While, narrow plant spacing (20 cm) between plants recorded the highest values of LAI and SLA characters in the both seasons of the study.

Increasing the plant spacing reduced the overlapping and the competition between plants which in role enabled plants to utilize its energy for maximum branching, number of leaves and subsequently the production of larger leaf area **(Saha *et al*., 2005)**. On the other hand, increasing AGR and decreasing SLA might be due to having high leaf area which reflected through total dry matter. While, higher plant densities reduced photosynthetically active radiation, they increased the LAI at fruiting level **(DaÞgan and Abak, 2003).**

Similar findings were obtained by **Alabi *et al*. (2014)** who found that leaf area/plant, LAR increased with in-row spacing and the highest values were obtained at 60x75 cm spacing. On eggplant **Amer (2004)** recorded that leaf area were increased with increasing plant spacing. In addition, On potato plant, the highest LAI was observed in early transplanted crop with closer spacing 40 cm x 10 cm **(Sen *et al*., 2014).**

c. Effect of the interaction between cultivars and plant spacing

Data in Table 4 indicated that cultivating Primo cultivar at (50 cm) had a significant effect on LA, LAR and AGR. On the contrary, there were no significant differences in the case of the interaction between primo cultivar and plant spacing (40 or 50 cm) in respect of LAR in the first season. Moreover, there were no significant differences in the interaction between them in respect to AGR in the second season.

The interaction treatment between Primo cultivar and plant spacing at 20 cm was the best interaction treatment in respect to LAI and SLA in both seasons of the study. This gradual decline in SLA might be due to having high leaf area.

Table 3: Effect of cultivars and plant spacing on growth analysis of sweet pepper plants during seasons of 2014 and 2015

Treatments	First season					Second season				
	Leaf area / plant (LA) (cm^2)	Leaf area index (LAI)	Leaf area ratio (LAR) (cm^2/ g)	Specific leaf area (SLA) (cm^2/ g)	Absolute growth rate (AGR) (g/day)	Leaf area/ plant (LA) (cm^2)	Leaf area index (LAI)	Leaf area ratio (LAR) (cm^2/ g)	Specific leaf area (SLA) (cm^2/ g)	Absolute growth rate (AGR) (g/day)
Cultivars										
Mohannad 4010	1475.31 b	0.64 b	27.15 b	103.56 b	0.96 b	1391.79 b	0.60 b	26.92 b	106.22 b	0.87 b
Primo	2367.36 a	1.03 a	37.86 a	124.46 a	1.26 a	2321.73 a	1.01 a	39.69 a	127.41 a	1.16 a
Plant spacing (cm)										
20	1644.07 d	1.17 a	30.46 d	119.34 a	1.05 c	1572.17 d	1.12 a	32.78 b	122.31 a	0.88 d
30	1734.16 c	0.82 b	31.39 c	116.37 b	1.07 c	1724.32 c	0.81 b	31.78 c	119.60 b	0.95 c
40	2046.39 b	0.73 c	32.97 b	110.44 c	1.14 b	1925.55 b	0.68 c	33.51 b	113.67 c	1.03 b
50	2260.73 a	0.64 d	35.20 a	109.90 d	1.20 a	2211.00 a	0.63 d	35.17 a	111.67 d	1.19 a

Values having the same alphabetical letter(s) in each column did not significantly different according to L.S.D at 0.05 of probability

Table 4: Effect of interaction between cultivars and plant spacing on growth analysis of sweet pepper plants during seasons of 2014 and 2015

Treatments		First season					Second season				
		Leaf area / plant (LA) (cm^2)	Leaf area index (LAI)	Leaf area ratio (LAR) (cm^2/g)	Specific leaf area (SLA) (cm^2/g)	Absolute growth rate (AGR) (g /day)	Leaf area / plant (LA) (cm^2)	Leaf area index (LAI)	Leaf area ratio (LAR) (cm^2/g)	Specific leaf area (SLA) (cm^2/g)	Absolute Growth rate (AGR) (g day)
Cultivars	**Plant spacing(cm)**										
Mohannad 4010	20	1253.01 h	0.89 c	24.67 g	103.29 e	0.92 f	1191.85 h	0.85 c	26.16 e	105.47 f	0.71 e
	30	1329.45 g	0.63 e	25.86 f	103.29 e	0.93 f	1250.84 g	0.59 e	24.84 f	107.36 e	0.82 d
	40	1485.25 f	0.53 f	26.63 e	104.37 d	0.98 e	1375.08 f	0.49 f	27.41 d	106.59 e	0.83 d
	50	1833.55 e	0.52 f	31.45 d	103.29 e	1.04 d	1761.41 e	0.50 f	29.30 c	105.47 f	0.12 b
Primo	20	2035.14 d	1.45 a	36.25 c	135.40 a	1.19 c	1952.50 d	1.39 a	39.40 b	139.16 a	1.06 c
	30	2138.88 c	1.01 b	36.93 b	129.45 b	1.21 c	2197.80 c	1.04 b	38.73 b	131.84 b	1.09 bc
	40	2607.53 b	0.93 c	39.32 a	116.51 c	1.30 b	2476.02 b	0.88 c	39.62 b	120.76 c	1.24 a
	50	2687.92 a	0.76 d	38.96 a	116.51 c	1.37 a	2660.60 a	0.76 d	41.04 a	117.88 d	1.26 a

Values having the same alphabetical letter(s) in each column did not significantly different according to L.S.D at 0.05 of probability

Yield and its components

a. Effect of cultivars

The presented data in Table 5 showed that, cv. Primo recorded higher values of average fruit weight, fruit yield/plant and total yield (ton/feddan), whereas cv. Mohannad 4010 recorded higher values of number of fruits/plant in both seasons of study. The variability among the two cultivars might be due to the different genetic factors between them. The obtained results are in accordance with those of (**Koner *et al*., 2015)** who found that Mekong emerged as superior in terms of more number of fruits, fruit weight and total yield.

b. Effect of plant spacing

It is evident from data in Table 5 showed that the widest plant spacing (50 cm) between plants reflected significant effect on average fruit weight, number of fruits/plant and fruit yield/plant in the two tested seasons with no significant differences in the case of the plant spacing (40 or 50 cm) in respect to average fruit weight in the first season. Moreover, it can be seen from such data that the narrow plant spacing (20 cm) caused a significant increase in total yield (ton/feddan), where the maximum values in this respect were recorded with increasing plant population.

The total number of fruits per plant decreased with increasing the planting density, this might be due to the effect of competition between plants and due to crowding these plants may have prevented the absorption of water and nutrients **(Kebe *et al*., 1998)**. In addition, higher plant density reduces light penetration, dry matter accumulation and causes the shading, thus reducing flowering bud development **(Adigun *et al*., 2014).**

Moreover, the highest yield was recorded with higher planting densities. This was probably due to increase in the number of plants per unit area and increased numbers of fruits per feddan which might contribute to the increase in production **(Cavero *et al*., 2001)**.

In general, the widest plant spacing had significantly affected on average fruit weight, number of fruits/plant and fruit yield/plant, these results are in agreement with those reported by **Jovicich and Cantliffe (2003), Islam *et al*.(2011)**, **Aminifard *et al*.(2012)** and **Alabi *et al*. (2014)**. On the other hand,

the total yield per feddan was found to be significantly increased with decreasing plant spacing. These results are in agreement with the reported results of **Dobromilska (2000), Nasto *et al.* (2009)** and **Aminifard *et al.* (2012**).

Table 5: Effect of cultivars and plant spacing on yield and its components of sweet pepper plants during seasons of 2014 and 2015

Treatments	First season				Second season			
	Average fruit weight (g.)	Number of fruits/ plant	Fruit yield/plant (g.)	Total yield (ton / fed.)	Average fruit weight (g.)	Number of fruits/ plant	Fruit yield/plant (g.)	Total yield (ton / fed.)
Cultivars								
Mohannad 4010	31.55 b	18.18 a	577.76 b	9.71 b	30.49 b	18.60 a	572.04 b	9.48 b
Primo	36.00 a	17.52 b	634.82 a	10.62 a	34.33 a	17.78 b	614.31 a	10.37 a
Plant spacing (cm)								
20	31.90 c	12.97 d	412.24 d	11.78 a	30.61 d	12.98 d	396.57 d	11.33 a
30	33.59 b	16.78 c	563.18 c	10.46 b	32.14 c	17.29 c	554.92 c	10.31 b
40	34.64 a	18.88 b	653.60 b	9.34 c	33.05 b	19.60 b	647.60 b	9.25 c
50	34.97 a	22.78 a	796.15 a	9.10 d	33.85 a	22.88 a	773.63 a	8.81 d

Values having the same alphabetical letter(s) in each column did not significantly different according to L.S.D at 0.05 of probability

c. Effect of the interaction between cultivars and plant spacing

Data in Table 6 indicated that the interaction between Primo cultivar and plant spacing at 50 cm recorded the maximum values of average fruit weight and fruit yield/plant with no significant differences between (40 or 50 cm) plant spacing in respect of average fruit weight (gm.) in the two seasons. On the other hand, total yield (ton/feddan) significantly increased with the narrow plant pacing (20 cm) between plants in the two seasons.

Furthermore, the interaction between Mohannad 4010 cultivar and plant spacing at 50 cm was the best interaction treatment which had significant effect on number of fruits/plant in both seasons of the study. Similar results were obtained by **Choudhary *et al.* (2014)** who found that the minimum fresh fruit weight and number of fruits per plant were recorded with the treatment combinations between variety Doctor and the narrow plant spacing (45x30).

Table 6: Effect of interaction between cultivars and plant spacing on yield and its components of sweet pepper plants during seasons of 2014 and 2015

Treatments		First season				Second season			
		Average fruit weight (gm.)	Number of fruits/ plant	Fruit yield/plant (gm.)	Total yield (ton / fed.)	Average fruit weight (gm.)	Number of fruits/ plant	Fruit yield/plant (gm.)	Total yield (ton / fed.)
Cultivars	**Plant spacing (cm)**								
Mohannad 4010	20	29.24 d	13.53 g	395.61 h	11.31 b	28.61 g	13.35 g	381.94 h	10.92 b
	30	31.88 c	17.10 e	545.14 f	10.13 d	30.16 f	17.81 e	537.14 f	9.98 d
	40	32.42 c	19.06 c	617.92 d	8.83 g	30.91 e	19.81 c	612.32 d	8.75 g
	50	32.67 c	23.03 a	752.39 b	8.60 h	32.30 d	23.43 a	756.78 b	8.28 h
Primo	20	34.56 b	12.41 h	428.88 g	12.26 a	32.61 c	12.61 h	411.21 g	11.75 a
	30	35.29 b	16.47 f	581.22 e	10.80 c	34.13 b	16.78 f	572.70 e	10.64 c
	40	36.86 a	18.70 d	689.28 c	9.85 e	35.20 a	19.40 d	682.88 c	9.76 e
	50	37.28 a	22.53 b	839.91 a	9.60 f	35.40 a	22.33 b	790.48 a	9.35 f

Values having the same alphabetical letter(s) in each column did not significantly different according to L.S.D at 0.05 of probability

Fruit quality

a. Effect of cultivars

Results listed in Table 7 showed the effect of the cultivars on fruit quality of sweet pepper fruits during seasons of 2014/2015. It is clear from such data that

there were no significant differences between the two tested cultivars on dry matter(%), T.S.S(%), N(%), P(%), and firmness(g/cm^2). On the other hand, primo cultivar recorded the highest value of K(%),while Mohannad 4010 cultivar showed higher values of vitamin C in fruits of sweet pepper.

These differences in fruit quality among the two cultivars were mainly due to the genetically differences. In addition, **Koner *et al.* (2015)** found that California Wonder cultivar recorded maximum values of vitamin C compare with other cultivars.

b. Effect of plant spacing

It is obvious from the same results in Table 7 that there were no significant differences between all plant spacing treatments which tested on all the studied traits in respect of fruit quality in sweet pepper fruits, except plant spacing at 50 cm which recorded the maximum values of vitamin C. These results coincided with those found by **DaÞgan and Abak (2003)** who reported that plant density did not show any effect on fruit quality characteristics, such as dry matter, total soluble solids. While, **Aminifard *et al.* (2012)** found that the highest vitamin C (127.7 mg/100 g) was observed in 30×100, while the lowest contain of vitamin C (120.7 mg/100 g) was observed in 30×50 cm.

c. Effect of the interaction between cultivars and plant spacing

Effect of the interaction between cultivars and plant spacing treatments on fruit quality of sweet pepper is presented in Table 8. It is of interest to note that, there were no significant differences between all the interaction treatments which were tested in respect to dry matter (%), T.S.S (%), N (%), P(%) and fruit firmness (g/cm^2) in fruits. While, the interaction treatment between plant spacing at 50 cm and cvs. (Primo or Mohannad 4010) was the best interaction treatment which had significant effect on vitamin C in fruits without significant differences between the two cultivars. Also, it is evident from such data that Primo cultivar gave the best values of K(%) in fruits with all different plant spacing from 20 to 50cm between plants without significant difference between them.

Table 7: Effect of cultivars and plant spacing on fruit quality of sweet pepper during season of 2015

Treatments	Dry matter (%)	T.S.S (%)	N (%)	P (%)	K (%)	Vitamin C (mg /100 g f.w.)	Firmness (g/ cm^2)
Cultivars							
Mohannad 4010	8.35 a	5.79 a	1.64 a	0.709 a	1.90 b	181.50 a	630.96 a
Primo	8.50 a	5.75 a	1.63 a	0.695 a	2.03 a	174.50 b	664.04 a
Plant spacing (cm)							
20	8.37 a	5.83 a	1.70 a	0.707 a	1.93 a	168.75 c	650.42 a
30	8.41 a	5.58 a	1.62 a	0.702 a	1.95 a	170.50 c	628.19 a
40	8.48 a	5.83 a	1.63 a	0.702 a	1.97 a	184.00 b	656.76 a
50	8.43 a	5.83 a	1.60 a	0.697 a	2.01 a	188.75 a	654.64 a

Values having the same alphabetical letter(s) in each column did not significantly different according to L.S.D at 0.05 of probability

Table 8: Effect of interaction between cultivars and plant spacing on fruit quality of sweet pepper plants during season of 2015

Treatments		Dry matter (%)	T.S.S (%)	N (%)	P (%)	K (%)	Vitamin C (mg /100 g f.w.)	Firmness (g/cm^2)
Cultivars	**Plant spacing (cm)**							
Mohannad 4010	20	8.30 a	5.83 a	1.68 a	0.709 a	1.85 c	175.00 d	637.86 a
	30	8.36 a	5.66 a	1.77 a	0.718 a	1.87 c	176.00 d	614.15 a
	40	8.40 a	5.50 a	1.65 a	0.715 a	1.94 bc	185.00 bc	638.01 a
	50	8.33 a	6.16 a	1.47 a	0.696 a	1.94 bc	190.00 a	633.84 a
Primo	20	8.45 a	5.83 a	1.71 a	0.706 a	2.01 ab	162.50 e	662.98 a
	30	8.46 a	5.50 a	1.46 a	0.687 a	2.03 ab	165.00 e	642.23 a
	40	8.56 a	6.16 a	1.61 a	0.690 a	2.00 ab	183.00 c	675.52 a
	50	8.53 a	5.50 a	1.72 a	0.698 a	2.08 a	187.50 ab	675.44 a

Values having the same alphabetical letter(s) in each column did not significantly different according to L.S.D at 0.05 of probability

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