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Araştırma Makalesi/Research Article

The Effects of Plant Density and Organic Fertilizer on Growth and Yield of Sweet Corn (*Zea mays* L. var. *saccharata* Sturt)

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Abstract: The present study was conducted to investigate the effect of plant density (A1:80000, A2:120000, and A3:160000 plant ha^{-1}) and organic fertilizer (B1:0 and B2:25 ton ha^{-1}) on growth and yield of sweet corn (*Zea mays* L. var. *saccharate*, Sturt cv. Succar, F1) in a private farm in Qushtapa, 30 km far from the center of Erbil in Iraq, during the spring seasons in 2017 and 2018 years. The experiment was designed in a factorial randomized complete block design (RCBD) with three replications. The traits studied were: plant height (cm), number of leaves, number of branches, chlorophyll content, leaf areas (m^2), dry matter content, cob length (cm), number of seed per row, com diameter (cm), number of cob per plant and number of row per con, seed number per cob, fresh seed yield(ton ha^{-1}) and fresh cob yield (ton ha^{-1}). The results of the experiment revealed that plant density and organic fertilization and their interaction were significant in almost all traits in both years.

Bitki Sıklığı ve Organik Gübrelemenin Tatlı Mısırın (*Zea mays* L. var. *saccharata* Sturt) Büyüme ve Verimine Etkisi

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Öz: Bu çalışma, bitki sıklığının (A1: 8 000, A2: 12 000 ve A3: 16 000 bitki/da) ve organik gübrelemenin (B1: 0 ve B2: 2.5 ton/da) tatlı mısır (*Zea mays* L. var. *saccharate*, Sturt cv. Succar, F1)' ın gelişim ve verimine etkilerini araştırmak amacıyla Erbil'in merkezine (Irak) 30 km uzaklıktaki Kuştepe’de özel bir çiftlikte, 2017 ve 2018 yıllarında yürütülmüştür. Deneme, tesadüf bloklarında faktöriyel deneme desenine göre 3 tekrarlamalı olarak planlanmıştır. İncelenen özellikler: bitki boyu (cm), yaprak sayısı, dal sayısı, klorofil içeriği, yaprak alanı (m^2), kuru madde içeriği, koçan uzunluğu (cm), sıra başına tohum sayısı, koçan çapı (cm), bitki başına koçan sayısı ve koçan başına sıra sayısı, koçan başına tohum sayısı, taze tohum verimi ve taze koçan verimi olmuştur. Deneme sonuçları, her iki yılda da hemen hemen tüm özelliklerde bitki yoğunluğu ve organik gübre ile iki uygulama interaksiyonun önemli olduğunu ortaya koymuştur.

1. Introduction

Corn (*Zea mays* L.) is one of the most essential crops widely planted in the world after wheat and rice. The cultivated area for crop production in the world 4.5% and so 3.5% in this ratio are belonged corn (Ahmad et al., 2011; Khodarahmpour, 2012). More than 3500 different uses are known for corn products (Milind and Isha, 2013). There are seven types of corn; waxy, pod, flint, dent, flour, popcorn and sweet corn. The most cultivated forms of corn are dent, popcorn and flint corn (Elci et al., 1994). This crop is used as food by human and animals. However, it is also produced for medicinal and industrial usages. Industrial production of several items such as alcohols, disposable containers, fabrics, oils, papers, plastics, proteins, starches, and sugars were reported for maize (Johnson et al., 2012). Sweet corn (*Zea mays* L. var. *saccharate*, Sturt) is a mutant corn having the locus Su (Sugary) on chromosome number 4. The genetic variation responses the increase of soluble sugars and polysaccharides in the endosperm of seeds (Tracy and Hallauer, 1994). Sweet corn consists of approximately 5 to 6% sugar, 10 to 11% starch, 3% water-soluble polysaccharides, and 70% water. Sweet corn also includes moderate levels of protein, vitamin A, and potassium (Walker and Dickerson 2009; Najeeb et al., 2011).

Organic fertilizers are the sources of organic matter in the soil and they can be an alternative to chemical fertilizers because they provide the plant with nutrients for a longer period, as well as they improve soil productiveness by increasing the activity of soil microorganisms (Belay et al., 2001). However, if an organic fertilizer is used as a balancing nutrient source with chemical fertilizers, it will increase the influence of fertilizers to yield, thus decreasing yield inconsistence (Yan and Gong 2010). The results of Chivenge et al. (2011) showed that the addition of organic resources could ameliorate nutrient storage while crop yields are augmented and more so for high quality organic resources.

Sweet corn is used as a vegetable and essential food for human beings. Nowadays, sweet corn is one of the most widespread vegetables in the world and its consumption is increasing due to its taste and abundance in vitamins. The processing (canning and freezing) and fresh vegetable value of this crop are the second and fourth respectively (Afsharmanesh, 2014). The storage material in the endosperm is composed of sugars-glucose and sucrose and of intermediate polysaccharides products (Naik, 2011).

Sahoo and Mahapatra (2007) established that increase in fertility level linearly increased the cob and silage yields of sweet corn, while studying the effect of plant population and fertility levels on yield and economics in sweet corn. Abuzar et al. (2011) showed the highest values for row numbers per cob and seed yield were reported for 60000 plant ha^{-1} treatment. However, the seed number per row and cob were reported for the lowest in higher plant densities. Their result evaluated 40000, 60000, 80000, 100000, 120000 and 140000 plants per hectare treatments. The results were compatible with Ali et al. (2017)'s findings showing that yield per plant decreases by increasing plant density, but grain yield per unit area increases. Above a certain limit of plant density, the yield is lost due to increase in the plant to plant unevenness and increase in plant unproductiveness as high plant density above the certain level elongates the duration between pollen shedding and silking, resulting in more unproductive plants. Singh (2017) have detected that the row spacing and sowing of sweet corn at 60 cm wide rows proved to be the best with respect to total weight of green cob (20.20 tons ha^{-1}) and kernel yield (8.07 tons ha^{-1}). Haddadi and Mohseni (2014) observed the best density of 75 000 plants ha^{-1} gave kernel average yield of 8.1 tons ha^{-1}. Jiang et al. (2013) stated that their experience with narrowness of the distance has led to increased efficiency in the use of nitrogen in grains, the harvest index and the ability to produce dry matter. Moreover, nitrogen transfer rates from roots, leaves, and leg covers were higher during grain formation. In the study of Mandić et al. (2015), the maize hybrids reacted positively to high crop densities with maximum forage and dry matter yields occurring at crop density 71 429 plants ha^{-1} (70x20 cm).

Ramezani et al. (2011) revealed that 85 cm row spacing increased leaf fresh weight (10.4%) and stem fresh weight (4.7%), but decreased cob fresh weight (4.6%) over 65 cm row spacing. Kresovic et al. (1997) carried out an experiment with two planting density (49300 and 59 500 plants ha^{-1}) and found a substantial effect of planting density on grain yield and the highest yield was obtained from 59 500 plants ha^{-1}. On the basis of two years results, Ahmad (2010) concluded that early maturing maize hybrid DK-919 could rather be grown at narrow ridges (45 cm) to obtain higher yields. The highest grain yield (7606-7 027 kg ha^{-1}) was obtained from 60 cm x 15 cm spacing (111

111 plants ha^{-1}) and was followed by 45 cm x 22.5 cm (98 765 plants ha^{-1}). The lowest grain yield was obtained from 75 cm x 30 cm spacing (44 444 plant ha^{-1}). The results indicated that row spacing, the most silage yield (42.23 ton ha^{-1}) and dry plant weight (13.88 ton ha^{-1}) were obtained from 65 cm row spacing, and dry plant weight was significantly different with other row spacing.

Sugiyanto, (2011) stated that organic fertilizers have increased the farmers' incomes and improved the soil fertility. In general, the policy encourages reuse of organic fertilizer has been a positive response by farmers. Ketcheson and Beauchamp (1978) showed that the manure treatment without N fertilizer gave yields comparable with any other treatment. Badaruddin et al. (1999) found that the addition of 10 tons of organic manure ha^{-1} gave the best increase in production 14% compared with the treatment of the witness, and the factors that took the amounts of chemical fertilizer equivalent to the amount contained in organic fertilizer gave the lowest increase in production 5 %, indicating that organic fertilizer is a growth factor in addition to containing nutrients. In an experiment to study the role of organic fertilizers and chemical in increasing the production of wheat, where the use of different amounts of organic fertilizer and chemical, found that the addition of organic fertilizer with chemical fertilizers gave an increase in production in all treatments (Nanwal et al., 1998). According to Chinthapalli et al. (2015), it would be wise to recommend the use of organic fertilizers for farmers seeking a better yield for optimum growth of legumes. Uyanoz (2007) evaluated in the study of organic and biological fertilizer applications increased significantly plant height, yield and number of pods. Moreover, there were better results in organic fertilizers than chemical fertilizers in each experimental year. The results of Lukiwati (2012) showed that the combination of organic and inorganic fertilizers from different sources produced a higher yield of sweet corn.

The objective of the present study was to determine optimal plant density in sweet corn growth and yield in Erbil-Iraq conditions and the effect of the plant density and organic fertilizer on growth and yield of sweet corn.

2. Materials and Methods

The field experiment was carried out during two years (2017 and 2018 spring growing seasons) in a private farm in Qushtapa, 30 km far from Erbil-Iraq [global positional system (GPS) reading (36°ON, 44°01E), (0411359, 03997002UTM)]. The composite soil sample was taken from the surface layer (0-0.3 m depth) before seed sowing and some chemical and physical properties of the studied soil in is shown in Table 1. The mixture of goat and sheep manure were dried (60˚C), ground, and sifted via a 0.5 mm sieve for various analyses and for the determined of some chemical properties in the manure are seen in Table 2-3. The climatologically data (the mean of air and soil temperature, rain and relative humidity around spring growing season (April-June) in 2017 and 2018) were taken from Erbil-Qushtapa metrological station as shown in Table 4.

The experiment was designed in a factorial randomized complete block design (RCBD) with three replications. Each replication consists of six experimental units and the total number of experimental units in each year was 18. The area of each experimental unit (plot size) was 2 x 3 = 6 m^2 and while the distance between blocks was 1.5 m, the distance between the experimental unit was1 m. The study included two factors: 1- Plant density (A) 2- Organic fertilizer (B). There are used three different types of density (80000, 120000 and 160000 plant ha^{-1}) (A1, A2 and A3, respectively) for sweet corn (*Zea mays* L. var. saccharata, Sturt, cv. Succar, F1), and two different level of organic fertilizer (0 and 25ton ha^{-1}) (B1 and B2, respectively). plant density in each of them consists of (48, 72 and 96 plants per 6m^2, and divided of the different row in each experimental unit (four, six and eight rows of plants) respectively, each row consist of (12 plants), the distance between plants was 25 cm. Organic fertilizer (Mixed in Sheep and Goat Fertilizer) (0 and 15 kg per 6m^2. Sweet corn harvest was performed manually during the beginning of June and the second half of June. The growth traits were determined before harvesting at the end of May and beginning of June. Plants from the central two rows from each plot were harvested and measured. Some vegetative growth traits of sweet corn and yield were determined as: plant height (cm), no. of leaves (leaf plant^{-1}), no. of branch (branch plant^{-1}), chlorophyll content (SPAD value), leaf area (m^2), dry matter (g per 100 g fresh matter), cob length (cm), no. of seed (seed row^{-1}), fresh cob yield (ton ha^{-1}), fresh seed yield (ton ha^{-1}) cob diameter (cm), no. of cob (cob plant^{-1}), no. of row (row cob^{-1}), no. of seed (seed cob^{-1}). Data were processed using ANOVA. The statistical tests were carried out using SPSS Statistics program. The significance level was set at P≤0.05. Differences between trait means were assessed using Duncan's Multiple Range Test at P≤0.05 level, and T-test was used at P≤0.05 to compare between the mean data of organic fertilizer application and between the years.

Table 1. Some chemical and physical properties of the studied soil.

Properties	Sand (g kg $^{-1}$)	Silt (g kg $^{-1}$)	Clay (g kg $^{-1}$)	Texture	PH	EC (dS m^{-1})	O.M (g)	N (g kg $^{-1}$)	P (mg kg $^{-1}$)	K (mmol L^{-1})
Value	118	432	450	Silty Clay	7.8	0.55	9.5	0.83	9.33	1.12

Table 2. Some chemical properties of the goat manure.

Properties	PH	EC (dS m^{-1})	N (g kg $^{-1}$)	P (g kg $^{-1}$)	K (g kg $^{-1}$)	Na (g kg $^{-1}$)	Ca (g kg $^{-1}$)	Mg (g kg $^{-1}$)	C (g kg $^{-1}$)	C/N Ratio
Value	7.98	8.1	8.5	4.92	10.5	3.2	7.3	12.7	190	22

Table 3. Some chemical properties of sheep manure.

Properties	PH	EC (dS m^{-1})	N (g kg $^{-1}$)	P (g kg $^{-1}$)	K (g kg $^{-1}$)	Na (g kg $^{-1}$)	Ca (g kg $^{-1}$)	Mg (g kg $^{-1}$)	C (g kg $^{-1}$)	C/N Ratio
Value	8.2	8.9	7.8	4.59	8.9	2.9	7	11.5	150	20

Table 4. The mean of monthly climatologically data during March to July in 2017 and 2018.

Months	Year	Air Temperature(C˚)			Average of Soil Temperature(C˚)		Average of Relative Humidity (%)	Average of Sum of Rain (mm)
		Max.	Min.	Average	Deep of 10 cm	Deep of 30 cm		
April	2017	25.1	12.3	18.7	21.6	20.1	52.0	24.3
	2018	26.1	13.9	19.9	22.5	22.3	45.3	69.9
May	2017	32.9	18.6	26.3	30.2	28.3	24.2	2.7
	2018	30.8	19.6	25.4	27.8	26.5	39.1	24.9
June	2017	38.9	24.0	32.4	35.4	33.8	15.3	----------
	2018	38.0	24.1	31.7	33.8	32.2	18.8	----------

3. Results

The statistical analysis and Duncan's Multiple Range Test at P≤0.05 level showed the significance levels among the treatments in sweet corn. Moreover, the T-test at P≤0.05 level was used for comparing between the years and showed significance level between years. The interaction between two factors (plant density and organic fertilizer) was shown in Table 5-6. There were significant differences between two factors it was higher for no of leaves, no of branch, chlorophyll content, leaf area and dry matter. In 2017 and 2018, 80000 plant ha^{-1} plant density with 25 tones ha^{-1} organic fertilizer gave the highest values: 17.67 leaf plant^{-1}, 2.27 branch plant^{-1}, 50.72 SPAD value, 0.045 m^2, and 44.62, respectively in 2017 and 13.87 leaf plant^{-1}, 1.67 branch plant^{-1}, 50.31 SPAD value, 0.045 m^2, 44.62 g DM in 100 g FM, respectively in 2018. The lowest values were recorded in 160000 ha^{-1} plant density with 0 tone ha^{-1} organic fertilizer: 10.33 leaf plant^{-1}, 1.13 branch plant^{-1}, 47.57 SPAD value, 0.040 m^2, 42.25 g DM in 100 g FM, respectively in 2017, and 9.93 leaf plant^{-1}, 1.07 branch plant^{-1}, 47.56 SPAD value, 0.041 m^2, 42.00 g DM in 100 g FM, respectively in 2018. However, for the plant height, the highest value was obtained from 160000 ha^{-1} the plant density with 25 ton ha^{-1} organic fertilizer: 160.94 cm in 2017 and 154.31 cm in 2018, but the lowest value was recorded for 80000 ha^{-1} plant density with 0 ton ha^{-1} organic fertilizer: 142.27 cm in 2017 and 140.41 cm in 2018.

Sweet corn was significantly influenced by the treatments of different levels of organic fertilizer on the all traits in 2017 and 2018, except no of branch and dry matter in 2018. However, plant density has significantly effective on the all traits except dry matter in 2017.

As shown in Table 5-9, the year significantly affects some traits. For plant density on the no. of row per cob (17.45 row cob^{-1}) was recorded maximum value in 2017 and the minimum value (16.68 row cob^{-1}) was recorded in 2018. However, there were significant effects in interaction between plant density and organic fertilizer on the plant height and no. of row per cob. The highest value was recorded in 2017 and the lowest value cultivated in 2018 as 160.94 cm and 17.13 row cob^{-1}and 140.41 cm and 16.33 row cob^{-1}, respectively. With further analysis of the treatment, it was determined that there were no significant effect of different level of year on all traits of organic fertilizer.

Table 5. The effect of different levels of plant density, organic fertilizer and their interaction on plant traits of sweet corn (plant height, no. of leaves and no. of branch) in 2017 and 2018.

Traits / Mean	Plant height (cm)		No. of leaves (leaf plant^{-1})		No. of branch (branch plant^{-1})	
	2017 *	2018 #	2017	2018	2017	2018
A_1B_1	142.27 c ± 2.41	140.41b ± 3.09	14.33 b ± 0.24	13.60 a ± 0.31	1.73 b ± 0.18	1.47 ab ± 0.18
CV%	2.93	3.81	2.90	3.89	17.63	20.83
A_1B_2	147.17 bc ± 2.48	144.60 b ± 1.55	17.67 a ± 1.68	13.87 a ± 0.71	2.27 a ± 0.29	1.67 a ± 0.24
CV%	2.92	1.86	16.50	8.81	22.21	24.98
A_2B_1	147.18 bc ± 1.71	144.37 b ± 2.89	10.73 c ± 0.52	9.80 c ± 0.35	1.20 c ± 0.12	1.07 b ± 0.06
CV%	2.01	3.47	8.40	6.12	16.67	10.83
A_2B_2	150.83 b ± 5.28	144.76 b ± 0.42	12.27 c ± 0.29	11.20 b ± 0.40	1.47 bc ± 0.07	1.27 ab ± 0.06
CV%	6.06	0.51	4.10	6.19	7.87	9.12
A_3B_1	153.40 b ± 2.19	143.15 b ± 1.49	10.33 c ± 0.35	9.93 c ± 0.68	1.13 c ± 0.07	1.07 b ± 0.07
CV%	2.48	1.80	5.91	11.80	10.19	10.83
A_3B_2	160.94 a ± 1.75	154.31 a ± 3.41	11.20 c ± 0.61	11.40 b ± 0.61	1.20 c ± 0.12	1.33 ab ± 0.13
CV%	1.88	3.83	9.45	9.28	16.67	17.32
B_1	147.61 b ± 1.93	142.64 b ± 1.42	11.80 b ± 0.67	11.11 b ± 0.67	1.36 b ± 0.11	1.20 a ± 0.08
CV%	3.92	2.99	16.91	17.98	25.32	22.05
B_2	152.99 a ± 2.71	147.89 a ± 1.94	13.71 a ± 1.13	12.16 a ± 0.52	1.64 a ± 0.18	1.42 a ± 0.10
CV%	5.31	3.93	24.71	12.82	33.74	21.61
A_1	144.72 b ± 1.90	142.51 b ± 1.81	16.00 a ± 1.06	13.73 a ± 0.34	2.00 a ± 0.19	1.57 a ± 0.14
CV%	3.21	3.11	16.30	6.22	23.66	21.98
A_2	149.00 b ± 2.61	144.56 ab ± 1.31	11.50 b ± 0.43	10.50 b ± 0.39	1.33 b ± 0.08	1.17 b ± 0.06
CV%	4.29	2.22	9.25	9.15	15.49	12.90
A_3	157.17 a ± 2.10	148.73 a ± 3.00	10.77 b ± 0.68	10.67 b ± 0.52	1.17 b ± 0.06	1.20 b ± 0.22
CV%	3.28	4.94	8.42	12.02	12.90	18.26

* The significance level was set at P≤0.05to differences between years using T test to compare between year. Differences between trait means were assessed using Duncan's Multiple Range Test at P≤0.05 level. A = Plant density (A1 = 80000 plant ha^{-1}, A2 = 120000 plant ha^{-1}, A3 = 160000 plant ha^{-1}). B =Organic fertilizer (B1 = 0 ton ha^{-1}, B2 = 25 ton ha^{-1}). AB = Interaction between plant density and organic fertilizer.

Table 6. The effect of different levels of plant density, organic fertilizer and their interaction on plant traits of sweet corn (chlorophyll , leaf area and dry matter) in 2017 and 2018.

Traits / Mean	Chlorophyll content (SPAD value)		Leaf area (m^2)		Dry matter (g DM in 100g FM^{-1})	
	2017	2018	2017	2018	2017	2018
A_1B_1	49.16 b ± 0.21	48.38 cd ± 0.33	0.043 a ± 0.000	0.041 bc ± 0.001	43.25 ab ± 0.53	43.20 ab ± 0.60
CV%	0.75	1.18	1.33	2.79	2.11	2.41
A_1B_2	50.72 a ± 0.25	50.31 a ± 0.36	0.045 a ± 0.001	0.045 a ± 0.001	44.97 a ± 0.16	44.62 a ± 1.03
CV%	0.84	1.25	3.42	3.37	0.63	3.98
A_2B_1	48.71 b ± 0.31	47.56 d ± 0.31	0.041 b ± 0.001	0.041 bc ± 0.001	42.64 b ± 0.82	43.82 ab ± 0.39
CV%	1.12	1.17	4.88	5.04	3.33	1.52
A_2B_2	49.65 b ± 0.20	49.79 ab ± 0.12	0.043 a ± 0.041	0.042 bc ± 0.001	43.99 ab ± 0.51	44.56 a ± 0.41
CV%	0.71	0.43	2.66	2.73	2.01	1.59
A_3B_1	47.57 c ± 0.22	47.88 cd ± 0.37	0.040 b ± 0.001	0.041 c ± 0.000	42.25 b ± 0.27	43.54 ab ± 0.50
CV%	0.79	1.35	2.50	1.42	1.11	1.99
A_3B_2	49.08 b ± 0.49	48.85 bc ± 0.53	0.044 a ± 0.001	0.043 b ± 0.001	43.41 ab ± 0.79	42.00 b ± 1.00
CV%	1.74	1.89	2.27	2.33	3.15	4.14
B_1	48.48 b ± 0.27	47.94 b ± 0.21	0.041 b ± 0.001	0.041 b ± 0.000	42.71 b ± 0.33	43.52 a ± 0.27
CV%	1.65	1.30	4.53	3.09	2.29	1.84
B_2	49.82 a ± 0.29	49.65 a ± 0.28	0.044 a ± 0.000	0.044 a ± 0.001	44.12 a ±0.36	43.73 a ± 0.61
CV%	1.78	1.72	2.78	4.00	2.43	4.18
A_1	49.94 a ± 0.38	49.34 a ± 0.48	0.044 a ± 0.001	0.043 a ± 0.001	44.11 a ± 0.46	43.91 ab ± 0.62
CV%	1.86	2.40	2.87	5.78	2.53	3.45
A_2	49.18 b ± 0.27	48.68 ab ± 0.52	0.042 b ± 0.001	0.042 b ± 0.001	43.32 a ± 0.53	44.19 a ± 0.30
CV%	1.34	2.63	4.60	3.83	2.99	1.67
A_3	48.37 c ± 0.41	48.37 b ± 0.36	0.042 b ± 0.001	0.042 b ± 0.001	42.83 a ± 0.45	42.77 b ± 0.61
CV%	2.10	1.84	5.63	3.52	2.60	3.48

* The significance level was set at $P \le 0.05$to differences between years using T test to compare between year. Differences between trait means were assessed using Duncan's Multiple Range Test at $P \le 0.05$ level. A = Plant density (A1 = 80000 plant ha^{-1}, A2 = 120000 plant ha^{-1}, A3 = 160000 plant ha^{-1}). B = Organic fertilizer (B1 = 0 ton ha^{-1}, B2 = 25 ton ha^{-1}). AB= Interaction between plant density and organic fertilizer. DM= dry matter, FM= fresh matter

The results presented in Table 7-8 showed that the interaction between two factors (plant density and organic fertilizer) and their values were different. The plant density 80000 plant ha^{-1} with 25 tones ha^{-1} organic fertilizer had the highest values in 2017 and 2018 for cob length, no. of seed per row, cob diameter, no. of cob per plant, no of row per cob and no. of seed per cob which were 20.22 cm, 37.67 seed row^{-1}, 14.93 cm, 1.47 cob $plant^{-1}$, 17.77 row cob^{-1}, 669.43 seed cob^{-1}, respectively in 2017, and were 20.22 cm, 37.67 seed row^{-1}, 14.93 cm, 1.47 cob $plant^{-1}$, 17.77 row cob^{-1}, 669.43 seed cob^{-1}, respectively, in 2018. The lowest values were recorded in 160000 and 120000 plant ha^{-1}plant density with 0 tone ha^{-1} organic fertilizers and they were 18.93 cm, 32.80 seed row^{-1}, 14.03 cm, 1.00 cob $plant^{-1}$, 16.80 row cob^{-1}, 553.23 seed cob^{-1}, respectively in 2017, and 18.85 cm, 32.80 seed row^{-1}, 13.80 cm, 1.00 cob $plant^{-1}$, 16.33 row cob^{-1}, 553.27 seed cob^{-1}, respectively, in 2018.

In general, sweet corn was significantly influenced by the treatment of organic fertilizer on the all traits except no. of cob per plant in 2017. However, there were significant difference for the plant density on the all traits except cob length, cob diameter and no. of cob per plant in 2017, and the no. of cob per plant and no. of row per cob in 2018.

As shown in Table 9, there were significant difference in the interaction between plant density and organic fertilizer in terms of the fresh seed yield ton per ha^{-1} and fresh cob yield ton per ha^{-1} in 2017 and 2018. The maximum value of these traits were obtained from 160000 plant ha^{-1} with 25 tones ha^{-1} and were 17.09 and 26.29 ton per ha^{-1}, respectively in 2017 and 16.99 and 26.15 ton per ha^{-1}, respectively in 2018. The minimum values of these traits were obtained from 80000 plant ha^{-1} with 0 tone ha^{-1} and were 8.90 and 13.69t on per ha^{-1}, respectively in 2017 and 7.96 and 12.41 ton per ha^{-1}, respectively in 2018.

The evaluation of data clearly showed that the treatments of different level of each main factor (organic fertilizer and plant density) was significantly effective on the fresh seed yield ton per ha^{-1} and fresh cob yield ton per ha^{-1}in 2017 and 2018.

Table 7. The effect of different levels of plant density, organic fertilizer and their interaction on plant traits of sweet corn (cob length, no. of seed row^{-1} and cob diameter) in 2017 and 2018.

Traits / Mean	Cob length (cm)		No. of seeds (seed row^{-1})		Cob diameter (cm)	
	2017	2018	2017	2018	2017	2018
A_1B_1	19.53 ab ± 0.35	19.20 cd ± 0.17	37.07 a ± 0.26	34.93 b ± 0.15	14.17 b ± 0.12	13.87 b ± 0.09
CV%	3.08	1.56	1.22	0.72	1.47	1.10
A_1B_2	20.22 a ± 0.12	20.10 a ± 0.12	37.67 a ± 0.27	37.83 a ± 0.12	14.93 a ± 0.23	15.13 a ± 0.35
CV%	1.00	1.00	1.25	055	2.71	4.04
A_2B_1	19.17 b ± 0.40	18.85 d ± 0.35	34.13 d ± 0.74	33.87 c ± 0.73	14.03 b ± 0.12	13.80 b ± 0.15
CV%	3.59	3.22	3.77	3.74	1.48	1.92
A_2B_2	19.55 ab ± 0.40	19.55 bc ± 0.35	35.63 b ± 0.32	35.43 b ± 0.41	14.67 a ± 0.29	14.27 b ± 0.15
CV%	3.55	3.12	1.55	1.98	3.43	1.76
A_3B_1	18.93 b ± 0.27	18.88 d ± 0.11	32.80 c ± 0.12	32.80 d ± 0.70	14.17 b ± 0.33	13.97 b ± 0.19
CV%	2.35	1.00	0.61	3.70	0.41	2.30
A_3B_2	19.77 ab ± 0.16	19.76 ab ± 0.18	35.33 b ± 0.23	35.53 b ± 0.48	15.00 a ± 0.58	14.77 a ± 0.19
CV%	1.41	1.57	1.14	2.36	0.67	2.18
B_1	19.21 b ± 0.19	18.98 b ± 0.12	34.67 b ± 0.67	33.87 b ± 0.43	14.12 b ± 0.05	13.88 b ± 0.08
CV%	2.98	2.05	5.80	3.78	1.16	1.68
B_2	19.85 a ± 0.16	19.80 a ± 0.14	36.21 a ± 0.39	36.27 a ± 0.43	14.87 a ± 0.12	14.72 a ± 0.18
CV%	2.45	2.17	3.25	3.59	2.43	3.57
A_1	19.88 a ± 0.22	19.65 a ± 0.22	37.37 a ± 0.22	36.38 a ± 0.65	14.55 a ± 0.21	14.50 a ± 0.33
CV%	2.76	2.76	1.41	4.40	3.50	5.52
A_2	19.36 a ± 0.27	19.20 b ± 0.27	34.88 b ± 0.49	34.65 b ± 0.51	14.35 a ± 0.20	14.03 b ± 0.14
CV%	3.37	3.47	3.46	3.62	3.41	2.45
A_3	19.35 a ± 0.23	19.32 ab ± 0.22	34.07 c ± 0.58	34.17 b ± 072	14.58 a ± 0.19	14.37 b ± 0.21
CV%	2.95	2.76	4.16	5.16	3.17	3.65

[*] The significance level was set at P≤0.05 to differences between years using T test to compare between yearss. Differences between trait means were assessed using Duncan's Multiple Range Test at P≤0.05 level. A = Plant density (A1 = 80000 plant ha^{-1}, A2 = 120000 plant ha^{-1}, A3 = 160000 plant ha^{-1}). B = Organic fertilizer (B1 = 0 ton ha^{-1}, B2 = 25 ton ha^{-1}). AB = Interaction between plant density and organic fertilizer.

Table 8. The effect of different levels of plant density, organic fertilizer and their interaction on plant traits of sweet corn (no. of cob plant^{-1}, row cob^{-1} and seed cob^{-1}) in 2017 and 2018.

Traits / Mean	No. of cob (cob plant^{-1})		No. of row (row cob^{-1})		No. of seed (seed cob^{-1})	
	2017	2018	2017 #	2018 #	2017	2018
A_1B_1	1.07 b ± 0.67	1.00 b ± 0.00	17.13 bcd ± 0.32	16.50 bc ± 0.17	635.24 ab ± 16.23	584.55 c ± 4.58
CV%	10.83	0.00	3.21	1.82	4.42	1.36
A_1B_2	1.47 a ± 0.24	1.53 a ± 0.24	17.77 a ± 0.43	17.13 a ± 0.34	669.43 a ± 20.98	648.22 a ± 13.20
CV%	28.39	27.15	4.22	3.42	5.29	3.53
A_2B_1	1.00 b ± 0.00	1.00 b ± 0.00	16.80 d ± 0.21	16.33 c ± 0.09	607.29 b ± 35.85	553.27 d ± 14.66
CV%	0.00	0.00	2.15	0.94	10.22	4.59
A_2B_2	1.07 b ± 0.67	1.07 b ± 0.07	17.33 abc ± 0.28	17.03 ab ± 0.35	617.76 b ± 14.39	603.83 bc ± 19.20
CV%	10.83	10.83	2.85	3.54	4.04	5.51
A_3B_1	1.07 b ± 0.67	1.00 b ± 0.00	16.87 cd ± 0.67	16.70 abc ± 0.31	553.23 c ± 2.92	547.90 d ± 17.67
CV%	10.83	0.00	0.68	3.17	0.92	5.59
A_3B_2	1.07 b ± 0.67	1.07 b ± 0.07	17.47 ab ± 0.12	17.27 a ± 0.20	609.97 b ± 5.33	613.57 b ± 11.72
CV%	10.83	10.83	1.19	2.03	1.51	3.31
B_1	1.04 a ± 0.03	1.00 b ± 0.00	16.93 b ± 0.12	16.51 b ± 0.12	598.59 b ± 16.57	561.90 b ± 8.85
CV%	8.44	0.00	2.17	2.13	8.31	4.72
B_2	1.20 a ± 0.10	1.22 a ± 0.11	17.52 a ± 0.17	17.14 a ±0.16	632.39 a ± 11.97	621.87 a ± 10.10
CV%	25.00	26.44	2.85	2.72	5.68	4.87
A_1	1.27 a ± 0.14	1.27 a ± 0.16	17.45 a ± 0.28	16.82 a ± 0.22	652.34 a ± 14.11	616.38 a ± 15.55
CV%	27.65	31.05	3.92	3.22	5.30	6.18
A_2	1.03 a ± 0.03	1.03 a ± 0.03	17.07 b ± 0.20	16.68 a ± 0.22	612.53 b ± 17.43	578.55 b ± 15.64
CV%	7.90	7.90	2.84	3.29	6.97	6.62
A_3	1.07 a ± 0.04	1.03 a ± 0.03	17.17 ab ± 0.15	16.98 a ± 0.21	581.60 b ± 12.98	580.74 b ± 17.48
CV%	9.68	7.90	2.11	2.99	5.47	7.37

* The significance level was set at P≤0.05to differences between years using T test to compare between years. Differences between trait means were assessed using Duncan's Multiple Range Test at P≤0.05 level. A = Plant density (A1 = 80000 plant ha^{-1}, A2 = 120000 plant ha^{-1}, A3 = 160000 plant ha^{-1}). B = Organic fertilizer (B1 = 0 ton ha^{-1}, B2 = 25 ton ha^{-1}). AB = Interaction between plant density and organic fertilizer.

Table 9. The effect of different levels of plant density, organic fertilizer and their interaction on yield traits of sweet corn (fresh seed yield and fresh cob yield) in 2017 and 2018.

Traits / Value	Yield (fresh seed) (ton ha^{-1})		Yield (fresh cob) (ton ha^{-1})	
	2017	2018	2017	2018
A_1B_1	8.90 e ± 0.29	7.96 f ± 0.30	13.69 d ± 0.45	12.41 f ± 0.33
CV%	5.67	6.54	5.68	4.55
A_1B_2	9.68 e ± 0.31	9.34 e ± 0.50	14.90 d ± 0.48	14.18 e ± 0.62
CV%	5.63	9.27	5.61	7.59
A_2B_1	11.56 d ± 0.09	11.32 d ± 0.37	17.78 c ± 0.14	17.41 d ± 0.57
CV%	1.37	5.72	1.36	5.71
A_2B_2	13.39 c ± 0.27	13.08 c ± 0.46	20.61 b ± 0.41	20.12 c ± 0.71
CV%	3.46	6.14	3.45	6.15
A_3B_1	15.86 b ± 0.56	15.76 b ± 0.47	24.40 a ± 0.86	24.25 b ± 0.72
CV%	6.10	5.15	6.10	5.14
A_3B_2	17.09 a ± 0.75	16.99 a ± 0.67	26.29 a ± 1.43	26.15 a ± 1.03
CV%	9.44	6.85	9.45	6.85
B_1	12.10 b ± 1.03	11.68 b ± 1.14	18.62 b ± 1.59	18.02 b ± 1.74
CV%	25.54	29.46	25.54	28.96
B_2	13.39 a ± 1.11	13.14 a ± 1.14	20.60 a ± 1.71	20.15 a ± 1.77
CV%	24.84	26.00	24.84	26.41
A_1	9.29 c ± 0.26	8.65 c ± 0.41	14.29 c ± 0.40	13.29 c ± 0.51
CV%	6.86	11.48	6.85	9.32
A_2	12.48 b ± 0.43	12.20 b ± 0.48	19.19 b ± 0.66	18.77 b ± 0.73
CV%	8.44	9.54	8.44	9.55
A_3	16.47 a ± 0.56	16.38 a ± 0.46	25.34 a ± 0.86	25.20 a ± 0.70
CV%	8.30	6.86	8.31	6.85

[*] The significance level was set at P≤0.05 to differences between years using T test to compare between years. Differences between trait means were assessed using Duncan's Multiple Range Test at P≤0.05 level. A = Plant density (A1 = 80000 plant ha^{-1}, A2 = 120000 plant ha^{-1}, A3 = 160000 plant ha^{-1}). B = Organic fertilizer (B1 = 0 ton ha^{-1}, B2 = 25 ton ha^{-1}). AB = Interaction between plant density and organic fertilizer.

4. Discussion and Conclusion

The results showed that an increase in plant density led to increasing of plant height. These are compatible with the findings of Griesh and Yakout (2001), Nakachew et al. (2018), Zamir et al. (2011) and Ali et al. (1998). However, Turgut (2000) reported that there was no plant density effect on plant height. Increasing density led to more competition for light, aeration and nutrients and consequently allowing the plants in these treatments to experience less generative growth and led to the number of cobs per plant was significantly diminished. These results are consistent with the results of Tianu et al. (1983) and Sharma and Adamu, (1984). The data indicated that the cob length decreased when the plant population size increased. These results are in agreement with the results of Karim et al. (1983) and Akcin et al. (1993) who determined that the cob length decreased linearly with increase in plant population size. Moreover, the reduction in the leaf area index was caused by the increase in the number of plants and density of plant because the wide and narrow row spacing or plant density of corn led to increase and decrease in the light extinction coefficient (Flenet et al., 1996).

However, the increase of the plant density led to decrease of the dry matter because dry matter production in the plants is directly linked to the use of solar radiation, which is influenced by canopy structure. An increase in plant density resulted in a reduction in the dry matter. It was due to a decrease in row spacing or plant density could be attributed to an increase in plants m^{-2} and consequently an increase in dry matter weight. This result is similar to the finding by Bauer et al., (1982) and Daughtry et al. (1983).

An increase in the yield at the highest density might be because of the greatest number of plants per unit area, which eventually resulted in higher biomass yield and it was agreed with results by Mooi (1991) and Megyes et al. (1999). Under high density, higher numbers of plants per unit area were responsible for higher yield. The higher plant population utilized the production resources more efficiently towards plant development. The lowest yield was recorded with the wider spacing (increase of plant density) and the highest yield was recorded with the narrow spacing (reduce of plant density). With an increase in plant density, there was an increase in the yield of the sweet corn. These results are in agreement with the results of the other researchers (Thakur et al., 1997; Fanadzo et al., 2007; Rathod et al., 2018). Wider row spacing can significantly increase almost all the growth attributes in sweet corn but compensate yield obtained in the density of plant population (narrow spacing) because of increasing the number of plant per area in narrower spacing if compared with wider spacing.

The organic fertilizer has significant effects on the all traits. Increasing of organic fertilizer led to the increase of all traits. Organic fertilizers are the sources of organic matter in the soil and important alternative to chemical fertilizers because they provide nutrients to the plant for a longer period, as well as increase soil productiveness by increasing the activity of soil microorganisms. These results are in accordance with the results of Belay et al. (2001), Murray and Anderson (2004) and Marlina et al. (2017).

In generally, the results showed that the traits were significantly influenced by the interaction between factors (the interaction between plant density and organic fertilizer) on all traits of sweet corn. These findings are compatible with those of Moraditochaee et al. (2012) and Dangariya et al. (2017). However, the results reported by Rathod et al. (2018), combined effect between density and fertilization, nutrient management, and bio-fertilizers did not reach the level of significance for growth, yield attributes, cob and fodder yield.

The analysis of variance showed that plant density of 80000 plant ha^{-1} has significant effect caused by the increase of some growth traits except plant height and yield, but then increase of the plant density to 160000 plant ha^{-1} caused to the increase of total plant height and yield. The organic fertilizer (25 ton ha^{-1}) has a positive effect on sweet corn, caused by the increase in total yield, plant height, and the other growth traits. Moreover, the effect of interaction between plant density and organic fertilizer led to the increase in the growth and yield of sweet corn.

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