Uluslararası Tarım Araştırmalarında Yenilikçi Yaklaşımlar Dergisi
International Journal of Innovative Approaches in Agricultural Research 2022, Vol. 6 (3), 270-278
https://doi.org/10.29329/ijiaar.2022.475.10

Original article

Effect of Alternative Row Spacing and Plant Densities on Fresh Ear Yield and Quality of Second Crop Super Sweet Corn Production

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Abstract

This study was conducted to increase the yield and quality of super sweet corn cultivation; for Vega Super Sweet Corn Variety at two different row spacing (25-45 cm, 70cm) and four different plant densities (15 cm, 20 cm, 25cm, 30 cm) during 2017 and 2018 in Bursa conditions. The research was done according to split plots of randomized blocks design with three replicates. The factors are row spacings and plant densities. Plant height, ear length, ear diameter, ear row number, number of ears per plant, fresh ear yield, and marketable ear percentage were investigated in this study. In the trial ear length, ear diameter, seed number in the ear, numbers of ears per plant, and fresh ear yield are founded to important in terms of statistics for row spacing, the other specialties were founded unimportant. For plant density; plant height, ear diameter, number of ears per plant, fresh ear yield, and marketable ear percentage are founded important in terms of statistics, and the other traits are unimportant. Ear diameter, seed number in the ear, number of ears per plant, and fresh ear yield were founded important in terms of statistics for row spacing and also plant density. According to research results of super sweet corn production for the second crop, the most suitable plant density is 20 cm for a 70 cm row spacing modal, and the most suitable plant spacing is 25 cm plant density for a 25- 45 cm row spacing modal in Karacabey conditions.

Keywords: Super sweet corn, Alternative Row Spacing, Plant Density, Fresh Ear Yield.

Received: 14 September 2022 * **Accepted:** 26 September 2022 * **DOI:** https://doi.org/10.29329/ijiaar.2022.475.10

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INTRODUCTION

Corn is one of the products that have an important place in human and animal nutrition due to its richness in nutrients and the industry due to its different usage areas (Burcu & Akgün, 2017). The development of sweet corn (*Zea mays saccharata* Sturt.) farming, which is usually grown fresh or for the canning industry, is gaining weight in terms of the consumption of corn as a human food source. Sweet corn is sweet when fresh because its endosperm is full of sugar. The protein and oil rate in the grain is higher than in other corn (Köycü & Yanıkoğlu, 1987).

Sweet corn stands out as a plant that attracts attention from the producers in our country because of its short growing period, low water consumption, high income from the unit area, and production with the equipment used in grain and silage corn cultivated in large areas (Eser & Soylu, 2020).

Information about the cultivation area and production amount of sweet corn in our country is not included in the plant production statistics. In the world, the production of sweet corn is 9.182.177 million tons, and the USA and Mexico are the leading countries with the highest production (Dayı, 2011).

Sweet corn breeding studies continue to develop day by day. Studies on the sugar ratio, which is the most important quality criterion, are of great importance in breeding studies, the aim of which is to obtain more productive and quality varieties. The results of this study, which was carried out to determine the most appropriate row spacing and plant densities to obtain optimum yield and quality in sweet corn production, will be a resource for the producers of the region.

MATERIALS and METHODS

Vega super sweet corn variety was used in this study. The research was carried out on the farmer's land in Bursa province, Karacabey district, Beylik neighborhood, in the 2017 and 2018 growing seasons. Seeding dates are 05.07.2017 and 15.07.2018. The experiment was conducted by using a randomized split-plot design with three replicates. The factors were composed of row spacing and plant density. The spacing between rows was placed on the main plots, and the plant density was placed on the subplots. Row spacings were determined as 70 cm and 25-45 cm, and plant density as 15 cm, 20 cm, 25 cm, and 30 cm. In the plots, there were four rows at 70 cm row spacing and 7 rows at 25-45 cm row spacing. The parcel length is 5 m. 50 kg/da base fertilizer NPK (15-15-15) was given to the experiment area and the irrigation of the experiment was done according to the drip irrigation method. Weed control was carried out by hand hoeing.

Harvest was done on 04.10.2017 in the first year and on 05.10.2018 in the second year. As the harvest criterion, the milk stage of the cobs was taken as a basis. In the 70 cm row spacing parcels the middle two rows were harvested, and in the 25-45 cm row spacing parcels, the middle four rows were harvested. Any plant from the beginning and the end of the row was not harvested.

The characteristics examined in the research were determined by considering the criteria of the sweet corn in the agricultural measurement and evaluation technical instructions determined by the Ministry of Agriculture and Forestry (Anonymous, 2010). In the study, plant height, ear length, ear diameter, seed number in the ear, ear per plant, fresh ear yield, and marketable ear percentage characteristics were investigated.

The data obtained from the research conducted in 2017 and 2018 were subjected to analysis of variance by the randomized split-plot design (Turan, 1995). The most appropriate row spacing and plant density were determined by regression analysis. The variance analyzes of the data obtained from the research were performed using the JUMP statistical package software. A probability level of 1% and 5% were used for significance tests, and the Least Significant Difference (LSD) was used at 5% for identifying different groups.

RESULTS and DISCUSSION

The variance analysis results of single years and combined years obtained from sowing with alternative row spacing and different plant densities in sweet corn variety are given in Table 1. For years, row spaces and plant densities have been effective on fresh ear yield and many yield elements. In the combined analysis of variance, the effect of plant densities was found to be significant in all other characteristics except the ear length. The effect of row spacing was significant for all traits except plant height and marketable ear rate. Plant spacing x plant density interaction was significant in terms of kernel number per ear, fresh ear yield, and marketable ear ratio. While the plant spacing x plant density x year interaction was insignificant except for the fresh ear yield, plant spacing x year interaction was found to be insignificant in all other features except the ear diameter and ears per plant. 2017, 2018, and two-year average values of yield and yield components are given in Table 2 and Table 3.

Table 1. Variance analysis of the alternative plant spacing and different plant densities for plant height, ear length, ear diameter, seed number in the ear, ear per plant, fresh ear yield, and marketable ear percentage in sweet corn at single and combined years (Means of Squares)

Source of Variance	DF		Plant Height			Ear Height			Ear Diameter			Seed Number in the ear		
	(1)	(2)	2017(1)	2018(1)	Combined (2)	2017(1)	2018(1)	Combined (2)	2017(1)	2018(1)	Combined(2)	2017(1)	2018(1)	Combined(2)
Years	-	1	-	-	43.89	-	-	1.20	-	-	0.02*	-	-	6772.33**
Blocks	2	4	0.10	211.36	105.73	0.17	0.28	0.22	0.005	0.02	0.01*	558.21	2513.47	1533.84
Plant Spacing (A)	1	1	18.55	20.16	0.016	1.26	0.003	0.70*	0.00	0.04	0.02*	1717.04	4312.12	5735.63**
A x Year	-	1	-	-	38.70	-	-	0.56	-	-	0.02*	-	-	293.53
Main Parcel Error	2	4	45.76	310.33	178.04	0.12	0.02	0.07	0.00	0.003	0.001	530.67	423.55	477.11
Plant Density (B)	3	3	156.10**	227.44*	379.83**	0.35	0.05	0.29	0.01*	0.01	0.02*	985.80**	2768.08	3283.67**
A x B	3	3	8.80	28.09	28.27	0.11	0.05	0.08	0.00	0.01	0.01	924.41**	1802.1	24535.27**
B x Year	-	3	-	-	3.73	-	-	0.11	-	-	0.00	-	-	470.21
A x B x Year	-	3	-	-	8.63	-	-	0.08	-	-	0.00	-	-	191.25
Sub Parcel Error	12	24	13.24	59.07	36.16	0.31	0.18	0.24	0.003	0.008	0.005	193.2	1224.88	709.04

Source of Variance	DF		Ear Per Plant			Fresh Ear Yield			Marketable Ear Percentage		
	(1)	(2)	2017(1)	2018(1)	Combined(2)	2017(1)	2018(1)	Combined (2)	2017(1)	2018(1)	Combined(2)
Years	-	1	-	-	0.35**	-	-	1280.3	-	-	2377.27**
Blocks	2	4	0.01	0.03	0.02	748.47	6480.31	3614.39	2.98	54.34	28.66
Plant Spacing (A)	1	1	0.03	0.094*	0.66**	93775.0	102064**	195751**	0.12	37.75	16.80
A x Year	-	1	-	-	0.31*	-	-	87.75	-	-	21.06
Main Parcel Error	2	4	0.01	0.009	0.01	7344.28	472.62	3908.45	36.62	21.25	28.93
Plant Density (B)	3	3	0.18**	0.08	0.25*	129933**	62631**	182602**	78.53**	189.88**	252.91**
A x B	3	3	0.06**	0.01	0.04	80018.4**	17793.2**	62547.5**	92.17**	68.06**	157.63**
B x Year	-	3	-	-	0.01	-	-	9961.44	-	-	15.51
A x B x Year	-	3	-	-	0.02	-	-	35264.1**	-	-	2.60
Sub Parcel Error	12	24	0.009	0.14	0.07	5259.0	3869.3	4564.2	10.51	6.47	8.49

*, ** statistically significant at the 0.05 and 0.01 probability levels, respectively.

1: Degree of freedom of singular years, 2: Degrees of freedom for two-year averages

Table 2. Mean plant height, ear length, ear diameter, and seed number in the ear values of different row spacing and plant densities in sweet corn.

	Plant Height (cm)			**Ear Height (cm)**			**Ear Diameter (cm)**			**Seed Number in the ear (number)**		
Plant Density (cm)	**2017**	**2018**	**Combined**	**2017**	**2018**	**Combined**	**2017**	**2018**	**Combined**	**2017**	**2018**	**Combined**
15	191.2 a	194.2 a	192.7 a	20.7	20.2	20.5	4.9 b	5.0	4.9 b	591.0 b	609.7	577.6 b
20	185.4 b	188.0 ab	186.7 b	20.5	20.2	20.3	5.0 a	5.0	5.0 a	618.1 a	599.8	613.9 a
25	182.0 bc	183.4 b	183.4 b	20.5	20.1	20.2	5.0 a	4.9	5.0 a	618.2 a	573.6	609.0 a
30	179.4 c	179.9 b	179.9 b	20.1	20.0	20.1	5.0 a	4.9	5.0 a	611.4 a	564.1	592.5 ab
Plant Spacing (cm)												
70	185.3	185.5	185.4	20.7	20.1	20.4 a	5.0	5.0	5.0 a	618.1	600.2	609.1 a
25-45	183.6	187.3	185.4	20.2	20.1	20.2 b	5.0	4.9	4.9 b	601.2	573.4	587.3 b
Mean	184.5	186.4	185.4	20.4	20.1	20.3	5.0 a	4.9 b	5.0	609.6 a	586.8	598.2

Table 3. Mean ear per plant, fresh ear yield, and marketable ear percentage values of different row spacing and plant densities in sweet corn.

	Ear Per Plant (number)			**Fresh Ear Yield (kg/da)**			**Marketable Ear Percentage (%)**		
Plant Density (cm)	**2017**	**2018**	**Combined**	**2017**	**2018**	**Combined**	**2017**	**2018**	**Combined**
15	0.9 c	1.1	0.8 b	1213.4 b	1223.6 b	1223.6 b	57.6 b	40.6 b	49.1 b
20	1.2 b	1.0	1.1 ab	1475.6 a	1460.9 a	1460.9 a	64.2 a	52.7 a	58.4 a
25	1.3 a	0.9	1.2 a	1474.9 a	1437.4 a	1456.2 a	65.7 a	52.1 a	58.9 a
30	1.1 b	0.8	1.0 ab	1227.8 b	1315.5 b	1271.6 b	64.3 a	50.1 a	57.2 a
Plant Spacing (cm)									
70	1.2	1.1 a	1.1 a	1285.4	1293.1 b	1289.2 b	62.9	50.1	56.5
25-45	1.1	0.7 b	0.9 b	1410.4	1423.5 a	1417.0 a	63.0	47.6	55.3
Mean	1.1 a	0.9 b	1.0	1347.9	1358.3	1353.1	63.0 a	48.9 b	55.9

Based on the study results, plant density for plant height was found to be statistically significant at 1% probability level in 2017 and combined years, and at a 5% probability level in 2018. The effect of the alternative row spacing model on plant height is statistically insignificant. As the plant density per unit area increased, the plant height values also increased. Plant height was found to be 192.7 cm at 15 cm plant density and 179.9 cm at 30 cm. Our results are similar to the results of some researchers who reported that the effect of row spacing on plant height was found to be significant, and plant height increased as plant density increased (Burcu & Akgün, 2017; Akman, 2002; Özerkişi, 2016). For all that, Taşçılar (2008) stated in her study that the twin-row planting model did not affect plant height.

The alternative spacing model on ear length was not significant in singular years, but it was significant at a 5% probability level in combined years. The effect of different plant densities on the ear length was not statistically significant. As the average of years, the highest average ear length was found to be 20.4 cm at 70 cm row spacing (Table 2). Kul (2012) and White (1986) stated in their studies that the ear length values increased as a result of the increase in row spacing. In some studies, it has been determined that the increase in plant density causes a decrease in the length of the ear (Moretti, 2012; Turgut, 2000).

Row spacing and plant density had a significant effect on the ear diameter. As the plant density increased per unit area, the ear diameter decreased. The diameter of the ear, which was 4.9 cm at 15 cm plant density increased to 5.0 cm at 20, 25, and 30 cm plant densities. The maximum ear diameter was obtained as 5.0 cm at 70 cm row spacing. The effect of row spacing on the diameter of the ear differs according to the years, making the row x year interaction significant. Özata (2013) and Turgut (2000) found similar results in their plant density studies on sweet corn.

In terms of the seed number in the ear, the average values of 2017 and the combined years, different plant densities, and plant spacing x plant density were found to be statistically significant at the 1% probability level. Plant spacing and years were found statistically insignificant in singular years, but significant at a 1% probability level in combined years (Table 1). The average seed number in the ear obtained from different row spacings is 609.1, the highest value in the combined years average is in 70 cm row spacing. In 2017, when different plant densities were important, the seed number of the ear varied between 591.0 and 618.2, while the highest value was obtained at 618.2 25 cm plant density. Since the values obtained from 20, 25, and 30 cm plant density were very close to each other, they were statistically insignificant and included in the same group. According to the two-year average data, the seed number of the ear varied between 577.6 and 613.9, and the highest value was determined as 613.9 at 20 cm plant density. The results obtained from 20 and 25-row spacing were found to be statistically insignificant for the seed number of the ear (Table 2). As the plant density increases, the seed number of the ear decreases due to the decrease in ear diameter and ear length. Similar findings have been revealed in many studies (Kul, 2012; Suksoon et al, 2007; Cesurer, 1995).

Row spacing and plant density had a significant effect on the ear per plant. As the plant density decreased, a certain increase was observed in the number of ears in the plant. The highest ear per plant was reached with 1.2 at 25 cm plant density. Considering the average values of 2018 and the combined years, in which the different row spacings are statistically significant, it is seen that the number of ears per plant at 70 cm row spacing in both results is 1.1 (Table 3). Findings related to the increase in the number of ears in the plant as the plant densities decrease have also been demonstrated in similar studies (Park et al, 1987; Turgut, 2000).

The effect of different plant densities and row spacing x plant density interaction on the average values of fresh ear yield was found to be statistically significant at 1% probability level in both single years and combined years' average values. While the effect of different row spacings on average fresh ear yield values was found to be statistically significant at 1% probability level in 2018 and combined years' average values, it was found to be insignificant in 2017 (Table 1). In combined years, the highest average value of ear yield was 1460.9 kg da^{-1} and at 20 cm plant density. In terms of different row spacing, the highest fresh ear yield was obtained from 25-45 cm row spacing. Row spacing x plant density interaction was found to be statistically significant in both single years and combined years. The highest value among the mean values of row spacing x plant density interaction was found to be 1549.3 kg da^{-1} in 2017, 1574.6 kg da^{-1} in 2018, and 1561.9 kg/da in combined years. These yield values were determined at 25-45 cm row spacing and 25 cm plant density (Table 3).

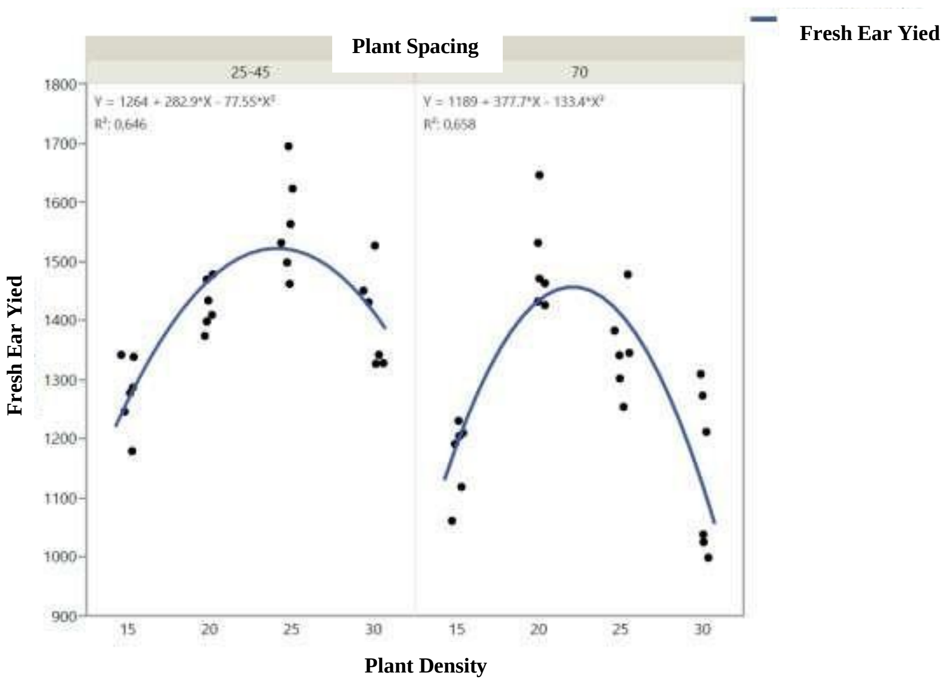

Figure 1. The relationship between different row spacing and plant density and fresh ear yield

In the results of the combined years, the effect of different row spacing and plant density on the fresh ear yield was quadratic. As a result of the calculations, the relations between the fresh ear yield and the row spacing of 25-45 cm and 70 cm, respectively, were found as y = 1264 + 282,9*X – 77,55*X² R²: 0,646 ve y = 1189 + 377,7*X – 133,4*X² R²: 0,658. As seen in figure 1, according to the combined years' average data, it is seen that the highest fresh ear yield average value results in the 25 cm plant density in the aquaculture with 25-45 cm row spacing. In the sowing model where the distance between rows is 70 cm, the highest fresh ear yield average value was determined at the frequency with 20 cm plant density (Figure 1). Değirmenci (2012), Küçükyağcı (2010), and Turgut (2000) determined in their studies that plant density affects the fresh ear yield and the results of the study are similar to our research.

In terms of marketable ear percentage, row spacing x plant density interaction and plant density were found to be statistically significant at the 1% probability level. In general, as the row spacing increased, the value of the marketable ear ratio increased. The highest marketable ear ratio value was obtained (58.9%) at 25 cm plant density, while the lowest value was obtained (49,1)% at 15 cm plant density (Table 3). The highest marketable ear ratio value (63.8%) was obtained from the 70 cm row spacing x 20 cm plant density interaction. Bozkurt (2016) obtained the highest marketable ear yield value from 40 cm row spacing in his plant density study on sweet corn varieties.

CONCLUSION

According to the results of the research, obtain the highest yield and quality in sweet corn cultivation, the most appropriate plant density was determined as 20 cm and 70 cm row spacing. The most suitable plant density was determined as 25 cm in the cultivation carried out at 25-45 cm row spacing. It would be beneficial for the regional producer to consider the most suitable planting method and plant density we have determined to obtain the highest yield in sweet corn production.

Acknowledgement

This study was produced from a master’s thesis.

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