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Effect of Nitrogen and Intra Row Spaces on Sweet Corn *(Zea mays saccharata* Sturt*)* Ear Characteristics

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Abstract: This study was conducted in south-eastern of Turkey during 1998 and 1999 with sweet corn as second crop to investigate the effects of different Nitrogen (N) application rates on some ear characteristics. In this study different nitrogen levels (150, 200, 250, 300 and 350 kg N ha^{-1}) and different Intra Row Spaces (IRS) (140 mm=102 040 plants ha^{-1}, 180 mm=79 370 plants ha^{-1}, 220 mm=64 930 plants ha^{-1}, 260 mm=54 940 plants ha^{-1}, 300 mm=47 620 plants ha^{-1}) were researched. Increasing nitrogen applications increased ear length, ear diameter, kernel number per ear and single fresh ear weight. At wider plant spacing, all yield characteristics were high.

Key words: Sweet corn, nitrogen application rates, intra row space, ear characteristics

INTRODUCTION

Sweet corn is favourable for fresh consumption because of its delicious taste, delicate crust, soft and sugary texture compared to other corn varieties. Sweet corn has been expended widespread in the world. Canned pure or mixed sweet corn with other foods are popular. Fresh, high quality sweet corn is widely popular among consumers. Fresh, high quality sweet corn is one of the most popular vegetables grown in home gardens and purchased by consumers at roadside stands and farmers' markets. At optimum market maturity, sweet corn will contain 5 to 6% sugar, 10 to 11% starch, 3% water-soluble polysaccharides and 70% water. Sweet corn also will contain moderate levels of protein, vitamin A (yellow varieties) and potassium.

Preliminary investigations conducted by Oktem and Oktem[1] showed that it is highly feasible to grow sweet corn in Southeastern Anatolia of Turkey. Stone *et al.*[2] reported that increasing nitrogen applications rate increased ear number per unit area and increasing plant density resulted in a decrease in ear length and grain weight of ear. Amano and Salazar[3] stated that increased seed and nitrogen application rates resulted an decrease in ear number per unit area. Wong *et al.*[4] noted that increased amount of nitrogen increased yield components. Perrin *et al.*[5] and Stoyanova *et al.*[6] stated that different amount of nitrogen applications did not have much effect on plant growth. Sweet corn does have some specific environmental and cultural needs that must be met for the plant to produce high, marketable yields. Other stressful conditions, such as deficiency of nutrients or unsuitable plant density, can reduce yields and cause small, deformed ears. The objective of this study was to determine the optimum seed density and nitrogen application rate for sweet corn production in semi-arid region.

MATERIALS AND METHODS

Experiment was conducted in the Field Research Facility of the Faculty of Agriculture at Harran University during 1998 and 1999, Sanliurfa, Turkey. The experimental field is located in Harran Plain (altitude: 465 m; 37°08' North and 38°46' East) where the climate varies from arid to semi-arid. The weather is hot and dry from May to September where temperatures can reach up to 46°C.

The texture of the research field was clay. Field capacity of the soil was 33.8% in dry basis, permanent wilting point was 22.6% and bulk density of the soil was 1.41 g cm^{-3}. Some chemical characteristics of research area soil was given in Table 1. Merit hybrid sweet corn variety (*Zea mays* var. *saccharata* Sturt*)* was used as a crop material. Table 2 provides the climatic data for the Sanliurfa City Meteorological Station located about 2 km distance from the research field. During the time period for the treatments, the weather conditions were hot, dry and the relative humidity was very low.

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The experiment was set up as a split plot with three replications. Main plots were N application rates (150, 200, 250, 300 and 350 kg N ha^{-1}) and sub-plots were intra row spaces (140 mm=102 040 plants ha^{-1}, 180 mm=79 370 plants ha^{-1}, 220 mm=64 930 plants ha^{-1}, 260 mm=54 940 plants ha^{-1} and 300 mm=47 620 plants ha^{-1}). Each subplot area was 14 m^2 (5x2.8 m) and consisted of 4 rows. Distance between rows was 700 mm. At sowing, triple super phosphate (46% P_2O_5) and potassium sulphate (50% K_2O) fertilisers were applied at the levels of 80 kg ha^{-1} pure P_2O_5 and K_2O. According to N application rates, urea (46% N) was applied in bands in two equal applications; one at seeding and the other at the 6 leaf stage. The banded N was positional 50 mm to the side and 50 mm below the seed.

The seeds were sown at a 50-60 mm depth on the 20th of June, 1998 (Day Of Year) (DOY 171) and the 23rd of June, 1999 (DOY 174). In both years, first irrigation water was applied to all treatments using a sprinkler irrigation system. After emergence of plants, plots were irrigated equally with drip irrigation system to the end of the starch filling period. There was 5 m distance between the main plots. Surface runoff did not occur during the experiments because a drip irrigation system was used.

When the kernel moisture was about 72%[7], ears from two rows in the centre of each plot were harvested manually on the 11th of Sept., 1998 (DOY 254) and the 16th Sept., 1999 (DOY 259). All fresh ear yield values were collected from the centre two rows from each sub-plots in all main plots due to avoid any border influence. Husks were removed from the ears. 20 ears without husk were selected randomly from every sub-plots of all main plots and ear lengths, ear diameters, kernel numbers per ear and single fresh ear yield values were measured.

An split-plot statistical analysis of variance (ANOVA) and Least significant (LSD) tests were conducted on the data combined over years.

RESULTS AND DISCUSSION

As seen Table 3 that Nitrogen (N) application rates and Intra Row Spaces (IRS) were significant ($p<0.01$) for all characteristics. NxIRS interactions were found significant on single fresh ear weight ($p<0.05$) and kernel number per ear ($p<0.01$). And also Y(year)xN and YxIRS interactions were significant ($p<0.05$) on ear length and single fresh ear yield, respectively.

Ear length: Ear length was the longest at 350 kg ha^{-1} N application as 202.8 and 208.8 mm in 1998 and 1999, respectively. Ear length was the shortest at 150 kg ha^{-1} N application as 172.0 and 164.2 mm in 1998 and 1999, respectively (Table 4). Based on IRS, the longest ears obtained from 300 mm IRS (203.1 mm) and the lowest at 140 mm IRS (170.8 mm) (Table 5).

Table 1: Some chemical characteristics of research area soil

Depth (m)	$CaCO_3$ (%)	Total salt (%)	pH	Org. matter (%)	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})
0-0.3	26.8*	0.071	7.6	1.0	22	24	1260
	25.3	0.076	7.5	1.1	28	25	1340
0.3-0.6	29.0	0.076	7.8	0.7	11	19	930
	23.1	0.073	7.7	0.8	13	22	890
0.6-0.9	34.0	0.070	7.4	0.8	5	17	850
	32.0	0.077	7.3	0.7	8	18	820

* Upper and down rows are 1998 and 1999 year values, respectively

Table 2: Monthly minimum, maximum and average temperature, relative humidity and total precipitation values during the growth period of sweet corn in 1998 and 1999*

Months	Temperature (°C) Min.	Max.	Ave.	Average relative humidity (%)	Total precipitation (mm)
June	17.8[†]	41.2	29.4	46.2	0.6
	18.8	40.0	28.8	43.6	1.6
July	19.8	45.4	33.0	43.8	-
	21.5	43.2	32.5	39.7	-
August	22.6	43.0	33.4	41.4	-
	20.5	43.0	31.2	44.7	26.0
September	15.1	39.6	27.0	53.3	-
	17.0	36.6	26.2	46.8	-
October	10.2	34.1	21.5	49.5	0.1
	11.3	35.6	21.0	51.2	8.4
November	8.8	27.9	16.7	66.4	22.7
	1.2	25.0	13.5	50.9	0.8

*Data collected from Sanliurfa Meteorological Station
[†]Upper and down rows are 1998 and 1999 year values, respectively

Table 3: Mean squares from the analysis of variance for sweet corn ear length, ear diameter, kernel number per ear, single fresh ear yield

Source of variation	df	Mean squares: Ear length	Ear diameter	Kernel number per ear	Single fresh ear yield
Year (Y)	1	15.4	1.2	2497.0**	1215.0**
R(Y)	4	493.7**	7.3*	899.0**	84.5
Nitrogen (N)	4	8268.8**	57.4**	38557.6**	5865.6**
YxN	4	404.6*	4.7	49.1	72.9
Error-1	16	96.9	2.0	162.6	101.3
IRS	4	5008.1**	32.3**	17293.6**	26246.8**
YxIRS	4	1.7	0.6	101.3	416.7*
NxIRS	16	95.4	0.7	1474.8**	243.4*
YxNxIRS	16	1.7	0.3	22.7	26.3
Error-2	80	156.8	2.1	205.1	118.7

*, ** Significant at the $p<0.05$ and $p<0.01$ probability levels, respectively

Table 4: The effect of N application rates on plant height, ear diameter and ear length

Nitrogen (kg ha^{-1})	Ear diameter	Ear length 1998	1999	Average
150	41.18c	172.00c	164.20c	168.10d
200	42.17b	178.40c	171.40c	174.90c
250	43.61a	193.40b	199.40b	196.40b
300	44.22a	197.40ab	203.40ab	200.40b
350	44.36a	202.80a	208.80a	205.80a
LSD	0.76	7.62	7.62	5.39

* There are no statistical differences among the treatments having the same letter(s) at 0.05 level according to LSD test

Table 5: The effect of intra row spaces on ear length, ear diameter and single fresh ear yield

IRS (mm)	Ear length	Ear diameter	Single fresh ear yield 1998	1999	Average
140	170.8d*	41.69c	191.90d	184.80d	188.40d
180	181.8c	42.82b	222.70c	229.60c	226.10c
220	192.2b	43.02b	244.30b	256.20b	250.20b
260	197.7ab	43.46b	251.40ab	258.20ab	254.80ab
300	203.1a	44.55a	255.10a	265.00a	260.00a
LSD	6.43	0.75	7.92	7.92	5.60

* There are no statistical differences among the treatments having the same letter(s) at 0.05 level according to LSD test

Table 6: The effect of N application rates and intra row spaces on kernel number per ear of sweet corn

Nitrogen (kg ha^{-1})	Kernel number per ear (number/ear) Intra row spaces (mm) 140	180	220	260	300	Average
150	395.0o*	422.0l-n	470.0j	487.5ı	510.0fg	456.9
200	407.5no	435.5kl	484.5ıj	498.5gı	529.0e	471.0
250	418.0mn	491.0hı	506.5f-h	519.5ef	550.5cd	497.1
300	426.0lm	520.5ef	534.5de	547.5d	570.5b	519.8
350	447.5k	564.5bc	535.5de	569.5b	610.0a	545.4
Average	418.8	486.7	506.2	524.5	554.0	

LSD: 16.45

* There are no statistical differences among the treatments having the same letter(s) at 0.05 level according to LSD test

Table 7: The effect of N application rates and intra row spaces on single fresh ear weight of sweet corn

Nitrogen (kg ha^{-1})	Single fresh ear weight (g) Intra row spaces (mm) 140	180	220	260	300	Average
150	179.0j*	209.5hı	217.0gh	229.0efg	238.5de	214.6
200	181.4j	221.5fgh	238.0e	251.0cd	256.5bc	229.7
250	183.3j	230.5ef	262.0abc	257.6abc	267.5ab	240.2
300	197.5I	236.5e	266.0ab	267.0ab	267.9ab	247.0
350	200.6I	232.6ef	268.2ab	269.2a	269.9a	248.1
Average	188.4	226.1	250.2	254.8	260.0	

LSD: 12.52

* There are no statistical differences among the treatments having the same letter(s) at 0.05 level according to LSD test

Increased nitrogen application increased ear length. Long ears were obtained from plants treated with higher rates of nitrogen. Similar results were also indicated in the literature[2,4]. It was noted that N deficiency in the soil negatively affects nitrogen metabolism and especially protein synthesis, resulting in less developed ears and shorter ears[8]. Short ears were obtained from high plant density plots while long ears were found at low plant density plots. Some researchers[2,9] report that ear length tends to decrease due to increasing plant density. Marketable ear number increased after 300 kg ha^{-1} N and 220 mm IRS. With increasing sowing densities, ears became short and marketable ear numbers and single ear weight decreased[9]. Stone *et al.*[7] reported that harvestable fresh ear length must be above 200 mm.

Ear diameter: Ear diameter ranged from 41.69 mm at 140 mm IRS to 44.45 mm at 300 mm IRS (Table 5). As seen from Table 4 that ear diameter value increased up to 350 kg N ha^{-1} treatment rendering the highest ear diameter value (44.36 mm).

Ear diameter was increased with application of N up to 250 N kg ha^{-1}. But above that application rate there was no significant increase. Some researchers[8] have indicated an increase of ear diameter with increased N application rates while some others reported no effect[3]. Ear diameters were sometimes increased by low plant population[10] and reduced with low nitrogen application and high plant population. Some researchers[11] reported that high plant population along with a nitrogen depravation has a negative impact on ear diameter parameters. High plant population, nitrogen depravation and a limited exposure of plants to the sun cause dry matter production to decrease. Therefore, ear diameter tends to decrease as the number of rows per ear increases and kernel size decreases.

Kernel number per ear: Considering N application rates, kernel number per ear ranged from 456.9 (150 kg ha^{-1} N) to 545.4 (350 kg ha^{-1} N). With the intra row spacing of 140 mm the number of kernels per ear was the highest (418.8) whereas the lowest value (554.0) was obtained from 300 mm intra row spacing (Table 6). Considering N x IRS interaction, the lowest number of kernels per ear was observed at 150 kg ha^{-1} N application rate x 140 mm IRS (395.0 kernel/ear) and the highest one was at 350 kg ha^{-1} N application rate x 300 mm IRS (610.0 kernel/ear). Grand mean of 1998 and 1999 years for kernel number per ear values were 494.0 and 502.1, respectively.

Lower application rates of N and dense seeding resulted in lower kernel number per ear (Table 6). Some researchers stated that nitrogen deficiency resulted in decreased number of kernels per ear[12], Thakur and Malhotra[11] pointed out that increased N application rates had positive effect on the number of kernels per ear[3,11]. Similar results of decreasing number of kernels per ear with dense seeding were reported[13].

Single fresh ear weigh: Table 7 shows that single fresh ear weighed between 214.6 g with N applied 150 kg ha^{-1} and 248.1 g with N applied 350 kg ha^{-1}. Based on IRS, single fresh ear weight ranged between 191.9 g (140 mm) and 255.1 g (300 mm) in 1998 while it was between 184.8 (140 mm) and 265.0 (300 mm) in 1999 (Table 5). As seen from (Fig. 1) the lowest single fresh ear weight value was obtained from 150 kg ha^{-1} N x 140 mm IRS (179.0 g) and the highest one from 350 kg ha^{-1} N x 300 mm IRS (269.9 g) interaction. Grand means for 1998 and 1999 years for

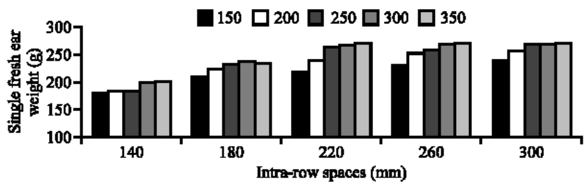

Fig. 1: Single fresh ear weight value at different intra-row spaces and nitrogen dosages

single fresh ear yields value were 233.1 and 238.8, respectively. Decreasing N application rate and seeding density resulted in lower single fresh ear weight values.

High N application rates and wide IRS applications increased single fresh ear weight value. Some researchers[2,11] reported similar results. Single fresh ear yield values increased up to 300 kg N and 300 mm IRS applications. Some other researchers[11,13] report decrease in single fresh ear weight with dense seeding. Lemcoff and Loomis[12] reported that single fresh ear weight decreased under low nitrogen and dense seeding conditions. Single fresh ear weight was low due to shorter ear length and light kernels on ear under low plant density and low nitrogen condition.

Rising of plant population increase the nitrogen requirement. High plant densities can lead to greater inter-plant competition for available nitrogen usage. However, nitrogen efficiency limited with the low plant density. Reduction in dry matter production due to low photosynthesis and plant competition for macro and micro nutrients in the soil were resulted in lack of growth, lowered fresh ear yield and short ears. Therefore; application rate of nitrogen and plant population have to be in balance.

The research results indicated that for fresh marketing 300 kg N ha^{-1} x 220 mm (64 930 plants ha^{-1}) IRS application would be optimal for sweet corn grown in semi-arid regions similar to the area in Turkey where this study was conducted. These results can give a perfective to similar regions like Harran Plain.

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