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Comparison of Different Twin Row and Narrow Row Sowing Methods in Corn A Clay-Textured Soil

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ABSTRACT

Narrow and twin row sowing methods are agronomic applications that aim to increase plant growth and yield by expanding the plant's growing area but, they are highly affected by environmental conditions. The aim of this study is to determine the applicability of different narrow row and twin row sowing methods in clay textured soil in main crop cultivation of corn, which an important grain. The study was carried out Diyarbakır province in the Southeastern Anatolia Region of Türkiye in 2016 and 2017. In the study carried out with two different corn varieties, line abreast narrow row, diagonal narrow row, line abreast twin row, diagonal twin row, single row 1 (70 cm row spacing, 20 cm intra-row spacing) and single row 2 (70 cm row spacing, 12.5 cm intra-row spacing) applications were tried. ADA 351 and Sakarya corn varieties were used in the study. As a result it was determined that line abreast narrow row, diagonal narrow row, line abreast twin row and diagonal twin row applications are not suitable for corn cultivation. The highest grain yield was obtained from single row and 12.5 cm intra-row spacing application.

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Introduction

Corn is a plant that is important for both human and animal nutrition and has a wide range of uses (Öztürk et al. 2019; Şahin, 2001; Özcan 2009; Prasanna 2012; Akkurt & Demirbaş 2021). Also it is an important industrial raw material due to its wide range of uses. Corn is the most produced grain in the world (Murdia et al. 2016; Özcan 2009; Turhal 2021). The yield of corn is about double that of wheat and barley (Özcan 2009). According to the data of the Turkish Statistical Institute for 2023, considering the total production amount in Türkiye, corn ranks third among cereals. In 2023, an average of 9 000 000 tons of corn was produced. The highest production among the regions is made in the Southeastern Anatolia Region. 24.90% of the corn cultivation area and 21.16% of the production amount are in this region in 2022. The corn plant is grown in many regions of Türkiye due to its adaptability to climatic conditions. Due to the suitable climatic conditions, corn can be grown as both the main crop and the second crop in the Southeastern Anatolia Region. Corn production has increased considerably with increasing irrigated areas within the scope of the GAP Project (Akkurt & Demirbaş 2021). It is thought that this rate will increase with more irrigated areas.

As in all cultivated plants, the success of cultivation in corn is directly related to the appropriate cultivation techniques for the region where the cultivation will be carried out. In the production of corn, it is necessary to fully implement the cultivation technique, use the suitable varieties and suitable seeds (Şahin 2001).

Significant advantages of twin row and narrow row sowing technique are known in corn. Some of these include increasing irrigation efficiency by reducing evaporation loss, increasing the chance of controlling weeds by increasing the plant population, and increasing the yield by creating a life triangle for the plant. In sowing made in narrow row spacing, the amount of seed deviation from row as well as the distance between plants in the row center affects the living area and therefore the seed distribution in the horizontal plane (Karayel 2010). However, it is known that narrow and twin row planting methods are highly affected by environmental conditions. Greveniotis et al. (2019) reported that environmental conditions can distort all other effects for 11 of the 12 traits studied, as a result of a 4-year study conducted with different plant populations in single and twin rows in corn. Therefore, positive results may not be obtained from these methods in every region.

The application of narrow row and twin row in corn has been tried in some regions in the world and in Türkiye. However, different shapes of narrow row and twin row spacing such as diagonal and line abreast have not been compared with single row spacing. A twin row corn study was conducted in Hatay province in Türkiye (Gözübenli et al. 2004). There are studies conducted under the conditions of the main crop in Konya province (Kırılmaz 2018) and the second crop in Sanliurfa province (Koşar 2015). However, there is no study conducted under main crop conditions in the Southeastern Anatolia Region, where there is a large corn production. For this reason, this study was planned to determine the performance of different twin and narrow row sowing methods in corn under the main crop cultivation conditions of the Southeastern Anatolia Region for two years.

Materials and Methods

Soil Properties of the Trial Area

The soil properties of the area where the trial was conducted were determined. As can be seen from Table 1, the area where the study was conducted has a low content of organic matter, low P_2O_5, high K_2O, and a clayey structure. The salt content of the trial area is low and contains 8.64% lime.

In the trial area, triple super phosphate and ammonium sulfate were used before sowing and urea fertilizer was used for topdressing. Triple super phosphate and ammonium sulfate were mixed into the soil before sowing, and urea was applied by fertigation method. With sowing, 8 kg of P_20_5 and 5 kg of N were applied, and 20 kg of N was applied as topdressing.

Climate Data

Diyarbakır province, where the experiment was conducted, the climate is hot and dry in summers and warm and rainy in winters. Most of the precipitation generally occurs in winter and early spring. Some meteorological data for the long-term average (1929-2023) in the months when corn is grown in Diyarbakır province are given in Table 2.

The Characteristics of the Varieties

Both ADA 351 and Sakarya varieties have vertical and wide leaves, yellow dent corn grain structure and number of days to ripening are medium-late (FAO 650). The plant height of ADA 351 variety is around 260-320 cm and the yield potential is 15000 kg ha^{-1} on average. The plant height of Sakarya variety is 245-275 cm and the yield potential is 12500-15500 kg ha^{-1}. The leaf angle of ADA 351 variety is narrower than Sakarya variety.

Irrigation

The trial was irrigated by drip irrigation. The amount of irrigation water applied during the irrigation season was determined by the Class A pan evaporation method every 4 days (Vural, 2007). The spacing of the laterals was 70 cm and equal irrigation amount applied to all applications. While 634 mm irrigation amount applied in 2016, 700 mm applied in 2017.

Table 1. Soil properties of the trial area.

Soil Properties	Units	Contents
Texture	-	Clay
Total salt	%	0.034
pH	-	8.10
Lime content ($CaCO_3$)	%	8.64
Available P_2O_5	kg ha^{-1}	28.60
Available K_2O	kg ha^{-1}	1421.80
Organic matter	%	0.98
Field capacity	%	49.06
Wilting point	%	21.66
Bulk density	g cm^{-3}	1.47

Table 2. Meteorological data of long-term (1929-2023) averages of Diyarbakir province

	Months							
	April	May	June	July	August	September	October	December
Average Temperature (^{0}C)	13.8	19.3	26.1	31.0	30.5	25.1	17.6	9.8
Average Highest Temperature (^{0}C)	20.5	26.6	33.6	38.4	38.3	33.4	25.4	16.4
Average Sunbathing Time (hours)	7.2	9.6	12.1	12.4	11.6	10.0	7.5	5.5
Monthly Total Rainfall Average (kg m^{-2})	68.3	44.4	8.6	1.3	1.0	5.3	32.5	55.9

Methods

Separate trials have been conducted for both varieties of corn. The study was carried out for 2 years in 2016 and 2017. Both trials were conducted with 4 replications according to the randomized block trial design. In the trial, the width of the parcel is 2.8 m and the length of the parcel is 6 m. There is a 2 m gap between parcels and between replications.

Sowing methods:

(1) Line abreast narrow row application (35 cm row spacing, 25 cm intra-row spacing)

(2) Diagonal narrow row application (35 cm row spacing, 25 cm intra-row spacing)

(3) Line abreast twin row application (20-50 cm row spacing, 25 cm intra-row spacing)

(4) Diagonal twin row application (20-50 cm row spacing, 25 cm intra-row spacing)

(5) Single row 1 (70 cm row spacing, 20 cm intra-row spacing)

(6) Single row 2 (70 cm row spacing, 12.5 cm intra-row spacing)

Single row 1 is the method used in conventional corn cultivation in this region. Single row 2 was tested in order to determine the result that will be obtained if the plant population used in narrow and twin row applications is applied in single row. In order to determine whether it is important for plants to be diagonal and line abreast in narrow row and twin row applications, both diagonal and line abreast applications were carried out.

Sowing date of corn was in the first week of May according to the weather conditions. All of the phosphorus (P_2O_5) and one-fifth of the nitrogen were applied into the soil before sowing. The remaining part of the nitrogen was given by fertigation method in equal amounts once in two irrigations until the milk stage. Sowing was done by hand. Harvest was done in the second week of October in both years.

Examined Features

Plant height, ear height, number of ears/plant and stem diameter parameters were measured and recorded in 10 randomly selected plants in each plot. Ear length and ear diameter were measured in 10 randomly selected ears from each plot, and grain/ear rate was determined by separating the grains from the ears. Grain yield was determined by converting plot yields to unit area yield based on 15% grain moisture.

Statistical Analysis

Analysis of variance was applied to the data obtained from the study and the difference between applications is grouped by the LSD test. JMP 5.01 statistical program was used for statistical analysis.

Results

The results obtained from different twin row and narrow row applications in the main crop corn cultivation for two years in a soil with a clay texture and climatic conditions that hot and dry summer months in the Southeastern Anatolia Region of Türkiye are as follows; as seen in Table 3, in the trial conducted with ADA 351 corn variety, the highest plant height was obtained from single row 1 application. The closest application to this is the single row 2 application. While there was no difference between applications in terms of ear height, the highest number of ears/plant was obtained from single row 2 and single row 1 applications, respectively (Table 3). In the experiment with Sakarya corn variety, the highest number of ears/plant was obtained from single row 1 and single row 2 applications respectively (Table 4).

It was observed that the highest ear length and ear diameter were obtained from single row 1 and single row 2 applications, respectively in the trial with ADA 351 variety (Table 5). In the experiment with Sakarya variety, the highest ear diameter was obtained from the single row 1 application (Table 6).

In terms of stem diameter parameter, the highest values were obtained in single row 1 application in the trial conducted with both varieties (Table 7, Table 8). Stem diameter is very important for plant growth and lodging resistance. The thin stem of the plants causes the plants to be easily overturned in windy weather. The highest grain yield was obtained from the single row 2 application in the trial carried out with ADA 351 corn variety.

In the trial carried out with Sakarya corn variety, there was no statistical difference between the applications, but it is seen that the highest yield value was in the single row 2 application.

Table 3. The averages and multiple comparison results of the parameters of plant height, ear height and number of ears/plant in the experiment carried out with ADA 351 variety.

Sowing Methods	Plant height (cm)			Ear height (cm)			Number of ears/plant		
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
L.A.N.R.	237.7	218.2	228.0 C	137.0	107.3	122.1	0.75	0.61	0.68 C
D.N.R.	241.8	228.8	235.3 A-C	138.2	108.8	123.5	1.02	0.59	0.81 A-C
L.A.T.R.	236.8	224.1	230.5 BC	137.5	106.2	121.8	0.99	0.55	0.77 BC
D.T.R.	238.8	226.3	232.6 BC	137.7	109.8	123.8	0.86	0.57	0.71 C
S.R. 1	246.5	236.0	241.2 A	139.0	112.6	125.8	0.90	0.85	0.87 AB
S.R. 2	246.5	229.0	237.7 AB	144.0	111.3	127.6	1.08	0.83	0.95 A
Mean	241.3	227.1		138.9A	109.3B		0.93A	0.67B	
CV		3.17			4.19			17.50	
LSD sowing methods		7.58**			n.s.			0.14**	
LSD year		n.s.			7.71**			0.14**	
LSD year*sowing methods		n.s.			n.s.			n.s.	

n.s. non-significant, *: significant at $P < 0.05$, **: significant at $P < 0.01$. L.A.N.R.: Line abreast narrow row, D.N.R.: Diaogonal narrow row, L.A.T.R.: Line abreast twin row, D.T.R.: Diaogonal twin row, S.R. 1: Single row 1, S.R. 2: Single row 2, CV: coefficient of variation; LSD: least significant difference

Table 4. The averages and multiple comparison results of the parameters of plant height, ear height and number of ears/plant in the experiment carried out with Sakarya variety.

Sowing Methods	Plant height (cm)			Ear height (cm)			Number of ears/plant		
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
L.A.N.R.	226.2	208.7	217.5	116.1	100.8	108.4	0.94 ab	0.63 c	0.78 B
D.N.R.	227.1	207.3	217.2	112.8	98.4	105.6	0.99 a	0.54 c	0.76 B
L.A.T.R.	222.5	205.5	214.0	114.1	98.8	106.4	0.99 a	0.54 c	0.76 B
D.T.R.	227.0	208.1	217.5	114.6	99.8	107.2	0.96 ab	0.53 c	0.75 B
S.R. 1	229.5	222.8	226.1	116.2	104.3	110.2	0.97 ab	0.90 b	0.93 A
S.R. 2	226.0	212.0	219.0	115.7	100.8	108.2	0.86 ab	0.82 b	0.84 AB
Mean	226.3 A	210.7 B		114.9 A	100.4 B		0.95 A	0.66 B	
CV		3.93			3.48			12.50	
LSD sowing methods		n.s.			n.s.			0.10**	
LSD year		14.68*			4.88**			0.10**	
LSD year*sowing methods		n.s.			n.s.			0.14**	

n.s. non-significant, *: significant at P < 0.05, **: significant at P < 0.01. L.A.N.R.: Line abreast narrow row, D.N.R.: Diaogonal narrow row, L.A.T.R.: Line abreast twin row, D.T.R.: Diaogonal twin row, S.R. 1: Single row 1, S.R. 2: Single row 2, CV: coefficient of variation; LSD: least significant difference

Table 5. The averages and multiple comparison results of the parameters of ear lenght, ear diameter and grain/ear rate in the experiment carried out with ADA 351 variety.

Sowing Methods	Ear lenght (cm)			Ear diameter (cm)			Grain/ear rate (%)		
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
L.A.N.R.	19.35	19.12	19.24 C	3.38	3.58	3.48 BC	88.98	85.76	87.37
D.N.R.	20.46	19.45	19.95 BC	3.45	3.54	3.49 BC	87.88	85.59	86.74
L.A.T.R.	20.01	18.90	19.45 C	3.37	3.54	3.45 BC	87.82	85.51	86.66
D.T.R.	20.37	18.55	19.46 C	3.25	3.51	3.38 C	87.56	85.57	86.57
S.R. 1	22.77	23.43	23.10 A	3.68	3.90	3.79 A	88.18	86.21	87.20
S.R. 2	20.28	21.56	20.92 B	3.51	3.62	3.56 B	88.62	86.47	87.54
Mean	20.54	20.16		3.44 B	3.61 A		88.17 A	85.85 B	
CV		6.53			3.11			1.52	
LSD sowing methods		1.34**			0.12**			n.s.	
LSD year		n.s.			0.17*			1.46**	
LSD year*sowing methods		n.s.			n.s.			n.s.	

n.s. non-significant, *: significant at P < 0.05, **: significant at P < 0.01. L.A.N.R.: Line abreast narrow row, D.N.R.: Diaogonal narrow row, L.A.T.R.: Line abreast twin row, D.T.R.: Diaogonal twin row, S.R. 1: Single row 1, S.R. 2: Single row 2, CV: coefficient of variation; LSD: least significant difference

Table 6. The averages and multiple comparison results of the parameters of ear lenght, ear diameter and grain/ear rate in the experiment carried out with Sakarya variety.

Sowing Methods	Ear lenght (cm)			Ear diameter (cm)			Grain/ear rate (%)		
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
L.A.N.R.	17.14	15.77	16.45	3.99	4.21	4.10 A-C	81.18	79.15	80.16
D.N.R.	16.16	15.72	15.94	3.82	4.21	4.02 BC	80.24	79.56	79.90
L.A.T.R.	16.53	16.22	16.37	3.91	4.15	4.03 BC	80.98	81.54	81.26
D.T.R.	16.76	16.32	16.54	3.95	4.06	4.00 C	82.23	79.46	80.84
S.R. 1	17.63	17.87	17.75	4.09	4.42	4.26 A	81.87	82.45	82.16
S.R. 2	16.49	16.12	16.30	4.08	4.29	4.18 AB	82.66	80.64	81.65
Mean	16.78	16.34		3.97 B	4.22 A		81.53	80.47	
CV		6.88			3.90			2.51	
LSD sowing methods		n.s.			0.16*			n.s.	
LSD year		n.s.			0.19*			n.s.	
LSD year*sowing methods		n.s.			n.s.			n.s.	

n.s. non-significant, *: significant at P < 0.05, **: significant at P < 0.01. L.A.N.R.: Line abreast narrow row, D.N.R.: Diaogonal narrow row, L.A.T.R.: Line abreast twin row, D.T.R.: Diaogonal twin row, S.R. 1: Single row 1, S.R. 2: Single row 2, CV: coefficient of variation; LSD: least significant difference

Discussion

Gözübenli et al. (2004) and (Balem et al. (2014) found no difference in plant height between single row and twin row. Similar results were obtained in the experiment carried out with Sakarya variety and in these studies. As a result of the study comparing 50 cm row spacing, 75 cm row spacing and twin row planting in corn, the highest plant height was obtained in 50 cm row spacing and twin row (Greveniotis et al. 2019). Ahmad et al. (2010) reported that plant height increased by narrowing the row spacing from 75 to 45 cm. In this study, different results were obtained with these literatures.

Gözübenli et al. (2004) found no difference between single row and twin row in terms of ear length and ear diameter. Contrasting results with this literature were found in the trial conducted with the ADA 35 variety. In the experiment carried out with Sakarya variety, similar results were obtained in terms of ear length and opposite results in terms of ear diameter. Greveniotis et al. (2019) reported that among corn planted with twin row, 75 and 50 cm row spacing, the highest ear length and ear diameter were obtained from 50 cm row spacing. Gözübenli et al. (2004) and Balem et al. (2014) informed that sowing twin row corn increased the stem diameter parameter in corn plant compared to single row. Contrasting results with these studies were found in trials with both variety. Stem diameter was found to be higher in single row 1corn sowing method.

Robles et al. (2012) reported that twin row corn sowing did not increase yield compared to single row. Haegele et al. (2014) informed that twin row planting did not increase yield compared to single row in their study in Lewisville. Balkcom et al. (2011) reported that irrigated twin row corn gives the same yield as single row corn. It was also stated that the effect of hybrid and plant population was greater. Balem et al. (2014) determined that twin row corn sowing increased yield compared to conventional spacing (0.7 m). Novacek (2011) determined that twin row corn cultivation had little effect on yield and plant growth. According to Gözübenli et al. (2004) determined that the twin row corn sowing increased the grain yield parameter in the corn plant compared to the single row. Acciares & Zuluaga (2006) reported that narrow row corn planting increased yield compared to wide row spacing sowing. The study conducted by Kratochvil & Taylor (2005) twin rows (two rows 19.05 cm inches apart on 76.2 cm centers) to corn produced in rows spaced 76.2 cm apart over a range of plant populations 4 different locations was compared. As a result of the study difference was found in only one location and the yield was higher in the 76.2 cm rows. Barbieri et al. (2008) determined that narrow rows increased corn grain yield. Stone et al. (2000) in a study conducted in three different environments (Waikato, Hawke's Bay & Manawatu), it was found that the effect of row spacing on yield and quality of corn was minimal and inconsistent. Maddonni et al. (2006) emphasized that the benefit of narrowing the row spacing (narrow row) in increasing the grain yield of the corn plant is not expected. Lancaster & Adee (2023) reported no difference in corn yield between 38.1 and 76.2 cm row spacing. Fuksa et al. (2023) stated that only limited success was achieved in increasing yield in narrow row spacing.

Table 7. The averages and multiple comparison results of the parameters of stem diameter and grain yield in the experiment carried out with ADA 351 variety.

Sowing Methods	Stem diameter (mm)			Grain yield (kg ha^{-1})		
	2016	2017	Mean	2016	2017	Mean
L.A.N.R.	17.15 cd	19.47 b	18.31 B	8187.30	6636.87	7412.08 C
D.N.R.	18.92 b	19.87 b	19.40 B	11307.52	7404.70	9356.11 B
L.A.T.R.	16.90 d	19.82 b	18.36 B	9953.75	7541.65	8747.70 BC
D.T.R.	18.72 bc	20.00 b	19.36 B	8791.42	7285.65	8038.53 BC
S.R. 1	22.42 a	21.85 a	22.13 A	9451.57	9110.05	9280.81 B
S.R. 2	18.91 b	19.65 b	19.28 B	11928.20	11383.90	11656.05 A
Mean	18.84 B	20.11 A		9936.63	8227.14	
CV		5.75			17.94	
LSD sowing methods		1.14**			1662.43**	
LSD year		1.14*			n.s.	
LSD year* sowing methods		1.61*			n.s.	

n.s. non-significant, *: significant at $P < 0.05$, **: significant at $P < 0.01$. L.A.N.R.: Line abreast narrow row, D.N.R.: Diaogonal narrow row, L.A.T.R.: Line abreast twin row, D.T.R.: Diaogonal twin row, S.R. 1: Single row 1, S.R. 2: Single row 2, CV: coefficient of variation; LSD: least significant difference

Table 8. The averages and multiple comparison results of the parameters of stem diameter and grain yield in the experiment carried out with Sakarya variety.

Sowing Methods	Stem diameter (mm)			Grain yield (kg ha^{-1})		
	2016	2017	Mean	2016	2017	Mean
L.A.N.R.	18.12	20.44	19.28 B	9466.04	7574.37	8520.21
D.N.R.	17.97	19.85	18.91 B	9266.06	6205.32	7735.69
L.A.T.R.	18.32	19.47	18.90 B	8902.52	6755.90	7829.21
D.T.R.	17.70	20.05	18.87 B	9416.32	6092.22	7754.28
S.R. 1	21.45	22.12	21.78 A	8334.34	6696.37	7515.36
S.R. 2	18.15	20.72	19.43 B	11077.14	7651.75	9364.45
Mean	18.62 B	20.44 A		9410.41	6829.33	
CV		4.96			18.14	
LSD sowing methods		0.97**			n.s.	
LSD year		1.02**			n.s.	
LSD year* sowing methods		n.s.			n.s.	

n.s. non-significant, *: significant at $P < 0.05$, **: significant at $P < 0.01$. L.A.N.R.: Line abreast narrow row, D.N.R.: Diaogonal narrow row, L.A.T.R.: Line abreast twin row, D.T.R.: Diaogonal twin row, S.R. 1: Single row 1, S.R. 2: Single row 2, CV: coefficient of variation; LSD: least significant difference

It is seen that different results were obtained from different studies conducted. Different narrow row and twin row corn cultivation did not provide an increase in yield compared to single row corn cultivation in this study. Haegele et al. (2014), Maddonni et al. (2006), Robles et al. (2012), and Balkcom et al. (2011) found similar results with this study in terms of grain yield.

Conclusion

As a result of the data obtained, it was concluded that line abreast narrow row, diagonal narrow row, line abreast twin row and diagonal twin row applications are not suitable in terms of both yield and yield parameters for corn cultivation under main crop conditions in the Southeastern Anatolia Region of Türkiye. Because better results were obtained from single row applications in all parameters examined. The highest grain yield was obtained from single row 2 application, which has the same plant density with different twin row and narrow row applications. Therefore, narrow row and twin row applications were not found to be advisable in the main crop grain corn cultivation in this region.

Declarations

Author Contribution Statement

Betül Kolay: Project administration, supervision, data collection, investigation, formal analysis, conceptualization, methodology, review and editingand writing the original draft

Özlem Avşar: Data collection and investigation

Uğur Bilge: Data collection and investigation

Kudret Berekatoğlu: Data collection and investigation

Sevda Kılınç: Data collection and investigation

Ferhat Oğurlu: Laboratory analysis

Şehmus Atakul: Data collection and investigation

Yener Çelik: Disease and pest monitoring in plants

Abdullah Eren: Data collection and investigation

Ali Rıza Öztürkmen: Supervision, conceptualization, methodology, review and editing

Fund Statement

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Conflict of Interest

The authors declare no conflict of interest.

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