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Full Length Research Paper

Seed drilling distance applications in sugar beet cultivation

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This research was conducted with the Leila sugar beet variety between 2007 and 2009 at the Sugar Institute Etimesgut and Ilgın experimental stations, and the aim of this research was to determine the most suitable seed distance in rows for sugar beet cultivation. Both experimental stations were located in the Central Anatolia region. Six different sowing distances were specified as the following methods: 8 (T1), 10 (T2), 12 (T3), 17 (T4), 19 (T5) and 21 cm (T6). Thinning and singling were applied only in the T1, T2 and T3 distances. The average germination was 65%, and there were no differences observed among the methods. The highest beet yield was found in T1, with a value of 57.61 t ha^{-1}, and T1 had the highest sugar content, refined sugar content and refined sugar yield with values of 18.27, 15.81%, and 9.08 t ha^{-1}, respectively. The lowest values for beet yield, sugar content, refined sugar content and refined sugar yield were found in T6 with values of 47.08 t ha^{-1}, 17.83%, 15.19% and 7.35 t ha^{-1}, respectively. Determined differences among the methods were significant at a level of 1%. The highest farmer income was obtained in T1, T2 and T4. If the soil preparation and sowing are fulfilled in favorable conditions, the T1, T2 and T3 methods are applicable in Central Anatolia. T4 is also more beneficial method in areas where there is a problem to meet labor demands. The T5 and T6 methods should be used with caution in fields with insufficient climate and soil conditions because differences in yield and quality may exist.

Key words: Precision drilling, seed distance in row, mechanical precision drilling machine, sugar beet, yield and quality.

INTRODUCTION

High quality and yield in field plants are only possible if planting machinery drills at an adequate density required by the plant, a straight distance in the rows and a straight distance between the rows. These requirements are important for decision makers in countries that have moved on from bunching and singling drilling to non-bunching and singling drilling. The optimum plant frequency distribution using agricultural practices in large areas, such as Turkey, is difficult to define. A square pattern in which the plant distance in the rows and between rows is 30 cm is ideal (Johnson et al., 1971). This life area gives every plant an equal chance to reach its maximum potential. In practice, however, a distance of 30 cm is not suitable for tillage, irrigation and harvest applications. In addition, climate, soil texture and regional changes of these characteristics are important factors to take into consideration when designing a sowing system.

Due to the fact that there are many factors that affect the plant number in a unit area, various studies have been performed to determine optimum plant frequency. Optimum plant frequency to obtain the highest yield and quality has been determined to be between 70000 and 90000 plants ha^{-1} (Saric and Nenadic, 1985; Jaggard, 1995). Distances of 50 cm between rows and 25 cm in rows for sugar beets in various countries are currently

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Table 1. Beet numbers per ha depend on the field emergence rate and seed distance in the row.

Seed distance in the row (cm)	Seed number in drilling*	Seed number in area (1000 seed/plant ha^{-1}) Field emergence rate (%)					
		30	40	50	60	70	80
8	278	83	111	138	166	194	222
10	222	**66**	88	111	133	155	177
12	186	**55**	74	92	111	129	148
17	131	**39**	**52**	**65**	78	91	104
19	117	**35**	**46**	**58**	70	81	93
21	106	**31**	**42**	**52**	**63**	74	84

*Not including double and empty seed gaps.

being used to ensure a yield of 80000 plants ha^{-1}. In Turkey, the sugar beet drill distances are 45 cm between rows and 20 cm in rows (Bilgin, 1987). Due to the cultural process and insect destruction, 12 to 20% of beets are lost from singling to harvest. Therefore, beet frequency in a unit area must be calculated to consider this lost. Table 1 shows the most suitable distance in rows for current conditions. In the case of drilling, the distance in rows match field emergence rate (shown in bold), and this distance must decrease to increase the plant number that must be planted in 1 ha to achieve the highest yield and quality. At these drilling distances, growers would suffer. Thus, the field emergence rate must be correctly specified, and the drilling distance in rows must also be determined. Climate, rainfall and temperature are important factors that are considered in the development period of sugar beet farming. The lowest night temperature during the beet development period is favorable in terms of dry matter production. Furthermore, sugar beets produce sugar at high levels in conditions of suitable precipitation or irrigation.

Daily water requirements of 400 to 600 mm for 1 kg of dry matter production are high. The water requirement during seed germination and seedling establishment is also quite high (Özgör, 1986). It is not possible for growers to control certain factors, such as annual climate and soil conditions. However, the negative impact of an insufficient quantity of precipitation can be reduced with irrigation. The following yield and quality factors can be controlled by growers: plant frequency (number of plants and plant distribution), seed variety selection, vegetation period (planting and harvesting times), field and seed bed preparation, maintenance (hoeing, plant protection, fertilization and irrigation), topping, harvest shape, and storage. Plant yields of fewer than 70000 plants ha^{-1} beet yield can slowly decrease over time, but some quality features can quickly decay. In addition, the beet yield and technological quality can decrease in fields that have empty gaps or high double-plant rates in rows (Tortopoğlu, 1994). The sizes of beets growing singly at equal distances in rows are likely to be homogeneous, and have high yields and technological quality. Proper plant distribution in fields also enables correct topping techniques by machines during harvesting.

Drilling monogerm seeds with precision drilling machines began in the mid 1960s throughout the world, particularly in European countries. Developments in sugar beet cultivation have been closely monitored in Turkey (Tufan, 1987). Since 1990, genetic monogerm seeds have been used, with seed consumption decreasing to 3 kg ha^{-1}. The germination performance, resistance against disease, resistance against pests, yield and internal quality of seed varieties have continuously increased after 1990, and studies on these parameters have started to focus on non-bunching and singling sugar beet agriculture. In field emergency power trials repeated every year by the Sugar Institute, the field emergency power of varieties has been determined to be between 56 and 86% (İnan et al., 2010). In current farming conditions, the germination rates vary between 30 and 60%, and the rates vary between years in Turkey due to small beet cultivation fields and semi-arid climate conditions, which result in inadequate or untimely agricultural applications. Therefore, drilling with a distance of 8 cm in rows is carried out 55% of the time (Günel et al., 2010). Inan (1993) studied the effect of 8, 15, 17, 19 and 21 cm drilling distances in rows on sugar beet yield and quality in Adapazarı and Ankara conditions. Inan (1993) specified that 70000 plant ha^{-1} could not be reached at a 21 cm drilling distance, which is necessary for optimum yield and quality. Differences in internal quality and beet yield are not significant until a 17 cm drilling distance for Adapazarı conditions and a 19 cm drilling distance for Ankara conditions are used. Moreover, Inan noted that the differences in quality and yield between the drilling distances greater than 17 and 19 cm are statistically important at a 1% level.

Çakmakçı and Oral (1995) studied the following effects on beet yield and quality: 45 cm distance between rows; bunching and non-bunching drilling at 8 and 15 cm distances in rows; and three field emergence levels of 60, 50 and 35%. Based on the results of their two-year study,

Table 2. Precipitation and temperature condition.

Year	Conditions	Etimesgut						Ilgın					
		April	May	June	July	August	September	April	May	June	July	August	September
	Precipitation (mm)	19	4	25	8	1	-	19	3	17	-	17	46
2007	Temperature (high)	27	37	40	43	42	39	23	30	36	38	36	32
	Temperature (low)	-4	5	10	13	14	6	-3	6	9	10	12	3
	Precipitation (mm)	25	30	25	-	1	29	26	25	11	4	-	87
2008	Temperature (high)	32	35	39	41	39	38	25	27	33	37	36	32
	Temperature (low)	1	1	8	11	14	2	3	3	7	10	10	7
	Precipitation (mm)	62	11	14	17	-	3	53	44	15	4	-	10
2009	Temperature (high)	26	33	38	39	39	36	22	27	33	37	38	32
	Temperature (low)	-1	8	6	14	10	2	-1	2	9	9	7	2

they reported that there is not a significant loss in terms of root and refined sugar yield in the case of 50 to 60% field emergence rate at a 15 cm drilling distance, and they stated that bunching agriculture can be applied in these conditions. Stanacev et al. (1981) specified that a 20 cm range for bunching agriculture is better than non-bunching planting at ranges of 10 and 15 cm. Nagy et al. (1981) also determined that an 8 cm range in bunching drilling is more advantageous than a 15 cm range in non-bunching drilling in terms of root and sugar yield. Currently, seed bed preparation, planting, cultural applications and plant protection techniques are significantly developed.

The germination power of genetic monogerm seeds has decreased the dependence of field emergence on weather conditions. Important factors, including drilling distances, allowing the required number of outputs in the field and sufficient plant numbers ensure the desired yield and quality on a regional level.

Post-drilling labor procurement has become more difficult each day, and labor costs are continuously rising in sugar beet agriculture. In European countries, these problems are being solved by non-singling and non-bunching drilling with adequate climate and soil conditions.

If the seed distances in rows are small, then bunching is not required in sparse sowing. In European countries, sugar beet drilling is largely applied with distances of 20 to 25 cm in rows. In recent years, the use of a drilling distance of 17 cm in rows with a 3.25 to 4.00 mm calibration range using thin-coated seeds has increased in Turkey. In good climate and soil conditions, this rate can be increased with appropriate seed bed preparation and emergence irrigation in required places. In this study, which was located in Central Anatolia, the applicability of drilling at distances of 10, 12, 17, 19 and 21 cm was compared to the existing drilling distance of 8 cm. Furthermore, the effects of non-singling and non-bunching drilling applications on sugar beet yield and quality were also taken into consideration.

Table 3. Methods and seed distances in the row.

Method	T1	T2	T3	T4	T5	T6
Seed distance	8	10	12	17	19	21

MATERIALS AND METHODS

This study was carried out between 2007 and 2009 at the Etimesgut and Ilgın trial stations (Turkish Sugar Factories Corporation). The soil at the Etimesgut trial station has a clayey soil texture, and the Ilgın trial station has a silty-clayey soil texture. Both areas have a terrestrial climate. Annual precipitation of Etimesgut was 236, 227 and 371 mm in 2007, 2008 and 2009 and Ilgın was 409, 326 and 401 mm, respectively. The distribution of precipitation was irregular in both areas throughout the year. The precipitation, the highest and lowest temperature from sowing time to harvest by months is given in Table 2. In the autumn, the fields were first prepared with subsoil and were then cultivated once with a moldboard plough using 2/3 of the phosphorous fertilizer. In the spring, the seed bed was prepared by applying the remaining 1/3 of the phosphorous fertilizer and half of the nitrogenous fertilizer. The remaining half of the nitrogenous fertilizer was applied before the first hoeing. According to the soil analysis results, the following amounts of the pure materials were applied to the soil: 16 kg of nitrogen, 6 kg of phosphorus and 8 kg of potassium. Genetic monogerm sugar beet seeds, named “LEILA”, originating from German KWS (Kleinwanzlebener Saatzucht A.G.-Einbeck) were used in the study. The average mass of 1000 seeds was 10.77 g, and the germination power was 90%. A mechanical precision drilling machine was used to sow the trial plots.

After completion of the whole field emergence, the trial plots were harrowed twice and pulverized once against underground insects. In the plots with seed drilling distances of 8, 10 and 12 cm, beets were manually bunched at 20 to 24 cm at the 4 to 6 leaf stage. In the other plots with drill 17, 19 and 21 cm, beets were singled and not bunched with more than one seedling in the queue but not bunched. Irrigation was started in June, based on soil and plant observations. Trial plots were irrigated seven times in the Ilgın experimental station, and trial plots were irrigated five times in the Etimesgut experimental station. An 8 cm seed distance, which has the maximum drilling ratio of 55% in Turkey, and seed distances of 10, 12, 17, 19 and 21 cm were considered in this study (Table 3). A tillage plot was created as a small plot trial in a completely randomized design with four replicates. The trial plots were 10 m long and 4.5 m wide. The distance between the iterations was 7 m to allow easy tractor steering, and the distance between the plots was 1 m. Initially, sugar beets were drilled in 10 rows in each plot, and the middle of the plot was evaluated after harvesting six rows. There were 410 beets in the planting plot and 180 beets in the harvest plot. The trial area was 1647 m^2. The planting parcel area was 45 m^2, and the harvest parcel area was 20 m^2. A motion transmission realizes a 0.64 transmission rate from the main wheel to six angular transmission axles and a 0.40 transmission rate from the axle to the unit core gearwheel. The total transmission rate from the main wheel to the unit core is 0.25.

Therefore, when the main wheel turns four times, the cell wheel turns one time to allow the number of seeds sown to be equal to the number of holes on the surface. The drilling distance setting on the machine was made by changing the transmission rate or changing the number of holes on the cell wheel. In this study, the drilling distance was controlled by changing the number of holes without changing transmission rate. For the various drilling distances, the following settings of the cell wheel were used: 90 holes for 8 cm, 70 holes for 10 cm, 58 holes for 12 cm, 38 holes for 17 cm, 34 holes for 19 cm, and 31 holes for 21 cm. After harvest, the beets were washed and weighed. The beets were then sampled for analysis with the aid of a fraise hob in an analysis laboratory. Dry matter was measured by a refract meter. Sugar content was considered to be the percentage of polar sugar (P). The polar sugar amount was determined by extracting 26 g of beet pulp with 178.2 ml of lead (Pb) acetate liquor, and polar meter readings were taken. Sodium (Na) and potassium (K) amounts were determined by a Betalyser using flame photometer principals. The α-N amount was also determined by a Betalyser using spectrophotometer principals. The refined sugar content (RSC) and refined sugar yield (RSY) values was calculated using the following equations (Reinefeld et al., 1974):

$$RSC = SE - [0.343 \times (Na + K) + 0.094 \times \alpha\text{-}N + 0.29)] \quad (1)$$

$$RSY = BY \times RSC \quad (2)$$

Where RSC is the refined sugar content (%), SE is the sugar content (%), Na is the amount of sodium (meq Na/100 g), K is the amount of potassium (meq K/100 g), α-N is amount of harmful nitrogen (meq N/100 g), RSY is the refined sugar yield (t ha^{-1}), and BY is the beet yield (t ha^{-1}). Variance analysis and F-tests were applied to the study outcomes in accordance with the trial plan. No comparisons were made where the F-value was found to be insignificant. Double comparisons in the case of significant F-values were made by Duncan's multiple comparison method.

RESULTS

Field emergence

When the field emergence was completed after sowing, the number of beet seedlings in the plot was counted and the field emergence rate was determined (Table 4). In general, the field emergence rate in both regions was similar at 65%. The field emergence rate is an important factor to consider when determining seed distance in rows. Moreover, the field emergence rate is an indicator of the region to be sown and of the time for when the applications should be carried out by the farmer. When using 70000 plants per ha, which is required for the highest yield and quality, 60% field emergence for a 19 cm drilling distance and 70% field emergence for 21 cm drilling distance must be ensured, as shown in Table 1.

Number of plants

The field emergence numbers and harvest times are shown in Table 5. The highest field emergence was obtained from T1, and the lowest field emergence was obtained from T6, which suggested that field emergence depended on the number of drilled seeds. If there were no double seeds and empty gaps, the theoretical seed numbers drilled per hectare are shown in Table 1. The highest number of seeds was drilled in T1 with 278000 seeds, and the lowest number of seeds was drilled in T6 with 106000 seeds. The beet number determined at harvest was similar to the field emergence number. The number of beets at harvest in T5 was slightly more than 70000 plants per ha, which is required for the highest yield and quality, and the number of beets at harvest in T6 was below this value.

Beet yield

The beet yield values obtained from both regions are shown in Table 6. During the three years, the beet yields obtained at the Ilgın experiment station were higher than the yields obtained at the Etimesgut experiment station. When the methods were compared, T1 had the highest value in each of the two regions, followed by T2. The difference between T1 and the other methods in Etimesgut was statistically significant at a level of 1%, and the difference between T1 and the other methods in Ilgın was statistically significant at a 1% level. The values for T1 were not significantly different between the two regions, and T1 had highest yield, followed by T2, T3 and T4. The lowest yield was obtained from T5 and T6. The average field emergence rates were similar, with values of 66 and 64% for the Etimesgut and Ilgın experiment stations (Table 4). However, while there were 196470 seedlings per ha in T1 when the field emergence was completed, and there were 89860, 82830 and 71760 seedlings per ha in T4, T5 and T6, respectively, when the field emergence was completed (Figure 1). The number of beets at harvest was 98770 in T1 followed by 79900, 77880 and 66500 in T4, T5 and T6, respectively. In T6, the number of beets at harvest was less than 70000 plants, which is the lower limit and is required for the highest yield and quality per ha. The number of beets in T5 was only slightly above the lower limit. Low beet numbers reduce the yield. When beet yield change was evaluated by field emergence, the beet yield decreased even though the field emergence was high in T4, T5 and T6, and this trend may have been due to the low unit area plant number at harvest (Figure 2).

Sugar content

The beet sugar contents in this study are shown in Table 7. When comparing the combined results from the three

Table 4. Field emergence rate (%).

Methods	2007		2008		2009		Mean	
	Etimesgut	Ilgın	Etimesgut	Ilgın	Etimesgut	Ilgın	Etimesgut	Ilgın
T1	47	64	82	81	50	38	60	61
T2	47	55	80	80	58	47	62	61
T3	43	48	74	81	59	56	59	62
T4	43	52	72	74	72	76	62	67
T5	45	54	74	78	74	84	64	72
T6	40	45	75	73	75	66	63	61
Mean	44	53	76	78	78	61	66	64

Table 5. Plant numbers at field emergence and harvest.

Method	Etimesgut mean (plants ha^{-1})		Ilgın mean (plants ha^{-1})		General mean (plants ha^{-1})	
	NFE*	NPHT**	NFE	NPHT	NFE	NPHT
T1	166430	95370	226501	102170	196466	98770
T2	137230	88540	173691	98040	155461	93290
T3	108330	82750	141681	92210	125006	87480
T4	81140	71670	98570	88121	89855	79896
T5	75130	71910	90521	83831	82826	77871
T6	66740	66710	76770	66290	71755	66500

*NFE, number at field emergence; **NPHT, number at harvest time.

Table 6. Beet yield values (t ha^{-1}).

Method	Etimesgut	Ilgın
T1	43.92^{a}	71.30^{a}
T2	40.62^{ab}	68.39^{b}
T3	38.47^{b}	67.26^{bc}
T4	37.98^{bc}	66.54^{bc}
T5	35.02^{cd}	64.93^{c}
T6	33.40^{d}	60.76^{d}
F	10.129**	15.211**
SEM	38.24±2.07	66.53±1.57

**P < 0.01.

years, there were no statistically significant differences in the sugar contents between T1 and T2, T3 and T4 for both regions. On the other hand, the differences in sugar contents between T1 and T5 and between T1 and T6 were significant at a 5% level ($p < 0.05$). Field emergence did not affect the sugar contents (Figure 3).

Refined sugar content

The beet refined sugar contents in this study are shown in Table 8. The difference in refined sugar contents among the methods was determined to parallel to the sugar content values. The highest refined sugar content was obtained from T1. The refined sugar contents in T2, T3 and T4 were similar to the refine sugar content in T1, and the differences among the methods were not significant. T5 and T6 had the lowest refined sugar content values (Figure 2).

Refined sugar yield

The beet refined sugar yield values in this study are shown in Table 9. T1 had the highest refined sugar yield values, followed by T2. While the difference between T1 and T2 was not significant, the differences between T1 and the other methods (T3, T4, T5 and T6) were significant at a 1% level. The lowest refined sugar yield value was found in T6, which was similar to the other measured parameters. The second lowest refined sugar yield was in T5. The refined sugar yield depended on field emergence with a declining trend resulting from increased seed distance (Table 4 and Figure 3). When taking into account the climate condition of the regions, a similar field emergence of 65% was observed in all plots (Table 4). Thus, only 65 of 100 drilled seeds were

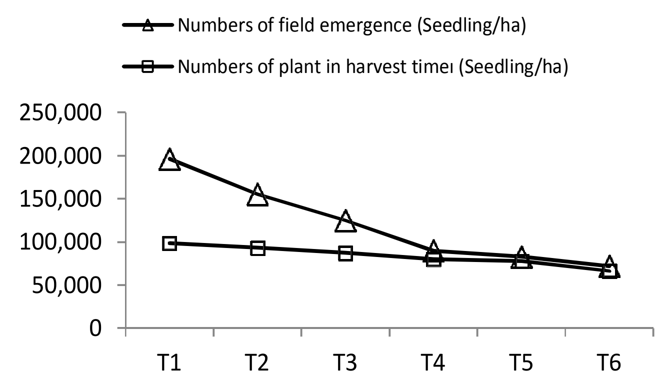

Figure 1. The average field emergence and plant numbers at harvest in the trial plots.

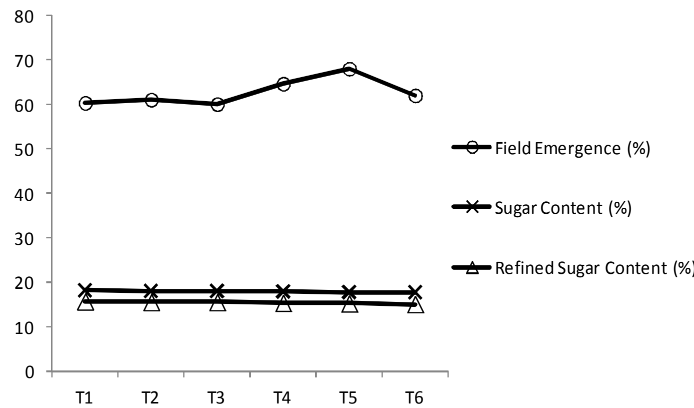

Figure 3. Changes of quality parameters according to methods.

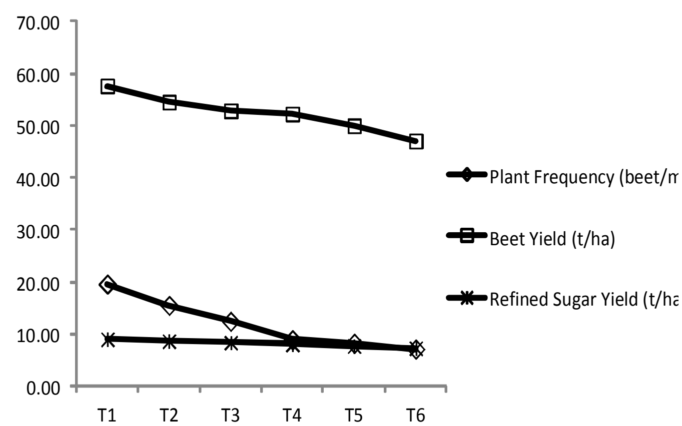

Figure 2. Changes of yield and plant frequency according to methods.

Table 7. Combined sugar content values from the three years (%).

Method	Etimesgut	Ilgın
T1	18.16^{a}	18.38^{a}
T2	17.94^{ab}	18.35^{a}
T3	17.90^{ab}	18.34^{ab}
T4	17.86^{ab}	18.16^{abc}
T5	17.65^{b}	18.11^{bc}
T6	17.62^{b}	18.04^{c}
F	1.266*	3.035*
SEM	17.86±0.31	18.23±0.15

*P < 0.05.

germinated in the Middle Anatolia region, which has the most suitable ecological conditions for sugar beets. In addition, 35 of 100 drilled seeds were lost due to climate deficiencies, soil deficiencies, pests and diseases. From field emergence to harvest, an average of 60% was lost in T1, T2 and T3, and an average of 8% was lost in T4, T5 and T6. The loss may be due to the singling and bunching applications. The increased seed drilling in the first three methods may have been due to the consideration for the guarantee of beet and sugar production even with lower field emergence values resulting from regional application and climate condition differences. Use of the T4 which includes the non-singling and bunching application, is currently increasing in sugar beet agriculture in Turkey. Application of the T6 method, which is extensively applied in European countries under the same conditions of the study region, is considered too risky. However, it may be possible to choose a final drilling distance if the climate and soil conditions are suitable, and the final drilling distance may be used in field applications if sufficient precautions are taken.

Total cost

The drilling seed amounts per unit area (kg ha^{-1}) depending on the seed distance; yield (t ha^{-1}) and farmer's income were calculated and represented as a relative value in Figure 3. The cost of 1 kg of processed and chemically dressed naked seed is $18.46 according to the Turkish Sugar Factories Corporation cost summary (TŞFAŞ, 2010). Half of the cost ($9.23) is taken from the farmers according to a sowing contract ($1 = 1.58 TL). A double seed average of 10% was observed and accepted, depending on the seed calibration of drilling naked sugar beet seeds with a mechanical precision sugar beet drilling machine. In this study, 3.29 kg of seeds per ha were drilled in T1 followed by 2.20 and 1.55 kg of seeds per ha in T3 and T4, respectively (mass of one thousand Leila seeds = 10.77 g). The seed cost based on 2010 farmer costs was $30.40 in T1, $20.34 in

Table 8. Combined refined sugar content values from the three years (%).

Method	Etimesgut	Ilgın
T1	15.28[a]	16.34[a]
T2	15.04[ab]	16.33[a]
T3	15.01[ab]	16.29[a]
T4	14.83[abc]	16.10[ab]
T5	14.60[bc]	16.02[b]
T6	14.39[c]	15.98[b]
F	3.003*	3.490*
SEM	14.86±0.33	16.18±0.15

*P < 0.05.

Table 9. Combined refined sugar yield values from the three years (t ha^{-1}).

Method	Etimesgut	Ilgın
T1	6.60[a]	11.56[a]
T2	6.28[ab]	11.12[ab]
T3	5.91[bc]	10.94[bc]
T4	5.50[cd]	10.62[cd]
T5	5.09[d]	10.42[d]
T6	5.01[d]	9.69[e]
F	9.266**	15.124**
SEM	5.73±0.37	10.73±0.29

**P < 0.01.

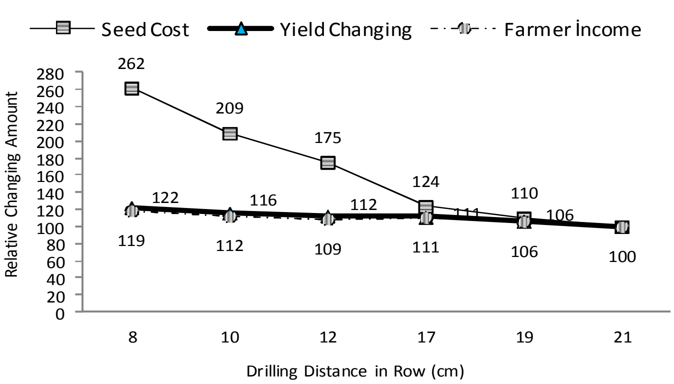

Figure 4. Changes in cost and income according to seed distances in the row.

T3 and $14.33 in T4. When considering the relative seed cost of 100 in T6, the seed costs were determined to be 262, 175 and 124 in T1, T3 and T4, respectively (Figure 4). When considering the relative beet yield in T6 to be 100, the beet yield was 122, 112 and 111 in T1, T3 and T4, respectively. The relative farmer incomes were 119, 109 and 111 for T1, T3 and T4, respectively. Singling and bunching were absolutely necessary in T1, T2 and T3, and this type of application added 200 TL ha^{-1} additional costs to the total cost for these methods (TŞFAŞ, 2010). Considering all conditions, T1 had the highest farmer income. Because labor supply is low, T4 would be difficult to apply in this region.

DISCUSSION

65% field emergence was obtained for all of the applied methods according to the combined results from the three years in the Eimesgut and Ilgın regions. The seed rate resulted in plant population ranging from 67000 to 99000 ha^{-1} and the adjusted root yield from 33 to 44 t ha^{-1} for Etimesgut and from 61 to 71 t ha^{-1} for Ilgın (Tables 5 and 6). The largest yield was usually produced by population ranging from 70000 to 200000 ha^{-1} and was never produced by population less than 70000 ha^{-1}. The field emergence amount was ideal for T1, T2, T3 and T4. However, this emergence amount may create risk for the last two methods depending on the regional and climate conditions. For the first three methods, the yield and quality values were high and similar. Also, sugar concentration and recoverable sugar content tended to increase as the plant population increased.

If sufficient precautions are taken, the T1, T2, T3 and T4 methods are applicable. However, yield and quality may be affected with the T5 and T6 methods depending on climate and soil conditions. The difference in adjusted root yield of different plant population was statically significant in the experiment. Thus, it is important to consider the cultural precautions that are affected by farmers. Climate conditions should also be suitable to obtain optimal conditions for high yield and quality in T5 and T6. The germination rate must be correctly predicted to determine the distance in rows. The most precise seed distribution uniformity, germination rate and factors related to the field and seed bed must be used to accurately predict the optimum plant frequency. Thus, seed germination and emergence rate during cultivation can be guaranteed to be fast and high, respectively. Increasing the seed drilling distance, providing sufficient seed frequency and providing sufficient plant distribution in non-bunching drilling applications can increase field emergence rates. Inan (1993) suggested that a 19 cm drilling distance is possible in Ankara conditions. T1 has the widest application area in Turkey, and T4 provides 53% savings in terms of seed waste and labor needs. Thus, these two methods are the most suitable methods for Turkey in terms of yield, quality and farmer incomes.

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