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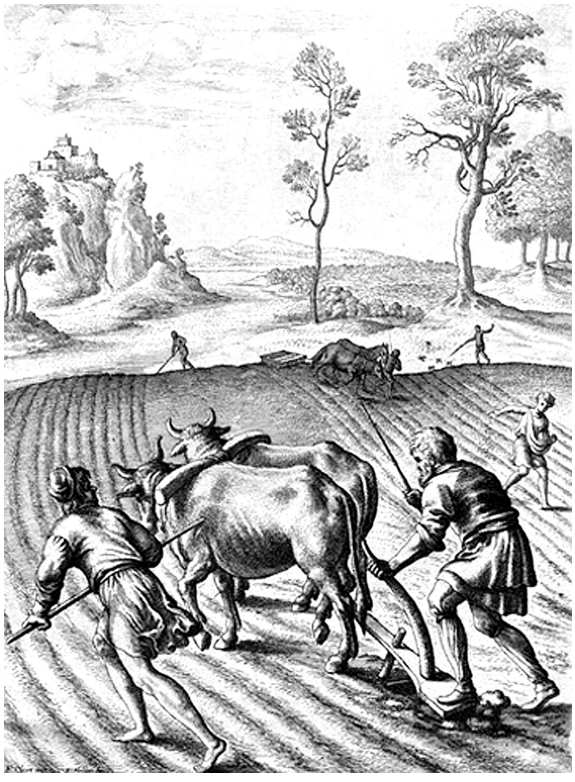

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Plant Density and Sowing Date Effects on Sugarbeet Yield and Quality

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Abstract: Experiments were conducted in 1999 and 2000 to determine the effects of plant density (intra-row spacing) and planting dates on yield and quality characters of sugar beet. Root yield was affected by plant spacing, sowing dates, and plant spacing x sowing dates in 2000. The 15 and 20 cm intra-row spacing produced higher root yield than the 35 cm intra-row spacing. Mean yields of plant spacing for the 5 May sowing date were less than of the 5 February or March sowings. The plant spacing x sowing date interaction was large for sugar yield in 2000. Sugar yield was significantly higher for the February and March sowing dates compared to 5 May. Date of sowing did not significantly affect purity, but percentage of dry matter was reduced from 27.24% for the 20 February sowing date to 24.78% for the 5 May sown plots in 1999. Ash content and noxious nitrogen were affected by sowing dates only in, 1999.

Key words: Sugar beet, plant density, sowing date, yield, quality

INTRODUCTION

Because of heterozygotic nature of its heritable characteristics, sugar beet is readily adaptable to different environmental factors, including climate. However, climatic conditions can affect the properties of the sugar beet roots. In general, if the crop is sown early with favourable climatic and soil conditions, it will produce good quality roots[1]. The composition of sugarbeet is mainly affected by cultivation methods such as N application, variety, planting date and population density[2]. Early sowing and high plant population[3] provided better leaf growth per unit area throughout the growing season. Earlier studies showed that short vegetation period in the late sowings reduced root yield[4,5], sugar content and sugar yield[6-8]. Many experiments show that on mineral soils a population of 75000 ha is the minimum required for maximum sugar yield. Usually, biomass yields have increased asymptotically with increased population, but these same experiments have demonstrated that sugar yields normally fail to increase with increased populations above 75 000 ha^{-1}[9]. Furthermore, for high root and sugar yield, plant population should be 70 000-110 000 plants ha^{-1}[7,10,11]. This study was therefore, carried out to evaluate the influence of plant spacing and sowing dates on root yield and quality traits in sugar beet.

MATERIALS AND METHODS

In 1999 and 2000 field trials were carried out in the South-East Anatolia Region of Turkey (on the Research Station of Agricultural Faculty, University of Dicle in Diyarbakir). The experimental design was a randomised complete block in a split-plot arrangement with four replications. Main plots were sowing dates, at approximately 2-week intervals. Split plots were 5 plant spacing (intra-row spacing). Split plots were five rows wide and measured 7 m long. Normal type monogerm sugar beet seeds (Tiara Cv.) were sown at dates of 5 February, 20 February, 7 March, 22 March and 5 April in intra-row spacings of 15, 20, 25, 30 and 35 cm under irrigated conditions. These spacings equal 116 000, 94 000, 81 000, 71 000 and 58 000 plants ha^{-1}, respectively. Seeds were sown by hand, three seeds per site 3 cm deep in rows 45 cm apart, and plants were thinned to one per location at the 2 to 4 leaf stage. All other agronomic practices were kept normal and uniform for all the treatments. Sugar beets were hand harvested during the first week of September and hand topped. Roots were taken from 6 m of each of the two centre rows. Beets were scrubbed free of soil and samples (3x25 kg) were taken to assess the quality parameters. Within 24 h of harvest the sucrose content and the other quality parameters of the fresh sugar beet roots were determined at the Elazığ Sugar Factory Laboratories. The roots were analysed for sucrose content (by cold digestion method), dry matter, purity, ash content and alpha amino nitrogen. The gross sucrose yield was calculated by multiplying root yield and sucrose content. Statistical analysis was conducted according to the Statistical Analysis System (SAS Institute, 1985)[12]. Differences among treatments were

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tested by analysis of variance and were compared using Duncan's multiple range tests and LSD values at the 0.05 level of significance.

RESULTS AND DISCUSSION

In 1999, root yield was not significantly affected by sowing dates, however, increased with early sowings (5 and 20 February) and 7 March sowings were gave yield more than 50 t ha^{-1}. Root yield was significantly affected by intra-row spacing and the 15, 20 and 25 cm intra-row spacings were higher yielding than 30 and 35 cm intra row spacings (Table 1). In 2000, the significant plant spacing x sowing date interactions that occurred were expected. Averaged across sowing dates, 15 cm intra-row spacing (116 000 plants ha^{-1}) produced 10 t ha^{-1} more root yield than 35 cm intra-row spacing (58 000 plants ha^{-1}). As shown in Fig. 1, in the late sowings and wider intra-row spacings, yield and quality affected negatively due to a short vegetation period and inadequate plant population[13]. Higher plant density did not compensate for the reductions in yield in the late sowing[7,14].

Sucrose yield was significantly affected by plant spacings in 1999 and sowing dates, plant spacing and plant spacing x sowing dates in 2000. Sucrose yield differed between plant spacing (population density), but not between sowing dates in 1999 and sucrose yield as much as 30% greater for plants in the narrowest as compared to the widest intra-row spacing (Table 1). In 2000, highly significant plant density x sowing date interaction for sugar yield indicated that sugarbeet crop with denser plant population should be sown early, as early sowing and denser plant population
produced the greatest root yield. Sucrose yields of sugar beet sown on 5 February were maximum at plant population density of 116 000 ha^{-1} at the 15 cm intra-row spacing (Fig. 2). Thus, the highest sugar yield was obtained from early sowing dates and denser stand and was similar with responses reported by other researchers in previous work[8,15,16].

Amino nitrogen differed significantly among sowing dates and among plant spacings in 1999, but not in 2000. No significant plant spacing x sowing date interactions occurred for amino nitrogen in both years. In 1999, amino nitrogen of the earlier sowing dates (5 and 20 February) was significantly greater than the three later sowing dates. Amino nitrogen for the five sowing dates ranged from 0.034 mol g^{-1} for the first planting date to 0.056 mol g^{-1} for the fifth sowing date (Table 1). Averaged among sowing dates, 15 and 35 cm intra row spacings produced more amino nitrogen than the other three intra-row spacings. The lower plant density reduced the quality mainly of

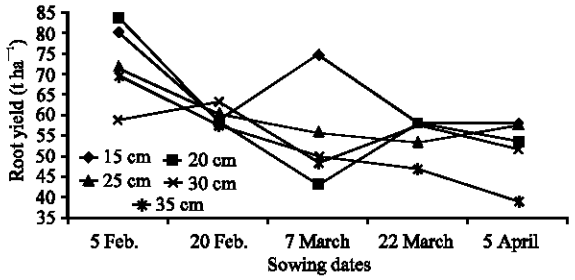

Fig. 1: The effect of sowing date and plant spacing on sugar beet root yield in 2000

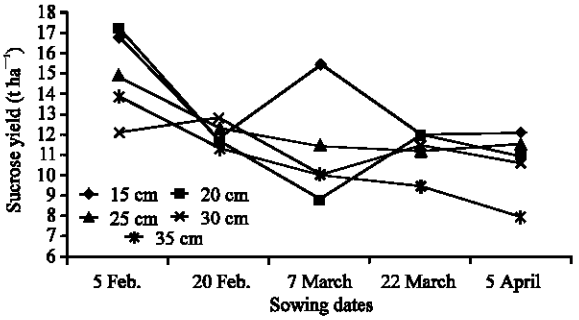

Fig. 2: The effect of sowing date and plant spacing on sugar beet sucrose yield in 2000

sugar content and sugar yield as a result of increased impurity content such as amino nitrogen[14,17]. In 2000, neither planting date nor plant spacing significantly altered the amino nitrogen. However, the lowest amino nitrogen was similarly obtained from 7 March, 20 and 5 February sowing dates. Furthermore, the lower plant density at 30 and 35 cm intra-row spacings compared with 15, 20 and 25 cm intra-row spacings were gave higher amino nitrogen (Table 2). Sowing date had a great effect on dry matter content in 1999. Dry matter increased over a long period reaching a maximum at the 20 February sowings (Table 1), and maximum value was 27.24%. Dry matter content in the April sown crop reached a level of only 24.78%. This result coincided with Gargia and Bellido[18]. Dry matter content for sowing dates in 2000 ranged from 90.28 to 89.27% and dry matter content was constant for sowing dates in all plant spacing. Plant density of 116 000 plants ha^{-1} (at the 15 cm intra row spacing) resulted in a slightly greater dry matter content than the other four plant spacing, even though the values did not statistically differ in the two experiments. Dry matter ranged from 25.29 to 25.27% in 1999 and from 24.20% to 24.78% in 2000 (Table 2).

Ash content was also affected by weather conditions in the first experiment, and the minimum values of ash content were 1.60 and 1.81% (at the 20 February and 5 February sowing dates, respectively). Later sowing

Table 1: Sugar beet yield and quality response to sowing date and plant spacing in 1999

Main effect	Root yield (t ha^{-1})	Sucrose yield (t ha^{-1})	α-Amino nitrogen (mol g^{-1})	Dry matter (%)	Juice purity (%)	Ash content (%)	Sucrose (%)
Sowing date							
5 Feb.	57.34	11.61	0.034c	25.14bc	89.31	1.81 cd	21.4
20 Feb.	54.46	11.06	0.044b	27.24a	87.45	1.60 d	20.9
7 Mar.	50.68	10.81	0.052a	25.31b	89.07	1.94 bc	20.7
22 Mar.	45.65	9.57	0.054a	25.32b	87.53	2.10 ab	20.3
5 Apr.	49.02	10.14	0.056a	24.78c	88.55	2.28 a	20.2
LSD (0.05)	ns	ns	0.006	0.49	ns	0.25	ns
Plant spacing (cm)							
15	57.25a	11.75a	0.053a	25.77	88.07	1.87	20.5
20	56.00a	11.40a	0.044b	25.50	88.3	1.92	20.5
25	54.75a	11.46a	0.044b	25.29	88.61	2.01	20.9
30	46.71b	9.63b	0.045b	25.6	88.52	1.91	20.5
35	42.44b	8.95b	0.053a	25.61	88.41	2.02	21.8
LSD (0.05)	5.52	1.18	0.006	ns	ns	ns	ns
Mean	51.53	10.63	0.047	25.55	88.36	1.94	20.8

*Means followed by the same letter(s) are not significantly different at the 0.05 probability, ns= non-significant

Table 2: Sugar beet yield and quality response to sowing date and plant spacing in 2000

Main effect	Root yield (t ha^{-1})	Sucrose yield (t ha^{-1})	α-Amino nitrogen (mol g^{-1})	Dry matter (%)	Juice Purity (%)	Ash content (%)	Sucrose (%)
Sowing date							
5 Feb.	72.76a	14.97a	0.043	24.25	89.27	2.01	20.30
20 Feb.	59.57b	11.98b	0.043	23.89	89.50	1.96	20.00
7 Mar.	54.23bc	11.14b	0.043	24.74	90.20	1.77	20.70
22 Mar.	54.86bc	11.20b	0.045	24.65	89.85	1.93	20.60
5 Apr.	52.00c	10.71b	0.046	24.80	90.28	1.78	20.60
LSD (0.05)	6.7	1.45	ns	ns	ns	ns	ns
Plant spacing (cm)							
15	65.90a	13.66a	0.042	24.78	90.2	1.75 b	20.80a
20	59.33bc	12.15b	0.043	24.58	90.07	1.86 ab	20.60a
25	59.61bc	12.25b	0.042	24.2	89.96	1.95 a	20.50a
30	56.01bc	11.43bc	0.047	24.45	89.52	1.91 a	20.40ab
35	52.57c	10.51c	0.046	24.31	89.33	1.98 a	20.00b
LSD (0.05)	5.52	1.17	ns	ns	ns	0.12	0.45
Mean	58.68	12.00	0.044	24.46	89.81	1.89	20.40

*Means followed by the same letter(s) are not significantly different at the 0.05 probability, ns= non-significant

resulted in much higher ash content and even at the highest plant density reached 2.28%. Thus, ash content increased if sowing was delayed beyond 7 March. Sowing dates did not influence ash content differently in the second experiment; they ranged from 1.77 to 2.01%. Maximum ash content was reached in both years in 5 April sowing date (Table 1). Intra-row spacings affected ash content in 2000 and higher plant density maintained inferior ash content. Minimum ash content was reached at 15 and 20 cm intra row spacings in both years, however, plant spacing did not significantly affect ash content in the first experiment, while was similar to ash content trend that was observed in 2000 (Table 2). These results agree with the findings of Yoshimura and Nomura[19], Eckhoff *et al.*[20] in which early sowings and narrow plant spacings were shown to have potential for decreasing ash content.

Both sowing date and plant spacing had no significant effect on juice purity in both years. However, juice purity generally decreased as the sowing date delayed[8] in 1999 (Table 1), but rather surprisingly, the highest values was obtained in the 2000 late sowing (Table 2). Juice purity for the five sowing dates ranged from 87.53% for the fourth sowing date to 89.31% for the first sowing date in 1999 and ranged from 89.27% for the first sowing date to 90.28% for the fifth sowing date in 2000. Plant spacing differences were also detected, while no significant variations in both years. In 1999, juice purity content was similar among all intra-row spacings and ranged from 88.07 to 88.61%. In 2000, however, juice purity was higher than those of 1999 and increased with higher plant density. Thus, as shown in Table 2, juice purity was greatest for the highest plant density at 15 cm intra-row spacing (90.20%).

As shown in Table 1, the data of the 1999 growing season, revealed statistically significant decreases in sugar content when plant spacing was increased from 15 cm intra row spacing and sowing was delayed by 15 days in each sowing dates. Sugar content showed a similar trend of decrease with increasing plant density and delayed sowing, however it is not statistically significant. The highest sugar content was produced when the crop was sown on 20 February, especially in 1999, although no significant variation existed when it was sown from 20 February to 5 April. A reduction in sugar content was observed after 7 March to until 5 April. The reduction was

about 1% in 1999 for 5 April sowing as against 5 February. As plant population increased, sugar content was enhanced[6-8]. Among the plant spacing, 15 cm intra-row spacing produced the highest sugar content, although the variation was statistically significant only during 1999. This result agree with the findings of Smith[21] and Vukov[22].

Studies conducted in 1999 and 2000 indicated that delays in sowing from mid-April to early May could result in lower root yields, especially if sowing is delayed by 4 weeks or longer. Results indicated that for the South-East Anatolia region, sowings may before Mid-April maximized root yields. Once conditions are suitable from 20 February onwards, sowing should be completed as rapidly as possible. Delays into late March and beyond increase the risk that soil will dry out, either during seedbed preparation or during the time when seeds are germinating. Results also indicated that narrow plant spacings either 15, 20 and 25 cm spacings gave higher root yields compared to 30 or 35 cm intra-row spacings early, optimum and later sowing dates, in 1999 and 2000. In conclusion it appears from this study that given 45 cm row widths a 30 or 35 cm spacing in the row with the resulting 71 000 or 58 000 plants per hectare results in lower gross root and sugar yield.

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