International Journal of Agricultural Research

ISSN 1816-4897

Academic Journals Inc.

www.academicjournals.com

International Journal of Agricultural Research 2 (3): 296-301, 2007
ISSN 1816-4897

Yield and Quality Component of Sugar Beet Grown under Northern Turkey Conditions

[1]Necdet Çamaş, [2]Cüneyt Çırak and [3]Sebahattin Albayrak
[1]Ondokuz Mayıs University, Vocational School of Bafra, Samsun, Turkey
[2]Department of Agronomy, Faculty of Agriculture,
Ondokuz Mayıs University, Samsun, Turkey
[3]Department of Agronomy, Faculty of Agriculture,
Süleyman Demirel University, Isparta, Turkey

Abstract: The present study was undertaken to determine the yield and quality performance of two sugar beet cultivars (Duetto and Leila) at five locations from Northern Turkey during 2004 and 2005 growing seasons. The experimental design was a randomized complete block design with three replications. Results of analysis of variance revealed significant differences among cultivars and locations with regard to parameters tested. cv. Leila was found to be superior to cv. Duetto with its high fresh root yield. Two locations (Bafra and *G. haciköy*) showed significantly higher fresh root and extract sugar yields. Lower values of non-sugar impurities (K, Na and α-amino-N content of root) and higher values of quality traits (sugar and extract sugar content and juice purity) were also observed in the same locations.

Key words: Sugar beet, root yield, extract sugar yield, non-sugar impurities

Introduction

Sugar beet (*Beta vulgaris* L.) is a temperate climate biennial root crop and the only species of agricultural importance in *Beta* genus. It is a crop cultivated for the production of sugar and, potentially, for the production of energy (bio-ethanol) (Rinaldi and Vonella, 2006). Sugar beet supplies oxygen during its vegetation period and crop residues of this plant are used as forage and organic matter supply for the soil. In addition to these benefits, its industrial residues have multiply uses (Çamaş and Esendal, 1999). Similar to many vegetal crop cultivated in the world, sugar beet contributed to the development of technologies (Feckova *et al*., 2005).

Sugar is produced in 121 Countries and global production now exceeds 120 million tons a year (FAO, 2006). Although, approximately 70% of total sugar production is supplied by sugar cane, a very tall grass with big stems which is largely grown in the tropical countries, sugar beet remains as unique source of sugar for relatively temperate zones of the world such as Turkey where is not suitable for sugar cane cultivation. Turkey is a major sugar beet producer of the world with Germany, France, Poland, Belgium, Russia, USA and Ukraine. Turkey produces about 14 million tones sugar beet on 330 000 ha and 2.5 million tones sugar per annum (FAO, 2006).

The introduction of a crop to a regional cropping system requires information concerning its performance under local environmental conditions and the sustainability of cropping systems can be achieved through the choosing of suitable environment and cultivar for each crop (Prośba-Białczyk *et al*., 2001). Because, production areas of a given crop have ecological conditions peculiar to themselves and yield and quality can vary greatly depending on cultivars to a large extent. Although

Corresponding Author: Cüneyt Çırak, Department of Field Crops, Faculty of Agriculture, Ondokuz Mayis University, 55139, Samsun, Turkey Tel: +90-362-312 19 Fax: +90-362-4576034

the planted area for sugar beet in Turkey has reached 330 000 ha during 2005 (FAO, 2006), information on the adaptation, yield and quality characters of this crop is limited. Thus, the main objective of the present study was to examine the adaptation ability, yield and yield components of two commercial sugar beet cultivars under Northern Turkey conditions.

Materials and Methods

Plant Material

Sugar beet cultivars Duetto and Leila were used as experimental material. Duetto has a conical root and low bifurcation, holes on the root and quite superficial. Growth over the soil surface is quite low. Leaves are long. Root yield is fairly good. Sugar yield and purity are high. It is resistant to drought and to *Cercospora*. Leila cultivar has conical root, bifurcation is rather low and growth over the soil surface is low. The leaves are long and upright, stalks are medium length. Root yield is high. It is over resistant to *Rhizomania* and resistant to *Cercospora*. In regions where *Rhizomania* is prevalent, sugar yield is quite high.

Experimental Procedures

The experiment was conducted at the locations Bafra (41°35′ N 35°56′ E Long and 15 m sea level), Ladik (40°56′ N 35°54′ E and 920 m sea level), Suluova (40°47′ N 35°41′ E and 484 m sea level), *G. haciköy* (40°52′ N 35°14′ E and 785 m sea level) and Osmancik (40°58′ N 34°51′ E and 449 m sea level), located in Northern Turkey. Sowings were performed on 8-11 th April, 7-10th April in 2004 and 2005, respectively. Climatic data for the research areas are given in Table 1. Soil types of Bafra, Suluova and *G. haciköy* are clay loam, while Osmancik and Ladik are silty clay loam. The experimental design was a randomized complete block design with three replications. Sowing rates were 8 kg ha^{-1} for all locations and cultivars. Individual plot size was 2×5 m = 10 m^2. Row spacing was 50 cm and intrarow spacing was 15-20 cm after decollation. 120-80-100 (kg ha^{-1}) N-P-K were incorporated into the soil prior to sowing and plots were watered during experimental period when necessary. Plants were harvested on 1-8th October, 4-11th October in 2004 and 2005, respectively. Samples of each plot consisting of 25-30 roots were obtained to determine the fresh root yield, root length and width, dry matter and sugar content of root, juice purity, non-sugar impurities (K, Na and α-amino-N content of root), extract sugar content and extract sugar yield. For laboratory analysis, Venema automatic beet laboratory system (Venema automation bv, Groningen, Holland) connected with a BETALYSER analyzing system was used.

Statistical Analysis

The data were objected to analysis of variance (ANOVA) using SAS (1998) program and differences among treatments were tested with LSD test (Level of significance $p<0.05$, 0.01 and 0.001). The means between years were compared with Tukey homogeneity test.

Table 1: Climatic data for the experimental locations

	Total rainfall (mm)			Mean temperature (°C)			Mean humidity (%)		
Locations	Long-period	2004	2005	Long-period	2004	2005	Long-period	2004	2005
Bafra	297	445	338	18.13	18.28	19.03	76.3	75.7	75.2
Ladik	228	145	107	14.22	14.10	14.71	62.5	61.9	61.4
Suluova	165	282	134	18.44	18.26	18.95	66.8	67.1	65.6
G. haciköy	257	281	197	17.79	17.61	18.52	52.5	51.3	51.2
Osmancik	213	298	160	20.13	19.58	21.62	62.7	63.6	57.5

Results and Discussion

The means between years were significantly different according to the Tukey homogeneity test. Therefore, data are presented for each year separately. Mean values of root yield and quality components for the sugar beet cultivars tested are shown in Table 2. The results of variance analysis revealed significant differences among locations in the fresh root yield, root length and width, dry matter content of root, non-sugar impurities (K, Na and α-amino-N content of root) and extract sugar yield. However, the location effect on sugar content, extract sugar content and juice purity was found to be insignificant. Similarly, no significant difference was detected between cultivars in all the traits with the exception of fresh root yield. In contrast to the significant location and cultivar effect, their interaction did not affect the parameters tested (Table 3).

Bafra and *G. haciköy* locations produced the highest fresh root yields (85.59 and 80.97 ton ha^{-1} for Bafra; 86.94 and 75.40 ton ha^{-1} for *G. haciköy* in 2004 and 2005, respectively) while the lowest values for this trait were observed in Ladik locations (46.06 and 42.85 ton ha^{-1} in 2004 and 2005, respectively). Similarly, the highest levels of root length and width were observed in Bafra and *G. haciköy* locations and Ladik locations produced the smallest roots in length and width. The results are not surprising given the fact that Bafra and *G. haciköy* locations have higher level of temperate and precipitation than the other ones which is in favor of higher fresh root yield, however Ladik location supplying the lowest fresh root yield observed in the present study have the lowest temperature and precipitation. As for the cultivars, Leila showed higher fresh root yield than Duetto in both years (78.38 and 71.44 ton ha^{-1} in 2004 and 2005, respectively). Previous studies conducted at different localities of Turkey cited fresh root yield of sugar beet from 25.69 to 58.15 ton ha^{-1} (Oral, 1978; Erel, 1980; Akinerdem *et al*., 1994; Çakmakçi and Oral, 1998; Gezgin *et al*., 2001). Combined the data for fresh root yield over locations and cultivars, it might be concluded that higher values were obtained under Turkey ecological conditions in the present study.

Dry matter content and extract sugar yield varied among locations, but not cultivars. *G. haciköy* location showed the highest values for both traits (22.73 and 23.99% dry matter content;

Table 2: Mean values of fresh root yield, root length and width, dry matter and sugar content of root, juice purity, non-sugar impurities (K, Na and a-amino-N content of root), extract sugar content and extract sugar yield in sugar beet grown at different locations from Northern Turkey

Locations	1	2	3	4	5	6	7	8	9	10	11
2004											
Bafra	85.59a	19.27bc	22.60a	9.93b	13.93	86.16	2.16bc	0.37c	3.63c	12.06	10.37a
Ladik	46.07c	20.10bc	19.63b	6.71d	15.20	87.82	1.81cd	0.65b	6.15a	12.41	5.71c
Suluova	77.75b	18.24c	20.61b	9.68b	13.47	84.14	2.78a	0.91a	5.10b	10.85	8.41b
G. haciköy	86.94a	22.73a	23.72a	10.80a	15.25	89.33	1.66d	0.76ab	4.75b	12.91	11.29a
Osmancik	77.40b	20.70b	20.11b	9.01c	13.30	86.58	2.32ab	0.83ab	4.89b	0.83	8.39b
Cultivars											
Duetto	71.13b	20.40	20.80	9.25	14.38	86.41	2.11	0.68	4.71	12.04	8.63
Leilla	78.38a	20.01	21.87	9.20	14.08	87.20	2.18	0.72	5.10	11.59	9.03
2005											
Bafra	80.97a	18.85b	19.26ab	9.30ab	13.93	85.12	2.02b	0.43c	4.28	11.83	9.08ab
Ladik	42.85c	20.89b	17.51b	6.51c	14.05	87.07	1.90b	0.63ab	5.58	11.45	4.87c
Suluova	73.06b	20.36b	18.33b	8.75ab	13.43	88.30	3.54a	0.79a	5.10	10.79	8.03ab
G. haciköy	75.40b	23.99a	21.29a	9.72a	15.38	88.77	1.75b	0.56bc	4.70	13.12	9.97a
Osmancik	70.22b	18.91b	18.00b	8.40b	13.22	87.07	2.15b	0.73a	4.54	10.79	7.68b
Cultivars											
Duetto	65.56b	19.97	18.51	8.49	13.78	87.29	2.20	0.66	4.78	11.42	7.59
Leilla	71.44a	21.23	19.24	8.58	14.22	87.30	2.34	0.59	4.90	11.83	8.46

[1]Fresh root yield (ton ha^{-1}), [2]dry matter content (%), [3]root length (cm), [4]root width (cm), [5]sugar content (%), [6]juice purity (%), [7]α-amino-N (mmol/100 g root), [8]Na (mmol/100 g root), [9]K (mmol/100 g root), [10]extract sugar content (%), [11]extract sugar yield (ton ha^{-1}). ***Values followed by the same letter(s) in each column are different at $p<0.001$ levels according to the Duncan Multiple Range Test

Table 3: Results of variance of analysis for mean values of parameters tested

Source variation	df	Fresh root yield			Dry matter content		
		Sum of squares	Mean square	F-value	Sum of squares	Mean square	F-value
Year (Y)	1	585.938	585.937	34.92***	2.293	2.293	0.53
Location (L)	4	11805.658	2951.415	175.90***	145.565	36.391	8.37***
Y×L	4	129.553	32.388	1.93	28.0760	7.0189	1.61
Block (Y×L)	20	206.997	10.350	0.62	117.155	5.8578	1.35
Cultivar (C)	1	646.948	646.948	38.56***	2.830	2.830	0.65
Y×L	1	6.991	6.990	0.42	10.242	10.242	2.36
L×C	4	3873.329	968.332	57.71	8.489	2.122	0.49
Y×C×L	4	6.648	1.662	0.10	16.804	4.201	0.97
CV (%)		5.72				10.22	
		Root length			Root width		
Year (Y)	1	0.794	0.794	0.21***	90.626	90.626	37.39***
Location (L)	4	34.917	8.729	2.34***	123.893	30.973	12.78***
Y×L	4	3.274	0.819	0.22	3.166	0.791	0.33
Block (Y×L)	20	53.623	2.681	0.72	21.022	1.051	0.43
Cultivar (C)	1	0.074	0.074	0.02	12.096	12.096	4.99
Y×L	1	2.009	2.009	0.54	0.420	0.420	0.17
L×C	4	17.682	4.421	1.18	4.932	1.233	0.51
Y×C×L	4	7.451	1.863	0.50	7.747	1.937	0.80
V (%)		7.74			7.27		
		Sugar content			Juice purity		
Year (Y)	1	7.142	7.142	17.13	3.611	3.611	0.50
Location (L)	4	93.028	23.257	55.80	83.762	20.941	2.89
Y×L	4	1.363	0.341	0.82	54.214	13.554	1.87
Block (Y×L)	20	5.500	0.275	0.66	219.713	10.986	1.52
Cultivar (C)	1	0.006	0.275	0.01	2.464	2.464	0.34
Y×L	1	0.058	0.058	0.14	2.297	2.297	0.32
L×C	4	0.241	0.060	0.14	8.501	2.125	0.29
Y×C×L	4	0.623	0.156	0.37	7.591	1.898	0.26
CV (%)		13.69			3.09		
		α-amino-N			Na		
Year (Y)	1	0.234	0.234	0.91	0.084	0.084	3.11
Location (L)	4	15.649	3.912	15.12***	1.404	0.351	12.94***
Y×L	4	1.685	0.421	1.63	0.118	0.029	1.08
Block (Y×L)	20	5.258	0.263	1.02	0.255	0.012	0.47
Cultivar (C)	1	0.143	0.143	0.55	0.002	0.002	0.08
Y×L	1	0.019	0.019	0.07	0.043	0.043	1.59
L×C	4	1.443	0.361	1.39	0.068	0.017	0.63
Y×C×L	4	1.257	0.314	1.21	0.627	0.157	2.78
CV (%)			23.04			24.78	

		K			Extract sugar content			Extract sugar yield		
Year (Y)	1	0.067	0.0673	0.11	0.555	0.555	0.14	9.785	9.785	3.75
Location (L)	4	23.081	5.770	9.55***	39.549	9.887	2.55	207.569	51.890	19.91***
Y L	4	2.532	0.633	1.05	2.548	0.637	0.16	1.355	0.339	0.13
Block (Y×L)	20	10.860	0.543	0.90	55.767	2.788	0.72	28.426	1.421	0.55
Cultivar (C)	1	0.965	0.965	1.60	0.007	0.007	0.00	6.036	6.036	2.32
Y×L	1	0.284	0.284	0.47	2.769	2.769	0.71	0.828	0.828	0.32
L×C	4	7.653	1.913	3.17	18.344	4.586	1.18	92.986	23.246	3.92
Y×C×L	4	3.923	0.981	1.62	8.159	2.040	0.53	5.45	1.363	0.52
CV (%)		15.96			16.80		19.15			

df: Degrees of freedom; CV: Coefficient of variation; * Significant at the 0.05 probability level; ** Significant at the 0.01 probability level; *** Significant at the 0.001 probability level

11.29 and 9.97 ton ha^{-1} extract sugar yield in 2004 and 2005, respectively). The results are in accordance with those of Çakmakçi and Oral (1998) and Gezgin *et al*. (2001) who reported sugar beet grown in Turkey to contain 21.1-22.8% dry matter. However, the same authors reported extract sugar yield as 6.18-8.75 ton ha^{-1}, apparently lower than the present values.

Significant differences were detected in non-sugar impurities (K, Na and α-amino-N content of root) among locations. The highest α-amino-N and Na contents in roots were found in Suluova (2.78 and 3.54 mmol/100 g root α-amino-N; 0.91 and 0.79 mmol/100 g root Na in 2004 and 2005, respectively). Similarly, K content of roots varied with locations significantly in 2004, but the locations effect on this quality parameter was insignificant in 2005. Plants from Ladik location had the highest root K content observed in the present study (6.15 and 5.58 mmol/100 g root in 2004 and 2005, respectively). α-amino-N is the organic form of N used by sugar beet plants for re-growth (Pocock *et al*., 1990) and increased amounts of α-amino-N has reduced extractability of sugar during factory processing because it binds sugar to molasses on a large scale (Harvey and Dutton, 1993). The acceptable amount of α-amino-N in sugar beet roots is 2.14 mmol/100 g root for mineral soils and 2.86 mmol/100 g root for organic soils according to Palmer and Casburn (1985). In this study, the limits were not exceeded by either locations or cultivars. K and Na in sugar beet roots are also considered as other molassigenic factors which cause enhanced sugar losses (Harvey and Dutton, 1993). Roots with K content of 3.59 and 5.13 mmol/100 g are considered to be commercially acceptable for processing (Milford *et al*., 2000). In our case, K content of roots was generally lower than these limits with the exception of roots of sugar beets grown in Ladik location in both years. Na treatment could be beneficial for sugar beet development if the soil Na level is low (Draycott, 1993). Generally, semi-arid regions, such as the experimental area where the present study was conducted suffer from high Na concentrations in soil. Hence, sugar beet growth could be suppressed by excess Na levels in the soil (Marschner, 1995) or high level of root Na content could be a main molassigenic factor during sugar beet processing (Honarvar and Alimoradi, 2003; Tsialtas and Maslaris, 2005). Barbanti (1994) defined the acceptable Na limit in sugar beet roots as 1.33 mmol/100 g root for Italy ecological conditions. In the present study, the observed Na contents in roots are evidently lower than that reported by Barbanti (1994).

In contrast to the other traits studied, sugar content, extract sugar content and juice purity did not vary among locations and cultivars. Mean values of these traits changed from 15.20 to 13.22% for sugar content, 13.12-10.83% for extract sugar content and 89.33-84.14% for juice purity depending on experimental applications. Sugar content, extract sugar content and juice purity of sugar beet grown in Turkey were reported as 17.58-18.91, 14.89-16.91 and 87.66-89.11%, respectively by Çakmakçi and Oral (1998). Prsent results for sugar and extract sugar content are lower than those of the previous report.

Conclusions

The main conclusions of this two-years field study can be stated as: 1. When data were combined over years and locations, cv. Leila is capable of producing higher yield than cv. Duetto, however there is no significant differences between them with respect to the quality traits examined. 2. In general, sugar and extract sugar content are low when compared to previous data, but this imperfection is overcame by high fresh root and extract sugar yields. 3. Among locations, Bafra and *G. haciköy* show significantly higher fresh root and extract sugar yields. Lower values of non-sugar impurities (K, Na and α-amino-N content of root) and higher values of quality traits (sugar and extract sugar content and juice purity) are also observed in these locations. Therefore, Bafra and *G. haciköy* locations are characterized by both high yield and quality potentials.

References

Akinerdem, F., B. Yildirim, B. Mülayim and M. Babaoglu, 1994. Determination of optimum plant density and its effect on yield and quality of sugar beet (in Turkish). Turk. J. Agric. Forest., 18: 21-25.

Barbanti, L., 1994. New Methods of Recommending N-fertilizer Use to Sugar Beet in the Mediterranean Area. In: Proceedings of the 57th Iirb Congress, Anonymous, (Ed.). Brussels, International Institute for Beet Research, Brussels, Belgium, pp: 281-294.

Çamaş, N. and E. Esendal, 1999. Effects of planting times and seedlingtransplanting on sugarbeet (*Beta vulgaris* L.) cultivars. OMU J. Agric., 14: 31-42.

Çakmakçi, R. and E. Oral, 1998. Effect of different field emergence rates on the yield and quality of sugar beet grown with and without thinning (in Turkish). Turk. J. Agric. Forest., 22: 451-461.

Draycott, A.P., 1993. Nutrition. In: The Sugar Beet Crop, Cooke and, D.A. and R.K. Scott (Eds.). Chapman and Hall, London, UK., pp: 239-278.

Erel, K., 1980. The effect of N and K fertilizations on yield and quality of sugar beet (in Turkish). Work Dairy of Sugar Institute, 4: 114-119.

FAO., 2006. Official web site of Food and Agriculture Organization of The United Nations. http://www.fao.org/waicent/portal/statistics_en.asp.

Feckova, J., V. Pacuta and I. Cerny, 2005. Effect of foliar preparations and variety on sugar beet yield and quality. J. Cent. Eur. Agric., 6: 295-308.

Gezgin, S., M. Hamurcu and M. Apaydin, 2001. Effect of boron application on the yield and quality of sugar beet (in Turkish). Turk. J. Agric. Forest., 25: 89-95.

Harvey, C.W. and J.V. Dutton, 1993. Root Quality and Processing. In: 338 Tsialtas and Maslaris the Sugar Beet Crop. D. A. Cookeand R. K. Scott (Eds.). Chapman and Hall, London, UK., pp: 571-617

Honarvar, M. and I. Alimoradi, 2003. Factors affecting quality of sugar beet at semi-arid areas of Isfahan. In: Proceedings of the 1st joint IIRB-ASSBT Congress, Anonymous (Ed.). San Antonio, International Institute for Beet Research, Brussels, Belgium, pp: 597-601.

Marschner, H., 1995. Mineral Nutrition of Higher Plants. Academic Press, London, UK.

Milford, G.F.J., M.J. Armstrong, P.J. Jarvis, B.J. Houghton, D.M., Bellett-Travers, J. Jones and R.A. Leigh, 2000. Effect of potassium fertilizer on the yield, quality and potassium offtake of sugar beet crops grown on soils of different potassium status. J. Agric. Sci., 135: 1-10.

Oral, E., 1978. The effect of different plant densities on growth and yield of sugar beet grown under Erzurum ecological conditions (in Turkish). Atatürk University Press, No. 546, pp: 151-162.

Palmer, M. and C. Casburn, 1985. Amino nitrogen analyses-factory experiences. Br. Sugar Beet Rev., 53: 73-76.

Pocock, T.O.,G.F.J. Milford and M.J. Armstrong, 1990. Storage root quality in sugarbeet in relation to nitrogen uptake. J. Agric. Sci., 115: 355-362.

Prośba-Białczyk, U., P. Regiec and M. Mydlarski, 2001. Impact of nitrogen fertilisation on the technological value of sugar beet cultivar roots. Electronic J. Polish Agricu. Univ., 4: 1-12.

Rinaldi, M. and A.V. Vonella, 2006. The response of autumn and spring sown sugar beet (*Beta vulgaris* L.) to irrigation in Southern Italy: Water and radiation use efficiency. Field Crops Res., 95: 103-114.

SAS, 1998. SAS Statistics Users Guide, Statistical Analysis System, 5th Edn., SAS Institute Inc. Carry, USA.

Tsialtas, J.T. and N. Maslaris, 2005. Effect of N fertilizaiton rate on sugar yield and non-sugar impurities of sugar beets (*Beta vulgaris*) grown under Mediterranean conditions. J. Agron. Crop Sci., 1991: 330-339.