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YIELD AND QUALITY CHARACTERISTICS OF SUGAR BEET CULTIVARS UNDER CONTINENTAL CLIMATIC CONDITIONS

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Abstract
Sugar yield in per unit area mostly depends on root yield and sugar ratios of the roots. The present research was conducted in 2012 in Mahzemin Village of Kayseri to determine yield and quality parameters of 22 different sugar beet genotypes (Sandrina KWS, Aranka KWS, Corvinia KWS, Pauletta KWS, 1 K222, Serenada KWS, SR 374, SR 380, SR 381, SR 485, SR 489, SR 490, SR 538, SR 540, Festina, Grinta, Dozer, Maden, Coyote, Diamente, Esperia KWS and Turbata). Experiments were conducted in randomized block design. The highest root yields were obtained from Serenada KWS (9475.0 kg/da); the highest sugar ratios from SR 538 (20.09%); the highest pure sugar ratios from Dozer (18.54%); the highest pure sugar yields from Serenada KWS (1625.1 kg/da); the lowest amino nitrogen (amino-N) ratios from SR 490 (0.75%) and Coyote (0.79%); the lowest sodium (Na) ratios from SR 490 80.64%) and SR 489 (0.65%) and the lowest potassium (K) ratios from Dozer (3.06%) genotypes.Considering the entire results together, the genotypes Serenada Kws, Corvinia KWS genotypes with the highest root yield, sugar ratio, pure sugar ratio and pure sugar yield; cultivars Dozer, SR538 and SR 490 with the lowest amino nitrogen, sodium and potassium ratios could be recommended to be cultivated in Kayseri province and other continental type of climatic zones.

Keywords: sugar beet, yield test, sugar content, sugar yield

1. INTRODUCTION

Sugar beet (*Beta vulgaris*, L.), a biennial, warm season crop, is the second important sugar crop after sugarcane, 40% of the sugar comes from sugar beet (Amr and Gaffer, 2010). Sugar beet is used for human nutrition, in chocolate and confectionery industry and ethanol production (Anonymous, 2013). The sugar beet has a special position in the Turkish agro-business segment, expanding the agricultural front by the development of new cultivars with broad adaptation to continental type, tolerance to biotic and abiotic factors, pest and disease resistance, and mainly with a high yield per planted area.

Sugar beet is considered to be a temperate crop; however, it can be grown in a wide range of climatic conditions. Sugar beet contains sucrose up to 21% (Memon et al., 2004). Sugar yield in per unit area mostly depends on root yield and sugar ratios of the roots. Sugar beet yield potential depends upon several factors. Temperatures at critical stages of growth, availability of moisture, availability of plant nutrition and solar radiation intercepted by the crop canopy are the main yield and quality limiting factors for sugar beet. Sugar beet root yield varied between 5000-9000 kg/ha

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and sugar content varied between 12 and 16% in different countries under different climatic conditions (Rychcik and Zawiślak, 2002; Azam Jah and., 2003; El-Karouri and El-Rayah, 2006; Ada et al., 2012; Turgut, 2012).

In turkey, during 2015-16 cropping season, 1 million 987 thousand tons tones sugar was produced. In 2015 the sugar consumption is 27 kg/person that were higher than that of the world sugar consumption of 22.6 kg/person (Anonymous, 2015). The sugar beet planting area was 275.272 ha and produced root yield was 15.950 million tones in Turkey. The mean yield of cultivars currently cultivated in Turkey was 59.8 tones ha. The sugar beet planting area was 275.272 ha and produced root yield was 15.950 million tones (Anonymous, 2014).

The aim of revealing the sugar beet cultivars recommended specifically for cultivation under continental type of climate is to inform growers about the breeding advance achieved every year in the creation of new cultivars. Therefore, main purpose of this study was to determine yield potential and quality criteria of new sugar beet cultivars under continental climatic condition.

2. MATERIALS AND METHODS

The present study was conducted in 2012 in Mahzemin Village of Kayseri, Turkey to determine yield and quality parameters of 22 sugar beet cultivars (Sandrina KWS, Aranka KWS, Corvinia KWS, Pauletta KWS, 1 K222, Serenada KWS, SR 374, SR 380, SR 381, SR 485, SR 489, SR 490, SR 538, SR 540, Festina, Grinta, Dozer, Maden, Coyote, Diamente, Esperia KWS and Turbata).

The soil of the experimental site, developed from alluvial deposits of river terraces. The soil of experimental plots was a clay silt loam with pH of 7.4, having 1.42% organic matter and 1.43% lime content (Table 1). The daily climatic data were obtained from the agro-meteorological station (Table 2). Experiments were conducted in randomized block design with three replications.

Total annual precipitation at the study site was 113.1 mm in 2012 and total mean annual precipitation was 213.7 mm in between 1970-2011. No rainfall occurred in August. Average air temperature was about 18.6 °C in the cropping period (April-October) while the mean relative humidity was around 48.3% in 2012 and total mean relative humidity was 57.2 % during the growing period (Table 2).

The seeds were sown by sugar beet drill in 29 April in 2012 in four-row plots, 6 m long with spacing of 0.45 m between rows and 0.12 m within rows in both years. The plant numbers of each plot was adjusted to 98 plants/plot by removing extra emerged plants. The sugar beet was grown under irrigated conditions with standard cultural inputs applied consistent with local agronomic practices. Plots were fertilized with 60 kg N, P, K ha before planting using a compound fertilizer (N–P–K) in the form of 15–15–15, and an additional 46 kg N kg/ha (as urea) was side-dressed. Overhead sprinkler irrigation was applied with approximately 2 weeks intervals. Harvest was done by hand with a fork in 18 September in 2012. During digging, root numbers in each plot were carefully counted and the root number was 98 in each plot except in two plots that they had 96 and 97 roots. The growing period of sugar beet cultivars was 172 days. Harvested sugar beet roots were cleaned and plot yields and other plant parameters were determined. The measured roots were sent to the laboratory of Kayseri Sugar Factor to determine chemical properties of the roots. At harvest, ten plants were randomly taken from each plot to estimate root length (cm), root diameter (cm), root fresh weight (g/plant), foliage fresh weight (g/plant), root / top ratio, total soluble solids of roots (T.S.S), which was determined in fresh root by using hand refractometer. Sucrose (%) was estimated polarimetrically on a lead acetate extract of fresh macerated roots according to Le - Docte (1927). Juice purity (%) was calculated by dividing Sucrose (%) / T.S.S (%). Root yield (t/ha): Sugar beet plants in two ridges were harvested, cleaned and collected, thereafter roots were

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separated and weighted in Kg, then after, it was converted to estimate root yields (ton/ha). Sugar yield (t/ha) calculated by multiplying root yield by sucrose percentage.
Data were statistically analyzed using ANOVA in the MSTAT-C computer program. When significant treatment differences occurred, means were separated using the LSD test at the 5% level.

3. RESULTS AND DISCUSSIONS

Root yield, digestion, Na, K, amino-N and increased sugar value of sixteen sugar beet cultivars were investigated under continental type of climate in 2012.
The mean root yield, digestion, Na, K, amino-N and increased sugar value for the testes sugar beet cultivars were given in Table 3.
The mean root yield was 76.874 kg/ha. The root yield of the beat cultivars varied between 53.500-94.750 kg/ha. Serenada KWS (94.750 kg/ha), Corvinia KWS (93.000 kg/ha), 1 K222 (91.750 kg/ha) and Aranka KWS (87.250 kg/ha) had the highest root yield. The root yield differences resulted from genetic make-up of the tested sugar beet cultivars. Sugar beet cultivar DOZER had the lowest root yield with 53.500 kg/ha. The highest root yielding cultivars Serenada KWS, Corvinia KWS, 1 K222 and Aranka KWS had 77.1%, 73.8, 71.5 and 63.1 % higher root yield that cultivar DOZER respectively. Radivojević and Dośenović (2006), Bolz et al. (1984), Kısaoğlu (1987), Güler (1992) Akınerdem et al. (1993), obtained mean root yield between 5000-8000 kg/ha in tested sugar beet cultivars and they stated that the root yield differences were the results of different genetic make-up and different environment.

Digestion (Sugar ratio (%)

The digestion rates of sugar beet cultivars were significant at the 0.01% level among sugar beet cultivars. The mean digestion was 18.82%. The digestion rate of cultivars varied between 16.79% and 20.09%. The highest digestion rate was obtained from SR 538 followed by Dozer and Esperia KWS. When sugar rate of cultivars were compared cultivars SR 538 (20.09%), Dozer (20.05%) and Esperia KWS (19.67%) had 19.7, 19.4 and 15.9% higher yield than the lowest sugar yielding cultivar Coyote (16.79%) respectively. It was reported in the previous studies that sugar content of tested cultivars were between %14.0-%17.0 (Bolz et al., 1984; Güler, 1992; Çelikel, 1989; Özcan, 1993; Rychcik ve Zawiślak 2002).

Sodium ratio (%)

The Na content of sugar beet cultivars varied significantly among sugar beet cultivars at the 0.01 level. The mean Na content was 10.2 kg/ha. Coyote had the highest Na content followed by Dozer and Festina. The lowest Na content was obtained from cultivar SR 538 with 6.3 kg/ha. The sugar beet cultivars Coyote (2.23), Dozer (1.83) and Festina (1.32) had 354%, 290% and 209% higher Na content respectively. Similarly Okut and Yıldırım (2004) and Çakmakçı et al. (1995) found significant sodium and potassium differences among sugar beet cultivars.

Potassiumratio (%)

The K content of sugar beet cultivars varied significantly at the 0.01 level. The mean K content was 4.02%. The highest potassium content was obtained from cultivar Serenada KWS followed by K222, Aranka KWS, SR 374 and Corvinia KWS. The lowest K content was obtained from cultivar Dozer (3.06). The sugar beet cultivars Serenada KWS (4.78), 1 K222 (4.63), Aranka KWS (4.61), SR 374 (4.54) had 56%, 52%, 50%, 48% and 47% higher K content than the lowest K yielding cultivar Dozer respectively. Our findings for potasium content were similar to the findings of Okut and Yıldırım (2004) and Kaya and Güler (2012).

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Table 1. The soil properties of the experimental area

Texture	Clay (%)	Silt (%)	Sand (%)	pH	Organic Madder (%)	Lime (%)	Availability	
							P_2O_5 (kg/ha)	K_2O (kg/ha)
Clay-silt	23.12	29.41	39.54	7.40	1.42	1.43	161.86	2097

Table 2. Climatic data of the experimental area

Month	Monthly precipitation (mm)		Monthly mean temperature (°C)		Monthly relative moisture (%)	
	2012	1970-2011	2012	1970-2011	2012	1970-2011
April	4.9	57.4	14.4	10.6	39.7	63
May	50.6	54.4	15.4	14.9	62.8	61.1
June	31.9	39.4	21.4	19.1	44.8	55.8
July	0.2	11.8	23.4	22.6	42.6	50.4
August	0	6.1	21.9	21.9	45.5	51
September	5.2	11.5	20.1	17.1	39.1	55
October	20.4	33.1	13.9	11.5	63.3	64.1
Total/Mean	**113.1**	**213.7**	**18.6**	**16.8**	**48.3**	**57.2**

Amino nitrogen ratio (%)

The α-amino N content of sugar beet cultivars varied significantly among sugar beet cultivars at the 0.01 level. The highest amino nitrogen ratio containing cultivars were 1 K222 (1.94%), Serenada KWS (1.87%) and Pauletta KWS (1.80%). The lowest amino nitrogen ratio containing cultivars were SR 490 (0.75%) and Coyote (0.79%). The amino-N differences amount the tested cultivars were assumed from nutrient absorption differences of sugar beet cultivars. In one study conducted in Eskisehir, Turkey the mean amino-N content of sugar beet cultivars was 1.55%. However, some researchers did not find any significant amino-N differences among cultivars (Özceylan and Esendal, 1986; Arslan, 1994; Okut and Yıldırım, 2004).

Refined sugar content (%)

The mean refined sugar content was 17.20%. The refined sugar content varied between 15.08-18.54%. The cultivars SR 538 (18.54%) and Serenada KWS (18.51%) having highest refined sugar content had 123% higher sugar content than the cultivar having the lowest sugar content (Coyote 15.08%) respectively.

Sugar yield (kg/ha)

The sugar yield of sugar beet cultivars varied significantly among sugar beet cultivars at the 0.01 level. The mean sugar yield of sugar beet cultivars was 13204 kg/ha. The sugar beet cultivars Serenada KWS (16.251 kg/ha) and Corvinia KWS (16.211 kg/ha) had the highest sugar yields. The lowest sugar yield in cultivars were SR 485 (9.292 kg/ha) and SR 540 (9.484 kg/ha). The higher rate of sugar yield resulted from the genetic make-up of the cultivars. Similarly Carter et al. (1985); O'Connor (1985); Takada et al. (1988) and El-Karouri and El-Rayah (2006) found significant sugar yield differences among sugar beet cultivars. The reported sugar yields in different environment were between 12950-15120 kg/ha (Özcan, 1993; Rychcik ve Zawiślak, 2002; Azam Jah et al. 2003; El-Karouri and El-Rayah, 2006; and Johari et al. 2008).

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Table 3. The investigated sugar beet parameters of sugar beet cultivars

Cultivar	Root yield (kg/ha)		Digestion (sugar content) (%)		Sodium (%)		Potassium (%)		Amino-N (%)		Increased sugar value (%)		Pure sugar yield (kg/ha)	
1 K222	91750	abc	19.18	abcde	0.82	bc	4.63	ab	1.94	a	17.40	abcdef	15905	ab
Aranka KWS	87250	abc	19.38	abcd	0.79	c	4.61	ab	1.63	abcde	17.64	abcde	15372	abc
Corvinia KWS	93000	ab	19.22	abcde	0.73	c	4.52	ab	1.36	abcdef	17.55	abcde	16211	a
Coyote	71250	efgh	16.79	g	2.23	a	4.07	abcd	0.79	f	15.08	g	10793	fgh
Diamente	7700.0	bcdef	18.87	abcdef	1.10	bc	3.80	bcde	0.84	ef	17.34	abcdef	13343	bcdef
Dozer	5350.0	ı	20.05	a	1.83	ab	3.06	e	0.85	ef	18.54	a	995.2	gh
Esperia KWS	8000.0	abcdef	19.67	ab	0.84	bc	4.03	abcd	1.20	abcdef	18.09	ab	1444.3	abcd
Festina	7200.0	efg	19.01	abcdef	1.32	abc	4.27	abc	1.23	abcdef	17.34	abcdef	1244.5	defg
Grinta	7250.0	efg	18.86	abcdef	0.86	bc	4.10	abcd	1.08	bcdef	17.27	abcdef	1256.3	defg
Maden	8675.0	abcde	19.40	abcd	0.71	c	4.10	abcd	1.18	abcdef	17.82	abcd	1546.5	abc
Pauletta KWS	8650.0	abcde	18.12	def	1.34	abc	4.31	abc	1.80	abc	16.29	efg	1399.9	abcde
Sandrina KWS	9050.0	abcd	17.74	fg	1.18	bc	4.39	abc	1.54	abcdef	15.98	fg	1439.7	abcde
Serenada KWS	9475.0	a	18.94	abcdef	1.00	bc	4.78	a	1.87	ab	17.16	abcdef	1625.1	a
SR 374	7150.0	efgh	18.32	cdef	1.25	bc	4.54	ab	1.16	abcdef	16.63	cdef	1195.5	defgh
SR 380	7550.0	cdef	18.99	abcdef	0.76	c	3.46	cde	1.00	cdef	17.55	abcde	1321.9	bcdef
SR 381	7600.0	cdef	18.03	ef	0.71	c	3.83	abcde	1.00	cdef	16.50	def	1249.8	defg
SR 485	5700.0	ghı	17.93	ef	1.03	bc	3.93	abcde	0.97	edf	16.37	efg	929.2	h
SR 489	7950.0	abcdef	19.44	abc	0.65	c	3.28	de	1.09	bcdef	17.99	abc	1426.8	abcde
SR 490	6675.0	fghı	18.74	bcdef	0.64	c	3.47	cde	0.75	f	17.35	abcdef	1157.5	efgh
SR 538	7650.0	cdef	20.09	a	0.63	c	3.80	bcde	1.72	abcd	18.51	a	1406.7	abcde
SR 540	5625.0	hı	18.32	cdef	0.84	bc	3.67	bcde	1.14	abcdef	16.81	bcdef	948.4	h
Turbata	7500.0	def	18.91	abcdef	1.20	bc	3.67	bcde	1.27	abcdef	17.25	abcdef	1292.9	cdef
Ortalama	7687.4		18.82		1.02		4.02		1.24		17.20		1320.4	
							Variation source							
Cultivar (C)	5.81**		4.24**		1.78*		2.77**		2.20**		3.88**		6.29**	
LSD	1383.3		1.09		0.86		0.79		0.69		1.19		238.4	
CV (%)	12.63		4.05		19.07		13.93		18.78		4.86		12.65	

[1] *,**: F-test significant at p <0.05, and p <0.01, respectively. ns: not significant.

4. CONCLUSIONS

Twenty two sugar beet cultivars were tested under continental climatic conditions in 2012. Significant differences were found among sugar beet cultivars for all of the investigated plant parameters. Considering the entire results together the genotypes Serenada KWS and Corvinia KWS had the highest root yield, sugar ratio, refined sugar ratio and sugar yield; cultivars Dozer, SR538 and SR 490 had the lowest amino nitrogen, sodium and potassium ratios. These cultivars could be recommended to be cultivated in Kayseri province and other continental type of climatic zones.

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