International Journal of Scientific Engineering and Science
Volume 6, Issue 8, pp. 34-37, 2022. ISSN (Online): 2456-7361

Variety and Harvesting Date Effect on Yield, Yield Components and Some Technological Characteristics of Sugar Beet (*Beta vulgaris* L.)

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Abstract— *The experiment was established to define the effects of sugar beet (Beta vulgaris L.) cultivars (Dozer, Dioneta, Cassandra, Leila and Agnessa) and harvesting dates (September 8, September 27, October 10 and November 1 in 2011; September 12, October 1, October 20 and November 8 in 2012) in 2011 and 2012 growing seasons in split plot design with 3 replications. It was determined that the effect of sugar beet cultivars was significant for all investigated parameters. All the investigated characteristics except root weight were significantly affected by harvesting dates (HD). Cultivar x harvesting date interaction was significant for biomass yield, root yield, dry matter, ash content, sugar content and α–N content. As the harvest date delayed, biomass yield, root yield, dry matter, ash content, sugar yield and α–N content significantly increased, but sugar content decreased. The results generally indicated that biomass yield, root yield, dry matter, ash content, sugar yield and α–N content decreased in earlier harvest dates of HD_1 and HD_2. When harvest date was delayed from HD_1 to HD_4, the sugar content was reduced approximately 9%.*

Keywords— *Sugar beet, cultivar, harvesting date, root and sugar yield.*

I. INTRODUCTION

Sugar beet (*Beta vulgaris* L.) is one of the important plants used sugar production in the world. Twenty percent of world sugar production is provided from sugar beet, the remaining 80% is from sugar cane (Varga et al., 2021). In Turkey, sugar is produced entirely from sugar beet. Turkey comes after countries such as Russia, USA, Germany and France with an annual production of approximately 16 million tons of beet and 2 million tons of sugar. Sugar beet plays an important role in the agriculture sector and agriculture-based industry in Turkey and maintains its importance with the added value it creates (Kul and Killi, 2021). The main strategy in sugar beet production is to grow high yield and quality sugar beet. Variety, climate, soil, pest and disease are the leading factors affecting yield and sugar content of sugar beet root. Sugar beet roots usually contain 13-20% sugar (Hoffmann, 2010). Time of harvest is one of the factors that effects on yield and quality of sugar beet crop (Al-Sayed et al., 2012). The harvest time of sugar beet depends on the physiological maturity and sugar content of the root. It is related to the variety, sowing time and climatic conditions (Kenter et al., 2006; Hoffmann et al., 2009; Alami et al., 2021). Delay in harvest enhanced root yield, sugar and extractable sugar content (Er and Inan, 1989). Delay in sugar beet harvest till the end of autumn leads to decrease in root and sugar yield and sucrose percentage (Brown, 1997). Some field experiments concerning the impact of environmental variables on the growth of sugar beet were carried out by Jaggard et al. (1998), Qi et al. (2005) and Kenter et al. (2006). The ripening of sugar beet depends on the beet variety. The time to reach physiological maturity should be compatible with the campaign period of the factory. As time progresses, the sugar content of varieties matured before the factory campaign period will decrease, the sugar rate and white sugar yield will also be low. In sugar beet, timely harvest will increase the quality of sugar beet. The amount of sugar produced at an expense will also increase. Depending on this increase, the cost of sugar production will fall. In this study, it was aimed to determine the effect on root yield and some quality characteristics of different varieties and harvesting dates under field conditions.

II. MATERIALS AND METHODS

Experimental Site and Conditions

Field study was conducted in Kahramanmaras city in 2011 and 2012, which is located in the East Mediterranean region of Türkiye (between 37º 53' north parallel and 36º 91' east meridians). The climate type in this area is Mediterranean, with hot and dry summers and warm and rainy winters. The study area had monthly air temperature between 6.1 and 30.5 °C. Annually total precipitation is average about 777 and 1158 mm but the total precipitation of during the sugar beet crop season is about 232 and 116 mm in 2011 and 2012 respectively. Soil had a sandy-clay texture, 1.0% low organic matter, 24.70% high lime content and pH of 7.8 slightly alkaline.

Experimental Material, Design and Cultural Practices

Five different sugar beet (*Beta vulgaris* var. *saccarifera* L.) varieties “Dozer, Dioneta, Cassandra, Leila and Agnessa” were planted in four rows with a planting density 45x20 cm in the fourth week of March in 2011 and 2012 and treated with four harvesting dates (September 8, September 27, October 10 and November 1, 2011; September 12, October 1, October 20 and November 8, 2012) in split plot design with 3 replications. The experimental area received 80 kg N and 80 kg P_2O_5 ha^{-1} as a seedbed application. Additional band-dressing of 100 kg N ha^{-1} was applied about 40 days after emergence. After emergence, plants were hoed 2 times by hand and machine. Overall 6

IJSES
International Journal of Scientific Engineering and Science
Volume 6, Issue 8, pp. 34-37, 2022. ISSN (Online): 2456-7361

furrow irrigations were applied. The harvest was done by hand at four different dates.

Data Collection

Root weight was determined by weighing the total roots of 10 plants from the center 2 rows of each plot. Biomass yield were determined for each treatment plot at crop maturity. The harvested sugar beet plants in the middle two rows of each plot were weighted and biomass yield (kg ha^{-1}) was calculated. After removing the heads and leaves of harvested sugar beet plants, the remaining root part was weighed and root yield (kg ha^{-1}) was calculated. The harvested sugar beets were made into paste at the Elbistan Sugar Factory. 10-15 g of crushed beet samples were taken and dried in an atmospheric oven at 105 °C until its weight remained constant. When it comes to constant weight, it is cooled in a desiccator for approximately 45 minutes with the mouth closed, and then the dry matter amount (%) is calculated by weighing (Hoffmann et al., 2005). Sugar analysis was done in Elbistan Sugar Factory. Sugar content (%) was measured with a polar meter after extraction of sugar from the pulp with lead acetate (Carruthers and Oldfield, 1960). Sugar yield was determined according to the equation given by (Killi and Kasap, 1994); Sugar yield (kg ha^{-1}) = Sugar content (%) *x* Root yield (kg ha^{-1}). Alfa amino (α–N) content was measured using Kubadinow-Weninger method in Elbistan Sugar Factory. The α–N content was determined by means of a spectrophotometer at a wave length of 600 nm. α–N data were calculated in mg per 100g fresh beet root (Hoffmann et al., 2009). Ash content was determined according to the procedure described in AOAC (2012).

Statistical Analyses

Data of yield and quality parameters from the study were analyzed using the MSTAT-C statistical programming. The significant of the difference between means was compared by least significant difference test (Protected LSD, $P < 0.05$).

III. Results and Discussion

The variance analysis of investigated characteristics are shown in Table 1. It could be seen in Table 1, all investigated parameters for cultivars and harvesting dates except root weight were statistically significant. C x HD interaction was significant for all examined traits except root weight and sugar yield.

TABLE I. Two year average values of investigated characteristics for different cultivars and harvesting dates of sugar beet.

	Root weight (kg)	**Biomass Yield (ton ha^{-1})**	**Root yield (ton ha^{-1})**	**Dry matter (%)**	**Ash content (%)**	**Sugar content (%)**	**Sugar yield (ton ha^{-1})**	**α–N content (mg 100 g^{-1})**
Cultivars (C)								
Dozer	0.42 c	57.25 b	48.04 b	22.97 a	2.71 b	16.70 a	7.97 b	0.051 c
Dioneta	0.42 c	58.87 b	48.50 b	22.46 b	3.20 a	15.71 b	7.50 b	0.052 c
Cassandra	0.72 a	66.83 a	59.10 a	21.52 c	3.14 a	15.34 b	8.89 a	0.057 b
Leila	0.63 b	68.08 a	60.54 a	23.22 a	3.33 a	15.75 b	9.36 a	0.062 a
Agnessa	0.49 c	68.96 a	58.21 a	23.06 a	2.81 b	16.60 a	9.66 a	0.060 a
$LSD_{0.05}$	0.08	4.2	3.5	0.42	0.24	0.45	0.79	0.002
Harvesting Dates (HD)								
HD_1	0.56	59.87 c	50.53 b	22.17 b	2.94 b	16.30 a	8.09 b	0.053 c
HD_2	0.51	62.57 bc	53.13 b	22.34 b	3.03 b	16.44 a	8.61 b	0.054 c
HD_3	0.53	67.10 a	58.87 a	22.94 a	2.96 b	16.39 a	9.57 a	0.056 b
HD_4	0.55	66.47 ab	56.97 a	23.13 a	3.22 a	14.94 b	8.43 b	0.064 a
$LSD_{0.05}$	Ns	3.9	3.7	0.27	0.16	0.35	0.62	0.002
			Analysis of variance for characteristics					
C	**	**	**	**	**	**	**	**
HD	Ns	**	**	**	**	**	**	**
C x HD	Ns	**	*	**	**	**	Ns	**

*, ** significant at the 0.05 and 0.01 level, respectively; for each trait, values within columns followed by the same letter are not significantly at P=0.05; Ns, non-significant

There were significant differences among the cultivars all studied parameters. Root weight values ranged from 0.42 kg to 0.72 kg and the cultivar Cassandra gave the highest root weight (0.72 kg). The varieties Cassandra, Leila and Agnessa produced higher biomass, root and sugar yield while the dozer and Dioneta produced lower. Dry matter contents ranged from 21.52% to 23.22% and the cultivar Cassandra had the lowest dry matter (21.52%). Dozer (22.97%), Leila (23.22%) and Agnessa (23.06%) had the higher dry matter content. Dioneta (3.20%), Cassandra (3.14%) and Leila (3.33%) cultivars with high ash content values gave the low sugar content. Dozer (16.70%) and Agnessa (16.60%) gave the higher sugar content. Leila (0.062 mg 100 g^{-1}) and Agnessa (0.060 mg 100 g^{-1}) produced higher and similar α–N content, but Dozer (0.051 mg 100 g^{-1}) and Dioneta (0.052 mg 100 g^{-1}) produced lower and similar α–N content. There were significant differences among the harvesting dates all studied parameters except root weight. As the harvest date delayed, biomass yield, root yield, dry matter, ash content, sugar yield and α–N content significantly increased, but sugar content decreased. The results generally indicated that biomass yield, root yield, dry matter, ash content, sugar yield and α–N content decreased in earlier harvest dates of HD_1 and HD_2. When harvest date was delayed from HD_1 to HD_4, the sugar content was reduced approximately 9%. In some early studies, it was found that biomass, root and sugar yield increased with delay of harvest time and it is indicated that significant increases in yield occurred with the prolongation of vegetation period (Stanacev et al., 1979; Beshelt and Gharbawy, 1993; Held et al., 1994; Jozefyova et al., 2003; Romaneckas et al., 2010).

Sugar beet cultivars reacted differently to different harvesting dates in terms of biomass yield, root yield, dry

matter, ash content, sugar content and α–N content, and the C x HD interaction was significant (Table 1 and Fig. 1, 2, 3, 4, 5, 6).

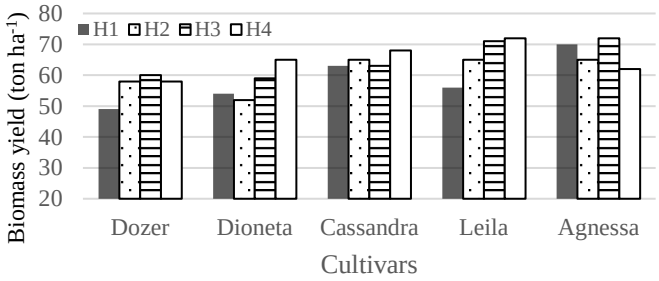

Fig. 1. Influence of harvesting dates on biomass yield of sugar beet cultivars

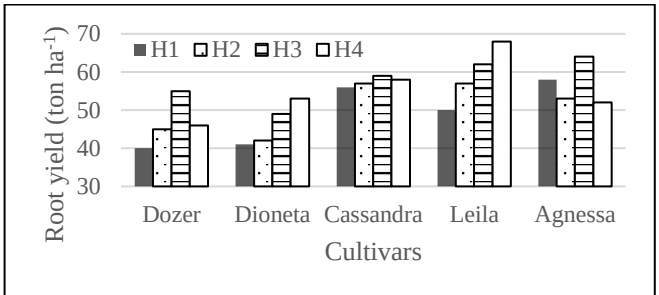

Fig.2. Influence of harvesting dates on root yield of sugar beet cultivras

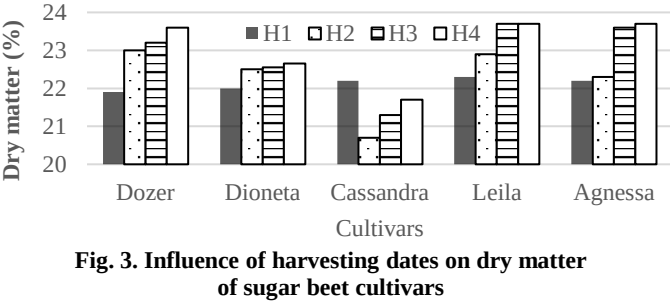

Fig. 3. Influence of harvesting dates on dry matter of sugar beet cultivars

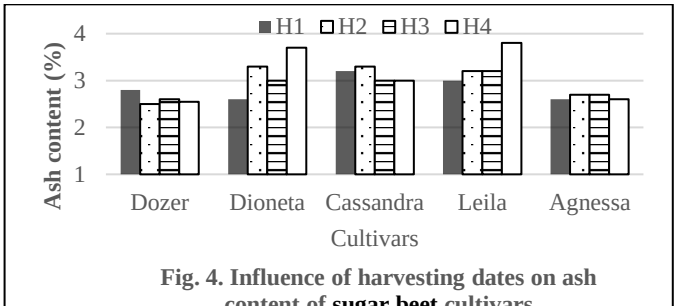

Fig. 4. Influence of harvesting dates on ash content of sugar beet cultivars

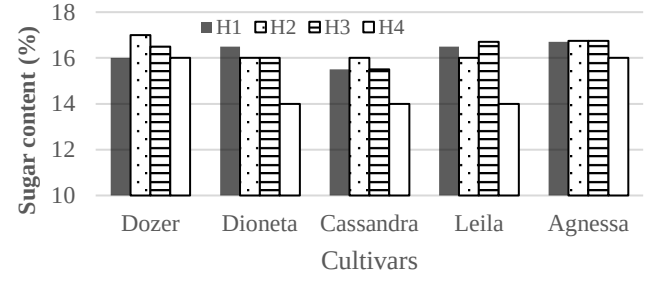

Fig. 5. Influence of harvesting dates on sugar content of sugar beet cultivars

Fig. 6. Influence of harvesting dates on α–N content of sugar beet cultivars

IV. Conclusion

It can be concluded that the variety effect was significant in all studied parameters, but all investigated parameters except root weight were affected from harvesting dates. In the study, biomass yield, root yield and sugar yield was between 57.22 and 68.96 tons, 48.04 and 60.54 tons, and 7.50 and 9.66 tons, respectively. It was concluded from the present study that all the investigated characteristics except root weight were significantly affected by harvesting dates. As the harvest time was delayed, all examined characteristics increased, except root weight. Delaying the harvest time from HD1 to HD3 had a positive effect, while later harvesting caused a decrease in sugar content.

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