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Original article

The effect of planting date and irrigation levels on enzymatic properties, yield and yield components of sugar beet (*Beta vulgaris* L.) cultivars

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Extended abstract

Introduction

Sugar beet has long-growth period and high-water use. Thus, managing to reduce water consumption and decline growth period causes to increase the crop productivity. Sugar beet provides more than one-half of sugar produced in the United States and about 40% of sugar production in the world. The root of this crop contains 13- 22% sugar content. In general sugar beet also has a major role in the human diet and it is the mainstay parts of the agriculture economy in Iran. The leaves of sugar beet comprise the main light receptor organ for a crop. Leaf area development early during the season causes more efficient use of sunlight since it is important to the formation and expansion of the canopy. Sugar beet in the primary growth stages needs a warm and sunny climate and optimum water supply for optimal photosynthesis and photoassimilate partitioning.

Material and method

This purpose study was performed in the research field of Hamedan in 2016. The experiment was conducted in a split-split plot based on RCB design with four replications. Experimental treatments were planting date at two levels as main plot (May 14 and June 28), irrigation at two levels as sub-plot (full irrigation and 75% of full irrigation or water requirement), and cultivar at 3 levels (two premature hybrids and the resistant cultivar to Rhizoctonia (Arya)) as sub-sub-plot at 2016 crop season. Studied traits were root yield, sugar content, sugar yield, and Enzyme activities such as SOD, PO, leaf chlorophyll, and some physiological and morphologic traits. SAS software version 9.1 was used to analyze the data. Also, the mean of the studied parameters was compared using the least significant difference test (LSD) at the level of 5 percent probability.

Results and discussion

Based on the results of the analysis of variance, the difference between planting dates in terms of superoxide dismutase content, root yield, sugar yield, white sugar yield, and water use efficiency was significant at the level of 1% probability. There was a significant difference between irrigation levels in

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terms of superoxide dismutase and water use efficiency at 1% probability level and membrane lipid peroxidation content, peroxidase enzyme, chlorophyll a, chlorophyll b, and carotenoid content at 5% probability level. There was a significant difference between the studied genotypes in terms of root yield and sugar yield at a probability level of 1% and in terms of white sugar yield and water use efficiency at a probability level of 5%. The interaction effect of culture date on genotype was significant in terms of the effect on the percentage of white sugar and yield of white sugar at the level of 1% probability. The interaction effect of irrigation levels in genotype was significant only on water use efficiency at the level of 1% probability. The results showed that irrigation level 75% of plant water requirement compared to 100% level increased, hydrogen peroxide content, membrane lipid peroxidation, peroxidase activity and superoxide dismutase activity by 14.83, 25, 17.38, and 26%, respectively and reduced chlorophyll a, chlorophyll b and carotenoid content by 15%, 12%, and 14%, respectively. Also, the amount of superoxide dismutase activity and root yield on planting on May 14 was 33% and 26% higher than planting on July 28, respectively. Root yield in 33868 and 33872 hybrids was higher than Aria cultivar. The results also showed that the difference between the planting dates of May 14 and June 28 in the two hybrids 33868 and 33872 was not significant in terms of sugar content, white sugar yield, and water use efficiency. Also, the planting date of June 28 increased the percentage of white sugar in both hybrids. Finally, two hybrids, 33868 and 33872, obtained the highest water efficiency in the treatment of 75% of the required water.

Conclusions

In the conditions that there is a possibility of delay in the cultivation of sugar beet, planting two hybrids, two hybrids 33868 and 33872, is recommended.

***Keywords*:** Antioxidant, Sugar content, Chlorophyll, Dehydration

Table 1. Results of field soil analysis before planting

Soil texture	Clay	Silt	Sand	K	P	O.C	pH	EC
	--------%----------			----- ppm -----		%		$dS.m^{-1}$
Silty-loamy	15.5	27.5	57	499	47.6	0.45	7.93	6.14

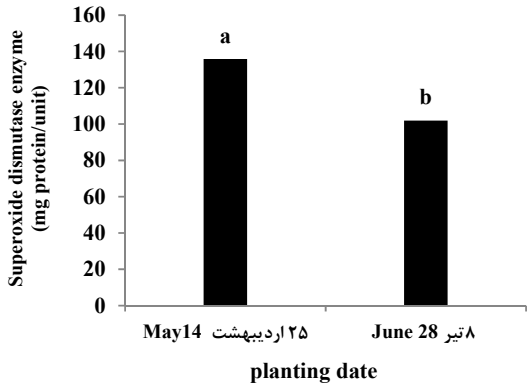

Fig. 1. Effect of planting date on the amount of superoxide dismutase in sugar beet

Table 2. Analysis of variance of quantitative and qualitative characteristics of sugar beet cultivars at different planting dates and irrigation levels

S.O.V	df	Hydrogen peroxide	Membrane lipid peroxidation	Peroxidase	Superoxide dismutase
Repetition	3	3220.31	169.56	10.29	1156.50
Planting date (A)	1	13333.33^{ns}	53.90^{ns}	55.10^{ns}	13797.54**
Error 1	3	2827.43	477.52	71.65	133.85
Irrigation (B)	1	31775.52*	3223.67**	722.22*	14162.42**
A*B	1	2.08^{ns}	1.30^{ns}	5.62^{ns}	46.48^{ns}
Error 2	6	4872.14	198.54	62.61	291.07
Cultivar (C)	2	265.76^{ns}	67.70^{ns}	7.24^{ns}	550.52^{ns}
A*C	2	27883.72^{ns}	30.00^{ns}	126.78^{ns}	1543.53^{ns}
B*C	2	2607.94^{ns}	125.85^{ns}	41.41^{ns}	914.88^{ns}
A*B*C	2	1263.41^{ns}	192.05^{ns}	2.18^{ns}	1194.32^{ns}
Error 3	24	5595.66	128.16	76.56	1103.15

Table 2. Continued

S.O.V	df	Chlorophyll a	Chlorophyll b	Carotenoids	Water use efficiency
Repetition	3	0.00711	0.00039	0.00862	0.05
Planting date (A)	1	0.00516^{ns}	0.00652^{ns}	0.02785^{ns}	0.07**
Error 1	3	0.00476	0.00184	0.01304	0.009
Irrigation (B)	1	0.24191*	0.01774*	0.45079*	0.46**
A*B	1	0.00032^{ns}	0.00115^{ns}	0.00137^{ns}	0.00^{ns}
Error 2	6	0.01859	0.00266	0.04459	0.02
Cultivar (C)	2	0.01343^{ns}	0.00066^{ns}	0.02423^{ns}	0.18*
A*C	2	0.00045^{ns}	0.00034^{ns}	0.00069^{ns}	0.09*
B*C	2	0.00717^{ns}	0.00307^{ns}	0.01888^{ns}	0.04**
A*B*C	2	0.02496^{ns}	0.00226^{ns}	0.0332^{ns}	0.01^{ns}
Error 3	24	0.02030	0.00220	0.03984	0.01

Table 2. Continued

S.O.V	df	Root yield	sugar content	Sugar yield	white sugar content	white sugar content
Repetition	3	70.57	1.52	3.10	2.85	2.70
Planting date (A)	1	2182.82**	2.72^{ns}	51.50**	0.15^{ns}	13.47**
Error 1	3	12.46	1.17	0.33	1.10	0.27
Irrigation (B)	1	95.51^{ns}	3.20^{ns}	0.06^{ns}	2.65^{ns}	0.02^{ns}
A*B	1	37.37^{ns}	0.13^{ns}	0.85^{ns}	0.74^{ns}	0.79^{ns}
Error 2	6	120.93	1.01	1.19	1.59	0.30
Cultivar (C)	2	501.28**	0.09^{ns}	7.42**	0.38^{ns}	2.02*
A*C	2	42.62^{ns}	3.30**	3.41*	5.84**	3.92**
B*C	2	44.86^{ns}	0.24^{ns}	1.92^{ns}	0.16^{ns}	1.11^{ns}
A*B*C	2	13.53^{ns}	0.49^{ns}	0.04^{ns}	0.22^{ns}	0.21^{ns}
Error 3	24	28.68	0.59	0.79	0.88	0.56

^{ns}, * and **: no Significant, Significant at 5% and 1% levels probability, respectively

Table 3. Comparison of the mean of irrigation treatments in terms of effect on the studied traits

Irrigation levels	Hydrogen peroxide	Membrane lipid peroxidation	Peroxidas	Superoxide dismutase	Chlorophyll a	Chlorophyll b	Carotenoid
	---------µM gr^{-1} FW---------		Mg protein unit^{-1}		----------Mg g^{-1} FW----------		
100% CWR†	346.88^{b}	64.92^{b}	36.83^{b}	136.08^{a}	0.97^{a}	0.317^{a}	1.42^{a}
75% CWR†	398.33^{a}	81.31^{a}	44.59^{a}	101.73^{b}	0.83^{b}	0.28^{b}	1.22^{b}

Means in each column, followed by similar letter(s) are not significantly different at 5% probability level, using lsd Test
† CWR= Crop water requirement

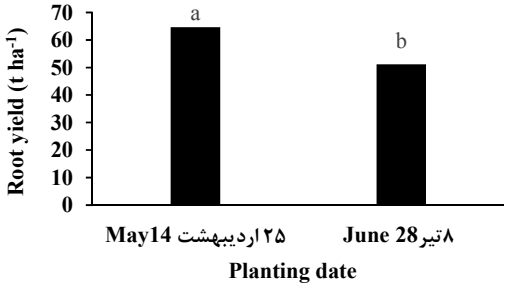

Fig. 2. Mean comparison of the planting date in terms of the root yield in sugar beet

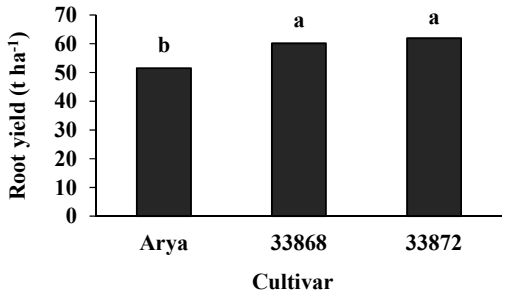

Fig. 3. Mean comparison of the cultivars in terms of the root yield in sugar beet

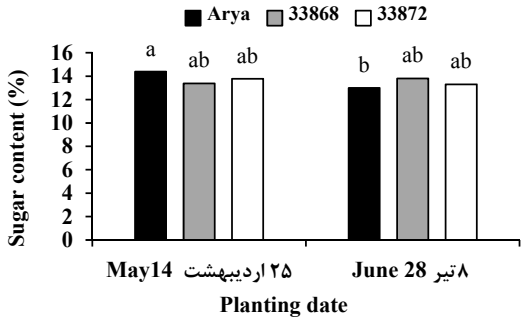

Fig. 4. Mean comparison of the interaction treatments of planting date and genotype on the of sugar content in sugar beet.

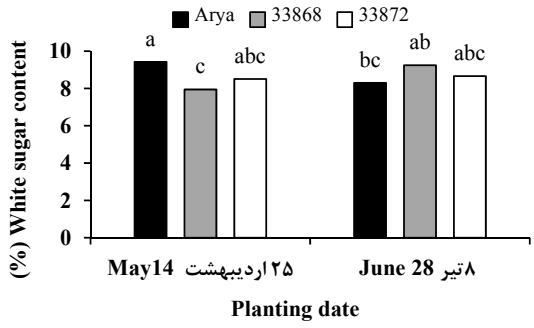

Fig. 5. Mean comparison of the interaction treatments of planting date and genotype on white sugar content in sugar beet.

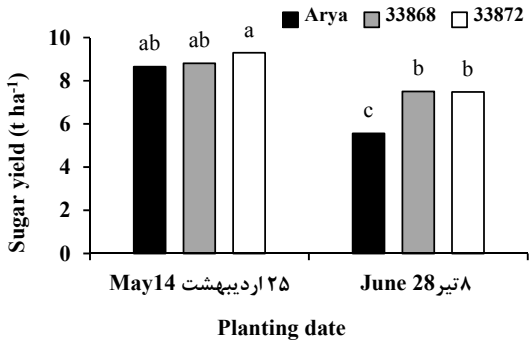

Fig. 6. Mean comparison of the interaction treatments of planting date and genotype on the of sugar yield in sugar beet.

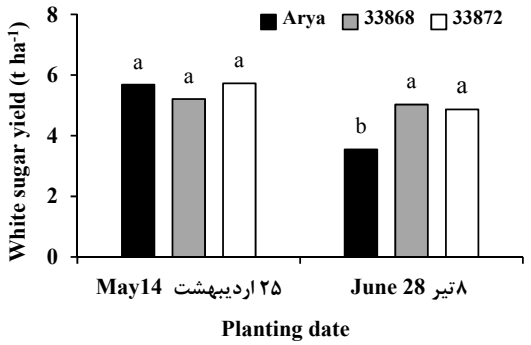

Fig. 7. Mean comparison of the interaction treatments of planting date and genotype on white sugar yield in sugar beet.

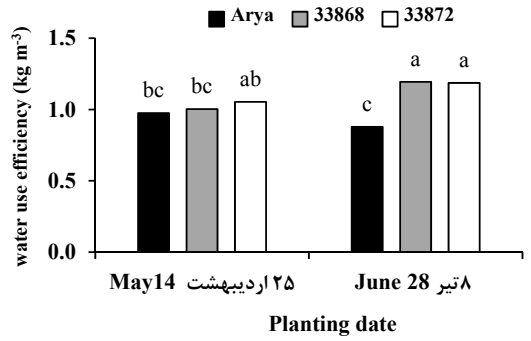

Fig. 8. Mean comparison of the interaction treatments of planting date and genotype on the water use efficiency in sugar beet

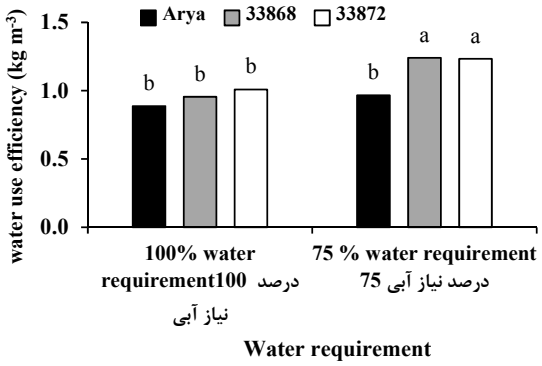

Fig. 9. Mean comparison of the interaction treatments of irrigation date and genotype on the water use efficiency in sugar beet