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Effects of sowing methods on the quantity and quality of sugar beet in saline regions

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ABSTRACT

Water and soil salinity in some regions of Isfahan, East Azerbaijan, and West Azerbaijan provinces and also other parts of Iran are the main hindrance for crop planting. Seeds of the tolerant crops to salinity such as cotton and sugar beet may have optimal germination and give acceptable performance if they become far from salt accumulation area. To evaluate the effects of different sugar beet planting methods on sugar beet quantity and quality in areas with salinity restriction, an experiment was carried out in a split split split plot design in three replications in 2004-05, in Research Station of Rudasht, Isfahan. Irrigation with two salinity levels including 8 ds/m and 12 ds/m were allocated to the main plot, two planting dates to the split plots, and three planting methods including two-rows under irrigation level, one row in flat plot, and on furrow to the split split split plots. Results showed that irrigation with 12 ds/m salinity level caused 17 and 18 % reduction in root yield and sugar content, respectively. Root yield was highly influenced by water salinity compared with other traits. Delay in planting, caused 31, 46 and 30 % reduction in root yield, sugar content and sugar yield, respectively. Reduction in both white sugar yield and sugar yield was owing to root yield reduction. No significant difference was found among three planting methods. White sugar yield and sugar yield percentage were higher in two rows planting method compared with two other methods. Delay in planting caused a significant decrease in sugar yield which is not recommended. Two rows planting is recommended owing to more simplicity in irrigation, mechanized planting and also decrease in production cost compared with two other methods.

Keywords: planting date, salinity, planting methods, sugar beet

INTRODUCTION

Saline lands cover 400-950 million hectares of area globally so that about 20.2 million hectares is located in US and 44 million hectares in Iran (Shani and Dudley 2001). It constitutes 30% of deserts and more than 50% of irrigated lands (Malakoty *et al*. 2003). These areas are managed through drainage renovation or modern irrigation systems which demands high costs. In saline soils, factors such as insufficient plant available water, solvent toxicity, and deleterious effects of excess sodium on physiological soil characters resulted in yield loss and plant death. Thus, owing to the arid climate and solvents excess in soil, a large number of crops are facing salinity. Salinity causes change in soil property and has a direct relationship with irrigation water volume (Malakoty *et al*. 2003). Sugar beet is tolerant to salinity so that its salinity threshold for electrical conductivity of soil saturation equals 7 ds m^{-1} (4.7 ds m^{-1} for irrigation water). Seed germination and seedling growth are the most sensitive stages in sugar beet life cycle and soil saturation salinity should not be more than 3 ds m^{-1}. With increase in soil saturation extract up to 8.7, 11, and 15 ds m^{-1}, sugar beet yield will decrease to 10, 25, and 50%, respectively and with increase in water salinity and soil saturation extract up to 16 and 24 ds m^{-1}, respectively sugar

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beet plant will die (Ayers and Westcot 1985). In a pot study conducted by Yazdani and Sari (1992) in Roudasht, Isfahan, effects of water salinity on cultivar T41R germination was evaluated. Results showed that this cultivar was sensitive to salinity during germination. In distilled water treatment, 81% of the seeds were germinated and with increase in water salinity up to 6 and 8 ds m^{-1}, germination rate decreased (Yazdani and Sari 1992). Germination rate decreased to 70 and 65% in 6 and 8 ds m^{-1} treatments, respectively. Yazdani (1992) also showed that using drainage water with 8 ds m^{-1} salinity level decreased sugar beet yield by 14%. In another study by Ebrahimian and Rezaei (2007), sugar beet reacted to water salinity and significant difference between sugar yield and white sugar yield was owing to significant difference in root yield. Therefore, among all quantitative and qualitative characters, root yield has received the highest influence by salinity. In a study by Jahadakbar (2007) in Roudasht, Isfahan, 8 and 12 ds m^{-1} water salinity decreased sugar beet root yield by 24 and 33%, respectively compared with check variety which was irrigated with 4 ds m^{-1} water salinity level (Jahadakbar 2007). Sugar content and root impurities did not affect sugar yield and white sugar yield, and root yield was the most important factor in sugar production (Jahadakbr and Marjovy 2006; Ebrahimian and Rezaei 2007). Therefore, among all quantitative and qualitative characters, root yield was influenced by salinity. The excess accumulation of salts around seed in soil prevents seed germination and initial growth or even causes stem death. Seed planting, 2-3 times more than recommended can be used to deal with low germination problem however it may cause unequal root density (Ebrahimian and Rezaei 2007). Proper cultivation method, platform, and also irrigation management can control soil salinity at critical growth stages (Malakoty *et al*. 2003). In furrow irrigation if the seeds are planted on the ridge, the water movement will be from furrow to the ridge centre. When water moves from both sides of the ridge, soil minerals will move with water which leads to minerals accumulation on the top of the ridge. Therefore by seed sowing on ridge, seeds are exposed to salt accumulation. When two rows of seeds are planted on ridge (on both sides of the ridge) seeds will be far from salt accumulation threat. In this method, water and soil minerals are accumulated near the ridge center which increases both germination and plant establishment probability. In one or two rows sowing, increase in water depth can solve mineral accumulation and help germination. For better soil salinity control, it is recommended to plant seeds on ridge slope with sowing row relatively above water level. Sowing on ridge slope can be changed to normal ridge after germination and early growth stage (Rhoades *et al*. 1992). In another method seed is placed slightly above warm water level. Soil temperature (even a few degrees) is important for plant cultivation in winter or early spring. For increasing soil temperature in northern hemisphere, row slopes are located toward south and to reduce it, the slope of the row will be located to the north side. After irrigation with saline water, a salt layer is formed on soil surface. In normal ridge planting or bilateral irrigation, to reduce salt layer damage, metal bar or chain net is pulled on ridge before seedling emergence. Breaking the salt crust provides better situation for seedling emergence (Ayers *et al*. 1985; Minhas and Gupta 1993). Taki and Godwin (2006) reported that both sides of trapezoid shaped ridge are the most arid soil area. The direction of water and mineral movement was into the two trapezoid shaped areas that were drier. As a result, the trapezoid shaped cracks are the salt accumulation area and by planting the seeds in the middle of the cracks, they will be far from salt accumulation. In a study by Dadkhah (2007), the total cost of two rows and plot sowing methods were compared. Results showed that two rows sowing is 4600000 Rials cheaper than plot sowing and had a greater economic advantage. This study evaluates the effects of different seedbed preparation methods together with two sowing dates, and two salinity levels on quantity and quality of sugar beet cultivar p29*MSC2-7233 for two years in Research Station of Irrigation and Drainage in Roudasht.

MATERIALS AND METHODS

This study was conducted in Research Station of Irrigation and Drainage in Roudasht, Isfahan during 2004-05. Split plot design with three replications in 2004 and four replications in 2005 was used. Because of the brei sample loss, 3 plots of 84 plots were not used in data analysis. Table 1 shows soil analysis results in both years.

Samples were taken from irrigation water and the water quality was analysed by mixing canal water (no salt restriction) with drainage water (salinity above 20 ds m^{-1}, Table 2).

Fertilizer consumption level was based on soil analysis and the Research Department of Soil and

Table 1. Soil characteristics of the experimental field before sowing in two years

Sampling depth (0-30 cm)	Electrical conductivity (ds m^{-1})	Total nitrogen (%)	Acidity ()	Organic carbon (%)	Sodium (mEq L^{-1})	Potassium (mEq L^{-1})	Phosphorous (mEq L^{-1})
2004	7.02	0.04	7.6	0.36	11	350	16.8
2005	9.69	0.04	7.5	0.38	15	345	19

Table 2. Average results of the qualitative parameters in irrigation water

Electrical conductivity (ds m^{-1})	Acidity (mEq g L^{-1})	Bicarbonate (mEq g L^{-1})	Chlorine (mEq g L^{-1})	Sulphate (mEq g L^{-1})	Total anions (mEq g L^{-1})	Calcium + magnesium (mEq g L^{-1})	Sodium (mEq g L^{-1})	Total cations (mEq g L^{-1})
8.05	7.4	4.85	62	26.2	95.4	30	68.4	97.5
12.04	7.6	5.60	92	38.1	140.7	36	104.2	140.9

Table 3. Average soil salinity in different seedbed preparation treatment and irrigation

		8 ds m^{-1}			12 ds m^{-1}		
		Planting method					
Year	Sampling (cm)	One row	Line in plot	Two rows	One row	Line in plot	Two rows
2004	0-30	10.81	8.01	12.95	14.47	12.57	16.04
2005	0-30	10.85	11.51	10.95	18.56	17.85	17.95

Water Consumption recommendation. Experiment was conducted in split split split plot design with three replications. Irrigation with two salinity levels including 8 ds m^{-1} and 12 ds m^{-1} were allocated to the main plot, two planting dates to the split plots, and three planting methods including two rows under warm water level, single row in plot, and on top of the ridge to split split split plots. First sowing date was selected based on land salinity level and the second date selection was based on root rot occurrence in Roudasht region which occurs owing to early planting. Thus, sugar factories tend to plant sugar beet after final cereal's irrigation in these areas. Soil saturation extract salinity was measured before and after sowing. Result of the average soil salinity in main plots is presented in Table 3.

All agronomical practices including irrigation, pest and disease management and manual cultivator were performed when required. Harvest was done at 18th November 2004 and 21st November 2005 after technological maturity. Root yield and plant number of all plots were measured and brei making for qualitative measurement was done. Data were analysed based on GLM using SAS software.

RESULTS AND DISCUSSION

ANOVA results showed that water irrigation salinity had significant effect on root yield, sugar yield and white sugar yield, and delay in sowing had significant effect on root yield, sugar yield, potassium, and white sugar yield. Sowing methods had only significant effect on root yield. Salinity × sowing date interaction had significant effect on root yield and sugar yield (Table 4).

Soil salinity was higher in 2005 compared with 2004 and the only significant difference was observed for average amino nitrogen (Table 5).

Results of the average quantitative and qualitative properties under salt stress in both years showed that with increase in salinity, both root yield (about 17%) and sugar yield (about 18%) were decreased significantly. However, root impurities and extraction coefficient had no significant difference (Table 6). This is also confirmed by other researchers. Jahadakbar and Marjovy (2006) and Ebrahimian and Rezaei (2007) showed that sugar content and root impurities in different experiments and within different years could not change sugar yield or white sugar yield in Roudasht. Root yield was the most important factor in sugar production in Roudasht and sugar yield increase was owing to root yield increase.

Delay in sowing caused significant decrease in root yield (about 31%), sugar yield (about 46%), and white sugar yield (about 30%), while for other root impurities except potassium and sugar content no significant difference was found (Table 7). Therefore, reduction in sugar yield and white sugar yield was due to root yield reduction with no effect by sugar content. Based on these results, delay in sowing is not recommended in this region and if the root rot problem be controlled in early sowing (which is likely due to irrigation method), sowing should be done in the earliest time in March. In saline lands unlike other areas without salt restriction, late sowing will not increase sugar content and as a result delay in sowing will significantly decrease sugar yield. This is consistent with previous studies conducted in Roudasht, Isfahan (Jahadakbr and Marjovy 2006; Ebrahimian and

Table 4. Analyses of variance for salinity, sowing date, and sowing method effects on qualitative characters of sugar beet within two years experiment

SOV	df	Mean squares							
		Root yield	Sugar content	Sugar yield	Sodium	Potassium	Amino nitrate	Extraction coefficient	White sugar yield
Year	1	58	6	0.19	0.14	2.15	37^{**}	19.5	0.86
Error A	5	13	5	1.7	1.36	2	2	40	1.78
Salinity	1	774^{**}	5	32^{*}	0.23	0.42	0.16	17	18.4^{*}
Salinity × year	1	73	0.3	1	9.87	3.77	2.46^{*}	29	0.5
Error B	5	73	6.5	4	5.48	2.76	0.5	121	3.8
Planting date	1	2592^{**}	5.6	73^{**}	17.08	21.94^{**}	0.3	53	41^{**}
Planting date × year	1	375^{**}	0.10	12.48^{**}	0.35	0.90	7^{**}	25	6.17^{*}
Planting date × salinity	1	228^{**}	0.95	9.35^{*}	0.46	0.11	0.65	4.49	5.08
Planting date × salinity × year	1	79	0.64	3.69	1.29	1	3.10	15	2.10
Error C	10	21	3.78	1.32	5.79	2.38	0.7	88	1.29
Planting method	2	95^{*}	1.66	2.98	1.60	0.18	0.6	9.96	2.15
Planting method × year	2	126^{**}	0.38	3.25	0.47	0.82	1.6	4.5	1.72
Planting method × salinity	2	16	2.99	1.69	5.88	0.11	4.4^{**}	98.20	1.84
Planting method × salinity × year	2	35	0.72	1.35	0.02	0.09	0.79	10.56	0.59
Planting method × planting date	2	31	0.50	1.76	0.06	0.31	3.25^{**}	17.61	1.24
Planting method × planting date × year	2	52	0.95	2.23	2.23	0.72	2.68	15.55	1.54
Planting method × salinity × planting date	2	59	1.32	3.04	3.90	0.01	0.45	85.58	2.75
Planting method × salinity × planting date × year	2	29	1.91	1.55	0.89	0.23	0.19	30.65	1.29
Error D	37	25	2.21	1.48	2.61	0.28	0.68	68.98	1.32

*, ** significant at 5% and 1% probability level, respectively

Table 5. Classification of average quantitative and qualitative properties of sugar beet under salt stress

Year	Root yield (t/ha)	Sugar content (%)	Sugar yield (t/ha)	Sodium (mEq g L^{-1})	Potassium (mEq g L^{-1})	Amino nitrogen (mEq g L^{-1})	Extraction coefficient (%)	White sugar yield (t/ha)
2004	35.50^{a}	17.43^{a}	6.21^{a}	^{a}	7.01^{a}	4.27^{a}	76.81^{a}	4.80^{a}
2005	33.49^{a}	17.84^{a}	6.02^{a}	^{a}	6.72^{a}	5.72^{b}	73.70^{a}	4.49^{a}

Means with same alphabet are not significantly different at 5% Duncan test

Table 6. Classification of average quantitative and qualitative properties of sugar beet under two water salinity level

Water salinity	Root yield (t/ha)	Sugar content (%)	Sugar yield (t/ha)	Sodium (mEq g L^{-1})	Potassium (mEq g L^{-1})	Amino nitrogen (mEq g L^{-1})	Extraction coefficient (%)	White sugar yield (t/ha)
2004	37.18^{a}	^{a}	6.68^{a}	^{a}	6.95^{a}	5.23^{a}	75.06^{a}	5.05^{a}
2005	31.21^{b}	^{a}	5.47^{a}	^{a}	6.73^{a}	5.03^{b}	74.39^{a}	4.15^{a}

Means with same alphabet are not significantly different at 5% Duncan test

Table 7. Classification of average quantitative and qualitative properties of sugar beet in two sowing dates under two water salinity levels

Planting date	Root yield (t/ha)	Sugar content (%)	Sugar yield (t/ha)	Sodium (mEq g L^{-1})	Potassium (mEq g L^{-1})	Amino nitrogen (mEq g L^{-1})	Extraction coefficient (%)	White sugar yield (t/ha)
First	40.49^{a}	17.44^{a}	7.15^{a}	4.68^{a}	6.34^{b}	5.26^{a}	73.81^{a}	5.41^{a}
Second	28.03^{b}	17.90^{a}	5.02^{b}	^{a}	7.38^{a}	5.02^{a}	75.40^{a}	3.81^{b}

Means with same alphabet in each column are not significantly different at 5% Duncan test

Rezaei 2007).

Year × sowing date interaction had significant effect on root yield, sugar yield, and white sugar yield (Table 4). First sowing date had no significant effect on root yield, sugar yield and white sugar yield in both years but second sowing date had significant effect on the above traits in both years (Table 8) and it could be possibly due to higher soil salinity level in the second year (Table 3).

Sowing date × salinity interaction effect on root yield and sugar yield was significant. In first sowing date, with increase in water salinity, root yield and sugar yield decreased significantly but in second sowing date, due to higher soil salinity, both water salinity levels had no significant effect on root yield and sugar yield (Table 9).

The highest root yield was observed in single row per plot sowing method which had significant

Table 8. Classification of year × sowing date on root yield, sugar yield, and white sugar yield

Year	Sowing date	Root yield (t/ha)	Sugar yield (t/ha)	White sugar yield (t/ha)
2004	First	39.22[a]	6.82[a]	5.29[a]
	Second	31.78[b]	5.60[b]	4.31[b]
2005	First	41.40[a]	7.39[a]	5.50[a]
	Second	25.26[c]	4.60[c]	3.44[c]
LSD 5%		5.06	0.95	0.65

Means with same alphabet in each column are not significantly different at 5% Duncan test

Table 9. Classification of year × salinity level on root yield, sugar yield, and white sugar yield

Sowing date	Water salinity	Root yield (t/ha)	Sugar yield (t/ha)
First	8	45.17[a]	8.09[a]
	12	35.58[b]	6.16[b]
Second	8	29.18[c]	5.27[a]
	12	36.75[c]	4.75[c]
LSD 5%		5.51	0.74

Means with same alphabet in each column are not significantly different at 5% Duncan test

difference with on ridge sowing and had no difference with two rows sowing (Table 10). Due to higher sugar content in two rows sowing, sugar yield and white sugar yield were higher in this method compared with two other methods. In previous study (Dadkhah 2007), comparison of two sowing methods costs in Roudasht showed that two rows sowing requires lower cost compared with single row per plot sowing.

Year × sowing method had significant effect on root yield (Table 4). Table 11 shows that in 2004, sowing methods had significant effect on root yield but in 2005, no significant effect was observed. Therefore, it can be concluded that with increase in soil salinity, sowing method cannot increase root yield.

CONCLUSION

With increase in salinity, root yield, sugar yield, and white sugar yield decreased significantly whilst sugar content and root impurities (sodium, potassium, and amino nitrogen) had no significant difference and significant decrease in sugar yield and white sugar yield was due to significant decrease in root yield. 2- Delay in sowing had only decreased root yield. Both sugar content and root impurities had no significant difference. Delay in sowing caused significant decrease in sugar yield in saline lands of Isfahan province which is not recommended. Also in late sowing due to higher soil salinity, water salinity could not cause significant difference in root yield. With increase in soil salinity, sowing methods could not influence root yield. 3- Overall, two rows sowing method is recommended over two other methods owing to the ease of irrigation, mechanized sowing, and decrease in production cost.

Table 11. Comparison of different sowing method effects on root yield within two years experiment

Sowing method	Root yield (t/ha)		
	Two rows planting	One row planting	Single row in plot
2004	36.12[b]	40.06[a]	30.75[c]
2005	34.01[bc]	32.64[bc]	33.87[c]
LSD 5%	4.30		

Means with same alphabet in each column are not significantly different at 5% Duncan test

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Table 10. Classification of average quantitative and qualitative properties of sugar beet in three sowing methods in saline lands

Sowing method	Root yield (t/ha)	Sugar content (%)	Sugar yield (t/ha)	Sodium (mEq g L^{-1})	Potassium (mEq g L^{-1})	Amino nitrogen (mEq g L^{-1})	Extraction coefficient (%)	White sugar yield (t/ha)
Two rows	34.87[ab]	18.07[a]	6.35[a]	3.88[a]	6.76[a]	4.80[b]	75.24[a]	4.91[a]
One row	32.48[b]	17.49[a]	5.72[a]	4.35[a]	6.89[a]	5.21[ab]	74.66[a]	4.30[a]
Line in plot	36.38[a]	17.45[a]	6.22[a]	4.49[a]	6.89[a]	5.40[a]	73.89[a]	4.64[a]

Means with same alphabet in each column are not significantly different at 5% Duncan test

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