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EFFECTS OF SOWING DATE, YEAR AND LOCATION OF SEED PRODUCTION ON ROOT YIELD AND SUGAR CONTENT IN TRIPLOID AND TETRAPLOID SUGAR BEET (*BETA VULGARIS* L.) CULTIVARS AT TWO DIFFERENT LOCATIONS

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ABSTRACT

Two sugar beet lines, a tetraploid pollinator (C3-3) and a male sterile diploid (RMST) from three locations: Poldasht Makoo (north west), Kamalabad Karaj (center) and Mahidasht Bakhtaran (west), in Iran, were grown on two sowing dates (August 10 and September 10) in two years (1984 and 1985) at Karaj and Shiraz research stations.

The results showed that there were significant differences between diploids and tetraploids, between the three locations of seed production, the two years and the two places of planting. However, the two sowing dates and the two years of seed production were not significantly different.

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اثرات تاریخ کاشت، سال و محل تولید بذر بر روی عملکرد ریشه و میزان قند ارقام دیپلوئید و تتراپلوئید چغندر قند در دو محل کاشت

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به ترتیب رئیس بخش تحقیقاتی مؤسسه چغندر قند، رئیس بخش تحقیقاتی چغندر قند مرکز شیراز و استاد اصلاح نباتات، دانشکده کشاورزی، دانشگاه تهران.

چکیده

دو رقم بذر چغندر قند در سه منطقه پل‌دشت ماکو، کمال آباد کرج و ماهیدشت باختران، یکی تتراپلوئید گرده‌افشان بنام (C3-3) و دیگری دیپلوئید نر عقیم رگه قرمز (RMST)، تولید شده در دو تاریخ بیستم مرداد و بیستم شهریور سالهای ۱۳۶۳ و ۱۳٦٤، در ایستگاه‌های تحقیقاتی کرج و شیراز کاشته شدند.

بذور تتراپلوئید و تریپلوئید برداشتی از سه منطقه کشت، دو تاریخ کاشت و دو سال کاشت بذر در سالهای ۱۳٦۵ و ۱۳٦٦ در مناطق کرج و شیراز بمنظور ارزشیابی مقدار محصول ریشه و درصد قند آنها در یک طرح بلوکهای کامل تصادفی با چهار تکرار کاشته شدند. نتایج بدست آمده نشان داد که بین ارقام بذر (تتراپلوئید و تریپلوئید)، مناطق تولید بذر، مناطق آزمایش بذر و سال آزمایش تفاوت معنی دار وجود دارد لیکن بین تاریخهای کاشت بذر و سالهای تولید بذر اختلاف معنی‌داری وجود ندارد.

INTRODUCTION

Sugar beet is one of the principal crops in Iran, covering an area of about 150 to 200 thousand hectares, and producing a total sugar yield of 500 to 750 thousand tons, annually (2). An amount of 4000 tons of triploid multigerm and monogerm seed, needed for sugar beet production each year, is produced by the Sugar Beet Seed Institute. This seed is produced biannually in several locations with different climatic conditions.

The effect of location, year and sowing date on quality and quantity of seed produced, is of special interest and little work has been done on this subject. It has been found that location of seed production affects physical properties and germination percentage of the seed produced (3, 8). Hendriksen and Sneep (5) reported that seed production in altitudes higher than 2000 m, causes an increase in the amount of selfing in sugar beet. Eviatar *et al.* (4) found that genotype × environment interactions cause changes in percent germination, earliness and amount of seed in wild barley. It has been found that seed size in tomato is affected by climatic conditions, and bigger seeds having larger cotyledons, produce earlier crops without affecting yield (7). Alimoradi *et al.* (1) reported that the location of sugar beet seed production has some effects on seed yield and its germination capacity. Longden (6) studying the influence of seed crop environment on the quality of sugar beet seed, found differences in ploidy level, bolting, root yield, and sugar content of beets produced by seed from different locations, however, he mentioned that true differences in root yield may not be a result of different locations. Gozdziewicz (Personal communication) believes that sugar beet seed produced in France yielded more beet root compared to the same seed produced in Poland.

The aim of this study was to find the effects of sowing date, year and location of sugar beet seed production on root yield and sugar content of sugar beet at two different planting locations.

MATERIALS AND METHODS

Two sugar beet lines, a tetraploid pollinator (C3-3) and a red stem male sterile diploid (RMST) were grown on two sowing dates (August 10 and September 10) in two years (1984 and 1985) in three locations: Poldasht Makoo (north west), Kamalabad Karaj (center) and Mahidasht Bakhtaran (west) in Iran. Some of the climatic characteristics of the three locations are shown in Table 1.

Table 1. Some of the geographic and climatic characteristics of locations of sugar beet seed production.

Characteristics	Kamalabad	Mahidasht	Poldasht
Longitude	51°, 02′	46°,50′	45°,05′
Latitude	35°,48′	34°,21′	39°,21′
Altitude (m)	1350	1603	800
Mean annual temperature (°C)	13.5	15.8	14.8
Maximum annual temperature (°C)	40.0	40.5	22.5
Minimum annual temperature (°C)	-12.0	-11.5	-20.0
Mean annual rainfall (mm)	240	452	189

The tetraploid and triploid seeds obtained from locations in two sowing dates in two years were compared for root yield and sugar content in 1986 and 1987 in two places, Karaj and Shiraz (south). The triploid and the tetraploid seeds were grown separately. Thus, each experiment consisted of 12 treatments: two sowing dates, three locations and two years. Each experiment was laid out as a randomized complete block design with four replications. Each plot consisted of four 9-m rows. The distance between rows was 0.61 m. Planting dates were April 13 and April 25 in 1986 and March 18 and April 14 in 1987 in Shiraz and Karaj, respectively. Post emergence weed control was carried out using Pyramin, 5 kg ha^{-1} and Betanal, 6 kg ha^{-1}, in Karaj ; however, in Shiraz mechanical weed control was used, three times at the early stages of plant growth. Plants were irrigated as required and sprayed against pests and mildew in both

locations in the two years. Harvesting was done on October 10-20 in both places. In Shiraz, the two middle rows of each plot and in Karaj, all four rows of each plot were harvested. Breis were taken from roots of each plot and carried to Karaj in a freezer for determining the sugar content of each sample. Data for root yield and sugar content of all samples were analysed statistically in two ways:

a) Simple statistical analysis, using the data for the 12 treatments, for triploid and tetraploid seeds grown in each place and each year, separately, and b) Combined statistical analysis, using the data for 24 treatments, 2×2×3×2, i.e., two types of seeds (tetraploids and triploids), two years of seed production, three locations of seed production and two sowing dates for seed production. Treatment means were compared by LSD test.

RESULTS

Simple Statistical Analysis

F-values for simple statistical analysis for root yield are shown in Table 2. Years of seed production show significant differences for tetraploid seeds in 1986 in Karaj and in 1987 in Shiraz. Locations of seed production significantly affected root yield of both triploid and tetraploid seeds in Karaj in 1987 and in Shiraz in 1986. Significant year × location interactions were observed for triploid seeds in Karaj for 1986 and 1987 crops.

Table 3 presents F-values for simple statistical analysis for sugar content. Locations of seed production show significant differences for triploid seeds in Karaj in 1987 and in Shiraz in 1986, as well as for tetraploid seeds in Karaj in 1986. There is one significant case of year × location interaction for tetraploid seeds in Shiraz in 1986.

Table 2. F-values for simple statistical analysis for root yield for triploids and tetraploids in Karaj and Shiraz in two years.

Treatment	Type of seed							
	Triploids				Tetraploids			
	Place							
	Karaj		Shiraz		Karaj		Shiraz	
	Year							
	1986	1987	1986	1987	1986	1987	1986	1987
Year of seed production	0.03	3.35	0.59	3.95	4.58*	0.15	1.06	6.31*
Location of seed production	2.20	5.55**	10.12**	2.60	2.93	3.74*	3.62*	0.48
Sowing date for seed production	0.14	0.99	0.11	0.05	3.24	2.81	0.59	0.06
Year × location	3.67*	4.18*	0.50	0.09	0.79	0.09	0.75	0.97
Year × sowing date	0.81	2.18	1.13	2.18	4.43*	0.04	0.05	0.28
Location × sowing date	0.89	0.26	0.52	0.14	0.55	0.68	1.84	1.01
Year × location × sowing date	1.02	2.42	0.61	0.57	1.64	1.65	4.30*	0.64

* Significant at 5% level.

** Significant at 1% level.

Table 3. F-values for simple statistical analysis for sugar content for triploids and tetraploids in Karaj and Shiraz in two years.

Treatment	Type of seed							
	Triploids				Tetraploids			
	Place							
	Karaj		Shiraz		Karaj		Shiraz	
	Year							
	1986	1987	1986	1987	1986	1987	1986	1987
Year of seed production	0.67	1.25	2.28	0.17	0.19	1.79	0.01	0.00
Location of seed production	0.04	3.36*	3.73*	2.42	3.79*	1.48	0.90	0.01
Sowing date for seed production	2.93	0.14	2.52	0.33	1.03	0.07	4.00	1.02
Year × location	0.71	2.72	2.63	1.82	0.09	1.81	3.43*	0.33
Year × sowing date	2.08	0.78	0.05	0.18	2.23	0.46	0.20	1.03
Location × sowing date	1.28	0.40	0.40	0.30	0.22	0.73	0.03	0.16
Year × location × sowing date	0.90	0.58	1.13	0.84	0.73	2.71	0.85	0.15

* Significant at 5% level.

** Significant at 1% level.

Mean values for root yield, sugar content and sugar yield for the three locations for triploid and tetraploid seeds in 1986 and 1987 crops in Karaj and Shiraz are given in Table 4. It is evident from this table that triploid seeds produced in Poldasht and Kamalabad yielded more root in 1987 crop in Karaj and in 1986 crop in Shiraz, compared to those produced in Mahidasht. However root yield of tetraploid seeds produced in Kamalabad was higher both in 1987 crop in Karaj and in 1986 crop in Shiraz. Triploid seed produced in Mahidasht had more sugar content than those obtained from other two locations in 1987 crop in Karaj and in 1986 crop in Shiraz. However, tetraploid seeds from Poldasht produced more sugar in 1986 crop in Karaj, compared to those obtained from Mahidasht and Kamalabad. Tetraploid and triploid seeds produced in Kamalabad yielded more sugar per hectare in 1987 crop in Karaj and in 1986 crop in Shiraz, respectively, compared to those obtained in Mahidasht and Poldasht. Seeds from Poldasht had the second rank for sugar yield, and seeds from Mahidasht had the lowest amount of sugar yield, in both cases.

Combined Statistical Analysis

Table 5 presents F-values for root yield and sugar content for the 4-factor statistical analysis (two types of seeds × two years of seed production × two sowing dates for seed production). Years of seeds production (Table 5) show only one significant case (root yield in 1987 crop in Shiraz) out of eight possible cases. Sowing dates also show one significant case namely, sugar content in 1986 crop in Shiraz. The two types of seeds, triploids and tetraploids, are significantly different for root yield in Karaj in both 1986 and 1987, and in Shiraz in 1987; and for sugar content only in 1986 crop in Karaj.

Locations of seed production show significant differences for root yield in three cases i.e., 1986 and 1987 crops in Karaj and 1986 crop in Shiraz, and for sugar content in two cases namely, 1987 in Karaj and 1986 in Shiraz.

Table 4. Mean values for root yield, sugar content and sugar yield for triploids and tetraploids obtained from three locations for 1986 and 1987 crops in Karaj and Shiraz.

Type of seed	Year	Place	Root yield (ton ha^{-1})					Sugar content (%)					Sugar yield (ton ha^{-1})				
			Kamal-abad	Mahi-dasht	Pol-dasht	Sig. level	L.S.D.	Kamal-abad	Mahi-dasht	Pol-dasht	Sig. level	L.S.D.	Kamal-abad	Mahi-dasht	Pol-dasht	Sig. level	L.S.D.
Triploid	1986	Karaj	51.74	53/83	55.29	N.S	-	17.15	17.23	17.16	N.S.	-	8.87	9.27	9.88	N.S.	-
Triploid	1987	Karaj	69.00	64.25	69.78	**	5.09	16.80	17.59	16.93	*	0.64	11.59	11.30	11.81	N.S.	-
Tetraploid	1986	Karaj	45.45	49.09	47.13	N.S.	-	18.48	18.04	19.13	*	0.78	8.40	8.86	9.02	N.S.	-
Tetraploid	1987	Karaj	57.25	50.18	53.36	*	5.57	17.21	17.67	17.43	N.S.	-	9.85	8.87	9.30	*	0.39
Triploid	1986	Shiraz	62.55	54.27	60.33	**	5.40	16.76	17.71	17.27	*	0.69	10.48	9.61	10.41	*	0.74
Triploid	1987	Shiraz	67.85	61.53	67.42	N.S.	-	16.93	17.33	17.39	N.S.	-	11.48	10.66	11.72	N.S.	-
Tetraploid	1986	Shiraz	61.64	59.10	57.69	*	4.57	17.86	17.29	17.91	N.S.	-	11.00	9.69	10.33	N.S.	-
Tetraploid	1987	Shiraz	63.29	60.62	60.62	N.S.	-	17.43	17.97	17.34	N.S.	-	11.03	10.89	10.51	N.S.	-

N.S. Non-significant.

* Significant at 5% level.

** Significant at 1% level.

Table 5. F-value for combined statistical analysis for root yield and sugar content for 1986 and 1987 crops in Karaj and Shiraz.

Treatment	Root yield (ton ha^{-1})				Sugar content (%)			
	Place							
	Karaj		Shiraz		Karaj		Shiraz	
	Year							
	1986	1987	1986	1987	1986	1987	1986	1987
Type of seed	45.84**	111.74**	0.25	5.23*	46.75**	3.35	0.01	0.50
Year of seed production	2.17	1.74	1.66	10.31**	0.72	0.00	1.64	0.31
Location of seed production	3.99**	7.22**	11.98**	2.18	2.22	4.31*	3.74*	0.05
Sowing date for seed production	0.59	3.54	0.12	0.11	3.44	0.02	6.48*	0.03
Seed × year	1.48	0.48	0.06	0.16	0.03	2.71	1.48	0.02
Seed × location	1.25	1.08	1.27	0.92	2.75	0.50	0.75	3.47*
Seed × sowing date	2.07	0.62	0.63	0.00	0.05	0.20	0.14	0.21
Year × location	0.72	0.84	0.10	0.82	0.98	2.31	3.27*	0.95
Year × sowing date	4.17*	0.43	0.30	2.04	4.31*	1.13	0.04	0.34
Location × sowing date	0.82	0.27	2.23	0.96	0.16	0.77	0.16	0.15
Seed × year × location	4.13*	1.77	1.20	0.27	0.71	2.03	2.84	1.83
Seed × year × sowing date	0.37	0.94	0.77	0.4	0.11	0.07	0.22	1.86
Seed × location × sowing date	0.61	0.75	0.31	0.22	1.05	0.20	0.25	0.06
Year × location × sowing date	2.26	3.39*	8.80**	1.17	0.60	2.46	1.84	0.36
Seed × year × location × sowing date	0.22	0.16	1.12	0.06	1.01	0.19	0.13	0.17

* Significant at 5% level.
** Significant at 1% level.

Mean values for root yield, sugar content and sugar yield for the three locations for 1986 and 1987 crops grown in Karaj and Shiraz are presented in Table 6. Mahidasht and Poldasht seeds produced more root yield in 1986 crop in Karaj compared to Kamalabad seeds. Seeds from Kamalabad and Poldasht yielded more root in 1987 crop in Karaj and in 1986 crop in Shiraz, copmared to those from Poldasht and Kamalabad. For sugar yield, the results showed that Poldasht seed in 1986 crop in Karaj, and Kamalabad and Poldasht seeds in 1987 crop in Karaj and 1986 crop in Shiraz produced more sugar yield than seeds from Mahidasht.

Table 7 shows mean values for root yield and sugar content for triploid and tetraploid crops for 1986 and 1987 in Karaj and Shiraz. Triploids are superior to tetraploids for toot yield in all four cases studied, the differences being significant in three cases. However, for sugar content, they are not significantly different except in 1986 crop in Karaj, in which tetraploids had higher sugar content than triploids.

Mean values for root yield and sugar content for the two years, 1986 and 1987 and triploid and tetraploid seeds in Karaj and Shiraz obtained from combined analysis using the two years of experiment instead of the two types of seed, are given in Table 8. In all four cases, root yield is higher for 1987, compared to 1986, three cases of which being statistically significant. However, sugar content showed a different result, i.e., there were only two significantly different cases between 1986 and 1987, in one of which 1986 was higher in sugar content and in the other, 1987 had higher sugar content.

Data obtained from combined analysis using the two experimental locations instead of the two types of seeds, are presented in Table 9 which show mean values for root yield and sugar content for Karaj and Shiraz for triploid and tetraploid seeds in 1986 and 1987. The three significant cases show that in Shiraz, root yield was higher than Karaj. However, for sugar content there are two significantly different cases, in one of which Shiraz being higher and in the other the reverse was true.

Table 6. Mean values for root yield, sugar content and sugar yield for the three locations for 1986 and 1987 crops in Karaj and Shiraz (from combined analysis)

Year	Place	Root yield (ton ha^{-1})					Sugar content (%)					Sugar yield (ton ha^{-1})				
		Kamal-abad	Mahi-dasht	Pol-dasht	Sig. level	L.S.D.	Kamal-abad	Mahi-dasht	Pol-dasht	Sig. level	L.S.D.	Kamal-abad	Mahi-dasht	Pol-dasht	Sig. level	L.S.D.
1986	Karaj	48.59	51.47	51.21	*	2.48	17.82	17.63	18.15	N.S.	-	8.65	9.07	9.29	*	0.23
1987	Karaj	63.12	57.21	61.57	**	4.63	17.01	17.63	17.18	*	0.43	10.73	10.08	10.57	*	0.27
1986	Shiraz	62.10	55.18	59.01	**	4.01	16.84	17.52	17.33	*	0.05	10.45	9.66	10.22	**	0.69
1987	Shiraz	65.57	61.07	64.02	N.S.	-	17.64	17.63	17.72	N.S.	-	11.56	10.76	11.31	-	-

N.S. Non-significant.

* Significant at 5% level.

** Significant at 1% level.

Table 7. Mean values for root yield and sugar content for triploids and tetroploids in 1986 and 1987 crops in Karaj and Shiraz (simple analysis).

Year	Place	Root yield (ton ha^{-1})				Sugar content (%)			
		Tri-ploid	Tetra ploid	Sig. level	L.S.D.	Tri ploid	tetra ploid	Sig. level	L.S.D.
1986	Karaj	53.62	47.23	**	2.67	17.18	18.55	**	0.1
1987	Karaj	67.67	53.60	**	3.78	17.11	17.44	N.S.	-
1986	Shiraz	59.05	58.47	N.S.	-	17.25	17.22	N.S.	-
1987	Shiraz	65.60	61.51	*	3.85	17.58	17.75	N.S.	-

N.S. Non- significant.
* Significant at 5% level.
** Significant at 1% level.

Table 8. Mean values for root yield and sugar content for 1986 and 1987 for triploid and tetraploid seeds in Karaj and Shiraz (combined analysis).

Type of seed	Place	Root yield (ton ha^{-1})				Sugar content (%)			
		1986 ploid	1987 ploid	Sig. level	L.S.D.	1986 ploid	1987 ploid	Sig. level	L.S.D.
Tri ploid	Karaj	53.62	67.67	**	2.83	17.18	17.11	N.S.	-
Tetra ploid	Karaj	51.85	58.85	**	3.72	18.55	17.44	**	0.4
Tri ploid	Shiraz	64.84	72.03	**	4.21	17.25	17.58	N.S.	-
Tetra ploid	Shiraz	58.47	61.51	N.S.	-	17.21	17.75	*	0.4

N.S. Non-significant.
* Significant at 5% level.
** Significant at 1% level.

Table 9. Mean values for root yield and sugar content for Karaj and Shiraz for triploid and tetraploid seed in 1986 and 1987 (combined analysis).

Type of seed	Year	Root yield (ton ha^{-1})				Sugar content (%)			
		Karaj	Shiraz	Sig. level	L.S.D.	Karaj	Shiraz	Sig. level	L.S.D.
Tri ploid	1986	53.62	59.05	**	2.94	17.25	17.18	N.S.	-
Tetra ploid	1986	47 12	57.69	**	3.10	17.22	18.55	**	0.56
Tri ploid	1987	67.67	65.60	N.S.	-	17.58	17.11	*	0.37
Tetra ploid	1987	53.60	61.65	**	4.71	17.75	17.44	N.S.	-

DISCUSSION

1. Location of seed production. The principal aim of this study was to find out whether the location of seed production affects root yield and sugar content produced by the seed. This study showed that out of eight cases, significant differences were found in four cases for root yield and in three cases for sugar content between seeds produced in different locations (Tables 2 and 3). In combined analysis (Table 5), five significant cases were observed, out of eight possible cases, for root yield and sugar content. These results suggest that location of seed production may exert some effects on the genetic make-up of the seed which is shown in differences in root yield and sugar content produced by the seed. The results are in accord with those obtained by Longden (6) and Gozdziewicz (personal communication).

2. Years of seed production. Out of eight experiments done on triploid and tetraploid seeds in two places (Karaj and Shiraz) in two years (1986 and 1987), only in two of them, tetraploid seeds in 1986 crop in Karaj and 1987 crop in Shiraz, significant differences were found for years of seed production (Table 2). In both cases, 1985 seeds produced more root yield than 1984 seeds (means are not presented here). However, there was no significant difference between years of seed production for sugar content in any of the eight cases. This indicates that year of seed production may not have much effect on seed quality in terms of root yield and sugar content produced by the seed.

3. Times of sowing for seed production. In this study, there was no significant difference between the two sowing dates for root yield and sugar content. Thus, it is concluded that although sowing dates have some effects on physical characteristics of seed produced (1), it has no effect on genetic properties of seed crops.

4. Year and place of experiment. 1987 crops showed significantly more root yield in three cases out of four. However, differences between years for sugar content are not clear-cut (Table 8). Higher root yield in 1987, compared to 1986, may be a result of earlier planting time, being 25 days and 11 days earlier in Shiraz and Karaj, respectively, in 1987 as compared to 1986. This shows the importance of timely sowing date for sugar beet.

Comparing the two places of experiment, Karaj and Shiraz, it is evident that Shiraz produced significantly more root yield than Karaj in three cases out of four (Table 9). However, for sugar content, again, there is no clear-cut difference between the two places. Higher root yield in Shiraz may be partly due to earlier planting date, being 12 and 26 days earlier in 1986 and 1987, respectively, compared to Karaj; and partly due to higher mean temperature in Shiraz, compared to Karaj.

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