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Identification of tetraploid pollinator resistant to leaf spot disease and bolting in sugar beet

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ABSTRACT

To identify sugar beet tetraploid pollinators tolerant to both leaf spot disease and bolting and also with optimum performance and quality, five tetraploid pollinators were crossed with the male sterile line SB17. New hybrids together with four susceptible and resistant checks were evaluated in randomized complete block design with four replications under autumn planting in Dezful region and spring planting in Karaj region for two years. Based on combined analysis results, hybrids SB17*Jot18 and SB17*B65T showed the utmost tolerance to leaf spot (3.12 and 3.93, respectively) and bolting (0.87 and 0.75%, respectively) in Dezful. On the basis of sugar yield, hybrids were classified into three clusters whereby the aforementioned hybrids were placed in one group with Monotona and Leila check varieties. Hybrid SB17*B65T had the highest sugar yield (7.13 t ha^{-1}) in Karaj. According to the results of this study, tetraploid pollinator B65T seems as a promising pollinator to be used in breeding programs.

Keywords: bolting, leaf spot disease, sugar beet

INTRODUCTION

Sugar beet leaf spot disease is one of the foliar diseases which imposes considerable damages to sugar beet cultivation in almost all warm and humid areas. The disease has yearly outbreak in Khuzestan province where autumn planting is prevalent (Abbasi 2003) and its economic damage is confined to Khuzestan province and Moqan plain (Abdollahian 2002). Bolting is also a limiting factor in autumn-planting of sugar beet in Khuzestan which influences the quantitative and qualitative characteristics of the crop in early planted fields (Sadeghian and Sharifi 1998). This phenomenon has a negative influence on both root and sugar yield making root harvest laborious. Bolted roots become small, fibrous and woody which disrupt sugar extraction in factory (Lasa and Sanz 1976).

The causal agent of leaf spot is *Cercospora beticola* Sacc. fungus causing 2-5 mm circular and limited spots at maturity. As the disease progresses, individual spots come together and make large areas of the leaves brownish and necrotic. Finally, burned leaves die while remain attached to the crown and young leaves in the center of the plant usually remain healthy (Draycott 2006). Smith and Martin (1978) reported an increase in root impurities such as Na, amino-nitrogen and total N with increase in disease severity. They also reported variation in root impurity accumulation in response to *C. beticola* infestation in tolerant cultivars. A study by Borrelli et al. (1995) showed that leaf spot disease only affects qualitative parameters in sugar beet, mostly increase in amino-nitrogen and to some extent K. Field studies showed that *C. beticola* decreases sugar yield, sugar content, and juice purity and increases impurities. Root weight loss is often correlated with disease severity and sugar beet roots with high impurities produced low sugar content and high

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molasses during sugar extraction process (Shane and Teng 1992). Yoshimura et al. (1992) evaluated the effects of *C. beticola* on yield and quality of seven sugar beet cultivars with different susceptibility. Results showed that amino-nitrogen increased with increase in disease severity; however, Na content varied according to cultivar type and that K content was not influenced. No correlation was reported between leaf infection index and cultivars ploidy level.

In most studies, natural epidemics were used for the evaluation of resistance to *C. beticola* (Dumitras 1979). In Iran, *C. beticola* evaluation at Qarakhil station yielded good results (Abbasi et al. 2002). In a study by Sadeghian and Sharifi (1999), some evaluated sugar beet lines showed optimum levels of tolerance to both *C. beticola* and bolting. Orazizadeh (2001) evaluated six sugar beet male sterile lines together with their single crosses for tolerance to both *C. beticola* and bolting. Results showed that O-type 7617 and its single crosses had optimum level of resistance to *C. beticola* compared with the other lines. The present study aimed to evaluate the tolerance of sugar beet triploid hybrids to bolting and *C. beticola* in order to identify tolerant pollinators.

MATERIALS AND METHODS

Five sugar beet triploid hybrids including SB17*JOT18, SB17*JOT13, SB17*ET5, SB17*B65T and SB17*19669 obtained from a cross between five tetraploid pollinators and a male sterile line (SB17) were used in this study. Rasoul and Persia cultivars were selected as resistant controls to bolting and *C. beticola*, Monatana as a resistant control to bolting, and Leila as resistant control to *C. beticola* and susceptible to bolting. The experiment was carried out as randomized complete block design with four replications. Different traits including total plant number, number of bolted plants, disease severity, root yield, and its qualitative characteristics were evaluated. Genotypes were subjected to natural infestation in Dezful and their tolerance to *C. beticola* was evaluated using standard ranking index of 1-9 (Rossi 1999; Abbasi 2002).

The plots were 8 m long and consisted of three rows, 0.5 m apart. Spring planting was conducted in Karaj and autumn planting in Dezful. The disease severity and bolting percentage were measured under autumn-planting condition in Dezful. During the growth period, necessary notes such as growth score, emergence date, number of bolted plants, and the time of leaf spot disease emergence were taken. At harvest, 0.5 m at both ends of the plot was discarded and the remained roots were harvested and weighed. In addition to root yield measurement, the pulp of each plot was sent to Sugar Technology laboratory for qualitative characteristics determination and chemical analysis. Data were analysed using SAS and SPSS software and mean comparison was conducted using LSD test. Treatments were clustered based on quantitative and qualitative traits.

RESULTS AND DISCUSSION

As only two years and two regions were included in this study, normal distribution and homogeneity of variances of the dataset were tested using Bartlett's test. Results showed uniform error variances for most of the traits which allowed the undertake combined analysis of variance. Combined analysis of variance results in Dezful region showed no significant effect of year on root yield, sugar content, white sugar yield and bolting.

Except bolting, year × treatment interaction was not significant for all traits which is not unexpected due to the high impact of environmental condition on bolting. Because of non-significant effect of year × treatment interaction on root yield, sugar content, and white sugar yield, standard error of the mean was used for the evaluation of treatments effect. On the basis of this variance, the treatment effect was significant for all traits except sugar content (Table 1). In this study, the foreign cultivar Monatana was used as a resistant control to bolting with the average root yield and white sugar yield of 79.14 and 11.98 t ha^{-1}, respectively. According to the mean comparison results (Table 2), Persia cultivar had the highest root yield (83.67 t ha^{-1}) and white sugar yield (13.74 t ha^{-1}) which had significant difference with Monatana cultivar in terms of sugar yield. All hybrids had significant ($P < 0.05$) difference with resistant control for root yield and white sugar yield. Among hybrids and across two years, hybrid No. 1 had the highest root yield (69.42 t ha^{-1}) and white sugar yield (10.50 t ha^{-1}) compared to the other hybrids and was selected as the best hybrid. Compared with the resistant domestic control (Rasoul), hybrid No. 1 was the only hybrid which had the least difference with Rasoul for root yield and sugar yield; however, its bolting percentage was lower than Rasoul (Table 2).

In terms of disease resistance, Monatana cultivar was the most susceptible cultivar and gained

Table 1. Combined analysis of variance for two-year experiments of nine cultivars and sugar beet hybrids in Dezful in 2007-08.

S.O.V.	df	Mean square			
		Root yield	Sugar content	White sugar yield	Bolting
Year	1	279.109^{ns}	26.040^{ns}	14.231^{ns}	1780.056^{ns}
Replication/year	6	127.587	10.355	4.631	117.500
Treatment	8	491.473**	3.086^{ns}	24.091**	3478.909**
Treatment × year	8	26.416^{ns}	1.723^{ns}	1.043^{ns}	297.430**
Error	48	25.118	0.979	0.818	28.156
Pooled error	56	51.534	2.702	1.861	

ns, *and**, non-significant, significant at 5 and 1% probability levels, respectively.

Table 2. Classification and mean comparison of nine cultivars and sugar beet hybrids in Dezful in 2007-08.

No.	Cultivar/hybrid	Root yield (t ha^{-1})	Sugar content (%)	White sugar yield (t ha^{-1})	Bolting (%)	Cercospora
Control	Monatunna	79.14	17.37	11.98	0	5.09
1	SB17*B65T	69.42**	17.39^{ns}	10.50*	0.75^{ns}	3.93*
2	SB17*ET5	68.87**	16.60^{ns}	9.55**	6.37^{ns}	3.81*
3	SB17*JIT13	66.68**	17.26^{ns}	9.94**	1.75^{ns}	3.71*
4	SB17*JOT18	65.00**	17.02^{ns}	9.39**	0.87^{ns}	3.12**
5	SB17*19669	57.35**	16.13^{ns}	7.76**	19.0^{ns}	4.46^{ns}
6	Persia	83.67^{ns}	18.18^{ns}	13.74*	18.75^{ns}	2.46**
7	Leila	72.56^{ns}	17.93^{ns}	11.57^{ns}	65.62*	3.25**
8	Rasoul	74.81^{ns}	17.37^{ns}	11.16^{ns}	10.12^{ns}	4.58^{ns}
	LSD 5%	7.179	1.644	1.364	19.885	0.913
	LSD 1%	9.566	2.190	1.818	28.934	1.237

ns, *and**, non-significant, significant at 5 and 1% probability levels, respectively.

Table 3. Combined analysis of variance for two years experiment of nine cultivars and sugar beet hybrids in Karaj in 2007-08.

S.O.V.	df	Mean square			
		Root yield	Sugar content	White sugar yield	Juice purity
Year	1	2229.67**	12.05^{ns}	0.50^{ns}	132.74*
Replication/year	6	107.44	35.04	1.70	8.43
Treatment	8	317.36*	9.25^{ns}	10.03**	32.85*
Treatment × year	8	68.35^{ns}	16.25^{ns}	1.52^{ns}	5.43^{ns}
Error	48	53.79	17.04	0.89	6.64
Pooled error	56	122.14	33.29	2.41	12.07

ns, *and**, non-significant, significant at 5 and 1% probability level, respectively.

the highest infection score (5.09). Rasoul cultivar together with hybrid No. 5, with infection score of 4.58 and 4.46, respectively, were placed in same group as Monatana. Persia with the infection score of 2.46 was the most resistant cultivar and showed significant difference with Monatana ($P < 0.01$). Other hybrids also showed significant difference with Monatana among which the hybrid No. 4 (SB17*Jot18) with infection score of 3.12 was the most tolerant hybrid which had lower infection score than Leila (Table 2).

The hybrids response to bolting was different. Based on the results, Leila with 65.62% bolting was the most susceptible cultivar and placed solely in one group. However, Monatunna and Rasoul had 0 and 10.12% bolting, respectively. Hybrids 1, 2, 3, and 4 were the most tolerant hybrids with 0.75, 6.37, 1.75, and 0.87% bolting; nevertheless, these hybrids displayed no significant difference with Monatunna (Table 2).

Combined analysis of variance in Karaj showed significant difference among treatments for root yield and juice purity (P<0.05) and also white sugar yield (P<0.01). However, no significant difference was observed for sugar content. The effect of year on root yield and juice purity was significant, but for sugar content and white sugar yield was not significant. The year × treatment interaction was not significant for any of the traits; therefore its variance was combined with the variance of error and used for the evaluation of treatment effect (Table 3).

In Karaj, Leila with root yield and white sugar yield of 71.56 and 9.80 t ha^{-1} , respectively, showed significant difference with tolerant control. Meanwhile, Monatunna yielded 59.0 and 7.22 t ha^{-1} root yield ad white sugar yield, respectively (Table 4). Among the five studied hybrids, hybrid No. 1 obtained 62.44 t ha^{-1} root yield and 7.13 t ha^{-1} white sugar yield in Karaj. It also had

Table 4. Classification and mean comparison of nine cultivars and sugar beet hybrids in Karaj in 2007-08.

No.	Cultivar/hybrid	Root yield (t ha^{-1})	Sugar content (%)	White sugar yield (t ha^{-1})	Juice purity (%)
Control	Monatunna	59.0	17.80	7.22	80.21
1	SB17*B65T	62.44^{ns}	16.14^{ns}	7.13^{ns}	78.33^{ns}
2	SB17*ET5	59.09^{ns}	18.76^{ns}	6.66^{ns}	78.50^{ns}
3	SB17*JIT13	51.94^{ns}	17.44^{ns}	6.18^{ns}	78.90^{ns}
4	SB17*JOT18	49.94^{ns}	16.14^{ns}	6.08^{ns}	80.75^{ns}
5	SB17*19669	55.14^{ns}	16.01^{ns}	6.49^{ns}	79.54^{ns}
6	Persia	59.97^{ns}	17.96^{ns}	7.34^{ns}	81.72^{ns}
7	Leila	71.56*	15.48^{ns}	9.80**	84.72*
8	Rasoul	59.75^{ns}	17.06^{ns}	7.60^{ns}	81.60^{ns}
	LSD 5%	11.052	5.770	1.552	3.474
	LSD 1%	14.726	7.688	2.069	4.629

ns, *and**, non-significant, significant at 5 and 1% probability level, respectively.

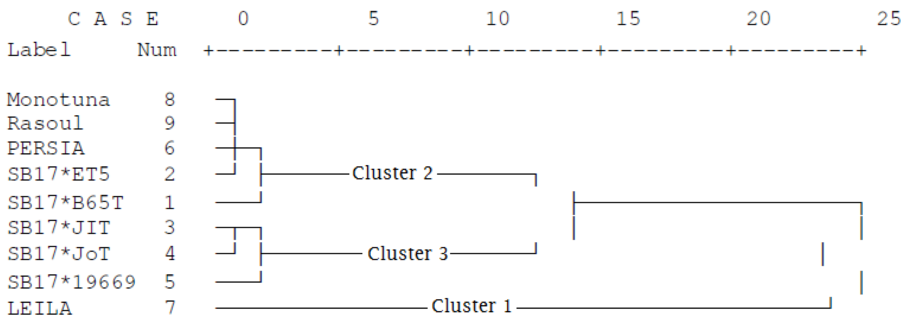

Figure 1. Cluster analysis based on yield and qualitative traits of sugar beet hybrids in Karaj in 2007-08.

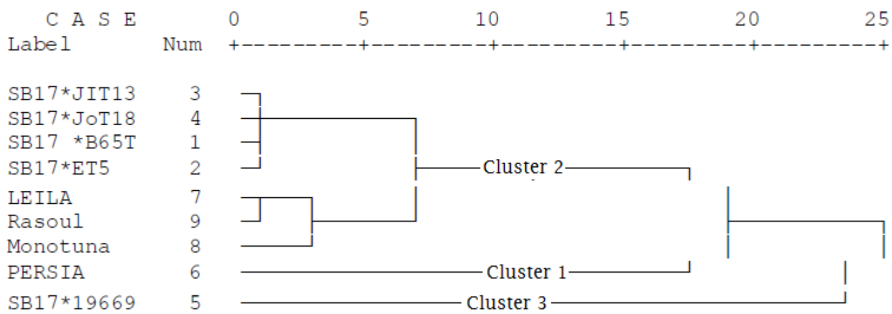

Figure 2. Cluster analysis based on yield and qualitative traits of sugar beet hybrids in Dezful in 2007-08.

more than 10 t ha^{-1} root yield difference with hybrids 3 and 4 with 1 t ha^{-1} higher white sugar yield than them. In general, in both regions, best hybrids didn't show a significant difference with Rasoul and the only superiority of them was their higher tolerance to cercospora and bolting. Cluster analysis, based on root yield, sugar yield, white sugar yield, sugar content, and white sugar content in Karaj (Mohammadi 2006), classified hybrids into three groups (Figure 1).

According to the results, Leila was placed in one group with optimum condition. This cultivar was recognized as the best treatment across the two-year experiments in Karaj. Cluster 2 was the closest cluster to this cultivar including treatments 8, 9, 6, 2 and 1. Considering all key yield characteristics, hybrids 1 and 2 could be placed in the same cluster with other three controls. Hybrids 3, 4 and 5 were also placed in cluster three but didn't show optimal condition compared with the other hybrids.

Cluster analysis results in Dezful, classified the hybrids into three clusters (Figure 2). Persia with resistance to the disease and semi-tolerance to bolting was placed in one cluster. It was also the best treatment in Dezful (Table 1). Contrary to Perisa, hybrid No. 5 (SB17*19669) was placed as the lowest-yielding hybrid in cluster three. Four other hybrids together with the three domestic and foreign controls including treatments 7, 8, 9, 3, 4, 1 and 2 were classified into one cluster. Cercospora leaf spot is widespread in southern regions as well as Moqan area and imposes remarkable damages to sugar beet crop (Arjmand

1994). Chemical control of the disease has environmental damages and is not recommended, therefore use of resistant cultivars is the only reliable and recommendable solution.

Hybrid evaluation across the two-year experiments illustrated the optimum potential of hybrids for disease tolerance and bolting resistance; however breeding programs for improving qualitative and quantitative traits should be continued. The parental lines of the superior hybrids should be used in the subsequent breeding cycles to improve their root yield and sugar content and from these lines, hybrids with improved tolerance to disease and also yield should be developed. In this study, hybrids SB17*Jot18 and SB17*B65T showed the lowest disease score of 3.12 and 3.93 and the lowest bolting percentage of 0.87 and 0.75, respectively. Based on sugar yield, hybrids were classified in three clusters with the abovementioned hybrids being placed in one group with Monatunna, Leila, and Rasoul. In Karaj, hybrid SB17*B65T had the highest sugar yield (7.13 t ha^{-1}) and in general showed superiority to the domestic hybrids. Therefore, breeding program for improving the quality and yield of B65T is recommended.

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