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Effect of bolting on root yield andqualities of autumn sugar beet cultivars

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ABSTRACT - One of the significant limitations in autumn cultivation of sugar beet is bolting. To investigate the quantitative and qualitative traits of root sugar beet cultivars and their resistance to bolting, a two-year (2018-2020) experiment was conducted as a randomized complete blocks design with three replications at Varsan Agricultural Research Station of Golestan Agricultural and Natural Resources Research and Education Center, Gorgan- Iran. Treatments included commercial autumn sugar beet cultivars [five imported cultivars (Montana, Jerra-kws, Rosagold, Chemineh, and Veles) and a domestic cultivar (Sharif). There was a significant difference in bolting rates of all cultivars in both years. Veles and Sharif cultivars had the highest bolting rate (41.7% and 33.3%) in both years, respectively. The bolting rate was higher in the second than in the first year. There was a significant difference between cultivars for root yield only in 2019. The highest (85.2 t ha^{-1}) and lowest (59.8 t ha^{-1}) root yields were obtained from Jerra-kws Chamine cultivars. There was a significant difference between cultivars for sugar purity, sugar extraction coefficient, and molasses sugar percentage in the second year. There was no significant difference between cultivars for sugar content and harmful nitrogen in both years. The cultivars showed different reactions in terms of bolting rate and other root qualitative traits (pure sugar, extraction coefficient, sodium, potassium, and harmful nitrogen levels) in the two years.

INTRODUCTION

Sugar beet is grown in 41 countries worldwide, mostly temperate regions, with a total cultivation area of 8.1 m ha (Mall *et al.,* 2021). The autumn cultivation of sugar beet is a prominent point of scientific discussion in various countries (Sadeghzadeh Hemayati *et al.,* 2012). The most crucial factor that can be considered as a clear indicator of the priority and superiority of autumn sugar beet compared to spring cultivation is the optimal consumption of rainfall during the growing season and higher water use efficiency in sugar beet cultivation (Sadeghzadeh Hemayati *et al.,* 2012). Spring sugar beet planting is limited in yield by a lack of adequate cover and inadequate canopy in May and June and the lack of adequate light when the sun is at its highest level (Jaggard *et al.*, 2009). The yield has increased by more than 26% due to faster canopy cover in autumn cultivation (Kirchhoff *et al.,* 2009).

One of the significant limitations of autumn cultivation is the bolting, because sugar beet goes to stalk and flower due to frost in winter and the subsequent conditions of long days in spring (Milford *et al.,* 2010). Bolting is affected by genetic, environmental, and physiological factors. This phenomenon is induced by Giberlic acid, day length, and chilling period (Sadeghian, 2014). Hosseinian *et al.* (2014) reported that HI1059 and Palma cultivars bolted 32.6% and 51.4% in 2019 in the Dezful region, respectively; meanwhile, none of the cultivars bolted in 2020 due to low temperatures and absence of prolonged coldness. Pfeiffer *et al.,* (2013) reported that the appropriate genotype can significantly prevent bolting. Occurrence of bolting in the early growing period of sugar beet plant significantly reduces root yield by up to 50%, severe sugar yield reduction by reducing sugar content and root yield and causing problems for sugar beet harvester machines (Hoffmann and Klug-Severin, 2011).

The quality of sugar beet is a combination of the physical and chemical properties determined by various criteria. Several factors can affect the quality of sugar beet (Hoffmann *et al*., 2009). These factors include the genetic potential of sugar beet cultivars, climatic conditions, place and year of sugar beet production, field management, harvesting, loading, transportation, and silage, and the efficiency of the sugar beet extraction process in the sugar factory (Hoffmann and Marlander, 2002). Hamidi *et al.* (2022) found a significant difference in root yield and quality traits, including sugar percentage, sodium, potassium, and harmful nitrogen, sugar extraction coefficient, and pure sugar percentage. The experiment aimed to select suitable genotypes for winter sugar beet cultivation in the Torbat Jam region. Hosseinzadeh Fazl *et al.,* (2020) reported a difference between cultivars regarding sugar content, sodium, and sugar extraction percentage. No differences occurred in root yield traits, potassium content, or harmful nitrogen levels. There was no significant difference between cultivars in molasses sugar as well. Refay (2010) reported a difference between autumn sugar beet cultivars for root yield, and root chemical composition, which may be related to the genetic structure of cultivars. Sugar beet root yield and its quantitative and qualitative traits are determined by genotype and environment. Hosseini *et al.,* (2021) reported that there was a significant difference between cultivars for sugar content (%) sodium of root (%) and free N levels in the root (%) of fodder beet cultivars. Mohammad Yousefi *et al.,* (2016) reported that the effect of genotype on bolting rate, sucrose percentage, cold resistance percentage, total root weight, root length, and root diameter was significant. This study aimed to identify bolting cultivars and the relationship between bolting and quantitative and qualitative traits of commercial sugar beet cultivars in autumn cultivation in Golestan province (Gorgan).

MATERIALS and METHODS

Field experiments and site conditions

The experiments were conducted in Varsan Agricultural Research Farm of Gorgan, Iran, affiliated with Golestan Agricultural Research and Training Center (36°51′17″N, 54°19′41″E, and 37 m altitude) in two growing seasons (2019 and 2020) (Figure 1). Soil analysis results regarding soil depth of 0 to 30 cm for the two growing seasons appear in Table 1. The chemical fertilizer required before planting was added to the soil, according to the soil and water nutrition laboratory of Golestan Agricultural Research Center. Accordingly, 300 kg ha^{-1} of urea and 200 kg ha^{-1} of triple superphosphate were used in both years. Moreover, 100 kg ha^{-1} of potassium sulfate was added to the soil in the first year only.

The experiment was conducted as a randomized complete blocks design with three replications. Six autumn sugar beet cultivars included five imported cultivars (Montana, Jerra-kws, Rosagold, Chemineh, Veles) and one domestic (Sharif). Veles and Montana cultivars were introduced from Sweden, Jerra-kws from Germany, Rosagold from the Netherlands, Chemineh from France, and Sharif from Iran. Seedbed preparation was performed before planting and involved plowing, leveling, furrowing, and retorting. Cultivars were planted on the first of November each year by planting the seeds on top of the stacks. Rows were spaced 50 cm apart and plant population density was approximately 11 plants per square meter (Vafadar et al., 2008). In 2018-2020, before the experimental setup and treatment applications, samples were taken from farm soil using a drill to determine the physical and chemical characteristics of the soil (Table 1). Accordingly, 300 kg ha^{-1} of urea and 200 kg ha^{-1} of triple superphosphate were used in 2018-2020. Moreover, 100 kg ha^{-1} of potassium sulfate was added to the soil in 2018 only.

Data analysis

The statistical analysis was carried out using SAS 6.4. software for the analysis of variance. The mean comparison of values was done using the least significant difference test ($P < 0.05$). To evaluate the homogeneity of variances, Levene's test was performed. Considering the error variance difference between the two years, performance in each year was analyzed separately.

Harvest time and dependent variables

Harvesting was done on the first of July. At harvest, plant root lines were removed. Root net weight was regarded as performance. To qualitatively analyze the roots of the cultivars, they were sent to a laboratory at the Sugar Beet Seed Institute (SBSI). The percentage of sugar (SC) (Abdollahian Noghabi *et al.,* 2005) was measured by polarimetry method, using the digital saccharometer device (Kunz, 2004), sodium, and potassium by flame photometry harmful nitrogen by the blue number method (Abdolahian Noghabi *et al.,* 2005). Other qualitative traits were calculated using Equations 1 to 4 to determine alkalinity (ALC), molasses sugar (MS), (Kunz et al., 2002), the percentage of extractable sugar (WSC), sugar extraction coefficient, or extraction efficiency (ECS). In the following equations, Na, K, and α-amino-N are harmful sodium, potassium, and nitrogen (meq in 100g of fresh root weight), and MS is molasses sugar (percentage), respectively. To calculate the bolting percentage, each plot was counted based on the number of bolting occasions.

Equation one $ALC = (K + Na)/\alpha\text{-amino-N}$

Equation two $MS = 0.343\ (Na + K) + 0.094\ (\alpha\text{-amino-N}) - 0.31$

Equation three $WSC = SC - MS$

Equation four $ECS = (WSC/SC) \times 100$

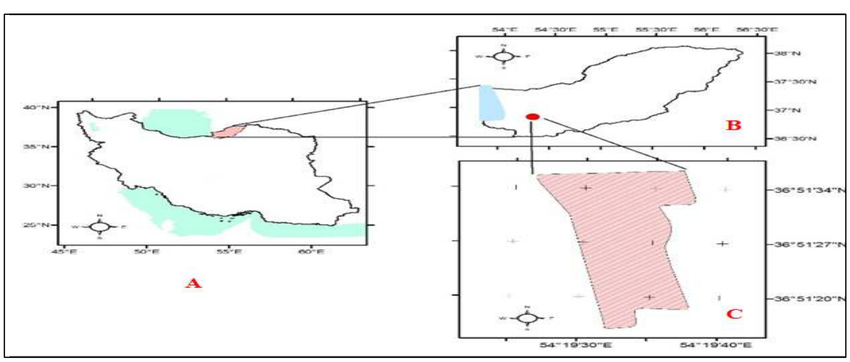

Fig 1. Location of Varsan Agricultural Research Farm C, Gorgan Province B, Iran A,

Table 1. Physicochemical characteristics of experimental field soil.

Year	Soil Texture	K (mg kg^{-1})	P (mg kg^{-1})	Total N (%)	EC [a] (dS m^{-1})	pH (1:10)	OC [b] (%)
2018	Silty clay loam	261	3.1	0.09	2.1	8	0.9
2019	Silty clay loam	323	4	0.12	1.4	7.7	1.2

[a] EC= electrical conductivity; [b] OC= Organic Carbon

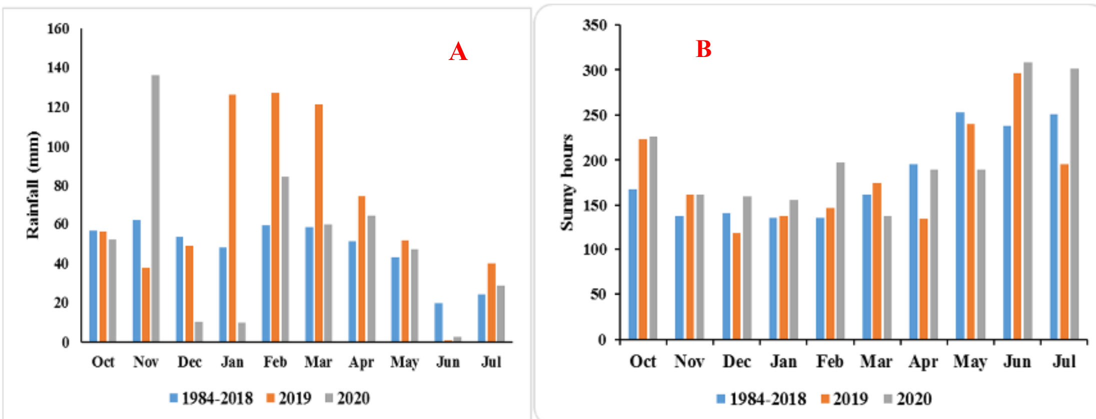

Fig 2. Long-term average weather conditions in years 2018-2020. [A] rainfall, [B] sunny hours

RESULTS and DISCUSSION

Climatic conditions

The average rainfall and the number of sunny hours of the long-term period in two years of the experimental area are shown in Figure 2. The highest precipitation in 2019 occurred in January, February, and March (average 120 mm). Rainfall in 2019 (194 mm) was higher than in 2020, but sunshine hours were higher in 2020 (Figure 2-A).

In 2019, the average minimum temperature (13.2 °C) was 0.5 °C higher than in 2020 (12.7 °C). The average minimum temperature in 2019 was 13.2°C, which was 0.5°C higher than in 2020. The minimum temperature was in January and February in 2019, which was 1 °C higher than in 2020. The number of frosty days was 8 and 13 in 2019 and 2020, respectively. While precipitation was high in 2019, sunny hours were higher in 2020. The total number of sunshine hours was 2473 in 2020 (Figure 2-B). Therefore, the number of days with a clear sky was higher in 2020. The weather conditions during the two years were different and it caused differences in the quantitative and qualitative traits of sugar beet for two growing seasons.

There was a significant difference between cultivars for bolting percentage root sodium, and potassium contents in 2018-2020 (Table 2). A significant difference was found between cultivars for root yield in 2019. However, the cultivars showed significant differences in pure sugar percentage, sugar extraction coefficient, and molasses sugar percentage in 2020. There was no significant difference between sugar beet cultivars for percentage of sugar concentration and harmful nitrogen in each year (Table 2). In summary, the cultivars showed different reactions for qualitative and quantitative traits in 2020 due to a more extended cold period in 2020. The conditions were provided for the occurrence of vernalization in 2020. Therefore, the highest rate of bolting occurred in 2020. Hamidi *et al.* (2022) and Fazel *et al.* (2022) observed differences in root yield of sugar beet cultivars.

Bolting rate

A significant difference was found between cultivars for bolting rate in 2018-2020 (Table 2). Veles and Sharif cultivars had the highest bolting rate. Veles and Jerra-kws cultivars had the highest (35%) and lowest (1.5%) bolting rates, in 2019, respectively (Table 3). In 2020, the highest (47.6%) and lowest (1.8%) bolting rates were obtained by Veles and Jerra-kws cultivars, respectively (Table 3). Mohammad Yousefi *et al.,* (2016) reported that the mean bolting rate among sugar beet genotypes was 69.7% and the HSF-796 genotype had the highest bolting rate. The Eudora genotype had a lower bolting rate than other genotypes. The results showed that Veles and Sharif cultivars had the highest rate of bolting in 2018-2020. Those cultivars which were sensitive to bolting were not suitable for the region. Nevertheless, Montana, Chemineh, and Jarra-kws cultivars had low bolting rates in 2018-2020 and they are suitable for cultivation in Golestan province (Table 3).

Root sodium, potassium, and nitrogen contents

Sugar beet cultivars had significant differences in root sodium and potassium contents in 2018-2020 (Table 2). In 2019, the highest (3.6 meq in 100 g) and lowest (1.68 meq in 100 g) root sodium contents were obtained in Jerra-kws and Chamineh cultivars, respectively. In 2020, the highest and lowest (1.75 meq in 100 g) root sodium content (3.21 meq in 100g) belonged to Jerra-kws and Veles cultivars, respectively (Table 3). The highest (5.13 meq in 100 g) and lowest (3.87 meq in 100 g) root potassium contents were found in the Sharif cultivar. In addition, the highest (5.59 meq in 100g) and lowest (3.90 meq in 100 g) root potassium contents were found in the Chamineh cultivar in 2020 (Table 3). Jahani Moghaddam *et al.,* (2017) reported significant differences in sodium and potassium contents of autumn sugar beet cultivars. Hosseinian *et al.,* (2019) reported significant differences in the potassium content of sugar beet cultivars. One of the most essential factors for sugar production technology is the sodium and potassium content in sugar beet, because these compounds are highly molasses and reduce production efficiency (Behzad *et al.,* 2010). Various researchers indicated that sodium and potassium contents, referring to ash in sugar factories, are significant indicators of sugar beet quality (Behzad *et al.,* 2010). Cultivars with high bolting rates showed a different reaction in root sodium and potassium contents in 2019. Moreover, the root sodium content of the Veles cultivar with the highest bolting rate (47%) in 2019 was in the lowest statistical group. In contrast, the root sodium content of the Sharif cultivar with a low bolting rate (38%), was higher than other cultivars without bolting. Also, the root potassium content of the Jerra-kws cultivar with low bolting was lower than the cultivars with high bolting rates (Sharif and Veles) in 2020. Overall, the results showed that root impurities were different in sugar beet cultivars, which may be one of the reasons for genetic differences. In addition, bolting caused an increase in the rate of root impurity followed by a decrease in root quality in 2018-2020 (Table 3).

Sugar extraction coefficient

The results showed that commercial cultivars had significant differences in sugar extraction in 2020 (Table 2). Moreover, the highest (82.4%) and lowest (75%) extraction coefficients were found in Rosagold and Sharif cultivars, respectively (Table 4). Hosseinzadeh Fazl *et al.,* (2020) and Hassanvandi *et al.,* (2022) reported differences in the quality characteristics of the roots of sugar beet cultivars, including the extraction coefficient. The sugar extraction coefficient is obtained by dividing the extractable sugar by the sugar percentage. Non-sugar soluble substances obtained in the root such as potassium, sodium, amino acids, betaine, and other nitrogenous compounds cannot be separated from the root during the sugar extraction process (Block *et al.,* 2006). Therefore, the accumulation of soluble substances makes the extraction of sugar difficult, increasing the sucrose content introduced into the molasses, thus decreasing the yield of white sugar (Block *et al.,* 2006). The results showed that in 2020, cultivars with high bolting rates showed a different value for the sugar extraction coefficient. The Sharif cultivar had the lowest sugar extraction rate among the cultivars, with a 38% bolting rate (Tables 3 and 4). The extraction coefficient of Veles, with 47% of bolting, was higher than the two cultivars without bolting (Montana and Chamine) (Tables 3, 4). Overall, the harmful elements of the roots were higher in the Sharif cultivar (Table 3); therefore, the sugar extraction rate was low too (Table 4).

Percentage of extractable sugar

The cultivars had significant differences in pure sugar percentage in 2020 (Table 2), and the highest (13.4%) and lowest (10.4%) pure sugar percentages belonged to the Veles and Sharif cultivars, respectively (Table 4). Hosseinian *et al.,* (2019) reported a significant difference between sugar beet cultivars for extractable sugar. Farahmand *et al.,* (2013) reported a significant difference between the genotypes for extractable sugar rates in Moghan, Iran.

The value of sugar beet is in the amount of sugar that can be extracted from it. Therefore, the purchase of this raw material is based on technological quality. The quality of sugar beet or its technological value is a distinguishing feature, and it is an indicator of a unique economic value in the sugar industry (Abdolhiyan Nougabi, 2008). In 2020, cultivars with a high bolting rate showed a different reaction for extractable sugar percentage. The extractable sugar percentage of the Veles was significantly lower than the Rosagold and more than the Montana cultivars. The extractable sugar percentage of the Sharif cultivar (with 47% bolting) was lower than other non-bolting cultivars. The higher root impurities (sodium, potassium, and harmful nitrogen), decreased the extraction rate of sugar beet. While no significant difference was found between cultivars for extractable sugar percentage in 2019, the percentage of extractable sugar in 2019 was 1.21% higher than in 2020 due to an increase in root size and performance in 2020. Therefore, the percentage of pure sugar decreased in 2020. Jahani Moghadam *et al.* (2017) showed a negative relationship between root yield and pure sugar percentage, which is consistent with the results of this experiment.

Molasses

Cultivars did not show a significant difference in sugar molasses content in 2019; however, they had a significant difference in 2020. (Table 2). The highest (2.78%) and lowest (1.85%) sugar molasses contents were obtained from Sharif and Veles cultivars, respectively (Table 4). The primary dry matter of molasses is sucrose making up about 21%, and a small amount of reducing sugars and raffinose. Therefore, the lower the sucrose content of molasses, the higher the quality of high extraction coefficient (Cook and Scott, 1993). The results showed that the amount of molasses changed with the emergence of stalking in sugar beet cultivars. The Veles cultivar had the highest bolting rate and lower molasses content than other cultivars. On the other hand, the Sharif cultivar, among cultivars with higher bolting rates, had the highest sugar molasses content. Overall, the results showed that among all cultivars, the Sharif was a sensitive cultivar to bolting (37 %), its root sodium, potassium, and sugar molasses contents were the highest. The amount and percentage of extractable sugar of the Sharif cultivar and its extraction coefficient became the lowest as well.

Table 2. Analysis of variance for yield and quality of autumn sugar beet cultivars of for two years

Years	Sources Change	Degrees of freedom	Ms									
			Sugar content	Root Sodium	Root Potassium	Root Nitrogen	Extractable sugar content	Extraction coefficient of sugar	Molasses	Alkalinity	Root yield	Bolting rate
2019	Replication	2	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
	Cultivar	5	ns	**	**	ns	ns	ns	ns	ns	**	**
	cv		3.9	15.5	4.1	12.9	5.9	2.3	9.7	15	7.5	12.1
			Mean of square									
2020	Replication	2	*	ns	ns	**	*	ns	ns	ns	ns	ns
	Cultivar	5	ns	*	**	ns	*	**	*	ns	ns	**
	cv		6	22.4	9.7	17.3	8.1	3.4	12.8	15.6	10.2	9.5

Ns non-significant, * significant at 5 percent probability level, and ** significant at 1 percent probability level.

Table 3. Comparison of bolting and root quality traits of autumn sugar beet cultivars during two cropping years.

	Bolting rate (%)		Root potassium content (meq in100g root)		Root sodium content (meq in100g root)	
	2018-2019	2019-2020	2018-2019	2019-2020	2018-2019	2019-2020
Montana	1 d	2 d	4.49 ab	5.11 a	2.43 b	2.29 ab
Chemineh	1.6 a	2 d	4.92 ab	5.59 a	1.68 c	2.66 ab
Rosagold	8.3 c	15.6 c	4.65 b	4.11 b	1.85 bc	1.76 b
Jerra-kws	1.5 d	1 d	3.87 c	3.09 b	3.06 a	3.21 a
Sharif	28.3 b	38.3 b	5.13 a	5.24 a	1.95 bc	3.11 a
Veles	35.8 a	47.6 a	4.69 b	4.01 b	1.76 c	1.75 b

Table 4. Comparison of some traits of autumn sugar beet cultivars during two cropping years.

	Root yield	White sugar content	Extraction coefficient of sugar	Molasses
	($t\ ha^{-1}$)		(%)	
	2018-2019	2019-2020	2019-2020	2019-2020
Montana	59.8 c	11.1 c	78.2 c	2.4 ab
Chemineh	59 c	11.3 bc	77.3 c	2.7 a
Rosagold	81.8 ab	13.4 a	84.2 a	1.9 bc
Jerra-kws	85.2 a	11.3 bc	79.3 bc	2.3 abc
Sharif	73.6 b	10.4 c	75.0 c	2.7 a
Veles	62.2 c	13.7 ab	84.1 ab	1.8 c

Means of each column with similar letters are not significantly different (LSD 1%).

Root yield

The results showed that sugar beet cultivars had a significant difference in root yield only in 2019 (Table 2). The highest (85.2 t ha^{-1}) and lowest (59.8 t ha^{-1}) root yields belonged to Jerra-kws and Chamineh cultivars (Table 4). Al-Sayed *et al.,* (2016) in Egypt, reported significant differences in root yield of sugar beet cultivars. Hosseinzadeh Fazl *et al.,* (2020) and Hamidi *et al*., (2022) in Razavi Khorasan province, Iran reported that the highest and lowest root yield were obtained from Giada and Sharif cultivars, respectively.
The cultivars had higher root yield in 2020 than in 2019 with no significant difference between them. The reason can be attributed to the potential of cultivars and their compatibility with environmental conditions. In 2020, at the beginning of the growing season (autumn to winter), the number of sunny hours were higher than in 2019 (Figure 2) which increased leaf area and made it possible to receive higher radiation in May and June. It coincided with the maximum solar radiation providing conditions for higher root yield. In addition, the soil conditions in 2020 were better than in 2019. Many authors indicated that environmental conditions can be considered the most critical limiting factors to production and quality of field crops (Pacuta *et al.,* 2021; Mohammadian, 2016, Curcic *et al*., (2018), which is consistent with the results of this experiment. The root yield of the Sharif cultivar with a 28% bolting rate was significantly lower than the Jerra-kws and higher than the Montana and Chemineh cultivars in 2019. On the other hand, the yield of the roots of veles cultivar with 38% bolting increased to Montana and Chemineh varieties (Table 3, 4). It seems that before the bolting phenomenon led to the creation of a wooden stem and the production of flowers, of reduction in yield and root quality was not noticeable. Damage of the bolting to the plant and the function of the roots was not significant in the harvesting stage. This result is in line with the findings of Hosseinian *et al.,* (2014).

Pearson's correlation matrix

The correlation coefficients between traits showed a negative and significant relationship between bolting rates and root sugar content, pure sugar, extraction coefficient, and nitrogen. A positive relationship between stem zinc and root performance was observed. (Table 5). The percentage of crude sugar (carat) has a direct effect and significant relationship with the sugar extraction coefficient. In contrast, the percentage of pure sugar, root yield, molasses sugar, root potassium, and sodium contents had a negative and significant correlation (Table 5). Jahani Moghadam *et al.,* (2017) reported a negative correlation between bolting rate and sugar extraction coefficient and a positive and significant correlation between gross sugar content and extraction coefficient and white sugar percentage. The sugar content showed a positive correlation with the percentage of pure sugar, but a negative correlation with the percentage of extraction coefficient. Root yield showed a negative and significant correlation with Sugar content, White sugar coefficient, Extractable sugar contents and Alkalinity, In contrast Positive and significant correlation with root nitrogen (Table 5), which was consistent with the results of Oroojnia *et al.,* (2012) and Nasri *et al.,* (2012). It seems that with the increased size of the sugar beet, its purity decreased and its impurities increased. The sodium, potassium, and root nitrogen contents showed negative and significant correlation with the sugar extraction coefficient. Root impurities were directly related to the sugar content of molasses and reduced the percentage of extractable sugar and sugar extraction coefficient largely by affecting the extractability of sugar.

CONCLUSION

Sugar beet cultivars showed different reactions to quantitative, qualitative traits and root performance during the two years of experiment. In addition to genetic differences between cultivars, root performance and, quantitative and qualitative traits were affected. Jerra-kws and Rosagold cultivars had a higher root yield than other cultivars and were suitable for cultivation in the region. Bolting caused a decrease in pure sugar content, the extraction coefficient, and increased the amount of root impurities and in general, the quality of sugar beet root decreased. In the tested area (Gorgan), bolting occurs very late. At that time, the plant has grown most of its growth and its root weight has almost stabilized. It seems that the phenomenon of stem bolting does not have much effect on the characteristics of sugar beet. In any case, the bolting bushes create an undesirable shape in the field from a physical point of view. On the other hand, the physical and chemical problems of the interference of the flowering stem with the root in the process of extracting sugar from the sugar beet root in the sugar factory also cause problems. Solving this issue requires additional research.

Table 5: Correlation coefficients between the traits.

	SC[1]	Na	K	N	WSC[2]	ECS[3]	Ms[4]	ALC[5]	Root yield	Bolting
SC	1									
Na	-0.57**	1								
K	-0.07ns	-0.09ns	1							
N	0.7**	0.49**	0.05ns	1						
WSC	0.97ns	-0.65**	-0.12ns	0.72**	1					
ECS	0.83**	-0.69**	-0.45**	-0.69**	0.93**	1				
M S	-0.57**	0.67**	0.61**	0.53**	0.72**	-0.91**	1			
ALC	0.38*	-0.05ns	0.3**	0.29ns	0.13ns	0.08ns	-0.41ns	1		
Root yield	-0.4*	0.35*	0.03ns	0.45	-0.42**	-0.4*	0.33*	-0.41*	1	
Bolting	-0.66**	0.2ns	0.1ns	0.64**	-0.63**	-0.51**	0.33ns	-0.16ns	0.74**	1

1- Sugar content, 2- White sugar coefficient, 3- Extractable sugar contents, 4- Molasses sugar, 5- Alkalinity

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تأثیر پدیده ساقه روی بر عملکرد و کیفیت ریشه رقم‌های چغندرقند پاییزه

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همبستگی

چکیده- یکی از محدودیت‌های عمده در کشت پاییزه چغندرقند (*Beta vulgaris* L.)، ساقه‌روی است. به منظور بررسی ویژگی‌های کمی و کیفی رقم‌های چغندرقند پاییزه و مقاومت آن‌ها به ساقه‌روی، آزمایشی در دو سال (۹۹ -۱۳۹۷) در قالب طرح بلوک‌های کامل تصادفی با سه تکرار در ایستگاه تحقیقات کشاورزی ورسن مرکز تحقیقات و آموزش منابع طبیعی، گرگان، ایران. اجرا شد. تیمارها شامل ارقام تجاری چغندرقند پاییزه [۵ رقم خارجی (مونتانا، جراکاواس، روزاگلد، چیمنه و ولس) و رقم داخلی شریف] بودند. بر اساس نتایج، رقم‌ها از نظر درصد ساقه‌روی در هر دو سال تفاوت معنی‌داری داشتند. در دو سال، رقم ولس و شریف بترتیب بیشترین درصد ساقه‌روی (۴۱/۷ و ۳۳/۳) را داشتند. درصد ساقه‌روی در سال دوم بیشتر از سال نخست بود. تنها در سال نخست بین رقم‌ها تفاوت معنی‌داری از نظر عملکرد ریشه مشاهده شد. بالاترین (۸۵/۲ تن در هکتار) و کمترین عملکرد ریشه بترتیب در رقم های جراکاواس و چمینه بدست آمد. در سال دوم از نظر درصد شکر خالص، ضریب استخراج قند و درصد قند ملاس تفاوت معنی‌داری بین ارقام حاصل گردید. از نظر صفات محتوای قند و نیتروژن مضره در هر دو سال تفاوت معنی‌داری بین ارقام وجود نداشت. ارقام از نظر درصد ساقه‌روی و سایر صفات کیفی ریشه (شکر خالص، ضریب استخراج، سدیم، پتاسیم و نیتروژن مضره) در دو سال واکنش‌های متفاوتی نشان دادند.