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The Investigation of Suitable Varieties for Autumn-Sown of Sugar Beet in the Warm Region of Kermanshah Province

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ABSTRACT

One of the most suitable areas for autumn beet cultivation is the tropical regions of Kermanshah province, which requires new cultivars appropriate for cultivation in these regions to be identified and introduced every year. For this purpose, an experiment including 10 sugar beet cultivars named Rosegold, Ratna, Silota, Jera, Beaufort, Rozanab, Barossa, FD15131014, BTS4770 and Joncal was conducted based on a randomized complete block design with four replications in Sarpol Zahab city, 2019. Each plot consisted of three eight-meter rows, with a row distance of 50 cm and the distance between the plants after thinning was 20 cm. Planting was done by hand. The Bolting percentage was recorded before harvest. At the time of harvest, root yield and quality characteristics including the percentage of sugar, sodium, nitrogen and potassium were measured, and the yield of pure and impure sugar and molasses sugar was calculated. The results showed that the yield of investigated cultivars (Rosagold, Beaufort, Gera, Ratna and Uncal) was 111, 116, 114, 105 and 119 tons per hectare with an average of 13-13.5% sugar and bolting was less than 7%. In the year of the experiment, the variety that had the largest cultivated area in the Sarpol Zahab area was the rosegold variety, but the Beaufort, Jara, Ratna, and Jankal varieties had performance and quality equal to or greater than this variety. The bolting percentage was below 3%. The four new varieties of sugar beet are better or equal to the rosegold variety and are recommended for cultivation in the tropical regions of Kermanshah province as an autumn crop.

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1. Introduction

Various solutions have been defined to increase the water consumption efficiency of important and basic agricultural products. Since sugar beet is considered one of the strategic products and compared to most crops, needs relatively more water, it is important to provide suitable solutions to increase water consumption efficiency in this crop (Zhou *et al*., 2022). Autumn sugar beet in some regions of Mediterranean areas in southwestern Spain, Portugal, Morocco, Tunisia, Egypt, Iraq, and parts of Iran cultivated (Rezaei and Fasahat, 2022). Iran is one of the regions where it is possible to produce sugar beet in spring and autumn. Due to the many relative advantages of autumn sugar beet cultivation, in recent years, the development of autumn sugar beet cultivation has been prioritized, and in this regard, the warm areas of Kermanshah province, such as Sarpol Zahab and Qasr Shirin, and parts of Gilangharb are the areas that autumn sugar beet can be cultivated (Jalilian and Nejafi, 2017). Autumn cultivation of sugar beet, in addition to less water requirement, will play a useful role in increasing soil fertility and reducing pests and diseases of two crops, wheat and corn, which are the main crops of these regions (Koch *et al*., 2018).

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Many studies have been conducted on various aspects of breeding and agronomy (Hasanvandi *et al*., 2022), plant pathology (Soltani *et al*., 2021), economics, quality (Rezaei *et al*., 2020) and other characteristics of autumn sugar beet cultivation in Iran during the past years. The results showed that sugar beet can be introduced as an important and effective autumn crop in the rotation system (Koch *et al*., 2018). The most important factor that can be introduced for the priority and superiority of autumn sugar beet cultivation over spring cultivation is the optimal use of rain in autumn during the growth period and the efficiency of water consumption in autumn sugar beet cultivation (Amiri *et al*., 2022). This issue becomes more important when water is considered the main factor limiting agriculture in Iran (Khorsandi *et al*., 2023).

Currently, the autumn cultivation of sugar beet is being developed or under study in different countries of the world, because the autumn cultivation of sugar beet has more economic benefits (Amiri *et al*., 2022). The limiting factor in the autumn cultivation of this crop is bolting which has been widely studied and it is possible to obtain cultivars with more resistance to bolting (Rezaei and Fasahat, 2022).

Several field experiments have been conducted in autumn beet growing areas and it has been shown that dry matter accumulation and sugar beet yield are influenced by planting date, nitrogen fertilizer, and harvest date (Abdollahi *et al*., 2020; Leilah and Khan, 2021).

In Iran, water consumption in spring sugar beet cultivation is estimated at 12-14 thousand cubic meters and in autumn cultivation at 7-9 thousand cubic meters per hectare (Taleghani *et al*., 2008). Due to the low yield of sugar in farmers' fields (in spring cultivation, on average, about 4.5 tons per hectare, and in autumn cultivation, about 4 tons per hectare), the efficiency of water consumption in production areas is approximately 330-390 grams sugar and in spring cultivation 450-580 grams of sugar per cubic meter of water used in autumn cultivation are estimated (Taleghani *et al*., 2008).

Based on the climatic countries' climatic conditions, it seems that introducing autumn sugar beet production in Iran is possible, and its development will cause a change in the cultivation of this strategic crop in the country. In Kermanshah province during the crop year 2014-2015, the number of 15 sugar beet cultivars suitable for autumn cultivation were investigated on several planting and harvesting dates and the two areas of Sarpol Zahab and Qasr Shirin, and the results showed that the suitable date of planting is 23rd Sep. to 7th Oct (Jalilian, 2019). Sarpol Zahab region in Kermanshah provinces is more suitable for autumn sugar beet cultivation than Qasr Shirin, and among the studied cultivars, Spartak, Silveta, Jaca, Levantea, Vico, Merak, and Azaba were better than other cultivars (Jalilian, 2016).

Considering that autumn sugar beet cultivation has started in the tropical regions of Kermanshah province and is developing in the last few years, it is necessary to investigate and determine suitable new cultivars in these regions. This research aimed to investigate the yield, quality, and bolting of 10 new autumn sugar beet cultivars in the Sarpol Zahab region of Kermanshah province.

2. Materials and methods

This experiment was carried out in the Sarpol Zahab region of Kermanshah province during 2019-2020. The experimental treatments included 10 sugar beet cultivars including Rosagold, Ratna, Silveta, Jerra, Bifort, Rosanab, Barrosa, FD15131014, BTS770, and Juncal. Cultivation was done on 13 October 2019 in the Zahab Plain in the form of a randomized complete block design in four replications. The cultivated land was under wheat cultivation in the previous year, and before the preparation of the land, 200 and 250 kg of phosphate and potash chemical fertilizers were used and mixed with the soil, respectively. Cultivation was done by hand and row spacing was 50 cm. Each plot consisted of 3 lines with a length of 8 meters and the distance between the plants in the row after thinning was set to 20 cm. Irrigation was a sprinkler system. The usual agricultural operation of sugar beet was done on time. 300 kg/ha of nitrogen fertilizer was used in two stages, one at the time of thinning and one in the middle of March. The bolting percentage determined before harvesting the root yield was determined and the root was prepared for qualitative analysis and determination. Traits of the percentage sugar, sodium, nitrogen and potassium of roots, molasses sugar, and gross and net sugar yield were measured. Data variance analysis was done with SAS software. Obtained data were subjected to ANOVA. The means were separated

using Fisher's Protected LSD test at the p>0.05 level of probability using SAS software.

3. Results and discussion

The results showed that there was a significant difference between cultivars for all the measured traits except for impure sugar and Root nitrogen (Tables 1 and 2).

Table 1. Results of variance analysis (Mean of squares) of some measured traits.

Source of Variation	df	Root yield	Impure sugar	Root sodium	Root potassium	Root nitrogen
Replication	3	94.1	0.93	0.012	1.079	0.040
Cultivar	9	216.2*	1.06^{ns}	0.471**	0.303**	0.207^{ns}
Error	27	102.6	0.64	0.058	2.157	0.056
C.V (%)		9.4	6.1	17.1	7.9	12.5

ns: Not-significant * and **: Significant at the 5% and 1% probability levels, respectively

Table 2. Results of variance analysis (Mean of squares) of some measured traits.

Source of Variation	df	Molasses sugar	Extractable sugar %	Impure sugar yield	Pure sugar yield	Bolting %
Replication	3	0.122	1.69	0.29	0.28	49.9
Cultivar	9	0.076**	1.62*	4.93*	4.14*	2494**
Error	27	0.024	0.56	1.92	1.43	88.2
C.V (%)		9.4	7.3	9.8	10.1	45.5

ns: Not-significant * and **: Significant at the 5% and 1% probability levels, respectively

The comparison of the average of the measured traits showed that there was a significant difference between the cultivars studied. The highest root yield was obtained in the Joncal cultivar, but Rosagold, Bifort, Jerra, Ratna, BTS, 4770, Barossa and Silveta cultivars were also in the same group as this cultivar (Table 3).

The mean percentage of impure sugar of the studied cultivars did not differ much, except for cultivar FD15131014, which had the lowest percentage of impure sugar, and the other cultivars were in the same statistical group. The cultivar FD15131014 showed the highest percentage of molasses sugar and root nitrogen. Also, the lowest extractable sugar percent and gross and pure sugar yields were related to this cultivar (Table 4). The average of traits related to root impurity, i.e. nitrogen, sodium, potassium, and molasses sugar, showed that cultivars have many differences (Table 3). In terms of the percentage of extractable sugar, except for FD15131014, which had the lowest percentage, other cultivars were in the same statistical group (Table 4). The average amount of pure sugar yield showed that BTS4770 and FD15131014 had the lowest amount and other cultivars were in the same statistical group (Table 4). The average percentage bolting, which is one of the most important traits in the autumn cultivation of sugar beet, was the lowest in Rosagad, Bifort, Jerra, Ratna, Juncal, and FD15131014 cultivars, and they were placed in a statistical group, and BTS4770, Barossa cultivars Rozanab and Silveta had the highest percentage of bolting. The variable percentage of bolting may be due to the genetic difference of the cultivars. Bolting is under the influence of genetic, environmental and physiological factors. Genes with additive and epistasis effects are also effective in this phenomenon. Gibberellic acid, day length and cold duration guide this phenomenon (Hourston *et al*., 2022).

Table 3. Mean comparison of sugar beet cultivars for studied traits.

Cultivar	Root yield (ton/ha)	Impure sugar (%)	Root sodium (meq \100 g Root)	Root potassium (meq \100 g Root)	Root nitrogen (meq \100 g Root)
Rosagold	110.7^{ab}	13.13^{ab}	1.31^{bcd}	3.43^{bc}	2.14^{a}
Bifort	115.8^{ab}	13.24^{a}	1.19^{cd}	3.62^{abc}	2.02^{a}
Jerra	113.9^{ab}	13.30^{a}	2.01^{a}	3.09^{c}	2.00^{a}
Ratna	105.3^{ab}	13.49^{a}	1.01^{d}	3.80^{ab}	1.87^{ab}
Juncal	119.1^{a}	12.95^{ab}	1.75^{ab}	3.72^{ab}	1.95^{ab}
BTS4770	101.9^{ab}	12.89^{ab}	1.57^{abc}	3.38^{bc}	1.51^{b}
FD15131014	98.7^{b}	12.04^{b}	1.77^{ab}	4.04^{a}	1.49^{b}
Barrosa	107.0^{ab}	13.73^{a}	1.08^{d}	3.45^{bc}	1.79^{ab}
Rosanab	97.4^{b}	13.75^{a}	1.07^{d}	3.37^{bc}	1.95^{ab}
Silveta	103.5^{ab}	13.65^{a}	1.40^{bcd}	3.45^{bc}	2.11^{a}

*The same letters in each column show non-significant differences at p<0.05, analyzed by Duncan's multiple range test.

Table 4. Mean comparison of sugar beet cultivars for studied traits.

Cultivar	Molasses sugar (%)	Extractable sugar (%)	Bolting (%)	Impure sugar yield (t/ha)	Pure sugar yield (t/ha)
Rosagold	1.5^{bc}	11.01^{ab}	6.8^{c}	14.49^{ab}	12.14^{ab}
Bifort	1.5^{bc}	11.11^{ab}	3.0^{c}	15.25^{a}	12.79^{a}
Jerra	1.6^{ab}	11.07^{ab}	0.2^{c}	15.13^{a}	12.60^{ab}
Ratna	1.5^{bc}	11.37^{a}	1.0^{c}	14.19^{ab}	11.96^{ab}
Juncal	1.7^{ab}	10.60^{ab}	0.2^{c}	15.43^{a}	12.63^{ab}
BTS4770	1.5^{bc}	10.76^{ab}	58.5^{a}	13.11^{bc}	10.93^{bc}
FD15131014	1.8^{a}	90.60^{b}	1.2^{c}	11.88^{c}	9.47^{c}
Barrosa	1.4^{c}	11.71^{a}	63.3^{b}	14.69^{ab}	12.53^{ab}
Rosanab	1.4^{c}	11.76^{a}	57.8^{a}	13.36^{bc}	11.42^{ab}
Silveta	1.5^{abc}	11.50^{a}	41.8^{ab}	14.09^{ab}	11.85^{ab}

*The same letters in each column show non-significant differences at p<0.05, analyzed by Duncan's multiple range test.

In autumn cultivation, cultivars are suitable that, in addition to high yield and quality, their bolting percentage is also minimal. Since the presence of too many flowering stems causes a decrease in sugar percentage, root yield, and purity of raw syrup high

bolting percentage is considered a negative characteristic for selecting cultivars suitable for autumn cultivation (Hoffmann *et al*., 2021). Therefore, among the investigated cultivars, cultivars should be selected and recommended with both acceptable yield and quality and low bolting percentage. Accordingly, among the investigated cultivars, Rozagad, Bifort, Jerra, Ratna, and Juncal respectively yield About 111, 116, 114, 105 and 119 tons per hectare with 13 to 13.5 sugar percentage and bolting less than 7% suitable and recommendable for cultivation in tropical areas of Kermanshah province. In the tropical regions of Kermanshah province, other cultivars have been studied in the past years, such as Spartak, Silota, Juncal, Levante, Vico, Merak, Neokos, and Azaba, which were acceptable in terms of yield and sugar percentage, but some of these cultivars in the years with cold weather, the percentage of bolting was high (Jalilian, 2016). Also, the climatic conditions of the cultivars' seed production can be effective on the traits investigated in this study. Ranji et al. (2001) reported that the percentage of bolting in the seeds produced in the cities of Karaj and Ardabil was 5.6 and 8.12%, respectively. Also, the average root yield in Karaj and Ardabil seeds was 62.90 and 60.67 tons per hectare, respectively, which did not have statistically significant differences. The average percentage of sugar in seeds produced in different years was 14.75% in Karaj and 14.55% in Ardabil, which was not statistically significant. Taking into account the characteristics of bolting percentage, root yield, sugar percentage and white sugar yield, Karaj seed was relatively superior to Ardabil seed.

4. Conclusion

Evaluation of suitable cultivars for autumn cultivation in the tropical regions of Kermanshah is of special importance. Based on the results of this research, some of the evaluated cultivars can be suitable for cultivation in these areas. In general, the results of this study showed that the response of different cultivars to the weather conditions of Sarpol Zahab City was different based on the measured traits. Currently, the cultivar that is cultivated in the Sarpol Zahab region is the Rosagold variety and was considered as a control in this experiment, but the cultivar of Bifort, Jara, Ratna, and Juncal has yield and quality equal to or more than this variety (bolting below 3%). the highest root yield (119.10 ton/ha) was related to the Juncal variety. While the highest percentage of gross sugar was related to the Rosanab variety. In the autumn cultivation of sugar beet, the percentage of stems is one of the important traits. Accordingly, Jerra and Juncal cultivars had the lowest bolting percentage, with about 0.2%. According to the results obtained from this study, the Juncal variety with the highest root yield per hectare and the lowest bolting percentage among the cultivated varieties is the most suitable variety for cultivation in the tropical regions of Kermanshah province, especially in Sarpol Zahab city.

Conflict of interests

All authors declare no conflict of interest.

Ethics approval and consent to participate

No human or animals were used in the present research. The authors have adhered to ethical standards, including avoiding plagiarism, data fabrication, and double publication.

Consent for publications

All authors read and approved the final manuscript for publication.

Availability of data and material

All the data are embedded in the manuscript.

Authors' contributions

All authors had an equal role in study design, work, statistical analysis and manuscript writing.

Informed consent

The authors declare not to use any patients in this research.

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