Jan. 31-Feb. 2, 2026

ISC

9th National and 1st International Conference of Plant Physiology

University of Guilan, Rasht, Guilan, Iran

Growth and Physiological Responses of Autumn Sown Sugar Beet Cultivars under Saline Soil Conditions

Marzieh Hassani[1]*, Mahmoud Reza Tadayon[2], Juan Carlos Contreras-Esquivel[3]

[1,2] Department of Agronomy, Faculty of Agriculture, Shahrekord University, Shahrekord, Iran

[3] Department of Food Research, Faculty of Chemistry, Autonomous University of Coahuila, Saltillo, México

Abstract

Soil salinity is one of the most important factors limiting the yield of agricultural crops worldwide, particularly in arid and semi-arid regions. Selecting salt-tolerant sugar beet cultivars is among the most common strategies employed by breeders. Accordingly, to evaluate the tolerance of five foreign sugar beet cultivars to soil salinity based on key morpho-physiological traits under field conditions, an experiment was conducted during the 2024–2025 growing season on the cultivars Amaldi, Granate, Antek, Shanon, and Akazia. The study was arranged in a randomized complete block design with six replications in the southwest of Fars Province under saline soil conditions (7 dS/m). Analysis of variance showed that all measured traits differed significantly among cultivars at the 1% probability level. Mean comparison indicated that plant height in Granate and Antek (70.45 and 71 cm, respectively), total chlorophyll (6.30 mg g⁻¹ fresh weight), carotenoids (1.53 mg g⁻¹ fresh weight), fresh plant weight (1696.29 g), Dry plant weight (184.10 g), root length (39.26 cm), single-root weight (1058.11 g), root yield (116393 ton/ha) and root sugar content (16.38 %) were highest in Antek, whereas Amaldi exhibited the lowest values for most morpho-physiological traits. Based on the results, Antek was identified as the superior and most salt-tolerant cultivar for autumn cultivation in saline soil regions.

Keywords: Morphology, Photosynthesis, Salt Tolerance, Yield components

Introduction

Soil salinity is a critical environmental stress threatening global agricultural production. Defined by an electrical conductivity (EC) exceeding 4 dS/m, it adversely affects plant growth. Globally, at least 45 million hectares of irrigated land are salt-affected, with projections suggesting salinity could contribute to the loss of up to 50% of the world's arable land by the mid-21st century (Anagholi et al., 2018). Salts impair growth primarily through two mechanisms: osmotic stress, which reduces root water uptake, and ionic toxicity, where excessive ion accumulation causes cellular damage. Sugar beet (Beta vulgaris L.), a high-yield biennial crop crucial for sugar production and bioindustry, is considered moderately tolerant and a strategic option for saline areas. Its salinity threshold is 7.0 dS/m (ECe), beyond which yield declines by approximately 5.9% per additional dS/m (Maas and Hoffman, 1977). This highlights the urgent need to identify and utilize salt-tolerant cultivars. The impact of salinity on sugar beet is multifaceted, involving complex physiological, morphological, and biochemical changes (Santos et al., 2016). While some reports indicate a potential increase in chlorophyll under moderate stress, excessive salinity typically leads to stomatal closure, reduced gas exchange, and diminished photosynthesis. Root growth is particularly vulnerable; salinity imposes osmotic stress that restricts root elongation and limits water access (Lv et al., 2019). Consequently, reductions in root fresh weight and overall biomass are common even at moderate levels (~3 dS/m), with severe disruption occurring at EC > 7 dS/m (Misra et al., 2020; Santos et al., 2016). Significant genetic variation exists among cultivars. Tolerant genotypes exhibit adaptive mechanisms such as enhanced antioxidant enzyme activity and lower sodium accumulation in tissues (Wang et al., 2019). For instance, while the cultivar 'Early Wonder' shows physiological decline with increasing salinity, 'Itapua' can tolerate levels up to ~6 dS/m. This variability underscores the potential for cultivar selection as a key strategy. Therefore, this study was conducted to evaluate the responses of autumn-sown sugar beet cultivars under hot, arid, and highly saline conditions, aiming to identify the most tolerant and high-performing foreign cultivar.

Materials and methods

The experiment was conducted in an agricultural field located 5 km from Kazeroon city, in the southwest of Fars Province, Iran, at the geographical coordinates of 51°39′15″ E longitude and 29°27′ N latitude, during the 2024–2025 cropping season. The study aimed to evaluate the response of autumn-sown sugar beet (*Beta vulgaris* L.) cultivars to saline soil conditions. The experimental design was a randomized complete block design (RCBD) with six replications. The experimental treatments consisted of five foreign sugar beet cultivars, namely Amaldi, Granate, Shanon, Antek, and Akazia. Sugar beet cultivation was carried out in soil with a salinity level of 7 dS/m. Prior to the initiation of the experiment, the physical and chemical properties of the experimental field soil were analyzed at a depth of 0–30 cm. Irrigation of the experimental field was carried out every 8 days, based on regional conditions, soil moisture status, and the conventional irrigation schedule for sugar beet. Prior to sowing, field preparation included plowing, disking, and land leveling. Each plot measured 3 × 5 m, with a planting density of 100,000 plants per hectare. Each plot consisted of six planting rows spaced 50 cm apart, and sugar beet was sown on ridges with an intra-row spacing of 20 cm. Sowing was carried out in mid-autumn according to local climatic conditions. Chemical fertilizers were applied before planting based on soil test results and laboratory recommendations. The plant height of sugar beet was measured at the 20-leaf stage using a ruler. To determine shoot fresh and dry weights, ten plants were randomly selected from each experimental unit; samples were oven-dried at 75°C for 48 hours. At harvest, the number of plants in each plot (excluding border effects) was recorded, and traits such as root length and single-root fresh weight were measured. Photosynthetic pigment concentrations (total chlorophyll and carotenoids) were determined using the Arnon method at the 20-leaf stage (Equation 1). Data analysis was performed using SAS software, and graphs were generated in EXCEL. Mean comparisons were conducted using the LSD test at the 5% probability level.

Equation (1)

$$\text{Total chlorophyll (mg g}^{-1}\text{)} = (7.05\times\text{Chl a}) + (18.09\times\text{Chl b}) \times \text{mL acetonemg}$$

$$\text{Carotenoids (mg g}^{-1}\text{)} = (1000\times\text{Abs470}) - (1.9\times\text{Abs663}) - (63.14\times\text{Abs646})\ 214$$

Results and discussion

Analysis of variance showed that the morpho physiological traits of sugar beet were significant at the 1% probability level, while single root weight and root yield was significant at the 5% level (Table 2). The results indicated that the cultivars Granate and Antek produced the greatest plant height, with values of 71 and 70.45 cm, respectively (Figure 1). The highest values for total chlorophyll (6.30 mg g⁻¹ fresh weight), carotenoids (1.53 mg g⁻¹ fresh weight), fresh plant weight (1696.29 g), dry plant weight (184.10 g), root length (39.26 cm), and single root weight (1058.11 g), root yield (116393 ton/ha) and root sugar content (16.38 %) were also recorded in the cultivar Antek (Figure 1). Salinity stress alters physiological and morphological traits, leading to reduced plant growth and productivity. Nevertheless, sugar beet exhibits moderate tolerance to salinity, which can influence its adaptability and performance under such conditions. Overall, the findings of this study demonstrate that saline soil markedly affects photosynthetic pigments, plant biomass, plant height, and root length and weight in sugar beet cultivars. Salinity stress causes physiological disturbances through ionic toxicity and osmotic stress, limiting water uptake and reducing pigment content and the observed increase in carotenoids in tolerant cultivars may serve as a protective mechanism and an indicator of tolerance (Abolali et al., 2019). While high salinity generally reduces root yield and sugar content, genotypic variation exists. Some cultivars (e.g., Romulus, P2s) demonstrate better resilience in yield and quality under saline conditions. Overall, managing soil salinity is crucial for optimizing sugar beet production, and selecting appropriate cultivars with tolerance to saline conditions is a key strategy (El-Desoky et al, 2025).

Table 2. Analysis of variance (mean squares) for morpho-physiological traits of sugar beet

Source of variation	DF	Plant height	Total chlorophyll	Carotenoids	Fresh plant weight	Dry plant weight
Block	5	20.411ns	0.029ns	0.002ns	9645.126ns	56.242ns
Cultivar	4	1152.806**	17.710**	0.828**	1767203.631**	18311.742**
Error	20	87.050	0.042	0.005	4567.279	131.480
C.V (%)	-	14.97	5.64	6.66	6.51	10.24

Source of variation	DF	Root length	Single-root weight	root yield	root sugar content
Block	5	14.606ns	5560.880ns	67292845.9ns	0.847ns
Cultivar	4	71.557**	12447.508*	150624428.6*	4.783**
Error	20	10.332	3689.273	44639643	1.179
C.V (%)	-	9.25	6.10	6.09	7.07

ns: non-significant; * and ** indicate significance at the 5% and 1% probability levels, respectively

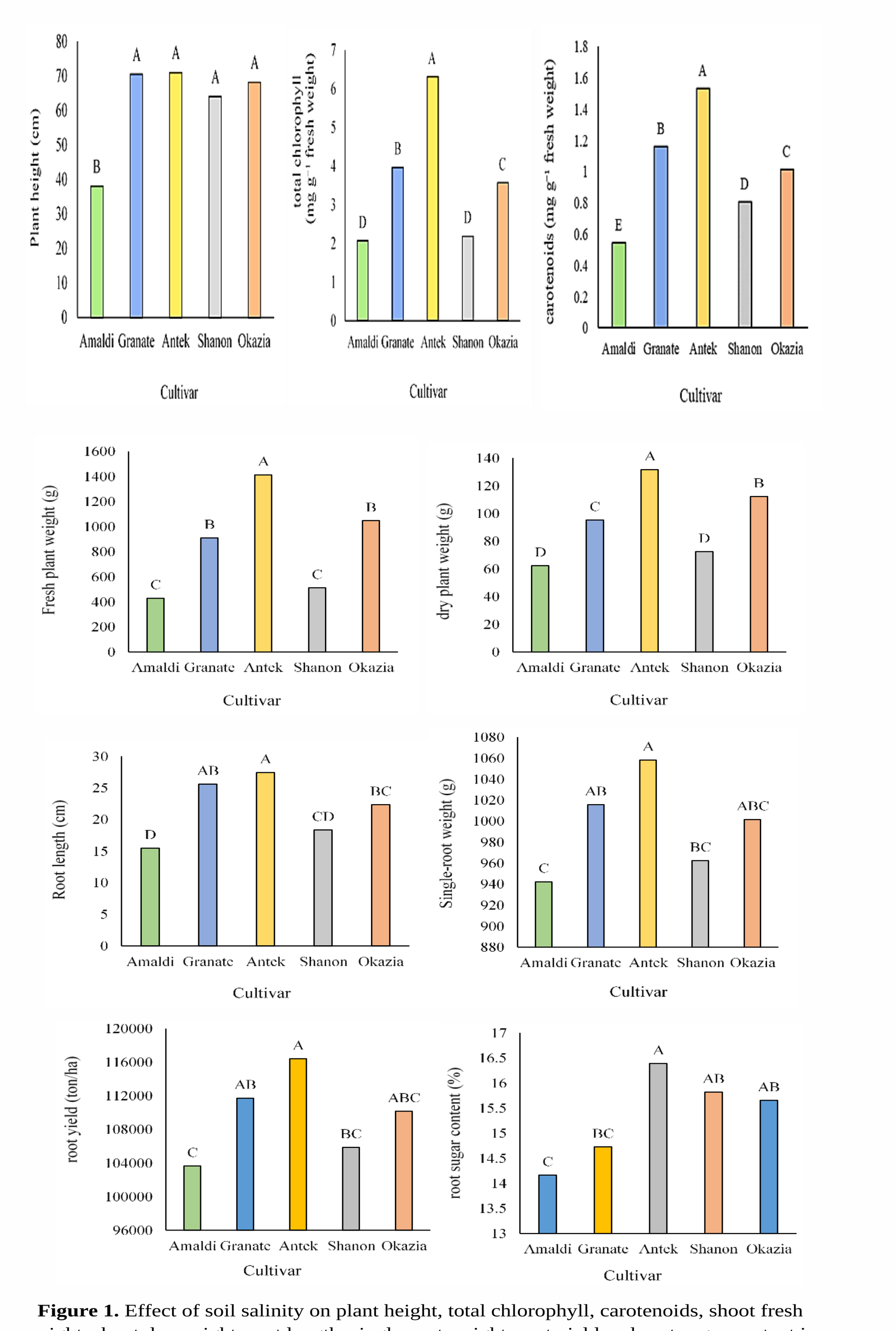

Figure 1. Effect of soil salinity on plant height, total chlorophyll, carotenoids, shoot fresh weight, shoot dry weight, root length, single-root weight, root yield and root sugar content in sugar beet cultivars.

Columns sharing the same letters are not significantly different from each other according to the LSD test at the 5% probability level.

Conclusion

Based on the results, soil salinity had a significant effect on the morpho-physiological traits of sugar beet cultivars. The findings of this study indicate that the growth parameters of sugar beet are strongly influenced by salinity stress, and that the identification and introduction of salt-tolerant cultivars represent one of the most effective strategies for mitigating salinity-related challenges and improving agricultural productivity. Among the evaluated cultivars, Antek exhibited the highest growth and yield performance. Therefore, this cultivar can be recommended as a commercial option for cultivation in regions with high soil salinity. Further complementary experiments are necessary to take more effective steps toward identifying cultivars with even greater salinity tolerance. Overall, based on the present results, the Antek cultivar can be cultivated by farmers in saline soil regions.

References

Abu-Ellail, F. F., Sadek, K. and El-Bakary, H. (2020). Evaluation of ten sugar beet varieties in terms of growth, yield and quality under different soil salinity levels. Journal of Sugar Beet, 35(2): 233-249. doi: 10.22092/jsb.2020.341558.1232

Anagholi, A., Rajabi, A., and Khayamim S. (2018). Response of Sugar beet Genotypes under Salinity Stress in Central Areas of Iran. International Journal of Pharmaceutical and Phytopharmacological Research, 8(6): pp.49-58.

El-Desoky, H., El-gamal, I., El-Safy, N., Selim, D., Ismail, M., Moursy, A., and Elhabbak, A. (2025). Effect of Salt Stress on Growth, Productivity and Root Quality of Two Sugar Beet (*Beta vulgaris* L.) Cultivars. Journal of Plant Production. 317-324. DOI: 10.21608/jpp.2025.383434.1461.

Lv, X., Chen, S., and Wang, Y. (2019). Advances in Understanding the Physiological and Molecular Responses of Sugar Beet to Salt Stress. Frontiers in Plant Science, 10: 1431. https://doi.org/10.3389/FPLS.2019.01431

Misra, V., Mall, A. K., and Pathak, A. D. (2020). Sugar Beet: A Sustainable Crop for Saline Environment (pp. 49–61). Springer International Publishing. https://doi.org/10.1007/978-981-15-0025-1_4

Maas, E.V., and Hoffman, G.J. 1977. Crop salt tolerance – current assessment. Journal of the Irrigation and Drainage Division. American Society of Civil Engineers 103(IR2): 115–134. https://doi.org/10.1061/JRCEA4.0001137

Santos, D. P., Santos, C. S., Silva, P. F., Pinheiro, M. P. M. A., and Santos, J. C. (2016). Crescimento e fitomassa da beterraba sob irrigação suplementar com água de diferentes concentrações salinas. 63(4): 509–516. https://doi.org/10.1590/0034-737X201663040011

Wang, Y., Stevanato, P., Lv, C., Li, R., and Geng, G. (2019). Comparative Physiological and Proteomic Analysis of Two Sugar Beet Genotypes with Contrasting Salt Tolerance. Journal of Agricultural and Food Chemistry, 67(21): 6056–6073. https://doi.org/10.1021/ACS.JAFC.9B00244