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*Original article*

# Evaluation of different genotypes of sugar beet (*Beta vulgaris* L.) in terms of biochemical and antioxidant properties under normal conditions and water deficit conditions

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## *Extended abstract*

### Introduction

Sugar beet (*Beta vulgaris* L.) is one of the important commercial crops that supply approximately 35% of the world's sugar and is widely cultivated in arid and semi-arid regions. Drought is one of the most important growth restricting environmental factors for crop species in arid and semi-arid regions of the world. Crop losses resulting from abiotic stresses such as drought or salinity can reduce crop yield by as much as 50%.

### Material and methods

to investigate the evaluation of different genotypes of sugar beet (*Beta vulgaris* l.) in terms of biochemical and antioxidant properties under normal conditions and water deficit conditions excrement was conducted in split-plot design based on complete random blocks with three replications in Miandoab Agricultural and Natural Resources Research Station at 2017-18 Crop seasons. Irrigation regimes at two levels, (normal Irrigation after 90 mm of evaporation and drought stress after the 10-leaf stage of sugar beet based on 200 mm of evaporation from the Class A evaporation pan) signed to the main plot, and 18 sugar beet genotypes were assigned to sub-plots. In this research root yield, coefficient of sugar extraction, Guaiacol peroxidase, Polyphenol oxidase, Superoxide dismutase, and proline content were measured. After collecting the data, the data were analyzed using SAS software version 9.1 and the comparison of the average of the studied characteristics was performed using LSD test at the probability level of five percent.

### Results and discussion

In the present study, the effect of the irrigation regime on all studied traits was significant except for the sugar extraction coefficient at the level of probability of 1%. Among the genotypes studied significant difference was observed in terms of all the studied traits, at the probability level of 1% Interaction of irrigation regime with genotypes on root yield, sugar extraction coefficient, guaiacol peroxidase, polyphenol oxidase, and proline content at 1% probability level and superoxide dismutase at 5% probability level was significant. The results showed that water deficit stress reduced root yield by 17.38% compared to normal irrigation conditions, while the content of glycol peroxidase, polyphenol

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oxidase, superoxide dismutase, and proline under water deficit conditions was an increase compared to normal irrigation conditions by 118.86, 82.1, 103.61 and 113.92 percent respectively. genotypes Mean comparison in terms of root yield showed that genotype No. 10 with an average of 85.77 t / ha under normal irrigation and 72.14 t / ha under water deficit stress had the highest root yield. Under normal irrigation conditions, the highest guaiacol peroxidase, polyphenol oxidase, superoxide dismutase activity, and proline content were belonged to genotypes 21, 15, 4, and 13, respectively. While underwater stress conditions, the highest values of these traits were recorded in cultivars 10, 20, 19, and 3, respectively. Based on the results of regression analysis under normal irrigation conditions, the Sugar Extraction Coefficient and proline content with the explanation of 80 percent of root yield variation were identified as the most important traits. Based on the results of path analysis, the two traits, directly and indirectly, showed a positive effect on root yield. Underwater deficit stress proline content, guaiacol peroxidase, and superoxide dismutase with 66.3% explanation of changes in root yield Were identified as the most effective traits on root yield. Besides, the mentioned traits had a positive effect on root yield based on the results of path analysis both directly and indirectly.

## Conclusion

Among the studied genotypes, cultivar F-20851 had the highest root yield in both irrigation conditions compared to other cultivars, so it can be concluded that the genotype has a high genetic potential for root yield production in different environmental conditions. Among Iranian cultivars, except for Paya cultivar, other cultivars had low ranks of root yield in both environmental conditions. It can be concluded that in addition to root yield, other enzymatic and biochemical properties of Iranian cultivars should be worked on to be competitive with foreign cultivars. In this study, proline content had a positive effect on root yield in both environmental conditions, so improving proline content could be a way to increase root yield in different environmental conditions.

***Keywords*:** Cultivars, Drought, Proline, Root yield

**Table 1. Evaluated Sugar beet genotypes**

| Number | Genotype | Number | Genotype |
|---|---|---|---|
| 1 | Pars | 10 | F-20716 |
| 2 | F-20722 | 11 | Sharif |
| 3 | F-20815 | 12 | F-20772 |
| 4 | F-20817 | 13 | Arya |
| 5 | F-20747 | 14 | Shokoofa |
| 6 | Paya | 15 | F-20814 |
| 7 | F-20723 | 16 | Ekbatan |
| 8 | F-20851 | 17 | F-20866 |
| 9 | F-20734 | 18 | F-20758 |

**Table 2. Physical and chemical properties of the soil**

| Soil texture | K | P | Ca | $NH_4$ | $NO_3$ | Mg | N (total) | O.C | T.N.V | pH | EC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ppm | | | | | | % | | | | $dS\ m^{-1}$ |
| Silty loam | 255 | 8.05 | 8 | 13.15 | 19.55 | 3.5 | 0.13 | 0.78 | 8 | 8 | 2.14 |

**Table 3. Combined analysis of variance of the studied traits in two years and normal and water deficit conditions**

| S.O.V | df | Root Yield | Sugar Extraction% | Guaiacol peroxidase | Polyphenol oxidase | Superoxide dismutase | Proline |
|---|---|---|---|---|---|---|---|
| **Year (Y)** | 1 | 16.18** | 46.39$^{ns}$ | 0.003$^{ns}$ | 0.008** | 4783.50$^{ns}$ | 0.01ns |
| **Y×R** | 4 | 0.03 | 32.75$^{ns}$ | 0.001 | 0.001 | 2444.56 | 0.005 |
| **Irrigation levels (I)** | 1 | 295.27** | 54.41$^{ns}$ | 21.64** | 0.13** | 132918.41** | 30.92** |
| **Y×I** | 1 | 12.32** | 29.56$^{ns}$ | 0.003$^{ns}$ | 0.004$^{ns}$ | 3538.71$^{ns}$ | 0.001ns |
| **$E_a$** | 4 | 0.07 | 28.25$^{ns}$ | 0.003$^{ns}$ | 0.0001 | 2622.18 | 0.016ns |
| **Genotype (G)** | 17 | 3461.63** | 184.88** | 1.71** | 0.013** | 9546.17** | 1.18** |
| **Y×G** | 17 | 1.85$^{ns}$ | 29.66$^{ns}$ | 0.01** | 0.002** | 2699.29$^{ns}$ | 0.012$^{ns}$ |
| **I×G** | 17 | 349.00** | 121.23** | 1.01** | 0.010** | 4419.36* | 0.33** |
| **Y×I×G** | 17 | 0.31$^{ns}$ | 30.61$^{ns}$ | 0.007$^{ns}$ | 0.001$^{ns}$ | 2852.89$^{ns}$ | 0.019** |
| **$E_b$** | 215 | 1.08 | 30.78 | 0.007 | 0.0010 | 2137.59 | 0.019 |
| **CV%** | | *5.49* | *6.56* | *10.22* | *18.77* | *23.61* | *9.54* |

ns, *, and ** were on significant, significant at level 5 and 1% respectively

**Table 4. Analysis of variance of traits related to quantitative and qualitative characteristics of sugar beet in two conditions (N: normal; S: water deficit)**

| S.O.V | df | Root Yield | | Sugar Extraction Coefficient | | Guaiacol peroxidase | |
|---|---|---|---|---|---|---|---|
| | | N | S | N | S | N | S |
| **Rep.** | 2 | 0.03 | 0.09ns | 0.07 | 65.47 | 0.0003 | 0.002 |
| **Year (Y)** | 1 | 0.13$^{ns}$ | 28.37** | 0.98ns | 74.68** | 0.0004$^{ns}$ | 0.006ns |
| **E1** | 2 | 0.02 | 0.04 | 0.30 | 56.27 | 0.005 | 0.001 |
| **Genotype (G)** | 17 | 243. 66** | 137.19** | 220.36** | 85.86$^{ns}$ | 0.207** | 2.52** |
| **Y×G** | 17 | 0.06$^{ns}$ | 20.10** | 0.17ns | 60.11$^{ns}$ | 0.014$^{ns}$ | 0.02** |
| **E2** | 68 | 0.09 | 0.16 | 0.14 | 61.41 | 0.009 | 0.005 |
| **CV%** | | *5.52* | *4.45* | *6.45* | *9.21* | *18.46* | *6.30* |

**Table 4. Continued**

| S.O.V | df | Polyphenol oxidase | | Superoxide dismutase | | Proline | |
|---|---|---|---|---|---|---|---|
| | | N | S | N | S | N | S |
| **Rep.** | 2 | 0.002 | 0.00046 | 835.32 | 51221.17 | 0.002 | 0.022 |
| **Year (Y)** | 1 | 0.006$^{ns}$ | 0.025** | 199815.1** | 28517.3$^{ns}$ | 0.009$^{ns}$ | 0.007ns |
| **E1** | 2 | 0.004 | 0.0027 | 176.67 | 49998.25 | 0.002 | 0.015 |
| **Genotype (G)** | 17 | 0.004** | 1.91** | 21866.78** | 107751.2** | 0.44** | 1.07** |
| **Y×G** | 17 | 0.001$^{ns}$ | 0.45** | 99205.70** | 45601.44$^{ns}$ | 0.003$^{ns}$ | 0.02* |
| **E2** | 68 | 0.002 | 0.0070 | 765.88 | 42665.12 | 0.001 | 0.014 |
| **CV%** | | *18.88* | *9.19* | *5.78* | *27.01* | *7.63* | *9.05* |

$^{*}$,$^{**}$ , and $^{ns}$ represent significant at of 5% and 1% probability level and not significant, respectively.

**Table 5. Mean comparison of the studied treatment for quantitative and qualitative traits of sugar beet in two years (N: normal; S: water deficit)**

| | Root Yield (t ha$^{-1}$) | | Sugar Extraction Coefficient | | Guaiacol peroxidase (µmole g$^{-1}$ FW) | |
|---|---|---|---|---|---|---|
| **Genotype** | **N** | **S** | **N** | **S** | **N** | **S** |
| **Pars** | 37.93m | 31.4m | 82.27j | 91.81 | 0.61be | 0.76hi |
| **F-20722** | 56.78k | 42.5k | 88.84gh | 90.69 | 0.53ef | 0.96f |
| **F-20815** | 74.23d | 60.72e | 85.55f | 88.688 | 0.4hi | 0.68ij |
| **F-20817** | 66.83f | 57.11f | 82.29ab | 87.67 | 0.41fgi | 1.17e |
| **F-20747** | 72.37e | 70.30c | 82.2k | 87.987 | 0.51efg | 1.21de |
| **Paya** | 64.15g | 49.70g | 81.11bc | 87.07 | 0.39hi | 0.79gh |
| **F-20723** | 62.66i | 49.92i | 80d | 86.06 | 0.41ghi | 0.72hij |
| **F-20851** | 85.7a | 72.14ab | 87.7c | 86.06 | 0.7bc | 3.20a |
| **F-20734** | 85.70a | 62.21d | 89.9gh | 85.985 | 0.31i | 0.67j |
| **F-20716** | 80.7c | 70.03c | 60m | 84.884 | 0.85ab | 1.19de |
| **Sharif** | 19.40o | 16.94o | 81.1fg | 84.084 | 0.46egh | 0.97f |
| **F-20772** | 61.7j | 46.71l | 85.5k | 84.084 | 0.47fgh | 2.23b |
| **Arya** | 61.98j | 41.04l | 70l | 83.883 | 0.35i | 0.75hij |
| **Shokoofa** | 56.51k | 47.01h | 81.1e | 82.782 | 0.70cd | 1.75c |
| **F-20814** | 83.12b | 73.94a | 89.9i | 82.182 | 0.91a | 1.26d |
| **Ekbatan** | 33.09n | 32.15n | 87.7i | 80.28 | 0.68cd | 0.86g |
| **F-20866** | 63.62h | 60.17e | 87.7h | 80.1 | 0.39hi | 0.87g |
| **F-20758** | 49.92l | 45.16j | 87.71a | 76.86 | 0.32i | 0.87g |

**Table 5. Continued**

| | Polyphenol oxidase mg/g FW | | Superoxide dismutase µmole/g FW | | Proline mg/g FW | |
|---|---|---|---|---|---|---|
| **Genotype** | **N** | **S** | **N** | **S** | **N** | **S** |
| **Pars** | 0.022de | 0.056ij | 9363.4a | 7499.17b-e | 0.635e | 1.16d |
| **F-20722** | 0.002e | 0.020l | 8812.7b | 5456.36de | 0.253i | 1.80a |
| **F-20815** | 0.013de | 0.111f | 6133.5c | 14800.58ab | 0.786c | 1.16d |
| **F-20817** | 0.025de | 0.049j | 5918.1c | 14085.15ab | 0.316gh | 1.46c |
| **F-20747** | 0.018de | 0.144c | 5853.2c | 12422.42a-d | 0.425f | 1.23d |
| **Paya** | 0.031cde | 0.119ef | 4847.7d | 6480.36cde | 0.258i | 1.02e |
| **F-20723** | 0.08abc | 0.126de | 4791.9d | 8077.89b-e | 0.263i | 1.3d |
| **F-20851** | 0.044cde | 0.035k | 4737.4d | 14713.41ab | 0.851b | 1.7ab |
| **F-20734** | 0.007de | 0.132d | 4714.1d | 6238.63cde | 0.848b | 1.7ab |
| **F-20716** | 0.039cde | 0.051j | 4592.3d | 13388.18abc | 0.983a | 1.8a |
| **Sharif** | 0.103a | 0.160b | 4231.6e | 9794.58b-e | 0.238i | 0.56g |
| **F-20772** | 0.097ab | 0.085g | 3822.7f | 9783.69b-e | 0.847b | 1.79a |
| **Arya** | 0.039cde | 0.017l | 3790.7f | 19394.32a | 0.443f | 1.26d |
| **Shokoofa** | 0.050b-e | 0.074h | 3452.2g | 9312.45b-e | 0.963a | 1.47c |
| **F-20814** | 0.048b-e | 0.066h | 3261.3g | 9425.84b-e | 0.695d | 1.66b |
| **Ekbatan** | 0.020d-e | 0.090g | 2774.0h | 3900.54e | 0.354g | 0.76f |
| **F-20866** | 0.056a-e | 0.065hi | 2563.1h | 4883.25e | 0.667de | 1.25d |
| **F-20758** | 0.043cde | 0.242a | 2512.4h | 5806.08de | 0.268hi | 0.43g |

Similar lettesrs for means indicating non significant difference at 0.05 probability level.

**Table 6. The correlation between traits, low numbers related to normal and high numbers related to water deficit conditions at two years**

| Traits | Root yield | Sugar extraction coefficient | Guaiacol peroxidase | Polyphenol oxidase | Superoxide dismutase | Proline |
|---|---|---|---|---|---|---|
| **Root Yield** | 1 | $0.03^{ns}$ | 0.30** | 0.34** | 0.26** | 0.56** |
| **Sugar extraction coefficien** | 0.71** | 1 | $0.14^{ns}$ | $-0.21^{ns}$ | $-0.05^{ns}$ | $0.12^{ns}$ |
| **Guaiacol peroxidase** | $0.16^{ns}$ | $0.02^{ns}$ | 1 | 0.20* | $0.17^{ns}$ | 0.43** |
| **Polyphenol oxidase** | $-0.15^{ns}$ | -0.25** | $-0.15^{ns}$ | 1 | $0.12^{ns}$ | $0.05^{ns}$ |
| **Superoxide dismutase** | 0.25** | $0.10^{ns}$ | $-0.02^{ns}$ | $0.01^{ns}$ | 1 | $0.13^{ns}$ |
| **Proline** | 0.48** | $0.15^{ns}$ | 0.39** | $-0.04^{ns}$ | 0.20* | 1 |

ns, *, ** significant and insignificant at 1 and 5% levels respectively

**Table 7. Results of stepwise regression analysis of the studied traits with root yield as dependent variable under normal condition**

| Variables | 1 | 2 |
|---|---|---|
| **Contrast** | -138.77 | -138.32 |
| **Sugar extraction coefficien** | 2.36 | 2.16 |
| **Proline** | | 27.86 |
| **$R^2$** | *0.71* | *0.80* |

**Table 8. Path analysis of traits affecting root yield under normal condition**

| | | Indirect effect | | |
|---|---|---|---|---|
| **Variables** | **Direct effect** | **Sugar Extraction Coefficien** | **Proline** | **R** |
| **Sugar Extraction Coefficien** | 0.65** | - | 0.057 | 0.71** |
| **Proline** | 0.38** | 0.097 | - | 0.48** |

**Table 9. Results of stepwise regression analysis of the studied traits with root yield as dependent variable under water deficit condition**

| Variables | 1 | 2 | 3 |
|---|---|---|---|
| **Contrast** | 27.89 | 21.73 | 19.91 |
| **Proline** | 19.76 | 18.92 | 18.20 |
| **Guaiacol peroxidase** | | 75.09 | 70.54 |
| **Superoxide dismutase** | | | 0.56 |
| **$R^2$** | 0.563 | 0.644 | 0.663 |

**Table 10. Path analysis of traits affecting root yield under normal condition**

| | | Indirect effect | | | |
|---|---|---|---|---|---|
| **Variable** | **Direct effect** | **Proline** | **Guaiacol peroxidase** | **Superoxide dismutase** | **Correlation** |
| **Proline** | 0.52** | - | 0.12 | 0.02 | 0.65** |
| **Guaiacol peroxidase** | 0.29** | 0.22 | - | 0.02 | 0.30** |
| **Superoxide dismutase** | 0.160* | 0.06 | 0.04 | - | 0.26** |