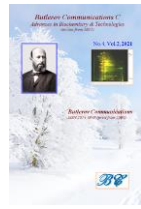
BUTLEROV HERITAGE

Butlerov Communications C
Advances in Biochemistry & Technologies
ISSN 2074-0948 (print)

2021. Vol.2, No.4, Id.15.
Journal Homepage: https://c-journal.butlerov.com/



Thematic section: Biochemical Research.
Subsection: Physiology and Biochemistry of Plants.

Full Paper

The Reference Object Identifier – ROI-jbc-C/21-2-4-15
The Digital Object Identifier – DOI: 10.37952/ROI-jbc-C/21-2-4-15
Received 22 October 2021; Accepted 25 October 2021

Physiological and biochemical characteristics of shoots triticale in NaCl-stress in the light of statistical methods

Viktor V. Ivanishchev
Department of Biology and Technologies of Living Systems. Tula State Lev TolstoyPedagogical University. Lenin Ave., 125. Tula, 300026. Russia.
Phone: +7 (4872) 65-78-08. E-mail: avdey_VV@mail.ru

Keywords: shoots of triticale (*Triticosecale*), NaCl-stress, physiological and biochemical characteristics, cluster analysis, principal component analysis (PCA), correlation analysis.

Abstract

The application of methods of cluster analysis, principal component analysis (PCA) and correlation analysis for processing data on alterations in the physiological and biochemical characteristics of triticale shoots made it possible to come to a number of conclusions that differ from the currently accepted ideas about the role of such antioxidant enzymes as catalase and guaiacol-peroxidase, as well as ascorbic acid in providing processes of adaptation of shoots to short-term NaCl-stress. The application of principal component analysis made it possible for the first time to note the importance of redox processes for such an indicator as water content. This conclusion is consistent with the positive values between the water content with electron transport (0.69), carbonic anhydrase activity (0.84), and lipid peroxidation (LPO) (0.69). It has been shown that the content of glutathione is closely related to the process of photosynthesis. The positive values of the correlation coefficients in pairs: glutathione – the intensity of photosynthesis (0.90) and glutathione – Rubisco (0.69) also confirm this point of view. It was found that guaiacol peroxidase can be (indirectly) associated with the presence of pigments, which is reflected in high values of the mutual correlation coefficients with the content of chlorophyll (0.84) and carotenoids (0.72). At the same time, under the experimental conditions, the enzyme is the most effective of those studied for the utilization of hydrogen peroxide ($r = –0.73$). The formation of a primary cluster between catalase and LPO can be interpreted as a direct relationship between the activity of this enzyme and membrane damage rather than membrane protection. Similar conclusions can be drawn with the PCA method and correlation analysis: $r = 0.94$ (catalase – LPO). The application of cluster analysis also suggests the importance of ascorbic acid for maintaining water exchange during the adaptation of triticale shoots to the action of short-term NaCl-stress. The same conclusion can be drawn when analyzing the data by PCA and correlation analysis: $r = 0.81$ (ascorbate – proline), $r = 0.79$ (ascorbate – stomatal conductance), $r = 0.79$ (ascorbate – transpiration).

For citation: Viktor V. Ivanishchev. Physiological and biochemical parameters of triticale shoots under NaCl-stress in the light of PCA method. *Butlerov Communications C*. **2021**. Vol.2. No.4. Id.15. DOI: 10.37952/ROI-jbc-C/21-2-4-15

References

[1] E.I. Koshkin. The physiology of crop sustainability. *Moscow: Drofa*. **2010**. 638p. (Russian)

[2] M. Torabi. Physiological and biochemical responses of plants to salt stress. *The 1st Intern Conf on New Ideas in Agricultural. Islamic Azad University Khoragsan Branch. 26-27 jan 2014. Isfahan, Iran.* **2014**. 25 p. https://www.semanticscholar.org/paper/PHYSIOLOGICAL-ANDBIOCHEMICAL-RESPONSES-OF-PLANTS Torabi/f8867445eae6156a0e16ef13f2c74e6c836be7e9#citing-papers.

[3] V.V. Ivanishchev, T.N. Evgrashkina, O.I. Boikova, N.N. Zhukov. Soil salinization and its influence the plants. *Proceedings of TulSU. Earth Sciences*. **2020**. Iss.3. P.28-42. (Russian)

[4] V.V. Ivanishchev. About the mechanisms of plant resistance to salt and specificity of salinization influence. *Proceedings of TulSU. Natural Sciences*. **2019**. Iss.4. P.74-88. (Russian)

[5] V.V. Ivanishchev. New directions of research in increasing the salt tolerance of plants. *Proceedings of TulSU. Natural Sciences*. **2021**. Iss.2. P.47-55. DOI: 10.24412/2071-6176-2021-2-47-55. (Russian)

[6] A. Sharma, M. Bakshi. Variability in Growth, Physiological, and Biochemical Characteristics among Various Clones of *Dalbergia sissoo* in a Clonal Seed Orchard. *International Journal of Forestry Research*. **2014**. Vol.2014. Article ID 829368, 9 pages. http://dx.doi.org/10.1155/2014/829368

[7] S. Chunthaburee, A. Dongsansuk, J. Sanitchon, W. Pattanagul, P. Theerakulpisut. Physiological and biochemical parameters for evaluation and clustering of rice cultivars differing in salt tolerance at seedling stage. *Saudi Journal of Biological Sciences*. **2016**. Vol.23. P.467-477.

[8] N. Nejat, H. Sadeghi. Finding out relationships among some morpho-biochemical parameters of Christ's thorn (*Ziziphus spina-christi*) under drought and salinity stresses. *Planta Daninha, Viçosa-MG*. **2016**. Vol.34(4). P.667-674. Doi: 10.1590/S0100-83582016340400006

[9] Z. Xie, C. Wang, S. Zhu, W. Wang, J. Xu, X. Zhao. Characterizing the metabolites related to rice salt tolerance with introgression lines exhibiting contrasting performances in response to saline conditions. *Plant Growth Regulation*. **2020**. Vol.92. P.157-164. https://doi.org/10.1007/s10725-020-00627-y

[10] M. Labra, F. Grassi, S. Imazio, T. Di Fabio, S. Citterio, S. Sgorbati, E. Agradi. Genetic and DNA-methylation changes induced by potassium dichromate in *Brassica napus* L. *Chemosphere*. **2004**. Vol.54. P.1049-1057. doi: 10.1016/j.chemosphere.2003.10.024

[11] K. Nakashima, H. Takasaki, J. Mizoi, K. Shinozaki, K. Yamaguchi-Shinozaki. NAC transcription factors in plant abiotic stress responses. *Biochimica et Biophysica Acta (BBA)-Gene Regulatory Mechanisms*. **2012**. Vol.1819. P.97. DOI: 10.1016/j.bbagrm.2011.10.005

[12] V.V. Ivanishchev. Investigation of the effect of short-term salt stress with the method of cluster analysis. *Butlerov Communications.* **2018**. Vol.54. No.4. P.134-139. DOI: 10.37952/ROI-jbc-02/18-54-4-134 (Russian)

[13] A.R. Garifzyanov, N.N. Zhukov. The effect of sodium chloride salinity on the content of ascorbate-glutathione cycle components in the organs of triticale. *Proceedings of TulSU. Natural Sciences*. **2012**. Iss.3. P.165-174. (Russian)
[14] A.R. Garifzyanov, N.N. Zhukov, V.V. Ivanishchev, A.A. Kosobryukhov. Regulation of water exchange in winter triticale under conditions of NaCl-salinity. *The Bulletin of Kharkiv National Agrarian University. Series Biology*. **2013**. Iss.1(28). P.34-43.
[15] CIRAS-2 Portable Photosynthesis System. *For Research*. http://www.potencialzero.com/media/33461/edsciras2.pdf.
[16] A.R. Garifzyanov, N.N. Zhukov, V.V. Ivanishchev, A.A. Kosobryukhov. The functional state of the photosynthetic apparatus of triticale seedlings under chloride salinity. *Proceedings of TulSU. Natural Sciences*. **2014**. Iss.1. Part 1. P.280-290. (Russian)
[17] H.K. Lichtentaller, A.R. Welburn. Determinations of total carotenoids and chlorophylls a and b of leaf extracts in different solvents. *Biochem. Soc. Trans*. **1983**. Vol.11(6). P.591-592.
[18] Y. Nakano, K. Asada. Hydrogen peroxide is scavenged by ascorbate-specific peroxidase in spinach chloroplasts. *Plant Cell Physiol*. **1981**. Vol.22. P.867-880.
[19] H. Aeby. Catalase *in vitro*. *Methods Enzymol*. **1984**. Vol.105. P.121-126.
[20] V.V. Ivanishchev. Biochemical experiment. *Tula: Publishing house of L.N. Tolstoy TSPU*. **2002**. 75p. (Russian)
[21] N.N. Zhukov, A.R. Garifzyanov, V.V. Ivanishchev. Dynamics of the activity of antioxidant enzymes in the organs of *xTriticosecale* against the background of NaCl-salinity. *Proceedings of TulSU. Natural Sciences.* **2012**. Iss.2. P.285-291. (Russian)
[22] A.R. Garifzyanov, N.N. Zhukov, YU.O. Pantyukhin, V.V. Ivanishchev. Features of NaCl-induced oxidative stress and dynamics of antioxidant enzyme activity in winter triticale organs. *Reports of RAAS*. **2012**. Vol.2. P.9-11. (Russian)
[23] N.N. Bureeva. Multivariate statistical analysis using RFP "STATISTICA". *Nizhny Novgorod*. **2007**. 112p. (Russian)
[24] D.A. Shabanov, M.A. Kravchenko. Statistical data analysis in zoology and ecology. **2011**. https://batrachos.com/biostatistic (Russian)
[25] V.V. Ivanishchev Application of principal component analysis to the indicators of water exchange of triticale shoots under NaCl stress. *Butlerov Communications.* **2020**. Vol.62. No.4. P.129-134. DOI: 10.37952/ROI-jbc-01/20-62-4-129 (Russian)
[26] H.W. Heldt, B. Piechulla. Plant Biochemistry (4 ed.). *Amsterdam et al.: Academic Press is an imprint of Elsevier*. **2011**. 647p.
[27] V.V. Ivanishchev, and N.N. Zhukov. On the interrelation of water exchange and photosynthesis in triticale sprouts with short-term action of sodium chloride. *Butlerov Communications*. **2018**. Vol.53. No.3. P.35-42. DOI: 10.37952/ROI-jbc-02/18-53-3-35 (Russian)
[28] V.V. Ivanishchev. Plant production process and its regulation. *Tula: Publishing house L.N. Tolstoy TSPU*. **2011**. 114p. (Russian)
[29] H. Kirst, S.T. Gabilly, K.K. Niyogi, P.G. Lemaux, A. Melis. Photosynthetic antenna engineering to improve crop yields. *Planta*. **2017**. Vol.245(5). P.1009-1018. DOI 10.1007/s00425-017-2659-y
[30] V.V. Ivanishchev The application of statistical methods to indicators of triticale photosynthesis under chloride stress. *Butlerov Communications.* **2020**. Vol.61. No.3. P.105-111. DOI: 10.37952/ROI-jbc-01/20-61-2-3-105 (Russian)
[31] N.N. Rudenko, L.K. Ignatova, T.P. Fedorchuk, Ivanov B.N. Carbonic anhydrases of higher plant photosynthetic cells. *Biochemistry*. **2015**. Vol.80(6). P.798-813. (Russian)

[32] D.S. Veselov. Stretch growth and water exchange in conditions of water scarcity. *Abstract of PhD Thesis.(Doctor Level on Biological Sciences). Ufa*. **2009**. 47p. (Russian)
[33] V.V. Ivanishchev Oxidative stress and low molecular weight antioxidants in triticale shoots under chloride salinization. *Butlerov Communications.* **2020**. Vol.62. No.6. P.125-130. DOI: 10.37952/ROI-jbc-01/20-62-6-125 (Russian)
[34] Yu.E. Kolupaev. The reactive oxygen species in plants under the action of stressors: the formation and possible functions. *The Bulletin of Kharkiv National Agrarian University. Series Biology*. **2007**. Vol.3. No.12. P.6-27.
[35] A.R. Garifzyanov, N.N. Zhukov, V.V. Ivanishchev. Formation and physiological reactions of oxygen active forms in plant cells. *Modern Problems of Science and Education*. **2011**. Vol.2. 21p. (Russian)
[36] V.V. Ivanishchev Oxidative stress and antioxidant enzymes in triticale shoots under chloride salinization. *Butlerov Communications.* **2020**. Vol.63. No.7. C.99-105. DOI: 10.37952/ROI-jbc-01/20-63-7-99 (Russian)
[37] Electronic handbook: Michaelis-Menten constants for some analytically important enzymatic reactions. https://www.chemport.ru/data/data952.shtml (Russian)
[38] L. Ghamsari, E. Keyhani, S. Golkhoo. Kinetics Properties of Guaiacol Peroxidase Activity in *Crocus sativus* L. Corm during Rooting. *Iranian Biomedical Journal*. **2007**. Vol.11(3). P.137-146.
[39] A.N. Hiner, J.N. Rodríguez-López, M.B. Arnao, E.L. Raven, F. García-Cánovas, M. Acosta. Kinetic study of the inactivation of ascorbate peroxidase by hydrogen peroxide. *Biochem J.* **2000**. Vol.348 (Pt 2). P.321-328.
[40] Y. Huang, D.-Y. Ge, H. Zong, J.-X. Yin, X.-N. Qu, S.-W. Lv. Active Site Mimicry of Glutathione Peroxidase by Glutathione Imprinted Selenium-Containing Trypsin. *Catalysts*. **2017**. Vol.7. P.282-290. doi:10.3390/catal7100282
[41] V.V. Ivanishchev. Indicators of the antioxidant system and oxidative stress of triticale shoots under chloride salinity. *Butlerov Communications.* **2020**. Vol.63. No.9. P.51-58. DOI: 10.37952/ROI-jbc-01/20-63-9-51 (Russian)
[42] Viktor V. Ivanishchev. Physiological and biochemical parameters of triticale shoots under NaCl-stress in the light of PCA method. *Butlerov Communications.* **2021**. Vol.68. No.12. P.137-146. DOI: 10.37952/ROI-jbc-01/21-68-12-137 (Russian)