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EFFECT OF SODIUM-IZOCATION SALTS ON THE ACTIVITY OF SUPEROXIDE DISMUTASE IN THE ROOTS OF BARLEY SEEDLINGS CULTIVATED IN WATER CULTURE

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Abstract. The activity of superoxide dismutase (SOD) in the root system of barley seedlings cultivated under sodium-izocation salinity conditions was studied. The SODactivity was found to be lower in the roots of 5-7-9-day-old barley seedlingscompared to the shoots. The research revealed that the activity of SOD increased starting from 5-day-old seedlings to 9-day-old seedlingsdepending on the day in the rootsas well as in theshoots.

According to the obtained results, the enzyme activity in 5-7-9-day-old barley sprouts grown in water culture depends on the concentration of sodium-izocation salts in the medium. It has been found that the SODactivity increases linearly in the root system of 5-7-9-day-old seedlings with the increasing concentration of sodium-izocation salts (25-50 mM). Although the activity of the enzyme begins to decreaseduring the subsequent increase in the concentration (75-100 mM), it is higher than the control. However, the change in the activity is not linear.

The increase in the activity of SOD under the influence of sodium-izocation salts is related to the defense mechanism activated under stress. Thus, the change in the activity of SOD due to the effect of sodium-izocation salts (NaCl, Na_2SO4) is adequate. The ions of the salts used were arranged in this order according to their ability to inhibit the SOD activity: sulfate anion more than chloride anion.

Keywords: *izocation, adequate, superoxide dismutase, antioxidant, salt stress.*

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1. Introduction

According to modern calculations, 15-23% of the dry area of the earth, including agricultural lands are saline soils (Khitrov *et al.*, 2019). Soil salinity, which is one of the main environmental factors, has a serious effect on the development and productivity of agricultural plants (Sun *et al.*, 2016). In Azerbaijan, there are more than 1.3 million hectares of saline soil (Mammadov, 2007).

From a chemical point of view, the type of salinity is determined by the amount of anions in the soil (Pilipenko, 2005). It should be noted that the salt composition in Azerbaijani soils is quite diverse: chloride-sulfate or sulfate-chloride type of salinization is widespread. Besides, carbonate salinity is not uncommon, and sodium salts are predominant (Mammadov, 2007).

Currently, sodium chloride salinity is considered the most dangerous (Wang *et al.*, 2013), because the damaging effect on plants is caused by both sodiumcations (Munns,

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Jafarzade B. (2022). Effect of sodium-izocation salts on the activity of superoxide dismutase in the roots of barley seedlings cultivated in water culture. *Advances in Biology & Earth Sciences, 7*(3), 218-223.

2005, 2008) and chlorine anions. Moreover, the high concentration of sodium negatively affects the structure of the soil. It should be noted that the accumulation of Na^+ cations in the soil significantly worsens the physical properties of the soil, leading to the disturbance of the soil structure and deterioration of the water and air regimes (Mammadov, 2007).

The most dangerous salinity in the soil is sodium-chloride salinity because chemically active ions such as Na^+ and Cl^- accumulate in plant cells in excess, have a negative effect on some physiological-biochemical processes, and ultimately sharply reduce productivity (Flowers & Colmer, 2008; Ibrahimova, 2015). In addition, the high concentration of sodium negatively affectsthe structure of the soil (Mammadov, 2007).

On the other hand, excessive accumulation of toxic ions such as Na^+ and Cl^- in the cell leads to the formation of reactive oxygen species, which creates oxidative stress (Parida & Das, 2005).

Thus, the study of the mechanisms of the salt effect on plant organisms is of theoretical and great practical importance. A number of researchers associate the toxic effect of salts on plants with the inhibition of the activity of cell enzymes (Kasumov, 2012, Abdiyev, 2017).

Under normal growth conditions, reactive oxygen species are formed during physiological processes occurring in plants. A need emergesfor the activity of the antioxidant defense system, which controls the level of free radicals (Kolupayev, 2007). The high concentration of salts creates oxidative stress, causing the accumulation of reactive oxygen species, which is the primary response of plants to salt stress.

The antioxidant enzyme system plays an important role in higher plants to reduce the negative effect of reactive oxygen species (Zhukov, 2012). Enzymes neutralizing reactive oxygen speciesare catalase, superoxide dismutase, ascorbate peroxidase, and other peroxidases.

Researchers have found a correlation between stress tolerance and the level of antioxidant system activity. The amount of reactive oxygen species, including superoxide radicals, is known to increase in plant cells under conditions of extreme salinity (Parida & Das, 2005).

Superoxide dismutase is one of the enzymes of the antioxidant defense system that plays the most important role in protecting cells and tissues from oxidative damage under salt stress conditions.

2. Object and method of the study

Barley plant, which is an important grain plant in our republic was chosen as the object of research. It is cultivated for food, fodder, and technical purposes and barley flour can be added to 20-25% wheat flour if needed. In the experiments,5-7-9-day-old seedlings of the Karabakh-22 variety were used. Seedlings were cultivated in Knop's solution, as well as in 25-100 mM NaCl and Na_2SO_4 solutions at a temperature of 20°C under normal aeration conditions. The SOD activity in barley seedlings was determined by the spectrophotometric method and calculated according to the reaction rate.

The research was carried out in 3-4 repetitions, the obtained results were processed statistically. In the studies, the accuracy rate was lower than 5%, the obtained results are mathematically reliable.

3. Results and discussion

The effect of very large amounts of sodium salts in the soil on some properties of plants is extremely diverse. It depends on the salinity of the soil, the plant species, and the variety. This, in turn, leads to changes in various morphometric characteristics of plants grown in saline soil, as well as biochemical processes occurring in them (Zhukov, 2016; Torabi, 2014; Belozerova, 2010, 2014).

Several defense systems exist in plant organisms. One such defense system is the cell enzyme system. In this regard, superoxide dismutase is one of the widely distributed enzymes in plants. A certain amount of superoxide dismutase is found in all cells, it catalyzes the dismutation reaction of superoxide anion radicals (from O_2^- to H_2O and O_2) and regulates their amount in the cell.

Despite numerous studies on the effect of salts on enzymes, most of this information is conflicting. On the other hand, the mechanism of the effect of salts on enzyme activity has not yet been fully clarified. Studying the activity of superoxide dismutase (SOD) in the first stages of ontogenesis under the influence of salts in plants is of both theoretical and practical importance.

The research was carried out on 5-7-9-day-old barley seedlings. It is considered that seed germination is the most critical stage of plant development and the most sensitive to external environmental factors. Since all physiological functions are at maximum activity during this stage, tolerance is also very low. As a result of the absorption of water by the seeds during the germination process, hydrolytic enzymes are first activated and the reserve nutrients are hydrolyzed into simpler substances - monomers. Then the synthesis of enzymes and oxidation processes accelerate. In the experiments, the effect of salt solutions of different concentrations on the activity of superoxide dismutase in barley seedlings was studied.

The activity of superoxide dismutase (SOD) was found to be lower in the roots (underground part) than in the shoots (above-ground parts) of 5-7-9-day-old barley seedlings.The research revealed that the activity of SOD in both roots and shoots of 5-7-9-day-old barley seedlings increased depending on the day. This indicates that the activity of superoxide dismutase increases due to the synthesis of the intracellular enzyme in the control variant (normal conditions). Besides, it can be assumed that the high activity of the enzyme under normal conditions is attributed to the low demand for it.

In addition, the activity of superoxide dismutase was studied in the underground parts of barley seedlings under the influence of different concentrations (25-100 mM) of isocation sodium salts (NaCl and Na_2SO_4).

The conducted studies have shown that the SOD activity in 5-7-9-day-old barley seedlings grown in water culture depends on the salt concentrations in the medium. As the concentration of NaCl in the medium increases (25-50 mM), the SOD activity increases linearly in the root system of 5-day-old seedlings, while the activity of the enzyme decreases during the subsequent increase in concentration (75-100 mM). Althoughthe activity of the enzyme was slightly weakened with increasing concentration of NaCl in a water culture (50-75 mM), it was higher than the control.However, the change in the enzyme activity was not linear (Figure 1).

It should be noted that at 50 mM NaCl, the activity of SOD in the root system increased by 15.2%, 17.4%, and 16.6%, respectively,in 5-, 7-, and 9-day-old seedlings compared to the control. At 100 mM NaCl, the activity of SOD in the root system of 5-,

7-, and 9-day-old barley seedlings was 8.9%, 6.2%, and 4.9% higher than the control, respectively (Figure 2).

Similar results were obtained in the case of sulfate salinity. Thus, the activity of SOD enhanced with increasing Na_2SO_4 concentrations (25-50 mM), while the subsequent increase in concentration (75-100 mM) led to a decrease in the enzyme activity, though it was higher than the control (Figure 3).

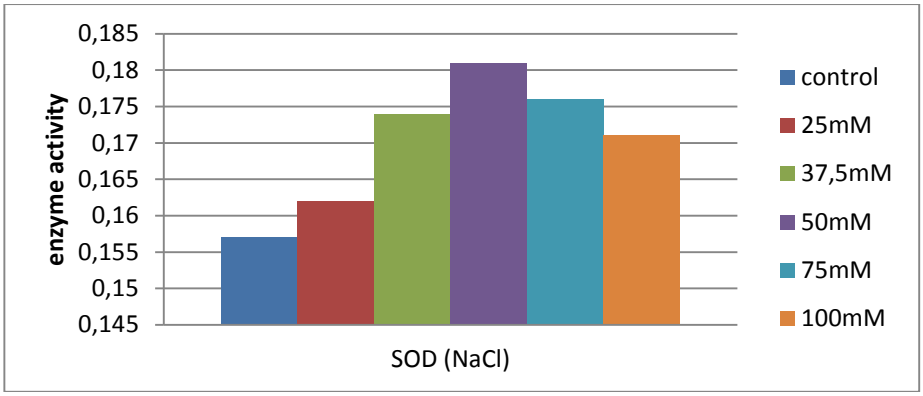

Figure 1. SOD activity in the root system of 5-day-old barley seedlings grown in water culture under different concentrations of NaCl

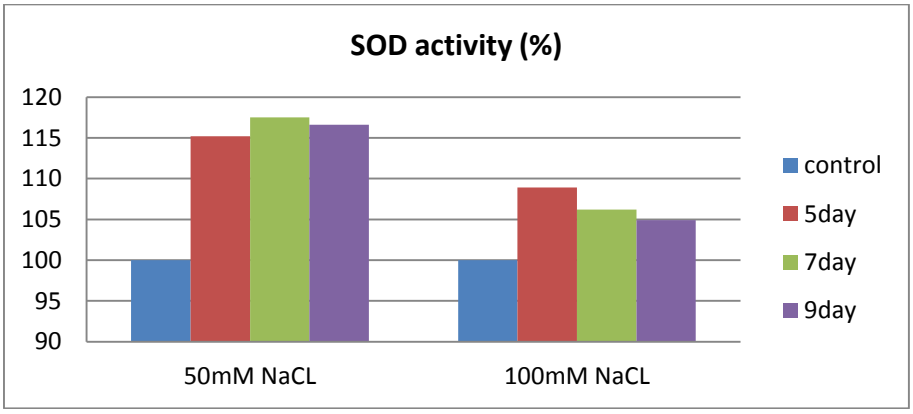

Figure 2. Comparative description of the activity of SOD in the root system of 5-7-9-day-old barley seedlings grown in water culture at 50mM NaCl

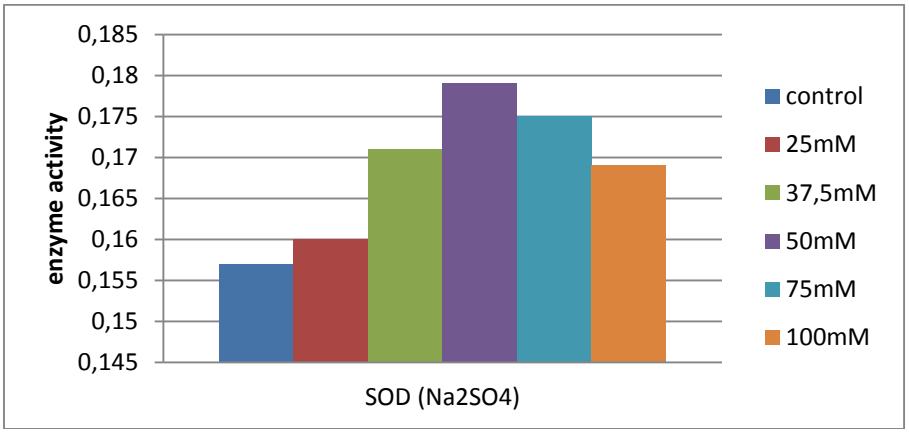

Figure 3. SOD activity in the root system of 5-day-old barley seedlings grown in water culture under different Na_2SO_4 concentrations

It should be noted that at 50mM Na_2SO_4, the SOD activity in the root system of 5-7-, and 9-day-old barley seedlings increased by 14%, 12.4%, and 14.1%, respectively, compared to the control. Besides, at 100 mM Na_2SO_4, the SOD activity in the root system of 5-,-7-, and 9-day-old barley seedlings was higher by 7.6%,5%, and 6.7% than the control, respectively (Figure 4).

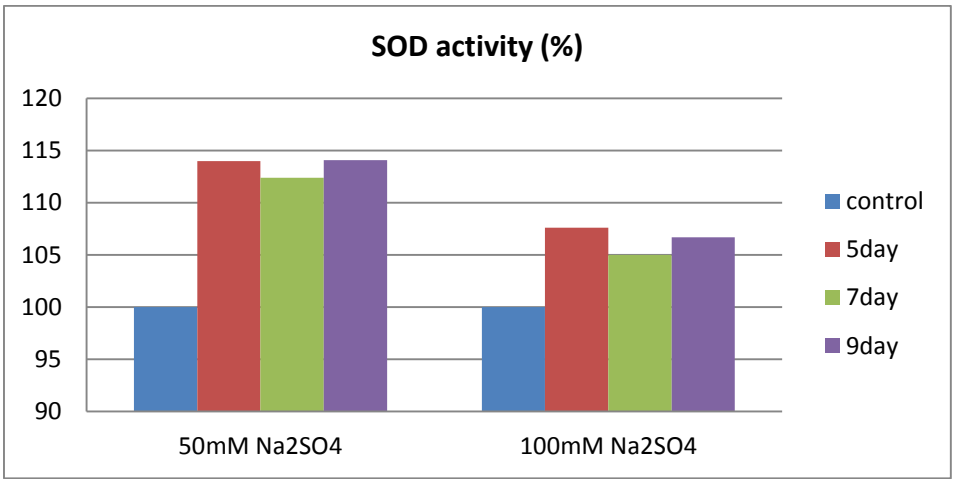

Figure 4. Comparative description of the SOD activity in the root system of 5-7-9-day-old barley seedlings grown in water culture under the influence of 50mM Na_2SO_4

The increase in enzyme activity under stress conditions can be explained by the increase in the synthesis of new enzyme molecules.

During long-term exposure to high-concentration salts (75-100 mM), the SOD activity may be weakened due to a decrease in the amount of superoxide radicals during neutralization. In addition, H_2O_2 and hydroxyl radical (OH^-) can cause enzyme inactivation or degradation.

The obtained results are consistent withthe literature data. Thus, according to some scientists (Wu *et al*., 2013), the increase in the activity of SOD serves to protect cells and tissues from oxidative damage under stress. There are also data on the weakening of SOD activity during long-term stress (Santos *et al*., 2011).

It should be noted that H_2O_2 formed as a result of the SOD action is an inhibitor of the enzyme. The activity of SOD depends on catalase and peroxidase, which belong to other defense system enzymes.

References

Abdiyev V.B. (2017). Research on alternative pathways of biological oxidation in plants under extreme salinity conditions. PhD thesis, Baku, p.44 (in Azerbaijani)

Ibrahimova U.F. (2015). Morphophysiological and biochemical characteristics of wheat seedlings exposed to salt stress. PhD thesis, Baku, p.20 (in Azerbaijani)

Mammadov G.S. (2007). Fundamentals of soil science and soil geography. Baku: Elm, p.664 (in Azerbaijani)

Flowers T.J., Colmer T.D. (2008). Salinity tolerance in halophytes. *New Phytol*., 179, 945-963.

Kolupaev, Yu.E. (2007). Reactive oxygen species in plants under stress: formation and possible functions. *Bulletin of Kharkiv National Agrarian University. Series Biology*, *3*(12), 6-26 (in Russian).

Belozerova, A.A., Bome, N.A. (2014). Study of the response of spring wheat to salinity by the variability of the morphometric parameters of seedlings. *Fundamental Research*. 12, 300-306 (in Russian).

Belozerova, A.A., Lukashenko, M.G. (2010). Peculiarities of development of spring wheat plants under saline conditions. *Successes of modern natural sciences*, 7, 143 (in Russian).

Zhukov, H.H., Garifyazanov, A.P., Ivanishev, V.V. (2012). Dynamics of antioxidant enzyme activity in Triticosecaleorgans against the background of NaCl salinity. *Proceedings of the Tula State University. Natural Sciences*, 2, 285-291 (in Russian).

Zhukov, N.N., Boykova, O.I., Ivanishchev, V.V. (2016). Physiological and biochemical mechanisms of adaptation of triticale seedlings under short-term NaCl salinity (scientific monograph). Tbilisi: MP Polygraph, 125 (in Russian).

Kasumov, N.A. (2012). *The mechanism of action of salts on the plant organism*. Lap Lambert Academic Publishing, Germany, 175 (in Russian).

Khitrov, N.B., Rukhovich, D.I., Kalinina, N.V., Novikova, A.F., Pankova, E.I., Cherneusenko, G.I. (2009). Assessment of areas of saline soils on the territory of the European part of Russia. *Soil Science*, 6, 627-635 (in Russian).

Munns, R. (2005). Genes and salt tolerance: bringing them together. *New Phytol.*, 67, 645-663.

Munns, R., Tester, M. (2008). Mechanisms of salinity tolerance. *Ann. Rev. Plant Biol*., 59, 651–681.

Parida, A.K., Das, A.B. (2005). Salt tolerance and salinity effects on plants. *Ecotox. Environ. Safety.*, 60, 324-34.

Pilipenko, V.N., Yakovleva, L.V., Fedotova, A.V. (2005). Current state of saline soils of the Volga Delta. *Fundamental research*, 8, 145-149.

Santos Campos, A., Aevedo, H., Caldeira, G. (2011). In situ and in vitro senescence induced by KCl stress: nutritional imbalance, lipid peroxidation and antioxidant metabolism. *J. Exp. Bot*., 52, 351-360.

Sun, Z.W., Ren, L.K., Fan, J.W., Li, G., Wang K.J., Guo, M.M., Wang, L., Li, J., Zhang, G.X., Yang, Z.Y., Chen, F., Li, X.N. (2016). Saltresponse of photosynthetic electron transport system in wheat cultivars with contrasting tolerance. *Plant Soil Environ*., 62, 515-521

Torabi, M. (2014). Physiological and biochemical responses of plants to salt stress. *The 1st Intern Conf on New Ideas in Agricultura*l. Islamic Azad University Khoragsan Branch. 26-27 Jan. Isfahan, Iran. p.25

Wang, X., Hou, C., Liu, J., He, W., Nan, W., Gong, H., & Bi, Y. (2013). Hydrogen peroxide is involved in the regulation of rice (Oryza sativa L.) tolerance to salt stress. *Acta Physiologiae Plantarum*, *35*(3), 891-900.

Wu, F., Zhang, G., Dominy, P. (2013). Four barley genotypes respond differently to cadmium: lipid peroxidation and activities of antioxidant capacity. *Environ. Exp. Bot.*, 50, 67-78.