THE INFLUENCE OF SALIN STRESS ON TOTAL WATER CONTENT AT THE FOLIARY LEVEL AND pH OF THE SOIL TO SOME BEAN GENOTYPES FROM NORTH-EASTERN ROMANIA

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Abstract: Salinity is an important abiotic factor, *which results in a significant reduction in yield of crop plants.This study was based on the analysis of the effect of excess NaCl on water content and water forms (free water, bound water and total water) and soil pH, to 7 bean genotypes sensitive to salts collected from saline soils from North-Eastern Romania (Iasi, Vaslui and Botosani).The overall objective of the study is to contribute to a better understanding of the physiological mechanisms involved in the saline stress intoleranceof the species Phaseolus vulgaris L. and the identification of salinity tolerant cultures.The results showed that, after 30 days of treatment, the pH of the soil has changed due to the application of saline solutions.Thus, by passing the pH from neutral to alkaline, there was a reduction in the permeability of cell membranes, inhibiting the absorption of soil water.The determinations of the water forms in the analyzed plants show that the bound water has higher values for the 200 mM NaCl treated group,to all the genotypes studied, which denotes the salinity resistance of the studied populations, due to the fact that the bound water content increases the biological resistance to dehydration induced by physiological drought, which consists of the difficulty of absorbing the water at a high external osmotic pressure. In particular, the Blăgeşti 2 and Trușești 2 genotypes have been highlighted, indicating a high tolerance biological capacity, which is explained by the fact that mineral salts and organic acids reduce the intensity of sweating. The data was analyzed by calculating the correlation coefficient with Microsoft Excel.*

Key words*: pH, soil, total water, Phaseolus vulgaris L.*

INTRODUCTION

At this point that approx.50% of all irrigated croplands are affected by of salts (FLOWERS,1999), what determines economic losses of approx. US$13 billion per year (GHASSEMI ET AL.,1995). Saline soils are major problems contributing to the low productivity of bean in arid regions (SHAMSELDIN AND WEMER, 2005). Plant growth and development are adversely affected by salinity. The initial phase of growth reduction is due to an osmotic effect, is similar to the initial response to water stress and shows little genotypic differences. The second, slower effect is the result of salt toxicity in leaves. In the second phase a salt sensitive species or genotype differs from a more salt tolerant one by its inability to prevent salt accumulation in leaves to toxic levels (MUNNS AND TESTER,1993). Salinity is a factors limiting the productivity of crop plants because most of the crop plants are sensitive to salinity caused by high concentrations of salts in the soil, and the area of land affected by it is increasing day by day. Salinity greatly affects crop production, depending on the level of salinity and the tolerance limit at the critical stage of the growth of a particular crop. The agricultural land is decreasing constantly due to adverse environmental condition and global climate change (HASANUZZAMAN ET AL., 2013). 45 million hectares of irrigated land are affected of salt (MUNNS AND TESTER, 2008). If saline lands will expand 50% of cultivable lands will be lost by the middle of the 21st century (MAHAJAN AND TUTEJA, 2005). Beans is cultivated all over the world, and is the most important legume (BROUGHTON ET AL., 2003). She is a glycophyte, and low soil salinity levels (2 dS•m−1) significantly reduce crop productivity (Maas and Hoffman, 1977). At a salinity equivalent to 100 mM NaCl, pod yield per plant in the common bean decreased by 85%(SZILAGYI, 2003). Therefore, to increase beans' crop yields over could be based on the selection of salt stress-tolerant cultivars (FITA ET AL., 2015).

MATERIAL AND METHOD

Phaseolus vulgaris L. has a great variability regarding the tolerance to salinity and that's why the biological material was represented by seven bean populations (Blăgești 1, Blăgești 2, Blăgești 3, Blăgești 4, Săveni, Moșna, Trușești 2), collected from saline soils in the Moldavian region, in 2018 and exposed to salt stress over a 30-day period. They were constantly wetted with saline at a concentration of 100 mM and 200 mM NaCl, treatment applied to the flowering phase of the plant. The bifactorial experience was performed in a randomized three-repeat block experiment; vegetation pots were used with weight of 12 L. The pH of the soil was determined using the pH meter apparatus using the pH-method in aqueous suspensions and saline in a soil: water ratio of 1:5 (mass/volume), and the results were expressed in pH units with two decimal places. In the experiment, bound water was calculated, referring to the percentage of water lost in the first hour and in 24 hours, but also in terms of free water. The results were statistically interpreted using the Microsoft Excel Data Analysis application, determining the magnitude of the effect in the linear correlation r (Pearson). In practical applications, we are interested not only in the presence and the meaning of the correlation, but also in the extent to which it manifests it self; this degree is appreciated by various statistical calculations.

RESULTS AND DISCUSSIONS

❖ Effect of saline stress on bound water

Salinity reduces the ability of plants to utilize water and causes a reduction in growth rate, as well as changes inplant metabolic processes (MUNNS, 1993; MUNNS, 2002). Furthermore, it decreases plant growth and yield, depending on the plant species, salinity levels, and ionic composition of the salts (YADAV ET AL., 2010).

The detrimental effects of salts on plants are the consequence of both a water deficit that results from the relatively high solute concentrations in the soil as well as a stress specific to Cl^- and Na^+, resulting in a wide variety of physiological and biochemical changes that inhibit plant growth and development and disturb photosynthesis, respiration, protein synthesis and nucleic-acid metabolism.

The water retention capacity at the foliar level can be appreciated by determining the ratio of free water to bound water, and the ratio between them ensures the survival of plants under stress conditions. Thus, under stressed saline conditions, the free water content decreases and the bound water increases the biological resistance to dehydration. Free water is the amount of water removed by sweating and dehydration, and bound water is that amount of water left in the tissues after dehydration, which is eliminated by drying (COVAȘĂ, 2016).

In saline stress conditions, when the vital plant activity decreases, there is an increase in the amount of water bound, thus ensuring the survival in such conditions. This aspect was also encountered in the studied populations in this experiment. Thus, after 15 days of treatment, higher values were seen than the control variant for the six genotype studied when a 200 mM NaCl concentration was used (figure 1).

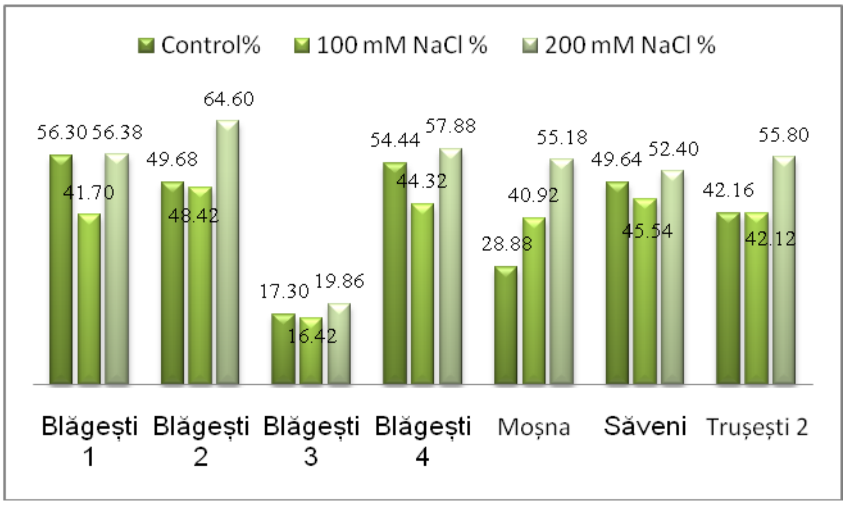

Figure 1. Influence of saline stress on bound water content after 15 days from treatment

After 30 days of application of saline solutions, the bound water shows higher values for the 200 mM treated group for all genotypes studied, which denotes the salinity resistance of the studied genotypes. In this case, the bound water content increases the biological resistance to induced dehydration (figure 2).

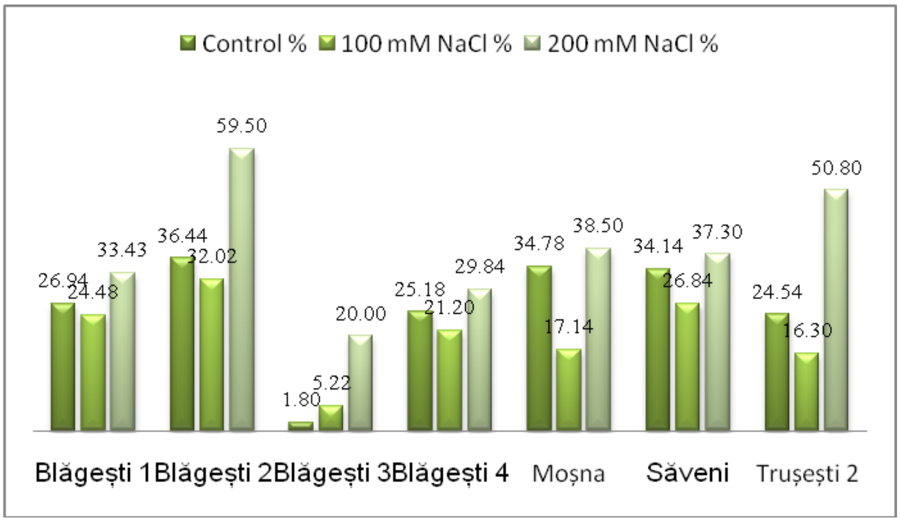

Figure 2. Influence of saline stress on bound water content after 30 days from treatment

❖ Influence of saline stress on the water content at the foliar level

In the plant body the water is found in two states, liquid and gaseous. Liquid water is the main component of all cells, being present in maximum amount in vacuoles and minimal in cellular organelles. This is in the form of free water and bound water (TOMA AND JITĂREANU, 2007). Free water is considered to be the amount of water lost through sweating and dehydration after a 24-fold exposure of the leaf at ambient temperature. It is retained with weak forces in the body of the plants and circulates slightly intra and intercellularly. It also ensures cellular turgidity, representing the environment of biochemical processes. At the same time, the free water content of the leaves appreciates the intensity of sweat water elimination. In salt plants, the concentration of the vacuolar juice is increased by the accumulation of mineral salts, soluble carbohydrates or organic acids that reduce the intensity of perspiration (COVAȘĂ, 2016).

After determining the free water content in the leaves, after 15 days of application of saline treatments, comparing the variants between them, an increase in its percentage for 5 of the 100 mM treated genotypes (Blăgeşti 1, Blăgeşti 2, Blăgeşti 3, Blăgesti 4, Săveni) is observed. If treatment with 200 mM saline is applied there is an increase in the free water content to a single genotype (Trusești 2) and a decrease of this content to six of the cultivation (Blăgeşti 1, Blăgeşti 2, Blăgeşti 3, Moşna, Săveni); in this case the minimum value (17.70%) belongs to the Blăgeşti 2 cultivar and the maximum value (40.07%) of the Blăgeşti 3 genotype (figure 3).

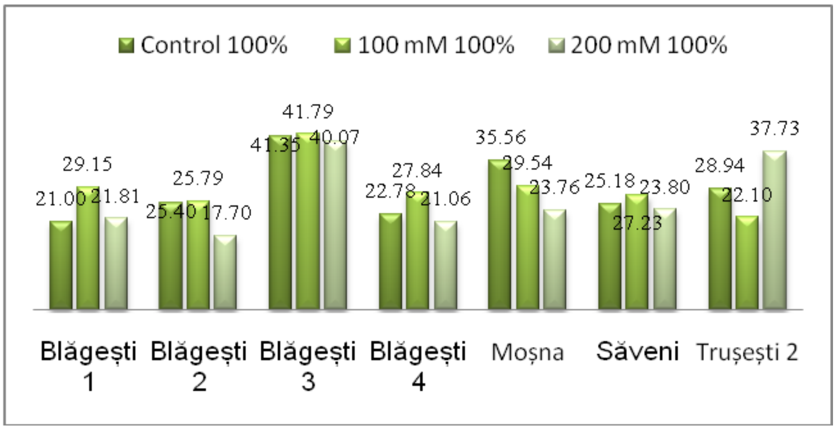

Figure 3. Influence of saline stress on free water content after 15 days from treatment

Analysis of free water content 30 days after application of saline treatments revealed an increase in the free water content for 5 of 100 mM treated genotypes and a decrease for 4 of the genotypes studied. Two genotypes (Blăgeşti 4 and Trușești 2), after 15 days and after 30 days, maintain a high percentage of the free water content in the two treatments.

To the other genotypes, 30 days after application of the saline solutions, there is a lower content of free water to the application of the 200 mM saline solution, which shows, according to the data presented in the literature, that the reduction of the free water content increases the biological tolerance of plants to abiotic stress conditions (COVAȘĂ, 2006; ŞUMĂLAN, 2009).

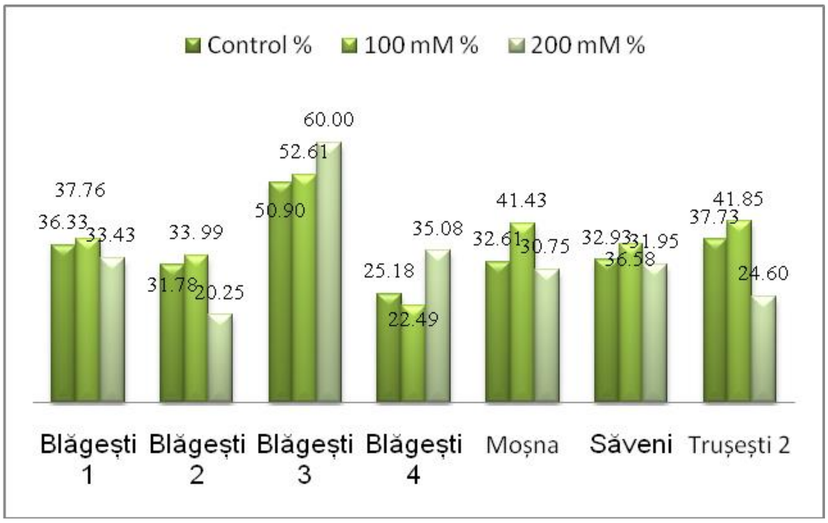

Figure 4. Influence of saline stress on free water content after 30 days of treatment

❖ **Influence of saline stress on soil pH**

Determination of pH is done on dry air samples and passed through a sieve with a 2 mm mesh side according to SR ISO 11464/19980. Under constant conditions, pH values of saline suspensions decrease with increasing saline concentration and increasing salt cation valence. The pH of the soil changes depending on the variation in water content and the content of soluble salts. Thus, during the warm and dry season, the amounts of soluble salts accumulated in the soil increase and they decrease the pH; once the watering is applied, the salts are delivered and the pH tends to increase and return to the maximum value in the soil (LUNGU AND RIZEA, 2017).

Soil pH expresses the activity of H^+ ions and represents the intensity of soil acidity. This is an attribute relatively easy to determine, characterizing the soil system to provide a global picture of his trophicity.

Since the activity of H^+ ions also determines the activity of other ions in the soil solution, it is an important indicator in the appreciation of its fertility. Soil response is important from plant nutrition point of view because pH influences the mobility and accessibility of soil nutrients. The pH value depends on the solubility of the soil constituents, both those containing the necessary ions in plant nutrition, and those that can release ions that can become toxic to the plant beyond a certain limit (LUNGU AND RIZEA, 2017).

Most crop plants can not withstand a pH below 4.5 or above 8. 3 (DAVIDESCU AND DAVIDESCU, 1981). In strongly acidic soils there is almost complete suppression of bacteria living in symbiosis with leguminous plants (*Rhizobium*), which need a weakly acidic or neutral reaction between pH 6.0 and 7.0. In soils with a relatively high salt content, the pH of the soil will range from 7.5 to 8.4 with a weak alkaine reaction. These pH values are explained by the saline effect of the neutral salts that accumulate (usually NaCl). To this is added the flocculant effect of the salts on the colloidal fraction in the soil, which reduces the hydrolysis of the exchangeable sodium.

As a rule, the soil pH is seasonally variable and is lower in dry and higher temperatures when the salt content of the soil solution increases, especially nitrates and sulphates (saline effect) (LUNGU AND RIZEA, 2017). Changing pH, especially in alkaline, reduces the permeability of cell membranes, inhibiting water absorption.

After 15 days of application of saline treatments, following ground analyzes, the pH recorded superior values to the control group. Values from the control group oscillated between 7.88-7.90, while following saline treatments the values increased, oscillating between 8.03 and 8.34 (figure 5). In this case, the pH values have changed due to the application of saline solutions, a low alkali pH is recorded, which allows optimum growth of plants, according to the data presented in the literature (LUNGU AND RIZEA, 2017).

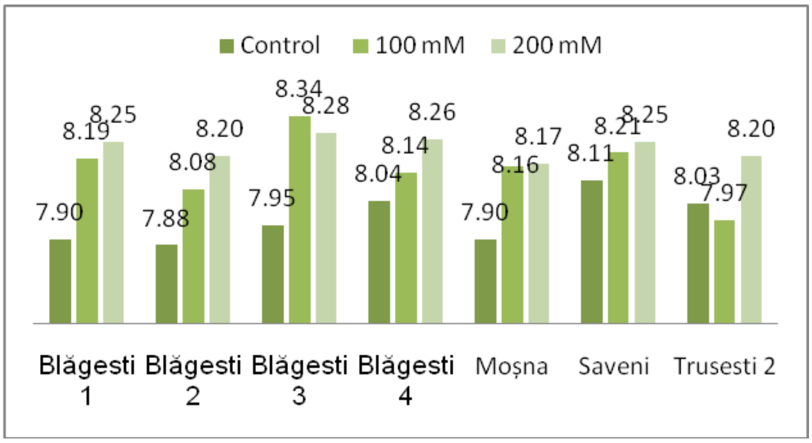

Figure 5. Influence of saline stress on soil pH after 15 days from treatment

Following soil analyzes, 30 days after application of saline treatments, the pH recorded values higher than the control group, oscillating between 8.02-8.19. Once time with the application of saline treatments, to the variant treated with 100 mM the values increased, ranging from 8.11 to 8.28. When applying a greater number of treatments, the pH has changed even further, increasing to the 200 mM treated variant; these values oscillated between 8.42 and 8.77 (figure 6). This time, a moderate alkaline pH has been reported, affecting plants, which primarily hinders the accessibility of certain chemical elements in the soil (iron), shows ferric chlorosis, particularly serious for plants.

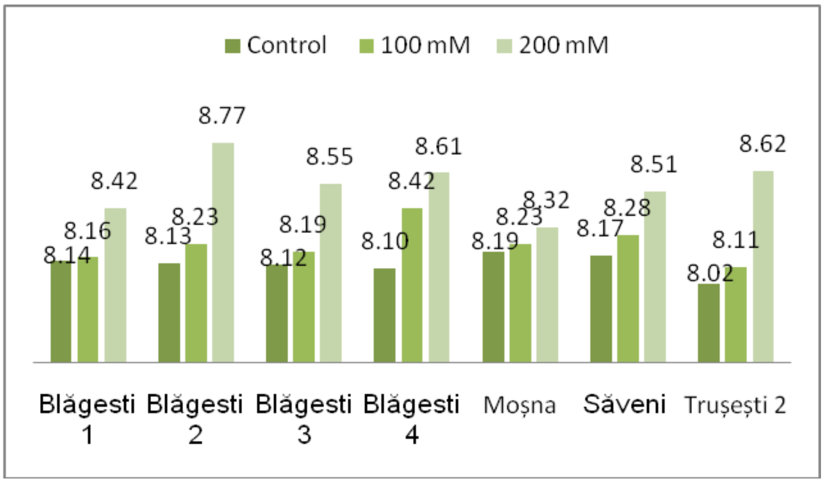

Figure 6. Influence of saline stress on soil pH after 30 days from treatment

❖ **Determining the correlation coefficient**

In nature, phenomena are in close association with the surrounding phenomena. That is why in practical applications we are interested in not only the presence and the meaning of the correlation, but also the extent to which it manifests itself; this grade is appreciated by statistical calculations. In this respect, the linear correlation coefficient Bravais-Pearson (DRAGOMIRESCU, 2003) was introduced to assess the correlation between two sizes.

In the present paper to have statistical coverage, various correlations have been made between the studied parameters. Thus, the correlation between soil pH and water bound after 15 days and 30 days after exposure to saline stress has been found to be acceptable in accordance with the rules established by Colton (1974). The pH of the soil had a negative influence on the percentage of bound water, in this respect the excess of chlorine having a toxic effect (figure 7 and figure 8).

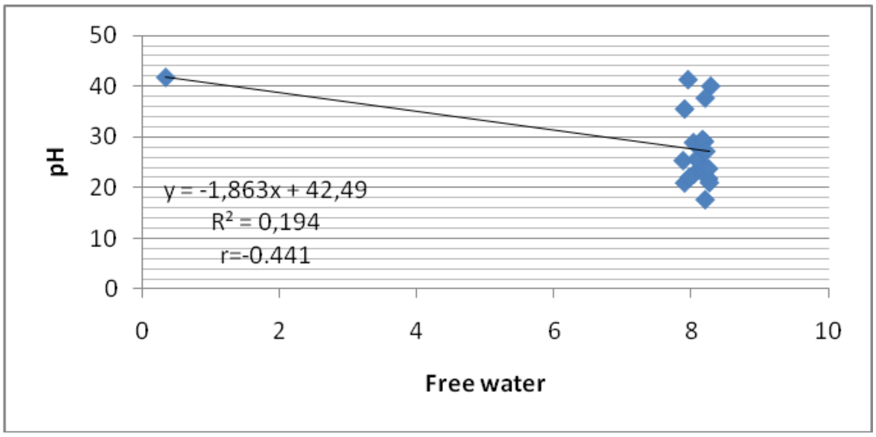

Figure 7. Correlation between soil pH and free water in leaves after 15 days of saline stress

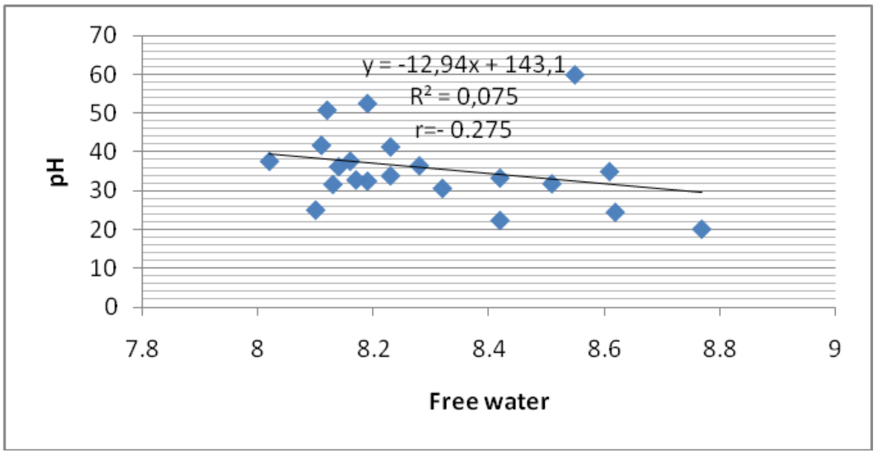

Figura 8 . Correlation between soil pH and free water in leaves after 30 days of saline stress

In contrast, the correlation between the pH of the soil and bound water after 15 days of exposure to salt stress showed a moderate to good degree of correlation (figure 9), according to the rules of Colton (1974). Instead, after 30 days there was a very good degree of association (Figure 10).

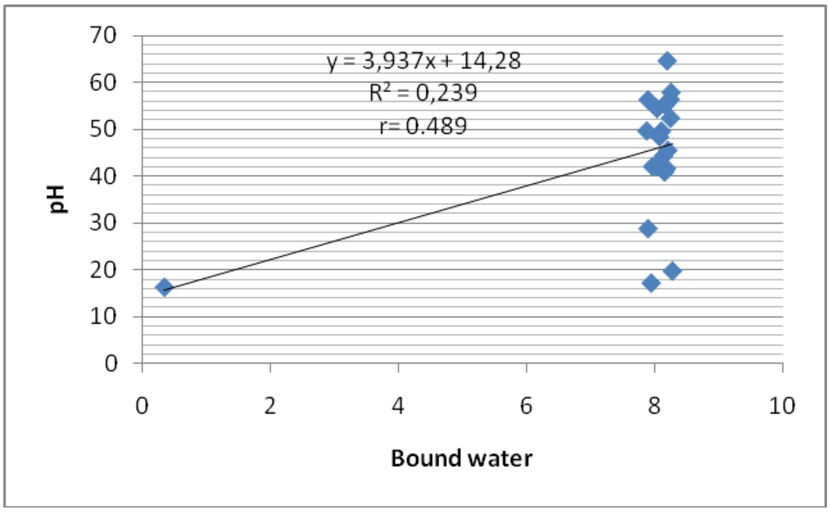

Figure 9. Correlation between soil pH and bound water in leaves after 15 days of saline stress

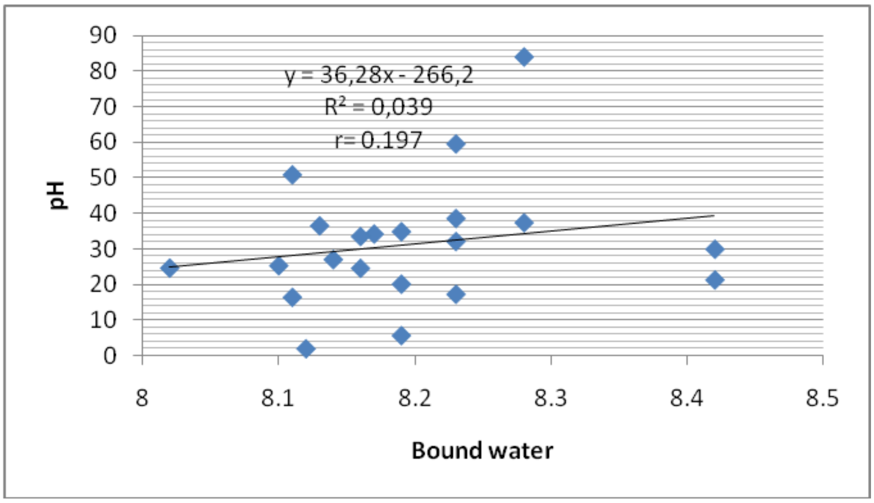

Figure 10. Correlation between soil pH and bound water in leaves after 30 days of saline stress

CONCLUSIONS

1. In saline stress conditions, an increase in the amount of bound water, at the 200 mM variant versus control, to all genotypes, has been associated with the resistance of plants, thus exhibiting a higher degree of adaptation.

2. At the end of the treatment, the analysis of free water content reveals a lower content to the 200 mM variant versus control, indicating a high biological tolerance capacity of plants under the influence of saline stress.

3. The pH of the soil under the influence of saline stress has become moderately alkaline; such a pH affects plants because it prevents the accessibility of certain chemical elements in the soil.

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