Impact of sea salt stress on growth and some physiological attributes of two soybean (*Glycine Max* L.) cultivars

R. I. EL-Kholy [1,*], A. I. Sayed [1], H. F. EL-Shaer [1], and M. S. Hanafy [2]

[1] *Agricultural Botany Department, Genetics unit, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt.*
[2] *National Research Centre, Plant Biotechnology Department, Genetic Engineering and Biotechnology Division, Cairo, Egypt.*

*Corresponding author E-mail: Ragab_Elkholy@azhar.edu.eg (R. EL-Kholy)

ABSTRACT

Two soybean cultivars (Giza 21 and Giza 35) were exposed to different sea-salt levels *in vitro*. Growth performance of the plants and biochemical indicators in shoots were measured. Shoot height (SH), leaf numbers (LN) and seedlings fresh weight (SFW) were decreased in both cultivars with an increase in the sea-salt concentration. Whereas, root length (RL) and seedlings dry weight (SDW) had insignificant changes due to salt stress in both cultivars compared to control. Salinization of seedlings has shown to increase sodium (Na^+), nitrogen (N), and phosphorus (P) ions accumulation in both cultivars. Contrary, K^+ and Ca^{2+} ions percentages increased in Giza 35 cultivar upon sea-salt stress of 4000 ppm, after which their percentages decreased to same level of the control. Notable, salinized seedlings of Giza 21 cultivar showed insignificant changes in K^+ and Ca^{2+} ions percentage under sea-salt stress. For organic osmolytes, proline increased in both cultivars under high sea-salt levels. The enzymatic activity of catalase (CAT) was significantly decreased in Giza 21 cultivar under 6000 ppm. However, insignificant changes in its activity were recorder in cultivar Giza 35 under sea-salt stress. Superoxide dismutase (SOD) activity was decreased in both cultivars under high sea-salt levels. Interestingly, The ascorbic acid oxidase activity in Giza 35 increased under sea-salt level of 2000 ppm followed by a decrease under 4000 ppm and finally the its activity significantly increased under high sea-salt stress of 6000 ppm. On the other hand, salt stress did not induce significant changes in AAO activity in Giza 21.

Keywords: *Glycine max;* ion contents; proline; salinity; antioxidant enzymes.

INTRODUCTION

Salt stress is one of the major abiotic stress factors that adversely affects growth and development of crops, in particular legumes, in arid and semi-arid regions. Over 20-50% of the whole arable land is affected by salinity as a result of climate change, application of fertilizers or from crop irrigation with saline water (Epstein et al. 1980; Meloni et al. 2004; Li 2008; Xu et al. 2011). Salinity not only interrupts ionic homeostasis in plants by ion toxicity and causing osmotic pressure, it is also negatively impacts enzymatic activity, photosynthesis process and cell turgor pressure (Munns 2002; Yamaguchi-Shinozaki and Shinozaki 2005; Shahbaz and Ashraf 2013). Although Na^+ and Cl^- are essential ions for plants, high accumulation of theses ions in plant cells gradually leads to cell death. The presence of high amounts of Na^+ and Cl^- ions generate reactive oxygen species (ROS) that cause fatal oxidative stress on plants (Khan et al. 2007; Craig Plett and Møller 2010; Teakle and Tyerman 2010; Roy et al. 2014). The response of plants to salinity is getting the attentions of many research groups worldwide due to its direct implication in the agriculture production. The adverse effect of salinity on plant is dependent on salt concentration, duration of exposure and plant developmental stage (Blum 1988; Maas E and Poss 1989; Gill 1990). Exposure of the plants to salinity affects various physiological changes such as reduction of photosynthetic activity, accumulation of organic acids, osmolytes and changes in carbohydrate metabolism (Munns 2002). Moreover, salt stress commonly reduces the chlorophyll contents but increases carotenoids in plant leaves and the salinized plants showed the highest values of total soluble sugars, proline and total free amino acid (Khalafallah et al. 2008).

In the recent decades, salinity has become one of the most limiting factors that reduce crop productivity throughout the world. The ever growing of human population and global climate change imposed urgent need to develop novel, sustainable and effective strategies to generate new crops cultivars that confer tolerance towards salinity, which is affecting agricultural sustainability in dry regions. Therefore, understanding the response of the plants to salt stress is a long-held objective of many research groups. Plants vary tremendously in their ability to tolerate salinity (Bischoff and Warner 1999).

Soybean (*Glycine max* L.) is an annual crop that belongs to family Fabaceae and is considered as the most important legume crop in the world (Ferguson and Gresshoff 2009). Beside its high protein contents (38-45%), it is accounted as a major oil crop (20%) worldwide and a main source for phospholipids, hormones and antioxidants (Choi and Rhee 2006). Soybean also provides phenolic compounds, tocopherols, organic acids, sugars and fatty acids, volatile compounds and sterols (Boué et al. 2003; Kumar V et al. 2009). In addition to its nutritional value, soybean cultivation improves the soil fertility by fixing the atmospheric nitrogen in association with *rhizobium*. Soybean is characterized as moderately salt sensitive instead of moderately salt tolerant (Katerji et al. 2000) and a reduction in the yield is occurring when soil salinity exceeds 5 dS/m (Maas EV and Hoffman 1977). The response of soybean to salinity stress depends on both cultivars and environmental conditions (Ghassemi-Golezani et al. 2009). Many reports can be found for the effect of salt stress on soybean using NaCl as a source of salinity i.e. (Essa 2002; Phang et al. 2008; Tunçturk et al. 2008; Hamayun et al. 2010; Farhoudi and Tafti 2011), however, the knowledge is still inadequate and demands more exploration to understand the response of soybean plants to the mixture of salts that usually found in nature. Salinity tolerance at germination and seedling stages is an important factor in establishing soybean in salt-effected soils. The present study outlines the impact of three sea-salt stress levels (2000, 4000 and 6000 ppm) on two soybean cultivars commonly grown in Egypt to assess their tolerance ability and mechanism against a mixture of salts (sea-salt) stress. Morphological and some physiological aspects associated with the plants under salinity stress at seedling stage were investigated to select suitable tolerant cultivar that can be used in future research and breeding programs.

MATERIALS AND METHODS

Plant materials

The seeds of two Egyptian soybean (*Glycine max* L.) cultivars named Giza 21 and Giza 35 were collected from Agricultural Research Centre, Filed Crop Research Institute, Giza, Egypt. These cultivars are widely cultivated in Egypt due to their resistance to cotton leaf worm. The pedigree, origin and weight of 100 seed are presented in Table (1).

Seeds germination and growth conditions

Uniform and healthy seeds of the two cultivars were surface-disinfected by overnight exposure to chlorine gas (Di et al. 1996) and were allowed to germinate on B5 medium (Gamborg et al. 1968) containing 2% sucrose, 3.0% Phytagel (Sigma) and the salt stress was induced by media-supplementation of 2000, 4000 and 6000 ppm of sea-salt (Sigma-Aldrich, S9883) and incubated at 24±2°C under a 16h/8h light/dark cycle for four weeks. The pH of the media was adjusted to pH 5.8 prior to autoclaving at 121°C for 15 min. After incubation, the salt-treated and untreated (control) seedlings (28 days old) were removed carefully for biochemical and physiological parameters analysis. For each treatment, a total of 24 biological replicates were harvested and the shoot height (cm), root length (cm), fresh and dry weights of whole plants were determined. The shoot samples were kept at -20 °C for further analyses.

Tissue Ion Analysis

Oven (80°C) dried shoot samples (100 mg) were extracted in 50 ml deionized water with continuous shaking and used for the determination of tissue ion percentage on a microprocessor based Ion Analyzer (Elico, India) using ion specific electrode to sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), Nitrogen (N) and Phosphorous (P) according to (Faithfull 2002).

Determination of proline

Free L-proline was determined according (Bates et al. 1973) with minor modifications. Shoot samples of 0.5 g were homogenized in a mortar and pestle with 10 ml of 3% aqueous sulfosalicylic acid (w/v) and then centrifuged at 18000 g for 15 min. Two ml of the supernatant was then added to a test tube, to which 2 ml glacial acetic acid and 2 ml freshly prepared acid ninhydrin solution (1.25g ninhydrin dissolved in 30 ml glacial acetic acid and 20 ml 6M phosphoric acid) were added. The test tubes were incubated in a water bath for 1 h at 100°C and then allowed to cool to room temperature. The reaction mixture was extracted with 4 ml of toluene and mixed vigorously for 15-20s. The test tubes were allowed to stand for at least 10 min to allow separation of the toluene and aqueous phases. The toluene phase was carefully pipetted out into a glass test tube and its absorbance was measured at 520 nm in a spectrophotometer using toluene as a blank. Proline content was calculated from a standard curve on a fresh weight basis.

Activity of antioxidant enzymes

Enzymes were extracted from fresh leaves (0.5 g) using a mortar and pestle with 5 ml of ice-cold extraction buffer containing 0.1 M phosphate buffer (pH 7.1). The homogenate was centrifuged at 15000 xg for 20 min at 4ºC. The supernatant was used for assaying catalase (CAT), superoxide dismutase (SOD) and ascorbic acid oxidase (AAO) activities.

The CAT activity was determined according to the method of Aebi (1984) in which the disappearance of H_2O_2 in a reaction mixture containing 0.3 ml 3% H_2O_2, 2.5 ml of 0.05 M phosphate buffer (pH 7.0) and 2.5 ml of plant extract is monitored by the decrease in absorbance at 240 nm. One unit of CAT was calculated by the change in the absorbance of 0.001 per min under assay conditions. Superoxide dismutase (SOD) activity was assayed by measuring its ability to inhibit the photochemical reduction of nitro blue tetrazolium (NBT) using the method of Beauchamp and Fridovich (1971). The reaction mixture contained 50 mM sodium phosphate buffer (pH 7.6), 0.1 mM EDTA, 50 mM sodium carbonate, 12 mM L-methionine, 50 μM NBT, 10 μM riboflavin and 100 μL of crude extract in a final volume of 3.0 ml. A control reaction was performed without crude extract. The SOD reaction was carried out by exposing the reaction mixture to white light for 15 min at room temperature. After 15 min incubation, absorbance was recorded at 560 nm using a spectrophotometer. One unit of SOD activity was defined as the amount of enzyme causing 50% inhibition of photochemical reduction of NBT. Ascorbic acid oxidase (AAO) activity was assayed according to the procedure of Oberbacher and vines (1963). Briefly, 3.0 ml of the substrate solution (8.8 mg of ascorbic acid in 300 ml phosphate buffer, pH 5.6) was mixed with 0.1 ml of the enzyme extract (supernatant). The absorbance change was measured at 265 nm for every 30 second for a period of 5 minutes. One unit of AAO was calculated by a decrease in OD265 of 0.05 per minute.

Statistical analysis

All of the experiments were conducted in at least triplicate and the results were tabulated as mean ± standard error (SE). Data were analyzed by analysis of variance (ANOVA). The means were compared using the least significant difference (LSD) test at the 0.05 probability level.

RESULTS AND DISCUSSION

Plant Growth

Data recorded in Figure (1) and Figure (2) show the effect of different levels of sea-salt stress (2000, 4000 and 6000ppm) on the growth of two soybean cultivars (Giza 21 and Giza 35). The growth attributes including shoot height (SH), root length (RL), leaf number (LN), seedling fresh weight (SFW) and seedling dry weight (SDW) were recorded after sowing soybean seeds *in vitro* for four weeks. In general, the obtained data revealed that some growth attributes of soybean cultivars were negatively affected by sea-salt stress. The germination percentage of both cultivars was reduced significantly by increasing the sea-salt level (data not shown). At control (non-saline), both cultivars were showed about 90% germination of seed. The germination of Giza 21 seeds was affected by salinity more than Giza 35. Increasing sea-salt stress to 6000 ppm reduced the germination percentages to 54% and 30% in Giza 21 and Giza 35, respectively. Shoot height (SH), leaf number (LN) and seedlings fresh weight (SFW) of both cultivars were reduced significantly by increasing the salinity level (Figure 2a,c,d). However, cultivar Giza 35 exhibited the highest values of SFW under sea-salt level of 4000 and 6000 ppm as compared to cultivar Giza 21. Salt stress induced inhibition of root length of Giza 35 under sea-salt level of 4000 ppm followed by an increscent to reach the same level of the control seedlings (Figure 2d). No significant changes were observed in the root length of Giza 21 under salt stress. Interestingly, salinity stress had negligible effect on SDW in both cultivars (Figure 2e).

The obtained results in agreement with those obtained by many research groups (Essa 2002; Phang et al. 2008; Tunçturk et al. 2008; Amirjani 2010; Hamayun et al. 2010; Farhoudi and Tafti 2011) who reported the adverse effect of salt stress on the growth attributes of soybean. Previous literatures reported that the ability of the seeds to germinate under salt stress indicates their genetic potential to salt stress (Essa 2002). The degree of salt tolerance of the plants is determined by various molecular and biochemical pathways (Shahid et al. 2020). The results reported here in a good harmony with those obtained by (Abel and MacKenzie 1964; Noble and Rogers 1994; Shannon 1994; Cordovilla et al. 1995; Yousef and Al-Saadawi 1997; Essa and Al-Ani 2001).

The negative effect of increased salinity level on shoot development reported in

present study is in agreement with previous studies of (Dash and Panda 2001; Munns 2002; Delgado and Sánchez-Raya 2007). The harmful effect of salinity on the shoot growth, leaf number and SFW may be due to the toxic effect of salts as well as inhibition of cytokinesis and cell expansion (Kurum et al. 2013) reduction in hormones that stimulate plant growth and increase in hormones that inhibit growth (Taiz and Zeiger 1998), excessive accumulation of NaCl in chloroplasts, which is associated with a reduction in the electron transport and inhibition of Photosystem II (PSII) activity (Kao et al. 2003), generation of osmotic stress which leading to reduction in water absorbance and cell division and differentiation (Nikee et al. 2014). Notable, the obtained results showed that high salt stress had negligible effect on root growth (Figure 2b). This response can be ascribed to the fact that roots are more tolerant than shoots against salinity (Noble and Rogers 1994; Cordovilla et al. 1995; Ghaderi et al. 2018). The obtained results in accordance with data in previous literatures (Mahgoub et al. 2016; Abdelraouf and Elgarhy 2017) who reported that soybean Giza 35 is a relatively salt stress tolerant compared to Giza 21 cultivar according to the growth parameters under salt stress.

Ion percentage

The data presented in (Fig. 3a, b) revealed that sea-salt treatments caused increases in N and P ion percentages. The Na^+, K^+ and Ca^{2+} ion percentages of the two cultivars were affected differently by changes in the salinity level (Fig. 3c, d,e). The Na^+ ion percentage in cultivar Giza 21 was in the range of control seedlings (not salinized) until sea-salt level of 4000 ppm after which the Na^+ ion percentage was increased significantly. However, Na ion percentage was increased significantly upon salt stress for Giza 35. Increasing the salinity to 4000 ppm resulted in increases the K^+ and Ca^{2+} ion percentages relative to control for Giza 35 followed by decreases to the same level of the control (Fig. 3d,e). However, salinity had negligible effect on the K^+ and Ca^{2+} ion percentages for Giza 21. These observations indicated that Giza 35 can accumulate more Na ion percentage in the shoots and can tolerate more salt stress than Giza 21 cultivar. The K^+ ion represent one of the most abundant cation in plant tissues and accounted as an important component of the plant cell osmotic potential (Reggiani et al. 1995). In our study, salt stress of 4000 ppm caused a progressive increase in K^+ ion percentage in Giza 35 which may help this cultivar to tolerate this high salt stress. however, all sea-salt stress treatment had negligible effect on the K^+ ion percentage in Giza 21 (Fig. 3d).

Ca^{2+} ion percentage significantly increased in Giza 35 under sea-salts stress of 4000 ppm, while the lowest Ca^{2+} percentage in Giza 21 cultivar under the same sea-salt stress was in the same range of unsalinzed plantlets (Fig. 3e). It is known that Ca^{2+} ion is an important factor during salt stress, due to its role in preserving membrane integrity (Rengel 1992; Ashraf and Orooj 2006) and in osmoregulation (Mansfield et al. 1990). Ca^{2+} ion accumulation in plant tissues suggested that the higher Ca^{2+} content in the plants might be a favor factor involved in conferring salt stress tolerance. In addition, previous studies reported that increased Ca^{2+} ion concentrations in many plants such as melon grown under salt stress could reduce the inhibitory effects of salinity stress on plant growth (Navarro et al. 2002; Kaya et al. 2003). In the present study the Ca^{2+} ion percentage was increased significantly in Giza 35 under sea-salt stress of 4000 ppm, while sea salt treatments had insignificant effect of Ca^{2+} percentage in Giza 21. These results confirm that Giza 35 could ameliorate the inhibitory effects of salt stress up to 4000 ppm better than Giza 21 by increasing the K^+ and Ca^{2+} ions percentage (Fig. 3d,e). Interestingly, The N percentage in the plantlet of Giza 21 under control condition was significantly higher than those in Giza 35, while upon sea-salt stress there were no significant difference between both cultivars under all treatments. The reduction in the N ion contents was greater in Giza 21 than Giza 35 under salt stress (Fig. 3a).

Proline concentration

The proline concentration followed an increasing trend under high sea-salt stress levels compared to control treatment. The highest proline concentration was observed in both cultivars under sea-salt stress of 6000 ppm with no significant differences between them under all treatments (Fig.4). In order to cope with salt stress, plants synthesize and accumulate osmolytes to ensure plant tolerance to a broad range of stress conditions such as salinity, drought, high light intensity and high temperatures (Paleg and Aspinall 1981; Delauney and Verma 1993; Hare PD et al. 1998; Mansour 2000; Lokhande et al. 2010). Proline is one of these osmoprotective agents, which accumulates in plants challenged to osmotic stress and plays a vital role in reducing the effect of salt stress by adjusting

the osmosis (De la Torre-González et al. 2018; El Moukhtari et al. 2020). In contrary, previous report suggested that proline accumulation is a reaction to salt stress and has minor role in promoting salt stress tolerance. For example, in tomato proline accounts small fraction of total concentration of active osmolytes (Pérez-Alfocea et al. 1993) Therefore, its role in osmotic adjustment and plant tolerance to osmotic stress is controversial (Hare P and Cress 1997). The accumulation of proline may be due to the increased stimulation of the enzymes in the biosynthesis of proline (Claussen 2005). The similar results have been reported by (Kumar PA et al. 2017). In the present study, proline proved to be important osmolyte for both soybean cultivars to cope with sea-salt stress. The contents of proline might have protected cell membranes against salt-induced oxidative stress and toxic ions. It can also be responsible for osmotic adjustment, facilitating water absorption, stabilizing the antioxidant system, reduce the deleterious effect of reactive oxygen species (ROS) and increases plants adaptability to salt stress (Szabados and Savouré 2010; Qureshi et al. 2013; Pottosin et al. 2014; Zouari et al. 2016). In the present study, higher proline concentrations were found in elevated sea-salt level for both cultivars. Constant results were reported in many plants including soybean (Çiçek and Çakırlar 2008; Amirjani 2010; Bakhoum et al. 2019), *Lupinus termis* (Rady et al. 2016), faba bean (Hanafy et al. 2013) and banana plants (Mazumdar et al. 2019).

Antioxidant enzyme activity

To reduce the adverse effects of ROS, plant cells develope a mechanism to suppress the accumulation of harmful intercellular ROS. This mechanism includes the action of anti-oxidative defense systems such as enzymatic ROS scavengers including CAT, SOD and AAO. In order to clarify the effect of sea-salt stress on oxidative stress parameters, CAT, SOD and AAO activities were measured. Data presented in Figure (5) revealed that CAT activity was not associated with significant changes at sea-salt treatments in the shoots of Giza 35 cultivars. However, CAT activity was significantly reduced in the shoots of Giza 21 cultivar upon sea-salt stress of 6000 ppm (Figure 5). Concerning SOD activity, the obtained data showed insignificant changes in its activity in the shoots of both cultivars under low sea-salt stress level (2000 ppm) relative to control treatment. SOD activity displayed significant reduction in both cultivars at sea-salt levels of 4000 and 6000 ppm with insignificant differences between cultivars (Figure 6). Interestingly, the AAO activity in Giza 21 showed insignificant changes in response to sea-salt stress. On the other hand, its activity in Giza 35 displayed a significant increase upon sea-salt stress followed by a reduction and finally the AAO activity displayed the highest value under sea-salt stress of 6000 ppm (Figure 7). The differences in the antioxidant enzyme activity in response to salinity stress can be linked to salt stress concentration (Kim et al. 2005; Jin et al. 2009).

Previous reports showed the reduction of antioxidant enzyme activities under salt stress (Abogadallah et al. 2010; Hafsi et al. 2010; Noreen et al. 2010; Yang et al. 2010). The decrease in the antioxidant enzymes activity at high and prolonged salt stress can be related to the adverse effect of the overproduction of ROS which inhibits the protein synthesis (Hu et al. 2012). Many research reports showed the induction of the cellular antioxidant machinery plays an important role for the protection against salt stress (Mittova et al. 2004). Constant with our results (Gulen et al. 2006; Keutgen and Pawelzik 2008; Ashraf 2009; Adss and Eldakrory 2015; Darko et al. 2017) also found that a significant changes in antioxidant enzyme activities under salt stress relative to control. Based on the results of the present study, different responses of the two soybean cultivars to sea-salt stress displayed a correlation between the salt stress tolerance and the activity levels of antioxidant enzymes. Lower susceptibility of Giza 35 cultivar to sea-salt stress might be associated with higher AAO at severe sea-salt stress level. It is apparent that the activity of CAT enzyme was significant decreased in the shoots of Giza 21 but not in the shoots of Giza 35 under the highest sea-salt level. Moreover, these results indicate that Giza 35 could cope with salinity by maintaining the CAT activity stable under salt stress. However, SOD activities did not display significant changes between both cultivars under the same sea-salt stress. Thus, this study demonstrates SOD did not contribute to salt tolerance in soybean. In literatures, many reports demonstrated the activity of antioxidant enzyme under salinity may differentiate salt tolerant and salt sensitive cultivars (Turhan et al. 2008). These findings support the fact that the activities of the antioxidant enzymes may act as a tolerant mechanism against salt stress in soybean.

CONCLUSION

Considering the data of the present study, it can be concluded that sea-salt salinity treatments induced a considerable variation in growth criteria, ion contents, enzymatic activity and nitrogenous compounds (proline) contents. Taking together the present study confirmed the genetic variability in salinity tolerance between the two soybean genotypes. Giza 35 was found to be relative more tolerant compared to Giza 21 based on the majority of growth parameters assessed.

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Table 1: Origin, pedigree and total weight of 100 seeds of soybean cultivars.

No.	Cultivar Name	Origen	Pedigree	100 seed in gram
1	Giza 21	Egypt	Crawford x Celest	20.101
2	Giza 35	Egypt	Crawford x M. Presto	14.132

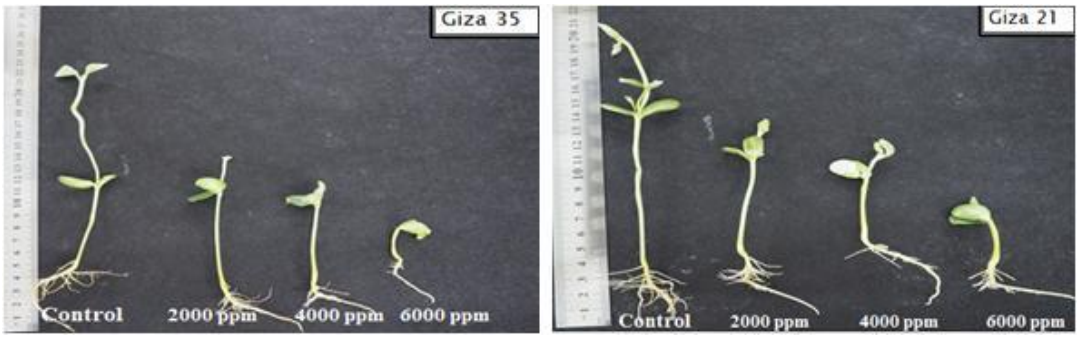


Figure. 1: Effects of different salinity levels from sea salts (0.0, 2000, 4000 and 6000 ppm) under in vitro culture condition in Egyptian Soy bean cultivars (Giza 21, Giza 35)

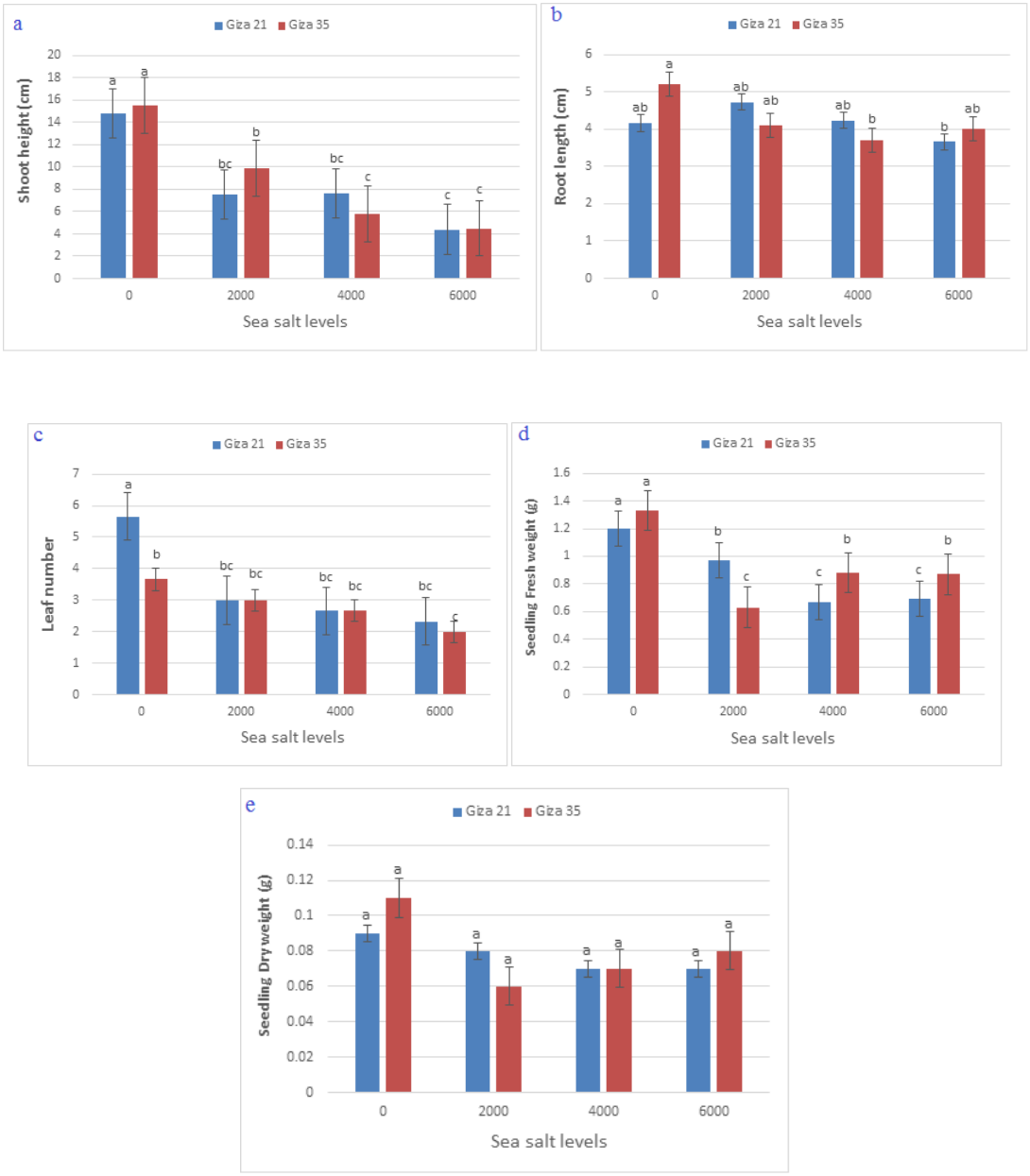
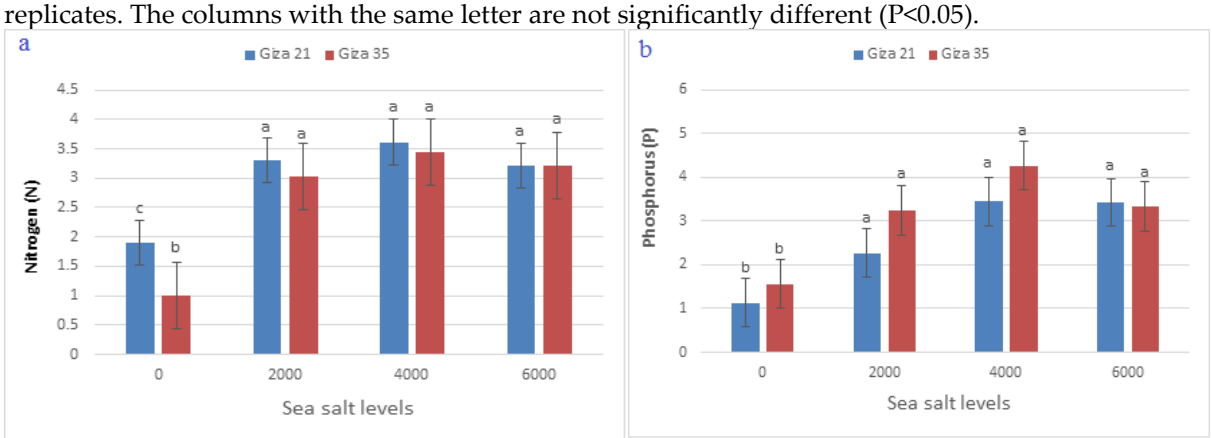


Figure 2: Changes in Shoot height (SH) (a), root length (RL) (b), leaf numbers (LN) (c), seedlings fresh weight (SFW) (d) and seedlings dry weight (SDW)(e). Data represent the means (± SE) of at least three replicates. The columns with the same letter are not significantly different (P<0.05).



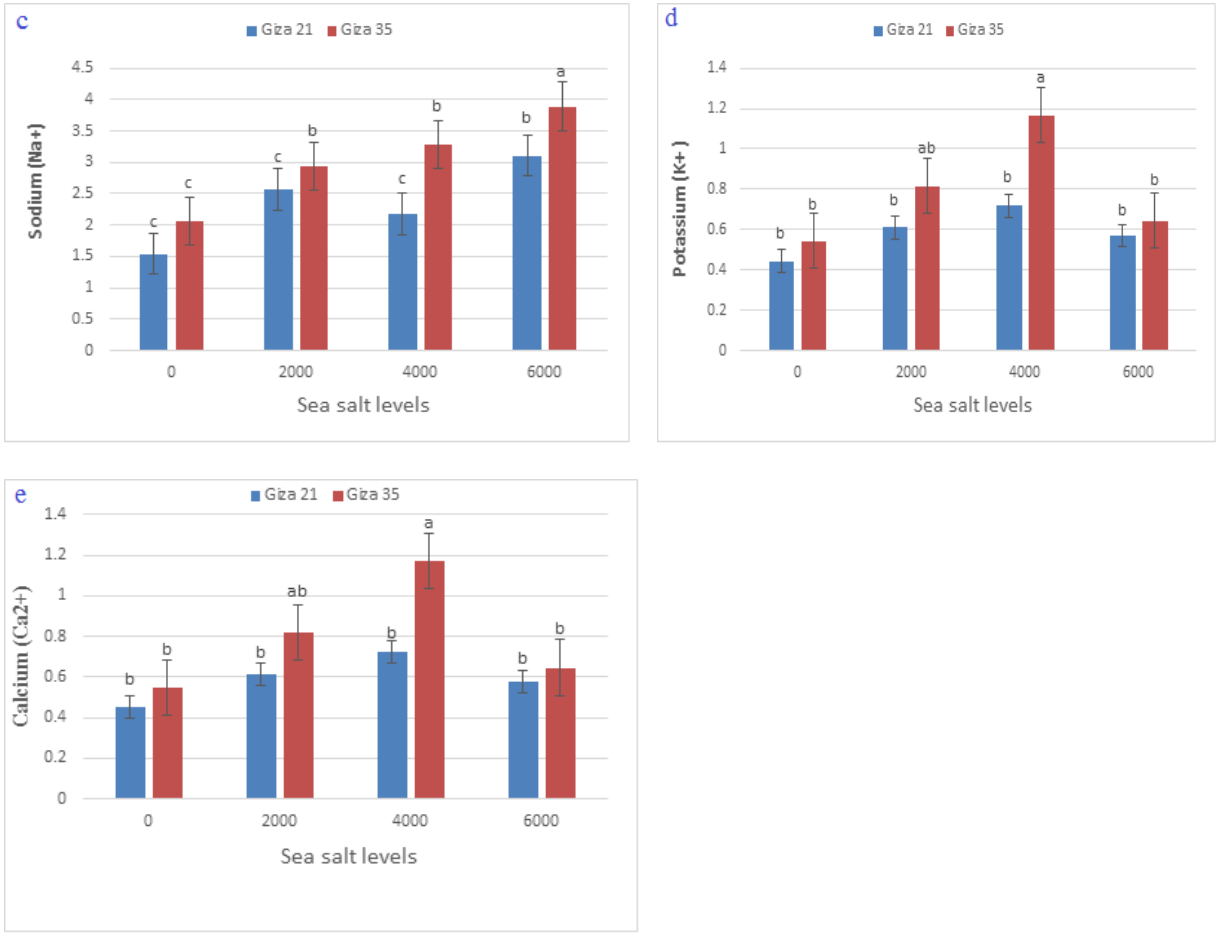


Figure 3: Changes in the nitrogen N- (a), phosphorus P (b), sodium Na+ (c), potassium K+ (d) and calcium Ca2+ concentration in leaves. Data represent the means (± SE) of at least three replicates. The columns with the same letter are not significantly different (P<0.05).

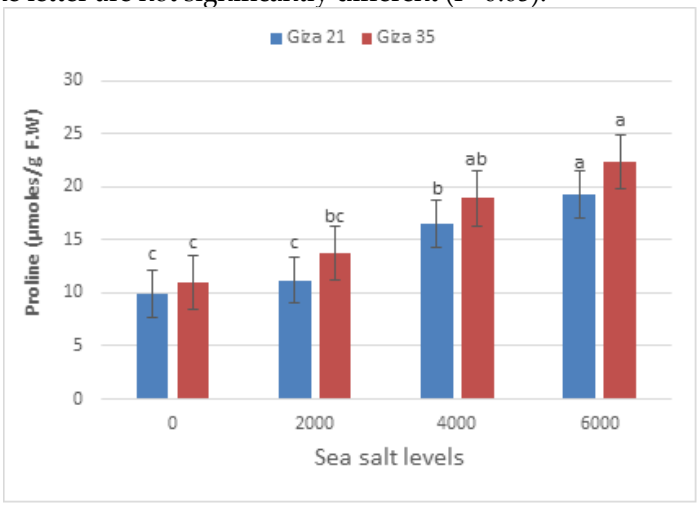


Figure 4: Proline content of two soybean cultivars at different sea salt stress levels. Data represent the means (± SE) of at least three replicates. The columns with the same letter are not significantly different (P<0.05).

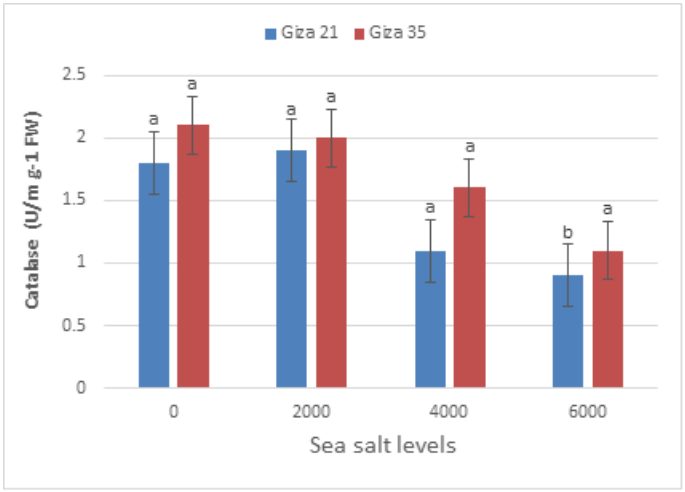


Figure 5: catalase activity of two soybean cultivars at different sea salt stress levels. Data represent the means (± SE) of at least three replicates. The columns with the same letter are not significantly different (P<0.05).

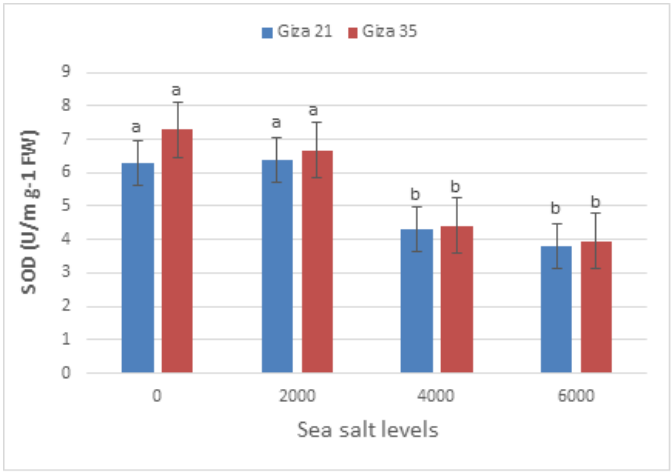


Figure 6: Superoxide dismutase activity of two soybean cultivars at different sea salt stress levels. Data represent the means (± SE) of at least three replicates. The columns with the same letter are not significantly different (P<0.05).

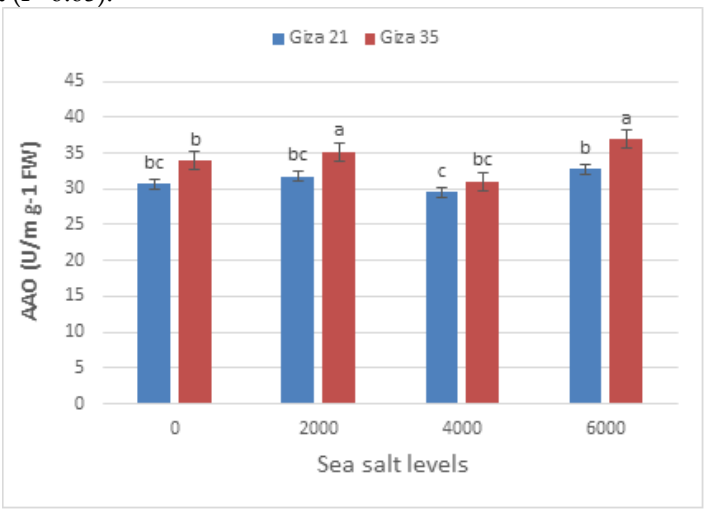


Figure 7: Ascorbic acid oxidase activity of two soybean cultivars at different sea salt stress levels. Data represent the means (± SE) of at least three replicates. The columns with the same letter are not significantly different (P<0.05).

تأثير الإجهاد الملحي على النمو وبعض العلاقات الفسيولوجية في صنفين من فول الصويا

رجب إبراهيم الخولي [1,*], عبدالهادي إبراهيم حسن سيد [1], حسام فوزي احمد الشاعر [1], مؤمن سيد حنفي [2]

[1] *قسم النبات الزراعى, شعبة الوراثة, كلية الزراعة, جامعة الازهر, القاهرة, مصر.*

[2] *قسم التكنولوجيا الحيوية النباتية, المركز القومى للبحوث, الجيزة, مصر.*

* البريد الإلكتروني للباحث الرئيسي: Ragab_Elkholy@azhar.edu.eg

الملخص العربى

استهدفت الدراسة تأثير الإجهاد السلبي لملح البحر على النمو والصفات الإنتاجية باستخدام صنفين من نبات فول الصويا هي (جيزة 21 وجيزة 35) وذلك بتعريضها لتركيزات صفر (مقارنة) و2000 و4000 و6000 جزء من المليون. تم قياس صفات النمو والمؤشرات الكيميائية الحيوية في البادرات مثل ارتفاع النبات وعدد الأوراق والوزن الرطب للبادرات. ووجد أنها قد نقصت في كل المعاملات بزيادة التركيز الملحي. بينما أعطت صفات طول الجذور والوزن الجاف للبادرات زيادة عن نباتات المقارنة. وقد وجد عند تحليل النباتات أن أيونات الصوديوم والنيتروجين والفسفور قد تجمعت بازدياد في الصنفين، بينما وجد أن أيونات الكالسيوم والبوتاسيوم قد ازدادت نسبتها المئوية في جيزة 35 على تركيز 4000 جزء في المليون ثم تناقصت بعد ذلك لتماثل بادرات المقارنة، وبالمقارنة لُوحظ أن صنف جيزة 21 أعطى فروقًا غير معنوية في أيونات البوتاسيوم والكالسيوم تحث تأثير الإجهاد الملحي. أما النشاط الأسموزي العضوي لإنزيم الكتاليز قد نقص في جيزة 21 على تركيز 6000 جزء في المليون وكان غير معنوي في جيزة 35 تحت الإجهاد الملحي. تبين من النتائج أن إنزيم الأكسدة الفائق ديسموتاز قد ازداد تحت الإجهاد الملحي في كل الصنفين زيادة قوية وكذلك نشاط إنزيم الاسكوربيك أوكسيديز قد نقص على 2000 جزء في المليون وازداد النقص على 4000 جزء في المليون وزاد ذلك بمعنوية عالية على تركيز 6000 جزء في المليون عن المقارنة. وعلى وجه العموم وجد أن الصنف جيزة 21 لا يحدث فيه معنوية في نشاط إنزيم الاسكوربيك أوكسيديز بالإجهاد الملحي.

الكلمات الاسترشادية : فول الصويا , الايونات , البرولين , الملوحة , إنزيمات مضادات الأكسدة.