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Characterization of Water Melon (*Citrullus lanatus*) Genotypes under High Salinity Regime

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Abstract

For horticultural crops and especially for vegetables, salinity is dilemma. It is the most limiting factor for plant growth and development by producing reactive oxygen species and ultimately oxidative stress. In the present study, the screening of watermelon (*Citrullus lanatus* Thanb. Mavs.) Cultivars was observed for salt tolerance. Four salinity levels (1.5, 3, 4.5, and 6 dS·m^{-1} NaCl) and six cultivars (Crimson, Charleston Gray, Anarkali, Chairman, Sugar Baby and Champion) tested for screening. It was observed that all morphological attributes and ionic contents were severely affected. But it was revealed by statistical analysis that Charleston Gray was affected least while Champion was most salt sensitive cultivar due to oxidative stress and ionic toxicity. It is concluded that different genotypes under consideration vary in their ability to tolerate salt stress.

Keywords

***Citrullus lanatus*, Watermelon, Salinity, NaCl, Abiotic Stress**

1. Introduction

Salinity is a global concern that limits the growth and productivity of all vegetables which is going to increase day by day. Increasing salinity caused a decrease in germination, root and shoot length, plant height, pod length, pod weight, photosynthetic rate and stomatal conductance. The Na^+ and Cl^- accumulations were linked with a decline in concentration of K^+ in leaves and roots. A high concentration of Na^+ and Cl^- was noted in both leaves

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and root portions under salinity (Shahid *et al*. 2011) [1]. Different types of salt-affected soils cover 10% of the total land surface. At present, there are nearly 954 million hectares of saline soils on the earth's surface. Pakistan occupies 6.3 million hectares salt affected soils (Aslam *et al*. 2000) [2]. Out of 6.3 million hectares, about 40% are saline and 60% are saline sodic, while 80% of salt affected area in Punjab is saline sodic (Khan, 1998) [3]. Watermelon is moderately sensitive to salinity. Its threshold for salt tolerance EC is 2.0 $dS \cdot m^{-1}$. Yield decrease due to salinity, 10% at EC 2.5 $dS \cdot m^{-1}$, 10% at 3.3, 25% at 3.5 and 50% at 4.5 $dS \cdot m^{-1}$ (Amacher *et al*. 2000) [4]. Many parts of the world are facing two most serious soil problems *i.e.* salinity and water logging (Shafqat *et al.* 1998) [5]. Salt-affected soils exist mostly under arid, semi-arid climate and cover about 955 million hectares of world (Szabolcs, 1991) [6]. Despite the various control measures, about 20 million hectares of land go out of production annually (Malcolm, 1993) [7]. Ahmad and Riffat (2005) [8] evaluated the effect of salinity on some physio-biochemical parameters in pea (*Pisum sativum* L. cv.). They concluded that all these changes were associated with a decrease in relative water contents and K^+ uptake. There was a significant increase in proline and sugar contents while nitrate reductase activity and chlorophyll contents were decreased. Salt stress also reduces the photosynthetic activity by reducing chlorophyll contents, number of stomata and stomatal conductance (Balal *et al*. 2012) [9].

As salinity is limiting factor for most of the horticultural crops, thus the present study was conducted to check that how different cultivars of the watermelons are effected due to different salinity levels.

2. Materials and Methods

The present study was carried out at glass house in Institute of Horticultural Sciences, University of Agriculture, Faisalabad (31˚30'N, 73˚10'E; 184 m above the sea level.), Pakistan. The experiment was laid out in completely randomized design (CRD) with two factors. The experiment was designed to investigate the salt tolerance potential of watermelon genotypes. At 3 leaf stage four salinity levels (1.5, 3, 4.5, and 6 $dS \cdot m^{-1}$ NaCl) and six cultivars namely (Crimson, Charleston Gray, Anarkali, Chairman, Sugar Baby and Champion) tested for screening and results compared with control (non-saline). Hoagland's solution was used as nutrient medium. After ten days plants were harvested for following parameters regarding mortality (%), shoot length (cm), root length (cm), total length (cm), total fresh weight (g), total dry weight (g), chlorophyll contents (SPAD), nitrogen (N) contents ($mg \cdot g^{-1}$ DW) and protein contents (mg) were recorded. Mortality (%) was calculated by dividing the number of seeds sprouted to total number of seeds sown. While root and shoot length was measured with the help of measuring scale. Dry weight was measured by keeping the sample in oven for 24 hour till constant weight. For measuring the nitrogen percentage, first leaves were passed through the digestion procedure and then nitrogen content was measured by Kjeldhal method.

The total protein contents were determined by multiplying nitrogen amount by a certain factor. This value is called the "crude protein" content. (AOAC, 2000) [10]. Collected data were analyzed statistically by applying Fisher's analysis of variance technique and significance of treatments means was tested by using LSD test at 5% probability level (Steel *et al*., 1997) [11].

3. Results

3.1. Morphological Attributes

It is visualized from the statistical analysis that differences among the treatments were highly significant. There was complete mortality of Chairman and Champion at highest salinity dose followed by (70%) followed by 3 $dS \cdot m^{-1}$ NaCl (47%) and control (16%). Cultivar Chairman exhibited mortality percentage (43%), followed by Anarkali (41%), Charleston Gray (40%), Sugar Baby (36%), Champion (36%) and the least mortality percentage was noted for Crimson (57%). The highest mortality percentage was found at highest salinity level where 100% mortality was observed in Chairman and Champion (**Figure 1(b)**).

The maximum shoot length was recorded in plants growing under 1.5 $dS \cdot m^{-1}$ NaCl and the lowest shoot length was recorded at 6.0 $dS \cdot m^{-1}$ NaCl level. Crimson genotype exhibited maximum shoot length, followed by Charleston Gray, Anarkali, Chairman, Sugar Baby and Champion. It was found that Anarkali had dominating salt tolerance potential due to this reason it presented less reduction in shoot length (**Figure 1(c)**).

The highest root length was found at 3.0 $dS \cdot m^{-1}$ NaCl followed by control, and least was recorded at 6 $dS \cdot m^{-1}$ NaCl. Varietal means were highly significant which revealed that cultivar Charleston gray exhibited maximum

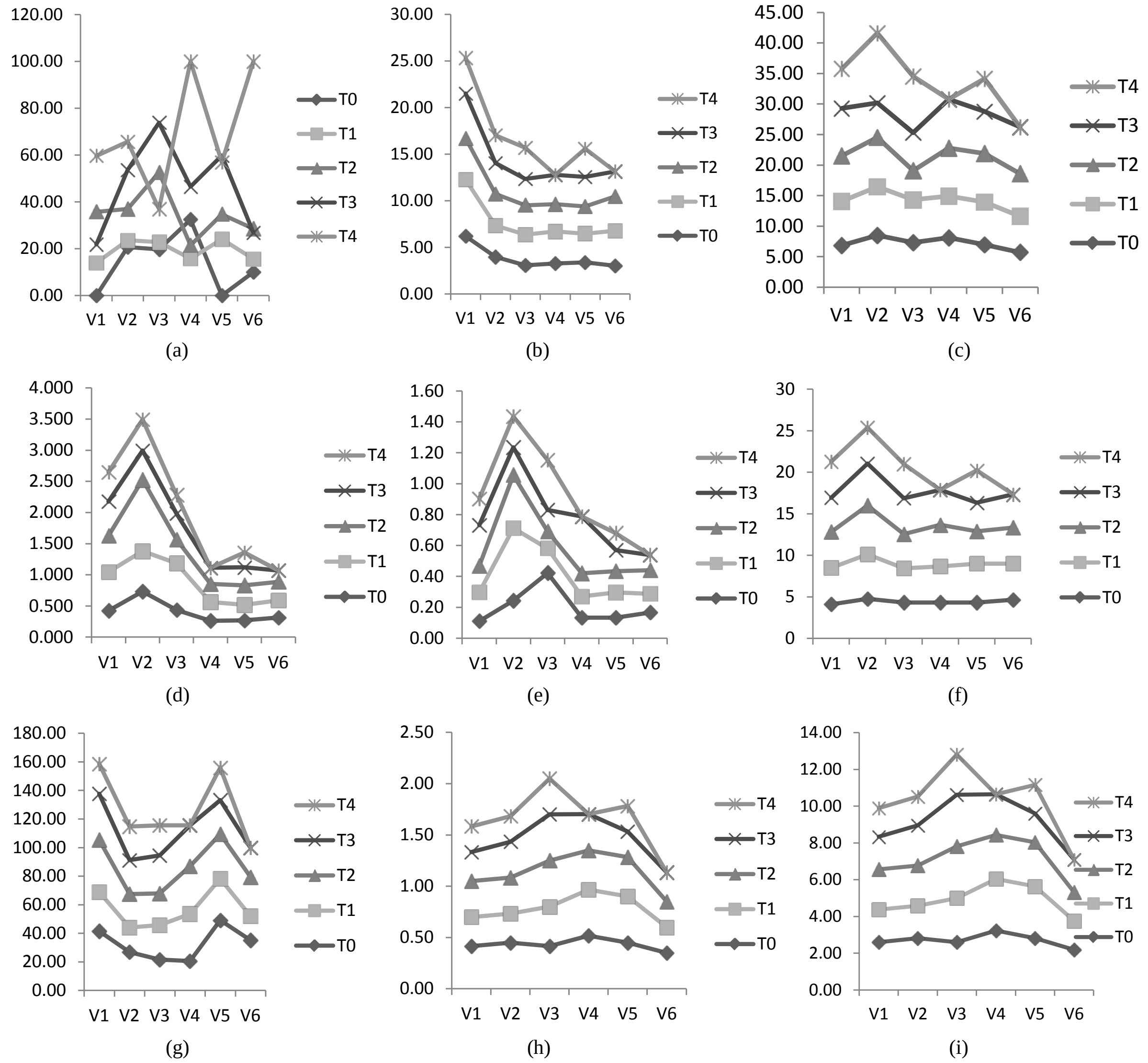

Figure 1. Response of different genotypes of water melon at different levels of salinity (a) Mortality (%); (b) Shoot length (cm); (c) Root length (cm); (d) Fresh weight; (e) Dry weight; (f) Number of leaves; (g) Chlorophyll contents; (h) Nitrogen contents (mg·g^{-1} DW); (i) Protein contents (mg·g^{-1} DW).

root length, followed by Crimson, Anarkali, Sugar Baby, Chairman and the least root length was noted case of Champion. The genotype × treatment means were also significant and revealed that all the genotypes responded differently to different treatments. The maximum root length was observed in 6.0 dS·m^{-1} NaCl and minimum at 1.5 dS·m^{-1} NaCl, respectively. Root length was reduced by all treatments but maximum decrease was noted in Anarkali at 3 dS·m^{-1} NaCl. Charleston gray showed significant behavior at all treatments than other cultivars, followed by Anarkali and Chairman (**Figure 1(d)**).

Data regarding plant fresh weight depicts maximum plant fresh weight was founded in 3 dS·m^{-1} NaCl and minimum in 1.5 dS·m^{-1} NaCl. Thus the highest salinity level is more damaging that resulted in maximum reduction in plant fresh weight. Genotype's means varied significantly, demonstrating that Charleston gray genotype showed greater plant fresh weight as compared to other cultivars (**Figure 1(e)**).

From the data it can be concluded that genotype Charleston gray exhibited maximum plant fresh weight at highest salinity application but Champion failed at these levels of salinity and displayed maximum reduction in plant fresh weight as compared to other cultivars as so we can say that cultivars like Charleston gray exhibited maximum plant fresh weight at higher salinity treatments are salt tolerant while the cultivars which failed to do this at same treatments like Champion are characterized as salt sensitive (**Figure 1(e)**).

With salinity maximum decrease in plant dry weight was found in Champion, followed Sugar Baby and Chairman. The maximum plant dry weight was founded in 1.5 $dS \cdot m^{-1}$ and the minimum in 6 $dS \cdot m^{-1}$. Thus the highest salinity level 6 $dS \cdot m^{-1}$ is more damaging that resulted in maximum reduction in plant dry weight. The maximum plant dry weight was observed at control and minimum at 4.5 $dS \cdot m^{-1}$ NaCl, respectively. Plant dry weight was reduced by all treatments but the maximum decrease was noted at 6.0 $dS \cdot m^{-1}$ NaCl. Charleston gray showed significant behavior at all treatments than other cultivars. From the data it can be concluded that among the cultivars Charleston gray showed comparatively better performance against all salinity treatments so, we can say that Charleston gray is salt tolerant genotypes while remaining five cultivars showed maximum decrease in plant dry weight so they are categorized as salt sensitive genotypes (**Figure 1(f)**).

The treatment 3.0 $dS \cdot m^{-1}$ NaCl gave highest number of leaves followed by 1.5 $dS \cdot m^{-1}$ NaCl, control and 4.5 $dS \cdot m^{-1}$ NaCl. The salinity application of 6 $dS \cdot m^{-1}$ NaCl treatment showed minimum number of leaves. Results for varietal means were found to be significant which showed that three varieties also showed different behavior for number of leaves. The Charleston gray variety gave maximum score for number of leaves under salinity conditions. The Champion gave minimum score for number of leaves under salinity conditions. The Charleston gray gave maximum score for number of leaves at 3.0 $dS \cdot m^{-1}$NaCl, Anarkaliat 3.0 $dS \cdot m^{-1}$ NaCl showed minimum score for number of leaves (**Figure 1(g)**).

3.2. Chlorophyll Contents

The recent findings approve these findings as salinity displayed an inhibitory effect on chlorophyll contents. The highest chlorophyll contents were found in control and lowest in highest salinity level. Varietal means were highly significant representing that Crimson cultivar showed the highest chlorophyll contents under salinity stress and Sugar baby at par followed by Anarkali, Chairman and Charleston gray, respectively while minimum chlorophyll contents were exhibited by Champion. The maximum chlorophyll contents were observed in control, it drastically reduced at 6.0 $dS \cdot m^{-1}$ NaCl (**Figure 1(h)**).

3.3. Nitrogen and Protein Contents

The maximum nitrogen contents were seen in Chairman whereas it was seen lowest in Champion. Lowest nitrogen contents were noted in Champion at 3.0 $dS \cdot m^{-1}$. The highest accumulation of nitrogen contents was verified in Chairman at control level. From the data it can be suggested that nitrogen contents uptake was significantly decreased with increasing salinity levels however, this reduction was found less in salt tolerant varieties rather than salt sensitive varieties.

The maximum plant protein contents were found at control and the minimum in it significantly decreased up to 6.0 $dS \cdot m^{-1}$ NaCl. The maximum protein contents were seen in Anarkali whereas it was seen lowest in Champion.

Lowest protein contents were noted in Sugar baby at 1.5 $dS \cdot m^{-1}$. The highest accumulation of protein contents was verified in Chairman at control.

From the data it can be suggested that protein contents uptake was significantly decreased with increasing salinity levels however, this reduction was found less in salt tolerant varieties rather than salt sensitive varieties. Comparatively Anarkali showed better performance against all salinity levels than other cultivars.

4. Discussion

Salinity is one of the most important dynamics reducing plant growth and delaying seed germination as well as final germination percentage (Rahman *et al*. 2000) [12]. The emergence and germination of pepper seeds was slow and non-uniform under normal as well as stress conditions (Demir and Okcu, 2004) [13]. As salinity decreases there was no mortality, but when salinities were maintained even at low levels 40% - 50% mortality (Meng *at el.* 2011) [14]. Decrease in shoot length could be attributed to increase in NaCl concentration leading to Na^+ and Cl^- toxicity because of their elevated concentration in growth medium (Pessarkali *et al.* 2004) [15]. In the present study shoot length of the watermelon cultivars is very much affected under saline conditions as the finding of (Brown *et al*. 2006) [16]. As salinity increased, root length of salt tolerant cultivars increased but a consistent decline was found in salt sensitive cultivars with increase in salinity (Maiti *et al*. 2010) [17]. Salt stress reduces the growth attributes including shoot length, root size, leaf area and fresh and dry weight of plants and there are many evidences which showed that turgor pressure was reduced due to salt stress (Ashraf and Harris, 2004) [18]. So, it can be suggested from current findings that reduction in turgor pressure is correlated with decline in root length as root length in all watermelon cultivars decreased by salinity stress.

These findings are strengthened by the findings of Ahmad and Riffat (2005) [8] who evaluated the effect of salinity on some physio-biochemical parameters in pea under four salt treatments (50, 100, 150 and 200 mM NaCl) for 30 days in sand culture experiments and reported that high NaCl concentrations caused a great reduction in fresh and dry weight of leaves and roots, but non-significantly influenced the number of leaves. They concluded that all these changes were associated with a decrease in the relative water contents and K^+ uptake. The proline and sugar contents were increased while nitrate reductase activity and chlorophyll contents were decreased. When salts accumulate to toxic level in leaves again the growth inhibition takes place, so ion toxicity of Na^+ and Cl^- could be the second reason for decreased plant fresh weight with increased salinity (Ibrahim, 2003) [19]. Fresh and dry weight of cotton plants was deleteriously affected by salt stress (Xie *et al*. 2008) [20]. A distinct decline was found in shoot dry weight of okra plants at all salinity levels (Abid *et al*. 2002) [21].

These findings are strengthened by the findings of Ahmad and Riffat (2005) [8] who evaluated the effect of salinity on some physio-biochemical parameters in pea under four salt treatments (50, 100, 150 and 200 mM NaCl) for 30 days in sand culture experiments and reported that high NaCl concentrations caused a great reduction in fresh and dry weight of leaves and roots, but non-significantly influenced the number of leaves. They concluded that all these changes were associated with a decrease in the relative water contents and K^+ uptake. The proline and sugar contents were increased while nitrate reductase activity and chlorophyll contents were decreased.

Salinity changes photosynthetic parameters including osmotic potential, water potential, transpiration rate, leaf temperature and relative leaf water contents. Salts also affect photosynthetic components such as enzymes, chlorophyll and carotenoids (Dubey, 1999) [22]. The reason behind this fact is that salinity stress results in minimization in the rate of leaf surface expansion and as a result leaves expansion reduces. Due to being membranous structure of chloroplast the reduction in chlorophyll contents is to be expected. Its consistency is dependent on membrane stability which infrequently undamaged under saline conditions (Ashraf and Harris, 2004) [18] so recent results confirm these findings as with increase in salt stress chlorophyll contents decreased. It can be suggested that in cultivar Sugar baby maximum salinity level had exerted minimum reduction in chlorophyll contents as compared to other cultivars thus proving to be salt tolerant characters. Whereas the highest chlorophyll contents reduction was found in Champion, so it was considered as salt sensitive. In leaves of tomato, due to salinity stress, the contents of total chlorophyll including Chl-a and Chl-b carotene were reduced (Khavari-Nejad and Mostofi, 1998). The negative effect of salt stress on germination, antioxidant enzymes, phenolic compounds, flavonoids may be partly corrected by phenyl urea (Ali *et al*., 2004) [23].

The negative effect of salts tress on germination, antioxidant enzymes, phenolic compounds, flavonoidS·may be partly corrected by phenyl urea (Ali *et al*. 2004; [23] Mahboobeh and Akbar, 2013) [24]. From the data it can be suggested that nitrogen contents uptake was significantly decreased with increasing salinity levels however, this reduction was found less in salt tolerant varieties rather than salt sensitive varieties (**Figure 1(i)**).

Protein contents decreasing is another is common in salt stress condition for many plant species (Merril, 1990; [25] Mahboobeh, and Akbar, 2013) [24]. From the data it can be suggested that protein contents uptake was significantly decreased with increasing salinity levels however, this reduction was found less in salt tolerant varieties rather than salt sensitive varieties. Anarkali showed better performance against all salinity levels than other cultivars (**Figure 1(i)**).

The possible reason for decrease in K^+ concentration with increase in salinity could be that as Na^+ is similar to K^+ and many K^+ transporters do not discriminate sufficiently between these cations, excess external Na^+ can not only impair K^+ acquisition but also lead to accumulation of Na^+ in plant cells. More Na^+ influx inhibits K^+ permeability to the cells thus decreasing its concentration (Pardo and Quintero, 2002) [26].

5. Conclusion

So it was concluded from the study that control showed the best behavior than salinity levels. Moreover, in varietal comparison, Crimson genotype exhibited maximum shoot length and chlorophyll contents. While maximum root length, fresh weight, dry weight and numbers of leaves were recorded in Charleston cultivar. On the other hand, Nitrogen and protein contents were maximum in Anarkali cultivar.

References

[1] Shahid, M.A., Pervez, M.A., Balal, R.M., Ahmad, R., Ayyub, C.M., Abbas, T. and Akhtar, N. (2011) Salt Stress Effects on Some Morphological and Physiological Characteristics of Okra (*Abelmoschus esculentus* L.). *Soil and Environment*, **30**, 66-73.

[2] Aslam, S.M., Ansari, R. and Khan, A.M. (2000) Saline Agriculture in Pakistan. *Industry and Economy*.

[3] Khan, M.A. and Gul, B. (1998) High Salt Tolerance in the Germinating Dimorphic Seeds of *Arhrocnemum macrostachyum*. *International Journal of Plant Sciences*, **159**, 826-832. http://dx.doi.org/10.1086/297603

[4] Amacher, J.K., Koenig, R. and Kitchen, B. (2000) Salinity and Plant Tolerance. Utah State University, No. AG-S0-03. https://extension.usu.edu/files/publications/publication/AG-SO-03

[5] Shafqat, M.N., Mustafa, G., Mian, S.M. and Qureshi, R.H. (1998) Evaluation of Physiological Aspects of Stress Tolerance in Wheat. P*akistan Journal of Soil Science*, **14**, 85-89.

[6] Szabolcs, I. (1991) Desertification and Salinization. In: Choukr-Allah, R., Ed., *Plant Salinity Research*, *New Challenges*, *Conference on Agriculture Management of Salt-Affected Areas*, Ajgadir, 12-13 September 1991, 10-15.

[7] Malcolm, C.V. (1993) The Potential of Halophytes for Rehabilitation of Degraded Land. In: Davidosn, N. and Galloway, R., Eds., *Productive Use of Saline Land*, *Aclar*. *Proceedings of Workshop*, Perth, 25-27 April 1993, 8-11.

[8] Ahmad, P. and Jhon, R. (2005) Effect of Salt Stress on Growth and Biochemical Parameters of *Pisum sativum* L. *Archives of Agronomy and Soil Science*, **51**, 665-672. http://dx.doi.org/10.1080/03650340500274151

[9] Balal, R.M., Khan, M.M., Shahid, M.A., Mattson, N.S., Abbas, T., Ashfaq, M. and Iqbal, Z. (2012) Comparative Studies on the Physio-Biochemical, Enzymatic and Ionic Modifications in Salt Tolerant and Salt Sensitive *Citrus rootstocks* under NaCl Stress. *Journal of American Society of Horticultural Sciences*, **137**, 1-10.

[10] AOAC (2000) Official Methods of Analysis. 17th Edition, Association of Official Analytical Chemists, Arlington.

[11] Steel, R.G.D., Torrie, J.H. and Dickey, D.A. (1997) Principles and Procedures of Statistics: A Biometrical Approach. 3rd Edition, McGraw-Hill Co., New York.

[12] Md. Shahidur, R., Matsumuro, T., Miyake, H. and Takeoka, Y. (2000) Salinity-Induced Ultrastructural Alternations in Leaf Cells of Rice (*Oryza sativa* L.). *Plant Production Science*, **3**, 422-429. http://dx.doi.org/10.1626/pps.3.422

[13] Demir, I. and Okcu, G. (2004) Aerated Hydration Treatment for Improved Germination and Seedling Growth in Aubergine (*Solanum melongena*) and Pepper (*Capsicum annum* L.). *Annals of Applied Biology*, **144**, 121-123. http://dx.doi.org/10.1111/j.1744-7348.2004.tb00324.x

[14] Meng, X.L., Dong, Y.W., Dong, S.L., Yu, S.S. and Zhou, X. (2011) Mortality of the Sea Cucumber, *Apostichopus japonicas* Selenka, Exposed to Acute Salinity Decrease and Related Physiological Responses: Osmoregulation and Heat Shock Protein Expression. *Aquaculture*, **316**, 88-92. http://dx.doi.org/10.1016/j.aquaculture.2011.03.003

[15] Pessarakli, M. and Kopec, D.M. (2004) Growth Responses of Bermudagrass and Seashore Paspalum to Different Levels of FerroGrow Multi-Nutrient Fertilizer. *Journal of Food*, *Agriculture & Environment* (*JFAE*), **2**, 284-286.

[16] Duan, D.Y., Li, W.Q., Liu, X.J., Ouyang, H. and An, P. (2006) Seed Germination and Seedling Growth of *Suaeda salsa* under Salt Stress. *Annals of Botany*, **44**, 161-169.

[17] Maiti, R.K., Vidyasagar, P., Umashankar, P., Gupta, A., Rajkumar, D. and González-Rodríguez, H. (2010) Genotypic Variability in Salinity Tolerance of Some Vegetable Crop Species at Germination and Seedling Stage. *Plant Stress Manage*, **23**, 204-209.

[18] Ashraf, M.P.J.C. and Harris, P.J.C. (2004) Potential Biochemical Indicators of Salinity Tolerance in Plants. *Plant Science*, **166**, 3-16. http://dx.doi.org/10.1016/j.plantsci.2003.10.024

[19] Ibrahim, M. (2003) Salt Tolerance Studies on Cotton. M.Sc. Thesis, Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad, Faisalabad, 495-498.

[20] Xie, X., Wang, J. and Yuan, H. (2008) High-Resolution Analysis of Catechol-Type Siderophores Using Polyamide Thin Layer Chromatography. *Journal of Microbiological Methods*, **67**, 390-393. http://dx.doi.org/10.1016/j.mimet.2006.04.022

[21] Abid, M., Ahmad, F., Ahmad, N. and Ahmad, I. (2002) Effect of Phosphorous on Growth, Yield and Mineral Composition of Wheat in Different Textured Saline-Sodic Soils. *Asian Journal of Plant Sciences*, **1**, 472-475. http://dx.doi.org/10.3923/ajps.2002.472.475

[22] Dubey, R.S. (1999) Protein Synthesis by Plants under Stressful Conditions. In: Pessarakli, M., Ed., *Handbook of Plant and Crop Stress*, Marcel Dekker Press Inc., New York, 365-397. http://dx.doi.org/10.1201/9780824746728.ch16

[23] Mahmood, A., Athar, M., Qadri, R. and Mahmood, N. (2008) Effect of NaCl Salinity on Growth, Nodulation and Total Nitrogen Content in *Sesbania sesban*. *Agriculturae Conspectus Scientificus*, **73**, 137-141.

[24] Mahboobeh, R. and Akbar, E.A. (2013) Effect of Salinity on Growth, Chlorophyll, Carbohydrate and Protein Contents

of Transgenic *Nicotiana Plumbaginifolia* over Expressing P5CS Gene. *Journal of Environmental Research and Management*, **4**, 0163-0170.

[25] Merril, C.R. (1990) Gel-Staining Techniques. In: Deutscher, M.P., Ed., *Methods in Enzymology*, Vol. 182, Academic Press, San Diego, 477-488.

[26] Pardo, J.M. and Quintero, F.J. (2002) Plants and Sodium Ions: Keeping Company with the Enemy. *Genome Biology*, **3**, reviews1017.1-reviews1017.4. http://dx.doi.org/10.1186/gb-2002-3-6-reviews1017