Journal of American Science

Websites:
http://www.jofamericanscience.org
http://www.sciencepub.net

Emails:
editor@sciencepub.net
sciencepub@gmail.com

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

Hydroponic evaluation of barley genotypes under salt stress

Mahwish Mustafa[1], Muhammad Ameel Riaz[2], Rashid Manzoor[3], Aqsa Latif[1]

[1]Center of Agricultural Biochemistry and Biotechnology, University of Agriculture, Faisalabad, Pakistan.
[2]Institute of Botany, University of the Punjab Lahore, Pakistan
[3]Department of Biotechnology, Muhammad Nawaz shareef University of Agriculture, Pakistan.

Abstract: Barley is susceptible to salinity but shows genotypic variation for salt tolerance. The hydroponic assessment of different barely genotypes for salt tolerance solution culture-based study was conducted to observe the behavior of varieties of *Hordeum Vulgare* L. against various salt concentrations. For this purpose, nine varieties were evaluated for 42 days at various salt levels (0mM, 100mM and 200mM). In this study the data on followed parameters like, root length, root fresh weight, root dry weight and chlorophyll contents were recorded. The study was organized and analyzed by CRD technique having 3 replications. By using standard procedures, the collected information of study was statistically organized. Among nine genotypes A02, A03 and A07 were declared salt tolerant on the basis of studied characters.

[Mahwish Mustafa, Muhammad Ameel Riaz, Rashid Manzoor, Aqsa Latif. **Hydroponic evaluation of barley genotypes under salt stress.** *J Am Sci* 2021;17(8):65-71] *ISSN 1545-1003 (print); ISSN 2375-7264 (online).* http://www.jofamericanscience.org 8. doi: 10.7537/marsjas170821.08.

Key words: Root length, salinity, barley

Introduction

Global food production will need to increase by approximately 50 % by 2050 to match the projected population growth (Flowers 2004). As most suitable land has already been cultivated, this implies a need for expansion into new areas. Some of these areas are severely affected by salinity and, hence, not suitable for traditional crops. Others can be made productive only by irrigation and, hence, are at threat of becoming saline. Barley (Hordeum vulgare L.) is classified as glycophytes (salt-sensitive), although they are moderately salt tolerant compared with other plants such as Arabidopsis thaliana (L.) and rice (Munns and Tester 2008). In terms of worldwide production, barley is the fourth most important cereal crop after wheat, maize (Zea mays L.) and rice. In addition, it has been reported that salinity decreased and delayed germination of barley. Lower levels of salinity delayed germination, whereas higher levels reduced the final percentage of seed germination. Despite extensive and numerous studies having been conducted over the past few decades on the responses and mechanisms of salinity tolerance in plants, little progress has been made to date in developing high-yielding, salt-tolerant genotypes because of the genetic and physiological complexity of salinity tolerance and a lack of reliable screening methods. Salinity affects seed germination through osmotic effects, ion toxicity (Hampson and Simpson, 1990) or a combination of the two (Huang and Redmann, 1995). In vegetative plants, salt stress causes reduced cell turgor and depressed rates of root and leaf elongation (Fricke *et al.*, 2006), suggesting that environmental salinity acts primarily on water uptake. Germination and seedling growth under saline conditions are the screening criteria that are widely used to select salt tolerant genotype (Abu-El-lail et al., **2014**). Othman et al. (**2006**) found that germination percentage of barley is greatly reduced under 300 mM NaCl; germination of some genotypes decreased from 84.5% (control) to 3.7% (under 300 mM). Adjel et al. (**2013**) found that as salinity increased from 0 to 150 mM NaCl treatment, germination percentage decreased from 86.0 to 50.9%, coleoptile length decreased from 2.5 to 1.5 cm, root length decreased from 35.4 to 8.3 cm, the number of roots decreased from 5.1 to 3.1 roots, the average shoot fresh weight decreased from 718.2 to 520.0 mg seedling^{-1}, and the average roots fresh weight decreased from 642.5 to 210.78 mg seedling^{-1}. They indicated that the reductions in traits associated with increased [Na^+], decreased [K^+], and K^+/Na^+ ratios. Fricke et al. (**2006**) reported a 68 and 64% biomass reduction in the barley cultivars Clipper and Arivat, respectively, under 250 mM NaCl vs. the control. Therefore, salinity has a dual impact on plant performance, acting either as an inhibitor of water uptake by roots, via an osmotic effect or as an accumulator of Na^+ and Cl^- ions, with subsequent toxic impacts. Roots are the first organ of plant to sense salinity in the rhizosphere and are the initial site to suffer from salt stress. Salinity reduces root development by inhibiting both root cell production and expansion and limiting the length of mature epidermal cells. These effects could be due to the toxicity of salts on the expanding cells metabolism, the reduced water availability for cell expansion and the induction of plant responses. Higher salt stress concentration is present in the environment of the developing countries which plays major role in disturbing the yield related potential of crops and also ecosystem of soil. The recent research was organized in order to screen the barley (*Hordeum vulgare* L.) genotypes at various salinity levels in solution culture to identify response of different barley genotypes and to classify them according to their salinity tolerance. So that best varieties can be selected according to level of salinity in the soil in order to get maximum production at the particular environment.

Materials and methods

A hydroponic experiment was conducted to assess the salt tolerance ability of 9 barley accessions in rain protected wire house. In this study, 9 different barley (*Hordeum vulgare* L.) genotypes were used. Seeds of barley cultivars were sown in laboratory in iron trays having 2-inch sand layer. Nursery was irrigated with the distilled water. Then nursery was shifted to glass house after 2-3 days. Nursery was transplanted into 3 tubs (100 L) with half strength of Hoagland's solution. Solution was kept aerated by aeration pumps. Nutrient solution was comprised of macro-nutrients nutrients $Ca(NO_3)_2.4H_2O$, KNO_3, $MgSO_4.7H_2O$, KH_2PO_4 and micro-nutrients H_3BO_3, $MnCl_2.4H_2O$, $ZnSO_4.7H_2O$, $CuSO_4.5H_2O$, $H_2MoO_4.H_2O$, Fe-EDTA (Johnson *et al.,* 1957). pH of solution was maintained at 6.5+0.5 throughout the experiment ((Kronzucker *et al.,* 2006). Nutrient solution was changed at interval of 8 days. Nutrient's solution was prepared by using distilled water.

Salinity was developed by using NaCl salt after three days of transplanting nursery into tubs. The NaCl salt was added in three installments to achieve the desired levels of 100 mM and 200 mM

TREATMENTS

The following treatments were used:

i.	T_1	Control
ii.	T_2	100 mM NaCl
iii.	T_3	200 mM NaCl

Harvesting

The plants were harvested after 42 days of salinity imposition in hydroponic system and then separated into root with the help of scissor. After taking root length and their fresh weight, the plant samples were collected in separate paper bags. The leaf chlorophyll content was determined before harvesting by using chlorophyll meter (Minolta SPAD. 502 Meter). Average (SPAD) reading was recorded form the measures (from leaf tip to leaf blade).

Results

Chlorophyll contents

The chlorophyll contents for different varieties of barley against various salt stress concentrations is shown in figure 1. The chlorophyll contents were significantly affected by salt stress. However, barley genotypes showed variability responses with respect to plant height under salt stress.

The barley genotypes A01 and A04 have maximum chlorophyll contents comparatively with other genotypes, while minimum chlorophyll contents were observed in A08 under control conditions. At 100 mM NaCl stress A02 and A09 genotypes performed better as compared to other genotypes. At 200 mM maximum chlorophyll contents were observed in A09 and A04 as compared to other barley genotypes.

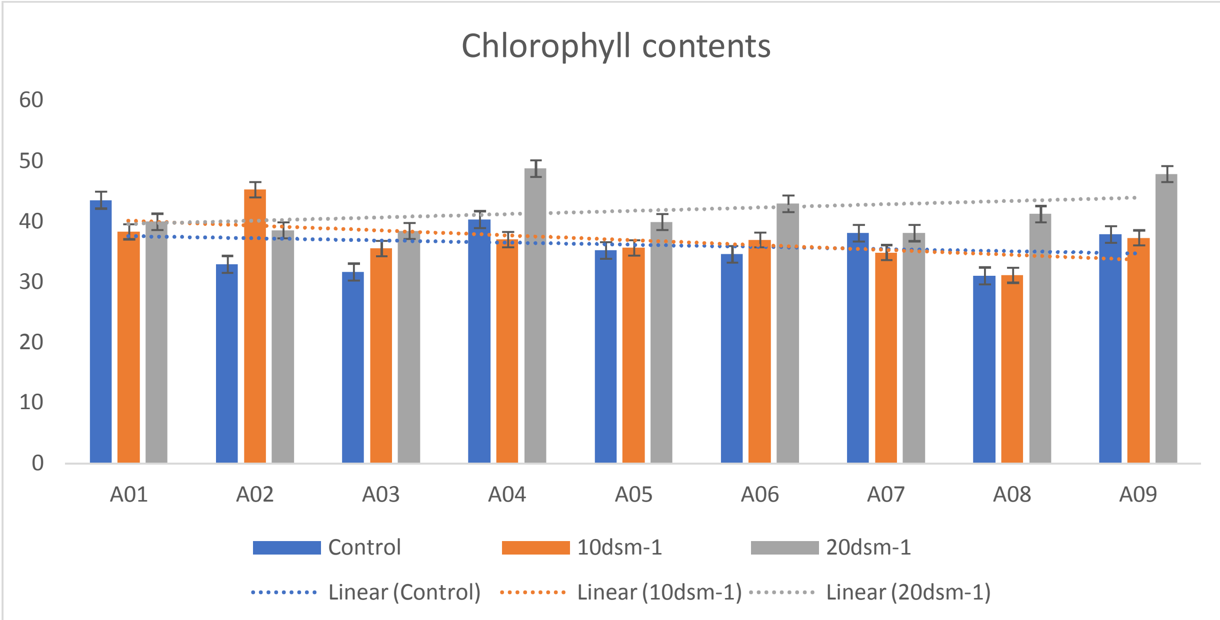

Figure 1: Effects of Salt stress on the Chlorophyll Contents (%) of different Barley (*Hordeum vulgar* L.) genotypes.

Root fresh weight

The results showed that root fresh weight was negatively affected with application of salt stress. It was observed that with increasing salt stress the root fresh weight was significantly decreased. However significant variation was observed in different barley genotypes with application of salt stress. The data root fresh weight of different barley genotypes explained that root fresh weight significantly decreased with increasing salt stress.

At control condition A07 showed higher root fresh weight followed A03, A04 and A05. The genotype A01 showed minimum root fresh weight as compared to other genotypes under control conditions. While with application of 100 mM NaCl stress A02, A03 and A08 genotypes showed maximum root fresh weight while genotype A05 showed minimum root fresh weight as compared other barley genotypes. At 200 mM barley genotypes showed good results in A09, A02 and A04 while A08 showed minimum root fresh weight as compared to other barley genotypes.

The results are according to (Levitt, 2004) who observed that reduced root fresh weight under saline conditions may be due to the decrease in water availability, osmotic potential at root surface or due to specific ion toxicity and nutrient imbalance. The reduced root fresh weight under saline conditions might be due to the decrease in water availability, osmotic potential at root surface, nutrient imbalance. And osmotic stresses are responsible for both inhibition or delayed seed germination and seedling establishment, under these stresses there is decrease in water uptake during imbibition's and salt stress may cause excessive uptake of ions stated by Demiral *et al.* (2005). Zynali and Hamdi (2002) also reported that addition of NaCl in the rooting medium caused reduction in root fresh weight. Due to reduction of root weight, it caused substantial reduction in photosynthetic rate in both of barley cultivars under saline conditions. Different levels of salinity had significant effects on plant growth and resulted in decrease in root fresh weight. Similar results have been reported by Kingsbury *et al.* (1984) that reduction in plant roots fresh weight by means of salt stress.

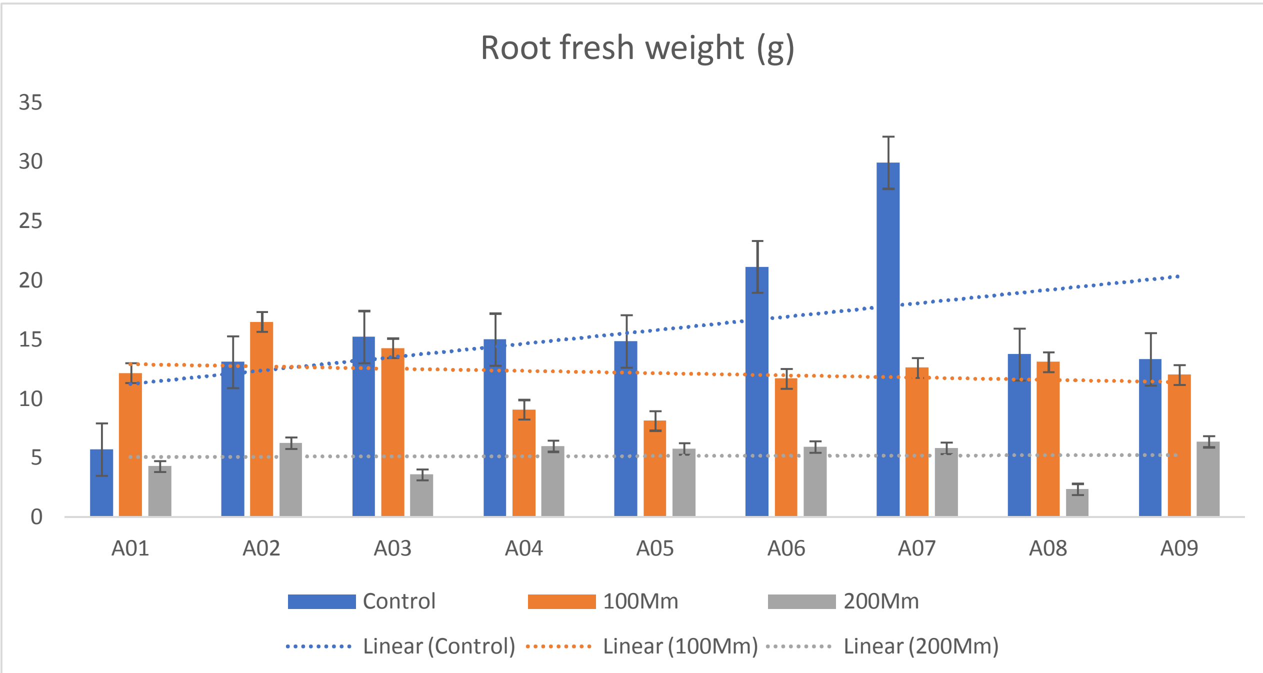

Figure 2: Effects of Salt stress on the root fresh weight of different Barley (*Hordeum vulgar* L.) genotypes.

Root length

The root length for different varieties of barley against various salt stress concentrations is shown in figure 2. The root length was significantly affected by salt stress and concentration of salts increases root length of barley genotypes decreases. However, barley genotypes showed variability responses with respect to root length under salt stress. The mean data root length justifies that it was considerably decreased with enhancing NaCl stress in different barley genotypes. The barley genotypes A07, A06, A03 and A02 have maximum root length comparatively with other genotypes, while minimum root length was observed in A01 under control conditions. At 100 mM NaCl stress A08, A02, and A03 genotypes performed better as compared to other genotypes. With increasing salt stress to 200 mM barley genotypes were most affected. At 200 mM maximum root length was observed in A04, A02 and A05 as compared to other barley genotypes.

The results are according to Jamil *et al*. (2005) who observed that under higher salinity levels canola varieties showed decrease in the root length. Jeannette (2002) observed that length of root decreased under higher salt stress levels because it delays seedling emergence and germination. The decrease in root length with increase in salinity may be due to the reduction in growth rate and imbalanced nutrition. Sun *et al*. (2005), described that because of higher salt stress and imbalance in composition of nutrients considerably decreased the length of roots. Under high salt stress conditions, the first emergence stage was affected. Due to higher salinity concentration seedling roots were affected that's way length of roots are decreased so elongation of roots does not take place described by Warner *et al*. (2004). This reduction is due to increase in soil solution Osmotic pressure and the imbalances in needed elements. Higher salinity levels in rooting medium cause stress and thus elements required by plants becomes unavailable hence cause decrease in plant's roots and shoots length indicated by Lopez *at el*. (2002).

Root dry weight

The root dry weight for different varieties of barley against various salt stress concentrations is shown in figure 2. The root dry weight was significantly affected by salt stress. However, barley genotypes showed variability responses with respect to root dry weight under salt stress. The mean data root dry weight justifies that it was considerably decreased with enhancing NaCl stress in different barley genotypes.

The barley genotypes A07 and A06 have maximum root dry weight comparatively with other genotypes, while minimum root dry weight was observed in A01 under control conditions. At 100 mM NaCl stress A02, and A09 genotypes performed better as compared to other genotypes. With increasing salt stress to 200 mM barley genotypes were most affected. At 200 mM maximum root length was observed in A01 and A09 as compared to other barley genotypes.

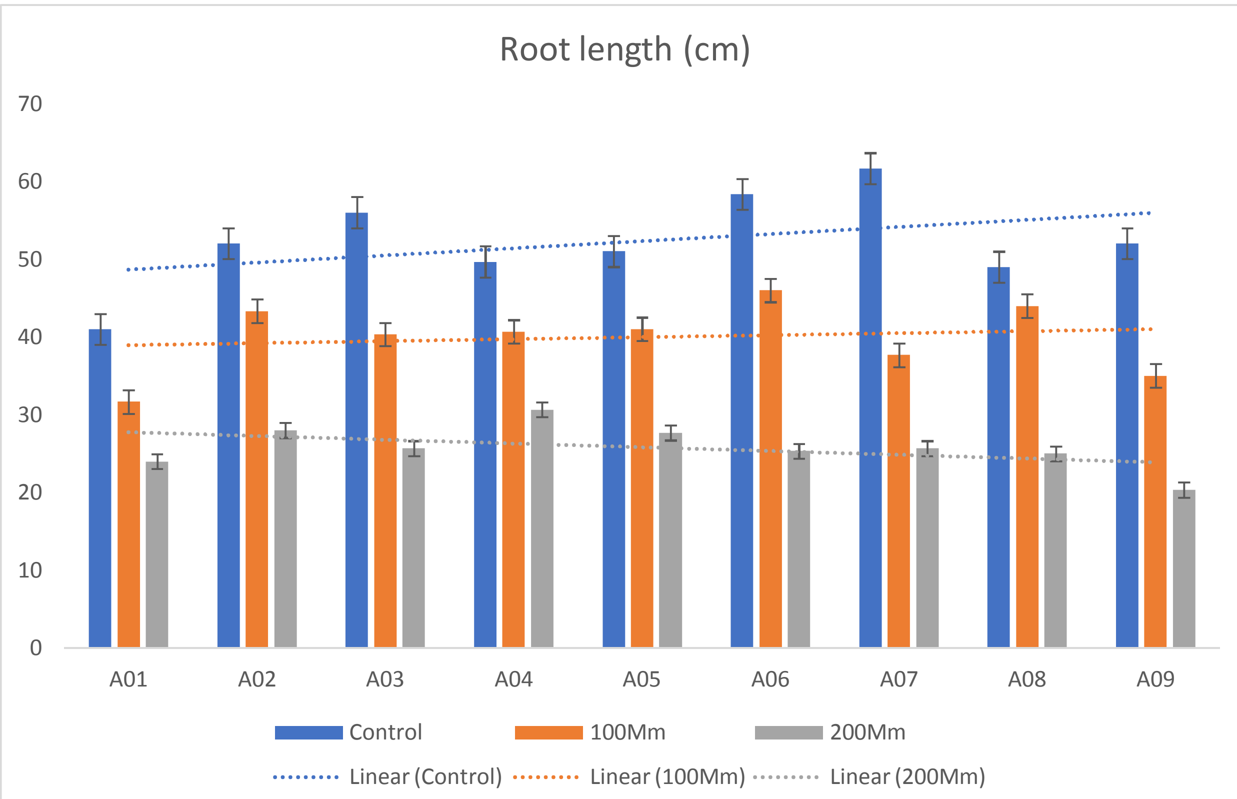

Figure 3: Effects of Salt stress on the root length of different Barley (*Hordeum vulgar* L.) genotypes.

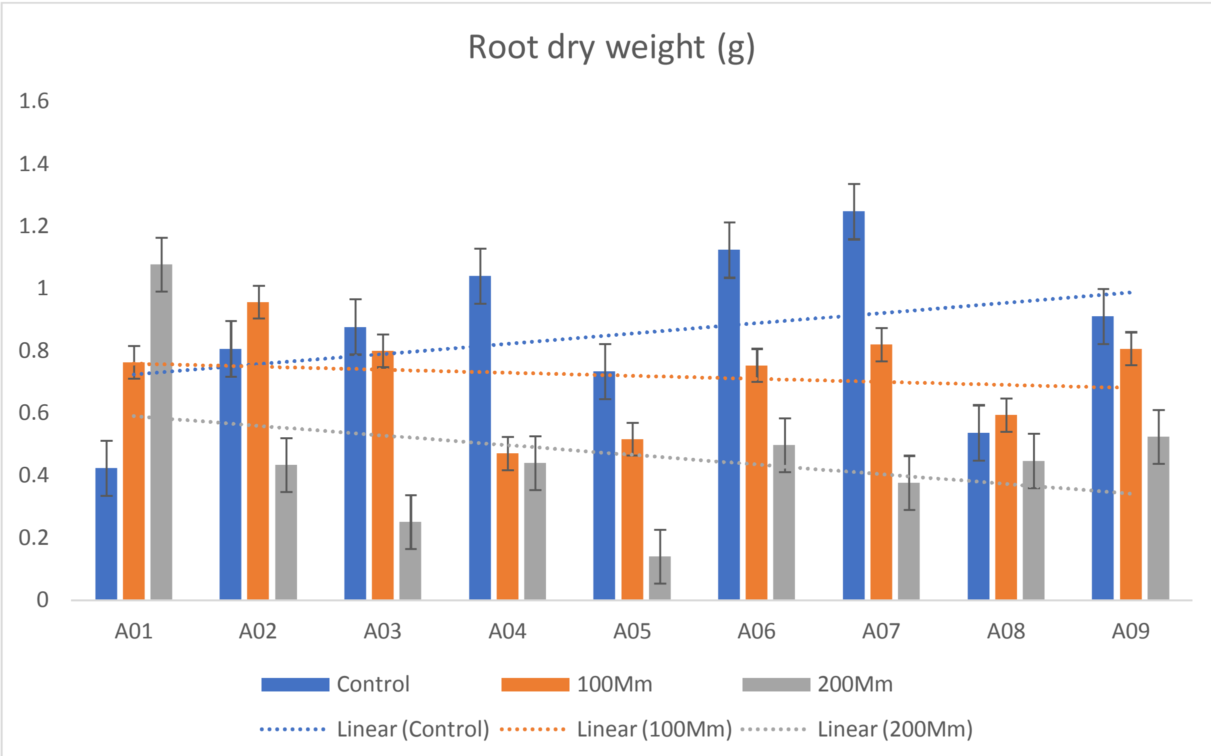

Figure 4: Effects of Salt stress on the root dry weight of different Barley (*Hordeum vulgar* L.) genotypes.

References

[1]. Abu-El-lail, F. F. B., Hamam, K. A., Kheiralla, K. A., & El-Hifny, M. Z. (2014). Salinity tolerance in 280 genotypes of two-rows barley. *Egyptian Journal of Plant Breeding*, *18*(2), 331-345.

[2]. Adjel, F., Bouzerzour, H., & Benmahammed, A. (2013). Salt stress effects on seed germination and seedling growth of barley (Hordeum Vulgare L.) genotypes. *Journal of Agriculture and sustainability*, *3*(2).

[3]. Baik, B.K. and S.E. Ullrich 2008. Barley for food: characteristics, improvement, and renewed interest. J. Cereal Sci. 48: 233-242.

[4]. Chartzoulakis, K., M. Loupassaki, M. Bertaki and I. Androulakis, 2002. Effects of NaCl salinity on growth, ion content and CO2 assimilation rate of six olive cultivars. Sci. Hort. 96: 235-247.

[5]. Duncan, D.B. 1955. Multiple range and multiple F tests. Biometrics. 11: 1-42.

[6]. Flowers, T. J. (2004). Improving crop salt tolerance. *Journal of Experimental botany*, *55*(396), 307-319.

[7]. Forster, B.P., R.P. Ellis, W.T.B. Thomas, A.C. Newton, R. Tuberosa and M.B. Salem. 2000. The development and application of molecular markers for abiotic stress tolerance in barley. J. Exp. Bot. 51: 19-27.

[8]. Fricke, W., Akhiyarova, G., Wei, W., Alexandersson, E., Miller, A., Kjellbom, P. O., ... & Volkov, V. (2006). The short-term growth response to salt of the developing barley leaf. *Journal of Experimental Botany*, *57*(5), 1079-1095.

[9]. Hampson, C. R., & Simpson, G. M. (1990). Effects of temperature, salt, and osmotic potential on early growth of wheat (Triticum aestivum). I. Germination. *Canadian Journal of Botany*, *68*(3), 524-528.

[10]. Hirich, A., H. Omaril, S. Jacobsen, N. Lamaddalena, A. Hamdy, R. Ragab, A. Jelloul and R. Choukr-Allah. 2014. Chickpea (*Cicerarietinum* L.) Physiological, chemical and growth responses to irrigation with saline water. AJCS 8:646-654.

[11]. Huang, J., & Redmann, R. E. (1995). Physiological responses of canola and weld mustard to salinity and contrasting calcium supply. *Journal of Plant Nutrition*, *18*(9), 1931-1949.

[12]. Illahi, L., J. Mussaret and F. Rehman. 2001. The effect of various saline conditions on

growth behavior of peanuts. Pak. J. Plant Sci. 12: 143-152.

[13]. Iqra Aslam, Meh Gul, Iqra Ghafoor, Rabia Yaseen, M. Usman Gani, H. M. Waseem, Rida Nawaz, Aiman Ali, Misha Iqba. Screening of barley genotypes on the basis of physiological parameters under salt stress. Nat Sci 2019;17(7):74-79.

[14]. Jamil, M., D. Lee, K.Y. Jung, M. Ashraf, S.C. Lee and E.S Raha. 2005. Salinity (Nac1) tolerance of Brassica species. J. Environ. Agri. Food Chem. 5: 970-976.

[15]. Jamil, M., M. Ashraf, S. Rehman, M. Ahmad, and E.S. Rha. 2012. Salinity induced changes in cell membrane stability, protein and RNA contents. Afr. J. Biotechnol. 11: 6476-6483.

[16]. Jeannette, S., R. Craig and J.P. Lynch. 2002. Salinity tolerance of phaseolous species during germination and early seedling growth. Crop Sci. 42: 1 584-1594.

[17]. Lopez, C.M.L., H. Takahashi and S. Yamazaki. 2002. Plant-water relations of kidney bean plants treated with NaCl and foliarly applied glycinebetaine. J. Agron. Crop Sci. 188: 73-80.

[18]. Muhammad Ahmad, Abbas Shoukat, Maria Anjum, M. Kamran, M. Qusain Saeed, Raza Hussain, Muhammad, Hadi Abbas and Yousuf shafiq. Assessment of tomato genotypes against salinity on the basis of morphological and physiological parameters in hydroponic conditions. Nat Sci 2019;17(2):56-70.

[19]. Munns, R., & Tester, M. (2008). Mechanisms of salinity tolerance. *Annu. Rev. Plant Biol.*, *59*, 651-681.

[20]. Othman, Y., Al-Karaki, G., Al-Tawaha, A. R., & Al-Horani, A. (2006). Variation in germination and ion uptake in barley genotypes under salinity conditions. *World Journal of Agricultural Sciences*, *2*(1), 11-15.

[21]. Rengasamy, P. 2010. Soil processes affecting crop production in salt affected soils. Funct. Plant Biol. 37: 613-620.

[22]. Safdar, H., A. Amin, Y. Shafiq, A. Ali, R. Yasin, A. Shoukat, M. U. Hussan, M. I. Sarwar. 2019. A review: Impact of salinity on plant growth. Nat Sci. 17(1):34-40.

[23]. Sairam, R.K. 1994. Effect of moisture-stress on physiological activities of two contrasting wheat genotypes. Indian J. Exp. Biol. 32:594-594.

[24]. Sairam, R.K., K.V. Rao and G.C. Srivastava. 2002. Differential response of wheat genotypes to long term salinity stress in relation to oxidative stress, antioxidant activity and osmolyte concentration. Plant Sci. 163: 1037-1046. Tahir, M., M. M. Zafar, A. Imran, M. A. Hafeez, M. S. Rasheed, H. S. B. Mustafa, and A. Ullah. 2018. Response of tomato genotypes against salinity stress at germination and seedling stage. Nat. and Sci. 16:10-17.

[25]. Sharma, R.G.D. and J.H. Garg. 2000. Saline agriculture research in Pakistan. proc. Indo-Pak. Workshop on Soil Salinity and Water Management. 2: 409-423, Islamabad, Pakistan.

[26]. Shelden, M.C., U. Roessner, R.E. Sharp, M. Tester and A. Bacic. 2013. Genetic variation in the root growth response of barley genotypes to salinity stress. Fun. Plant Biol. 40: 516-530.

[27]. Steel, R.G.D., J.H. Torrie and D.A. Dickey. 1997. Priciples and procedures of statistics: A biometrical approach. McGraw Hill Book Co. Inc. New York, USA.

[28]. Sun, C.W., T.C. Liang and V. Romheld. 2005. Effects of foliar and root applied silicon on the enhancement of induced resistance to powdery mildew in Cucums sativus. J. Plant Pathol. 54: 678-685.

[29]. Tavakoli, E., F. Fatehi, S. Coventry, P. Rengasamy and G.K. McDonald. 2011. Additive effects of Na+ and Cl– ions on barley growth under salinity stress. J. Exp. Bot. 62: 2189-2203.

[30]. Tiessen, H. 1994. The role of K+ and Ca2+ for amelioration of salinity in agriculture. Soil Sci. 371: 783-785.

[31]. Warner, M.K., F. Chueng and C.D. Town. 2004. Legume Transcription Factor: Global regulators of plant development and response to the environment. physiol. plant. 144: 538-549.

[32]. Yadav, S. and N.B. Singh. 2004. Strategies to enhance yield of rapeseed-mustard in India. Physiol. Plant. 5: 235-245.

7/25/2021