International Journal of Research in Agriculture and Forestry
Volume 6, Issue 2, 2019, PP 1-7
ISSN 2394-5907 (Print) & ISSN 2394-5915 (Online)

Evaluation of Salt Tolerance in Different Varieties of Barley (Hordeum Vulgare)

Muhammad Arshad Ullah[1], Muhammad Rasheed[2] and Raheel Babar[3]

[1] *Land Resources Research Institute, National Agricultural Research Centre, Islamabad. Pakistan.45500*

[2] *PMAS -Agronomy Department,University of Arid Agriculture, Rawalpindi. Punjab, Pakistan*

[3] *Forestry, Range, Watershed and Wildlife management, Baluchistan Agriculture College, Quetta. Pakistan*

****Corresponding Author:*** *Muhammad Arshad Ullah , Land Resources Research Institute, National Agricultural Research Centre, Islamabad. Pakistan.45500*

ABSTRACT

Soil salinity is the foremost abiotic stress in plant cultivation sturdily affecting yield universally and it restrict the crop yield. Barley is consumed as food and in manufacture of brew all over the world. In the present study, screening of few barley varieties for their tolerance against salt stresses and then be able to find the best tolerant variety. A pot study was conducted to evaluate the salt tolerance of barley varieties under different salinity cum sodicity levels [S0=3.78dSm-1+ 14.78 (mmol L-1)1/2 and S1= 12.34dSm-1 +29.87 (mmol L-1)1/2].Seeds of five barley varieties namely PK--30046, PK--30163, RD--2508, BH--924 and Shahara were sown in pots at green house of Land Resources Research Institute, National Agricultural Research Centre, Islamabad, Pakistan during, 2018 for screening against salt tolerance At S0 [3.78dSm-1+ 14.78 (mmol L-1)1/2]Shahara barley variety attained the highest grain yield (3.42 tha-1) which was statistically similar to BH-924 barley variety. PK-30046 and PK-30163 barley varieties are statistically at par with each other under S0 [3.78dSm-1+ 14.78 (mmol L-1)1/2)].Shahara barley variety attained the highest grain yield (2.46 tha-1) which was statistically similar to BH-924 barley variety under S1 [12.34dSm-1 +29.87 (mmolL-1)1/2]. % decrease (K+/ Na+) over S0 resulted very interesting information related the salt tolerance degree among barley varieties. BH-924 attained the highest salt tolerance among other barley varieties due to having the lowest % decrease (K+/ Na+). Out of five varieties of Hordeum vulgare BH 924 and RD 2508 are the good salt tolerant varieties in comparison to others.

Keywords: *Hordeum vulgare, PK--30046, PK--30163, RD--2508, BH--924, Shahara, Saline- sodic, K+/ Na+ and grain yield*

INTRODUCTION

A limited success to enhance crop yields under salinity stress has made due to accessible facts of salt tolerance methodologies have not been changed into functional selection criteria to estimate a ample array of genotypes inside and athwart species. Munns et al., (2000) ; Chen et al., (2008) and James et al., (2008) evaluated the salt tolerance at germination and emergence stages in wheat and barley, and large genotypic differences were reported, although this premature assessment shows a little relation to overall recital in saline environment (Munns et al., 2002). However Na+ elimination and K+/Na+ ratios have been recommended elect consistent qualities for salt-tolerant crops screening (Munns et al., 2002; Munns and James, 2003; Poustini and Siosemardeh, 2004). Salt tolerance studies amid the key cereals have determined on Na+ transport and accumulation except some current work in both field and greenhouse experiments has questioned this guess (Dang et al., 2008, Tavakkoli et al., 2010b, 2011). Further, Tavakkoli et al., (2010a) investigated the relative importance of different mechanisms between directly related species/ varieties and as well as the salinity stress harshness. Zhu, (2002) reports the salinity involves osmotic, ionic (mainly due to Na+, Cl−, and SO42−) and minor stresses e.g. nutritional imbalances and oxidative stress in glycophytes. Biochemical strategies such as regulation of ion uptake by roots and their transport into leaves; selective exclusion of salt ions; ion compartmentalization; synthesis of compatible osmolytes for osmotic adjustment; changes in the membrane structure; induction of antioxidative enzymes for neutralization of reactive oxygen species (ROS); and stimulation of phytohormones for growth regulation (Zhu, 2001; Parida and Das,2005). Species, genotype, plant stage, composition, and strength of the salinizing solution affect the amount by which one mechanism influence the plant (Läuchli and Grattan, 2007).

Experiments on tomato, rice, barley, and citrus point to that salt tolerance are a quantitative attribute concerning many genes and relatively a number of environmental factors (Flowers, 2004). Tomato is receptive to moderate salt stress and is grown in increasingly affected by salinity areas (Frary et al., 2010). On the other hand, some wild relatives salt-tolerant tomato are simple to cross with cultivated tomato and offer a affluent resistance and tolerance genes source for biotic and abiotic stresses, plus salinity (Hajjar and Hodgkin, 2007). The resistant varieties may grow better in the salt-affected areas due to tolerance against salt stress. Antagonistic influence of Na+ to that of K+Na+ ultimately affects the stomatal conductance by decreasing K+/Na+ (Shahid et al., 2011; Sabra et al., 2012). Excess salt decreases the partial CO_2 pressure resulting stomata closure (Abbruzzese et al., 2009) with the internal CO_2 concentration and consequently CO_2 concentration is largely regulated the CA activity (Tiwari et al., 2005). Rubisco is the main enzyme for carbon fixation that mainly regulates the photosynthetic accumulation and metabolism energy. Hayat et al., (2011) reported decrease in the activity of CA by salinity. Similarly, photosynthetic attributes decrease (PN, Ci, E, and WUE) in salinity response has also been investigated in Brassica juncea (Yusuf et al., 2008).

Halophytes salt tolerance methods were deliberated by Lüttge (2002), Lovelock and Ball (2002), and Cushman and Bohnert (2002). Plants exhibit a "two-stage growth response to salinity." Growth reduction occurs within minutes after exposure to salinity in the first stage that is due to an osmotic effect. Specific-ion effect appears in the second and slower stage, may take days, weeks, or months and can lead to salt toxicity in the plant, primarily in the older leaves (Munns 2002a, 2005).

Salinity caused reduction in leaf growth not by a leaf-water deficit (Fricke and Peters 2002). This conclusion is supported by recent scientific work (summarized in Munns et al., 2006). Na+ ion exclusion during growth under saline conditions is generally considered salt tolerance (Colmer et al., 2005; Kook et al., 2009).

Reduction in agricultural crops production within many arid and semi arid areas of the world was caused due to salinity where rainfall is insufficient to leach salts from the root zone (Rengasamy, 2006). Na+ and Cl– ions are considered the most important because both Na+ and Cl– are toxic to plants when they accumulate to high concentrations (Hasegawa et al. 2000). High concentrations of Na+ in the soil solution can deteriorate soil structure, which may aggravate salinity effects by impeding drainage plus availability of water affects like the soil dries (Bennett et al., 2009).

The recent work has focused on Na+ exclusion as the main pathway to improved salt tolerance (Tester and Davenport 2003; Munns and Tester 2008). In spite of this, there is a correlation between the ability to exclude Na+ and salt tolerance among genotypes of major crop plants (Munns and James 2003; Poustini and Siosemardeh 2004). Genc et al. (2007) for example, found that Na+ exclusion was not a predictor of salt tolerance in hydroponics. It was suggested that a reason for this was that Na+ exclusion is but one of several mechanisms of salt tolerance and by focusing on a single trait, the interacting effects of other mechanisms are overlooked (Genc et al. 2007; Munns and Tester 2008). The importance of tolerance to osmotic stress has been re-investigated (James et al. 2008) or a combination of different tolerance mechanisms is must (Rajendran et al. 2009).

Developing selection criteria work for improved salt tolerance has been made through solution culture, either in hydroponic system (Munns et al. 2002; Genc et al. 2007), or sand-based system (Munns 2002), with the implied hypothesis that differences in Na+ exclusion in hydroponic systems will result in improved performance in the field. Strong evidence to support this is deficient and the ability of solution culture to recognize optimum yield producing genotypes under stressed conditions in the field needs to be decisively evaluated (Gregory et al. 2009).

Cl– toxicity symptoms are recognized in some plant species, particularly woody perennials (White and Broadley 2001), much less information is available on Cl– toxicity in grain crops. Some recent work has questioned this assumption that Cl– toxicity is not a major cause of reductions in growth of grain crops (Chi Lin and Huei Kao 2001; Hong et al. 2009). Variation in yield was correlated with the concentration of soil Cl– and not with Na+ despite high uptake of both ions by plants in field studies of south-east Queensland saline soils (Dang et al. 2006). Modeling suggested that the over-riding effect on yield was the osmotic effects (Hochman et al. 2007). Growth of cereals have been comprehensively disturbed by salinity (Munns 2002; Munns and James 2003; Colmer et al. 2005; Munns et al. 2006).

Omotic adjustment has particular importance for adaptation mechanisms, which needs ions uptake and formation of companionable solutes (Vetterlein et al., 2004). Genetic differences in Na+ exclusion have demonstrated in hydroponic studies, (Munns et al.2006; Genc et al. 2007). Other studies in several plant species including rice (Oryza sativa L) maize (Zea mays L.) and wheat (Triticum aestivum L.) Genc et al. 2007) have demonstrated that salt tolerance is not necessarily correlated with the content of leaf Na+ and that the other mechanisms of salt tolerance (osmotic tolerance and tissue tolerance) may interact with ion exclusion to determine the overall level of salt tolerance. The reduction in the moderately tolerant and salt-sensitive genotypes has been linked with a combination of stomatal and non-stomatal factors (Ashraf, 2001),Temperature, moisture, radiation, nutrients and gases can either enhance or check the growth and development of the plant. These factors may act as stress leading to injury and in extreme cases the death of the plant (Jaleel et al., 2007). Soil salinity is a major constraint to food production because it limits crop yield and restricts use of land previously uncultivated. Agricultural production is severely reduced by soil salinity and the damaging effect of salt accumulation in agricultural soils has an environmental concern (Jaleel, 2009). Salinity effects are more noticeable in arid and semiarid regions due to limited rainfall, high evapo-transpiration and high temperature plus poor water and soil management shares to the salinity problem and causing a great threat in agricultural production (Jaleel et al., 2008). Salinity stress negatively affects agricultural yield globally reducing production whether it is for survival or economic gain (Anonymous, 2000).Water and soil management practices have improved agricultural production in marginalized saline soils (Yokoi et al., 2002). Salt-tolerant plants (halophytes) have evolved to grow of these soils, with halophytes and less tolerant plants showing a wide range of adaptations (Flowers and Flowers, 2005). Barley is selected as a model to study due to its use as food by a large population of the world and could show a promising tolerant against biotic and abiotic stresses. The present study has been done to evaluate the salt tolerance of Barley's different varieties under saline environment.

MATERIALS AND METHODS

A pot study was carried out to identify the salt tolerance of barley varieties under different salinity cum sodicity levels [S0=3.78dSm-1+ 14.78 (mmol L-1)1/2] and [S1= 12.34dSm-1 +29.87 (mmol L-1)1/2].Seeds of five barley varieties namely PK--30046, PK--30163, RD--2508, BH--924 and Shahara were sown in pots at green house of Land Resources Research Institute, National Agricultural Research Centre, Islamabad, Pakistan during, 2018 for screening against salt tolerance 10 Kg soil was used to fill each pot. 10 seeds of Barley (Hordeum vulgare) were sown in each pot. Fertilizer was applied @60-50-40 NPK Kg ha-1. Completely randomized deign was applied with three repeats. Data on grain yield were collected. Potassium and sodium ion concentrations were determined in plant tissues of barley varieties. Collected data were statistically analysed and means were compared by LSD at 5 % (Montgomery, 2001).

Table1. *Effect of salinity cum sodicity on yield and K+/ Na+ of barley (Hordeum vulgare L) varieties*

Varieties	Grain yield (tha^{-1})		%decrease over S_0	Na^+ (%)		K^+ (%)		K^+/Na^+		% decrease (K^+/Na^+) over S_0
	S_0	S_1		S_0	S_1	S_0	S_1	S_0	S_1	
PK-30046	3.10c	2.16bc	30.33	2.38	10.32	0.81	0.82	0.34	0.08	76.47
PK-30163	3.04c	1.99c	34.54	2.41	11.34	0.88	0.79	0.36	0.07	82.22
RD-2508	3.24ab	2.25b	30.56	2.44	9.88	0.78	0.83	0.32	0.08	75.00
BH-924	3.36a	2.46a	26.79	2.78	10.01	0.75	0.74	0.27	0.07	74.07
Shahara	3.42a	2.64a	22.88	2.56	11.05	0.82	0.77	0.31	0.07	77.42
LSD	0.18	0.22	--------							-------

RESULTS AND DISCUSSIONS

Barley (Hordeum vulgare) is a cereal grain breeded from the annual grass. It uses as a main animal fodder and certain distilled beverages and as a part of different health foods and medicines. It is used in soups and stews and in barley bread of various cultures, globally. Data indicated in table-1 showed significant differences in grain yield among seven barley varieties. At S0 = [3.78dSm-1+ 14.78 (mmol L-1)1/2] Shahara barley variety attained the highest grain yield (3.42 tha-1) which was statistically similar to BH-924 barley variety. PK-30046 and PK-30163 barley varieties are statistically at par with each other under S0 = [3.78dSm-1+ 14.78 (mmol L-1)1/2]. Shahara barley variety attained the highest grain yield (2.46 tha-1) which was statistically similar to BH-924 barley variety under S1 (12.34dSm-1 +29.87 (mmolL-1)1/2). PK-30163 barley variety gained the least grain yield (1.99tha-1). Table-1 provided very alarming results in % decrease at S1 over S0.The lease % decrease in grain yield (22.88) was attained in Shahara barley variety than other varieties. Therefore this barley variety showed minimum loss due to toxic effects of salinity cum sodicity. Increasing salinity and sodicity affected inverse on grain yield of these barley varieties as presented in table-1. Cultivars of various crop plants show discernible variations for salt tolerance, e.g. mustard (Hayat et al., 2011) and barley (Belkhodja, 1994). Besides, closure of stomata is linked with NaCl induction (Wang et al., 2011), then it decreases partial CO2 pressure. In addition, salinity impairs photosynthesis and photosynthetic electron transport chain. Presence of excess Na+ in the salt-stressed plants causes a membrane injury, which is expressed as (Sabra et al., 2012). Besides, salinity impairs photosynthesis and photosynthetic electron transport chain (Sudhir and Murthy, 2004). Salinity reduces yields of agricultural crops in many arid and semi arid areas of the world due to leaching salts from the root zone (Rengasamy, 2006).

Sairam, and Tyagi, (2004) investigated that seed germination, seedling growth, vegetative growth, flowering and fruit set are adversely affected by high salt concentration, eventually diminished economic yield with produce quality. Na+ (%) in barley plant tissues showed variations among varieties as indicated in table-1. Na+ (%) was higher in BH-924 as well as Shahara barley varieties at S0 while Na+ (%) in PK-30163 was the maximum than other varieties under S1. K+ (%) as depicted in table-1 exhibited variations among varieties. However, PK-30163 barley variety attained the highest K+ (%) than other varieties at salinity level S0. Under S1 salinity level K+ (%) was the highest in RD-2508. K+/ Na+ got the top position by PK-30046 barley variety at S0. Although in S1 all the varieties presented approximately the similar results but lower than at first salinity level i.e. S0. The ratio of Na+ and Cl– content to percentage dead leaf weight was calculated as an index of tolerance to Na+ and Cl– in the leaves (Munns and James 2003). Selection of Clipper and Sahara barley cultivars was based on the criteria of Na+ exclusion and salt tolerance (Rivandi 2009; Widodo et al. 2009). Triticeae salt tolerance is generally associated with Na+ ion exclusion and plant's capability to maintain acquirement and retain passable K+ levels during growth under saline conditions (Kader & Lindberg, 2005; Colmer et al., 2005). Tavakoli et al., (2010) reported that salt tolerant barley genotype `Afzal' produced more dry mass compared to salt sensitive genotype under salt stress conditions (200 mM NaCl) and higher tolerance in genotype Afzal was associated with a higher K+/Na+ ratio of the shoots. Reduced growth under saline conditions is a common response of many plant species including barley (Mahmood et al., 1996; Niazi et al., 1987, 1992). Garthwaite et al. (2005) reported that among Hordeum spp., growth of H. vulgare was more adversely affected by salinity (150-450 mM) compared to wild species.

% decrease (K+/ Na+) over S0 resulted very interesting information related the salt tolerance degree among barley varieties. BH-924 attained the highest salt tolerance among other barley varieties due to having the lowest % decrease (K+/ Na+). In wheat, grain yield was correlated with Na+ exclusion and associated enhanced K+/Na+ discrimination (El-Hendawy et al., 2005). Kronzucker et al., (2006) reported that growth response of a cultivar can be identical in the presence of cytosolic Na+/K+ ratios that differ by as much as five-fold. Wild Hordeum species maintained lower concentrations of Cl- in leaves than H. vulgare even at high salinity, and such restricted entry of Cl- and Na+ into shoots was related to salt tolerance (Garthwaite et al., 2005).

CONCLUSION

% decrease (K+/ Na+) over S0 resulted very interesting information related the salt tolerance degree among barley varieties. BH-924 attained the highest salt tolerance among other barley varieties due to having the lowest % decrease (K+/ Na+).

REFERENCES

[1] Abbruzzese G, Beritognolo I, Muleob R, Piazzaia M, Sabattia M, Mugnozza GS, Kuzminsky E. 2009. Leaf morphological

plasticity and stomatal conductance in three Populus alba L. genotypes subjected to salt stress. Environ. Exp. Bot. 66:381-388.

[2] Anonymous, 2000. Indian Agriculture in Brief. 27th edition, Agriculture Statistics Division, Directorate of Economics and Statistics,Ministry of Agriculture, Govt. of India, New Delhi.

[3] Ashraf M. 2001. Relationships between growth and gas exchange characteristics in some salt-tolerant amphidiploid Brassica species in relation to their diploid parents. Environmental and Experimental Botany 45, 155–163.

[4] Belkhodja R, Morales F, Abadila A, Gomez-Aparisi J, Abadia J. 1994. Chlorophyll fluorescence as a possible tool for salinity tolerance screening in barley (Hordeum vulgare L.). Plant Physiol. 138:92-96.

[5] Bennett SJ, Barrett-LennardEG, ColmerTD. 2009. Salinity and water logging as constraints to salt land pasture production: a review. Agriculture Ecosystems & Environment 129, 349–360.

[6] Chen Z, Shabala S, Mendham N, Newman I, Zhang G, Zhou M. 2008. Combining ability of salinity tolerance on the basis of $NaCl^{-}$induced K+ flux from roots of barley. Crop Science 48, 1382–1388.

[7] Chi Lin C, Huei Kao C.2001. Relative importance of Na^{+}, Cl–, and abscisic acid in NaCl induced inhibition of root growth of rice seedlings. Plant and Soil 237, 165–171.

[8] Colmer TD, Munns R, Flowers TJ .2005. Improving salt tolerance of wheat and barley: future prospects. Australian Journal of Experimental Agriculture 45, 1425–1443.

[9] Cushman, J. C., and Bohnert, H. J. 2002. Induction of Crassulacean acid metabolism by salinity molecular aspects, in Salinity: environment-plants-molecules, A. Läuchli and U. Lüttge, eds., Kluwer Academic Publishers, New York, 361–393.

[10] Dang Y, McDonald M, Routley R, Dalal RC, Singh D, Orange D, Mann M. 2006. High chloride in subsoil: a key indicator for potential grain yield losses in southwest Queensland. (The Regional Institute Ltd: Gosford, NSW)

[11] Dang YP, Dalal RC, Mayer DG, 2008. High subsoil chloride concentrations reduce soil water extraction and crop yield on Vertisols in north-eastern Australia. Australian Journal of Agricultural Research 59, 321–330.

[12] El-Hendawy, S.E., Y. Hu and U. Schimdhalter. 2005. Growth, ion content, gas exchange, and water relations of wheat genotypes differing in salt tolerance. Aust. J. Agr. Res., 56: 123-134.

[13] Flowers TJ.2004. Improving crop salt tolerance. J. Exp. Bot. 55:307-319.

[14] Flowers, T.J. and S.A. Flowers, 2005. Why does salinity pose such a difficult problem for plant breeders? Agricultural Water Management, 78: 15-24.

[15] Frary A, Göl D, Keles D, Ökmen B, Pinar H, Sigva HÖ, Yemenicioglu A, Doganlar S.2010. Salt tolerance in Solanum pennellii: antioxidant response and related QTL. BMC Plant Biol. 10:58.

[16] Fricke, W., and Peters, W. S. 2002. The biophysics of leaf growth in salt-stressed barley: A study at the cell level. Plant Physiol., 129, 1–15.

[17] Garthwaite, A.J., R. von Bothmer and T.D. Colmer. 2005. Salt tolerance in wild Hordeum species is associated with restricted entry of Na+ and Cl- into the shoots. J. Exp. Bot., 56: 2365-2378.

[18] Genc Y, McDonald GK, Tester M.2007. Reassessment of tissue Na^{+} concentration as a criterion for salinity tolerance in bread wheat. Plant, Cell & Environment 30, 1486–1498.

[19] Gregory PJ, Bengough AG, Grinev D, Schmidt S, Thomas WTB, Wojciechowski T, Young IM.2009. Root phenomics of crops: opportunities and challenges. Functional Plant Biology 36, 922–929.

[20] Hajjar R, Hodgkin T.2007.The use of wild relatives in crop improvement: a survey of developments over the last 20 years. Euphytica 156:1-13.

[21] Hasegawa PM, Bressan RA, Zhu J-K, Bohnert HJ (2000) Plant cellular and molecular responses to high salinity. Annual Review of Plant Physiology and Plant Molecular Biology 51, 463–499.

[22] Hayat S, Mir BA, Wani SA, Hasan SA, Irfan M, Ahmad A.2011. Screening of salt-tolerant genotypes of Brassica juncea based on photosynthetic attributes. J. Plant Interact. 6:53-60.

[23] Hochman Z, Dang YP, Schwenke GD, Dalgliesh NP, Routley R, McDonald M, Daniells IG, Manning W, Poulton PL.2007. Simulating the effects of saline and sodic sub soils on wheat crops growing on Vertosols. Australian Journal of Agricultural Research 58, 802–810.

[24] Hong C-Y, Chao Y-Y, Yang M-Y, Cho S-C, Huei Kao C (2009) Na+ but not Cl– or osmotic stress is involved in NaCl-induced expression of Glutathione reductase in roots of rice seedlings. Journal of Plant Physiology 166, 1598–1606.

[25] Jaleel, C.A., 2009. Soil Salinity RegimesAlters Antioxidant Enzyme Activities in Two Varieties of Catharanthus roseus. Botany Research International, 2(2): 64-68.

[26] Jaleel, C.A., R. Gopi and P. Manivannan, 2007. Antioxidative potentials as a protective mechanism in Catharanthus roseus (L.) G. Don. Plants under salinity stress. Turk. J. Bot., 31: 245-251.

[27] James RA, Caemmerer SV, Condon AGT, Zwart AB, Munns R (2008) Genetic variation in tolerance to the osmotic stress component of

salinity stress in durum wheat. Functional Plant Biology 35, 111–123.

[28] James RA, Munns R, Von Caemmerer S, Trejo C, Miller C, Condon AG. 2006. Photosynthetic capacity is related to the cellular and sub cellular partitioning of Na^+, K^+ and Cl^- in salt affected barley and durum wheat. Plant, Cell and Environment 29, 2185–2197.

[29] Kader, M.A. and S. Lindberg. 2005. Uptake of sodium in protoplasts of salt-sensitive and salt-tolerant cultivars of rice, Oryza sativa L., determined by the fluorescent dye SBFI. J. Exp. Bot., 56: 3149-3158.

[30] Kook, H.S., T. Park, A. Khatoon, S. Rehman and S.J. Yun. 2009. Avoidance of sodium accumulation in the shoot confers tolerance to salt stress in cultivated barley. Pak. J. Bot., 41: 1751-1758.

[31] Kronzucker, H.J., M.W. Szczerba, Moazami-Goudarzi and D.T. Britto. 2006. The cytosolic Na^+:/K^+ ratio does not explain salinity-induced growth impairment in barley: a dual-tracer study using $42K^+$ and $24Na^+$. Plant Cell Environ. 29: 2228-2237.

[32] Läuchli A, Grattan SR .2007. Plant growth and development under salinity stress. In: Jenks MA, Hasegawa PM, Mohan SJ (eds), Advances in molecular breeding toward drought and salt tolerant crops, pp. 1-32. Springer, New York.

[33] Lovelock, C. E., and Ball, M. C .2002. Influence of salinity on photosynthesis of halophytes, in Salinity: Environment-plants-molecules, A. Läuchli and U. Lüttge, eds., Kluwer Academic Publishers, New York, 315–339.

[34] Lüttge, U. 2002. Performance of plants with C4-carboxylation modes of photosynthesis under salinity, in Salinity: Environment-plants-molecules, A. Läuchli and U. Lüttge, eds., Kluwer Academic Publishers, New York, 341–360.

[35] Mahmood, K., K.A. Malik, M.A.K. Lodhi and K.H Sheikh. 1996. Seed germination and salinity tolerance in plant species growing

[36] Montgomery, D. C. 2001. Design and Analysis of Experiments (5th Ed.) John Willey and Sons, New York, USA. p. 64-65.

[37] Munns R.2002. Comparative physiology of salt and water stress. Plant, Cell & Environment 25, 239–250.

[38] Munns R, Hare RA, James RA, Rebetzke GJ. 2000. Genetic variation for improving the salt tolerance of durum wheat. Ausralian Journal of Agricultural Research 51, 69–74.

[39] Munns R, Husain S, Rivelli AR, James R, Condon AG, Lindsay M, Lagudah ES, Schachtman DP, Hare RA. 2002. Avenues for increasing salt tolerance of crops, and the role of physiologically based selection traits. Plant and Soil 247, 93–105.

[40] Munns R, Husain S, Rivelli AR, James R, Condon AG, Lindsay M, Lagudah ES, Schachtman DP, Hare RA.2002. Avenues for increasing salt tolerance of crops, and the role of physiologically based selection traits. Plant and Soil 247, 93–105.

[41] Munns R, James RA (2003) Screening methods for salinity tolerance. Plant and Soil 253, 201–218.

[42] Munns R, James RA, Lauchli A .2006. Approaches to increasing the salt tolerance of wheat and other cereals. Journal of Experimental Botany 57, 1025–1043.

[43] Munns R, James RA, Lauchli A. 2006. Approaches to increasing the salt tolerance of wheat and other cereals. Journal of Experimental Botany 57, 1025–1043.

[44] Munns R, James RA. 2003. Screening methods for salinity tolerance: a case study with tetraploid wheat. Plant and Soil 253, 201–218.

[45] Munns R, Tester M .2008. Mechanisms of salinity tolerance. Annual Review of Plant Biology 59, 651–681.

[46] Munns, R. 2005. Genes and salt tolerance: Bringing them together. New Phytol., 167, 645–663.

[47] Munns, R. 2002a. Comparative physiology of salt and water stress. Plant Cell Environ., 25, 239–250.

[48] Munns, R., James, R. A., and Läuchli, A. 2006. Approaches to increasing the salt tolerance of wheat and other cereals. J. Exp. Bot., 57, 1025–1043

[49] Niazi, M.L.K., K. Mahmood and K.A. Malik. 1987. Salt tolerance studies in different cultivars of barley (Hordeum vulgare L.) on saline wastelands. Biol. Plant., 38: 309-315.

[50] Niazi, M.L.K., K. Mahmood, S.M. Mujtaba and K.A. Malik. 1992. Salinity tolerance in different cultivars of barley (Hordeum vulgare L.). Biol. Plant., 34: 465-469.

[51] Parida AK, Das AB.2005. Salt tolerance and salinity effects on plants: a review. Ecotox. Environ. Saf. 60:324-349.

[52] Poustini K, Siosemardeh A.2004.Ion distribution in wheat cultivars in response to salinity stress. Field Crops Research 85, 125–133.

[53] RajendranK, TesterM,RoySJ .2009. Quantifying the three main components of salinity tolerance in cereals. Plant, Cell & Environment 32, 237.

[54] Rengasamy P .2006. World salinization with emphasis on Australia. Journal of Experimental Botany 57, 1017–1023.

[55] Rivandi A .2009. Toward map-based cloning of Na+ exclusion gene from barley (Hordeum vulgare L.). (The University of Adelaide: Adelaide)

[56] Sabra A, Daayf F, Renault S.2012. Differential physiological and biochemical responses of three Echinacea species to salinity stress. Sci. Hortic. 135:23-31.

[57] Sairam, R.K. and A. Tyagi, 2004. Physiological

and molecular biology of salinity stress tolerance in plants. Curr. Sci., 86: 407-420.
[58] Shahid MA, Pervez MA, Balal RM, Mattson NS, Rashid A, Ahmad R, Ayyub CM, Abbas T. 2011.Brassinosteroid (24-epibrassinolide) enhances growth and alleviates the deleterious effects induced by salt stress in pea (Pisum sativum L.). Aust. J. Crop Sci. 5:500-510.
[59] Sudhir P, Murthy SDS.2004. Effects of salt stress on basic processes of photosynthesis. Photosynthetica 42:481-486.
[60] Tavakkoli E, Fatehi F, Coventry S, Rengasamy P, Mcdonald GK. 2011. Additive effects of Na^+ and Cl^- ions on barley growth under salinity stress. Journal of Experimental Botany 62, 2189–2203.
[61] Tavakkoli E, Rengasamy P, Mcdonald GK. 2010a.The response of barley to salinity stress differs between hydroponics and soil systems. Functional Plant Biology 37, 621–633.
[62] Tavakkoli E, Rengasamy P, Mcdonald GK. 2010b. High concentrations of Na^+ and Cl^- ions in soil solution have simultaneous detrimental effects on growth of faba bean under salinity stress. Journal of Experimental Botany 61, 4449–4459.
[63] Tavakoli, F., S. Vazan, F. Moradi, B. Shiran and K. Sorkheh. 2010. Differential response of salt-tolerant and susceptible barley
[64] Tester, M. and R.J. Davenport. 2003. Na^+ transport and Na^+ tolerance in higher plants. Annals of Botany, 91: 503-527.
[65] Tiwari A, Kumar P, Singh S, Ansari SA .2005. Carbonic anhydrase in relation to higher plants. Photosynthetica 43:1-9.
[66] Vetterlein D, Kuhn K, Schubert S, Jahn R.2004. Consequences of sodium exclusion on the osmotic potential in the rhizosphere – comparing of two maize cultivars differing in Na+ uptake. Journal of Plant Nutrition and Soil Science 167, 337–344.
[67] Wang X, Geng S, Ri YJ, Cao D, Liu J, Shi D, Yang C.2011. Physiological responses and adaptive strategies of tomato plants to salt and alkali stresses. Sci. Hortic. 130:248-255.
[68] White PJ, BroadleyMR.2001. Chloride in soils and its uptake and movement within the plant: a review. Annals of Botany 88, 967–988
[69] Widodo , Patterson JH, Newbigin E, Tester M, Bacic A, Roessner U.2009.Metabolic responses to salt stress of barley (Hordeum vulgare L.) cultivars, Sahara and Clipper, which differ in salinity tolerance. Journal of Experimental Botany 60, 4089–4103.
[70] Yokoi, S., R.A. Bressan and P.M. Hasegawa, 2002. Salt Stress Tolerance of Plants JIRCAS Working Report, pp: 25-33.
[71] Yusuf M, Hasan SA, Ali B, Hayat S, Fariduddin Q, Ahmad A.2008..Effect of salicylic acid on salinity-induced changes in Brassica juncea. J. Integr. Plant Biol. 50:1-7.
[72] Zhu JK.2001.Plant salt tolerance. Trends Plant Sci. 6:66-71.

Citation: *Muhammad Arshad Ullah, Muhammad Rasheed and Raheel Babar "Evaluation of Salt Tolerance in Different Varieties of Barley (Hordeum Vulgare)" International Journal of Research in Agriculture and Forestry, 6(2),pp 1-7*