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SCREENING AND SELECTION FOR ADAPTATION OF WHEAT GENOTYPES IN NATURALLY SALT-AFFECTED SOILS

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ABSTRACT

Wheat cultivars of diverse origin were tested against different salinity levels in laboratory as well as in naturally saline fields in different ecological zones. Ten Genotypes were studied for germination test at 6 different salinity levels ranging from 0-25 dSm^{-1} (2, 5, 10, 15, 20, 25, EC= dSm^{-1}). Then were studied for the relative growth rate at different levels of salinity and after their study in the laboratory, were tested in the naturally saline areas of Punjab province. Under germination percentage study, the varieties viz. NR-243, Sarsabz, Sarcc-3 and Sarcc-6 were found less affected than other varieties. As regards the relative plant growth, varieties viz. Sarcc-3, NR-243 and Sarsabz were tolerant to salinity at seedling stage while Inqlab was graded as sensitive to salt stress. Regarding field performance, significant differences were observed in the varieties grown under different saline environments and varieties x environment interaction. Varieties x environment (Lin) interaction was non significant. Based on overall yield performance, the Sarcc-3 genotype produced the highest seed yield (2.969 t/ha) followed by NR-243 (2.624 t/ha) and Sarcc-6 (2.587 t/ha). Regression coefficient values showed non significant differences to unity while standard deviation to regression also showed significant differences to zero. These results indicated that the genotypes viz. SArcc-3, NR-243 and Sarcc-6 are better tolerant to saline environment as compared to others.

Key-words: Wheat genotypes, salinity, seed germination, plant growth, yield.

INTRODUCTION

Wheat (*Tritcum aestivum* L) is the staple food for a large part of the world population including Pakistan. It is grown on 8303 (thousand hectares) with an overage yield of 2.614 tones/ha with total production of 21.700 (million tons) (Anon , 2005-2006). This is for below than that of most of the countries of the world like Germany (7.9 tons/ha), France (6.6 tons/ha), Egypt (6.4 tons/ha).

Out of 20.2 million hectares of cultivated land in Pakistan, 6.8 million hectares are affected with salinity. Out of this, the affected area in Punjab province is 2.67 million hectares. The salinity area has been categorized into four major classes namely very severe saline lands (652 thousands hectares), severely saline (738.3 thousands hectares), moderately saline (804.8 thousands hectares) and slightly saline area (472.4 thousands hectares). (Anon, 2002)

One example of new strategy is breeding crops for increased salt tolerance. It is possible to improve the genetic tolerance of wheat crop to salinity and thereby increase the productivity of marginal lands. Efforts to breed for salinity tolerance are slow due to limited knowledge of genetics of tolerance, inadequate screening techniques, low selection efficiency and poor understanding of salinity and environmental interaction.

It is now well established that some plant species can tolerate high salinity (Glenn *et al,* 1996, Rehman *et al,*1998). Significant differences in their *character effectiveness* have also been reported among varieties of different species including wheat (Akhtar *et al,* 1994, 1998; Saqib *et al,* 1999) and cotton (Qadir and Shams, 1997; Ashraf and Ahmad, 2000).The differential behavior of plant species may be helpful for exploitation of these soils by growing fairly tolerant genotypes. This paper reports the results of different studies pertaining to seed germination in Petri dishes, solution culture, and ion uptake behavior and field performance of ten wheat genotypes in different ecological zones of the Punjab province under natural saline field condition. These studies would help identify genotypes with high yield along with their better adaptivity in different saline environments.

MATERIALS AND METHODS

Germination Test

Seed germination of wheat cultivars viz. NR-243, Sarrsabz, Pasban-90, Sarcc-1, Sarcc-2, Sarcc-3, Sarcc-5, Sarcc-6, 2013 and 3158 was tested in Petri-dishes, having six salinity levels (EC=0, 5, 10, 15, 20 and 25 dSm^{-1}). Salinity levels were prepared by the addition of Na_2SO_4, $CaCl_2$, $MgCl_2$, and NaCl in the ratio of 10: 5: 1: 4 (on equivalent basis) to Hoagland nutrient solution (Qureshi *et al,* 1977). Ten seeds of each cultivar (in 3 replicates) were placed in Petri dishes lined with filter paper well soaked with respective treatment solution. Petri dishes were covered by a black cloth to avoid light. Percentage of seed germination was recorded daily after initiation of germination over a period of ten days. A seed was considered germinated when both radical and plumule had emerged.

Plant Growth

Pre-germinated seeds of wheat were planted in pots containing thoroughly acid washed quartz gravel (5-25mm dia) filled in plastic buckets. Ten plants were transplanted in each pot with 10% Hoagland nutrient solution. Strength of the nutrient solution was raised up to 50% for 1-2 days for establishment of plants. Salinity was raised up to 15 EC dSm^{-1} with stepwise increase of EC=5 dSm^{-1} day^{-1}.The experiment was conducted in RCB design with four replicates. The nutrient and salt solutions were circulated twice daily and changed after one-week interval. After 2-3 days when healing of plant roots was accomplished, first harvesting was done. Second harvest was taken after 14 days interval of first harvest. Three plants in each harvest were taken and after washing in distilled water were dried with tissue paper. Fresh weight of both roots and shoots were recorded. The material was dried at 70 °C for 72 h in forced air oven. The relative growth rate (RGR) was calculated by the formula:

RGR = 1/W x $\delta w/\delta t$ gg^{-1} day^{-1}
W = Where dry weight of shoot of the initial harvest
δw = Dry weight of shoot at final harvest – dry weight of shoot at initial harvest
δt = Number of days between initial harvest and final harvest

The dried plant material was ground and digested in concentrated HNO_3 (Aslam, 1985 and Rashid, 1986). The digest was subjected to flame photometer to determine the concentration of various cations, (Na^+, K^+) (Lauchli and Wieneke, 1979).

Field Performance

Wheat cultivars were tested in the natural saline fields of district Faisalabad, Toba Tek Singh and Jhang at twenty three different locations during three consecutive years, 2004-2005, and 2005-2006. Nine cultivars of wheat viz. NR-243, Sarrsabz, Pasban-90, Sarcc-1, Sarcc-2, Sarcc-3, Sarcc-5, Sarcc-6, 2013 and 3158 were sown in RCB design in four replications. Soil samples were collected before and after the harvest of the crop. The physiochemical analysis had pH = 9.32, EC =16.6 $dSm^{-1,}$ SAR = 49.88. At maturity, grain yield was recorded and subjected to analysis of variances (Steel and Torrie, 1980) and stability parameters following Eberhart and Russell model (1966).

RESULTS AND DISCUSSION

Effect of Salinity on Seed Germination

Seed germination was little affected up to salinity level of EC 10 dSm^{-1}. But, thereafter, it progressively decreased. However, the germination was always 40 percent or higher in all the cultivars even at salinity levels of 25 dSm^{-1}. The cultivars in general, did not differ much among themselves at each salinity level. The only notable exceptions were NR-243, Sarsabz, and Sarcc-3. Seed germination in these cultivars were less affected than other varieties at various levels and it was 60, 62, and 61 percent even at EC=25 dSm^{-1}. In contrast, all other cultivars had 40-49 percent seed germination at EC=25 dSm^{-1} (Table1).

Singh *et al.* (2000) studied 20 wheat genotypes having EC=2.8 and 20.8 dSm^{-1} along with control. The germination percentage declined under salinity stress. The genotypes Raj-3077 and Kharchia-65 were most tolerant to salinity while Raj-4530 Raj-3934 was most susceptible genotypes.

Effect of Salinity on Plant Growth

The mean performance for salinity rating, Na^+, K^+ and K^+/ Na^+ in the shoots of wheat cultivars is presented in table-2. It is clear from the data that variety Sarcc-3 had the highest relative growth rate i.e. 0.140 gg^{-1} day^{-1} followed by Sarsabz and NR-243 which gave 0.138 and 0.135 RGR, respectively. The lowest RGR was noticed in Sarcc-1and Sarcc-2 (0.089 gg-1 day-1). When plants are grown under saline conditions, as soon as the new cell start its elongation process, the excess of salts modifies the metabolic activities of the cell wall causing the deposition of various materials which limit the cell wall elasticity. Secondary cell wall appears sooner, cell walls become rigid and consequently the turgor pressure efficiency in cell enlargement is decreased (Acesves *et al*, 1975). The other expected causes of this reduction could be the shrinkage of the cell contents, reduced development and differentiation of tissues, unbalanced nutrition, damage of membrane and disturbed avoidance mechanism (Kent and Lauchli, 1985). Salinity also decreased the shoot fresh and dry weight of all the genotypes significantly when compared to control. High sodium and chloride concentration in the rooting medium could have suppressed the uptake of K^+,Ca^{++} and NO_3^- and ultimately the growth (Gorham and Wyn Johens, 1993). The reduction and the shoot dry weight under saline conditions were also due to reduced growth as a result of decreased water uptake, toxicity of sodium and chloride in the shoot cell as well as reduced photosynthesis (Brugnoli and Lauter, 1991). The mean performance for salinity rating K^+, Na^+ and K^+/ Na^+ in shoot of wheat showed that variety Sarcc-3 is tolerant to salinity at seedling stage and gave K^+/ Na^+ (3.92) while the lowest K^+/ Na^+ was observed in genotype Sarcc-5 (2.16) and was graded as sensitive to salt stress.

Table 1. Effect of Different Salinity Levels on Seed Germination of Various Cultivars of Wheat.

Cultivar	Salinity levels (EC=dSm^{-1}) Germination Percentage					
	Control	**5**	**10**	**15**	**20**	**25**
NR-243	100	95	90	82	70	60
Sarsabz	100	97	92	86	73	62
Pasban-90	100	90	70	65	56	42
Sarcc-1	100	92	78	73	60	43
Sarcc-2	100	90	75	70	58	40
Sarcc-3	98	91	88	76	67	61
Sarcc-5	96	90	86	71	56	46
Sarcc-6	95	93	89	72	58	51
2013	100	92	85	70	57	50
3158	100	91	84	71	58	49

Table 2. Salinity Means of Na^+, K^+ and K^+/ Na^+ and Relative Growth Rate (RGR) of Shoot of Some Wheat Cultivars Grown under Salinized Solution Culture.

Entries	Na+ (mol m^3)	K+ (mol m^3)	K^+/ Na^+	RGR ($gg^{-1}d^{-1}$)
NR-243	0.68	1.84	2.70	0.135
Sarsabz	0.58	1.99	3.43	0.138
Pasban-90	0.53	2.0	3.77	0.125
Sarcc-1	0.85	2.60	3.06	0.089
Sarcc-2	1.00	2.67	2.67	0.098
Sarcc-3	0.60	2.35	3.92	0.140
Sarcc-5	0.87	1.88	2.16	0.128
Sarcc-6	0.77	2.10	2.73	0.129
2013	0.62	1.98	3.19	0.131
3158	0.64	1.90	2.97	0.133

Table 3. Combined analysis of variance table for Wheat 2004-05, 2005-06.

Values	Source	Degree of freedom (d. f)	Sum of squares (s. s)	Mean square (m. s)	F value	Prob.
1	Replication	2	33528.050	16764.025	0.7835^{NS}	0.0000
2	Factor A	11	10751847.942	977440.722	45.6837**	0.0000
4	Factor B	9	21543250.903	2393694.545	111.8766**	0.0000
6	AB	99	6386651.864	64511.635	3.015**	0.0000
7	Error	238	5092212.617	21395.851		
	Total	359	43807491.375			

High K^+/Na^+ selectivity in plants under saline conditions has been suggested as an important selection criterion for salt tolerance (Rains1972; Floulers *et al*, 1977; Greenway and Munns 1980; Wyn Jones 1981; Ashraf 1994 a;

Gorham *et al*, 1997; Ashraf 2002; Wenxue et al. 2003). In Agropyron SSP., The high salt tolerance of A. elongatum relative to A. intermedium, is associated with its higher uptake of K^+ under saline conditions (Elzam and Epstein, 1969). Experimentation with wheat indicates that salt tolerance is associated with an enhanced K^+/Na^+ discrimination trait (Dvorak *et al*, 1994; Gorham et al. 1997). Kafkafi (1984) concluded that roots of the salt tolerant Beta vulgaris ahd a greater affinity for K^+ relative to Na^+ than did the salt sensitive phaseolus vulgaris. In cotton, Rathert (1982) demonstrated that salt-induced reduction in leaf K^+ content was lower in the salt tolerant cultivar Giza 45, than in the salt sensitive cultivar, sandarac,. Similarly, in soybean, Lauchli & Wieneke (1979) found that the salt tolerant cv. Lee, accumulated more K^+ in its leaves than did the salt sensitive cv. Jakson,. However, He and Cramer (1993a) did not find a relationship between K^+/Na^+ ratio and slat tolerance of Brassica species. They concluded that neither K^+/Na^+ ratio nor K^+-Na^+ selectivity was correlated with the relative salt tolerance of six rapid cycling Brassica species either at the whole plant or cullus levels, suggesting that these parameters are unreliable selection criteria. Recently, Munns and James (2003) have found that although Na^+ exclusion had a positive relationship with salinity tolerance of different tetraploid wheat, K^+/Na^+ ratio showed little relationship. A similar mechanism of ion uptake has also been observed in barley (Wenxue *et al.*,2003)

Field Screening of Wheat Cultivars for Salt Tolerance

Grain yield performances at different locations

Combined analysis of variance (Table-3) indicated that varieties and environments showed highly significant differences. The significant differences in varieties may be due to the variations in their genetic make up that forced the varieties to exhibits different behaviour in different environments. The varieties x environment interaction also showed highly significant differences which was an indication that the data can be further processed for stability analysis. Pooled analysis of variance indicated highly significant differences in environments (Table 4). Varieties x Env. (Lin) was non significant.

Table 4. Pooled analysis of variance table for wheat 2004-05, 2005-06.

Source	**Degree of freedom (d. f)**	**Sum of squares (s. s)**	**Mean square (m. s)**	**F. Value**
Total	119	12.892	0.108	
Environments	11	3.584	0.326	**
Varieties	9	7.179	0.798	44.030
Varieties x Environment	99	2.128	0.021	
Environment + Varieties x Environment	110	5.712	0.052	
Environment (Lin)	1	3.584	3.584	
Varieties x Environment (Lin)	9	0.317	0.035	1.941^{NS}
Pooled Deviation	100	1.812	0.018	0.848^{NS}
Pooled Error	240	5.126	0.021	

Table 5. Stability parameters of wheat genotypes tested under various environments 2004-05, 2005-06.

Sr. #	**Genotype**	**Mean Seed Yield (tones/ha)**	**Regression co-efficient (bi)**	**Standard deviation to regression (S^2d)**
1	NR-243	2.624	1.317	0.008
2	Sarsabz	2.510	0.919	0.009
3	Pasban-90	2.158	1.352	0.027
4	Sarcc-1	2.355	1.404	0.017
5	Sarcc-2	2.050	0.652	0.039
6	Sarcc-3	0.969	1.218	0.005
7	Sarcc-5	2.386	0.532	0.040
8	Sarcc-6	2.587	1.047	0.017
9	2013	2.564	0.810	0.008
10	3158	2.559	0.749	0.012

The genotype x environment interaction (G x V) may be of cross over or non cross nature depending upon the mean performance of the genotypes over different environments. A non cross over G x E interaction is that in which case the ranking of genotypes remains constant across environments and the interaction is significant because of changes in the magnitude of response (Baker, 1988; Matus *et al*, 1997) or a cross over G x E interaction, in which a significant change in rank occurs from one environment to another (Matus *et al*, 1997). The genotypes differed significantly in their mean seed yield performance. Overall, Sarcc-3 produced the highest seed yield (2.967 t/ha) followed by NR-243 (2.624 t/ha) and 2013 (2.564 t/ha). At 12 locations, Sarcc-3 ranked first position.

Maximum regression coefficient value (1.404) was estimated in Sarcc-1 followed by NR-243 (1.317) and Pasban-90 (1.352). However, all the values of regression coefficient showed non significant differences to unity.

The highest values of regression coefficient obtained more than unity indicated its response to favorable environments/conditions (Eberhart and Russell, 1966). Finely and Wilkinson (1963) obtained a linear regression of seed yield for each variety in the mean yield of all varieties for each location. Accordingly, a stable variety is the one for which the regression coefficient does not differ from zero and the stability is defined as the consistency in performance of a variety over varying environments (Table 5).

In this study almost all the values of standard deviation to regression were non-significant from zero. Lin *et al*. (1986) pointed out that large deviation from regression coefficient should not be considered as a measure of stability but should be taken as an indication of the inadequacy of the model to estimate stability.

Stability parameter showing similar results had been earlier reported in different field crops such as chickpea (Khan *et al.*, 1988), mungbean (Rajput *et al.*, 1986), barley (Voltas *et al.*, 1999), Sesame (Lanrentin and Montilla, 1999), wheat (Mehta *et al.*, 2000). (Sial *et al.*, 2000) and lentil (Sarwar *et al.*, 2003)

It is well known effect that regression coefficient (bi) should be a parameter of response and deviation to regression as a parameter of stability along with above average seed yield. Accordingly regression value near 1.00 indicates less response to environmental changes, and hence showing more adaptiveness. Thus, a genotype with unit regression coefficient (bi=1) and deviation not significantly different form zero ($s^2d=0$) is said to be the most stable genotype. The results of wheat genotype at different salt-affected ecological zones studied under this research work indicated that Sarcc-3 fits optimum standard of stability in respect of standard deviation to regression coefficient. Based on average grain yield and regression coefficient and standard deviation to regression (S^2d) genotype SArcc-3, NR-243 and Sarcc-6 were better as compared to other genotypes under study.

CONCLUSION

Based on high seed yield and stable performance of Sarcc-3 NR-243 and Sarcc-6 in different saline environment, it may be concluded that by promoting the cultivation of these genotypes in saline areas, such as studied here, the yield of wheat can be enhanced and ultimately it will be helpful to improve the economic position of the growers of those areas.

REFERENCES

Akhtar, J., J. Gorham and R.H. Qureshi., (1994). Combined effect of salinity and hypoxia in wheat (*Triticum aesitivum L.*) and wheat-*Thinopyrum amphiploids*. *Plant and Soil* 66:47-54.

Akhtar, J., J. Gorham, R.H. Qureshi and M. Aslam, (1998). Dose tolerance of wheat to salinity and hypoxia come late with root dehydrogenize activities or parenchyma formation. *Plant and Soil* 201:275-284.

Anonymous. (2002). *Agricultural Statistics of Pakistan*. Government of Pakistan, Ministry of Food, Agriculture and Live Stock, Economic Wing, Islamabad pp. 83-84.

Anonymus (2005-2006). Government of Pakistan, Finance Division, Economic adviser's wing, Islamabad. Pp-15

Ashraf, M. (2000):Salt tolerance of cotton: some new advances. *Crit. Rev. Plant Sci.* 21(1):1-30

Ashraf, M. and S. Ahmad. 2000. Influence of sodium chloride on ion accumulation, yield components and fiber characteristics in salt tolerant and salt sensitive lines of cotton (*Gossypium hirsutum L.*) *Field Crops Res.* 66:115-127.

Ashraf,M.(1994a): Breeding for salinity tolerance in plants. *Crit. Rev. Plant Sci*,, 13:17-42.

Baber, R.J. 1988. Test for crossover genotype – environmental interaction. *Can.J.Plant Sci.*68:405-410.

Dvorak, J, M. M. Noaman, S. Goyal, and J. Gorham, (1994). Enhancement of the salt tolerance of *Tritium turgidum* by the knal locus transferred from the *Triticum aestivum* chromosome 4D by homoeologous recombination. Theor. Appl. Genet. 87:872-877.

Eberhart, S. and W.A.Russel, (1966). Stability parameters for comparing varieties. *Crop Sci.* 6:36-40.

Elzam, O.E and E. Epstein, (1969): Salt relation of two grass species differing in salt tolerance I. Growth and salt content at different salt concentrations. II. Kinetics of the absorption of K^+ and Cl by their excised roots. *Agrochemica*, 13:190-196.

Finlay, W. and G.N.Wilkinson, (1963). The analysis of adaptation in a plant breeding programme. *Aust.J.Agric.Res*. 14:742-754.

Flowers, T. J, P.F.Troke, and A.R.Yeo, (1977). The mechanism of salt tolerance in hapophytes. *Annu. Rev.Plant Physiol*. 28:89-121.

Glenn., E., R. Pfister, J. J. Brown, T. L. Thompson, and J. W. O. Leary, (1996). Na and K accumulation and salt tolerance of *Atriplex canescens* (Chenopodiaceae) genotypes. *Am. J. Bot*, 83: 997-1005.

Gorham, J, J. Bridges, J. Dubcovsky, J. Dvorak, P. A. Hollington, M. C. Luo, and J. A. Khan, (1997). Genetic analysis and physiology of a trait for enhanced K^+/Na^+ discrimination in wheat. *New Phytol.* 137:109-116.

Greenway, H. and R. Munns, (1980): Mechanism of salt tolerance in non-halophytes. *Annu. Rev. Plant Physiol,* 31:149-190.

He, T. and G. R. Cramer, (1993a): Salt tolerance of rapid cycling *Brassica* species, in relation to potassium/sodium ration and selectivity at the whole plant and callus level. *J. Plant Nutr.* 16:1263-1277.

Kafkafi, U. (1984): Plant nutrition under saline conditions. In: (Shainberg, I. and Shalhevet, J. ed.), *Soil salinity under irrigation processes and management*. Springer, Berlin, pp.319-338.

Khan,I.A., B.A.Malik and M.Bashir, (1988). Investigation of genotype x environment interaction for seed yield in chickpea (*Cicer arietinum L.*) *Pak.J.Bot.* 20:201-204.

Lauchli, A. and J. Wieneke, (1979): Studies on growth and distribution of Na^+, K^+, and Cl in soybean varieties differing in salt tolerance. *Z. Pflanzenern. Boden*, 142:3-13.

Lauchli, A. and J. Wieneke, (1979). Studies on growth and distribution of Na^+,K^+ and Cl^- in soybean varieties differing in salt tolerance. *Zeilschrift pflanz. Boden*, 142: 3-13.

Laurentin, H.E. and D.Montilla, (1999). Analysis of genotype by environment interaction in sesame (S*esamum indicum* L.*)* population. *Sesame and Safflower Newsletter;* 14:26-31.

Lin C.S., M.R. Binns, L.P.Lefkovitch. (1986). Stability analysis: Where do we stand? *Crop Sci*,.26: 894-900.

Matus, A., A.E. Slinkard and C.V.Kessel, (1997). Genotype x environment interaction for carbon isotope discrimination in spring wheat. Crop Sci. 37: 97-102.

Mehta, H., R.N.Sawhney, S.S.Singh, H.B. Chaudhary, D.N.Sharma and J.B.Sharma, (2000). Stability analysis of high yielding wheat at varying fertility levels, *The Indian Genetics and Plant Breeding*, 60:471-476.

Munns, R. and R. A. James, (2003): screening methods for salinity tolerance: a case study with tetraploid wheat. *Plant Soil* 253:201-218.

Qadir, M. and M. Shams, (1997). Some agronomic and physiological aspects of salt tolerance in cotton (*Gossypium hirsutum L*.), *J. Agron. Crop Sci*. 179: 101-106.

Qureshi, R. H., M. Salim, Z. Aslam and G.R. Sandhu, (1977). An improved gravel culture technique for salt tolerance studies on plant. *Pak. J. Agri. Sci*. 16 (2-3): 11-18.

Rains, D. W. (1972). Salt transport by plants in relation to salinity. *Annu. Rev. Plant Physiol.* 23:367-388.

Rajput, M.A.,G.Sawar and K.H.Tahir (1986). Stability for grain yield in mungbean mutants. *Bangladesh J. Nuclear Agri*.2:58-59.

Rashid, A. (1986). *Mapping zinc fertility of soils using indicator plants soils analysis*. Ph. D. dissertation, University of Hawaii, HI, USA.

Rathert, G. (1982): Influence of estreme K/Na ratios and high substrate salinity on plant metabolism of crops differing in salt tolerance. Mineral distribution variability among different salt tolerant cotton varieties. *J. Plant Nutr*. 5:183-193.

Rehman, S. P, J. C. Harris and W.E. Bourne, (1998). The effect of sodium chloride on the Ca^{++}, K^+ and Na^+ concentration of the seed coat and embryo of *Acaciatortilis* and *A. cortacea*. *Ann. Appl. Biol.* 133: 269-279.

Saqib M., R.H. Qurshi, J. Akhtar, S. Nawaz and M. Aslam, (1999). Effect of salinity and hypoxia on growth and ionic compositions of different genotypes of wheat. *Pak. J. Soil Sci*. 17: 1-8.

Sarwar, G., M.S. Sadiq, M. Saleem and G. Abbas (2003). Genotype x environment interaction in newly developed lentil germplasm under cotton based cropping system. Proc. *Sustainable utilization of plant genetic resources for agricultural production*, 17-19 Dec.2002, NARC, Islamanad.pp.219-226

Sial, M.A., M.A.Arain and M.Ahmad. (2000). Genotype x environment interaction on bread wheat grown over multiple sites and years in Pakistan. *Pakistan J .Botany*, 32: 85-91.

Singh, Ak; Vijay, Prakash, E.R.D Sastry, V. Prakash, (2000). Effect of salinity stress on seed germination seeding growth of wheat. *Agricultural Science-Digest*, India pp. 96-98.

Steel, R.G.D. and J.H.Torrie, (1980). *Principles and Procedures of Statistics*. Mc Graw Hill Book Company, Inc. New York.

Voltas, J., I. Romugosa, A. Lafarga, A. Parmesto, A. Samero and J.L. Aruns, (1999). Genotype by environmetal interaction for grain yield and carbon isotope discrimination of barley in Mediterranean Spain. *Aust.J.Agric. Res*. 50: 1263-1271

Wenxue, W, P. E. Bilsborrow, P.Hooley, A. Fincham, E. Lombi, and B. P. Forster, (2003): Salinity induced differences in growth, ion distribution and partitioning in barley between the cultivar Maythorpe and its derived mutant Golden Promise. *Plant Soil* 250:183-191.

Wyn Jones, R. G. (1981): Salt tolerance. In: *Physiological processes limiting plant productivity* (Johnson, C.B. ed.). Butterworths, London, 271-292.

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