http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences, 2 (3): 693-696, 1999 *Research Article*

Intravarietal Variability in Wheat Grown under Saline Conditions

Mohammad Jamal Khan, H. Rashid, A. Rashid and R. Ali
Department of Soil Science, NWFP Agricultural University, Peshawar, Pakistan

Abstract

Performance of nine selected wheat cultivars (*Triticum aestivum* L.) was studied during 1995-1996 under saline field environments at village Gundhari, distt. Nowshera. Site soil is recent river alluvium, sandy loam to clay loam in texture, slightly to highly saline and irrigated with tubewell water of 4 dS m^{-1}. Two adjacent fields were surveyed by EM 38 at 2×2 m to identify areas of uniform salinity. Increase of root zone salinity decreased progressively all the plant traits including grain yield and yield component. Grain and straw yield were reduced by 69 and 64 percent respectively at the highest salinity level. Salinity tolerance ranking of cultivars based on absolute grain yield was SARC 3 > Bakhtawar 92 > Kharchia 65 > Blue Silver > SARC 1 > WS 10 > Mutant 1 > KTDH 10 > TW 161. Leaf Na increased, K and K/Na ratio decreased significantly with increase of root zone salinity. Sodium exclusion and K/Na discriminatory accumulation in leaf had contributed salt tolerance to wheat crop but these relationship could not be established in all cultivars.

Introduction

Salinity and sodicity problem of irrigated agricultural land is widespread and increasing worldwide. In Pakistan, about 5.8 million hectares are salt affected out of which 3.1 mha lies in canal-commanded irrigated area of wheat belt (Chaudhry *et al.*, 1978). The rapid increase in population (13% per annum) has greatly increased the demand for agricultural products. The Government of Pakistan figures (Government of Pakistan in 1988) project that the country must produce 50 percent more wheat by the end of this century. In Pakistan wheat was grown on 7.5 m ha^{-1} in 1997-98 season with estimated production of 17 million tones (Daily Frontier Post, May 4, 1997). Country demand for current year is nearly 20 million tones with deficit of 3 million tones. It may be possible to increase agricultural output by increasing productivity on areas unaffected by salinity and water logging, but this would require additional inputs which farmers would be unable to afford. The other strategy would be to use marginal lands and waters to increase production.

Wheat crop is grown on all types of land including salt affected soils. Although wheat is classified as moderately salt-tolerant crop (Maas and Hoffman, 1977), yield on world scale are greatly reduced by salinity. Yield losses on moderately salt affected soils of Pakistan average about 64 percent. Therefore, it is important to develop wheat varieties that will not only survive but also produce economic yield under conditions of moderate to high salinity. The main objective, of this work was to identify and develop salt tolerant wheat cultivar(s) that will not only survive but will produce economic yield under conditions of moderate to high field salinity.

Materials and Methods

The research trial was conducted in salt affected area at Gundhari, near Risalpur air base, Nowshera. The site soil is Kabul river alluvium. The soil has stratified profile with light to medium texture and varying in salinity and sodicity status. Only source of irrigation is farmer's tubewell, the water having salinity hazard of 4 dS m^{-1}.

Plant Material: Nine selected wheat genotype were grown on the site. Genotype TW 161, KTDH 19, Mutant 1 and Kharchia 65 were supplied by the Center of Arid Zones Studies, University of North Wales, Bangor, U.K. and WS 10 and Bakhtawar 92 by Nuclear Institute of Food and Agriculture, (NIFA) Tarnab, Peshawar. Seed of SARC 1 and SARC 3 were provided by Saline Agriculture Research Cell, University of Agriculture Faisalabad. Blue Silver population was developed at Department of Soil Science, NWFP Agricultural University, Peshawar.

Experimental Details: Two adjacent weeds free fields were surveyed for salinity appraisal by EM 38 on 2×2 m grid. Three saline areas per field were delineated based on EM 38 readings with three replications. The experimental design was randomized complete block with split plot arrangement, with field as main plot and genotype as sub plot. Each individual plot consisted of 4 rows 4 m long and 25 cm apart for each genotype. Wheat was planted at the rate of 100 kg ha^{-1}. Before sowing, half nitrogen 160 kg ha^{-1}) as ammonium nitrate was mixed in soil while other half was side dressed at tillering stage. After planting, only three irrigations of tubewell saline water were applied.

Soil Analysis: The composite soil sample collected before sowing were analyzed for the general physico-chemical properties. Before analysis, the soil was air dried and ground with mortar and pestle and passed through 2 mm sieve. All the standard methods for salinity measurement (Richards, 1954) were followed. Soil texture and organic matter contents were determined by following Jones (1989) (see Table 1 a for soil analyses). Salinity profile was determined before crop sowing and after crop harvest with the help of EM 38 is given in Table 1 b and 1 c.

Table 1: Physico-chemical properties of salt affected fields
a. General Properties at sowing time

Property	Values	
Clay (%)	Field A	Field B
Silt (%)	20.00	28.60
Sand (%)	22.20	20.40
Textural class	57.80	51.00
Saturation (%)	Silt loam	Clay loam
Organic matter (%)	28.00	32.00
Available K^+) mg Kg^{-1})	0.92	0.85
Lime (%)	144.00	155.00
pH of saturation paste	8.30	8.40
Electrical conductivity of saturation extract (ECe) (dS m^{-1})	8.00	13.60
Soluble Ca^{2+} + Mg^{2+} (meL^{-1})	3.00	78.00
Soluble Na^+ (meL^{-1})	44.00	58.00
Sodium Adsorption ration (SAR)	10.40	9.40

Table 1 b: Profile soil salinity calibrated from horizontal EM 38 readings 10-56 cm depth)

Replications	Field A	Field B
	--------------------dSm^{-1}------------------------	
1	3.05	4.73
2	3.12	5.09
3	3.30	5.43
4	3.75	6.49
5	4.00	7.22
6	3.98	7.29
7	4.47	8.87
8	5.10	5.59
9	4.88	6.69
Mean	3.96 a	7.15 b

Table 1 c: Salinity status at harvesting time (0-30 cm) depth

Replications	Field A	Field B
	--------------------dSm^{-1}------------------------	
1	4.29	7.77
2	5.04	8.20
3	5.17	8.55
4	5.86	11.65
5	6.19	11.96
6	6.05	12.25
7	8.23	17.23
8	8.77	20.19
9	8.56	17.83
Mean	6.46 a	12.85 b

Leaf Analysis: At boot stage, ten young fully expanded leaves per cultivar were collected for ions determination. The finely ground leaf sample of 250 mg was digested with 1 ml HNO_3 solution over night (Rashid, 1986) and after boiling, the volume was made to 50 ml. Potassium and sodium in the diluted aliquot were estimated by flame photometer.

Results

Grain and Straw Yield: Grain yield of different genot grown under saline field condition indicated that field genotypes had significant effect on grain production their interaction was non significant (Table 2). Grain yield decreased significantly with increase of field salinity. In salinity area (Field B) the grain yield reduced by 56 percent as compared to low saline area (Field A). Significant differences among the genotypes for grain production was also noted. SARC 3, followed by Bakhtawar 92, Kharchia 65 had higher yield whereas KTDH 19 and 161 produced lower yield. Blue silver, SARC 1, WS 10 Mutant 1 had medium ranking of grain production. Grain yield reduction of cultivars in high saline filed B compared to low saline field A ranged from 25 percent. Minimum reduction was noted in SARC 1. Bakhtawar 92 and maximum yield losses occurred in 161 and KTDH 19. From these observation it can inferred that wheat genotypes SARC 1 and Bakhtawar (with high grain yield) exhibited a level of tolerance.

Table 2: Grain yield of wheat genotypes grown in fields

Genotypes	Field A (Low saline)	Field B (High saline)	Mean
	----------------------kg ha^{-1}------------------------		
TW 161	1316	482	899.0_1
WS 10	1736	798	1266.0_1
KHARCHIA 65	1830	994	1387.0_1
SARC 1	1476	1108	1292.0_1
SARC 3	1970	1082	1526.0_1
B.SILVER (POP)	1670	1024	1347.0_1
BAKHTAWAR 92	1786	1200	1493.0_1
KTDH 19	1442	522	982.0_1
MUTANT 1	1452	970	1211.0_1
Mean	1631 a	910 b	

Standard Error For Field Genotype Field × Genotype
177 88 124 NS

Mean values followed by same letters either in row columns are not statistically different from each other Analysis of variance of straw yield data (Table 3) revealed that saline field and genotypes had significantly and affted straw production while their interactive effect was significant. Straw yield decreased significantly in high saline field B as compared to field A and cumulative yield reduction was 41 percent. Cumulative cultivars straw yield values showed that TW 161 produced maximum straw 3190 kg ha^{-1} while Mutant 1 gave the minimum of 1 kg ha^{-1}. TW 161 is thus significantly higher st producing cultivar as compared to other tested cultiv The reason of high straw yield and low grain yield of 161 is that it produced more unproductive tillers was increased straw yield.

Table 3: Total dry matter of wheat genotypes grown in saline fields

Genotypes	Field A (Low saline)	Field B (High saline)	Mean
	kg ha^{-1}		
TW 161	4718	3236	3977 a
WS 10	4634	1950	3292 bc
KHARCHIA 65	5006	2434	3720 a
SARC 1	4152	2944	3548 ab
SARC 3	4926	2758	3442 a
B.SILVER (POP)	4346	2712	3529 ab
BAKHTAWAR 92	4308	2458	3383 ab
KTDH 19	4156	1796	2976 b
MUTANT 1	3614	2208	2911 b
Mean	4429 a	2500 b	

Standard Error For Field Genotype Field × Genotype
298 255 360 NS

Table 4: Leaf Sodium contents of wheat genotypes grown in saline fields

Genotypes	Field A (Low saline)	Field B (High saline)	Mean
	%		
TW 161	1.64	2.02	1.83 ade
WS 10	1.42	2.13	1.78 dc
KHARCHIA 65	1.90	2.98	2.44 a
SARC 1	1.57	2.71	2.14 bc
SARC 3	1.51	2.28	1.90 cd
B.SILVER (POP)	1.41	2.11	1.77 de
BAKHTAWAR 92	1.87	2.14	2.01 cd
KTDH 19	1.91	2.65	2.28 ab
MUTANT 1	1.93	2.05	1.99 cd
Mean	1,68 a	2.34 b	

Standard Error For Field Genotype Field x Genotype
298 255 360 NS

Table 5: Leaf Potassium contents of wheat genotypes grown in saline fields

Genotypes	Field A (Low saline)	Field B (High saline)	Mean
	%		
TW 161	3.10	2.18	2.64 a
WS 10	2.99	1.74	2.37 a
KHARCHIA 65	2.74	1.85	2.30 a
SARC 1	2.29	2.17	2.23 a
SARC 3	3.01	2.47	2.74 a
B.SILVER (POP)	2.48	2.01	2.25 a
BAKHTAWAR 92	2.56	1.93	2.25 a
KTDH 19	2.78	2.11	2.45 a
MUTANT 1	2.59	1.87	2.23 a
Mean	2.73 a	2.04 b	

Mean values followed by same letters either in rows columns are not statistically different from each other.

Table 6: Leaf K/Na ratios contents of wheat genotypes grown in saline fields

Genotypes	Field A (Low saline)	Field B (High saline)	Mean
	%		
TW 161	1.89	1.08	1.46 a
WS 10	2.10	0.82	1.46 a
KHARCHIA 65	1.44	0.62	1.03 a
SARC 1	1.45	0.80	0.89 a
SARC 3	1.99	1.08	1.54 a
B.SILVER (POP)	1.75	0.95	1.35 a
BAKHTAWAR 92	1.37	0.90	1.14 a
KTDH 19	1.45	0.80	1.13 a
MUTANT 1	1.34	0.91	1.12 a
Mean	1.64 a	0.88 b	

Mean values followed by same letters either in rows or columns are not statistically different from each other.

Leaf Na+ and IC Concentration: Leaf Na concentration (Table 4) shows that saline field and genotypes had significant effect on Na^+ content while their interaction was nonsignificant. Maximum mean Na^+ content was recorded in field B which has high salinity. Kharchia 65 and KTDH 19 accumulated comparatively more leaf Na^+ while WS 10 and Blue Silver accumulated less Na^+. Leaf K^+ concentration was significantly reduced with raise in salinity while genotypes and their interaction was non significant (Table 5). Plants grown on low saline field A had more leaf K^+ than grown on field B. SARC 3 and RW 161 cultivars had accumulated higher K^+ content.

Leaf K/Na ratio was significantly affected by salinity level while the ratio in genotypes did not change significantly but variation were very clear (Table 6). Maximum ratio of 2.1 was noted in TW 161 which produced less yield while the lowest value of 0.8 was recorded SARC 1 grown under high saline field.

Relationship Study: Grain yield data was correlated with leaf ion content, Correlation between grain yield and leaf Na^+ was negatively and significant ($r = -0.60$) while leaf K^+ was positively correlated ($r = 0.72$) with grain yield.

Discussion

The most common plant response at salt stress is a general reduction in growth and yield. As salt concentration increases above threshold level, both the growth rate and ultimate yield decreases progressively. However, the threshold level and the rate of growth reduction vary widely among different crop species and even cultivars (Maas, 1996). Since saline soils in the field generally consist of a mixture different salts. Specific ion effects are minimal and osmotic effects predominate in the growth suppression of herbaceous crop. In present study, grain and biomass decreased invariably with the increase of root zone salinity in both fields. Maximum reductions were noted at higher salinity level because root zone salinity exceeded the threshold value (about 6 dS m^{-1}) of wheat crop. Wheat crop is moderately tolerant (Maas and Hoffman, 1977) and similar adverse effect of root zone salinity on its plant traits have been reported by Qureshi *et al*. (1980), Rashid (1986), Kumar and Kumar (1983), Iqbal (1991) and Gill *et al*. (1993). On average, grain and dry matter yield were generally declined with root zone salinity, but some cultivars like TW 161 and KTDH 19 produced more dry matter yield as compared to grain yield resulting low harvest index. Crop sensitivity to salinity continually changes during the growing season. With wheat crop, it appears that the most serious effect of salt stress during the vegetative and early reproductive stage is suppression of tiller formation (Rashid, 1986; Maas, 1996). In the present trial it was observed that many emerged seedling died in early growth period decreased tiller formation ultimately low yield. In salt sensitive varieties (TW 161 and KTDH 19) shriveled seed were produced as compared to salt tolerant cultivars (Bakhtawar 92 and SARC 3). One reason may be that both the exotic cultivars KTDH 19 and TW 161 produced less grain yield due to early advent of summer in Peshawar valley thus these cultivars proved to be salt sensitive at grain filling stages.

Significant negative correlation of leaf Na and significant positive correlation of leaf K^+ and K^+/Na^+ ratios with grain production indicated that cultivars accumulated more sodium had poor yield and the varieties which maintained higher tissue K^+ produced more grain yield. It is assumed that reduced growth of wheat plant at higher salinity of field B was due to ion excess in the tissue caused by enhance Na^+ uptake (Greenway and Munns, 1980; Rashid, 1986; and Gorham, 1994). These results also suggest that wheat crop has Na^+ and Cl^- exclusion mechanism to cope with substrate salinity as some higher yielding varieties accumulated less Na^+ and maintain higher tissue K^+ level. SARC 3 followed by Bakhtawar 92 and Kharchia 65 proved to he salt tolerant cultivars. SARC 3 seemed suitable for cultivation in moderate to high salinity while Bakhtawar 92 can be grown in slight to moderate saline area. Wheat grain production can be enhanced by increasing plant population as the tillers production is reduced by salinity. Cultivars maintaining high K^+/Na^+ ratio may be the possible reason of salt tolerance.

References

Chaudhry, M.B., M.A. Mian and M. Rafiq, 1978. Nature and magnitude of salinity and drainage problems in relation to agricultural development in Pakistan. Pak. J. For., 28: 70-72.

Gill, K., S. Aliqacar and K.N. Singh, 1993. Effect of interaction of flooding and alkalinity at various growth stages on grain yield of wheat (*Triticum aestivum* L.). Indian J. Agric. Sci., 63: 795-802.

Gorham, J., 1994. Salt tolerance in the Triticeae: K/Na discrimination in some perennial wheatgrasses and their amphiploids with wheat. J. Exp. Bot., 45: 441-447.

Greenway, H. and R. Munns, 1980. Mechanisms of salt tolerance in nonhalophytes. Annu. Rev. Plant Physiol., 31: 149-190.

Iqbal, Z., 1991. Study of salt tolerance of selected wheat cultivars/lines. M.Sc. Thesis, NWFP Agriculture University, Peshawar.

Jones, Jr. J.B., 1989. Soil Testing and Plant Analysis Laboratory Manual. Benton Laboratories, Athens, Georgia, pp: 26-30, 33-36.

Kumar, D. and P. Kumar, 1983. Genotype × environment interactions in wheat under salinity. Sabrao. J., 15: 98-101.

Maas, E.V. and G.J. Hoffman, 1977. Crop salt tolerance-current assessment. J. Irrig. Drainage Div., 103: 115-134.

Maas, E.V., 1996. Plant response to soil salinity. Proceedings of the 4th National Conference and Workshop on the Productive Use and Rehabilitation of Saline Lands, Albany, Western Australia, March 25-30, 1996, Promaco Conventions Pty. Ltd., pp: 385-391.

Qureshi, R.H., R.M. Ilyas and Z. Aslam, 1980. Screening of wheat (*Triticum aestivum*) for salt tolerance. Pak. J. Agric. Sci., 17: 19-25.

Rashid, A., 1986. Mechanisms of salt tolerance in (*Triticum aestivum* L.). Ph.D. Thesis, University of Agriculture Faisalabad, Pakistan.

Richards, L.A., 1954. Diagnosis and Improvement of Saline and Alkali Soils. Agriculture Handbook No. 60, United State Government Printing Office, Washington, DC., USA., Pages: 160.