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RESPONSE OF FEW NEWLY DEVELOPED SALT-TOLERANT WHEAT LANDRACE SELECTIONS UNDER NATURAL ENVIRONMENTAL CONDITIONS

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Abstract

Performance of five selected wheat (*Triticum aestivum* L.) cultivars and a local variety as a check were studied during 1990-2001 at Agriculture Research Sub-Station Kot Deji, District Khairpur. The experiment was conducted at three different sites having salinity of 4, 6.5 and 7.8 dSm^{-1}, respectively. Taller plants were produced by CAZS1a while significantly long spikes with more seeds per spike and higher grain weight were produced by CAZS2. Site-I with low salinity produced taller plants ($P < 0.05$), more spike and significantly higher grains. While the lowest values for all the parameters were recorded at Site three, which was due to higher salinity. Salt tolerance ranking based on grain weight was CAZS2 > CAZS1a > TJ-83 > CAZS1b > CAZS3 > CAZS4. The study suggests that at higher salinity (Site-III), the CAZS2 has potential of producing economic yield while at low salinity (Site-I), CAZS1a, CAZS1b and local variety are equally effective.

Introduction

Soil salinity/sodicity is one of the major and increasing problems in irrigated agriculture in Pakistan, particularly where wheat and rice are grown in the same system. The areas affected by varying degrees of salinity/sodicity are reported at around 6.3 M ha within Canal Command areas, of which half is cultivable or cultivated to some extent (Rafique, 1990) and much is waterlogged. Ghassemi *et al.* (1995) estimated about 14 percent of irrigated land to be badly affected by salinity in Pakistan. The rapid increase in population has greatly increased the demand for agricultural products. It may be possible to increase agricultural output by increasing productivity on areas unaffected by salinity and waterlogging, but this would require additional inputs which farmers would be unable to afford. The strategy would be to use marginal lands and water to increase production.

Wheat is grown on all type of soils and is classified as a moderate, salt tolerant crop (Maas & Hoffman, 1977). Yield losses on salt affected soils of Pakistan average about 64 %. Therefore, it is important to develop wheat varieties that will not only survive but also produce yield under conditions of moderate to high salinity. The main objective of this study was to evaluate few newly developed hexaploid wheat landrace to select genotypes for grain yield potential which could be grown at varying degrees of salinity/sodicity in salt-affected areas of Khairpur.

Materials and Methods

Field experiments were conducted at three different locations under varying degrees of salinity/sodicity at the Experimental Agriculture Research Sub-Station, Kot Deji and village Lanishan, District Khairpur, Sindh, Pakistan during the Rabi season 2000-2001. Initially the seeds were sown during the Rabi season 1999-2000 on clay loamy soil which had 4.01 ECe and 7.5 pH. Five wheat landrace selections, designated CAZS1a, CAZS1b, CAZS2, CAZS3, and CAZS4 were used in these experiments. The genotypes CAZS1a-CAZS4 are landrace previously selected for salt-tolerance in pots and floodbences at 150 mol. m^{-3} NaCl concentration under controlled environment. The electrical conductivity (ECe) and pH of the soil at all three experimental sites were analyzed and the sites were categorized as Site1, Site 2 and Site 3. Site 1, 2 and 3 had ECe of 4.01, 6.40 and 7.80 dSm^{-1} while a pH of 7.80, 8 and 8.10, respectively. Eight plants were selected at random from each genotype. The data were recorded on plant height (cm), spike length, number of grains per spike and grain yield (g) per plant. The genotypes CAZS1a-CAZS4 along with TJ83 as check were used in these saline field trials (Table 1). Data were statistically analysed and least significant differences (LSD) employed.

Results and Discussion

Landrace may have been selectively adapted to perform in a stable manner under different conditions. It has, therefore, been suggested that this type of material should be evaluated under different environmental conditions (Sayed, 1985). However, the test of salt-tolerant material is that selected lines must show their potential in farmer's field (Sayed & Gadallah, 1983; Wyn Jones & Gorham, 1990; Nieman & Shannon, 1997).

Considering these suggestions, the present study was planned to evaluate landrace genotypes previously selected for the sodium Na^+ and high potassium/sodium (K^+/Na^+) ratio under natural field conditions. The genotypes used in these experiments showed significant differences ($p<0.05$) between them at increasing levels of salinity/sodicity at different locations for plant height, spike length, number of grains and grain yield per plant (Table 2-5). The effects of salinity on these traits were clear at the highest level of ECe, *i.e.* 7.8 dSm^{-1}. Almost all genotypes had significantly lower plant height, spike length, grains per spike and grain yield per plant at higher salinity level. Effects were significant at the highest ECe level. The variety TJ-83 was the most adversely affected of all the landrace genotypes. It could be that TJ-83 was not bred for salt tolerance, although the genotype CAZS1a showed highest plant growth than that of the other genotypes at the site 1 and 3. The plant height significantly reduced at the location 3 in comparison to location 2, while at the location 2 did not show significant difference from the location 3 (Table 2). Similar effects of salinity on plant growth have been reported by Li *et al.* (2001) and Noaman (2000) on wheat plants. Reid & Smith (2000) found significant reduction in growth when they exposed wheat seedlings at 150 mM NaCl. High accumulation of ions, such as Na^+ and Cl^- interfere with the uptake of other ions, leading to critical nutrient deficiencies or other toxic effects on plants (Gupta & Sharma, 1990). Recently, Akram *et al.* (2002) found impacts of salinity on the yield and yield components of different wheat varieties in a pot experiment and found significant reduction in the spike length, number of grains per spikelet and grain yield per plant.

The genotype CAZS2 showed significantly highest spike length than that of the other genotypes at both upper ECe levels. However, it produced highest number of grains and had significantly and consistently highest grain yield than all genotypes except the genotype CASZ1a, although the difference was not significant. In this work, the

Table 1. The origin of 5 landrace wheat genotypes and their sodium Na^+ concentration and potassium/sodium (K/Na) ratio under controlled environment. (n = 4)

Genotypes	Origin under controlled	Sodium Na^+ (150 mol. m^{-3})		Potassium/Sodium K/Na	
		Mean	SE ±	Mean	SE ±
CAZS1a	Landrace B25/4	57.5	6.45	5.54	0.86
CAZS1b	Landrace B25/4	57.2	5.60	5.45	0.57
CAZS2	Landrace B25/4	74.6	14.80	6.45	1.71
CAZS3	Landrace B25/4	69.8	8.30	5.16	0.68
CAZS4	Landrace B25/4	56.7	4.97	6.06	0.48
TJ-83	Commercial in Sindh	89.6	15.24	4.87	0.66

Table 2. Plant height (cm) of wheat genotypes at three sites differing in salinity.

Genotype	Site I	Site II	Site III	Mean
CAZS1a	96.88	90.25	85.63	90.92
CAZS1b	66.25	60.88	61.75	62.96
CAZS2	64.13	61.13	57.13	60.79
CAZS3	62.13	59.75	56.38	59.42
CAZS4	63.88	60.88	56.63	60.46
TJ-83	65.13	61.75	57.88	61.58
Mean	**69.73**	**65.77**	**62.56**	
ECe (dSm^{-1})	4.01	6.40	7.80	
pH	7.80	8.00	8.10	

$LSD_{(0.05)}$ for Sites = 2.09, $LSD_{(0.05)}$ for Varieties = 2.15, Interaction (S x V) = *

* = Significant at 0.05 probability level.

Table 3. Spike length (cm) of wheat genotypes at three sites differing in salinity.

Genotype	Site I	Site II	Site III	Mean
CAZS1a	12.18	11.01	9.66	10.95
CAZS1b	11.55	10.94	9.69	10.73
CAZS2	13.14	12.53	11.96	12.54
CAZS3	11.41	10.60	9.39	10.47
CAZS4	10.74	10.26	8.66	9.89
TJ-83	12.41	10.48	8.45	10.45
Mean	**11.90**	**10.97**	**9.64**	
ECe (dSm^{-1})	4.01	6.40	7.80	
PH	7.80	8.00	8.10	

$LSD_{(0.05)}$ for Sites = 0.55, $LSD_{(0.05)}$ for Varieties = 0.68, Interaction (S x V) = **

** = Significant at 0.01 probability level.

Table 4. Grains per spike of wheat genotypes at three sites differing in salinity.

Genotype	Site I	Site II	Site III	Mean
CAZS1a	36.75	32.75	29.75	33.08
CAZS1b	34.00	31.63	28.75	31.46
CAZS2	39.00	36.75	34.50	36.75
CAZS3	28.75	26.88	23.88	26.50
CAZS4	25.00	22.38	20.00	22.46
TJ-83	33.88	25.25	20.50	26.54
Mean	32.90	29.27	26.23	
ECe (dSm^{-1})	4.01	6.40	7.80	
pH	7.80	8.00	8.10	

$LSD_{(0.05)}$ for Sites = 1.57, $LSD_{(0.05)}$ for Varieties = 1.46, Interaction (S x V) = **
** = Significant at 0.01 probability level.

Table 5. Grain yield (g) per plant of wheat genotypes at three sites differing in salinity.

Genotype	Site I	Site II	Site III	Mean
CAZS1a	17.03	15.72	14.77	15.84
CAZS1b	13.75	11.72	11.53	12.33
CAZS2	17.99	16.99	15.20	16.73
CAZS3	12.32	11.03	11.07	11.48
CAZS4	10.74	8.58	8.85	9.39
TJ-83	17.04	12.72	10.77	13.51
Mean	14.81	12.79	12.03	
ECe (dSm^{-1})	4.01	6.40	7.80	
pH	7.80	8.00	8.10	

$LSD_{(0.05)}$ for Sites = 1.05, $LSD_{(0.05)}$ for Varieties = 1.06, Interaction (S x V) = **
** = Significant at 0.01 probability level.

genotypes CAZS1a and CAZS2 showed significantly and consistently highest grain yield. The main reason could be that these genotypes had highest K^+/Na^+ ratios than that of the other landrace genotypes (Table 1). Enhanced leaf K^+/Na^+ ratio is another factor determining salt tolerance in wheat (Munns *et al.*, 2000; Poustini & Ciocemardeh, 2001). The gene *kna1* that controls enhanced K^+/Na^+ discrimination is located on the long arm of the 4D chromosome (Shah *et al.*, 1987; Dvorak & Gorham, 1992; Gorham, 1993; Dvorak *et al.*, 1994) and has been shown to operate at all salt concentrations, although it is most obvious at low salinities (< 100 mol. m^{-3}) (Gorham, 1990).

It is concluded that with increasing level of salinity, almost all growth parameters decrease significantly. The genotypes CAZ1a and CAZS2 showed high spike length, more number of grains and highest grain yield per plant as compared to all other genotypes. Although Na^+ concentration of CAZS2 was higher in comparison with the other genotypes, the response of selections for grain yield was variable in different growing areas. The yield stability of CAZS1a and CAZS2 selections under variable growing conditions is important. The results confirmed that the salt-tolerance potential of the previously selected genotypes under controlled environment was superior to that of TJ-83.

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