Pak. J. Bot., 35(5): 771-777, 2003.

GENETIC VARIABILITY OF SOME PRIMITIVE BREAD WHEAT VARIETIES TO SALT TOLERANCE

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Abstract

Using gravel culture technique, an experiment was conducted to study the genetic variability of some primitive bread wheat varieties to salt tolerance. Eight primitive bread wheat varieties acquired from late Prof. Dr. A. R. Rao, Director CHIDS, Pakistan were grown in plastic pots having four salt (NaCl) treatments *i.e.* 0.0, 0.5, 1.0 and 1.5 % NaCl along with Hoagland solution with five replications. Dry weight per plant, number of tiller per plant, shoot and root length, nitrate reductase activity (NRA), total nitrogen, K and P contents decreased while Na content increased with increase in salinity in all the varieties. However, varieties 236/1 and 245/1 performed better than others regarding above mentioned parameters. All the varieties survived upto 1.5 % NaCl. Primitive bread wheat varieties 236/1 and 245/1 have the highest salt tolerance potential as they showed dry matter reduction less than 50 % at the highest salinity level.

Introduction

Salinity decreases plant's growth and yield to various degrees depending on plant species, salinity level, and ionic composition of the salts that contribute to it (Ashraf *et al.*, 2002). The problem of exploiting saline lands and brackish water is being tackled by the international scientific community with two broad approaches (Qureshi *et al.*, 1998). There are attempts: 1) to domesticate and develop natural halophytes for their productive potential, and 2) to breed salt tolerant varieties of most important crop plants by conventionally established methods or by new methods which go under the general head of biotechnology (Garcia *et al.*, 1995). The latter appear to be the most important in future because the transfer of individual gene from tolerant to sensitive species is possible. This will be more efficient if we would identify the physiological or biochemical characters which confer salt tolerance (Ashraf *et al.*, 2002). There are many evidences available in literature which indicate that wild or primitive species/varieties of crop plants are more salt tolerant than the modern ones (Forster *et al.*, 1987; Shah *et al.*, 1987; Munns, 1993; Martin *et al.*, 1994).

The present study was conducted to screen the available germplasm of primitive wheat varieties for salt tolerance and to identify the physiological or biochemical marker/trait for salt tolerance. The other objective was to generate information about our primitive germplasm which may help in evolving new salt tolerant and high yielding wheat varieties.

Materials and Methods

Seeds of twenty primitive wheat genotypes were acquired from late Prof. Dr. A. R. Rao, Director CHIDS, Pakistan who collected the germplasm from all over Pakistan. After germination test only eight best performing ones were used in this study. Seedlings were raised in plastic pots containing sand, 1/5 Hoagland solution (Hoagland & Arnon, 1950). When 10 days old, the plants were transferred to 6 L plastic pots containing white marble gravel and 1/5 strength Hoagland solution using gravel culture technique. (Qureshi *et al.*, 1977). These pots had holes at the bottom and were placed in 10 L pots. After one week, treatment of NaCl (0.0, 0.5, 1.0 and 1.5 %) were used each had three repeats. The concentrations of NaCl were increased in steps of 0.5 %/day to avoid osmotic shock till the desired concentrations were achieved. Another week later, the solution were changed and same treatments were created in ½ strength Hoagland solution and allowed to grow for three weeks. The solution lost by evapo-transpiration were maintained by adding the respective Hoagland solution. The pH in all pots were noted daily, if above 7 few drops of concentrated H_2SO_4 were added. Solutions were changed every week.

After one month, plants were harvested, their shoot and root lengths were measured, washed twice with tap water and once with distilled water oven dried at 65 °C for a week and ground in a Willey micro mill to pass a 2 mm sieve. The dried ground material was digested in sulphuric acid and hydrogen peroxide (Wolf, 1982) and analysed by Jackson's (1962) method. Sodium and potassium were analysed by flame photometry. phosphorus by spectrophotometer using Barton's reagent and total nitrogen by Kjeldahl's method. The data were statistically analysed and DMRT test was used to compare the treatment and varietal means (Steel & Torrie, 1982).

Results

Growth: The biomass per plant (Fig. 1) indicated that sodium chloride caused depression in biomass almost in all the wheat genotypes except at 0.5 % NaCl, where a little increase was noted in some wheat genotypes (such as in wheat genotypes 236/1, 234/2, 237/4, 245/1 & 238/5). Wheat genotypes 236/1, 234/2, 237/4 & 245/1 performed better at 1.0 % NaCl treatment while in 1.5 % NaCl, non-significant differences were recorded in all the genotypes except in genotypes 238/5, 236/1 & 234/2, where the differences were significant when compared with other genotypes. In primitive wheat varieties, number of tillers were much higher than modern wheat cultivars. However, number of tillers were significantly influenced by NaCl. Number of tiller per plant decreased with increase in salinity except at 0.5 NaCl, where enhancement was recorded in some genotypes (234/4, 234/2, 237/4, 245/1, 238/5 & 238/8). Maximum number of tillers were produced by 236/1, 234/2 and 237/4 under 1.0 % NaCl, while differences at 1.5 % NaCl were non-significant. Similarly, shoot and root length reduced with the increase in NaCl concentrations in all wheat varieties but under 0.5 % NaCl a non-significant increase was noted in some wheat varieties. On the basis of biomass and growth parameters primitive varieties can be divided into two groups, good performing *i.e.* 241/9, 237/4, 236/1, 234/2 & 245/1, while others can be categorized as poor performing.

Physiological parameters: Results clearly indicated that nitrate reductase activity (NRA) reduced with increase in salinity in all the wheat varieties, however, 0.5 % NaCl enhanced NRA in some wheat varieties such as 241/9,236/1 & 238/5. Wheat varieties 241/9, 234/2, 236/1 & 237/4 performed better at 1.0 % NaCl than others. Overall varietal means showed that variety 234/2 and 237/4 were the most tolerant ones. Total nitrogen content in shoot varied from 25.2 to 3.5 mg. g^{-1} dry weight under different salinity treatments. Salinity treatment reduced the total nitrogen content with increase in NaCl concentrations in all wheat genotypes. Non-significant differences were recorded under 0.5 % NaCl, however, at 1.0 and 1.5 % NaCl varieties best performing were 241/9, 236/1, 234/2 & 236/5 and others were poor performing ones.

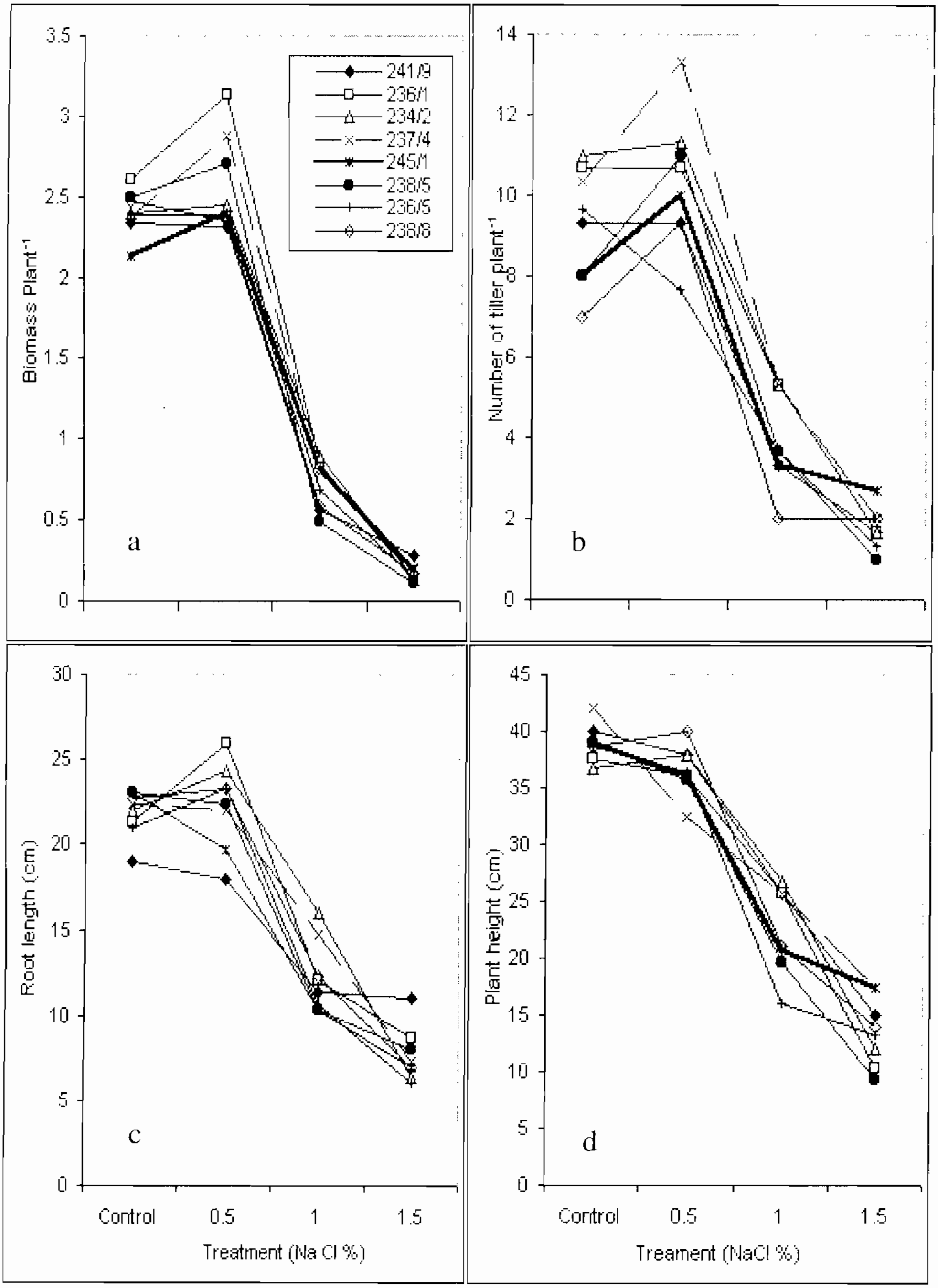

Fig. 1. Effect of salinity on growth of some primitive wheat varieties.
(a) Biomass. plant^{-1} (b) Number of tiller. plant^{-1} (c) Root length (d) Plant height

Table 1. Effect of salinity on K^+ content in different primitive wheat genotypes.

Wheat genotypes	K^+ content mg. g^{-1} D.Wt Treatment (NaCl %)				
	0.00	0.5	1.0	1.5	Mean
241/9	16.4	13.6	5.3	2.4	9.4 b
236/1	16.8	10.6	6.6	2.6	9.2 b
234/2	17.5	11.6	7.7	1.7	9.6 b
237/4	18.3	7.6	5.6	3.3	8.7 b
245/1	18.3	11.1	9.1	5.0	11.0 a
238/5	17	11.1	6.4	1.6	9.0 b
236/5	15.5	11.9	8.9	3.8	10.0 a
238/8	16	9.4	9.5	3.3	9.6 b
Mean	17 a	10.9 b	7.4 c	3.0 d	

Table 2. Effect of salinity on Na^+ content in different wheat genotypes.

Wheat genotypes	Na^+ content mg. g^{-1} D.Wt Treatment (NaCl %)				
	0.0	0.5	1.0	1.5	Mean
241/9	1.3	2.1	3.4	3.9	2.7 ab
236/1	1.1	2.3	3.1	3.7	2.5 c
234/2	1.3	2.7	2.8	4.1	2.7 ab
237/4	1.1	2	2.7	3.7	2.4 c
245/1	1.0	2.4	3.4	3.8	2.6 ab
238/5	1.0	2.2	2.9	4.2	2.6 ab
236/5	1.1	2.7	3.3	4.0	2.7 ab
238/8	1.0	2.5	3.5	4.1	2.8 a
Mean	1.1 d	2.4 c	3.2 b	4.0 a	

Table 3. Effect of salinity on P content in different wheat genotypes.

Wheat genotypes	P content mg. g^{-1} D.Wt Treatment (NaCl %)				
	0.0	0.5	1.0	1.5	Mean
241/9	4.2	3.6	3.1	2.7	3.4 ab
236/1	4.2	3.5	3.3	2.8	3.4 a b
234/2	4.4	3.4	3.2	2.6	3.4 ab
237/4	4.4	3.1	2.8	1.9	3.1 c
245/1	4.0	3.9	3.9	2.8	3.7 a
238/5	4.3	4.0	2.5	1.8	3.2 b
236/5	4.3	4.1	2.8	2.1	3.3 ab
238/8	4.2	4.1	3.8	2.4	3.7 a
Mean	4.2 a	3.7 b	3.2 c	2.4 d	

Potassium (K^+) content decreased with increase in NaCl concentrations. Maximum reduction was recorded under highest salinity level. Wheat varieties 234/2, 245/1 & 236/1 maintained higher K^+ content upto 1 % NaCl. However, under 1.5 % NaCl only 245/1 & 236/5 had higher K^+ than others. On the other hand Na^+ increased with the increase in salinity. Lower accumulation of Na^+ was recorded in those varieties which had higher K^+ contents. Reduction in P contents was observed in all the wheat genotypes with the increase in salinity, however, varieties 245/1, 236/1 & 241/9 maintained higher P contents under all salinity levels.

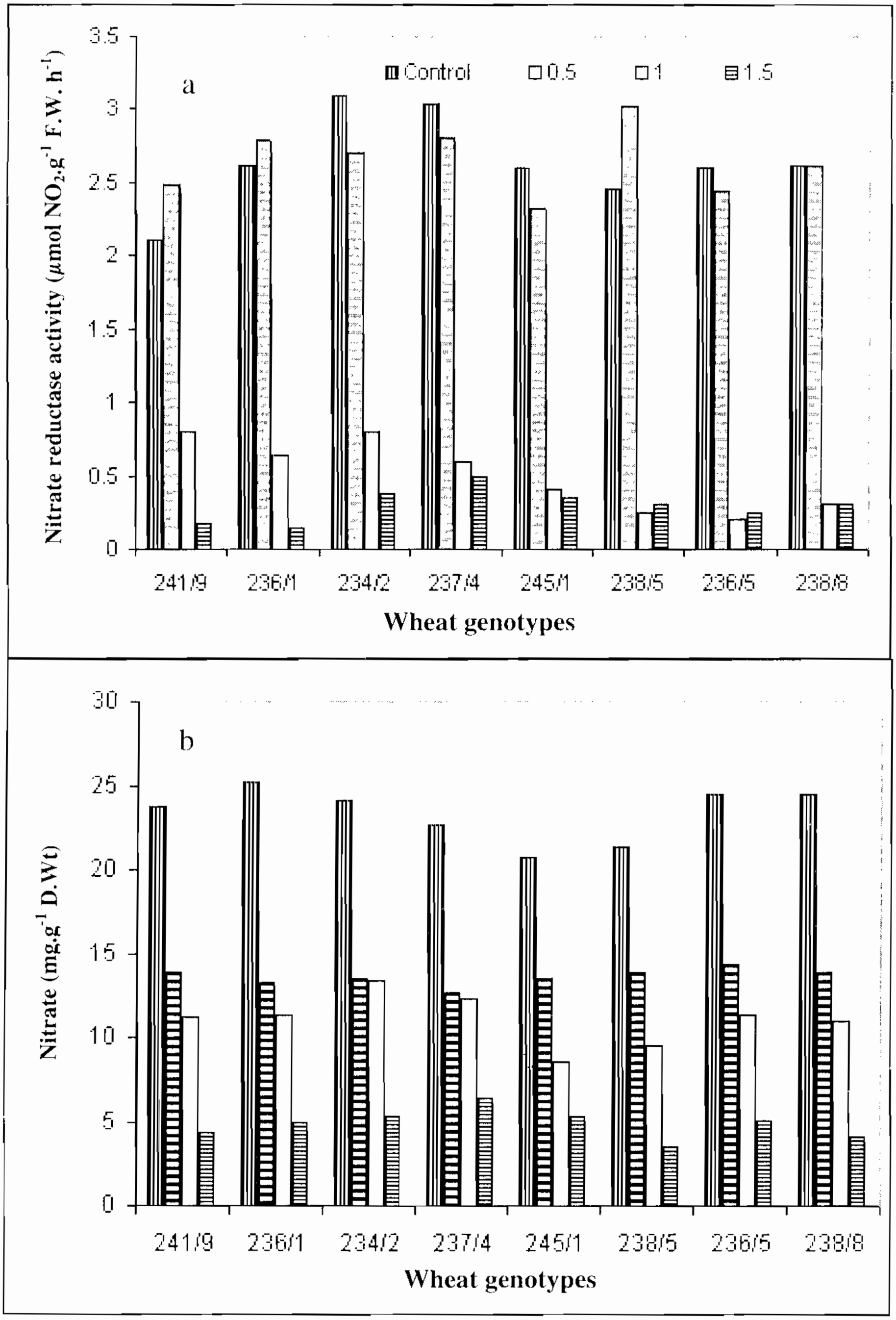

Fig. 2. Effect of Salinity on (a) nitrate reductase activity and (b) total nitrogen content in different primitive wheat varieties.

Discussion

Varietal differences in salt tolerance have been recorded in primitive wheat in the present study. There are many reports which indicate similar results (Khan & Ashraf, 1988; Pessarakli & Huber, 1991; Ashraf *et al.*, 1999; Ashraf *et al.*, 2002) in different crop plants. The biomass, number of tiller per plant and shoot and root lengths data indicated that varieties can be divided into two groups tolerant/best performing i.e., 236/1, 237/4, 234/2 & 245/1 while the other group: poor performing contained other varieties. However, all the varieties survived upto 1.5 % NaCl which showed that these varieties had more salt tolerance potential than other modern wheat varieties. Many reports (Forster *et al.*, 1987; Shah *et al.*, 1987) showed that most of them died at 1.5 % NaCl. There are many factors which are responsible for the depression in growth in these varieties. These varieties differ in Na, N, P, K and nitrate reductase activity (NRA) which might be one of the causes in growth depression. The higher uptake of Na^+ directly or indirectly causes growth depression, either by decreasing uptake of other anions such as nitrate (Khan *et al.*, 1990) or by direct effect of high local concentrations by reducing uptake of K, N and P. Results of present study confirmed that NRA, N, P, and K, reduced in the plants growing under saline conditions. Specific ion toxicity results due to penetration of injurious concentrations of Na^+ and Cl^- in the protoplast, which may cause inactivation of enzymes, inhibition of protein synthesis, changes in membrane permeability and damage to cell organelles. Ionic or nutritional imbalance results in salt stressed plants due to the competition of salt ions with nutrients. (Ashraf & Khan, 1994; Dubey, 1997).

A negative effect of sodium chloride on the uptake of nitrogen and NRA was observed in the present study (Fig. 2 a,b). The effect was more pronounced in poor performing varieties. Similar results have also been reported by Khan *et al.*, (1990) who found reduction in nitrogen and NRA in sorghum under saline conditions. The nitrogen in the medium is available in the form of NO_3 whose uptake is reduced under saline environments (Keltjens & VanUlden, 1987; Khan *et al.*, 1990). The NRA is an inducible enzyme and its activity depends upon the availability of substrate *i.e.* NO_3. The negative effect of salt on NRA can therefore be explained as a reduced nitrate supply to plant, which is very clear from the present study and as a result lower total N contents were observed in plants under saline conditions. The findings of Schrader *et al.* (1967) and Khan *et al.* (1990) showed that NRA in the cytoplasm is protected against the adverse effect of salinity and this gives support to the explanation of the reduction in total nitrogen. Wyn-Jones (1981) found that salt within the plant cell are compartmentalized into vacuole, again indicating that they may not have direct effect on NR activity or synthesis. Positive correlations were observed between biomass and NRA.

From the above results it can be concluded that wheat varieties with higher NAR, N, P, and K^+ and lower Na^+ are tolerant ones. The study also showed that primitive wheat varieties have more salt tolerance potential than modern one, however, other results showed (unpublished data) that the primitive varieties had more number of tillers, biomass but with low grain yield. So they can be used in the breeding programme to develop salt tolerant and high yielding varieties.

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