PHYSIOLOGICAL RESPONSE OF WHEAT (*Triticum aesitivum* L.) VARIETIES AS INFLUENCED BY SALINITY STRESS

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ABSTRACT

Response of seven wheat (*Triticum aesitivum* L.) varieties; Lu-26, Inqilab-91, Bakhtawar, Parwaz-93, Pak-81, Pasban-90 and Potohar-1 was determined under NaCl salinity in glasshouse. The plans were exposed to 100 mol m^{-3} NaCl and its effect on physiological parameters relating to salinity tolerance like; relative growth rate, chlorophyll contents, proline accumulation, Na^+, K^+ uptake and their fluxes was recorded. The relative salinity tolerance of the wheat varieties was determined on the basis of their survival percentage in 400 mol m^{-3} NaCl. The survival percentage was greater of LU-26 (85%) followed by Punjab-85 (65%) and Inqalab-91 (55%). The survival of other varieties was between 25-40 %. K: Na and, Chlorophyll contents were greater in Lu-26, followed by Punjab-85 and Inqalab-91. The same varieties showed greater fluxes of K^+ and lesser of Na^+. Based on the survival percentage and physiological data the wheat variety Lu-26, performed best followed by Inqalab-91 and Punjab-85 were also found better under saline conditions. Bakhtawar, Potohar, Parwaz, Pasban, and Pak-81 were relatively salt sensitive and showed less survival, relative growth rate and higher uptake of sodium under NaCl salinity. Physiological parameters like low fluxes of Na^+ and high of K^+, high shoot K:Na and chlorophyll contents were found to be useful parameters related to salinity tolerance of wheat.

Keywords: Salinity, wheat, sodium and potassium uptake, K: Na, chlorophyll, proline.

INTRODUCTION

Salinity is one of the major problem for both irrigated and rainfed agriculture. Over 6% of world's land area and 20% of the world's irrigated land are currently affected by salinity (Munns, 2002). Wheat is the most important grain crop grown, giving about one third of the total annual cereal production world-wide. In Pakistan, wheat is cultivated on total area of about 7 mha and within the area of irrigated wheat production, about 1.2 mha are affected by salinisation/ sodicity causing annual losses of 2-3 million ton of grain (Qayyum and Malik, 1988). Due to this alarming situation development of wheat cultivars that could produce substantial yield under such adverse conditions deserve the highest priority.

The growth response to salinity is often regarded as a useful basis of evaluation for resistance (Weimberg and Shannon, 1988). In wheat, in first step salinity reduces the growth due to the osmotic effect of salt and then accumulation of excess ions causes injury and hence reduces the supply of assimilates to the growing regions (Munns, 1993). Thus uptake and transport of low Na^+ and maintenance of high K/Na in the leaves or shoot is associated with salt resistance of wheat and some other species (Shah *et al.,* 1987, Poustini and Siosemardeh**,** 2004, Hussain and Munns, 2005.). During osmotic adjustment, many plants accumulate proline in response to salt stress widely believed to function as a protector against salt damage (Wang *et al.,* 2007).

To improve the salt tolerance of wheat various approaches like introduction of new salt tolerant gene, screening of large germplasm/cultivars collection, conventional breeding and non-conventional crossing with wheat relatives have been used. The ultimate aim is to exploit variation in salt tolerance within wheat and its progenitors or close relatives to produce new wheat with more tolerance than modern wheat cultivars. In a large number of international wheat collection successes have been made in finding tolerant wheat lines/cultivars (Colmer *et al.,* 2005). Physiological approach based on the mechanisms of salt tolerance by using physiological traits to select germplasm with low sodium uptake or with high selectivity for K over Na have successfully contributed in selecting for salt tolerance (Shah *et al.,* 1987). In wheat there is large genetic variation for salt tolerance at critical stages in the cultivated gene pool (Royo and Abio, 2003), and identifying genotypes that are tolerant to saline and/or sodic subsoils is a practical and relatively simple way of improving crop yield and profitability on these difficult soils. The aim of the present study was to investigate variation in salinity tolerance of some widely grown wheat varieties on the basis of physiological responses like plant growth, ion uptake, K: Na ratio and accumulation of proline.

MATERIALS AND METHODS

Seven wheat varieties, LU-26, Punjab-85, Inqilab-91, Bakhtawar, Pasban-90, Parwaz-93, Pak-81, and Potohar-1 were used in the study. Wheat variety, LU-26 relatively a salt resistant and Pak-81 a salt sensitive to salinity were used as check.

The experiment was conducted in a glasshouse under controlled environment (temperature between 25º to 35±3ºC). Seeds of seven wheat varieties were grown in plastic tubs of 20 kg capacity filled with sterilized plastic beads and 10 liters aerated Hoaglands solution. The solution was renewed once a week. Each cultivar was replicated three times in separate tubs having 12 plants per replicate. Ten-day-old plants were treated with salinity at 100 mol m^{-3} NaCl in 25 mol m^{-3} daily increments until the final concentration was reached. Three days after completion of salinity, recently matured leaf of 10 plants of each cultivar were analyzed for sodium (Na^+), potassium (K^+) Chlorophyll and proline concentration. The Na^+, K^+ and Chlorophyll concentration were determined on a leaf dry weight basis as described by Yeo *et al*., (1990). Proline was determined by method of Bates *et al.,* (1973). The Na^+, K^+ fluxes and relative growth rate (RGR) was calculated by sequential harvests of six plants at 5 days after salinisation (DAS) and at 25 DAS. The shoots were washed with distilled water several times to ensure that no salt was present on the exterior of the plant, dried at 80 °C for 48 h and Na^+, K^+ contents were determined as described above. Roots of each plant were separated and dry weight was recorded. The fluxes of sodium (J_{Na}) and potassium (J_K) were calculated on a root dry weight basis and expressed as µmol g^{-1} root dry weight day^{-1} (Pitman, 1975).

$$J = \frac{(M_2 - M_1)}{W_R (T_2 - T_1)}$$

$$W_R = \frac{(W_2 - W_1)}{\log_e (\frac{W_2}{W_1})};$$

M_1 and M_2 are total ion contents: viz. content per unit dry weight × dry weight.

W_2 and W_1 are root dry weights at T_2 and T_1 and M_1 and M_2 are the total ion contents at times T_1 and T_2. W_R is an average weight of root or shoot between these harvests.

The RGR which reflect the growth potential under the conditions imposed was determined according to the formula of West *et al.,* (1920).

$$RGR = \frac{InW_2-InW_1}{T_2-T_1}$$

W_2 and W_1 are dry weights at the first and second harvests, respectively; T_2-T_1 is the time interval in days between those harvests and In is the natural log.

The relative salinity resistance of the above wheat varieties was determined on the basis of their survival percentage in 400 mol m^{-3} NaCl by raising the salinity of the rest of plants growing in NaCl salinity (100 mol m^{-3}) to 400 mol m^{-3}. Survival percentage was calculated by subtracting the number of dead plants from the total number of plants divided by the total number of plants and multiplied by 100.

RESULTS AND DISCUSSION

Check tolerant cultivar LU-26 was used as a quantification of genotypic performance to salinity stress. The varieties used in the study showed significant differences for survival under high salinity (Fig. 1). The survival percentage of the wheat varieties observed was in the order of LU-26 > Punjab-85 > Inqalab-91> Bakhtawar≥ Parwaz> Pasban ≥Pak-81. Generally, survival or visual assessment of salt damage is the criterion for overall measurement of plant performance and these characteristics are normally chosen on their better correlation with overall performance. This assessment criterion is used in field for evaluation of salinity damage during mass screening of rice and wheat (Yeo *et al.,* 1990; Poustini, 2002). In this study survival percentage was used as a quantification of genotypic performance under salinity stress. Based on the survival percentage in saline medium, the wheat cultivar LU-26 was found tolerant having highest survival (above 80 %) under salinity (Fig. 1). Other wheat varieties Punjab-85 and Inqalab-91 also showed better survival (above 50 %) than rest of the varieties used in the study (Fig. 1). The wheat variety LU-26 is a well known salt tolerant variety and in wheat salinity evaluation experiments, it is used as a tolerant check (Qureshi *et al.,* 1980).

The K:Na and, Chlorophyll contents recorded in the leaf of tested wheat varieties was greater in Lu-26, followed by Punjab-85 and Inqalab-91 (Table.1). Data of K^+ and Na^+ fluxes is presented in Fig. 2. Greater fluxes of K and less of Na were observed for relatively tolerant wheat varieties (LU-26, Punjab-85 and Inqalab-91) and vice versa of Pasban and Pak-81. In monocots salinity tolerance is associated with the ability of plant to exclude Na^+ and maintain high K/Na in shoot tissues (Tester and Davenport, 2003; Poustini and Siosemardeh, 2004). In present study, the leaf K:Na ratio, showed differences in the wheat cultivars used and those having higher leaf K:Na were LU-26, followed by Punjab-85 and Inqalab-91 which had also shown high survival. The same tolerant varieties also showed greater fluxes of K and less of Na. In wheat genotypic variation in Na^+ and K^+ uptake has already been reported (Munns, 2007; Husain and Munns, 2005). Enhanced leaf K/Na ratio and greater fluxes of K and less of Na are the factors determining salt tolerance in wheat (Mahar *et al.,* 2003; Poustini and Siosemardeh, 2004; Munns, 2007). The gene kna1 that controls enhanced K/Na discrimination is located on the long arm of the 4 D chromosome (Shah *et al.,* 1987) and has been shown to operate at all salt concentrations. Hussain and Munns, (2005) reported that in wheat genotypes the trait of low leaf Na^+ and K/Na discrimination could be used to increase the salt tolerance of current wheat varieties.

Decrease in chlorophyll contents results in reduction of photosynthesis under salt stress (Delfine *et al.,* 1999) and chlorophyll contents could be used as an index of salt tolerance for selection of crop plants tolerance against salinity stress. The chlorophyll contents measured in leaf after salinization was greater in the tolerant varieties; LU-26, Punjab-85 and Inqalab-91 as compared to the sensitive Pothar and Pak-81 (Table 1). In wheat, the low Na^+ uptake genotype showed greater chlorophyll retention than the high Na^+ uptake genotype. Highest relative growth rate of the wheat cultivars LU-26 and Inqalab-91 was recorded under salinity (Fig. 3). The relative growth rates of other varieties were variable. Kingsbury *et al.,* (1984), also found less suppression in the RGR of tolerant wheat lines under salinity stress. Proline contents were increased with salinity but did not correlate with the salinity tolerance (Table.1). Salt stress increased the concentrations of proline in tolerant and sensitive wheat varieties but there was considerable variation in the amount of proline observed among the wheat varieties in response to salinity.

The data demonstrate that wheat cultivars having greater leaf K:Na, K ion flux, and growth under saline conditions could lead their high survival. The additional aspects of less chlorophyll damage under such condition are a potential of resistant cultivars and could be used as an index of salt tolerance for selection of wheat tolerance against salinity stress. It also demonstrates that high biomass of wheat seedlings under NaCl salinity could be used as a criterion for screening wheat genotypes against salinity stress

Fig. 1. Survival percentage of wheat varieties under NaCl (400 mol m^{-3}) salinity. Each bar represents the mean value of 24 plants with standard error of mean.

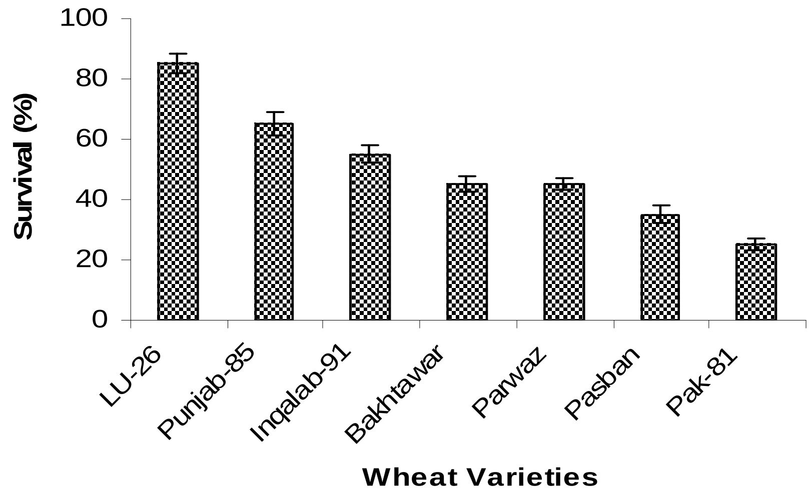

Fig. 2. Average fluxes (µ mol g^{-1} dwt day^{-1}) of Na (J_{Na}) and K (J_K) in wheat varieties, during the growth stage 5-20 days at 100 mol m^{-3} NaCl salinity.

Fig. 3. Relative Growth Rate (mg mg^{-1} day^{-1}) of wheat varieties growth in 100 mol m^{-3} NaCl salinity, during the growth stage 5-20 days after salinization. Each bar represents the standard error mean.

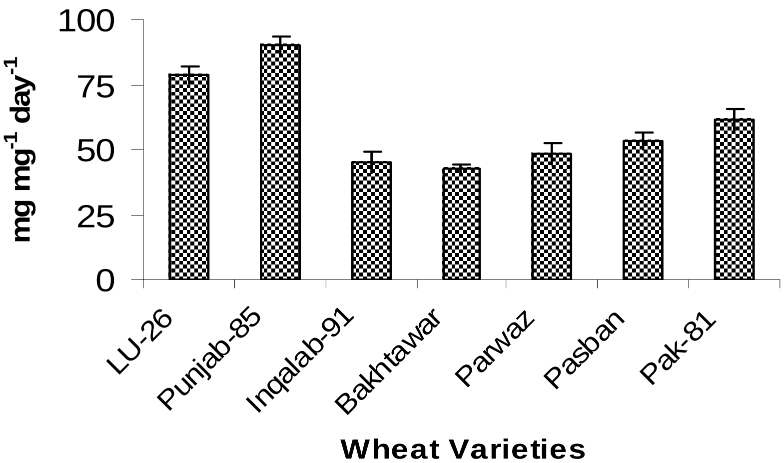

Table 1. Mean sodium, potassium concentration, chlorophyll and proline concentration (mg g^{-1} dry weight) in leaf of wheat varieties under 100 mol m^{-3} NaCl salinity.

Varieties	Na^+	K^+	K : Na	Chlorophyll	Proline
LU-26	0.70±0.02	2.22±0.13	3.19±0.22	2.72±0.03	100±6.4
Punjab-85	0.84±0.01	1.68±0.05	2.00±0.08	1.61±0.11	80±4.1
Inqalab-91	0.87±0.03	1.77±0.06	2.04±0.13	1.35±0.06	155±6.4
Bakhtawar	0.77±0.02	1.12±0.03	1.45±0.08	1.46±0.02	160±10.1
Parwaz	1.43±0.04	1.08±0.01	0.75±0.03	1.65±0.04	117±4.5
Pasban	1.17±0.03	1.78±0.04	1.52±0.07	1.47±0.04	240±5.8
Pak-81	1.17±0.03	1.72±0.05	1.47±0.07	1.22±0.07	245±8.7

± represent standard error mean.

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