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COMPARATIVE PERFORMANCE OF SOME WHEAT GENOTYPES GROWING UNDER SALINE WATER

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Abstract

Salt tolerance of sixteen wheat genotypes was studied using gravel culture technique in lysimeters. One week old wheat seedlings were exposed to salinity created with NaCl. Four salinity levels, i.e. control (1.5 dS m^{-1}), low saline (6.0 dS m^{-1}), medium saline (9.0 dS m^{-1}) and highly saline (12.0 dS m^{-1}) and three replications were maintained. Irrigation was applied as and when required with $1/4^{th}$ Hoagland nutrient solution of respective concentrations. Salinity level of each treatment was regularly monitored and maintained through out the growing period. Yield and yield components were recorded at the time of crop maturity. On the basis of less than 50% reduction in different growth variables, five genotypes viz. LU-26s, HT-45, ESW-9525, V-8319, Sarsabz were found tolerant, whereas Bhittai. Marvi, Chakwal-86, DS-17, Sussi (SD-66), Zardana were found medium tolerant, SD1200/51, Khirman, V-7012 medium sensitive and RWM-9313, SH-43 sensitive. Tolerant wheat genotypes were successful in maintaining low Na and high K uptake and high K/Na ratio.

Keywords: screening, gravel culture, salt tolerance, K/Na ratio

Introduction

High soil salinity is one of the important environmental factors that limit distribution and productivity of major crops (Ashraf *et al.,* 2005; Chandan *et al.,* 2006). Agricultural productivity in arid and semiarid regions of the world is very low that is due to accumulation of salts in soils (Gorham, 1995; Shannon, 1998; Ashraf *et al.,* 2002; Munns, 2002). Saline medium causes many adverse effects on plant growth by creating osmotic stress, ion toxicity and nutritional imbalance or a combination of these factors (Ashraf, 1994; Marschner, 1995; Ashraf, 2004). All these factors adversely affect the plant growth, physiological and biochemical metabolism (Ashraf & Sarwar, 2002; Munns, 2002; Munns & James, 2003).

Wheat is the major cereal crop of Pakistan, which is grown all over the country. It is grown to meet the food demand of ever growing population of Pakistan. But per hectare yield of wheat is far below than its yield potential, which may be due to the different reason i.e. lack of proper water and nutrient managements, unavailability of fertile soils, salinity, water logging and drought. In Pakistan salinity is a serious threat for wheat production. The most of underground water utilized for wheat cropping is brackish, however, some areas are irrigated with canal water but having lack of drainage system and both the irrigation systems are increasing the soil salinity problem. Due to which heavy losses in crop yield are reported. Pakistan spends a large amount of its foreign exchange in importing the wheat to fulfill the food demands of its rapidly expanding population. In addition to soil degradation in many parts of the world, there are less new lands available for cultivation, which can be used as arable land are of poor quality which

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cannot provide good economic returns. An important aspect of this, particularly in countries of arid and semi-arid regions, is gainful utilization of these saline areas. To achieve optimal food production in saline regions, the most appropriate and logical choice is growing salt tolerant crops/cultivars the best suited for these regions (Khan & Abdullah, 2003). Therefore, a study was conducted in gravel culture under control conditions to assess the salt tolerance of some wheat genotypes.

Material and Methods

To examine the salt tolerance potential in wheat genotypes an experiment was conducted in lysimeters, filled with gravels. The growing media was irrigated by 1/4th strength Hoagland solution, salinized by commercial NaCl salt to attain three salinity levels (i.e. control (1.5), 6.0, 9.0 and 12.0 dS m^{-1}). Sixteen wheat genotypes (LU-26S, Sussi (SD-66), SD-1200/51, Bhittai, Marvi (SD-4), Khirman, RWM-9313, HT-45, ESW-9525, V-7012, Zardana, SH-43, Chakwal, DS-17, V-8319 and Sarsabz) obtained from Mutation Breeding Division of Nuclear Institute of Agriculture, Tandojam Pakistan were sown in a randomized manner with three replicates. The genotype LU-26S was included as a check. Plants were allowed to grow upto maturity. At physiological maturity flag leaves of the plants were collected for chemical analysis. Yield and yield components were recorded after harvesting the plant at maturity. The reduction at highest salinity level over control as 50 % reduction was calculated to compare the salt tolerance potential in different wheat genotypes. Plant samples (flag leaf) were oven dried at 65±5^{o}C and dried ground material was extracted with 0.1 M acetic acid as describe by Ansari & Flowers, (1986) and Na and K concentrations in the aliquot were determined through flame photometer (PFP 7, Jenway, UK). The data collected were statistically analyzed (Steel & Torrie, 1980)

Results

The growth observations recoded at maturity showed that there was liner decrease in all the growth parameters with increasing salinity of the medium. The grain yield of different wheat genotypes recorded at highest salinity levels (i.e. 12dS m^{-1}) was ranged from 1.5 to 2.4 g $plant^{-1}$. The genotype ESW-9525 showed minimum reduction (36.0%) in grain yield, when compared with control. Maximum reduction over control was recorded in RWM-9313 (66.67%). The other genotypes showing < 50% reduction in grain weight $plant^{-1}$ as compared to LU-26s (38.24%), However, Sarsabz (41.18%) and HT-45 (41.67%) were very close check LU-26S in grain yield reduction (Table 1). The genotype ESW-9525 performed better than that of salinity check variety (LU26S).

The comparison regarding growth, yield and yield components of different wheat genotypes (Table 2) clearly indicated that genotypes LU-26S, HT-45, ESW-9525 and Sarsabz maintained all the 8 recorded parameter more than 50 % over control at highest salinity level (12 dS m^{-1}). Wheat genotypes Sussi(DS-66), Bhittai, Marvi, Chakwal and DS-17 maintained 7 out of 8 growth and yield components more than 50 % while Zardana was successful in maintaining 6 out of 8; V-7012, DS-1200/51 and Khirma 5 out of 8 and RWM-9313 maintained 4 out of 8 above mentioned parameters. The poorest performance was noted in case of SH-43 which maintained only 3 out of 8 parameters more than 50 % at highest salinity level (Table 2).

There was an increase in sodium uptake with increasing salinity. The better performing genotypes had comparatively less sodium uptake than the sensitive ones.

Table 1. Yield performance (g plant^{-1}) of different wheat genotypes as affected by (NaCl) salinity.

Genotypes	A Control 1 dS m^{-1}	B 6 dS m^{-1}	C* Red (%)	D 9 dS m^{-1}	E* Red (%)	F 12 dS m^{-1}	G* Red (%)
LU-26S	3.4	3.0	11.76	2.6	23.53	2.1	38.24
Sussi (SD-66)	4.5	3.6	20.00	3.0	33.3	2.4	46.7
SD-1200/51	4.8	3.9	18.75	2.7	43.75	2.4	50.00
Bhittai	4.2	3.0	28.57	2.7	35.71	2.1	50.00
Marvi (SD-4)	4.5	3.9	13.33	3.0	33.33	2.1	53.33
Khirman	4.2	3.6	14.29	2.7	35.71	2.1	50.00
RWM-9313	5.4	3.9	27.78	3.0	44.44	1.8	16.67
HT-45	3.6	3.0	16.67	2.4	33.33	2.1	41.67
ESW-9525	3.3	2.7	18.18	2.1	36.36	2.1	36.36
V-7012	5.1	3.9	23.53	3.0	41.18	2.4	52.94
Zardana	3.6	3.6	0.00	2.7	25.00	2.1	41.67
SH-43	3.3	2.1	36.36	1.8	45.45	1.5	54.55
Chakwal	2.7	2.1	22.22	1.8	33.33	1.5	44.44
DS-17	2.7	2.4	11.11	1.8	33.33	1.5	44.44
V-8319	3.9	3.3	15.38	2.4	38.46	2.1	46.15
Sarsabz	3.4	3.0	11.76	2.7	20.60	2.4	41.18
LSD for treatments ($P \geq 0.05$)		0.337					
LSD for varieties ($P \geq 0.05$)		0.645					

Where, C* Reduction (%) = (A-B/A) x 100, E* Reduction (%) = (A-D/A) x 100, G* Reduction (%) = (A-F/A) x 100

However all the better performing genotypes (ESW-9525, Sarsabz, HT-45, S-24), had more sodium uptake than the Check genotype (LU-26S) but had less Na^+ than all genotypes (Table 3). The highest Na^+ uptake was recorded in DS-17 which was closely followed by Zardana, Sussi (SD-66), SD-1200/51, V-7012, SH-43 and Khrishma while the others form the medium group regading Na^+ uptake.

The trend for K^+ was reverse to that of sodium it decreased with the increase in salinity (table 3). Minimum reduction in K^+ uptake at highest level of salinity was noted in wheat genotype HT-45 (13.5 %) followed by SD-1200/51 (15 %), RWM- 9313 and SH-43 (20 %), V-7012 (21.43 %), DS-17 (22.45 %) while others had higher reduction in K^+ uptake over control but all the wheat genotypes maintained reduction in K^+ less than 50 %. The increasing uptake of sodium resulted in a decrease of K/Na ratio in the plant leaves. The check genotype (LU-26S) had maintained the maximum K/Na ratio (1.88) and minimum reduction over control (79.55). The better performing genotypes (Sarsabz, S-24, HT-45, and ESW-9525) showed 84.31, 85.35, 85.40 and 85.78, respectively.

Discussion

Genetic variation for salt tolerance, as defined by parameters such as growth and yield, has been reported in many crop species (Flowers *et al.*, 2000; Ashraf *et al.*, 2002).

Table 2. Wheat genotypic performance calculated on the basis of less than 50 % reduction in growth, yield and yield components under saline conditions.

Genotypes	Biomass	Plant height	Productive tillers	Spike length	Spikelet	No. of grains	Grain weight $plant^{-1}$	1000-grain weight	No of variables having < 50 % reduction	
LU-26S	+	+	+	+	+	+	+	+	8	T
Sussi (SD-66)	-	+	+	+	+	+	+	+	7	MT
SD-1200/51	-	+	+	+	+	+	-	-	5	MS
Bhittai	+	+	+	+	+	+	-	+	7	MT
Marvi (SD-4)	+	+	+	+	+	+	-	+	7	MT
Khirman	-	+	+	+	+	+	-	-	5	MS
RWM-9313	-	+	+	+	+	-	-	-	4	S
HT-45	+	+	+	+	+	+	+	+	8	T
ESW-9525	+	+	+	+	+	+	+	+	8	T
V-7012	-	+	+	+	-	+	-	+	5	MS
Zardana	-	+	-	+	+	+	+	+	6	MT
SH-43	-	+	-	-	+	-	-	+	3	S
Chakwal	-	+	+	+	+	+	+	+	7	MT
DS-17	-	+	+	+	+	+	+	+	7	MT
V-8319	+	+	+	+	+	+	+	+	8	T
Sarsabz	+	+	+	+	+	+	+	+	8	T

Note: **+** = Less than 50 % reduction over control, - = More than 50 % reduction over control
T = Tolerant MT = Medium tolerant MS = Medium sensitive ; S = Sensitive

Therefore, it is necessary to find genetic variation in different plant species, which is useful for the breeding programs for salt tolerance in different crops (Ashraf *et al.*, 1999). In the present study salinity induced marked reduction in plant growth and yield of all the wheat genotypes. The reduction in growth may either be due to the reduction in cell size or to inhibition of the mitotic activity (Ashraf *et al.*, 2002). Salinity also reduced both these attributes inhibiting water uptake due to osmotic potential of stress created due to the excessive salt concentration in the growth medium (Ashraf *et al.*, 2005). The main cause of growth inhibition in NaCl induced plants is the difficulty in uptake of mineral nutrients due to competition with Na^+ (Ashraf & Sarwar, 2002). In present study wheat genotypes ESW-9525, LU-26S, Sarsabz, HT-45, performed better than other and successful in maintaining minimum reduction in yield i.e. 36.36, 38.24, 41.18 and 41.67 % over control at the highest salinity level (12 dS m^{-1}). These genotypes also showed good performance for other growth and yield parameters (Table 2). The better performance of these genotypes may due the maintenance of better K/Na ratio under saline conditions. Similar results were reported by Khan & Ashraf (1988) for sorghum Ashraf & Sarwar (2002) for Brassica and Sarwar & Ashraf (2003) for wheat.

The sensitivity of some crops (Flowers & Hjibagheri, 2001) to salinity has been attributed to the inability to keep Na^+ and Cl^- out of the transpiration stream. Plants limiting the uptake of toxic ions, or maintaining normal nutrient ion contents, could show

Table 3. Leaf sodium (Na), potassium (K) content and K/Na ratio in different wheat genotypes under normal and saline conditions.

Genotypes	Leaf Na^+ content (%)			Leaf K^+ content %			K/Na ratio		
	Control	12 dS m^{-1}	Increase (%)	Control	2 dS m^{-1}	Decrease (%)	Control	12dS m^{-1}	Decrease (%)
LU-26S	0.24	0.80	70.0	2.20	1.50	46.67	9.17	1.88	79.55
Sussi (SD-66)	0.17	2.90	94.14	2.55	1.60	37.25	15.00	0.55	96.32
SD-1200/51	0.14	2.20	93.64	2.00	1.70	15.00	14.29	0.77	94.59
Bhittai	0.20	1.50	86.67	2.60	1.80	30.77	13.00	1.20	90.77
Marvi (SD-4)	0.20	1.40	85.71	1.98	1.30	34.34	9.90	0.93	90.62
Khirman	0.14	1.40	90.00	2.30	1.30	43.48	16.43	0.93	94.35
RWM-9313	0.10	1.30	92.31	2.00	1.60	20.00	20.00	1.23	93.85
HT-45	0.23	1.40	83.57	1.85	1.60	13.50	11.56	0.84	85.40
ESW-9525	0.16	0.90	82.22	2.25	1.80	25.00	17.31	0.90	85.78
V-7012	0.18	2.80	93.57	2.10	1.65	21.43	11.67	0.59	94.95
Zardana	0.13	2.50	94.80	2.00	1.40	30.00	15.38	0.56	96.36
SH-43	0.17	2.20	92.27	2.00	1.60	20.00	11.76	0.73	93.82
Chakwal	0.13	1.20	89.17	2.50	1.50	40.00	19.23	1.25	93.50
DS-17	0.09	2.80	96.79	2.45	1.90	22.45	27.22	0.68	97.51
V-8319	0.19	1.3	85.38	2.55	1.80	41.68	11.59	0.65	89.72
Sarsabz	0.40	1.90	78.95	2.55	1.80	41.68	18.21	1.00	84.31
LSD (P≥0.05)									
Treatments		0.238			0.523			2.345	
Varieties		0.425			0.638			4.672	

Note: Decrease or increase (%) = (Value of control plant -value of treated/value of control) x 100

greater tolerance; uptake mechanisms that discriminate between similar ions such as Na^+ and K^+, could be useful selection traits; and breeding for efficient nutrient uptake or low ion accumulation could be a simple way to improve salt tolerance. Selection within varieties or lines with low Na^+ transport has been accomplished in rice (Yeo *et al.*, 1988), while intra-varietal variation for Na^+ uptake and yield in saline conditions has been found in wheat (Khanzada *et al.*, 1993), and low Na^+ lines of sorghum have been selected (Khan & Ashraf, 1988). It is evident from the present results that all sixteen cultivars clearly show differing responses to high salt concentrations with respect to nutrient assimilation (unpublished data). Sodium (Na^+) accumulation increased with increasing salt stress in all the wheat genotypes. However, all the wheat genotypes accumulated more sodium (Table 3) than that of check variety (LU-26S). Sodium (Na^+) does not play any important role in plants and its high concentration is toxic for many enzymatic activities of plants (Maathuis & Amtmann, 1999). LU-26S, Sarsabz, ESW-9525, HT-45, can be called as salt tolerant cultivar due to low Na^+ accumulation in the leaves. The increase in tissue Na^+ due to salinity can be explained by the fact that Na^+-ATPases do not exist in plants (Garciadeblas *et al*., 2001). The presence of high amount of Na^+ in the growth medium favours the influx of Na^+ but retards its efflux. The efflux of Na^+ against its electrochemical potential gradient is an energy demanding process, which is restricted due to the absence of Na^+-ATPases, thus increasing the accumulation of Na^+ under saline conditions.

Decreasing trend was observed in K^+ accumulation due to salinity stress in the present study with wheat. The decrease in K^+ contents was due to the presence of excessive Na^+ in growth medium because high external Na^+ content is known to have an antagonistic effect on K^+ uptake in plants (Jeschke, 1984; Khan & Aslam, 1992; Sarwar & Ashraf, 2003). It is also reported that salt tolerance is associated with higher K^+ contents (Khan & Ashraf, 1988; Ashraf & Sarwar, 2002) because of involvement in osmotic regulation and competitive effect with Na^+ (Ashraf *et al.*, 2005). However, salt tolerance is not simply a matter of ion avoidance or accumulation, rather a regulation of ions induces osmotic adjustment to avoid imbalance in tissues leading to further disturbances in plant metabolism. In the present study extent of genetic variation for salt tolerance was found in different wheat genotypes (Table 3). From literature (Khanzada *et al.*, 1993; Ashraf & Sarwar, 2002) it is evident that most of the crops with higher K^+ and lower Na^+ in the tissues produced higher biomass and were thus tolerant to salinity. A positive correlation was found between tissue K^+ and growth and a negative relationship between growth and Na^+. So this characteristic can be used to develop salt tolerant varieties of different crops. In contrast, there are few reports that show otherwise relationships among these attributes. For example, Isla *et al*. (1997) showed that ion content should not be used to screen for salt tolerance in barley and sorghum (Khan & Ashraf, 1988), mungbean (Ashraf & Naqvi, 1996). However, durum wheat, which lacks the D genome of bread wheat, tends to accumulate more Na^+ and less K^+ than bread wheat under salinity stress. The trait for K^+/Na^+ discrimination affects transport of K^+ and Na^+ to the shoots, with little effect on root ion concentration or anion concentration in the leaves, and the main site of action is thought to be at xylem loading in the roots (Gorham *et al.*, 1990). It acts at all salt concentrations, but is most apparent below 100 mol m^{-3} NaCl. At higher concentrations other mechanisms controlling ion accumulation appear to be more important. This trait has been used in attempts to confer enhanced salt tolerance in wheat.

It was concluded that on the basis of less than 50% reduction in different growth variables, five genotypes viz. LU26S, HT-45, ESW-9525 and Sarsabz can be categorized as salt tolerant genotypes. It can also be concluded that genotypes with higher K/Na ratio were more salt tolerance than those with low K/Na ratio.

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