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Differential Yield Responses of Barley Genotypes to NaCl Salinity

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ABSTRACT

Different responses were exhibited by three different barley i.e., 268/2, 237/4 and Jow 87 at four levels of NaCl root zone salinity *viz*, control (2.5), 10, 15 and 20 dSm^{-1}. Experiment was conducted in pots in Botanical Garden University of Agriculture Faisalabad by developing salinity in @ of 2 dSm^{-1} per day. It was reported that salinity caused reduction in all the yield components of the barley genotypes such as spike length, number of spikelets per spike, fertile tillers per plant, biomass per plant, grain yield and 100 grain weight. Least reduction for the components was noted in the 268/2 genotype even at 20 dSm^{-1} while Jow-87 displayed maximum reduction for these parameters.

Key Words: Salinity tolerance; Barley genotypes; Yield components; NaCl salinity

INTRODUCTION

Plant growth is adversely affected by root zone salinity (Sharma, 1995) but salt sensitivity of plants changes considerably during the development stages (Akram *et al.*, 2002; Wilson *et al.*, 2000). Reproductive growth of crop plants exhibits more tolerance than the germination and vegetative growth (Francois *et al.*, 1988). Developmental shifts in relative salt tolerance also vary according to the genotypes. Salinity tolerance is crucially important at reproductive stage of the plant growth (Francois & Kleiman, 1990). Salinity disturbed starch sugar balance and ultimately reduced the grain yield of barley (Gill, 1979). Salinity induces a marked reduction in spike and leaf development (Maas & Grieve, 1990), tillering capacity, spike length, number of spikelets and kernels per spike in wheat (Grieve *et al.*, 1992; Akram *et al.*, 2002). It is widely recognized that soil salinity associated with excess NaCl adversely affects the plant growth and yield of plant by depressing the uptake of water and metabolism (Ashraf *et al.*, 1998; Akhtar *et al.*, 2001). Barley is considered a salt tolerant glycophyte crop. Present experiment was set to investigate yield responses of three barley genotypes under different levels of salinity and to study their comparative behavior in terms of different yield components to different salinity levels.

MATERIALS AND METHODS

The seeds of three barley genotypes (*Hordeum vulgare* L.) i-e., 268/2 (tolerant), 237/4 (medium tolerant) and jow-87 (sensitive) (Javed *et al.*, 2001) were obtained from germplasm bank of the Department of Botany University, of Agriculture, Faisalabad. The plants were raised in 30 cm earthen pots filled with 10 kg of loam soil (ECe = 2.5 dSm^{-1}). The pots were lined with double layer of good quality polyethylene sheet to restrict the seepage of soil solution. Three uniform seedlings were maintained per pot. The pots were kept in an open field under natural light. Four levels of salinity *i.e.* 2.5 (control), 10, 15 and 20 dSm^{-1} were developed based on the field capacity of soil. Original ECe of the soil was accounted for while developing salt levels. Plants were allowed to grow in normal soil to reproductive stage and then NaCl solution was applied @ 2 dSm^{-1} per day, until the final levels were achieved. The pots were irrigated with tap water (ECe = 0.8 dSm^{-1}) to maintain the soil moisture up to the field capacity. At maturity spike length, number of spikelets per spike, number of grains per spikelet, 100-grain weight, number of fertile tillers per plant, biomass per plant and yield per plant were determined. Treatments in this factorial experiment were arranged in Completely Randomized Design with three replicates.

RESULTS

Spike length. All the genotypes showed significant ($P<0.01$) differences for spike length as affected by increased levels of salinity, with a non-significant ($P>0.01$) interaction of genotypes and salinity level (Table I). Applied salinity caused a substantial reduction in spike length of all the genotypes but the reduction was the lowest in the tolerant 268/2 followed by 237/4 and Jow-87, respectively.

Number of spikelets per spike. Significant ($P<0.01$) difference was noted among the genotypes for the number of spikelets/spike under increased root zone salinity, and a significant ($P<0.01$) interaction of both the factors (Table I). Reduction was noted in number of spikelets/spike in all genotypes due to salinity but the effect was most prominent in Jow-87. Effect of salinity on number of spikelets was comparable in tolerant 268/2 and medium responsive 237/4 but it was worst in the sensitive genotype i.e. Jow-87.

100-grains weight. A significant (P<0.01) difference in 100-grains weight of all the genotypes noted under increased salinity levels (Table I). But the interaction of both the factors was found to be non-significant. Increased root zone salinity reduced the 100-grains weight of the genotypes but the maximum reduction was noted in the sensitive one Jow-87.

Grain yield per plant. Increase salinity induced significant (P<0.01) differences for grain yield per plant in all the three Barley genotypes (Table I). No interaction was noted between the two factors. Applied salinity caused a significant reduction in grain yield in all the three genotypes, but this effect was more pronounced in sensitive genotype Jow-87. Less decrease in grain yield per plant was noted in genotype 268/2 followed by 237/4 under salinized rhiosphere.

Fertile tillers per plant. A significant (P<0.01) reduction in the numbers of fertile tillers per plant was noted under increased levels of salinity in all the three barley genotypes. Interaction was also significant (p<0.01) for the two factors i.e genotypes and salinity. At all levels of salinity 268/2 genotype responded better for this parameter followed by 237/4 while genotype Jow-87 responded poorly even at the 10 dSm^{-1} salinity level.

Biomass per plant. All the barley genotypes showed significant (P<0.01) differences for the biomass per plant under increased levels of salinity i.e. 10, 15, 20 dSm^{-1} including controls. The interaction between genotypes and salinity levels was found non-significant. Salinity adversely affected biomass per plant but the most severely affected genotype was Jow-87 while, 268/2 and 237/4 were less affected under the increased salinity levels.

DISCUSSION

Yield parameters *i.e*. spike length, number of spikelets per spike, number of grains per spikelet, 100-grains weight and yield per plant showed a reduction with increase in root zone salinization but the effect was varied in different barley genotypes (Table I). It was noted that terminal spikelets appeared earlier under salt stress, and the number of spikelets primordial was reduced which was more pronounced in sensitive Jow-87 as compared with tolerant 268/2 followed by 237/4. Salinity stress tended to shorten the duration of spikelet differentiation, resulting in fewer spikelets per spike. These results are supported by the findings of several workers (Maas & Grieve, 1990; Grieve *et al.,* 1993; Francois *et al.*, 1994) who conclude that salinity significantly decreased the number of spikelet primordial on the main spike. The florets in the basal spikelets appear to be significantly less viable than those in the apical spikelets under saline conditions (Grieve *et al*., 1992). A reduction in floret viability seriously affects the total number of kernels per spike (Francois *et al*., 1994). Our results are in conformity with above finding that number of grains per spikelet decreased with increased in salinity and this effect was more pronounced in sensitive genotype Jow-87. NaCl stressed barley genotypes during vegetative stage, had a shorter spikelet development stage, which resulted in fewer spikelets per spike (Maas & Grieve, 1990), thus reducing the number of grains per spike. Genotype 268/2 followed by 237/4 gave significantly higher 100-grain weight than sensitive genotype Jow-87 even at 20 dSm^{-1}. Grain weight is largely determined by the duration and rate of grain filling (Kirby, 1974; Wardlaw *et al.*, 1980). Therefore,

Table I. Statistical analysis (mean square) of yield parameters under NaCl salinity

S.O.V	d.f.	Spike length	Number of spikelets per plant	Fertile tillers per plant	Biomass per plant	Grain yield per plant	100-grain weight
Genotypes (G)	2	38.67**	127.24**	4.52**	74.42**	28.66**	1.77**
Salinity levels (dSm^{-1}) (T)	3	124.13**	694.53**	42.54**	350.13**	114.33**	8.30*
G x T	6	1.21ns	9.80**	0.400*	4.63ns	2.72ns	0.141ns
Error	24	0.83	2.66	0.11	2.25	1.28	0.261
Comparison of means							
G1xT0		17.64ns	37.56a	7.67a	26.43ns	15.66ns	3.24ns
G1xT1		15.04ns	30.22c	6.00c	22.01ns	13.78ns	2.55ns
G1xT2		12.41ns	22.78de	3.03fg	19.32ns	11.70ns	2.00ns
G1xT3		10.31ns	19.14fg	3.18f	13.03ns	9.55ns	1.31ns
G2xT0		16.97ns	35.99ab	6.88b	25.66ns	15.99ns	3.18ns
G2xT1		14.18ns	24.33d	4.61d	20.16ns	12.61ns	2.04ns
G2xT2		11.27ns	20.02ef	2.97fg	16.87ns	10.53ns	1.72ns
G2xT3		8.71ns	16.39g	2.21hi	11.93ns	7.47ns	1.01ns
G3xT0		15.40ns	34.33b	6.83b	24.72ns	14.99ns	3.09ns
G3xT1		12.24ns	20.21ef	4.00e	17.16ns	10.81ns	1.62ns
G3xT2		8.02ns	18.71fg	2.51gh	12.02ns	8.50ns	1.00ns
G3xT3		5.63ns	10.40h	1.72i	7.40ns	4.24ns	.035ns

**Significant at P< 0.01 and ns = non significant environmental stresses that tend to shorten the grain filling period will significantly reduce final grain weight (Maas & Grieve, 1990). Salt stress accelerates maturation and grain filling in some cereal crops (Francois *et al.*, 1986, 1988). Therefore, nearly consistent reduction in grain weight at the higher salinity levels could be result of shortened grain filling period as reported by Francois *et al*. (1994). In nutshell increase in salinity decreased grain yield per plant in all the three genotypes. At 20 dSm^{-1} maximum grain yield was produced by 268/2 followed by 237/4, while lowest grain yield was exhibited by sensitive genotype-Jow-87. Effect of salinity was most pronounced on the yield components, which were developing at the time of salt stress. Consequently, salinity deprived their contribution to grain yield. These results are supported by the work of Francois *et al.* (1994) who stated that yield components which were stressed by salinity during their development contributed less to grain yield.

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