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Impact of NaCl Salinity on Yield Components of some Wheat Accessions/Varieties

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ABSTRACT

A study was undertaken to investigate the effects of increased levels of NaCl salinity (2.5, 10, 15, 20 dS m^{-1}) on some yield components and their correlation with some growth parameters of salt tolerant (234/2), medium responsive (243/1) and sensitive (Fsd-83) accessions/varieties (Acc/Var) of wheat (*Triticum aestivum* L.). Salinity levels were developed stepwise. Salinity reduced spike length, number of spikelets per spike, number of grains per spikelet, 100-grain weight and grain yield per plant. The extent of reduction varied greatly with tolerance and salinity levels. The reduction entailed adverse effect on 100-grain weight and grain yield per plant. Significant correlation ($P<0.01$) was found between shoot dry weight, leaf area and transpiration rate and the grain yield.

Key Words: Wheat; Salinity; Salt tolerance; Yield components

INTRODUCTION

Increased soil salinity as a noxious environmental factor affects all the aspects of plant growth and development. Salt affected soils generally have very low productivity because of dominance of the soluble salts (salinity) and/or exchangeable Na^+ ions.

Salinity tolerance is very important at reproductive stage of plant growth (Francois & Kleiman, 1990). Plant height at maturity declines linearly while quantity of grain decreases non-linearly with increasing root zone salinity (Steppuhn & Wall, 1997). Maas and Grieve (1990) observed reduction of spikelet and kernel number per spike under the influence of root zone salinity.

Grieve *et al.* (1992) found a reduction in tillering capacity, spike length, number of spikelets and kernels per spike of moderately salt stressed wheat, but suggested that increase in number of kernels per spikelet lead to grain yield enhancement. Likewise, a considerable reduction in absolute and derived parameters was recorded in sunflower under saline conditions (Wahid *et al.*, 1999). In salt affected areas, where germination or tillering capacity is reduced, crop yield can be increased by increasing planting density (Grieve *et al.*, 1992; Wahid *et al.*, 1999). It is widely recognized that soil salinity associated with excess NaCl adversely affects the growth and yield of plants by depressing the uptake of water and minerals and normal metabolism (Muhammad *et al.*, 1987; Lea-Cox & Syversten, 1993; Song & Fujiyama, 1996; Ashraf *et al.*, 1998; Akhtar *et al.,* 2001). The excess salts reduce plant growth primarily because these increase the utilization of energy that the plant must use to acquire water from the soil and to make biochemical adjustments. This energy is diverted from processes that lead to growth and yield (Yeo, 1983). Salinity also decreases the number of leaves produced by main stem, spike length, number of spikelet per spike and number of kernels per spike in wheat (Maas & Grieve, 1990).

The present study was undertaken to investigate the comparative effects of different salinity levels on yield components and their correlation with growth parameters of some tolerant and sensitive accessions/varieties of wheat.

MATERIALS AND METHODS

Twenty wheat Accessions/Varieties (Acc/Var) were obtained from gene bank of department of Botany, University of Agriculture, Faisalabad and rigorously screened for tolerance to salinity at seedling, tillering and grain filling stages of growth. Out of these Acc/Var 234/2, 243/1 and Fsd-83 with EC_{50} of 17.95, 16.91 and 11.07 dS m^{-1}, respectively, were selected for the present study as tolerant, moderately responsive and sensitive to salinity.

Experimental and growth conditions. Seedlings of the above mentioned Acc/Var were sown in 25 cm earthen pots filled with 10 kg of soil and each pot had ten seeds of each Acc/Var. The pots were lined with double layer of good quality polythene to restrict seepage of soil solution and were kept in net house under sunlight. The seedlings of uniform size were thinned to five per pot. Four levels of salinity (2.5, 10, 15 and 20 dS m^{-1} along with control) of the soil were developed. Salt levels were developed by a daily increment of 2 dS m^{-1} until the final levels were achieved. The pots were frequently irrigated with tap water (ECe 0.8 dS m^{-1}).

Yield parameters. Shoot and root lengths, shoot and root dry weights, leaf area per plant and number of tillers were recorded at booting stage for measuring correlation between these parameters and grain yield. Dry weight was taken after drying the samples at 80ºC for 72 h. At maturity spike length, number of spikelets per spike, grains per spikelet, 100-grains weight and yield per plant were determined.

RESULTS

Spike length. All the Acc/Var showed significant (P<0.01) differences for spike length as affected by increased levels of salinity, with a significant (P<0.01) interaction of Acc/Var and salinity levels (Table I). Applied salinity caused a substantial reduction in spike length of all the Acc/Var but the reduction was the lowest in the tolerant 234/2 followed by 243/1 and the sensitive Fsd-83.

Number of spikelets per spike. A significant (P<0.01) difference was noted among the Acc/Var for the number of spikelets per spike under increased root zone salinity along with a significant (P<0.01) interaction of both the factors (Table I). There was a reduction in number of spikelets per spike in all the Acc/Var due to salinity but the effect was most prominent in Fsd-83. More saline with the growth medium with increased salinity level fewer were the number of spikelets per spike. Effect of salinity on number of spikelets was comparable in both the tolerant (234/2) and medium responsive (243/1) Acc but it was worst affected in sensitive Var Fsd-83.

Number of grains per spikelet. Number of grain per spikelet differed significantly (P<0.01) in all the three Acc/Var with the increase of root zone salinization (Table I). The interaction of Acc/Var x salinity was also significant (P<0.01). Applied salinity lowered the number of grains per spikelet in all Acc/Var but a sharp decrease was evident in sensitive variety Fsd-83. The tolerant (234/2) and medium responsive (243/1) Acc behaved almost similarly for this parameter.

100-grains weight. A significant (P<0.01) difference in 100-grains weight of all the Acc/Var was noted under increased salinity levels (Table I). The interaction of both these factor was also found to be significant (P<0.01). Increased root zone salinity reduced the 100-grains weight of the Acc/Var but the maximum reduction was noted in the sensitive one Fsd-83.

Grain yield per plant. Increased salinity induced significant (P<0.01) differences for grain yields per plant in all the three wheat Acc/Var (Table I). Salinity x variety interaction was also significant (P<0.01). Applied salinity caused a significant reduction in grain yield in all the three Acc/Var, but this effect was more pronounced in sensitive Var Fsd-83 while less decrease was noted in Acc 234/2 followed by 243/1.

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 wheat Acc/Var (Table I). It was noted that terminal spikelets appeared earlier under salt stress, and the number of spikelets primordia was reduced which was more pronounced in sensitive Fsd-83 as compared with tolerant 234/2 followed by 243/1. 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 concluded that salinity significantly decreased the number of spikelet primordia 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

Table I. Some yield parameters of three wheat Acc/Var grown under increased salinity

Acc/Var	Salinity levels dSm^{-1}	Yield parameters				
		Spike length (cm)	Number of spikelet per spike	Number of grain per spikelet	100 grain weight (g)	Yield per plant (g)
234/2	Control	16.12	19.03	2.58	3.82	5.71
	10	15.03	18.37	2.34	3.63	5.03
	15	14.62	16.88	2.24	3.05	4.22
	20	14.04	15.65	2.02	2.43	2.24
243/1	Control	16.42	20.49	2.61	3.93	5.43
	10	15.30	18.77	2.44	3.47	4.62
	15	14.45	17.39	2.13	2.93	4.02
	20	13.22	15.29	1.91	2.30	2.00
Fsd 83	Control	14.88	18.80	2.62	4.47	6.61
	10	13.20	14.18	1.50	2.53	3.84
	15	12.30	12.60	0.78	1.90	1.42
	20	9.08	10.01	0.60	1.70	0.94
Summary of significance of variance sources (F-ratio)						
S.O.V.	d.f					
Salinity (S)	3	804.73**	440.12**	597.70**	651.40**	16.97**
Acc/Var (A)	2	60.70**	42.05**	49.90**	92.50**	45.63**
S × A	6	79.91**	95.02**	70.30**	6.70**	56.18**

** Significant at P<0.01

Table II. Correlation coefficient (r) of grain yield with some growth and photosynthetic parameters of wheat Acc/Var

Parameters	Control	20 dS m^{-1}
Shoot length (cm)	-0.9030^{NS}	0.9959^{NS}
Shoot dry weight (g)	-0.3321^{NS}	0.9995**
Root length (cm)	0.7219^{NS}	0.9900^{NS}
Root dry weight (g)	0.9920^{NS}	0.9804^{NS}
Leaf area (cm^2)	-0.9693^{NS}	0.9999**
Number of tillers	0.8007^{NS}	0.9874^{NS}
Rate of photosynthesis	-0.9937^{NS}	0.9718^{NS}
Rate of transpiration	-0.9997**	0.9999**
Stomatal conductance	0.6836^{NS}	0.9848^{NS}

** = Significant at 1% level of significance

conformity with above finding that number of grain per spikelet decreased with increase in salinity and this effect was more pronounced in sensitive Var Fsd-83. NaCl stressed wheat during apex 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.

Accessions 234/2 followed by 243/1 gave significantly higher 100-grain weight than sensitive Var. Fsd-83 even at 20 dS m^1. Grain weight is largely determined by the duration and rate of grain filling (Kirby, 1974; Wardlaw *et al.,* 1980). Therefore, 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).

Increase in salinity decreased grain yield per plant in all the three Acc/Var. At 20 dS m^1 maximum grain yield was produced by Acc234/2 followed by 243/1, while lowest grain yield was exhibited by sensitive Var Fsd-83. 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.

The reduction in grain yield in wheat Acc/Var under salt stress conditions can be explained by assessing relationship of growth and photosynthetic parameters with grain yield at control and 20 dS m^1 (Table II). It was observed that shoot dry weight, leaf area and rate of transpiration showed significant ($P<0.05$) correlation with grain yield under highest level of salinity (20 dS m^1).

CONCLUSIONS

Greater leaf area, greater dry weight of shoot and higher rate of photosynthesis can be used as markers in wheat for greater grain yield under salinity are. It is logical that leaf area determines the photosynthetic ability of plant which ultimately contributes in grain filling. On the other hand greater shoot dry weight which is conditioned with greater tillering helps in dilution of toxic ions and reduction of their transport to the photosynthetically active parts.

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