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COMPARATIVE PERFORMANCE OF DIFFERENT WHEAT VARIETIES UNDER SALINITY AND WATERLOGGING. I. GROWTH PARAMETERS

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Present study was undertaken to find out the wheat variety suitable for the areas affected with the dual stress of salinity and hypoxia. Matrix culture techniques were used to simulate the field conditions. Growth parameters like shoot fresh weight and total biomass were affected adversely by both the stresses while root fresh weight was increased with hypoxia and decreased with salinity stress. Among the cvs. Blue Silver, Chinese Spring, LU 26S, Pato and 7-Cerros, the cv. Blue Silver showed the least reduction in different growth parameters compared with the others.

INTRODUCTION

Many parts of the world are facing the associated problem of salinity and waterlogging (hypoxia). It has been estimated that salinity decreases crop production on one third of the world's irrigated land i.e. 40 m ha (Maas and Hoffman, 1977). In Pakistan, 5.7 mha are salt affected and 1.8 mha are permanently waterlogged. In low-lying moderately salt-affected rice lands (0.85 mha) as well as lands with saline-sodic and sodic patches (1.2 mha), the major effects occur through the dispersed soil structure which result in poor penetration of roots, air and water (Qureshi, 1986).

The salt-affected soils particularly with heavy texture and deteriorated structure affect wheat growth adversely at the time of first irrigation because of hypoxic conditions induced by temporary flooding. Wheat varieties selected for salt tolerance do not perform well when exposed to double stress of salinity and hypoxia. The present study was conducted to find out a wheat variety tolerant to the combined effects of salinity and hypoxia.

MATERIALS AND METHODS

The experiment was conducted in plastic pots filled with a mixture of gravel, composte and vermiculite in the ratio of 2:1:1, respectively on volume basis. This medium was selected to achieve uniform conditions of salinity and at the same time to retain toxins produced by anaerobic respiration near the root surface as bubbling N_2 gas through hydroponic culture will dislodge them from the root surface. These toxins act as stimulators or inhibitors for certain adaptations to anaerobic conditions.

Seeds of wheat cultivars Blue Silver, Chinese Spring, LU 26S, 7-Cerros and Pato were soaked in running water for overnight and sprouted seeds were sown in the pots. A solution containing $Ca(NO_3)_2$ (2mM) and $MgSO_4$ (1mM) was sprinkled daily (500 mL pot^{-1}) until appearance of first leaf. After that modified Phostrogen nutrient solution (Phostrogen Limited, Corwen, Clwyed, UK) alongwith micronutrients (Hoagland and Arnon, 1950) was sprinkled for two days. On the following day, salinity was increased @ 25 mM NaCl + 2.5 mM $CaCl_2$ daily in the saline treatments till the highest salinity level (150 mM NaCl and 15 mM $CaCl_2$) was achieved. The medium was saturated with the respective solution and then drained immediately. Hypoxic conditions were created one day after the required salinity level was achieved by allowing the solution to remain in the root zone.

fortnightly and then weekly after bubbling excess amount of N_2 gas through the solutions.

Plants were harvested after a stress period of four weeks and fresh weights of shoot and root were recorded. Calculations were made for shoot to root ratio, total biomass produced and data were analysed statistically by applying ANOVA technique and DMR test (Steel and Torrie, 1980) following CRD with three replications.

Table 1. Effect of salinity x hypoxia interactions on fresh weight of shoot ($g\ p^{-1}$) in wheat varieties (average of 3 replications)

Variety	Control	Hypoxic	Saline*	Saline hypoxic*	Average
Blue Silver	7.55 bc	8.01 bc (106.1)	3.28 def (43.4)	2.45 efgh (32.5)	5.32 B
Chinese Spring	8.72 b	4.18 d (47.9)	3.07 defg (35.2)	1.40 gh (16.1)	4.35 C
LU 26S	11.88 a	6.87 c (57.8)	3.54 de (29.8)	2.26 efgh (19.0)	6.14 A
7-Cerros	7.92 bc	4.41 d (55.8)	2.40 efgh (30.3)	1.19 h (15.0)	3.98 C
Pato	4.75 d	3.28 def (69.1)	1.67 fgh (35.2)	0.91 h (19.2)	2.65 D
Average	8.16 A	5.35 B (65.2)	2.79 C (34.2)	1.64 D (20.1)	

*NaCl 150 mol m^{-3} + $CaCl_2$ 15 mol m^{-3}.
Values in parenthesis indicate per cent of control.
Means with different letters differ significantly at $P = 0.05$.

Saline and non-saline solutions were applied to the respective aerobic treatments and drained immediately. For hypoxia treatments, solutions were replaced initially

RESULTS AND DISCUSSION

Hypoxia decreased fresh weight of shoot in all the varieties significantly except

Blue Silver (Table 1). Salinity was more injurious to growth compared with hypoxia and significantly reduced the growth of all the wheat varieties. Combined effects of salinity and hypoxia were even more serious but non-additive as reduction in fresh weight of shoot due to hypoxia and salinity was 34.8% and 65.8%, respectively while combined effects of salinity and hypoxia reduced fresh weight of shoot by only 79.9%.

additive in case of Blue Silver but non-additive in case of Pato. This might be due to a small increase in the fresh weight of shoot at non-saline hypoxic compared with non-saline-aerobic treatment. In case of Chinese Spring, both the salinity and hypoxia individually decreased the fresh weight of shoot significantly while the combined effects of salinity and hypoxia on the fresh weight of shoot were negative but non-additive. Reduction in fresh weight due to hypoxia was 52.1% and salinity gave a reduction of 64.8% but their combined effect induced only 83.9% reduction in fresh weight of shoot (Table 1).

Table 2. Effect of salinity x hypoxia interactions on total biomass {fresh weight of shoot + root (g p^{-1})} in wheat varieties (average of 3 replications)

Variety	Control	Hypoxic	Saline*	Saline hypoxic*	Average
Blue Silver	8.82 bc	9.90 b (112.2)	3.76 e-i (42.6)	3.43 e-j (38.9)	6.48 A
Chinese Spring	9.45 b	6.94 cd (73.4)	3.42 e-j (36.2)	1.87 hij (19.8)	5.42 B
LU 26S	12.89 a	8.65 bc (67.1)	3.94 e-h (30.6)	3.17 f-j (24.6)	7.16 A
7-Cerros	8.55 bc	5.32 def (62.2)	2.71 g-j (31.7)	1.63 ij (19.1)	4.55 B
Pato	5.65 de	4.20 efg (74.3)	1.91 hij (33.8))	1.23 j (21.8)	3.25 C
Average	9.07 A	7.00 B (77.2)	3.15 C (34.8)	2.66 C (29.3)	

*NaCl 150 mol m^{-3} + $CaCl_2$ 15 mol m^{-3}.
Values in parenthesis indicate per cent of control.
Means with different letters differ significantly at P = 0.05.

Blue Silver and Pato suffered significant reduction in fresh weight of shoot under saline treatment while effect of hypoxia at both salinity and control was non-significant. Combined effects of salinity and hypoxia on fresh weight of shoot was super-

Table 3. Effect of salinity x hypoxia interactions on fresh weight of root (g p^{-1}) in wheat varieties (average of 3 replications)

Variety	Control	Hypoxic	Saline*	Saline hypoxic*	Average
Blue Silver	1.27 b	1.89 a	0.48 e-h	0.98 bcd	1.15 A
Chinese Spring	0.74 d-g	0.79 c-f	0.34 fgh	0.46 e-h	0.58 B
LU 26S	1.01 bcd	1.79 a	0.40 fgh	0.91 b-e	1.03 A
7-Cerros	0.63 d-g	1.24 bc	0.31 gh	0.45 e-h	0.66 B
Pato	0.90 b-e	0.92 b-e	0.24 h	0.32 fgh	0.60 B
Average	0.91 B	1.33 A	0.35 D	0.63	

*NaCl 150 mol m^{-3} + $CaCl_2$ 15 mol m^{-3}.
Means with different letters differ significantly at P = 0.05.

Hypoxia reduced growth of LU 26S significantly under non-saline conditions but non-significantly under saline conditions. Salinity reduced the fresh weight of shoot significantly whereas hypoxia had no adverse effect on growth. The combined effect of salinity and hypoxia was again non-additive.

Pato, an exotic cultivar, gave the poorest performance both under normal and stress conditions. Salinity had severe effect on its shoot growth, causing a reduction of 64.8%, hypoxia gave a reduction of 30.9% while their combination reduced yield by 80.8% which indicted that the reduction due to the two stress factors was non-additive.

Comparison of varieties revealed that Blue Silver was the most tolerant to salinity and hypoxia with the highest relative shoot weight (% of control) under hypoxia (106.1), salinity (43.4) and combined saline hypoxia (32.5) conditions. John *et al.* (1977), Trought and Drew (1980) and Barrett-Lennard (1986 and 1988) also reported similar results.

Salinity decreased total biomass significantly but the effect of hypoxia was non-significant in case of cvs. Blue Silver, Chinese Spring and Pato (Table 2). Pato produced significantly less total biomass under salinity stress but the combined effects were even more injurious although statistically not different from that with salinity alone.

Root growth was generally reduced under saline conditions but was enhanced under hypoxic conditions (Table 3). This might be due to the development of new adventitious roots under hypoxic conditions. Visual observations indicated that root length decreased under hypoxic conditions but their number and diameter increased (data not shown). Chinese Spring and 7-Cerros indicated a non-significant reduction in fresh weight of root due to salinity. In the case of cvs. Blue Silver, LU 26S and 7-Cerros maximum fresh weight of root was observed under non-saline-hypoxic condition which was significantly higher than all other treatments. Saline-aerobic treatment produced the least fresh weight of root. Saline conditions decreased the fresh weight of root significantly in LU 26S while waterlogging increased the root growth.

Table 4. Effect of salinity x hypoxia interactions on shoot:root ratio in wheat varieties (average of 3 replications)

Variety	Control	Hypoxic	Saline*	Saline hypoxic*	Average
Blue Silver	6.95 c-g	4.23 efg	7.24 c-f	2.52 g	5.23^{NS}
Chinese Spring	8.53 b-e	5.31 d-g	9.85 abc	3.05 fg	6.69
LU 26S	11.97 ab	3.76 fg	9.05 bcd	2.50 g	6.82
7-Cerros	13.36 a	3.54 fg	8.44 b-e	2.72 fg	7.02
Pato	5.92 c-g	3.57 fg	7.16 c-f	2.77 fg	4.86
Average	9.35 A	4.08 B	8.35 A	2.71 B	

*NaCl 150 mol m^{-3} + $CaCl_2$ 15 mol m^{-3}.
Means with different letters differ significantly at P = 0.05.

Hypoxia decreased the shoot to root ratio significantly both under the saline and non-saline conditions (Table 4). The trend was similar in all the varieties except Blue Silver, Chinese Spring and Pato in which non-saline treatments showed non-significant differences in shoot to root ratio. The reason might be that the varieties sensitive to hypoxia could not adapt to this stress. So these varieties tried to produce more number of roots at the expense of shoot to cope with such adverse conditions and ultimately the shoot to root ratio decreased.

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