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GROWTH PHYSIOLOGY OF SORDAN GRASS (*SORGHUM BICOLOR* X *SORGHUM SUDANESE*) UNDER SALINE CONDITIONS

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A hydroponic study was conducted in the wire house to evaluate the physiological behaviour of sordan grass to NaCl salinity. Seedlings of sordan grass were exposed upto 17 days to four levels of NaCl salinity developed in Hoagland nutrient solution. Coefficient of relative inhibition indicated more than 50% growth reduction at 100 mol m^{-3} NaCl and onwards. Increasing level of salinity reduced plant fresh weight, dry weight, leaf area, relative growth rate and net assimilation rate. Concentration of Na^+, Cl^- and proline in the sordan grass leaf increased while those of K^+ and Mg^{++} decreased with increasing salinity level. Salinity also decreased the leaf water potential, osmotic potential and turgor pressure. Relationships between growth parameters, osmotic adjustment and water balance in leaves are discussed.

INTRODUCTION

Salinity is inimical to plant growth through numereous complex interactions including specific toxic effects, osmotic effects and/or induced nutrient deficiency (Wyn Jones, 1981). Plants exposed to saline environment may overcome these problems through physiological tolerance involving compartmentation and osmotic adjustment using organic and inorganic solutes (Flowers *et al.*, 1977) and acquisition of mineral elements needed for growth and functional metabolism, particularly the uptake of K^+ in case of NaCl salinity (Jeschke, 1984). In the present study, the seedlings of sordan grass (*Sorghum bicolor X S. sudanese*), a new introduction from U.S.A., were subjected to NaCl stress to evaluate its salinity tolerance, osmotic adjustment and water relations.

MATERIALS AND METHODS

A hydroponic study was conducted in the wire house of the department of Crop Physiology, University of Agriculture, Faisalabad, during 1988. Seedlings of sordan grass were exposed upto 17 days to four levels (0, 50, 100, 150 mol m^{-3}) of NaCl salinity developed in Hoagland nutrient solution (Hoagland and Arnon, 1950). The experiment was laid out in completely randomized design with four repeats. The experimental set–up and the techniques used were generally similar to Qureshi *et al.* (1990). Plant fresh weight, dry weight and leaf area were measured after 17 days of plant growth at maximum stress and for this purpose randomly selected 6 plants from each repeat were harvested. Leaf area was measured with leaf area meter (LI–COR, 3000, USA). Net assimilation rate (NAR), relative growth rate (RGR), and coefficient of relative inhibition (CRI) were calculated using formulae described by Radford (1967) and Mercado (1973). Two harvests at an interval of 7 days were made for calculations of growth rates. Osmotic pressure and various organic and inorganic solutes were determined from the cell sap of the uppermost, fully expanded leaves. The methods of sap extraction and osmotic determinations were generally as described by Gorham *et al.* (1984). Inorganic ions (Na^+, K^+, Ca^{++} and Mg^{++}) were measured by flame emission in a PFP I Flame Photometer and Pye Unicam Atomic Absorption Spectrophotometer. Chloride was determined using Corning Chloride Analyser–925. Proline was determined by the method of Bate *et al.* (1973). Leaf water potential was measured with water potential apparatus (Chas W. Cook and Sons, Birmingham, B 42 ITT, England) following the method described by Scholander *et al.* (1964). Turgor pressure was calculated as difference of water potential and osmotic potential. The data collected were statistically analysed according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

Plant growth: Growth of sordan grass was severely depressed by NaCl salinity and the increase in salinity was accompanied by a corresponding decrease in plant fresh weight, dry weight,fresh weight:dry weight ratio, leaf area and relative growth rate (Table 1). The values of coefficient of relative inhibition indicated that more than 50% growth inhibition occurred between 100 and 150 mol m^{-3} NaCl salinity. The growth inhibition might be attributed to NaCl induced changes in the physiology of plant via effects on mineral contents and water relations (Kuper, 1984), increased level of growth inhibitors, completely neutralizing the presence of growth promoting substances (Khan et al., 1976), increased respiration and utilization of large amounts of assimilates in respiration maintenance (Schwerz and Gale, 1983). Net assimilation rate remained unaffected with salinity.

Plant water relations: The sordan grass plants exposed to salinity stress exhibited greatly disturbed water relations (Table 2). Leaf water and osmotic potentials decreased with increasing levels of salt, in compliance with the fundamental requirement of the plant to maintain its water status (see Wyn Jones et al.,1984). Adequate turgor pressure, comparable to control plants was maintained at low salinity level (50 mol m^{-3} NaCl) followed by a substantial decrease at 100 and 150 mol m^{-3} NaCl level. The latter effect could be attributed to inhibited water uptake by plants in the presence of NaCl(Wainwright, 1980).

Solute concentration of leaves: Ionic composition of the sordan grass

Table 1. Growth of sordan grass as affected by different levels of NaCl salinity

Salinity level (mol m^{-3})	Fresh weight (— g $plant^{-1}$ —)	Dry weight (— g $plant^{-1}$ —)	Fresh weight Dry weight ratio	Leaf area $plant^{-1}$ (cm^2)	Relative growth rate ($g\ g^{-1}\ day^{-1}$)	Net assimilation rate ($mg\ cm^{-2}\ day^{-1}$)	Coefficient of relative inhibition
Control	33.94 a+	4.03 a	8.11 a	204.71 a	0.183 a	2.45	
50	25.74 b	3.34 b	7.79 a	168.87 b	0.173 a	2.60	0.286 c
100	11.50 c	1.68 c	6.88 b	60.13 c	0.129 b	2.94	0.502 b
150	5.14 d	0.78 d	6.46 c	29.04 d	0.082 c	2.78	0.694 a
Significance	**	**	**	**	**	NS	**

NS, *, ** Non significant, significant at the 5% and 1% levels, respectively.
+ Mean seperation within coloumns by Duncan's Multiple Range test, 5% level.

Table 2. Effect of NaCl salinity on Leaf water relations and solute accumulation in sordan grass

Salinity level (mol m^{-3})	Leaf water Potential (–bars)	Leaf osmotic potential (–bars)	Leaf turgor pressure (bars)	Na^+	K^+	Cl^-	Ca^{++}	Mg^{++}	Proline (ug mL^{-1})
				(———mol m^{-3}				———)	
Control	2.32 d+	8.16 d	5.85 a	5.5 d	120.1 a	14.90 d	5.07	6.28 a	11.63 c
50	3.71 c	9.54 c	5.83 a	22.3 c	100.8 b	33.15 c	4.29	5.03 b	14.84 b
100	5.72 b	11.43 b	5.71 b	98.1 b	67.6 c	104.67 b	4.12	3.71 c	14.70 b
150	13.02 a	18.63 a	5.61 c	250.6 a	58.5 d	208.58 a	4.33	3.83 c	28.47 a
Significance	**	**	**	**	**	**	NS	**	**

NS, *, ** Non significant, significant at the 5% and 1% levels, respectively.
+ Mean seperation within columns by Duncan's Multiple Range test, 5% level.

Table 3. **Relationship between water relations, solute contents and growth parameters of sordan grass under NaCl salinity**

	Water Potential	Osmotic Potential	Turgor Pressure	Na^+	K^+	Cl^-	Proline
	correlation coefficient						
(1) Growth Parameters							
Fresh weight	0.8480*	0.8460*	0.8301*	–0.8754*	0.9616*	–0.9089*	–0.7725*
Dry weight	0.8818*	0.8796*	0.8637*	–0.9162*	0.9561*	–0.9380*	–0.8137*
Leaf area	0.8579*	0.8549*	0.8724*	–0.8964*	0.9743*	–0.9271*	–0.7705*
Relative growth rate	0.9192*	0.9108*	0.8825*	–0.9431*	0.8730*	–0.9482*	–0.8651*
Net assimilation	$0.4367^{N.S.}$	$0.4369^{N.S.}$	$0.3648^{N.S}$	$-0.4169^{N.S}$	$0.1020^{N.S}$	$-0.3328^{N.S}$	–0.5118*
(2) Water Relations							
Water potential				0.9875*	0.8340*	–0.9779*	–0.9744*
Osmotic potential				–0.9865*	0.8298*	–0.9771*	–0.9757*
Turgor pressure				–0.9134*	0.8928*	–0.9887*	–0.8175*

*Significant relationship at 5% probability level.

N.S = Non–significant.

was highly altered when grown under NaCl salinity (Table 2). Increase in salinity from 50 to 150 mol m^{-3} NaCl had severe depressive effect on K^+ and Mg^{++} concentration of leaves with concomitant accumulation of large amounts of Na^+ and Cl^- while Ca^{++} contents remained unchanged. Leaf free proline contents significantly increased with increasing salinity. At 50 and 100 mol m^{-3} NaCl level, the proline contents were statistically similar. The highest proline contents were recorded in leaves of plants stressed with 150 mol m^{-3} NaCl and could be attributed to restricted utilization of proline in oxidation and protein synthesis (Bull and Stewart, 1983).

Relationships between various parameters of growth, solute concentrations and plant water relations are shown in Table 3. Water relation parameters (water potential, osmotic potential and turgor pressure) were positively correlated with all growth parameters. The NAR, however, showed relatively week relationship with these parameters. Leaf Cl^-, Na^+ and free proline contents also showed a significant but negative correlation toward plant growth and water relation parameters, which means that as the concentration of these ions in leaves increased, the plant growth and water potential decreased. K^+ exhibited significantly positive relationship with plant growth and water relations and the increased growth and higher values of water potential were observed with large amount of K^+ in leaves. The positive effect of K^+ accumulation in leaves indicates its role in osmotic adjustment.

From the results of this study it is obvious that sordan grass resisted to NaCl salinity upto only 50 mol m^{-3} and the higher salinity levels (100 mol m^{-3} and 150 mol m^{-3} NaCl) disturbed the physiology of this crop either through accumulation of toxic ions (Na^+ , Cl^-) or reduced water potential.

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