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COMPARATIVE SALT TOLERANCE STUDIES ON DIFFERENT PLANT SPECIES (*SESBANIA AEGYPTICA, SESBANIA ACULEATA, ELUSINE CORACANA, SORGHUM BICOLOR* AND *SORGHUM SODANESE*)

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Comparative salt tolerance and cell sap composition for Na, K, Ca and Cl of 4 plant species *Sesbania aegyptica, S. aculeata, Elusine coracana, Sorghum bicolor* and *S. sodanese* was studied using different salinity levels of control, EC 5, 10, 15 and 20 dS m. Results indicate that fresh and dry weights of shoots decreased with increasing salinity. A 50% reduction in the whole plant biomass was observed in dhancha at a much higher salinity level as compared to other plant species. Sodium and chloride concentrations in leaf sap of four plant species increased with increase in salinity while K and Ca decreased significantly.

Key words: Salt tolerance, Cell sap composition for Na, K, Ca and Cl.

Introduction

The problem of soil salinity is enormous in the arid and semi arid regions of Pakistan which hamper the crop production very seriously. According to an estimate about 5.6 million hectares of the agricultural land in the most important and productive part of Pakistan i.e. the Indus plain, is affected by salinity to varying degrees [1]. The problem of salinity is complicated further by sodicity resulting from high sodium and low calcium percentage on the soil exchange complex. Approximately 80% of the salt affected area in the Punjab and 50% in the whole Pakistan is saline sodic [2]. For the reclamation of saline and saline sodic soils different chemical and biological methods have been tried with some amplification [3]. As cultivation of salt tolerant crop is basic to the biological approach of soil reclamation, there is need to select crops with higher salt tolerance as large difference in salt tolerance occur between crop species.

The work reported here deals with the comparative salt tolerance of janter (*Sesbania aegyptica*) and dhancha (*Sesbania aculeata)* with maddal (*Elusine coracana*) and sordan (*Sorghum bicolor* and *Sorghum sodanese*) the last being the recently introduced salt tolerant hybrid.

Materials and Methods

The experiment was conducted in the green house and laboratories of the Soil Science Department, University of Agriculture, Faisalabad. Plastic coated metal trays (60x30x5 cm) were used for raising nursery of dhancha, janter, sordan and maddal crops using canal water for irrigation. After 3-4 days of the emergence, the plants were transplanted in plastic containers (20 litre capacity having aerated 1/2 Hoagland and Arnon solution [4]).

Seedlings were held in place with the help of foam in the holes of thermopal sheets floating on the solution . The following salinity levels control, EC 5, 10, 15 and 20 dSm were achieved finally in respective tubs in step wise manner. Salinity was produced by adding NaCl in 15 litre canal water in a plastic tub. Seedlings of janter, dhancha, maddal and sordan were transplanted in each tub. Nutrient solution was changed regularly after every 3-4 days. The crops were harvested one month after the final salinity levels were achieved. Leaf samples were collected before harvesting the crop for the determination of Na, K, Ca and Cl from cell sap. Experimental data were analysed statistically using Duncan's Multiple range test [5]).

Results and Discussion

Effect of salinity on fresh weight. Fresh weight of shoot decreased significantly with increase in salinity (Table 1). Ayers [6] claimed that reduction in fresh weight was due to excessive absorption of salts and their accumulation in the free space that led to stunted growth.

To find out the salinity tolerance limit of the species, salinity value was calculated by the 2 formulae (given below) that was expected to cause a 50% reduction in shoot fresh weight.

$Y=a+b\ (x)$ (linear regression equation) ---------- (1)

$Y=100-b\ (EC-A)$ (Maas and Hoffman [7]) ---------- (2)

Dhancha which seems to have relatively higher salt tolerance gerenally, produced lower shoot fresh weight than maddal which may thus be more economical to grow, but 50% reduction in yield calculated for dhancha crop was at a much higher salinity level than other plant species.

Effect of salinity on dry weight. Dry weight of shoot decreased significantly with rise in the salinity level (Table 2). At the maximum salinity of 20 dSm maximum decrease in dry

weight was observed. Sandhu *et al.* [8] concluded that the fresh and dry weights of *Diplachne fusca* decreased with increasing salinity of the rooting medium.

A 50% reduction in yield was given by the two formulae (mentioned earlier) took place in dhancha followed by janter at much higher salinity level than in sordan and maddal.

Effect of salinity on Na^+ concentration. Sodium concentration in leaves of four plant species increased significantly with increasing salinity (Table 3). The increase in the Na^+ concentration was related to the increasing concentration of NaCl in the rooting medium, which ultimately resulted in the increase uptake of sodium ions. In sordan grass it was maximum (179.7 m mol kg) followed by maddal (166.9m mol Kg) and dhancha (164.7m mol kg) but statistically the differences among these species were non significant. However janter had statistically the lowest concentration of Na^+ in the leaf cell sap.

The increase in Na^+ was more at 20 dS m compared with control. Similar conclusions about the increase in sodium concentration in plant due to salinity were drawn by Bower and Wadleigh [9], and Francois *et al.* [10].

Effect of salinity on K^+ concentration. Increase in salinity significantly decreased the potassium concentration with increase in Na^+ levels of the growth medium due to the antagonistic effect of sodium (Table 4). The results regarding the decrease in potassium concentrations influenced by salinity is in conformity with those of Mehta and Desai [11] and Muhammad and Ata [12].

There were difference in potassium concentration, maximum mean K^+ conc. was observed in dhancha after control and the minimum was in sordan.

Effect of salinity on Ca^{++} concentration. Ca^{++} concentrations in leaf cell sap decreased significantly with the rise in salinity stress (Table 5). The maximum mean Ca^{++} concentration in leaf was recorded under control conditions where no salinity was applied. It decreased significantly with increase in salinity to EC of 5 dS m. However, further increase in salinity upto 15 dS m) did not cause significantly. It is evident that mean calcium concentration in leaf sap of the four crops did not differ significantly.

As for as the salinity crop interaction was concerned the effects were non significant. The results are same as observed by Bernstein and Pearson [13] and Poonia and Bhumbla [14].

Effect of salinity on chloride concentrations in cell sap. The data regarding the effect of salinity on chloride concentration of leaf cell sap of the 4 plant species are presented in Table 6. It is evident that increasing level of salinity caused significant increase in Cl concentration of leaf cell sap in all the plant species. The concentration was more than ten fold at EC 20 dS m compared with control. The increase in the Cl concentration in the leaf sap at high salinity was related to the increasing concentration of Cl in the nutrient solution, which ultimately resulted in the increased uptake of Cl by the plant.

The maximum mean Cl concentration in leaf was observed in sordan grass followed by dhancha but these 2 species were statistically at par. The minimum chloride concentration was obtained from maddal but the difference between the two species i. e. janter and maddal was non-significant.

Chloride in leaf increased significantly with increased NaCl concentration in the external solution Cl concentration was obtained under control where no salinity was present. It is evident from the data that the mean Cl concentration in-

TABLE 1. EFFECT OF SALINITY ON SHOOT FRESH WEIGHT (GRAM PER FOUR PLANTS) OF FOUR PLANT SPECIES.

EC dS m^{-1}	Janter	Sordan	Dhancha	Maddal	Mean
Control	52.3d	81.5c	51.9d	140.8a	81.6A
5	49.0de (93.7)	71.5c (87.7)	44.5 de(85.7)	95.0 b (67.5)	65.0 B
10	33.1 ef (63.3)	26.9 ef (33.0)	38.1 e (73.4)	50.4 d (35.8)	37.1 C
15	23.9 f (45.7)	18.8 fg (23.0)	30.8 ef (59.4)	42.2 de (30.0)	28.9 D
20	10.6 g (20.3)	11.2 g (13.7)	21.6 fg (41.6)	23.5 f (16.7)	16.7 E
Mean	33.8 C	42.0 B	37.4 B	70.4 A -	-

Means with different letters differ significantly at P = 0.05, Values in the parenthesis represent percentage of the respectively control.

TABLE 2. EFFECT OF SALINITY ON SHOOT OVEN DRY WEIGHT (GRAM PER FOUR PLANTS) OF FOUR PLANT SPECIES.

EC dS m^{-1}	Janter	Sordan	Dhancha	Maddal	Mean
Control	7.1 de	12.6 c	7.7 de	20.6 a	12.0 A
5	6.9 de (97.9)	9.4 d (74.6)	7.0 de(90.9)	15.2 b (73.8)	9.6 B
10	5.4 e (76.1)	5.0 e (40.5)	5.3 e (68.8)	9.1 d (44.2)	6.2 C
15	4.9 e (69.0)	4.5 e (35.7)	4.5 e (58.4)	7.1 de(34.5)	5.2 D
20	3.0 e (42.2)	3.5 e (27.8)	3.1 e (40.2)	4.4 e (21.3)	3.5 E
Mean	5.5 C	7.0 B	5.5 C	11.3 A -	-

Means with different letters differ significantly at P = 0.05, Values in the parenthesis represent percentage of the respectively control.

TABLE 3. EFFECT OF SALINITY ON SODIUM CONCENTRATION IN LEAF CELL SAP (mmol kg^{-1}) OF FOUR PLANT SPECIES.

EC dS m^{-1}	Janter	Sordan	Dhancha	Maddal	Mean
Control	12.9 f	29.2 f	31.4 ef	24.9 f	24.6 E
5	70.6 e	117.3 d	115.1 d	109.7 de	103.1 D
10	128.2 d	208.6 bc	152.1 d	169.5 cd	164.6 C
15	168.4 cd	246.7 b	202.1 c	248.8 b	216.5 B
20	210.0 bc	296.7 a	322.7 a	281.4 ab	277.9 A
Mean	118.2 B	179.7 A	164.7 A	166.9 A	-

Means with different letters differ significantly at P = 0.05.

TABLE 4.EFFECT OF SALINITY ON POTASSIUM CONCENTRATION IN LEAF CELL SAP (MMOL KG^{-1}) OF FOUR PLANT SPECIES.

EC dS m^{-1}	Janter	Sordan	Dhancha	Maddal	Mean
Control	126.9	110.2	133.9	131.3	125.6 A
5	110.2	89.7	112.7	96.7	102.3 B
10	85.2	72.3	97.3	74.9	82.4 C
15	57.6	59.5	64.0	58.3	59.9 D
20	41.6	44.8	49.9	39.0	43.8 E
Mean	84.3 AB	75.3 B	91.5 A	80.0 AB	

Means with different letters differ significantly at P=0.05.

TABLE 5.EFFECT OF SALINITY ON CALCIUM CONCENTRATION IN LEAF CELL SAP (MMOL KG^{-1}) OF FOUR PLANT SPECIES.

EC dS m^{-1}	Janter	Sordan	Dhancha	Maddal	Mean
Control	12.4	12.0	13.9	11.1	12.4 A
5	9.0	9.8	10.1	10.1	9.7 B
10	8.6	8.1	8.2	8.5	8.3 B
15	7.2	7.0	7.5	7.8	7.4 B
20	5.6	5.3	5.8	6.6	5.8 C
Mean	8.7	8.4	8.9	8.8	-
			N.S		

Means with different letters differ significantly at P = 0.05. N.S. = Non-significant.

TABLE 6.EFFECT OF SALINITY ON CHLORIDE CONCENTRATION IN LEAF CELL SAP (MMOL KG^{-1}) OF FOUR PLANT SPECIES.

EC dS m^{-1}	Janter	Sordan	Dhancha	Maddal	Mean
Control	8.8 h	18.5 h	17.3 h	9.0 h	13.4 E
5	32.8 gh	47.8 fg	35.3 g	36.8 g	38.2 D
10	75.5 e	85.8 e	78.0 e	60.0 f	75.8 C
15	145.8 d	161.0 c	171.0 c	133.5 d	152.8 B
20	198.8 b	248.8 a	237.0 a	201.3 b	221.4 A
Mean	92.3 B	112.4 A	107.7 A	88.3 B	-

Means with different letters differ significantly at P = 0.05.

creased consistently with increase in salinity to EC 5,10,15, and 20 dS m. The differences among all the salinity levels were statistically significant, the results are also in line with earlier findings 12,15].

Conclusion

The main conclusions of the present study are summarized as under.

(i). As salinity increased, significant decrease in shoot fresh and dry weight was observed.

(ii). On the basis of fresh weight maddal proved more tolerant followed by sordan, janter and dhancha.

(iii). Based on 50% yield reduction calculated by the 2 formulae (mentioned earlier), dhancha remained the most salt tolerant.

(iv). As the salinity increased sodium and chloride concentrations in leaf sap increased significantly, this might be due to the presence of NaCl salinity.

(v). Potassium and calcium concentrations decreased significantly with increase in salinity.

References

1. G.R. Sandhu and R.H. Qureshi, Reclam. and Revege. Res., **5,** 106 (1986).
2. S. Muhammad, Pak. Sci. Conf. Karachi . Dec. 26-30, Pak Assoc. Adv. Sci., 6-B Gulberg II, Lahore 11 (1983).
3. S. Muhammad and A. Khaliq, Bull. Irrig. Drain and Flood Control Res. Council, 50-54 (1975).
4. D.R. Hoagland and D.I. Arnon. Calif. Agric. Exp. Stan. Cir., **347,** 32 (1950).
5. D.B. Duncan, Biometrics **II,** 1 (1955).
6. A.D. Ayers, Agron. J., **44** (2), 82 (1992).
7. E.V. Maas and G.J. Hoffman, Texas Tech. Univ. Lubbock Texas, (1977), pp. 187-198.
8. G.R. Sandhu, Z. Aslam, M. Saleem, A. Sattar, R.H. Qureshi, N. Ahmad and R.G. Wyn Jones, Plant Cell and Env., **4,** 177 (1981).
9. C.A. Bower and C.H. Wadleigh, Soil Sci. Soc. Amer. Proc., **13,** 218 (1948).
10. L.E. Francois, E.V. Maas, T.J. Donovan and V.L. Youngs Agron. J., **78,** 1053 (1986).
11. B.V. Mehta and R.S. Desai, J. Soil Water Conser., India, **6,**168 (Soil and Fert. Abst., **22,** 1224 (1959).
12. S. Muhammad and A.M. Ata, Pak. J. Soil Sci., **1** (1-2), 11 (1983).
13. L. Bernstein and G.A. Pearson, Soil Sci., **82,** 247 (1956).
14. S.R. Poonia and D.R. Bhumbla Ind. J. Agri. Sci., **43** (10), 954 (Soil and Fert. Abst., **38** (1975).
15. J. Gorham, R.G. Wyn Jones and E.Mc Donnell, Plant and Soil, **89,** 15 (1985).