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SODICITY EFFECTS ON GROWTH AND CHEMICAL COMPOSITION OF *DIPLACHNE FUSCA*

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Abstract

Sodicity tolerance tests on kallar grass (*Diplachne fusca*) were carried out in a pot experiment to evaluate its resonse to high soil ESP levels. Results indicate that dry matter yield of kallar grass was not much affected with increasing soil sodicity. A 50% reduction in yield was observed at ESP level of 73. Sodium content of plant increased with a concomitant reduction in K, Ca, Mg and Cl contents with the increase of sodicity levels. Kallar grass could be classed as highly tolerant to soil sodicity.

Introduction

About 33.0% (12.0 million acres) of irrigated soils (37.0 million acres) of Pakistan have been adversely affected by different types of salts and 60% of the salt affected soils in Pakistan are saline-sodic in nature. Out of this 2.5 million acres are classified as impermeable (dense) saline-sodic soils. In addition, small chunks of non saline-sodic soils (69,700 acres) occur as slick spots (Muhammed, 1978). Furthermore, through the use of high sodium underground water, many normal/saline soils have been converted into sodic soils (Choudhry *et al.,* 1978). It is a common experience that the rate of amelioration of dense saline-sodic and sodic soils without the application of amendments is slow, and time consuming. Even the use of large quantities of gypsum has not always been successful in maintaining or increasing the soil hydraulic conductivity because of limited solubility (less than 0.2%) under field conditions (Branson & Fireman, 1960). Amelioration of such soils is not economically feasible (Rafiq, 1975). To deal with such soils, Sandhu & Malik (1975) proposed a plant succession programme wherein kallar grass (*Diplachne fusca)* was recommended as a pioneer plant to grow in the deteriorated soils. Characteristics of the plant have been discussed by Khan (1966) and Hussain & Hussain (1970). No report is available that gives the tolerance limit of this plant to sodic soil conditions. This paper deals with the growth response of kallar grass to soil sodicity under controlled conditions. The effect of high soil sodicity on plant composition has also been investigated.

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Materials and Methods

The experiment was conducted in glazed pots. For preparing soils, having a range of exchangeable sodium percentage (ESP) levels, a normal garden loam soil (physico-chemical analysis given in Table 1) was air dried, passed through 2 mm sieve and mixed thoroughly. Calculated amounts of sodium bicarbonate solution in distilled water were sprayed on to the soils which were then subjected to alterante wetting and drying cycles for 2 months to achieve equilibrium. The ESP levels attained were 15, 29, 44, 59 and 72. Original soil having ESP of 7 served as control.

Table 1. Analysis of the soil used for the experiment

pH_e-	7.95
EC_e-	2.4 mmhos cm^{-1}
SAR-	3.0
$CaCO_3$	3.5%
Organic Matter-	0.67%
Sand-	54%
Silt-	30%
Clay-	16%
Textural Class-	Loam

Kallar grass having 3 root stumps. uniform weight and appearance were planted in each pot cartaining 10 kg of soil/pot and irrigated with canal water. Every effort was made to keep the moisture level, temperature and sunlight uniform for all the treatments.

Two cuttings of grass, the first one after 25 days of growth and the second one 18 days later, were taken and fresh and dry weights recorded. Representative plant samples from each pot were taken and washed with distilled water prior to analysis. Ash contents of plants were determined as per Jackson (1960) and chlorides were determined according to the method of Chapman & Pratt (1961). Sodium, potassium and calcium were determined by flamephotometery and magnesium by atomic absorption spectrophotometer.

Results and Discussion

A. *Effect of different ESP levels on plant yield*

The data on fresh and dry matter yield (Table 2) revealed that at ESP 15, the fresh weight yield increased significantly as compared to control while the increase in dry matter yield was non-significant. Above this sodicity level the yields were significantly reduced at each level of ESP. This indicated that succulence of kallar grass was substantially enhanced at ESP 15. Jennings (1967) has reported that Na had the ability to bring about succulence in plants and that it acted as a specific stimulant for growth.

Table 2. Effect of different sodicity levels on growth and ash content of kallar grass.

ESP level	Green matter yield g/pot	Dry matter yield g/pot	Ash content %
7	171.8b	60.1a	7.18a
15	189.5a	62.3a	7.23a
29	153.7c	53.0b	7.19a
44	138.5d	47.9c	7.14a
59	116.5e	40.9d	6.52a
72	82.5f	30.0e	6.70a

Means followed by the same letter are not significantly different at P 0.05.

Favourable effects of Na on plant growth have also been reported for sunflower (Ansari & Alam, 1978), sugar beet (El-Sheikh *et al*, 1967) and *Atriplex* (Brownell, 1968).

The decreased yield observed with increasing ESP levels of soil is possibly due to the deteriorated physical condition of the soil or due to direct toxic effect of excessive Na concentration in the root medium. Peterson (1961) attributed low yield of plants in sodic soils to increasing exchangeable Na and pH of the growth medium. The adverse effects of sodic soils on plants may result from high concentration of Na, low Ca, Mg and K availability and dispersion of soil resulting in poor aeration. Decrease in growth of many plants with increasing ESP has also been reported by Dower & Wadleigh (1948) and Pearson & Bernstein (1958).

There was approximately 50% reduction in dry matter yield of kallar grass at an ESP of 73 as compared to control (ESP-7). This plant is therefore more tolerant than *Sesbania aculeata*, where 50% reduction in dry matter yield took place at an ESP of 55 (Salim, *et al.*, 1978).

Kallar grass is also more tolerant than Kentucky blue grass and common Bermuda grass in which growth reduced by 35 to 50% at ESP levels of 26-28 (Lunt *et al.*, 1964). The plant also seems to have greater tolerance to sodicity than tall wheat grass as reported by David & Peterson (1962). Kallar grass could therefore be classified as highly tolerant to sodicity according to the classification of Pearson (1960).

B. *Effect of ESP levels on plant composition*

i) *Ash content*

Ash content of plant tissue is an index of total ion retention in the plant body under test. The data presented in Table 2 showed that with increase in soil sodicity, ash content of kallar grass was little affected, which might be due to the excretion of salts through the leaves of kallar grass plant subsequent to absorption. It is probable that at higher ESP levels, increase in ash percentage due to greater absorption of Na was offset by reduced uptake of other cations like K and Ca.

ii) *Na, K. Ca and Mg contents*

Data on Na content of kallar grass grown at differnet ESP levels, showed some increase in Na content with increase in the soil ESP (Table 3). Na content in case of plants grown in control soil was 15.6 me 100 g dry weight and it increased to 23.9 me/100 g dry weight at ESP level of 72. This increase in Na content of plants against a relatively constant level of ash content indicates unbalanced uptake of cations. With the increase in sodicity, the level of solbule Na in soil solution increases whereas that of other ions remains constant or decreases due to the precipitation of Ca and Mg. This increase in soluble sodium percentage of soil seems to be responsible for the observed increase in Na content of plant tissue. Similar results were also reported by Pearson & Bernstein (1958) and Salim *et al.* (1978).

Table 3. Effect of different sodicity levels on chemical composition of kallar grass

ESP level	Na	K	Na+K	Ca	Mg	Cl
			me/100 g dry wt.			
7(*Control*)	15.6a	41.0a	56.6a	28.7a	25.8a	27.0ab
15	19.9b	33.3b	53.2ab	25.7b	25.6ab	27.8a
29	21.2bc	32.5b	53.7ab	23.0bc	23.9abc	24.5b
44	21.7bc	28.2c	49.9b	21.0c	22.9abc	21.5bc
59	21.7bc	26.4c	48.1b	20.7c	22.2bc	19.6c
72	23.9c	25.5b	49.5b	21.0c	21.1c	18.5c

Means followed by the same letter are not significantly different at P 0.05.

It is apparent that the ability of the plant to absorb and retain K, Ca and Mg decreased with increasing sodicity levels, maximum decrease being in case of K which was around 35% at ESP 72 compared to control. At ESP 15 both K and Ca were significantly reduced compared to control while the decrease in Mg content was non-significant upto ESP 44. It is deduced that at high ESP levels this plant cannot maintain a high K level which is considered to be an important factor for salt tolerance in many plants (Wyn-Jones & Storey, 1978), but maintained a reasonably uniform $Na^+ + K^+$ level which according to Ahmed (1978) was responsible for high salt tolerance in certain plant species. In this case Na could partially replace K, possibly in its osmo-regulatory functions.

Cl content

The data on Cl content of plants at different ESP levels (Table 3) showed a definite decreasing pattern with increasing ESP of soil. The Cl content of 27.0 me/100 g dry weight in case of control decreased to 18.0 mg/100g dry weight when soil ESP increased to 72. This could be attributed to antagonistic effect of HCO_3/CO_3 ions on Cl uptake. Similar results have also been reported on *S. aculeata* by Salim, *et al,* (1978). This could also be explained on the basis of salt excretion mechanism present in kallar grass. The efficient excretory mechanism is considered to be responsible for its high tolerance to sodicity.

Consequently Kallar grass is a suitable plant for initial colonization of highly sodic and saline-sodic barren lands which are otherwise difficult to reclaim.

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References

Ahmad, N. 1978. Aspects of glycinebetaine phytochemistry and metabolic functions in plants. Ph.D. Thesis, Univ. of Wales, Cardiff, U.K.

Ansari A.Q. and S.M. Alam. 1978. Effect of sodium on the electro-chemical potential difference and growth of sunflower plants. Proc. Workshop/Seminar on Membrane Biophysics and Development of salt tolerance in plants. Univ. of Agric. Faisalabad, March 11-21 (in press).

Bower, C.A. and G.H. Wadleigh, 1948. Growth and cationic accumulation by four species of plants as influenced by various levels of exchangeable sodium. Soil, Sci. Soc. Am. Proc; 13: 218-223.

Branson, R.L. and M. Fireman. 1960. Reclamation of impossible alkali soils. Trans. 7th Intern. Cong. Soil Sci; 1: 543-552.

Brownell, P.F. 1968. Sodium as an essential micronutrient for some higher plants. Plant & Soil, 28: 161-164.

Chapman, H.D. and P.F. Pratt. 1961. Methods of analysis for soils, plants and waters. Div. of Agric. Univ. of Calif. p. 97-98.

Chaudhry, M.B., M.A. Mian and M.Rafiq. 1978. Nature and magnitude of salinity and drainage problems in relation to agricultural development in Pakistan. Pakistan Soils Bulletin No. 8, Soil Survey of Pakistan, Lahore.

David, L, and H.B. Peterson, 1962. Sodicity tolerance of tall wheat grass. Agron. J. 54: 382-384.

El-Sheikh, A.M., A. Ulrich and T.C. Broyer. 1967. Sodium and rubidium as possible nutrients for sugar beet plants. Plant Physiol., 42: 1202-1208.

Hussain, M and A. Hussain, 1970. Tolerance of *Diplachne fusca* Beauv. (Australian grass) to salt and alkali: Res. Pub. Vol. II No. 25. Directorate of Land Reclamation, Lahore.

Khan, M.D. 1966. Kallar grass-a suitable grass for saline lands. Agric. Pak., 17: 375.

Jackson, M.L. 1960. Soil Chemical Analysis. Prentice Hall Inc. Englewood Cliffs, New York.

Jennings, D.H. 1967. Electrical potential measurements, ion pumps, and root exudation-a-comment and a model explaining cation selectivity by the root. New Phytol., 66: 357-369.

Lunt, O.R., C. Knempffe and U.B. Youngman, 1964. Tolerance of 5 turf grass species to soil alkali. Agron. J., 56: 481-483.

Muhammed, S., 1978. Salt affected soils of Pakistan. Proc. Workshop/Seminar on Memberane Biophysics and Development of salt tolerance in plants. Univ. of Agric., Faisal abad March 11-21 (in press).

Pearson, G. A. 1960. Tolerance of crops to exchangeable sodium. Agric. Inf. Bulletin No. 216. ARS, USDA.

Pearson, G.A. and L. Bernstein, 1958. Influence of exchangeable sodium on yield and chemical composition of plants-wheat, barley, oats, rice, tall fescue and tall wheat grass. Soil Sci. 86: 254-261.

Peterson, H.B., 1961. Some effects on plants of salt and sodium from saline and sodic soils. Proc. of Teh. Symp., 163-167.

Rafiq, M., 1975. Saline, saline alkali and waterlogged soils of the Indus Plain: their characteristics, causes of formation and measures needed for reclamation. Proc. Int. Conf. on Waterlogging and Salinity, Lahore.

Salim, M. Z. Aslam, G.R. Sandhu and R.H. Qureshi, 1978. Influence of exchangeable sodium on the growth and chemical composition of *Sesbania aculeata*. Proc. Workshop/Seminar on Membrane Biophysics and Development of Salt Tolerance in Plants. Univ. of Agric, Faisalabad. March 11-21 (in Press).

Sandhu, G.R. and K.A. Malik 1975. Plant succession A key to the utilization of saline soils. The Nucleus 12: 35-38.

Wyn Jones, R.G. and R., Storey, 1978. Salt stress and comparative physiology in the Gramineae. II. Glycinebetaine and proline accumulation in two salt- and water-stressed barley cultivars. Aust. J. Plant Physiol., 5, 817-29.