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The influence of sodium chloride salinity on the growth and mineral nutrition of horsegram, *Dolichos biflorus* L.

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Abstract

Dolichos biflorus plants were grown in sand culture in the presence of five levels of sodium chloride ranging from 25 to 150 mM. The plant was found to possess a good salt tolerance capacity since a general decline in growth was evident only above NaCl concentration of 75 mM. Salt concentrations above 100 mM reduced the yield in terms of average pod number. The analysis of inorganic constituents revealed marked alterations in the mineral nutrition of the plant under saline conditions. Salt stress caused accumulation of sodium in all plant parts although it was more prenounced in roots and stem. The leaves accumulated large amounts of chlorides under saline conditions. The potassium content in the roots and stem markedly decreased due to salinity. The leaves retained a high potassium level up to 50 mM NaCl treatment. Salt stress caused an increase in the calcium content in leaves and roots. The accumulation of phosphorus and magnesium in different plant parts was favoured by salt stress. A reduction in the manganese content in salt stressed leaves was noticed while higher doses of salinity favoured iron accumulation in different plant parts. A possible involvement of these alterations in the salt tolerance behaviour of the plant is discussed.

Key words: *horsegram, Dolichos biflorus, salinity, growth, mineral nutrition*

INTRODUCTION

Millions of hectars of soil throughout the world are too saline to support normal crop growth and more land is becoming saline due to improper irrigation management and faulty agronomic practices. Although selection and breeding of salt tolerant crop species and crop varieties has been widely accepted as a fruitful strategy to deal with this problem, this approach seems limited only to conventional crop species and varieties (Maas and Hoffman 1976). It is quite possible that few nonconventional

and underexploited crops may exhibit a salt tolerance potential and can play a role in reclamation of saline soils. With this view in mind, an attempt has been made in the present investigation to study the salt tolerance of a minor legume crop, horsegram (*Dolichos biflorus* L. Synn. *Macrotyloma uniflorum* Lam.) which is widely cultivated near the coastal areas of the Kolhapur region.

MATERIAL AND METHODS

Plants of *Dolichos biflorus* L. were raised from seeds (collected locally), in plastic containers containing acid-free silica sand in Hoagland nutrient medium. Fifteen-day-old seedlings were subjected to salt stress. The plants were treated with 0 (control), 25, 50, 75, 100 and 150 mM NaCl in a Hoagland nutrient medium, twice a week alternating with an equal amount of water to avoid excessive salt accumulation and loss of water due to evaporation in the sand. After two months of treatment, the plants were analyzed for various growth parameters and inorganic constituents. The analysis of inorganic constituents was done from oven-dried plant parts following an acid digestion process. Na, K and Ca were estimated flame-photometrically. For estimation of magnesium and phosphorus, the colorimetric methods of Drosdoff and Nearpass (1948), Sekine et al. (1972) were followed. The methods of Durie et al. (1965) were employed for estimation of iron and manganese. Chloride was estimated titrimetrically following the method of Volhard (1956).

RESULTS AND DISCUSSION

The effects of increasing salinity of different growth parameters are shown in Fig. 1. It is clear that all parameters showed a marked decrease above 75 mM NaCl treatment. The nodulation process was also found to be affected above this dose. At 50 mM NaCl a slight stimulation of plant growth with respect to shoot and root length and pod number was noticed. The highest dose of NaCl (150 mM) caused a decrease of over 50% in dry and fresh weight and pod number. These observations indicate that this legume possesses an appraciable salt tolerance as the growth and yield was not affected much by concentrations of salts up to 50 mM. In this respect, this legume species exhibits a response similar to *Vigna sinensis* and *Phaseolus aureus* (Imamul Huq and Larher 1983a). A general growth retardation under higher salinity regimes has been reported

for several legume species (Imbamba 1973, Balasubramanian and Sinha 1976, Helal and Mengel 1981, Imamul Huq and Larher 1983b).

Changes in the level of various mineral solutes in different plant parts induced by increasing concentrations of NaCl are shown in Table 1. It is evident that there was an increase in the sodium content in all plant parts due to salt treatment. The degree of sodium accumulation was considerably greater in the leaf tissue relative to the control, although

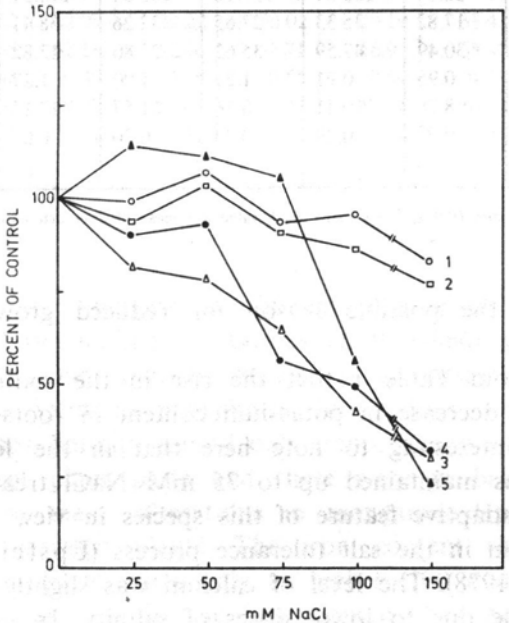

Fig. 1. Effect of increasing NaCl concentration on various growth parameters of horsegram. 1 — shoot length, 2 — root length, 3 — fresh weight per plant, 4 — dry weight per plant, 5 — number of pods per plant

even root and stem sodium contents were quite high. Along with sodium, the chloride contents under saline conditions also increased in all three plant parts. The degree of chloride accumulation relative to control plants was very high in the root tissue although the maximum chloride contents were recorded in the stem tissue. In this respect *Dolichos* differs from other legumes such as *Vigna sinensis* and *Phaseolus aureus* which accumulate more chloride in root tissue after exposure to salt stress (Imamul Huq and Larher 1983a, b). Our observations further indicate that no stochiometry is maintained between sodium and chloride contents in salt stressed horsegram. These observations recall the work of Guggenheim and Waisel (1977). It can be seen from Table 1 that there is considerable accumulation of both sodium and chloride in root, stem and leaf tissue

Table 1

Effect of NaCl salinity (in mM) on mineral constituents *

Element	Control	25	50	75	100	150	Control	25
	root							
Sodium	55.67	83.51	222.69	278.37	334.04	445.39	40.36	139.18
Potassium	90.02	79.82	65.47	63.83	67.11	32.74	57.29	28.64
Calcium	25.95	31.98	37.92	19.96	31.94	31.94	78.84	75.85
Chloride	13.03	51.04	135.64	155.16	185.53	194.21	25.01	57.56
Phosphorus	27.65	17.82	35.33	27.65	32.26	38.41	11.67	18.43
Magnesium	21.66	30.49	47.59	35.62	22.80	12.82	56.99	40.47
Manganese	1.00	0.95	0.91	1.21	1.00	1.27	0.47	0.48
Iron	11.24	8.76	10.41	8.76	11.57	17.19	3.80	3.30
Potassium/ Sodium	1.62	0.95	0.29	0.23	0.20	0.07	1.42	0.20

* Values are expressed as meq $(100\ g)^{-1}$ dry tissue. Each value is a mean of three determinations.

and this may be the possible reason for reduced growth (Greenway and Munns 1980).

It is evident from Table 1 that the rise in the sodium content was accompanied by a decrease in potassium content in roots of salt stressed horsegram. It is interesting to note here that in the leaves, a similar potassium level was maintained up to 75 mM NaCl treatment. This can be considered an adaptive feature of this species in view of the key role played by potassium in the salt tolerance process (Epstein 1972, Storey and Wyn Jones 1978). The level of calcium was slightly elevated in the root and leaf tissue due to lower doses of salinity. In stems no definite pattern in this respect was evident. By protecting membrane integrity, calcium plays an important role in the selective transport of potassium, the principal osmoticum in glycophytes in the presence of excess sodium, thereby making the plants more salt tolerant (Clarkson and Hanson 1980, Epstein 1980). Our observations indicate that horsegram possesses a good ability of maintaining an optimum calcium level under saline conditions. In this respect it differs significantly from a salt sensitive bean plant which shows a reduced calcium absorption rate under saline conditions (Starck and Kozińska 1980). It can be seen from the Table that salt stress caused the lowering of the magnesium level in the stems while in leaves and roots the magnesium contents exhibited a rise under lower concentration of NaCl only. An increase in the magnesium content under saline conditions has been reported by many workers (Syed and Swaify 1972, Guillen et al. 1978) and according to Imamul Huq and Larher (1983b). This may be associated with the increase of chlorophylls in salt stressed plants. The phosphorus content under saline conditions also

in different organs of horsegram (*Dolichos biflorus* L.)

50	75	100	150	Control	25	50	75	100	150
stem				leaf					
167.02	201.82	299.25	327.08	12.53	24.36	69.59	104.39	187.90	194.86
40.92	41.33	49.10	57.29	155.50	163.68	159.59	130.94	110.48	81.84
67.86	63.87	91.82	82.83	130.74	167.66	171.66	177.64	136.72	97.80
132.40	116.13	142.16	226.73	51.04	184.43	203.97	210.48	132.40	210.48
19.97	32.25	47.62	62.99	29.22	30.02	29.19	38.41	40.39	70.67
27.36	33.62	41.60	42.18	42.46	56.71	56.99	58.42	47.87	42.75
0.42	0.47	0.48	0.49	0.55	0.55	0.54	0.53	0.30	0.48
3.31	3.14	9.59	9.09	14.05	8.43	10.74	10.91	20.16	26.44
0.24	0.20	0.16	0.17	12.41	6.72	2.29	1.25	0.59	0.42

showed a considerable increase in different plant parts (Table 1). These observations recall the findings of Gates et al. (1966) and Cooper and Dumbroff (1973). Our findings suggest that horsegram possesses an ability to provide optimum phosphorus for various metabolic processes under saline regimes. Salinity caused only minor changes in the mangenese content in different plant parts and these were probably not sufficient to account for any major alterations in manganese-dependent metabolic processes in salt stressed plants. The iron content showed a marked increase in different plant parts only at higher (100 and 150 mM) levels of salt stress. An increase in the iron content has been attributed to membrane damage and reduced growth of the top (Mass et al. 1972). It is quite probable that in horsegram such damage occurs only at high levels of salinity.

It is evident from the foregoing account that horsegram (*Dolichos biflorus* L. Synn. *Macrotyloma uniflorum* Lam.) possesses a fairly good salt tolerance capacity which is very well reflected in the pattern of mineral nutrition of this legume. It will be interesting to study the fate of compatible organic solutes and nitrogen metabolism in this legume under saline conditions. Such studies are in progress.

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Wpływ zasolenia chlorkiem sodu na wzrost i odżywianie mineralne roślin Dolichos biflorus L.

Streszczenie

Rośliny *Dolichos biflorus* hodowano na piasku w pięciu różnych stężeniach chlorku sodu (od 25 do 150 mM). Okazało się, że *Dolichos* ma dobrą tolerancję na zasolenie; wyraźne zahamowanie wzrostu było widoczne dopiero przy stężeniu soli ok. 75 mM. Stężenie NaCl 100 mM zmniejszało plon, w przeliczeniu na średnią liczbę strąków. Analiza składników nieorganicznych wykazała wyraźne zmiany w mineralnym żywieniu roślin w warunkach zasolenia. Stress solny spowodował akumulację sodu we wszystkich częściach rośliny, ale największą w korzeniach i łodydze. Liście, w warunkach zasolenia, zgromadziły duże ilości chlorków. Zasolenie NaCl spowodowało wyraźne zmniejszenie się zawartości potasu w korzeniach i łodydze. Liście zachowały wysoki poziom potasu aż do dawki 50 mM NaCl. Stress solny spowodował zwiększenie się zawartości wapnia w liściach i korzeniach. Stress solny sprzyjał akumulacji fosforu i magnezu w różnych częściach rośliny. Zaobserwowano zmniejszenie się zawartości manganu w liściach stresowanych solą, podczas gdy duże dawki NaCl sprzyjały akumulacji żelaza w różnych częściach rośliny. Dyskutowane są przypuszczalne zależności tych, tak różnych, reakcji rośliny na zasolenie.