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VARIATION IN RESPONSES OF *SORGHUM BICOLOR* (L.) MOENCH ACCESSIONS TO THE EFFECT OF NaCI + CSCi, AND NaCI SALINITY

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The responses of IT *Sorghum bicolor* accessions to NaCI alone, and NaCI + $CaCl_2$ (1:1 molar ratio) were compared at seedling stage. There were 4 EC levels of each type of salinity, EC4, EC6, EC8, ECIO dSm-'. and one control having EC 0.3. After 14 days of growth in salinity, the longest root of each accession was measured and compared with that in control solution. Analysis of variance of indices of salt tolerance revealed that both the salinities caused significant reduction' in root lengths of all the accessions, and the data showed that the roots of accessions were reduced more in mixture of salts than in single salt, showing detrimental effects of NaCI + $CaCl_2$. It was also revealed that accessions responded differently to both type of salinities, and some accessions exhibited superior salt tolerance. Differential responses of accessions to salinity suggest that improvement in salinity tolerance of the present' sorghum material may be possible through selection and breeding.

Key words: calcium chloride, relative salt tolerance, sodium chloride, sorghum accessions

INTRODUCTION

There is a variety of ions present in the soil, and these combine with each other in different proportions to result in the development of salinity. Although saline areas are predominantly affected by Na" and CI- ions, cations of other kinds of salts, particularly of Ca^{2+} are also of frequent occurrence (Shannon, 1984). The experiments using barley and other plant species showed that presence of NaCI in the growing medium had affected the uptake of Ca^{2+} ions by shoots (Bajwa and Bhumbla, 1971; Lynch and Lauchli, 1985). In other experiments cultivars of wheat (Ashraf and McNeilly, 1988), barley (Morales et al., 1992) and cotton (Khan et al., 1998) differed considerably in their responses to salinity developed by mixing NaCI + $CaCl_2$ There is, however, no information available about simultaneous comparison of genotype responses to the combined effect of NaCI + $CaCl_2$, and to NaCI alone.

Sorghum bicolor (L.) Moench is adapted to tropical areas affected by salinity and is grown for forage as well as for food grains. According to Francois et al. (1984) and Maas et al. (1986), sorghum is moderately tolerant to salinity. Further studies revealed that varieties of sorghum responded differently to salinity and suggested that the possibilities of improving salinity tolerance in the species are present (Azhar and McNeilly, 1987, 1988, 1989; Hassanein and Azab, 1993; Azhar and Khan, 1997). All these studies involved single NaCI salt to develop salinized root media to compare the genotype responses to salinity. In the present investigations the responses of some sorghum accessions to mixed salinity (NaCI + $CaCl_2$) and NaCI alone were assessed simultaneously in order to see which type of salinity is more detrimental to plant growth.

MATERIALS AND METHODS

Eleven accessions used in the study were geographically unrelated and were obtained through the kind co-operation of various gene banks. The accessions are: Double TX (U.S.A.). Giza 114, Pale SSIT, Red Jampur, Roma (pakistan), INRA133, INRA353, (INRA, Guadeloupe), B378 Redlan (Australia), SSV5, CE 145-166, and CE 151-186 (Gambia). The responses of accessions to salinity were evaluated at seedling stage using the solution culture technique (Azhar and McNeilly, 1987). The salinity was developed by adding NaCI alone, and NaCI in mixture with $CaCl_2$ (1:1 molar ratio) in 1/10 Rorison's nutrient solution (Hewitt, 1966r Salinity was quantified as electrical conductivity (EC), and 4 EC levels, EC4, EC6, EC8, and ECIO dSm^{-1}, and one control, without added salt having EC 0.3, were used. Approximately 20 seeds of each accession were sown on a 3-layer deep raft of black alkathene beads floating on the surface of 300 cm' solution in plastic beakers. Pots were arranged in a completely randomized design with 3 replications, in a growth room maintained at 25 ± 1QC and relative humidity of 80%. Pots were enclosed within perplex chambers to maintain humidity, minimize evaporation of the solutions, and thus avoided the necessity to change the solutions during the experimental period.

After two weeks growth, the longest root length of 10 randomly taken seedlings from each of the three replicates were measured. Mean values for root length (cm) in each replicate, in each test solution were compared with those in control solution, to determine relative salt tolerance of accessions (Maas, 1986). The indices of salt tolerance were subjected to analysis of variance technique in' order to see whether the genotypic differences for salt tolerance were significant.

RESULTS

Mean squares obtained from analysis of variance (Table 1) revealed that for pool data, the effects of NaCI or NaCI + $CaCI_2$, accessions and EC levels differed significantly (P ≤ 0.01). The interaction terms, salinities x accessions, salinities x treatments were also significant (P ~ 0.01), however, accessions x treatments was non-significant (P ~ 0.05). Increasing EC levels of each type of salinity caused significant reduction in root length of all the accessions (salinities x accessions x treatments significant at (P ~ 0.01).

The indices of salt tolerance showed marked contrast in the responses of accessions to NaCI salinity (Table 2), and EC4 appeared to have stimulated root length of Double TX (104%), Pak SSII (113%), Roma (101%), INRA 353 (120%) and CE 151-186 (108%), and in contrast NaCI salinity resulted into significant reduction in root lengths of INRA 133 (77%), B378 Redlan (77%), and CE 145-166 (78%). Although NaCI caused a significant reduction in root lengths compared with controls, the roots of Giza 114, and Pak SSII remained unaffected up to EC8, having relative tolerance of 82% and 89% respectively. At EC8, index of tolerance of INRA 353 and CE 151-186 is 69% and 65% respectively, and these indices did not differ significantly from those of Giza 114 and Pak SSII, but differed significantly from those of other seven accessions. Relative value of INRA 133 at EC8 is only 26%. At ECI0, although there occurred a significant reduction in root length of all ~e accessions, yet Giza 114 (78%), Pak SSII (60%) and CE 151-186 (62%) had considerable root lengths and differed significantly from the remaining eight accessions. From comparison of overall performance, accession Giza 114, Pak SSII, INRA 353 and CE 151-186 were found to produce 86%, 90%, 84%, 83% root lengths respectively in salinized solution and thus may be regarded as tolerant, whereas INRA 133 with mean value of 26% appears to be sensitive, The remaining six accessions with values ranging 60 - 62% can be termed moderately tolerant to NaCI salinity.

Indices of salt tolerance based upon root lengths in NaCI + $CaCI_2$ provided further estimates of the salinity tolerance of various accessions (Table 2). The mixture of salts had decreased root lengths of all the accessions, but some of the accessions were markedly affected when exposed even to the lowest salinity level. Thus INRA 133 and B 378 Redlan were affected the most at EC4, with a tolerance index of 61% and 67% respectively. By contrast, SSV5 (95%), CE 145-166, (89%), Red Jampur (115%), Pak SSII (82%), and Double TX (86%) had the greatest index of tolerance. These data also revealed that with progressive increase in salinity level, the relative behaviour of accessions decreased markedly at high salinity due to NaCI + $CaCI_2$, but differences in responses between accessions were still evident. At EC8 and ECI0, accession Double TX with the highest tolerance indices i.e. 27% and 15% respectively, and Red Jampur having 37% and 26% respectively exhibited superior salt tolerance. Accessions B378 Redlan, CE 145-166 and CE 151-186 did not survive at ECI0. However, from overall assessment of accessions, Double TX and Red Jampur with a mean value of 44% and 61% respectively appeared to be the most tolerant, whereas Giza 114, Roma, INRA 133, B 378 Redlan and CE 151-186 with tolerance indices ranging 28 to 31% were the most sensitive to the combined effect of NaCI + $CaCI_2$.

DISCUSSION

Assessment of salinity tolerance of a crop species using relative values had been suggested by Maas (1986). The indices of salt tolerance based upon 14-dayold root lengths tested under hydroponic conditions helped compare the responses of 11 *Sorghum bicolor* accessions to NaCI alone and NaCI + $CaCI_2$ salinity. Root lengths data were successfully used to distinguish salt tolerant and normal populations of a number of grass species in saline and non-saline habitats (Hannon and Bradshaw, 1968; Leim et al., 1985), and in other studies on salinity tolerance in sorghum (Azhar and McNeilly, 1987; Hassanein and Azab, 1993; Azhar and Khan, 1997).

Although root lengths of all the accessions were reduced significantly in both the salinities, the differences among the accessions were still evident under increasing EC due to single salt and combination of NaCI + $CaCI_2$. Similar adverse effects of salinity had been noted on other?plant species e.g. *Triticum aestivum* (Ashraf and McNeilly, 1988), *Hordeum vulgare* (Morales et al., 1992) and *Gossypium hirsutum* (Khan et al., 1998). The relative salt tolerance data of both the salinities (Table 2) clearly indicated that the magnitude of reduction in root lengths of the accessions measured in NaCI + $CaCI_2$ was exceedingly greater than that in NaCI alone. The detrimental effects of both the salinities on root lengths were pronounced, both within and between the salinity, at EC6, EC8, and ECIO, and accession differences were still discernible. Thus Giza 114, Pak SSII, INRA353 and CE 151-186 in NaCI with the highest relative mean values were shown to be the tolerant accessions, whereas Double TX, Red Jampur, Roma, SSV5 and B378 Redlan appeared to be moderately tolerant. 1NRA133 with the lowest index of tolerance was sensitive to NaCI salinity. However, the pattern of genotypic responses to mixed salinity was different. Although the adverse effect of NaCI + $CaCl_2$ on root growth was the most marked, accession Red Jampur with maximum tolerance index showed superior tolerance, and Double TX and ~SSV5 were moderately tolerant. Accessions 1NRA133, B378 Redlan and CE 151-186 may be considered as more sensitive to NaCI + $eaCI_2$ salinity. The data given in Table 2 revealed that the joint presence ofNaCI and $CaCl_2$ in the nutrient media was more injurious to the roots of sorghum than isosmotic concentration of NaCI, particularly at EC8 in which B378 Redlan, CE 145-166 and CE 151-186 did not survive. It seems that due to increased concentration of Cl ions (from the two sources of salinity) in the growing medium, the accessions exercised higher influx of Cl ions" which may" have affected root growth more seriously than that in the concentration of NaCI alone as suggested by Salim (1989). However, analysis of different plant parts may be made for Cl concentration to substantiate the reason of differential responses of accessions to salinity.

In previous studies accession Double TX had been categorized as moderately tolerant to salinity (Francois et al., 1984; Maas et al., 1986). The present study has substantiated salinity tolerance of Double TX. Similarly, based upon indices of salt tolerance, Hassanein et al. (1993) found Giza 114 as tolerant accession at seedling stage and the seedlings showed their superior tolerance at maturity. The superior tolerance of Giza 114 had also been noted. Thus from the root length data at seedling stage it seemed possible to predict better salt tolerance of genotypes at maturity. Thus the variation existing in the plant material used in this study may be exploited by developing an effective breeding programme for improving salinity tolerance in sorghum plant.

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Table I. Mean squares from analysis of variance of sorghum accessions to NaCI and NaCI + $CaCl_2$ solutions

Variation due to	Degrees of freedom	Root length
Salinities(S)	1	81795.6**
Accessions (Acs)	10	1306.9**
Treatments(Tmt)	3	44812.6**
SxAcs	10	1839.3**
SxTmt	3	3406.0**
Acs x Tmt	30	136.9NS
S x Acs x Tmt	30	226.0**
Residual	176	97.4

** = Differences significant at 1% probability;
NS = Non-significant differences:

Table 2. Relative root leugtb of" sorghum aceessiODs grown in NaCland NaCI + $CaCl_2$ SolutiODS

Accessions	EC4	EC6	EC8	EC 10	Means
Double TX	103.7	76.3	54.5	41.6	69.03
	(86.0)	(48.9)	(26.8)	(14.9)	(44.15)
Giza 114	93.0	91.9	82.4	77.8	86.28.
	(73.7)	(27.9)	(16.9)	(7.9)	(31.6)
Pak SSII	112.5	98.6	88.9	59.5	89.88
	(82.4)	(31.1)	(15.0)	(8.0)	(34.13)
RedJampur	79.4	63.6	57.2	45.9	61.53
	(115.6)	(63.6)	(37.3)	(26.1)	(60.65)
Roma	100.8	77.9	54.1	37.2	67.50
	(72.8)	(29.6)	(13.2)	(7.3)	(30.73)
1NRA133	77.4	62.1	26.1	20.1	46.43
	(60.7)	(31.2)	(14.6)	(6.2)	(28.18)
1NRA353	120.4	95.3	69.4	50.4	83.88
	(72.8)	(38.4)	(17.0)	(7.9)	(34.03)
SSV5	94.5	84.5	60.4	47.4	71.70
	(95.3)	(40.8)	(16.8)	(7.2)	(40.03)
B378Redlan	76.8	69.0	59.7	55.6	65.28
	(67.0)	(37.6)	(15.0)	(-)	(29.00)
CE 145-166	77.9	69.1	53.6	38.4	?9.75
	(82.2)	(72.8)	(12.9)	(-)	(36.23)
CE 151-186	107.5	96.9	45.3	62.4	83.03
	(78.3)	(27.5)	(14.1)	(-)	(29.98)

Cd 5% = 1.79

* = The relative values given in the parentheses are of the accessions tested in salinity due to NaCI and $CaCl_2$.

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