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BRIEF COMMUNICATION

Emergence, growth and nutrient composition of sugarcane sprouts under NaCl salinity

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Abstract

The changes induced by 80 and 120 mM NaCl during emergence and growth of sprouts in salt-tolerant (CPF-213) and sensitive (L-116) genotypes of sugarcane were determined. The rate and percentage of emergence of sprouts, length and dry mass of shoot and root, and number of nodal roots decreased under salinity. Concentrations of Na and Cl increased and those of K, Ca, N and P decreased with a rise in substrate salinity. A greater salinity tolerance ability of CPF-213 than L-116 was attributable to greater root mass and higher nutrient concentrations in the sprouts of the former genotype.

Additional key words: genotypes, salt tolerance, mineral nutrients, *Saccharum officinarum*, nodal buds.

Increased soil salinity has a multitude of effects on the plant growth and development. Salinity tolerance is a cost effective phenomenon, as a considerable amount of energy is spent either to avoid or for the inevitable uptake of excess of ions present in the growth medium and their sequestering at cell, tissue and organ levels (Yeo 1983).

The emergence and establishment of seedlings is crucial under salinity, as they determine final crop stand and productivity (Wahid *et al.* 1999a,b). Better growth of clover and tomato plants was assigned to greater content of K and Ca, and lower content of Na and Cl (Rogers and Noble 1991, Al-Rawahy *et al.* 1992). This revealed that effective regulation of nutrients is an important salt tolerance strategy of different species. Sugarcane is commercially propagated from sets (nodal buds). It is sensitive to salinity at different growth stages, but large genotype differences do occur (Rozeff 1995, Wahid *et al.* 1997). Sensitivity of sugarcane to salinity at various growth stages is mainly manifested by the reduced photosynthetic efficiency under salinity (Meinzer *et al.* 1994, Plaut *et al.* 2000, Akhtar *et al.* 2001), thus crippling the biosynthesis of sucrose (Lingle and Weigand 1997, Nasir *et al.* 2000). Weigand *et al.* (1996) and Lingle *et al.* (2000) reported a significant relationship between mineral and sucrose contents of juice in the stalk of high and low sucrose cane cultivars. This information suggests that changes in the endogenous nutrient content of sugarcane play a pivotal role for tolerance to salinity during entire growth period.

Specific distribution pattern of some physiologically important bud nutrients may play a crucial role in the success of sprouts to emerge and grow under saline conditions. This study reports the extent of changes in the rate of emergence and growth of sprouts, and the concentrations of nutrients triggering these changes in a NaCl-tolerant and a NaCl-sensitive genotype.

Genotypes of sugarcane (*Saccharum officinarum* L.) selected for this study were rigorously screened previously under NaCl salinity. CPF-213 with salt tolerance limit (EC_{50}) of 18.5 dS m^{-1}, and L-116 with EC_{50} of 11.2 dS m^{-1} were declared salt tolerant and sensitive, respectively (Akhtar 2000).

The experiment was carried out in tanks measuring 1.35 m (long) × 0.75 m (wide) × 0.45 m (deep), lined with double layer of polyethylene sheet, filled with soil and kept in a net house during March-April 1995, and repeated in 1996. Soil pH was 7.6, electrical conductivity (EC) 2 dS m^{-1}, and it contained [mg kg^{-1}] Na^+ 57, K^+ 430, Cl^- 298, SO_4^{2-} 48, Ca^{2+} + Mg^{2+} 960, NH_4^+ 7.2, and NO_3^- 15.8, as determined by standard methods (Black 1965). The salt solution was applied to the soil for achieving concentrations of 80 and 120 mM NaCl. Single noded sets (fifty in each tank) of each genotype were sown (bud position upward). The tanks were applied with ground

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water, whenever needed, having EC 0.8 dS m^{-1}. Design of the experiment was completely randomized with three replications. The experiment lasted for 50 d and the data on the rate of bud sprouting and emergence was recorded in 10-d intervals. A set was considered as sprouted with emergence of shoot up to 2.5 cm above the soil. At the termination of experiment, the shoots and roots were excised for determination of length and dry matter yield (after drying at 70 °C for 3 d). Meteorological conditions during the experimental period (March-April 1996) were: day/night temperature 26 ± 2 °C/13 ± 2 °C, relative humidity 64 ± 8 %, and rainfall 20 mm.

Dried shoots and roots were ground, digested in concentrated HNO_3 at 250 °C for 3 h to determine Na and K with flame photometer (*Corning*, Essex, U.K.), and Ca with atomic absorption spectrophotometer (*Pye Unicam Ltd.*, Cambridge, U.K.). Total N was determined by micro-Kjeldahl method. For the estimation of P, the dried ground material was digested in HNO_3:$HClO_4$ (3:1) for 3 h at 300 to 350 °C and estimated with molybdate-vanadate reagent (Yoshida *et al.* 1976).

As there was no great difference in the growth and nutrient composition of genotypes during 1995 and 1996, the data presented here pertain only to the year 1996. The *ANOVA* of various parameters for this completely randomized experiment was done using *COSTAT* software and means were compared by Duncan's New Multiple Range Test.

The emergence, rate and final percentage of sprouts was significantly ($P < 0.01$) reduced under increasing salinity (Table 1). The emergence started on day 10 after sowing in both the genotypes under control condition, but under salinity (120 mM) it was greatly delayed in L-116 and was recorded on day 30 after sowing. Contrarily, CPF-213 showing sprouts emergence on day 10 after sowing under salinity, managed markedly greater final emergence of sprouts than L-116 (Table 1).

Applied salinity significantly ($P < 0.01$) reduced the shoot and root length of sprouts (Table 2). CPF-213 proved superior to L-116 in giving elongated shoots. Likewise, dry mass of shoot and root was significantly ($P < 0.01$) reduced in both the genotypes under increased salinity, but L-116 displayed a greater reduction in dry mass of both the parts (Table 2).

The tolerant genotype (CPF-213) had a greater rate of sprout emergence (Table 1) and vigorous growth of sprouts as determined in terms of elongation, dry mass of shoot and root and production of greater number of nodal roots as compared to L-116 (Table 2). An increased sprouting and growth of tolerant genotype was possibly due to a greater sustainability of bud and nodal root initials under salinity.

Significant ($P < 0.01$) genotype differences were evident in the contents of Na, K, Cl and K:Na ratio for both shoot and root, and Na and Cl content of root (Table 3). A greater accumulation of Na and Cl was noted in shoot and root of L-116 with increasing salinity. The K concentration was higher in the shoots and roots of the tolerant than the sensitive genotype, where its accumulation was the lowest at 120 mM NaCl in shoot. Although K:Na ratio considerably decreased under salinity, it was markedly greater in CPF-213 than in L-116. Similarly, the genotypes under salinity indicated significant ($P < 0.01$) differences in the concentrations of shoot P and N, and root Ca and P (Table 3). Applied salinity decreased the content of Ca, N and P, but tolerant genotype exhibited a lower reduction of Ca and N in shoot and root and P in root, as compared to sensitive genotype.

The concentrations of Na and Cl increased linearly with increased salinity, but the extent of increase was greater in case of L-116. Contrarily, the concentrations of all the nutrients, studied here, were substantially higher in CPF-213 as compared to L-116, under salinity (Table 3). This indicated that tolerant genotype managed to restrict the entry of Na and Cl in to the sprouts and maintain a higher content of K, Ca, and P in the seedlings. The enhanced content of these nutrients appeared to buffer the toxicity of Na and Cl, and enabled the tolerant genotype to exhibit better growth of cane sprouts. The increased concentrations of these nutrients are crucial in controlling ceratin physiological and biochemical processes (Leigh and Wyn Jones 1984, Lin and Kao 1995, Wahid *et al.* 1999a). It is suggested that such a pattern of growth and distribution of nutrients is essential for accruing better growth of seedlings under salinity.

Table 1. Sprout emergence [%] of sugarcane genotypes CPF-213 and L-116 under salinity on different days after sowing. Means sharing same letter are non-significantly ($P > 0.05$) different.

Genotype	NaCl [mM]	10	20	30	40	50
CPF-213	control	16a	46a	57a	67a	78a
	80	14a	35ab	46ab	65a	72ab
	120	8b	28b	33b	44b	65b
L-116	control	22a	43a	59a	70a	88a
	80	0b	8b	15b	27b	38b
	120	0b	0b	5c	8c	12c

Table 2. Some growth characteristics of sprouts of sugarcane genotypes under increased salinity (50 d after sowing). Means sharing same letter are non-significantly ($P > 0.05$) different.

Genotypes	NaCl [mM]	Length [cm]		Dry mass [mg plant^{-1}]		Number of nodal roots [plant^{-1}]
		shoot	root	shoot	root	
CPF-213	control	6.7a	9.3a	88.4a	490a	37.5a
	80	6.0a	7.8ab	63.3b	340ab	33.2a
	120	5.0b	6.4b	48.9b	229b	26.9b
L-116	control	5.8a	12.0a	86.2a	518a	37.0a
	80	4.3b	8.6b	42.1b	166b	23.9b
	120	2.7c	5.5c	33.4b	119c	19.6c

Table 3. Nutrient composition [mmol g^{-1}(d.m)] or [%(N)] of shoot and root of sugarcane genotypes under increased salinity (50 d after sowing). Means sharing same letter are non-significantly ($P > 0.05$) different.

Genotypes	NaCl [mm]	Na		K		K:Na		Cl		Ca		P		N	
		shoot	root	shoot	root	shoot	root	shoot	root	shoot	root	shoot	root	shoot	root
CPF-213	control	23.4c	30.0c	109.6a	102.1a	4.67a	3.4a	32.7b	40.8c	25.4a	30.4a	198.0a	193.3a	3.79a	2.70a
	80	52.0b	94.6b	90.9ab	89.4a	1.54b	1.0b	82.9a	97.6b	24.1a	25.5a	170.2a	189.0a	3.49ab	2.42b
	120	75.6a	127.0a	78.0b	76.2b	1.04b	0.6b	98.5a	116.3a	22.1a	23.3a	162.2a	152.4b	3.28b	2.34b
L-116	control	25.3c	30.0c	118.0a	107.1a	4.65a	3.6a	37.6c	44.5b	28.1a	30.2a	182.3a	178.9a	3.77a	2.73a
	80	70.8b	93.0b	76.0b	76.9b	0.93b	0.8b	95.1b	121.6a	20.8b	19.1b	144.6b	154.1b	3.30b	2.39b
	120	113.0a	147.6a	62.0b	71.4b	0.54c	0.5b	118.1a	132.6a	18.2b	17.4b	130.5b	144.3b	3.09b	2.30b

In conclusion, root growth was relatively more sensitive to NaCl stress than shoot growth, as CPF-213 with greater root mass exhibited greater NaCl tolerance. Na more inhibited the growth of sprouts than Cl. Decreased concentrations of Na and Cl, and increased ones of K, Ca, and P reflected better ability of CPF-213 to combat salinity. Such a pattern of growth and of distribution of nutrients is a plausible strategy of salinity tolerance at this stage of sugarcane growth, and it may be accorded due consideration while selecting sugarcane genotypes for growing in saline fields.

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