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Response of two greenhouse pepper hybrids to NaCl salinity during different growth stages

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Abstract

The salt tolerance of two greenhouse bell-pepper hybrids (*Capsicum annuum* L., ‘Sonar’ and ‘Lamuyo’) was studied during germination, seedling growth and vegetative growth in hydroponic culture. Salinity treatments were imposed by irrigating with half-strength Hoagland solution containing 0, 10, 25, 50, 100 and 150 mM/l of NaCl. Salinities up to 50 mM delayed germination but did not reduce the final germination percentage. It was reduced significantly at 100 and 150 mM NaCl in both hybrids. Seedling growth was reduced significantly with salinities higher than 10 mM NaCl. Plant growth parameters such as plant height, total leaf area and dry weight were significantly ($P=0.05$) reduced at salinities higher than 25 mM NaCl in both hybrids. Roots had the highest Na^+ concentration compared to leaves, which increased with increasing salinity, while Cl^- in leaves was much higher than Na^+ . Potassium concentration of plant tissues was less affected than Na and Cl by salinity increase. Total fruit yield in both hybrids was significantly reduced at salinities higher than 10 mM NaCl, the reduction being 95% at 150 mM NaCl. Both, fruit number per plant and fruit weight were reduced by the salinity. Our results suggest that during the growth stages studied, the hybrid ‘Lamuyo’ is more sensitive to salinity than the hybrid ‘Sonar’. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: *Capsicum annuum*; Germination; Leaf area; Dry weight; Yield; Ion content; Salt tolerance

1. Introduction

The decline in availability of fresh water for irrigation due to allocation to other sectors (urban and industry), especially in arid and semi-arid regions such as the

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Mediterranean basin, results in the intensive use of low quality water (saline, reclaimed) to satisfy the increasing demand for irrigation. The use of such water causes an increase of soil salinity, which may have negative effects on the growth and yield of crops. Recent research developments on plant breeding and selection, soil and water management, irrigation and drainage technologies enhance and facilitate the use of such water for irrigation with minimum adverse impacts on soil productivity and environment (FAO, 1990).

One of the most effective ways to overcome salinity problems is the introduction of salt tolerance to crops. It has been reported that differences in salt tolerance exist not only among different species, but also within certain species (Yeo and Flowers, 1988; Heuer and Plaut, 1989; Botia et al., 1998). Furthermore, the sensitivity or tolerance may differ according to the culture medium, the type of salinity and the plant growth stage. Exposure to NaCl salinity affects water and ion transport processes in plant, which may change the nutritional status and ion balance (Läuchli and Epstein, 1990) as well as many physiological processes (Seeman and Critchley, 1985; Munns and Termaat, 1986).

Although the tolerance of many field grown vegetable crops to water and soil salinity has been reported (Maas and Hoffman, 1977; Yamez et al., 1992), less information is available on the effects of salt on greenhouse vegetables (Meiri et al., 1981; Sonneveld, 1988; Chartzoulakis and Loupassaki, 1997) and especially on pepper (Sonneveld, 1979; Sonneveld and Van der Burg, 1991; De Kreij, 1999). The use of saline water in combination with over-fertilization often causes problems in pepper production, which is considered moderately sensitive to salinity (Ayers and Westcot, 1985).

The primary purpose of this study was to evaluate the behavior of greenhouse pepper hybrids 'Sonar' and 'Lamuyo' during germination, growth and fruiting stages in hydroponic culture under various salinity levels. These hybrids were chosen because they are the main ones grown in the southeastern part of Crete, where groundwater with high salt content (mainly Na^+ and Cl^- due to sea water intrusion) is commonly used for irrigation. We also investigated the allocation of Na, K, Cl and Ca within plant tissues of pepper grown under saline conditions.

2. Materials and methods

2.1. Salinity treatments

Five salinity treatments and a control were used. NaCl was added to tap water (EC 0.3 dS/m, 0.3 mM Na, 0.5 mM Cl) at 0, 10, 25, 50, 100 and 150 mM to half-strength Hoagland solution in increments of 25 mM per day to avoid salt shock. The respective electrical conductivity (EC) of the solutions at 25°C were 1.2, 2.4,

4.1, 7.1, 12.6 and 17.8 dS/m. During vegetative and fruiting stages, plants in all treatments were irrigated with microtubes for 30 s giving 650 ml to each plant, twice daily, using submersible pumps. After application, each solution returned to its tank through a closed system. Every 3 days the solution of each tank was brought to its initial volume by addition of deionized water, while a fresh solution was supplied every 10 days, in order to avoid changes in solution concentration greater than 5%. Each treatment was applied to 16 plants in a completely randomized design.

2.2. Germination and seedling growth

Twenty five seeds of each pepper (*Capsicum annuum* L.) hybrid ('Sonar' and 'Lamuyo') were placed on a filter paper in a Petri dish. The paper was imbibed in six NaCl solutions at 0, 10, 25, 50, 100 and 150 mM and excess solution was drained. The seeds were incubated for 7 days at 26°C and 90% R.H. in a dark germination chamber. The germinated seeds (appearance of rootlet) and rootlet elongation were recorded daily. Each treatment was replicated four times.

For seedling growth, 20 seeds of each hybrid, well-germinated in tap water, were planted at 10 mm depth in small plastic pots filled with peat. The pots were placed in a glasshouse with controlled environment at a temperature of $22\pm3^{\circ}\text{C}$ and ambient sunlight for 17 days and were irrigated daily with the above mentioned NaCl solutions. The number of emerged seeds, the height, the leaf area and the dry weight of the seedlings were measured on the day 17 after planting.

2.3. Vegetative growth and yield

For plant growth, uniform pepper seedlings grown for 17 days in small pots filled with peat and irrigated with tap water, were transplanted on 15 March 1995 into 8.5 l containers filled with sand–perlite (1:3, v/v), and supplied with half-strength recycling Hoagland solution. The plants were grown at ambient sunlight in a heated glasshouse where the temperature ranged between 16 and 33°C (mean minimum and maximum) for about 3 months. Addition of the above mentioned NaCl amounts were made to half-strength Hoagland solution 5 days after transplanting, when the plants had developed three true leaves. Gas exchange measurements were made every week on the upper fourth or fifth fully expanded leaf, between 9:30 and 10:30 a.m., using a portable gas exchange system (Li-6200, Li-Cor, USA). At the end of the sixth week, eight plants were randomly chosen from each treatment for plant height, total leaf area and dry weight measurements. In the same plants the sodium, chloride, and potassium concentration in the upper fully expanded leaves and the roots were determined. The number and the weight of fruits from eight plants of each treatment were recorded until the end of third month from salt addition.

2.4. Mineral analysis

Plant tissue samples were dried at 70°C for 48 h, finely ground and extracted with dilute nitric acid. Sodium and potassium concentrations of extracts were determined using a flame photometer (JENWAY, PEP-7) and chloride using a chloride meter (JENWAY, PCLM-3).

2.5. Data analysis

The layout of the experiment was in a complete randomized design. The data were subjected to ANOVA and Duncan's least significant difference (LSD) test to check the significance.

3. Results

3.1. Germination and seedling growth

External NaCl salinity up to 50 mM delayed germination but did not reduce the final percentage at the end of the test; at 100 and 150 mM the ability to germinate was reduced significantly in both hybrids (Fig. 1). Radicle elongation of germinated seeds was more affected than germination by salinity. The hybrid 'Lamuyo' was more affected than hybrid 'Sonar', showing a 50% reduction in radicle length at 50 mM NaCl at day 7 after starting the test (Table 1).

Only at 150 mM NaCl was the emergence of germinated seeds significantly affected by salinity; at day 17 after planting the seeds, a reduction of 15 and 25% in emerged seeds for hybrids 'Sonar' and 'Lamuyo', respectively, was observed compared with the other four salinity levels (Table 2). The seedling height and the total leaf area were significantly reduced at salinities higher than 10 mM NaCl, while the dry weight was affected at all salinity levels studied in both hybrids (Table 2).

3.2. Vegetative growth and yield

At vegetative growth stage (6 weeks after planting), the plant height, the leaf area and the dry weight were significantly reduced at salinities higher than 25 mM NaCl (Table 3) for both hybrids, the decrease being slightly higher for 'Lamuyo'. The plant height decreased significantly with increasing salinity, the reduction being 20, 31 and 44% of the control for 'Sonar' and 29, 40 and 49% of the control for 'Lamuyo' at 50, 100 and 150 Mm, respectively (Table 3). Total leaf area reductions were greater than those of height: 39, 56 and 70% of the control for 'Sonar' and 42, 66 and 82% of the control for 'Lamuyo' at 50, 100 and 150 mM, while total dry weight reductions for those salinities were smaller.

Fig. 1. Effect of NaCl salinity on seed germination percentage of two pepper hybrids over 7 day period.

Table 1

Radicle length of seed of pepper hybrids 'Sonar' and 'Lamuyo', germinated under increasing NaCl salinity^a

NaCl salinity (mM/l)	Radicle length ^b (mm)	
	Sonar	Lamuyo
0	21.15 (a)	21.16 (a)
10	21.29 (a)	19.54 (a)
25	19.63 (a)	13.63 (b)
50	14.38 (b)	10.25 (c)
100	6.17 (c)	6.45 (d)
150	1.38 (d)	0.84 (e)
LSD (5%)	1.84	2.52

^a Measurements were made 7 days after salt imposition.

^b Means in the same column followed by different letters indicate significant differences by Duncan's multiple range test at $P < 0.05$.

Table 2

Effects of NaCl salinity on the emergence and seedling growth of pepper hybrids ‘Sonar’ and ‘Lamuyo’^a

NaCl salinity (mM/l)	Sonar ^b				Lamuyo ^b			
	Emergence (%)	Height (cm)	Leaf area (cm ²)	Dry weight (g)	Emergence (%)	Height (cm)	Leaf area (cm ²)	Dry weight (g)
0	100.0 (a)	12.42 (a)	40.99 (a)	0.153 (a)	100.0 (a)	14.45 (a)	39.73 (a)	0.124 (a)
10	100.0 (a)	11.68 (a)	37.93 (a)	0.123 (b)	100.0 (a)	13.80 (a)	36.42 (a)	0.102 (b)
25	100.0 (a)	9.62 (b)	25.69 (b)	0.093 (c)	100.0 (a)	12.50 (b)	32.54 (b)	0.094 (c)
50	98.2 (a)	5.85 (c)	13.52 (c)	0.061 (d)	100.0 (a)	8.95 (c)	21.26 (c)	0.073 (d)
100	93.7 (a)	3.40 (d)	4.98 (d)	0.031 (e)	91.5 (a)	1.67 (d)	5.99 (d)	0.018 (e)
150	85.5 (b)	0.99 (e)	1.64 (e)	0.014 (f)	75.0 (b)	Y ^c	Y	0.003 (f)
LSD (5%)	7.2	0.92	3.38	0.012	8.1	0.70	3.27	0.011

^a The measurements were made on plants grown for 17 days in peat and watered by different nutrient solutions.

^b Means in the same column followed by different letters indicate significant differences by Duncan’s multiple range test at $P < 0.05$.

^c No aerial parts were developed.

Total fruit yield, number of fruits per plant and average fruit weight for both hybrids are presented in Table 4. From results of the control treatment, ‘Lamuyo’ appeared more productive than ‘Sonar’, due to a larger fruit load. However, total fruit yield decreased significantly with increasing salinity above 10 mM in both hybrids, the decrease being higher for ‘Lamuyo’. The number of fruits per plant was quite constant up to 50 mM in both hybrids and decreased significantly at higher salinities, while the average fresh fruit weight decreased significantly at salinities higher than 25 mM NaCl.

Table 3

Vegetative growth of ‘Sonar’ and ‘Lamuyo’ pepper hybrids grown at six salinity levels for 6 weeks

NaCl salinity (mM/l)	Sonar ^a			Lamuyo ^a		
	Plant height (cm)	Leaf area (cm ²)	Plant dry weight (g)	Plant height (cm)	Leaf area (cm ²)	Plant dry weight (g)
0	28.1 (a)	20.984 (a)	27.13 (a)	26.8 (a)	19.433 (a)	28.46 (a)
10	27.9 (a)	21.415 (a)	28.52 (a)	25.2 (a)	20.827 (a)	28.27 (a)
25	26.8 (a)	21.646 (a)	29.09 (a)	24.2 (a)	19.215 (a)	29.27 (a)
50	22.4 (b)	12.784 (b)	19.03 (b)	19.0 (b)	11.327 (b)	20.80 (b)
100	19.4 (c)	9.205 (c)	14.38 (c)	16.1 (b, c)	6.639 (c)	12.87 (c)
150	15.8 (d)	6.244 (d)	10.19 (d)	13.3 (c)	3.546 (c)	8.21c
LSD (5%)	1.46	1.209	1.59	1.39	2.312	1.72

^a Means in the same column followed by different letters indicate significant differences by Duncan’s multiple range test at $P < 0.05$.

Table 4

Total fruit yield of ‘Sonar’ and ‘Lamuyo’ pepper hybrids grown at six salinity levels for 3 months

NaCl salinity (mM/l)	Sonar ^a			Lamuyo ^a		
	Yield/ plant (kg)	Fruit number/plant	Average fruit weight (g)	Yield/ plant (kg)	Fruit number/plant	Average fruit weight (g)
0	1.43 (a)	15.6 (a)	91.7 (a)	1.73 (a)	19.3 (a)	89.6 (a)
10	1.44 (a)	16.1 (a)	89.4 (a)	1.78 (a)	19.8 (a)	89.9 (a)
25	1.19 (b)	14.2 (a)	84.1 (a)	1.36 (b)	16.2 (a, b)	83.9 (a)
50	0.87 (c)	13.5 (a, b)	64.4 (b)	0.89 (c)	15.0 (b)	59.3 (b)
100	0.45 (d)	11.3 (b)	43.7 (c)	0.37 (d)	9.3 (c)	39.7 (c)
150	0.11 (e)	4.8 (c)	22.9 (d)	0.08 (e)	5.1 (d)	15.7 (d)
LSD (5%)	0.12	2.1	8.4	0.14	2.5	7.2

^a Means in the same column followed by different letters indicate significant differences by Duncan’s multiple range test at $P<0.05$.

The marketable yield (fruit weight >80 g) was 94.4, 94.1, 93.2, 77.0 and 26.6% of the total yield for ‘Sonar’ for 0, 10, 25, 50 and 100 mM, respectively, while no marketable yield was harvested at 150 mM. For ‘Lamuyo’ marketable yield was 98.2, 96.6, 91.9 and 67.4% of the total for the 0, 10, 25 and 50 mM, respectively; at 100 and 150 mM, no marketable yield was harvested. For both hybrids the reduction in fruit number per plant contributed nearly as much to the yield reduction as did fruit weight (Table 4).

Marketable yield response to salinity of irrigation water was analyzed using the Maas–Hoffman linear model (Maas and Hoffman, 1977). The results obtained for both hybrids placed bell-pepper in the moderately salt-sensitive category. Both hybrids presented the same threshold value of 1.8 dS/m (Fig. 2). However, the

Fig. 2. Relative yield response of pepper hybrids to increasing external NaCl salinity using the Maas–Hoffman model.

Fig. 3. The effect of external NaCl salinity (mM) on Na^+ content of different plant tissues of pepper hybrids. Vertical bars represent $\pm$ S.E. of the means when larger than symbols ($n=6$).

slope (the rate of the yield reduction as salinity increased beyond threshold) was different; for 'Sonar' it was 8.4%, much lower than 14% given by Maas (1986), while for 'Lamuyo' it was 11.7%, close to 12.8% given by Sonneveld (1988) for greenhouse pepper. The average value for zero yield was 13.7 dS/m for 'Sonar' and 10.3 dS/m for 'Lamuyo'.

3.3. Tissue mineral content

Sodium concentration (% DW) was higher in roots than in leaves and increased significantly as salinity increased in both hybrids (Fig. 3). Leaf Na concentration was low and started to increase slightly above 25 mM in both hybrids. Chloride concentration in both leaves and roots increased with increasing salinity in both hybrids, being higher in most cases in the roots (Fig. 4). Salinity effects on K^+

Fig. 4. The effect of external NaCl salinity (mM) on Cl^- content of different plant tissues of pepper hybrids. Vertical bars represent $\pm$ S.E. of the means when larger than symbols ($n=6$).

Fig. 5. The effect of external NaCl salinity (mM) on K^+ content of different plant tissues of pepper hybrids. Vertical bars represent $\pm$ S.E. of the means when larger than symbols ($n=6$).

concentration were less evident than those of Na and Cl. The concentration of K in leaves was not significantly influenced by salinity, while roots exhibited lower K concentration than the leaves with the trend to decrease with increasing salinity of nutrient solution (Fig. 5).

3.4. Leaf photosynthetic characteristics

The photosynthetic rate at 25 and 50 mM salinity levels, measured on five successive weeks after salinization, was almost the same as that of the control plants (data not shown). Plants salinized at 100 and 150 mM NaCl showed a reduction of 32 and 48% for 'Sonar' and 37 and 55% for 'Lamuyo', respectively, on week 5 (Table 5).

Table 5

Photosynthesis (P_n), stomatal conductance (g_s) and WUE of fully expanded leaves of pepper hybrids 'Sonar' and 'Lamuyo' 5 weeks after salinization^a

NaCl salinity (mM/l)	Sonar			Lamuyo ^b		
	P_n ($\mu\text{mol m}^{-2} \text{s}^{-1}$)	g_s (cm s^{-1})	WUE ^b	P_n ($\mu\text{mol m}^{-2} \text{s}^{-1}$)	g_s (cm s^{-1})	WUE ^b
0	13.9 $\pm$ 0.9	0.52 $\pm$ 0.14	5.01 (a)	14.0 $\pm$ 1.0	0.63 $\pm$ 0.11	4.30 (a)
25	13.6 $\pm$ 1.0	0.48 $\pm$ 0.13	4.86 (a)	13.4 $\pm$ 1.4	0.61 $\pm$ 0.14	4.12 (a)
50	12.4 $\pm$ 1.3	0.41 $\pm$ 0.07	4.95 (a)	12.8 $\pm$ 1.2	0.57 $\pm$ 0.12	4.18 (a)
100	9.5 $\pm$ 1.4	0.29 $\pm$ 0.05	6.29 (b)	8.9 $\pm$ 1.3	0.32 $\pm$ 0.10	5.52 (b)
150	7.3 $\pm$ 1.2	0.22 $\pm$ 0.04	6.88 (c)	6.3 $\pm$ 1.4	0.23 $\pm$ 0.05	6.05 (b)

^a Conditions were: CO_2 , 360 mbar; O_2 , 21% (vol.%); PPFD, 950–1100 $\pm$ 120 $\mu\text{mol m}^{-2} \text{s}^{-1}$; air temperature, 27 $\pm$ 2°C. Values are means $\pm$ S.D. ($n=6$).

^b Means in the same column followed by different letters indicate significant differences by Duncan's multiple range test at $P<0.05$.

The decline in photosynthesis was associated with a large reduction in stomatal conductance at increased salinity levels. The water use efficiency (WUE), estimated as the ratio of CO₂ uptake to H₂O loss, increased by 25 and 40% under the severe salt stress (Table 5).

4. Discussion

Growth medium salinity may affect seed germination by decreasing the ease with which the seeds take up water because of while the activity and events normally associated with germination get either delayed and/or proceed at a reduced rate. NaCl salinity may also affect germination by facilitating the intake of toxic ions, which may cause change of certain enzymatic or hormonal activities of the seed (Smith and Comb, 1991). These physico-chemical effects upon the seed seem to result in a slower and/or lower rate of germination.

Salinity affected seedlings growth more than seed germination. Hence, seedling emergence was reduced significantly only at 150 mM NaCl, while seedling growth expressed as height, leaf area and dry weight was reduced when external salinity exceeded 10 mM NaCl (Table 2). The reduction in growth could be a combined effect of osmotic stress (Greenway and Munns, 1980), which is more harmful to plants during the succulent seedling stage and the higher ion uptake (Dumbroff and Cooper, 1974). Rhoades (1990) reported that some plants are relatively tolerant during germination, but become more sensitive during emergence and early seedling stages. This is the case for both pepper hybrids and thus any failure at this stage will reduce the plant stand. From the above results, it can be concluded that seedlings grown at intermediate salinities (25 mM NaCl) and showing vegetative characteristics similar to those of the control will behave adequately after transplantation.

Reduced growth was the only visible plant response to salt stress up to 50 mM NaCl. None of the hybrids showed symptoms that would indicate ion toxicity. At 100 mM NaCl and especially 150 mM NaCl the reduction was more pronounced and accompanied by toxicity symptoms in lower leaves (chlorosis and burning of leaf margins). The effect of salinity on leaf area of 6-week plants was greater than that on plant height and dry weight (Table 3). The decline in leaf growth is the earliest response of glycophytes exposed to salt stress (Munns and Termaat, 1986). Wignarajah et al. (1975) reported that in beans high NaCl levels inhibited leaf expansion, and it was largely due to an inhibition of cell division rather than to cell expansion. Furthermore, at high salinity levels (100 and 150 mM NaCl) leaf abscission contributes to the reduced pepper leaf area (data not shown). This is caused by ion accumulation in the leaves, particularly the old ones (Greenway and Munns, 1980).

Inhibition of vegetative growth and yield in both pepper hybrids at high salinity levels is associated with marked inhibition of photosynthesis (Table 5). A more detailed study (Nieman et al., 1988) suggests that the salt stress reduced the growth of pepper because it reduced assimilation of photosynthate, possibly a consequence of reduced UDPG, UTP and ATP pools in the growing leaves. In our study, there was partial closure of stomates, as evidenced by the decline in stomata conductance at those salinity levels (Table 5), that could have caused the reduction in photosynthesis. However, Bethke and Drew (1992), who investigated the cause of photosynthesis reduction in pepper under salt stress, concluded that reductions in photosynthesis are primarily at non-stomatal, biochemical level and closely correlated with the concentration of both Na^+ and Cl^- in leaf tissue. The increased concentration of both ions recorded in our experiment at high salinity levels (Figs. 3 and 4) may be related with the reduced rates of photosynthesis. On the other hand, the WUE increased under the severe salt stress (Table 5). This is because salinity reduced water loss more than it reduced carbon gain. The increase in WUE, induced by stomatal reduction in transpiration rate, is considered to be an adaptive response of the plant to salinity, which is then capable of reducing the amount of solution uptake and thus the solutes accumulated in the plant for each unit of fixed carbon (Brungoli, 1992).

Salt tolerance in glycophytes is associated with the ability to limit uptake and/or transport of saline ions (mainly Na^+ and Cl^-) from the root zone to aerial parts (Greenway and Munns, 1980). Our data (Fig. 3) suggest this occurs in pepper. The accumulation of Na^+ in roots provides a mechanism for pepper to cope with salinity in rooting medium and/or may indicate the existence of an inhibition mechanism of Na^+ transport to leaves. In a recent work Zandstra-Plom et al. (1998) studied the sodium fluxes in sweet pepper plants grown under mild salt stress (15 mM NaCl). They also found that sodium is preferably accumulated in roots and in pith cells in the lower part of the stem, which play a decisive role in the re-circulation of sodium throughout the plant. A similar behavior has been reported for other glycophytes including beans (Seeman and Critchley, 1985) and squash (Graifenberg et al., 1996). In contrast to Na, Cl^- concentration in leaves increased almost linearly with salinity, showing that pepper is unable to exclude Cl^- ions from the leaves (Fig. 4). As a result, leaf Cl^- accumulation exceeded that of Na^+ for all treatments (see also Bethke and Drew, 1992). The higher concentration of Cl^- than Na^+ may result from different capabilities for compartmentation of these ions in the vacuoles. Non-halophytes appear to be able to accumulate Cl^- in the vacuoles of their cells, but many are deficient in the mechanisms needed for Na^+ inclusion in the vacuoles (Mennen et al., 1990).

Although under saline conditions the K^+ content in many glycophytes is severely reduced (Greenway and Munns, 1980), salinity led only to a decrease in

K^+ concentration of roots in pepper plants. This may have resulted from substitution of Na^+ for K^+ , or increased K^+ efflux out of the roots to the surrounding medium (Lynch and Lauchli, 1984; Cramer et al., 1985). Similar results have been reported by Gomez et al. (1996) and Cornillon and Palloix (1997). The K^+ concentration in leaves of both hybrids was not affected by salinity (Fig. 5). This suggests that pepper plants are able to maintain high K^+ levels in leaf lamina, and that this may act as the major monovalent cationic osmoticum in the presence of external salt. The decrease of K^+ recorded in pepper root, which resulted in low K/Na ratio, may also provide a mechanism by which pepper achieves ionic balance following uptake of high Na^+ concentrations in roots (Slama, 1986; Storey and Wyn-Jones, 1978). Thus sodium exclusion from leaf lamina combined with the ability to maintain relatively a high K concentration in leaves may provide pepper with a successful mechanism for tolerance to low and moderate salinity levels.

Our results indicate that in both hybrids salinity-associated decrease in yield started at the same salinity level in rooting medium of 1.8 dS/m, which is slightly higher than 1.5 dS/m estimated by Maas (1986). However, since the rate of yield reduction of the cv ‘Sonar’ is lower than that of cv ‘Lamuyo’, we can conclude that cv ‘Sonar’ is more suitable, when saline water should be used for irrigation. Furthermore, such work is useful for plant breeders by proposing early tests for screening new or existing hybrids for their tolerance to salt.

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