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Effect of salt stress on morphological characters of mango rootstocks

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Abstract
A pot culture experiment was conducted during 2015 – 2016 at College Orchard, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore for the identification of salt-tolerant rootstocks in mango. The experiment was laid out under Factorial Completely Randomized Design (FCRD) with two replications. The rootstocks involved in the study are Alphonso, Banganapalli, Sendhuram, Neelum and Bangalora. Three levels of salt concentration 25 mM NaCl, 50 mM NaCl and 75 mM NaCl along with one control were applied. The above-mentioned salinity levels were imposed by application of the salt water to the respective plots (seedlings grown in polybags) upto 90 days at an interval of 2 -3 days depending upon moisture availability. The results indicated that in general, with increasing salt levels, all the morphological parameters like plant height, stem girth, number of leaves, leaf area and specific leaf weight were proportionately reduced in all the rootstocks studied. However, among the rootstocks, the Alphonso rootstocks expressed a mild decrease in the above-said parameters with increasing salt levels. On the other side, Bangalora rootstocks seemed to be very sensitive to salinity which has registered greater reduction in the growth parameters. Regarding 'salinity damage score' the maximum value was recorded by Bangalora (5.00) whereas, the minimum value was recorded by Alphonso (2.70) followed by Neelum (2.99) at 75 mM NaCl concentrations.

Keywords: salt stress, morphological characters, mango rootstocks

Introduction
Mango (*Mangifera indica* L.) belonging to the family Anacardiaceae, is an important fruit crop of the tropical and subtropical regions being grown in more than 100 countries of the world (Purseglove, 1972) [12]. Mango is very sensitive to soil salinity at younger stage (Srivastav *et al*., 2007) [14]. Its production is hampered due to restricted growth of the plant, root expansion hampered, low success and survivability due to high salinity (Roy *et al*., 2014) [13]. With the increasing population and continuous pressure on agricultural land, it has now become necessity to find out a practical solution for the effective harnessing of salt-affected soils for stepping up the production. For tackling the problem of soil salinity, it would be appropriate to develop salt tolerant rootstocks instead of going for soil reclamation (Dubey *et al*., 2006) [3]. Propagation through seed is abandoned long time back due to the genetic variability expressed by seedling progenies. As an alternative, mango has been propagated through grafting where rootstock is an important component. Since rootstocks form the basal component which faces all the stress situations, like drought, salinity etc., it is high time that rootstocks with tolerance to these abiotic stresses have to be developed. Although many workers have studied the effect of salinity on mango, very little efforts have been made to identify rootstocks tolerant to different composition of salts. Hoult *et al.* (1996) [4] opined that salt toxicity leads to limited mango productivity in arid environments. So, it is necessary to utilize salinity-tolerant rootstocks in mango for grafting programme in order to mitigate this problem. Keeping this view under consideration, we investigated the morphological characters of five indigenous mango rootstocks to determine the differences in growth and development of seedlings under salinity conditions.

Materials and Methods
The pot culture experiment was conducted with four levels of NaCl, *i.e.*, 0.0 mM NaCl (Tap water), 25, 50 and 75 mM NaCl on five different mango rootstocks, namely, Alphonso, Banganapalli, Sendhuram, Neelum and Bangalora.

Plants were screened for salt stress under semiprotected condition upto three months. Fully matured stones from healthy mango fruits were collected and utilized for raising the seedlings. Stones were washed and cleaned to remove the adhering pulp and dipped in water. Floated stones were discarded and only sunken stones were used as seed material. The mango seedlings were transplanted from raised nursery beds and planted in polybags of size 40 x 30 cm. The bags were filled with 5 kg potting mixture containing sand, soil and FYM in the ratio of 1:2:1. Bags were provided with punched drain holes at the bottom for drainage. The control plants were irrigated with water without any added NaCl (EC = 1.6 dSm^{-1} and pH- 6.8).

Plant height, Stem girth and No. of leaves per plant were measured after 90 days of salt treatments and leaf area was measured by using a standard leaf area meter (Model LiCOR 3000). The specific leaf weight (SLW) was estimated by the method of Pearce *et al.* (1968) [11]. To assess the foliar symptoms due to salt stress, scoring was done using a scale of 1-5 with plants showing no symptoms being scored as 1 and those with maximum foliar damage as 5 as given below (modified from Lee, 1995) [6].

The experiments were arranged in a factorial completely randomized design with two replicates. The obtained data were statistically analysed using LSD at 0.05.

S. No.	Extent of salinity damage	Given score
A	No visible salinity damage to leaves	1
B	Slight salinity damage to leaves (25% marginal scorching of leaves)	2
C	Moderate salinity damage to leaves (50% scorching and yellowing of leaves)	3
D	High salinity damage to leaves (75% scorching, yellowing and drying of leaves)	4
E	Severe salinity damage to leaves, almost all leaves were drying (100% drying of leaves)	5

Results and Discussion

Mango rootstocks showed significant differences for plant height and stem girth (Table 1). The plant height observed at 90 days after salt treatment was significantly influenced by both rootstocks and salt treatments. Among the rootstocks, all the rootstocks were found to be significantly different from each other. The highest value was recorded by Alphonso (28.93 cm) followed by Neelum (22.83 cm) and the least value was recorded by Bangalora (17.57 cm) which was on par with Sendhuram (17.78 cm). The mean plant height in various salt concentrations was also significantly different from each other, whereas the mean plant height ranged from 16.10 cm (75 mM NaCl) to 28.28 cm (0 mM NaCl). Regarding the interaction effect, significant differences were observed between them like the main effect. The highest plant height was recorded in Alphonso (32.72 cm) under 75 mM NaCl treatments, whereas the least plant height was recorded in Bangalora (10.76 cm) under the same treatment. The reduction in growth might be due to the toxic effect of salt, disturbing the plant growth and causing leaf injury and reduction in the uptake of major nutrients. The findings of the experiment are in accordance with the results of study conducted by Srivastav *et al.* (2007) [14] in Mango.

Under salt stress condition, the middle lamella gets damaged which leads to reduction in stem girth. In the present investigation, it was found that the least reduction in stem girth was observed in Alphonso rootstocks and the highest reduction in stem girth was recorded in Bangalora rootstocks under 75 mM salt treatments. The findings of the experiment are in accordance with results of study conducted by Verslues *et al*. (2006) and Roy e*t al*., 2014 [13] in mango. Comparing the performance of different rootstocks, the cultivar Alphonso registered higher number of leaves and the lower number of leaves was recorded by Bangalora rootstocks at higher levels of salt (75 mM NaCl). Munns (1993) [7] indicated that salt in plants reduces growth by causing premature senescence of old leaves and hence reduced supply of assimilates to growing regions. Sensitive cultivars accumulate ions more quickly than tolerant cultivars and this ion accumulation leads to leaf death and progressively death of the plant. Similar observations were made by Pandey *et al*. (2014) [10] with different polyembroynic varieties of mango where higher number of leaves was recorded by tolerant rootstock 'Olour'.

The leaf area in rootstocks was found to be significantly different from each other, where the highest mean leaf area (66.22 cm^2) was recorded in Alphonso and the least mean leaf area (53.38 cm^2) was observed in Bangalora. The mean leaf area in various salt concentrations was also significantly different from each other, where the highest leaf area (98.10 cm^2) was registered by 0 mM NaCl treatments and the lowest leaf area (34.87 cm^2) was recorded in 75 mM NaCl treatments. Significant differences were observed in the interaction effect between rootstocks and salt levels. The higher leaf area (40.89 cm^2) was recorded in Alphonso and the lower leaf area (24.74 cm^2) was recorded in Bangalora under 75 mM NaCl treatments. The reduction in leaf area under different concentrations of salt treatment could be due to the reduced development and differentiation of tissues, shrinkage of the cell contents, unbalanced nutrition, damage of membrane and disturbed 'avoidance mechanism'(Khayyat *et al*., 2014) [5].

'Specific leaf weight' is a measure of thickness of leaf. Thick leaves usually have a high chlorophyll content and a higher content of photosynthetic enzymes per unit leaf area. In the present study, a comparison of SLW indicates that SLW of Alphonso and Neelum were generally higher than the other rootstocks studied and these rootstocks exhibited tolerance to salinity levels. Even at a higher concentration of salinity (75 mM NaCl), Alphonso (0.40 mg cm^{-2}) recorded better values for specific leaf weight as compared to Bangalora (0.22 mg cm^{-2}) and Sendhuram (0.25 mg cm^{-2}) rootstocks. The findings of the experiment are in accordance with results of study conducted by Anusuya (2014) [1] in banana.

The salinity damage score observed after imposing salt stress was significantly influenced by both rootstocks and salt treatments (Table 1). In the case of rootstocks, the maximum salinity damage score was observed in Bangalora (3.90), followed by Sendhuram (3.13), whereas minimum salinity damage score was found in Alphonso (1.95). Among the salinity levels, 0 mM NaCl recorded no salinity damage, in which plants remained in healthy condition. At 50 mM NaCl level, the minimum damage score was observed in variety Alphonso (2.33), whereas the maximum damage was recorded in Bangalora (4.98). At 75 mM NaCl concentration, rootstock Alphonso (2.70) recorded minimum salinity damage, whereas maximum salinity damage was recorded in Bangalora (5.00) over control. Higher damage with score more than 4 was also observed in rootstocks Sendhuram and Bangalora.

The leaf injury could be due to the accumulation of toxic levels of Cl^- and Na^+, ion imbalance, nutrient deficiencies and water stress. The transport of Cl^- ions takes place mainly in the transpiration stream, which explains the presence of high concentration of these ions in leaves and the subsequent salt injury. Munns (2002) [8] also reported that, ionic stress results in premature senescence of older leaves and toxicity symptoms (chlorosis, necrosis) in mature leaves. Similar observations were reported by Bar *et al*. (1998) [2], Neocleous and Vasilakakis (2007) [9] and Tanveer *et al*. (2009) [15] where higher leaf injury was recorded with increasing level of salt concentrations.

Based on overall performance of morphological parameters, it can be concluded that salinity tolerance increased in the following order Bangalora < Sendhuram < Banganapalli < Neelum < Alphonso rootstocks.

Table 1: Effects of rootstock and NaCl stress on plant height, stem girth, number of leaves per plant, leaf area per plant, specific leaf weight (SLW) and salinity damage score (SDS) in mango seedlings.

Treatment		Plant height (cm)	Stem girth (mm)	No. of leaves plant $^{-1}$	Leaf area plant $^{-1}$	SLW (mg cm^{-2})	SDS
Rootstocks	NaCl (mM)						
Alphonso	0	32.72	6.38	13.75	99.85	0.50	1.00
	25	30.10	5.83	12.00	71.31	0.48	1.80
	50	27.40	5.63	10.63	52.83	0.45	2.33
	75	25.50	4.72	9.63	40.89	0.40	2.70
Banganapalli	0	27.74	6.79	11.38	96.04	0.48	1.00
	25	19.58	5.82	10.38	53.11	0.47	2.30
	50	17.80	5.25	8.88	48.58	0.44	2.81
	75	15.13	4.85	6.88	35.60	0.33	3.51
Sendhuram	0	25.69	6.72	10.25	101.43	0.42	1.00
	25	18.29	5.67	8.63	58.08	0.38	2.83
	50	15.61	5.46	6.38	45.53	0.33	4.08
	75	11.55	4.79	5.00	38.50	0.25	4.61
Neelum	0	28.74	6.75	12.00	97.43	0.48	1.00
	25	24.39	6.22	11.13	66.41	0.46	2.01
	50	20.65	5.20	9.38	51.24	0.40	2.44
	75	17.56	4.59	7.13	34.60	0.36	2.99
Bangalora	0	26.53	6.65	11.25	95.77	0.45	1.00
	25	19.33	6.28	7.88	53.31	0.37	4.61
	50	13.69	5.19	5.63	39.70	0.28	4.98
	75	10.76	4.13	4.00	24.74	0.22	5.00
CD (p=0.05)		0.70	0.27	1.09	2.47	0.03	0.13

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