Pak. J. Bot., 52(4): 1143-1158, 2020. DOI: http://dx.doi.org/10.30848/PJB2020-4(11)

PERFORMANCE OF MANGO SCION CULTIVARS UNDER VARIOUS LEVELS OF ARTIFICIALLY INDUCED SALINITY STRESS

NIAZ AHMED[1], SARA KHALID[1], ABDUL GHAFFAR GREWAL[3], MUHAMMAD ARIF ALI[1], MUHAMMAD AKBAR ANJUM[2], ASHFAQ AHMAD RAHI[4] AND SUBHAN DANISH[1]

[1]*Department of Soil Science, Faculty of Agricultural Sciences and Technology, Bahauddin Zakariya University, Multan-60800, Pakistan*
[2]*Department of Horticulture, Faculty of Agricultural Sciences and Technology, Bahauddin Zakariya University, Multan-60800, Pakistan*
[3]*Mango Research Station, Shujaabad, Multan, 60800, Punjab, Pakistan*
[4]*Pesticide Quality Control Laboratory, Multan, 60000 Punjab, Pakistan*
[*]*Corresponding author: niaz.ahmad@bzu.pk*

Abstract

Continuous use of poor quality of irrigation has played an imperative role in the development of soil salinization in arid and semi-arid areas of the world. Besides the application of various physical, chemical and biological amendments, identification and cultivation of salts tolerant species is a promising solution to ensure crops cultivation under adverse saline condition. A lot of work has been documented so far, on reduction in growth and yield of different crops under salinity stress. However, identification and cultivation of salinity tolerant mango cultivars (cv's.) have not received appreciable attention. Therefore, the current study was conducted to evaluate salinity tolerance among various mango cv's. Eighteen months old seedlings of 8 mango cultivars (Langra, Anwar Retaul No. 12, Sufaid Chaunsa, Anwar Retaul, Aman Dusehri, Fajri, Samar Bahisht Chaunsa and Sindhri) grafted on desi (sucking type) mango irrigated with irrigation water under different levels of salinity (15, 30, 45, 60, 75 and 90mM NaCl). Tap water (TW) was used as control. Results confirmed that scion height, rootstock height, number of leaves, scion dry weight, rootstock fresh and dry weighs were significantly greater in cv. Langra as compared to Sindhri at 15, 30, 45, 60, 75 and 90 mM NaCl. A significant improvement of 0.78, 1.12, 1.17, 1.62, 2.20, 2.14 and 2.40-fold in chlorophyll content validated the salinity tolerant competency of Langra comparative to Sindhri at TW, 15, 30, 45, 60, 75 and 90 mM NaCl respectively. Less electrolyte leakage while significant improvement in relative water content, stomatal conductance and transpiration rate confirmed that cv. Langra has more tolerant, while Sindhri is sensitive towards salinity stress.

Key words: Chlorophyll content, Gas exchange attributes, Irrigation water, *Mangifera indica*, Morphological attributes, Salinity.

Introduction

Mango (*Mangifera indica* L.) is an important fruit crop being grown in more than 110 countries located in tropical and subtropical regions. Indo-Burma region is considered the center of origin for mango cultivation (Singh, 1976). It is now cultivated and produced on a commercial scale in India, China, Thailand, Indonesia, Mexico, Philippines, Pakistan, Nigeria, Guinea and Brazil. Because of its diverse flavor, taste and shades of color, it is rightly called as king of fruits (Anees *et al*., 2011; Anon., 2013; Kumar *et al*., 2017).

Mango is a tropical tree, but it can endures a wide range of temperatures. It grows well both in low (25 cm) and high (250 cm) rainfall areas (Majumder & Sharma, 1985). Though mango has adapted to both tropical and subtropical climatic conditions, it performs well in regions from sea level to 600 m altitude (Laxman *et al*., 2016). In India, mango has adapted to the varied climatic conditions from the tropically south to the sub-mountainous regions of north India (30 N) and altitudes up to 1400m (Majumder & Sharma, 1985; Laxman *et al*., 2016).

In Pakistan, the area under mango cultivation is 167.5 thousand hectares with an annual production of 1,732 thousand tones being the second major fruit crop of Pakistan after citrus. It is also ranked 4th in world production. Pakistan contributes 7.38 % of the total mango trade across the world (Anon., 2005). The average yield of Pakistan is 11.20 tons/ha which is below world average. In Pakistan, more than 110 varieties are being planted that made Pakistan 5th largest producer of mango in the world (Pakistan Observer, 2017). The more common cultivars are Sindhri, Samar Bahisht Chaunsa, Aman Dusehri, Malda, Fajri, Anwar Retaul, Langra etc. Both in domestic and international markets, Samar Bahisht Chaunsa and Sindhri are considered as good varieties in term of taste and demand (Ghafoor *et al*., 2010; Baloch *et al.,* 2017). However, the adverse effects of salinity on the physiology of mango ultimately lead to growth suppression and poor yield (Anon., 2005).

It is documented that mango generally accumulates 2.5-3.0 times more sodium than other species in both old and young leaves (Samra, 1985), yet it is sensitive to saline conditions (Maas & Grattan, 1999), that results in scorched leaf tips and margins, leaf curling, reduced growth, abscission of leaves and death of trees (Schaffer *et al*., 1994). Salt stress also affects physiological parameters, viz. water potential, stomatal conductance and photosynthesis in leaves (Laxman *et al*., 2016). Typically, growth decreases more or less linearly as salinity increases beyond a threshold level (Heuvelink *et al*., 2003). However, information regarding salt tolerance of mango rootstocks is still lacking, particularly in terms of salinity influence on mango fruit yield (Ayers & Westcot, 1985; Maas & Grattan, 1999; Mustaq *et al*., 2019).

The salinity level of more than 0.2% adversely influenced the uptake of nutrients (Ahmed and Ahmed, 1997). Higher chloride ion concentration in soil caused reduction in the nitrogen content of mango leaves than by SO_4 ions (Jindal *et al*., 1979a; b), which might be due to their specific effect on inhibition of NO_3 absorption and higher absorption of ammonium. The uptake of N, P, K, Ca, Mg, Zn and Fe were also adversely affected by increasing levels of salinity (Schmutz & Ludders, 1994). Saline water ranging from 0.7 to 5.7 dS m^{-1} EC also caused reductions in N, K, Ca and Mg contents in leaves but did not affect the contents of P and S. However, there are some rootstocks that have potential to perform better under saline conditions i.e. rootstock, Espada, that can reatin higher Na and P (Silva *et al*., 2004).

Therefore, the current study was conducted with the aim to find out salt tolerant cultivars of mango that can perform well on Desi (sucking type) rootstock under saline conditions in Pakistan.

Material and Methods

Experimental site: A pot culture experiment was conducted in the wire-house of Faculty of Agricultural Science and Technology Bahauddin Zakariya University, Multan.

Mango cultivar collection: Grafted plants of eight mango cultivars i.e., Langra, Anwar Retual No. 12, Sufaid Chaunsa, Anwar Retual, Aman Dusehri, Fijri, Samar Bahisht Chaunsa and Sindhri were collected from Mango Research Institute Multan. The age of grafted cultivars was 18 months ± 5 days. All cultivars were grafted on Desi (sucking type). Selection of grafted plants was done manually on the basis of uniform height, scion and rootstock diameter.

Artificial salinity development: The study includes seven levels of salinity developed by addition of analytical grade NaCl salt in deionized water. In each pot one-liter of artificially developed saline water was added after every four days according to the treatment plan. However, in control watering was done with tap water having EC 0.69 dS m^{-1}.

Potting medium and nutrients application: The plants were raised in in plastic pots containing 10 kg potting medium. The composition of potting medium was sugarcane baggase + silt + coconut fiber in a ratio of 65:30:5 (w/w). The chemical properties of the medium were as; pH = 7.5, EC = 2.35 dSm^{-1}, Extractable P = 85 mg kg^{-1}, Extractable K = 2162 mg kg^{-1}, Extractable Fe 3.98 mg kg^{-1}, Extractable Zn = 0.74 mg kg^{-1}, Extractable Mn = 1.60 mg kg^{-1} and Cu = 0.13 mg kg^{-1}. To fulfil the requirement of macro and micronutrients half-strength Hoagland nutrient solution was applied (Hoagland & Arnon, 1950) throughout the experiment.

Experimental design and treatments: There were seven different levels of irrigation water salinity which included control = tap water (TW), 15, 30, 45, 60, 75 and 90 mM NaCl containing water applied to the plants of eight mango cultivars. The experiment was arranged 2 factorials completely randomized design (CRD) with 3 replicas.

Harvesting: After 120 days of treatments application, plants were harvested. Initially, plants were separated into leaves, roots, rootstock and shoots (scion). After that samples were washed with distilled water, blotted and dried at room temperature. Fresh weight of scion, rootstock, leaves and roots were noted on top balance. For measurement of height measuring tape was used. For diameter, Vernier calliper was used. The collected plant samples were initially weighted on balance to determined fresh weight. After that oven drying was done at 80ºC for 72h to achieve constant weight for dry weight assessment and further chemical analyses.

Electrolyte leakage (EL): Electrolyte leakage was determined by using an electrical conductivity meter (CC-501, Elmetron, and Zabrze, Poland). From the youngest fully expanded leaf, six leaf discs were taken randomly from whole leaves. After collection, leaf discs were washed with distilled water three times to remove the contaminations. Leaf discs were then taken in a test tube having 10 ml of distilled water. At room temperature samples were incubated for 24 h on a shaker. After the incubation, the first electrical conductivity (EC1) of the solution was measured. The same samples were autoclave for 20 min at 120ºC and second electrical conductivity (EC2) was taken after cooling the solution at room temperature. By using the equation of Lutts *et al*., (1995) electrolyte leakage was calculated:

$$\text{Electrolyte leakage (\%)} = \frac{\text{EC2} - \text{EC1}}{\text{EC1}} \times 100$$

Relative water content (RWC) of leaves: From the youngest fully-expanded leaf, 3 to 5 leaf discs of 1 cm diameter were cut using the leaf punch. Then weighed the leaf discs and washed 3 times with distilled water to remove the contaminants and placed into a 10 ml conical flask. Leaf discs were sink in 10 ml distilled water at 4 ºC for 40 h in dark. Turgid mass of the leaf discs was recorded and samples were dried in an oven at 80 ºC until permanent dry mass was achieved (Almeselmani *et al*., 2011). The following formula was used to estimate RWC of leaves.

$$\text{RWC (\%)} = \frac{\text{FM} - \text{DM}}{(\text{TM} - \text{DM})} \times 100$$

where, FM is fresh mass, DM is dry mass and TM is turgid mass.

Chlorophyll content: Total chlorophyll content was determined according to Arnon (1949). Initially, 0.5g of leaf discs were crushed in 80% solution. After filtration, the desired volume of 20 ml was made with acetone. Finally, absorbance was taken at 645 and 663nm for calculation of total chlorophyll.

$$\text{Total chlorophyll } (\text{mg g}^{-1}\text{ FW}) = \frac{(20.2 \times \text{OD645}) + (8.02 \times \text{OD 663})\text{V}}{1000\text{ (W)}}$$

where

V = Final volume made

W = Gram of fresh leaf sample

FW = Fresh weight

Gas-exchange parameters: For 3 min using a portable photosynthetic system (LI-6200, LI-COR Inc., Lincoln, NE, USA) the transpiration rate, internal CO_2, net photosynthetic rate and stomatal conductance were measured from 9:00-11:00 am. A top fully expanded leaf was taken and put into the leaf chamber and observations were recorded when atmospheric CO_2 concentration and RH reached a stable value.

Statistical analysis: Statistical analysis was performed following standard statistical procedure (Steel *et al*., 1997). Two factorial ANOVA was applied to examine the significance of treatments. For comparison, Tukey's test was applied at $p \leq 0.05$.

Results

Both main and interactive effects of mango cultivars and various levels of soil salinity differed significantly for scion and rootstock height. For scion height (Fig. 1), Langra performed significantly better comparative to all other cultivars at control (Tap water). However, at 15 and 30 mM NaCl Langra and Aman Dusehri remained statistically alike to each other but differed significantly as compared to Sindhri. However, Langra remained significantly better at 45, 60 and 70 mM NaCl as compared to Sindhri. However, all the cultivars remained statistically alike to each other at 90 mM NaCl level for scion height. The maximum increase of 109, 71.4, 72.9, 90.7, 76.0 and 67.6% in scion height of Langra was noted comparative to Sindhri at TW, 15, 30, 45, 60 and 75 mM NaCl respectively. For rootstock height (Fig. 2), Langra. Sufaid Chaunsa, Anwar Retual, Fajri and Samar Bahisht Chaunsa remained statistically alike to each other but differed significantly comparative to Sindhri. At 15 and 30 mM NaCl, all the mango cultivars remained significantly better except Anwar Retaul No. 12 as compared to Sindhri for rootstock height. However, at 45 mM NaCl all the mango cultivars differed significantly better except Anwar Retaul No. 12 and Fajri as compared to Sindhri for rootstock height. It was noted that Langra and Samar Bahisht Chaunsa performed significantly better comparative to Fajri and Sindhri for rootstock height. However, Langra remained significantly best at 75 and 90 mM NaCl for rootstock height as compared to Sindhri. Maximum increase of 49.5, 43.7, 52.4, 53.1, 46.9, 87.3 and 92.6% in rootstock height of Langra was noted comparative to Sindhri at TW, 15, 30, 45, 60, 75 and 90 mM NaCl respectively.

Both main and interactive effects of mango cultivars and various levels of soil salinity differed significantly for scion and rootstock diameter. For scion diameter (Fig. 3), no significant difference was observed among cultivars when irrigated with tap water. At 15 mM NaCl, Langra, Anwar Retaul No. 12, Sufaid Chaunsa and Anwar Retaul remained statistically alike to each other but differed significantly from Sindhri for scion diameter. Both Langra and Sufaid Chaunsa remained significantly best comparative to Sindhri for scion diameter at 30 mM NaCl salinity level. However, at 45, 60 and 70 mM NaCl salinity levels, Langra differed significantly from Sindhri. It was observed that all the cultivars remained statistically alike to each other at 90 mM NaCl salinity level for scion diameter. Maximum increase of 53.0, 68.2, 68.2, 75.0 and 78.9% in scion diameter of Langra was noted comparative to Sindhri at 15, 30, 45, 60 and 75 mM NaCl salinity levels respectively. For rootstock diameter (Fig. 4), no significant difference was observed among the cultivars when irrigated with tap water and salinity levels 75 and 90 mM NaCl. It was observed that Langra performed significantly better comparative to Sindhri at salinity levels 15, 30 and 45 mM. At 60 mM NaCl, Langra and Sufaid Chaunsa both remained statistically alike to each other but differed significantly as compared to Sindhri. The maximum increase of 73.3, 78.6, 127.3 and 109.1% in rootstock diameter of Langra was noted comparative to Sindhri at 15, 30, 45 and 60 mM NaCl salinity levels respectively.

Both main and interactive effects of mango cultivars and various levels of soil salinity were found statistically significant for scion and rootstock fresh weighs (Table 1). For scion fresh weight, Langra and Sufaid Chaunsa performed significantly better comparative to all other mango cultivars when irrigated with tap water. At 15 mM NaCl salinity level, Langra performed significantly better comparative to all other mango cultivars for scion fresh weight. Langra, Sufaid Chaunsa and Fajri did not differ significantly for scion fresh weight but they differed significantly from all other mango cultivars at 30 mM NaCl salinity level. Langra, Anwar Retaul No. 12, Samar Bahisht Chaunsa and Anwar Retaul remained statistically alike to each other but only Langra and Anwar Retaul No. 12 performed significantly better comparative to Aman Dusehri and Sindhri for fresh weight of scion. No significant change was observed in scion fresh weight of different mango cultivars at 60, 75 and 90 mM NaCl salinity levels. Maximum increase of 47, 195, 161 and 285% in fresh weight of scion of Langra was noted comparative to Sindhri when irrigated with tape water, salinity levels 15, 30 and 45 mM NaCl respectively. For rootstock fresh weight, no significant change was noted among all the mango cultivars when irrigated with tap water and salinity level 15 mM NaCl. However, all the cultivars remained statistically similar to each other but performed significantly better comparative to Sindhri for rootstock fresh weight at salinity levels 30, 45 and 60 mM NaCl. At salinity levels of 75 and 90 mM NaCl, the performance of Langra remained significantly better for fresh weight of rootstock comparative to Sindhri. The maximum increase of 47, 80, 85, 81 and 174% in fresh weight of rootstock was noted comparative to Sindhri at salinity levels of 30, 45, 60, 75 and 90 mM NaCl respectively.

Both main and interactive effects of cultivars and salinity levels were statistically significant for leaves and roots fresh weight (Table 2). Langra performed significantly better comparative to all other cultivars when irrigated with tap water for leaves fresh weight. Langra, Anwar Retaul No. 12, Sufaid Chaunsa, Retaul, Aman Dusehri, Fajri and Samar Bahisht Chaunsa performed significantly better comparative to Sindhri at 15 mM NaCl salinity level for leaves fresh weight. Both Langra and Aman Dusehri remained statistically alike to each other but performed significantly better comparative to all other cultivars for leaves fresh weight at salinity level 30 mM NaCl. Langra at salinity level 45 and 60 mM NaCl remained significantly better comparative to Sindhri for leaves fresh weight. However, all the cultivars remained statistically alike to each other at salinity levels of 75 and 90 mM for leaves fresh weight. The maximum increase of 45, 44, 234, 234 and 227% in fresh weight of leaves was noted in Langra comparative to Sindhri when irrigated with tap water and salinity levels 15, 30, 45 and 60 mM NaCl respectively. In case of roots fresh weight, no significant change was noted among various cultivars of mango irrigated with tap water and salinity levels 15, 30, 45, 60, 75 and 90 mM NaCl. On an average, Langra remained significantly better comparative to all the cultivars for roots fresh weight. However, roots fresh weight remained statistically alike when plants were irrigated with tap water and 15 mM NaCl salinity levels but differed significantly better as compared to salinity levels 45, 60, 75 and 90 mM NaCl in different mango cultivars. The results showed that the maximum increase of 52.2% in root fresh weight was noted in Langra comparative to Sindhri while tap water irrigated plants showed the maximum increase of 105% in root fresh weight comparative to salinity levels 90 mM NaCl.

Both main and interactive effects of cultivars and salinity levels were significant for scion and rootstock dry weighs (Table 3). For scion dry weight, Langra and Anwar Retaul performed significantly better comparative to Sindhri when irrigated with tap water. Langra and Anwar Retaul at salinity levels 15 and 30 mM NaCl performed significantly better as compared to Sindhri. The dry weight of Fajri and Samar Bahisht Chaunsa scion was also significantly greater comparative to Sindhri at salinity levels 30 mM NaCl. It was also noted that Langra, Anwar Retaul and Fajri performed significantly better as compared to Sindhri at salinity level 45 mM NaCl. At salinity levels of 60, 75 and 90 mM NaCl, Langra performed significantly better comparative to Sindhri. However, Anwar Retaul No. 12, Anwar Retaul and Fajri at salinity levels 60, 75 and 90 mM NaCl also performed significantly better comparative to Sindhri. Maximum increase of 0.52, 0.68, 1.12, 2.34, 3.51, 4.70 and 6.0-fold in scion dry weight was noted in Langra as compared to Sindhri when applied tap water and salinity levels of 15, 30, 45, 60, 75 and 90 mM NaCl respectively. In case of rootstock dry weight, Langra, Sufaid Chaunsa, Aman Dusehri and Fajri remained significantly better comparative to Sindhri at TW. Among all the mango cultivars, Langra and Sufaid Chaunsa performed significantly better from Anwar Retaul No. 12, Fajri, Samar Bahisht Chaunsa and Sindhri at salinity level 15 mM NaCl. Langra and Sufaid Chaunsa performed significantly better comparative to Anwar Retaul No. 12, Aman Dusehri and Sindhri at salinity level 30 mM NaCl. Langra, Sufaid Chaunsa, Anwar Retaul and Fajri remained statistically similar to each other but differed significantly from Anwar Retaul No. 12 and Sindhri at salinity level 45 mM NaCl. However, at salinity level of 60 mM NaCl Langra, Sufaid Chaunsa and Anwar Retaul performed significantly better comparative to Anwar Retaul No. 12, Aman Dusehri and Sindhri for rootstock dry weight. It was also noted that performance of Langra cultivar remained significantly better comparative to all other cultivars at salinity levels 75 and 90 mM NaCl for rootstock dry weight. The maximum increase of 0.52, 0.47, 0.83, 0.69, 1.25, 7.16 and 6.82-fold in rootstock dry weight was noted comparative to Sindhri when Langra was irrigated with tape water and salinity levels 15, 30, 45, 60, 75 and 90 mM NaCl respectively.

Both main and interactive effects of cultivars and salinity levels were found statistically significant for leaves and roots dry weight (Table 4). Langra, Anwar Retaul No. 12, Anwar Retaul, Aman Dusehri, Fajri and Samar Bahisht Chaunsa performed significantly better from Sindhri when irrigated with tap water for leaves dry weight. Langra and Fajri performed significantly better from Sufaid Chaunsa, Anwar Retaul, Aman Dusehri, Samar Bahisht Chaunsa and Sindhri at salinity levels 15, 30 and 45 mM NaCl for leaves dry weight. Langra performed significantly better from all other cultivars for leaves dry weight at salinity levels 60, 75 and 90 mM NaCl. The maximum increase of 0.57, 1.04, 1.86, 1.99, 2.98, 3.39 and 5.87-fold in dry weight of leaves was noted in Langra comparative to Sindhri when irrigated with tap water and various levels of salinity 15, 30, 45, 60, 75 and 90 mM NaCl respectively. In case of roots dry weight, Langra, Anwar Retaul, Aman Dusehri and Fajri performed significantly better from Anwar Retaul No. 12, Samar Bahisht Chaunsa and Sindhri when irrigated with tap water. Langra, Sufaid Chaunsa, Aman Dusehri and Fajri performed significantly better from Anwar Retaul No. 12, Anwar Retaul, Samar Bahisht Chaunsa and Sindhri at salinity level 15 mM NaCl for roots dry weight. However, at salinity levels 30, 45, 60, 75 and 90 mM NaCl Langra performed significantly better from Sindhri roots dry weight. Maximum increase of 63.1, 56.0, 83.5, 95.0, 93.2 and 128.1% in dry weight of roots was noted in Langra as compared to Sindhri when irrigated with tap water and salinity levels 15, 30, 45, 60 and 75 mM NaCl respectively.

Both main and interactive effects of cultivars and salinity levels were found statistically significant for number of leaves (Fig. 5) and total chlorophyll content (Fig. 6). Langra, Sufaid Chaunsa, Anwar Retaul No. 12, Fajri and Samar Bahisht Chaunsa were statistically similar to each other but remained significantly different from Sindhri when irrigated with tap water for number of leaves. At salinity level 15 mM, Langra, Anwar Retaul, Aman Dusehri and Samar Bahisht Chaunsa performed significantly better from Fajri and Sindhri for number of leaves. However, Langra performed significantly better as compared to Sindhri for number of leaves at salinity levels 30, 45, 60, 75 and 90 mM NaCl. Maximum increase of 26.7, 18.5, 16.2, 13.5, 10.5, 7.50 and 5.27% in number of leaves was noted as compared to Sindhri where Langra was cultivated with tap water irrigation and salinity levels 15, 30, 45, 60, 75 and 90 mM NaCl respectively. In case of total chlorophyll content, Langra, Anwar Retaul No. 12 and Sufaid Chaunsa performed significantly better as compared to Samar Bahisht Chaunsa and Sindhri when irrigated with tap water. It was observed that Langra and Anwar Retaul No. 12 performed significantly better from Sindhri at salinity levels 15, 30, 45, 60, 75 and 90 mM NaCl for total chlorophyll content. Sufaid Chaunsa, Anwar Retaul, Aman Dusehri, Fajri and Samar Bahisht Chaunsa also performed significantly better from Sindhri for total chlorophyll content at salinity levels 15, 30, 45, 60, 75 and 90 mM NaCl. Maximum increase of 0.78, 1.12, 1.17, 1.62, 2.20, 2.14 and 2.40-fold in total chlorophyll content was noted in Langra as compared to Sindhri when irrigated with tap water and salinity levels 15, 30, 45, 60, 75 and 90 mM NaCl respectively.

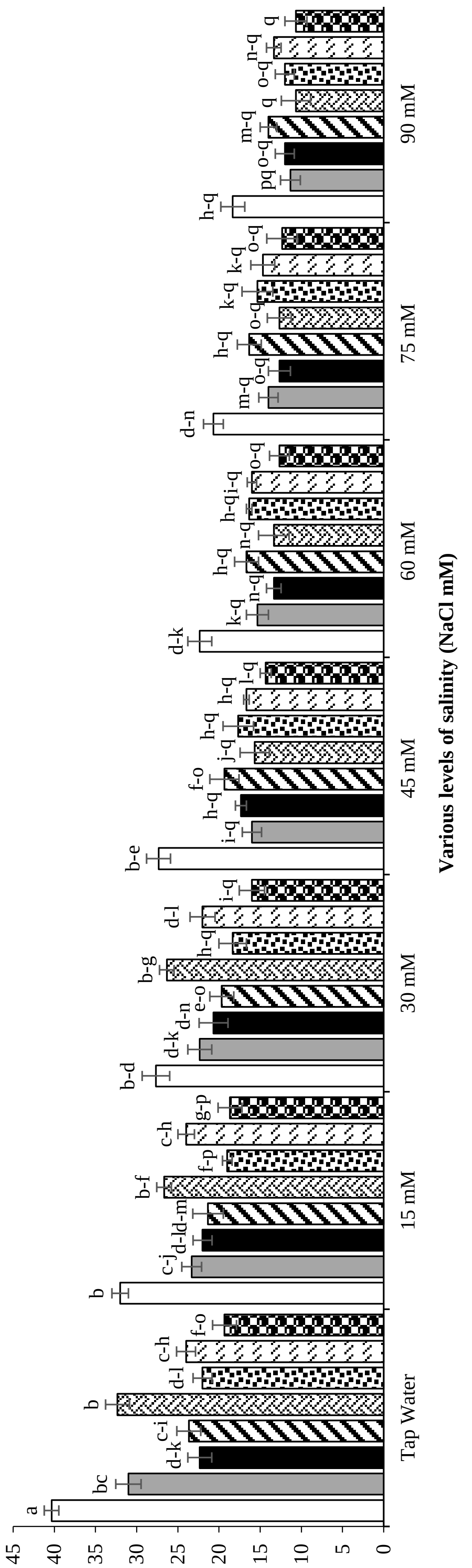

Fig. 1. Effect of various levels of NaCl induced artificial salinity stress on scion height in different mango cultivars.

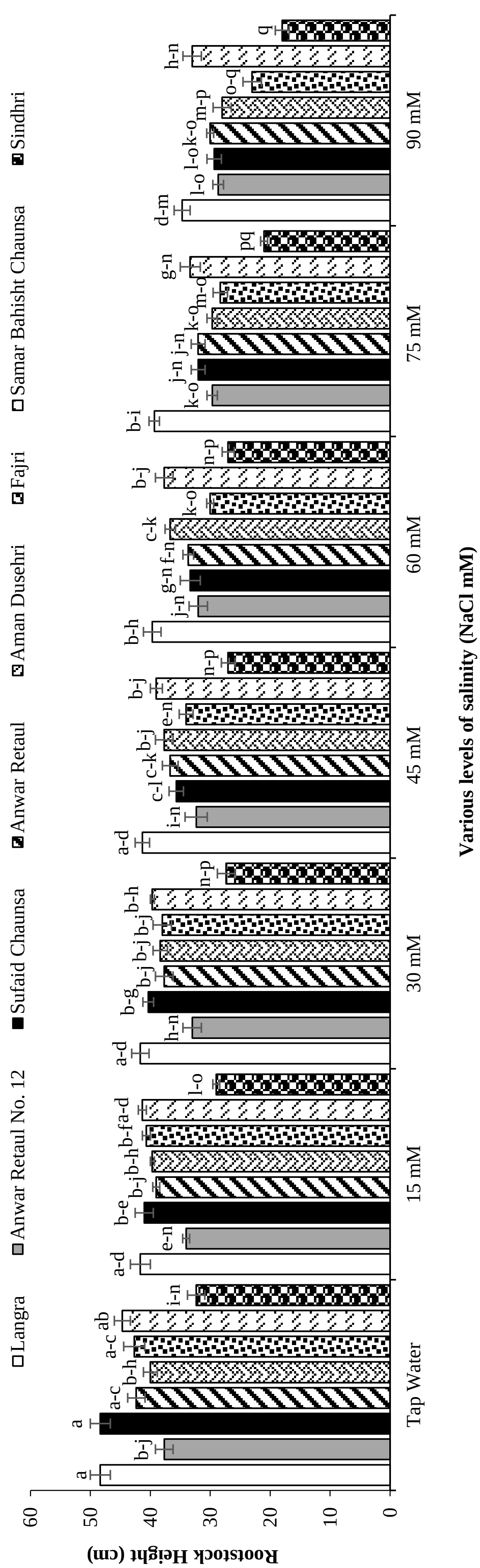

Fig. 2. Effect of various levels of NaCl induced artificial salinity stress on rootstock height in different mango cultivars.

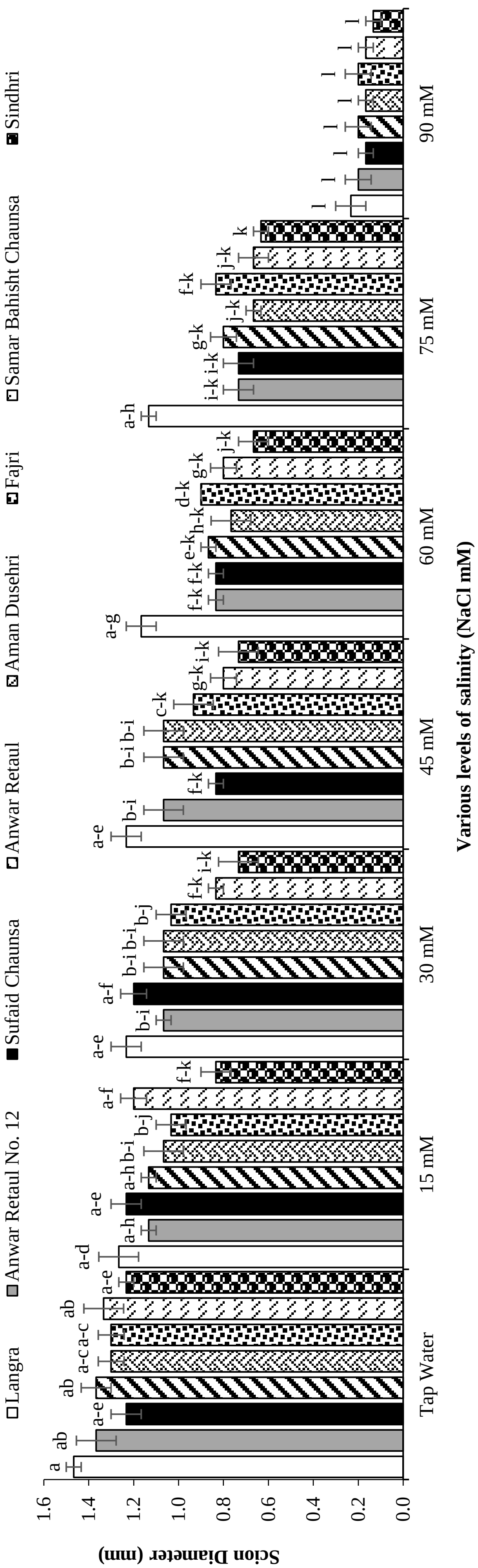

Fig. 3. Effect of various levels of NaCl induced artificial salinity stress on scion diameter in different mango cultivars.

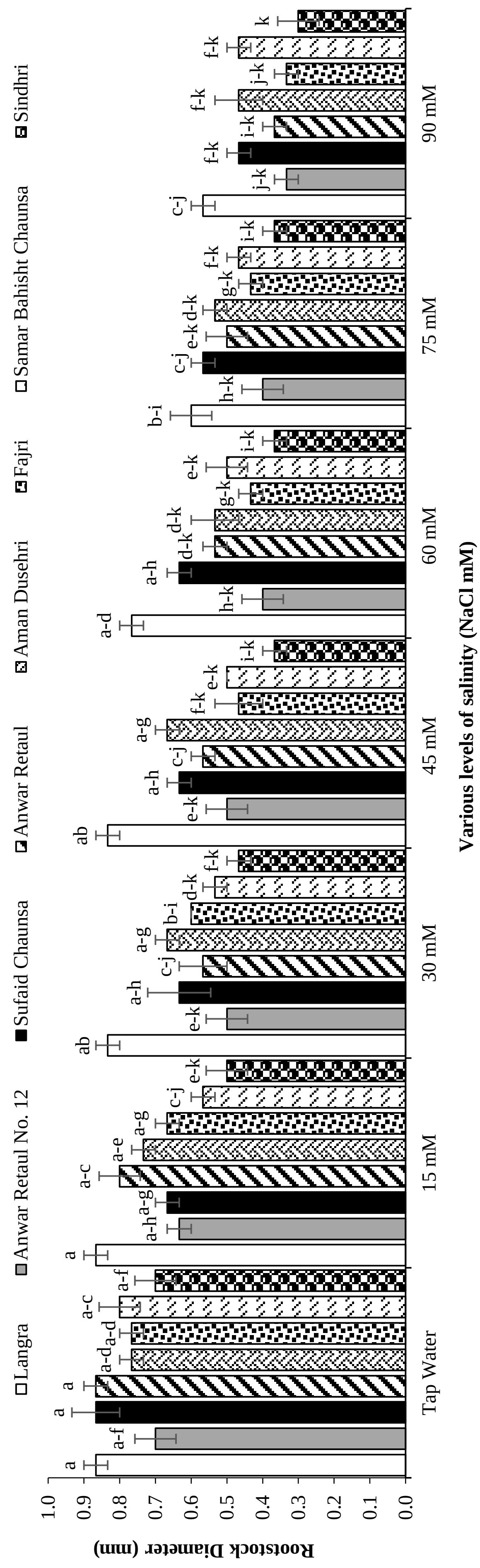

Fig. 4. Effect of various levels of NaCl induced artificial salinity stress on rootstock diameter in different mango cultivars.

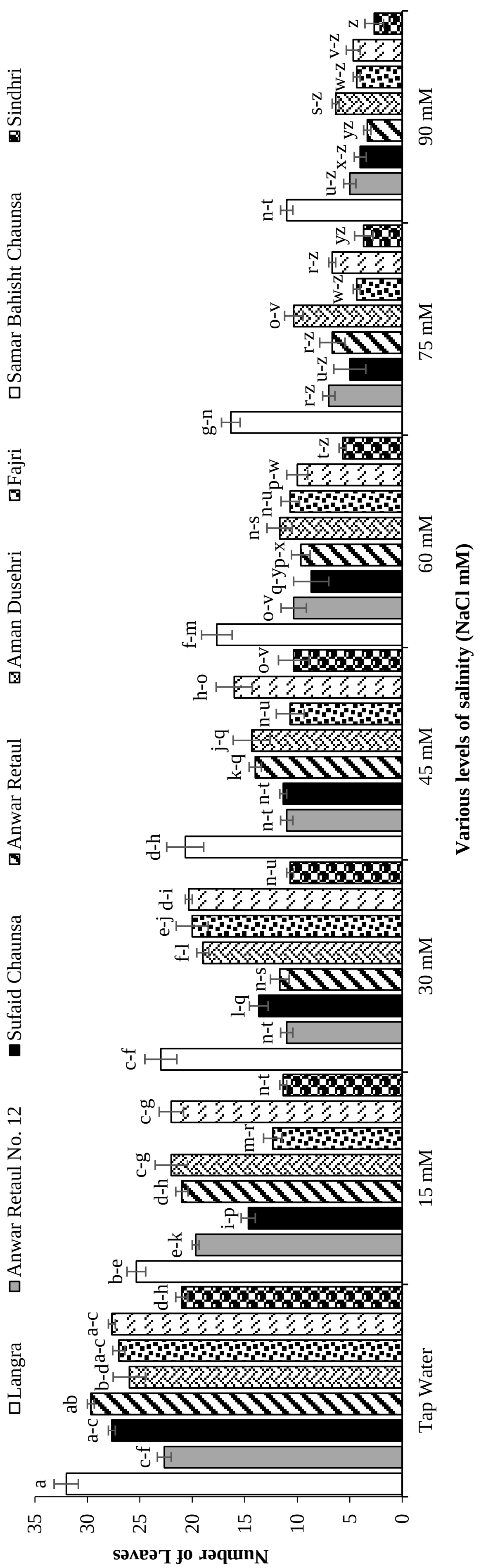

Fig. 5. Effect of various levels of NaCl induced artificial salinity stress on number of leaves in different mango cultivars.

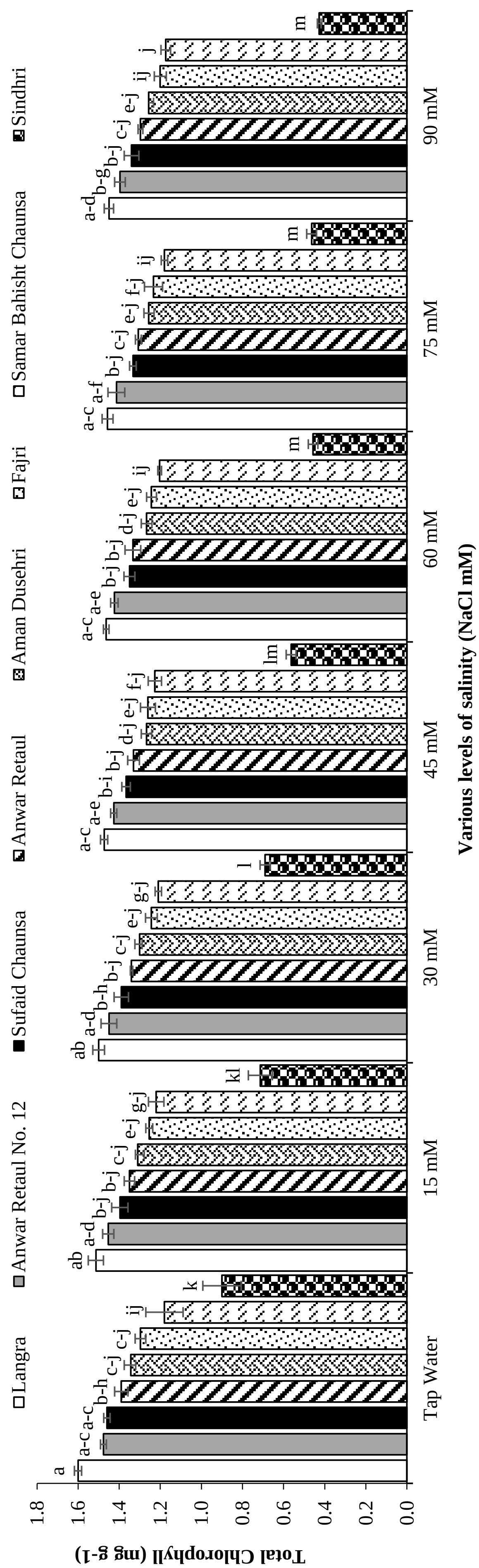

Fig. 6. Effect of various levels of NaCl induced artificial salinity stress on total chlorophyll content in different mango cultivars.

Table 1. Effect of various levels of NaCl induced artificial salinity stress on scion and rootstock fresh weight in different mango cultivars.

Mango cultivars	Scion fresh weight (g)							
	Various levels of salinity (NaCl mM)							
	Interactive Effect (cultivars × salinity levels)							ME (cultivar)
	TW	15	30	45	60	75	90	
Langra	13.4 ± 0.8^{a}	13.4 ± 0.9^{a}	$11.2 \pm 0.3^{a-c}$	$7.23 \pm 1.0^{d-g}$	$2.32 \pm 0.9^{i-l}$	$2.07 \pm 0.1^{i-l}$	$1.62 \pm 0.4^{j-l}$	7.31^{A}
Anwar Retaul No. 12	$9.87 \pm 0.6^{b-d}$	$9.47 \pm 0.5^{b-e}$	$8.42 \pm 0.7^{b-f}$	$5.35 \pm 0.5^{f-i}$	$2.11 \pm 0.1^{i-l}$	1.58 ± 0.4^{kl}	1.33 ± 0.6^{kl}	5.45^{BC}
Sufaid Chaunsa	13.4 ± 0.9^{a}	11.5 ± 0.4^{ab}	$10.4 \pm 0.4^{a-d}$	$3.56 \pm 0.8^{h-l}$	$1.87 \pm 0.2^{j-l}$	1.53 ± 0.3^{kl}	1.40 ± 0.3^{kl}	6.24^{B}
Anwar Retaul	$9.01 \pm 0.5^{b-e}$	$7.09 \pm 0.6^{d-g}$	$6.06 \pm 0.6^{e-h}$	$3.85 \pm 0.3^{g-l}$	$1.85 \pm 0.3^{j-l}$	1.83 ± 1.0^{kl}	1.22 ± 0.1^{kl}	4.41^{DE}
Aman Dusehri	$9.09 \pm 0.6^{b-e}$	$7.09 \pm 0.6^{d-g}$	$6.06 \pm 0.6^{e-h}$	$1.93 \pm 0.3^{j-l}$	$1.63 \pm 0.2^{j-l}$	1.61 ± 0.4^{kl}	1.46 ± 0.3^{kl}	4.12^{EF}
Fajri	$11.4 \pm 0.6^{a-c}$	$8.06 \pm 0.0^{c-f}$	$8.02 \pm 0.8^{c-f}$	$3.56 \pm 0.8^{h-l}$	$2.10 \pm 0.1^{i-l}$	$1.94 \pm 0.7^{j-l}$	1.30 ± 0.6^{kl}	5.19^{CD}
Samar Bahisht Chaunsa	$11.4 \pm 0.6^{a-c}$	$8.10 \pm 0.6^{b-f}$	$6.06 \pm 0.6^{e-h}$	$5.02 \pm 0.5^{f-j}$	$1.63 \pm 0.2^{j-l}$	1.26 ± 0.5^{kl}	1.60 ± 0.4^{kl}	5.01^{C-E}
Sindhri	$9.09 \pm 0.6^{b-e}$	$4.53 \pm 0.0^{g-k}$	$4.29 \pm 0.9^{g-l}$	$1.88 \pm 0.3^{j-l}$	1.58 ± 0.4^{kl}	1.61 ± 0.4^{kl}	0.96 ± 0.1^{l}	3.42^{F}
ME (S)	10.8^{A}	8.65^{B}	7.58^{C}	4.05^{D}	1.89^{E}	1.68^{E}	1.36^{E}	
	Rootstock fresh weight (g)							
Langra	22.3 ± 0.4^{a}	$21.8 \pm 0.9^{a-d}$	$21.5 \pm 0.9^{a-c}$	$20.9 \pm 0.4^{a-d}$	$20.5 \pm 0.7^{a-d}$	$19.0 \pm 0.6^{a-f}$	$18.1 \pm 0.4^{c-g}$	20.6^{A}
Anwar Retaul No. 12	$22.0 \pm 0.7^{a-c}$	$21.6 \pm 0.7^{a-d}$	$20.1 \pm 0.7^{a-e}$	$18.4 \pm 0.6^{b-g}$	$17.2 \pm 0.9^{d-g}$	$11.0 \pm 0.0^{i-l}$	$7.70 \pm 0.9^{l-m}$	16.9^{B}
Sufaid Chaunsa	$21.5 \pm 0.0^{a-c}$	$21.4 \pm 0.8^{a-c}$	$21.0 \pm 0.8^{a-d}$	$20.7 \pm 0.6^{a-d}$	$16.5 \pm 0.3^{e-g}$	$12.4 \pm 1.3^{h-j}$	$7.70 \pm 0.9^{l-m}$	17.3^{CD}
Anwar Retaul	$21.8 \pm 0.9^{a-c}$	$21.7 \pm 0.7^{a-d}$	$20.5 \pm 0.7^{a-d}$	$20.0 \pm 0.9^{a-e}$	$19.6 \pm 0.6^{a-f}$	$18.1 \pm 0.4^{c-g}$	$11.1 \pm 0.5^{i-l}$	19.0^{D}
Aman Dusehri	$21.7 \pm 0.9^{a-c}$	$21.5 \pm 0.7^{a-d}$	$21.4 \pm 0.7^{a-d}$	$19.7 \pm 0.8^{a-e}$	$16.5 \pm 0.9^{e-g}$	$15.8 \pm 0.6^{f-h}$	$9.50 \pm 0.4^{j-m}$	18.0^{BC}
Fajri	$21.4 \pm 0.4^{a-c}$	$20.8 \pm 0.4^{a-d}$	$20.6 \pm 0.4^{a-d}$	$19.6 \pm 0.4^{a-f}$	$19.4 \pm 0.5^{a-f}$	$17.3 \pm 0.3^{d-g}$	$10.1 \pm 0.6^{j-m}$	18.5^{B}
Samar Bahisht Chaunsa	22.1 ± 0.6^{ab}	$20.8 \pm 0.4^{a-d}$	$19.6 \pm 0.4^{a-f}$	$19.0 \pm 0.5^{a-f}$	$18.1 \pm 0.6^{c-g}$	$12.0 \pm 0.6^{h-k}$	$8.30 \pm 0.4^{k-m}$	17.1^{CD}
Sindhri	$21.1 \pm 0.7^{a-d}$	$19.3 \pm 0.5^{a-f}$	$14.6 \pm 0.5^{g-i}$	$11.6 \pm 0.6^{i-k}$	$11.1 \pm 0.6^{i-l}$	$10.5 \pm 0.8^{j-l}$	6.60 ± 0.8^{m}	13.5^{E}
ME (S)	21.7^{A}	21.1^{A}	19.9^{B}	18.7^{C}	17.4^{D}	14.5^{E}	9.90^{F}	

Different letters showed statistical different at $p \leq 0.05$. ME = Main effect; S = Various levels of salinity

Table 2. Effect of various levels of NaCl induced artificial salinity stress on leaves and roots fresh weight in different mango cultivars.

Mango cultivars	Leaves fresh weight (g)							
	Various levels of salinity (NaCl mM)							
	Interactive Effect (cultivars × salinity levels)							ME (cultivar)
	TW	15	30	45	60	75	90	
Langra	25.3 ± 0.5 a	20.4 ± 0.3 b	18.7 ± 0.9 b-e	5.68 ± 0.7 h-j	5.33 ± 0.7 h-k	3.60 ± 0.3 j-n	2.29 ± 0.4 k-o	11.6 A
Anwar Retaul No. 12	18.1 ± 0.6 b-e	16.0 ± 0.9 de	11.4 ± 0.4 f	4.43 ± 0.9 i-m	3.44 ± 0.9 j-n	1.63 ± 0.0 l-o	1.50 ± 0.3 l-o	8.05 C
Sufaid Chaunsa	20.4 ± 0.9 b	16.4 ± 0.6 de	8.01 ± 0.4 gh	2.54 ± 0.7 j-o	1.68 ± 0.7 l-o	1.62 ± 0.7 l-o	1.26 ± 0.9 m-o	7.44 CD
Anwar Retaul	17.7 ± 0.6 b-e	17.0 ± 0.5 c-e	5.33 ± 0.3 h-k	2.54 ± 0.7 j-o	1.63 ± 0.7 l-o	1.33 ± 0.3 m-o	0.93 ± 0.6 no	6.63 D
Aman Dusehri	20.3 ± 0.9 b	18.7 ± 0.9 b-e	15.6 ± 0.7 e	5.33 ± 0.3 h-k	1.85 ± 0.3 l-o	1.66 ± 0.3 l-o	0.92 ± 0.6 no	9.20 B
Fajri	17.7 ± 0.3 b-e	17.4 ± 0.3 b-e	12.1 ± 0.6 f	4.57 ± 0.5 i-l	2.69 ± 0.5 j-o	1.49 ± 0.5 l-o	1.50 ± 0.3 l-o	8.21 C
Samar Bahisht Chaunsa	20.0 ± 0.6 bc	19.1 ± 0.6 b-d	7.45 ± 0.6 g-i	2.83 ± 0.4 j-o	1.86 ± 0.4 l-o	2.34 ± 0.3 k-o	1.25 ± 0.4 m-o	7.83 C
Sindhri	17.5 ± 0.4 b-e	9.07 ± 1.0 fg	5.60 ± 0.2 h-j	1.70 ± 0.3 l-o	1.63 ± 0.3 l-o	1.28 ± 0.2 m-o	0.22 ± 0.1 o	5.28 E
ME (S)	19.6 A	16.8 B	10.5 C	3.70 D	2.51 E	1.87 EF	1.23 F	
	Roots fresh weight (g)							
Langra	22.2 ± 0.2 a	19.7 ± 0.4 a-e	19.2 ± 0.4 a-h	19.0 ± 0.6 a-h	18.1 ± 3.5 a-h	13.0 ± 2.0 b-j	11.6 ± 0.3 d-j	17.5 A
Anwar Retaul No. 12	21.0 ± 0.6 a-c	13.8 ± 0.2 a-j	14.7 ± 0.3 a-j	11.5 ± 0.3 d-j	11.1 ± 0.6 f-j	10.7 ± 2.2 h-j	7.00 ± 1.5 j	12.8 CD
Sufaid Chaunsa	19.5 ± 0.4 a-f	19.2 ± 0.3 a-h	11.7 ± 0.3 d-j	16.6 ± 0.8 a-i	12.7 ± 0.7 c-j	11.7 ± 0.3 d-j	8.40 ± 1.4 ij	14.3 BC
Anwar Retaul	18.1 ± 0.6 a-h	14.7 ± 3.2 a-j	18.9 ± 0.2 a-h	18.4 ± 0.6 a-h	11.1 ± 0.6 e-j	11.1 ± 0.6 e-j	11.1 ± 0.6 e-j	14.8 BC
Aman Dusehri	21.5 ± 0.7 ab	19.5 ± 0.4 a-f	18.0 ± 3.5 a-h	12.2 ± 0.6 d-j	10.8 ± 0.4 g-j	10.7 ± 0.4 h-j	11.1 ± 0.7 e-j	14.8 BC
Fajri	19.4 ± 3.9 a-g	19.3 ± 0.6 a-g	18.4 ± 0.9 a-h	14.8 ± 3.2 a-j	14.0 ± 2.5 a-j	11.7 ± 0.3 d-j	9.20 ± 0.6 ij	15.3 AB
Samar Bahisht Chaunsa	19.8 ± 0.3 a-d	19.0 ± 0.6 a-h	13.7 ± 0.7 a-j	13.3 ± 0.4 b-j	13.0 ± 2.5 b-j	11.7 ± 0.6 d-j	11.0 ± 0.6 f-j	14.5 BC
Sindhri	14.4 ± 2.8 a-j	13.7 ± 0.7 a-j	13.0 ± 3.0 b-j	13.1 ± 0.6 b-j	10.8 ± 0.4 g-j	9.00 ± 1.6 ij	6.70 ± 1.7 j	11.5 D
ME (S)	19.5 A	17.4 AB	16.0 BC	14.8 CD	12.7 DE	11.2 EF	9.5 F	

Different letters showed statistical different at $p \leq 0.05$. ME = Main effect; S = Various levels of salinity

Table 3. Effect of various levels of NaCl induced artificial salinity stress on scion and rootstock dry weight in different mango cultivars.

Mango cultivars	Scion dry weight (g)							
	Various levels of salinity (NaCl mM)							
	Interactive Effect (cultivars × salinity levels)							ME (cultivar)
	TW	15	30	45	60	75	90	
Langra	4.32 ± 0.03 ^{a}	3.93 ± 0.09 $^{a-c}$	3.92 ± 0.07 $^{a-c}$	3.85 ± 0.07 $^{a-d}$	3.70 ± 0.07 $^{a-d}$	3.48 ± 0.03 $^{a-d}$	3.29 ± 0.07 $^{a-g}$	3.78 ^{A}
Anwar Retaul No. 12	3.32 ± 0.09 $^{a-g}$	3.11 ± 0.03 $^{b-h}$	2.30 ± 0.03 $^{g-m}$	2.28 ± 0.09 $^{g-m}$	2.00 ± 0.03 $^{i-o}$	1.67 ± 0.07 $^{k-q}$	1.16 ± 0.06 $^{n-r}$	2.26 ^{C}
Sufaid Chaunsa	3.43 ± 0.07 $^{a-f}$	3.24 ± 0.07 $^{b-h}$	2.38 ± 0.06 $^{e-k}$	1.16 ± 0.03 $^{n-r}$	1.07 ± 0.03 $^{o-r}$	0.97 ± 0.07 $^{o-r}$	0.85 ± 0.03 $^{p-r}$	1.87 ^{D}
Anwar Retaul	3.96 ± 0.07 ^{ab}	3.52 ± 0.03 $^{a-d}$	3.47 ± 0.09 $^{a-e}$	3.08 ± 0.09 $^{b-i}$	2.84 ± 0.03 $^{c-j}$	1.36 ± 0.06 $^{k-r}$	1.22 ± 0.06 $^{m-r}$	2.78 ^{B}
Aman Dusehri	3.47 ± 0.06 $^{a-e}$	2.98 ± 0.09 $^{b-i}$	1.22 ± 0.09 $^{m-r}$	1.22 ± 0.09 $^{m-r}$	1.47 ± 0.09 $^{k-r}$	1.05 ± 0.03 $^{o-r}$	0.84 ± 0.03 $^{p-r}$	1.75 ^{D}
Fajri	3.44 ± 0.06 $^{a-e}$	3.16 ± 0.07 $^{b-h}$	3.11 ± 0.07 $^{b-h}$	3.00 ± 0.09 $^{b-i}$	2.78 ± 0.00 $^{d-j}$	2.19 ± 0.07 $^{h-n}$	2.18 ± 0.06 $^{h-n}$	2.84 ^{B}
Samar Bahisht Chaunsa	3.57 ± 0.09 $^{a-d}$	2.98 ± 0.06 $^{b-i}$	2.98 ± 0.03 $^{b-i}$	1.31 ± 0.06 $^{k-r}$	1.26 ± 0.06 $^{l-r}$	1.08 ± 0.07 $^{o-r}$	0.72 ± 0.03 ^{qr}	1.99 ^{CD}
Sindhri	2.85 ± 0.03 $^{c-j}$	2.34 ± 0.07 $^{f-l}$	1.85 ± 0.09 $^{j-p}$	1.15 ± 0.09 $^{n-r}$	0.82 ± 0.07 $^{p-r}$	0.61 ± 0.03 ^{qr}	0.47 ± 0.03 ^{r}	1.44 ^{E}
ME (S)	3.55 ^{A}	3.16 ^{B}	2.65 ^{C}	2.13 ^{D}	1.99 ^{D}	1.55 ^{E}	1.34 ^{E}	
	Rootstock dry weight (g)							
Langra	10.4 ± 0.03 ^{a}	9.37 ± 0.03 $^{a-d}$	8.85 ± 0.03 $^{b-f}$	8.20 ± 0.03 $^{c-j}$	8.18 ± 0.03 $^{c-k}$	7.59 ± 0.06 $^{f-n}$	6.57 ± 0.03 $^{l-s}$	8.46 ^{A}
Anwar Retaul No. 12	8.66 ± 0.06 $^{b-h}$	7.68 ± 0.03 $^{f-m}$	6.45 ± 0.06 $^{m-t}$	6.18 ± 0.06 $^{n-u}$	6.07 ± 0.06 $^{o-u}$	5.39 ± 0.06 $^{q-v}$	4.39 ± 0.03 $^{v-x}$	6.40 ^{C}
Sufaid Chaunsa	9.67 ± 0.07 ^{ab}	9.15 ± 0.03 $^{a-e}$	8.72 ± 0.09 $^{b-g}$	7.91 ± 0.03 $^{e-l}$	7.64 ± 0.03 $^{f-m}$	5.13 ± 0.03 $^{t-w}$	3.95 ± 0.03 $^{w-x}$	7.45 ^{B}
Anwar Retaul	8.27 ± 0.03 $^{b-i}$	7.97 ± 0.06 $^{d-l}$	7.38 ± 0.07 $^{g-o}$	7.24 ± 0.03 $^{h-o}$	6.79 ± 0.03 $^{j-q}$	5.16 ± 0.06 $^{s-w}$	1.55 ± 0.03 ^{y}	6.34 ^{CD}
Aman Dusehri	10.3 ± 0.03 ^{a}	8.86 ± 0.03 $^{b-f}$	6.77 ± 0.03 $^{k-q}$	6.10 ± 0.03 $^{o-u}$	5.44 ± 0.07 $^{p-v}$	2.19 ± 0.03 ^{y}	2.00 ± 0.07 ^{y}	5.95 ^{DE}
Fajri	9.44 ± 0.03 $^{a-c}$	7.53 ± 0.03 $^{f-n}$	7.42 ± 0.00 $^{g-o}$	7.04 ± 0.07 $^{i-o}$	6.64 ± 0.03 $^{l-r}$	4.84 ± 0.03 $^{u-x}$	4.22 ± 0.03 $^{v-x}$	6.73 ^{C}
Samar Bahisht Chaunsa	7.73 ± 0.06 $^{e-m}$	7.67 ± 0.03 $^{f-m}$	7.53 ± 0.03 $^{f-n}$	5.03 ± 0.00 $^{t-x}$	4.85 ± 0.06 $^{u-x}$	4.85 ± 0.03 $^{u-x}$	3.68 ± 0.03 ^{x}	5.91 ^{E}
Sindhri	6.85 ± 0.06 $^{i-p}$	6.36 ± 0.06 $^{m-t}$	5.34 ± 0.03 $^{r-w}$	4.84 ± 0.03 $^{u-x}$	3.64 ± 0.03 ^{x}	0.93 ± 0.03 ^{y}	0.84 ± 0.06 ^{y}	4.11 ^{F}
ME (S)	8.92 ^{A}	8.07 ^{B}	7.31 ^{C}	6.57 ^{D}	6.16 ^{E}	4.51 ^{F}	3.40 ^{G}	

Different letters showed statistical different at $p \leq 0.05$. ME = Main effect; S = Various levels of salinity

Table 4. Effect of various levels of NaCl induced artificial salinity stress on leaves and roots dry weight in different mango cultivars.

Mango cultivars	Leaves dry weight (g)							
	Various levels of salinity (NaCl mM)							
	Interactive Effect (cultivars × salinity levels)							ME (cultivar)
	TW	15	30	45	60	75	90	
Langra	6.52 ± 0.3 ^{a}	6.15 ± 0.2 ^{ab}	5.74 ± 0.1 $^{a-c}$	5.52 ± 0.3 $^{a-d}$	5.15 ± 0.1 $^{b-e}$	5.04 ± 0.3 $^{b-f}$	5.04 ± 0.3 $^{b-f}$	5.59 ^{A}
Anwar Retaul No. 12	6.25 ± 0.2 ^{ab}	4.59 ± 0.2 $^{c-g}$	3.28 ± 0.2 $^{h-l}$	1.97 ± 0.0 $^{n-x}$	1.67 ± 0.2 $^{r-x}$	1.64 ± 0.3 $^{r-x}$	0.85 ± 0.1 ^{wx}	2.89 ^{DE}
Sufaid Chaunsa	4.29 ± 0.2 $^{d-i}$	3.24 ± 0.2 $^{i-m}$	2.18 ± 0.2 $^{l-u}$	1.99 ± 0.1 $^{m-w}$	1.78 ± 0.1 $^{r-x}$	1.29 ± 0.0 $^{r-x}$	0.92 ± 0.2 $^{v-x}$	2.24 ^{F}
Anwar Retaul	6.51 ± 0.3 ^{a}	3.66 ± 0.3 $^{g-k}$	3.28 ± 0.2 $^{h-l}$	3.16 ± 0.2 $^{i-n}$	2.99 ± 0.0 $^{j-q}$	2.45 ± 0.3 $^{k-r}$	1.27 ± 0.1 $^{r-x}$	3.33 ^{C}
Aman Dusehri	5.67 ± 0.3 $^{a-c}$	3.28 ± 0.2 $^{i-l}$	3.22 ± 0.2 $^{i-n}$	2.42 ± 0.2 $^{k-s}$	2.05 ± 0.0 $^{l-w}$	1.17 ± 0.6 $^{s-x}$	1.01 ± 0.0 $^{u-x}$	2.69 ^{E}
Fajri	6.18 ± 0.2 ^{ab}	5.36 ± 0.2 $^{a-e}$	5.30 ± 0.2 $^{a-e}$	4.54 ± 0.3 $^{c-h}$	3.85 ± 0.2 $^{f-j}$	3.06 ± 0.0 $^{i-o}$	2.52 ± 0.3 $^{k-r}$	4.40 ^{B}
Samar Bahisht Chaunsa	6.18 ± 0.2 ^{ab}	3.88 ± 0.1 $^{f-j}$	3.65 ± 0.3 $^{g-k}$	2.30 ± 0.2 $^{l-t}$	2.15 ± 0.2 $^{l-v}$	1.74 ± 0.2 $^{q-x}$	1.70 ± 0.0 $^{r-x}$	3.09 ^{CD}
Sindhri	4.14 ± 0.2 $^{e-j}$	3.01 ± 0.0 $^{j-p}$	2.01 ± 0.1 $^{m-w}$	1.85 ± 0.2 $^{o-x}$	1.29 ± 0.1 $^{r-x}$	1.15 ± 0.1 $^{t-x}$	0.73 ± 0.1 ^{x}	2.03 ^{F}
ME (S)	5.72 ^{A}	4.15 ^{B}	3.58 ^{C}	2.97 ^{D}	2.62 ^{E}	2.19 ^{F}	1.76 ^{G}	
	Roots dry weight (g)							
Langra	11.6 ± 0.2 ^{a}	10.8 ± 0.3 $^{a-c}$	10.7 ± 0.3 $^{a-c}$	9.18 ± 0.6 $^{c-h}$	7.88 ± 0.2 $^{h-m}$	6.66 ± 0.7 $^{k-t}$	5.78 ± 0.2 $^{p-y}$	8.94 ^{A}
Anwar Retaul No. 12	8.22 ± 0.2 $^{f-k}$	7.51 ± 0.3 $^{h-p}$	6.97 ± 0.2 $^{j-r}$	5.51 ± 0.3 $^{q-z}$	5.49 ± 0.3 $^{q-z}$	5.12 ± 0.6 $^{s-A}$	4.40 ± 0.2 $^{x-B}$	6.17 ^{D}
Sufaid Chaunsa	9.67 ± 0.3 $^{b-g}$	10.4 ± 0.2 $^{a-d}$	8.03 ± 0.2 $^{g-l}$	4.92 ± 0.4 $^{t-A}$	4.33 ± 0.3 $^{x-B}$	4.22 ± 0.6 $^{y-B}$	3.49 ± 0.3 ^{AB}	6.44 ^{CD}
Anwar Retaul	11.1 ± 0.3 ^{ab}	7.66 ± 0.2 $^{h-n}$	7.55 ± 0.3 $^{h-o}$	8.81 ± 0.3 $^{d-i}$	6.81 ± 0.2 $^{j-s}$	6.04 ± 0.0 $^{n-x}$	5.04 ± 0.3 $^{t-A}$	7.57 ^{B}
Aman Dusehri	10.8 ± 0.3 $^{a-c}$	10.3 ± 0.3 $^{a-d}$	8.54 ± 0.3 $^{e-j}$	6.31 ± 0.2 $^{l-v}$	6.22 ± 0.2 $^{m-w}$	3.71 ± 0.2 ^{AB}	1.70 ± 0.4 ^{CD}	6.80 ^{C}
Fajri	10.0 ± 0.3 $^{a-e}$	9.89 ± 0.2 $^{a-f}$	9.66 ± 0.3 $^{b-g}$	6.82 ± 0.3 $^{j-s}$	6.22 ± 0.2 $^{m-w}$	4.74 ± 0.3 $^{u-A}$	4.00 ± 0.3 $^{z-B}$	7.34 ^{B}
Samar Bahisht Chaunsa	7.66 ± 0.3 $^{h-n}$	7.52 ± 0.3 $^{h-p}$	6.87 ± 0.2 $^{j-s}$	6.50 ± 0.3 $^{k-u}$	5.24 ± 0.2 $^{r-A}$	4.53 ± 0.3 $^{w-B}$	3.92 ± 0.2 $^{z-B}$	6.04 ^{D}
Sindhri	7.11 ± 0.3 $^{i-q}$	6.90 ± 0.2 $^{j-r}$	5.82 ± 0.2 $^{o-y}$	4.71 ± 0.3 $^{v-A}$	4.08 ± 0.1 $^{y-B}$	2.92 ± 0.3 ^{BC}	0.75 ± 0.3 ^{D}	4.61 ^{E}
ME (S)	9.51 ^{A}	8.88 ^{B}	8.02 ^{C}	6.59 ^{D}	5.78 ^{E}	4.74 ^{F}	3.64 ^{G}	

Different letters showed statistical different at $p \leq 0.05$. ME = Main effect; S = Various levels of salinity

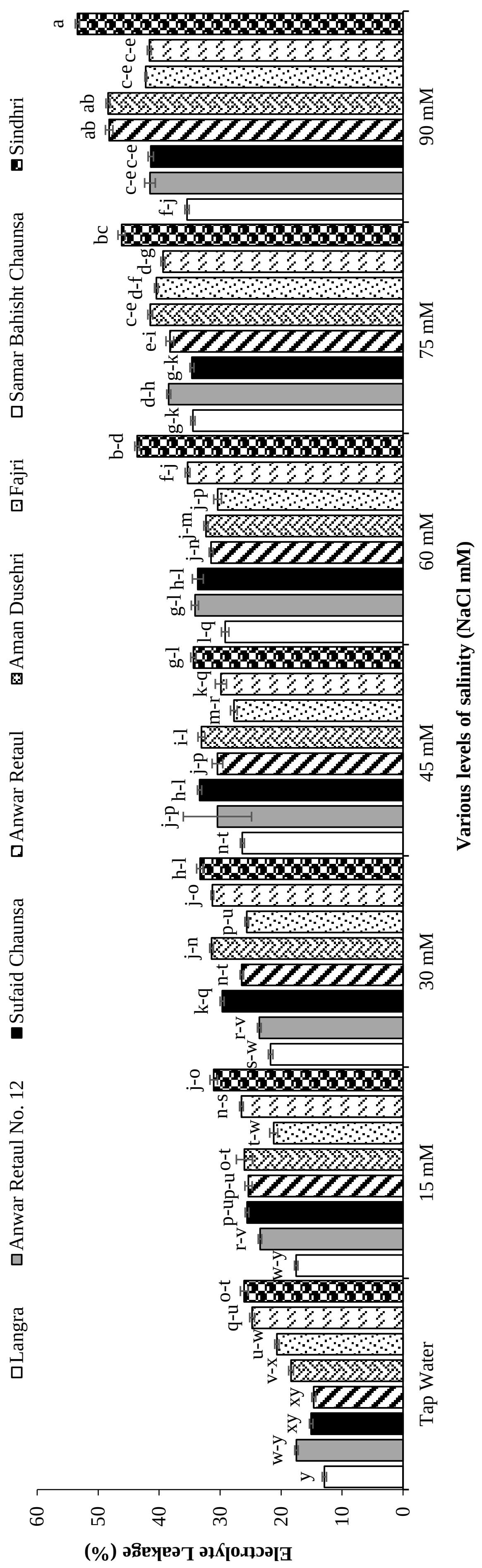

Fig. 7. Effect of various levels of NaCl induced artificial salinity stress on electrolyte leakage in different mango cultivars.

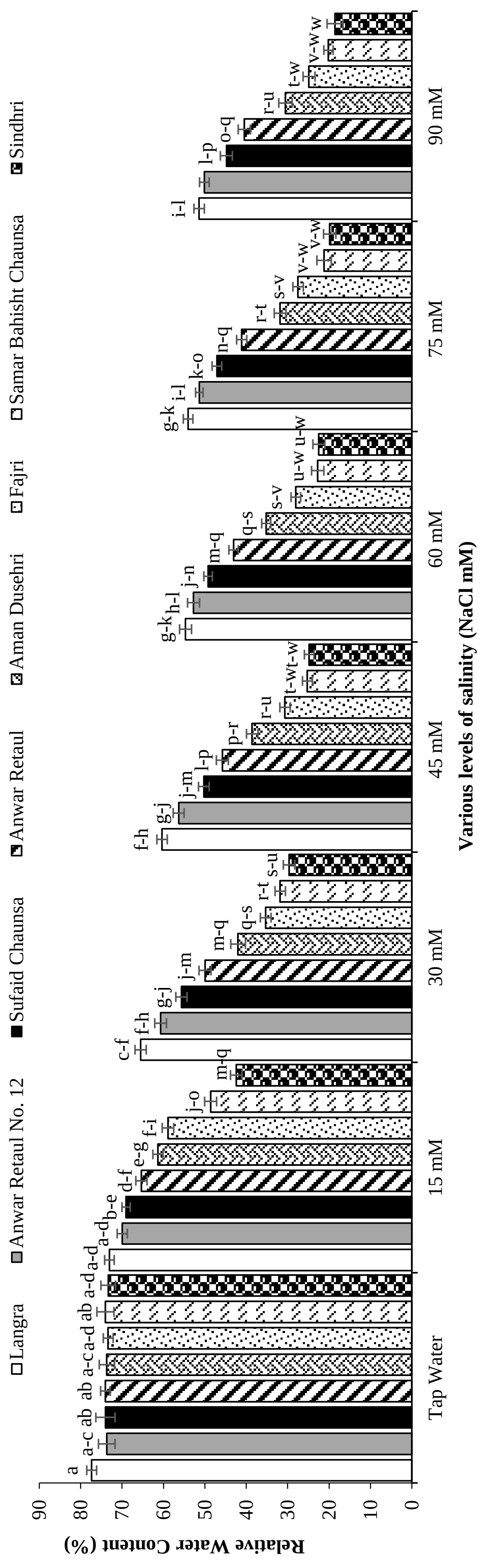

Fig. 8. Effect of various levels of NaCl induced artificial salinity stress on relative water content in different mango cultivars.

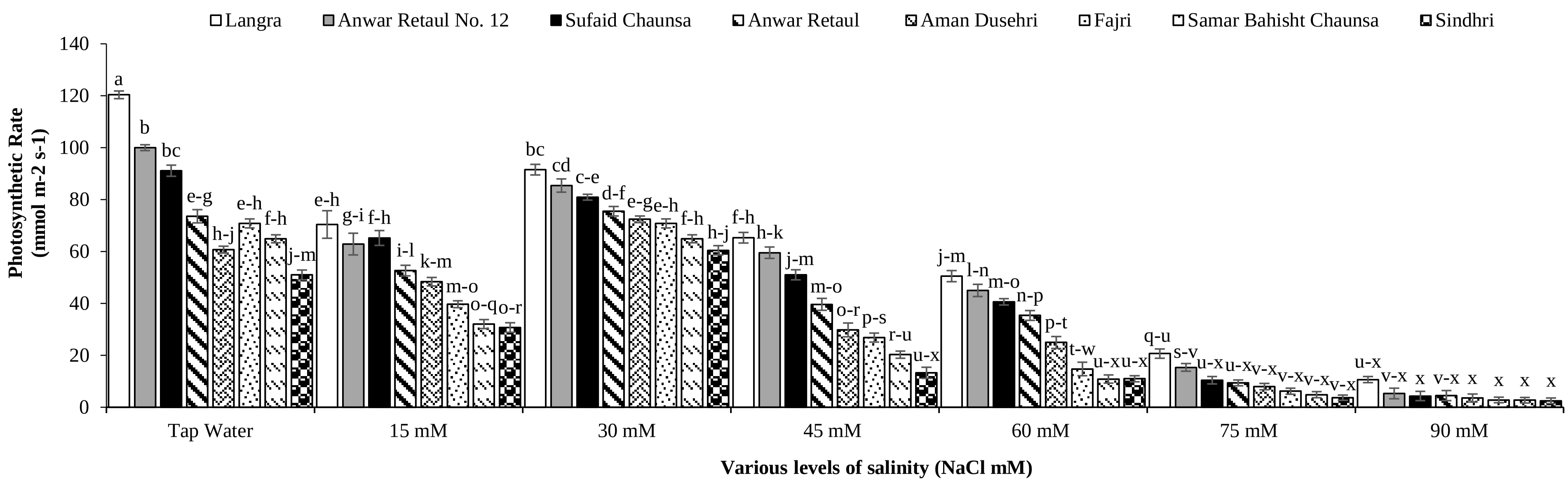

Fig. 9. Effect of various levels of NaCl induced artificial salinity stress on photosynthetic rate in different mango cultivars.

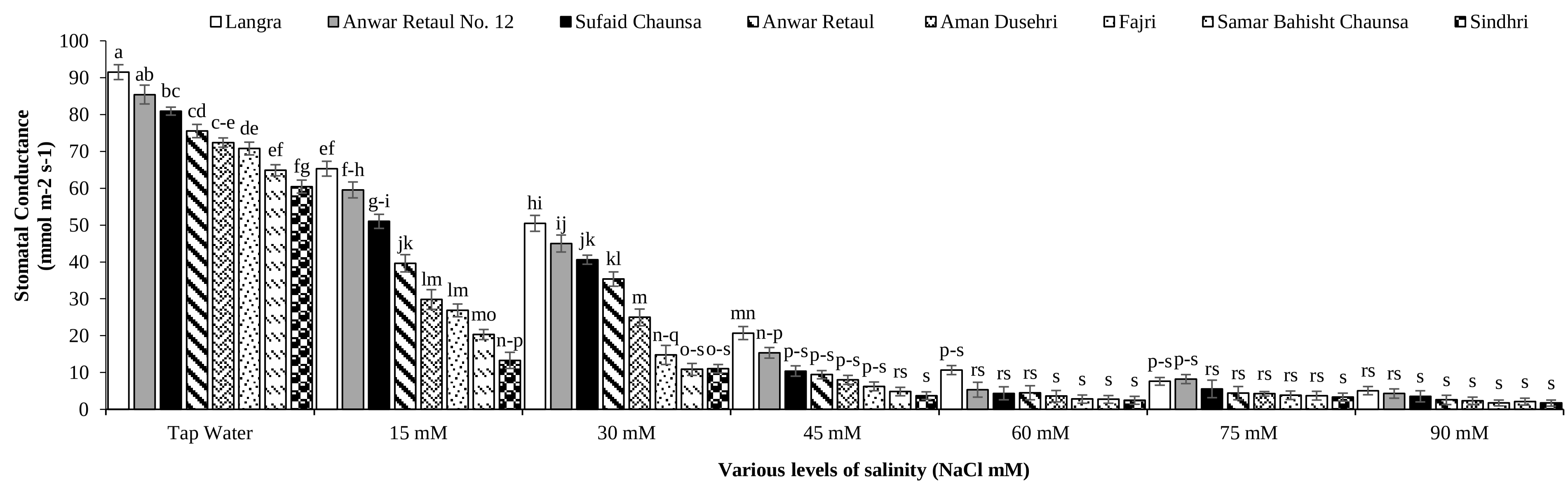

Fig. 10. Effect of various levels of NaCl induced artificial salinity stress on stomatal conductance in different mango cultivars.

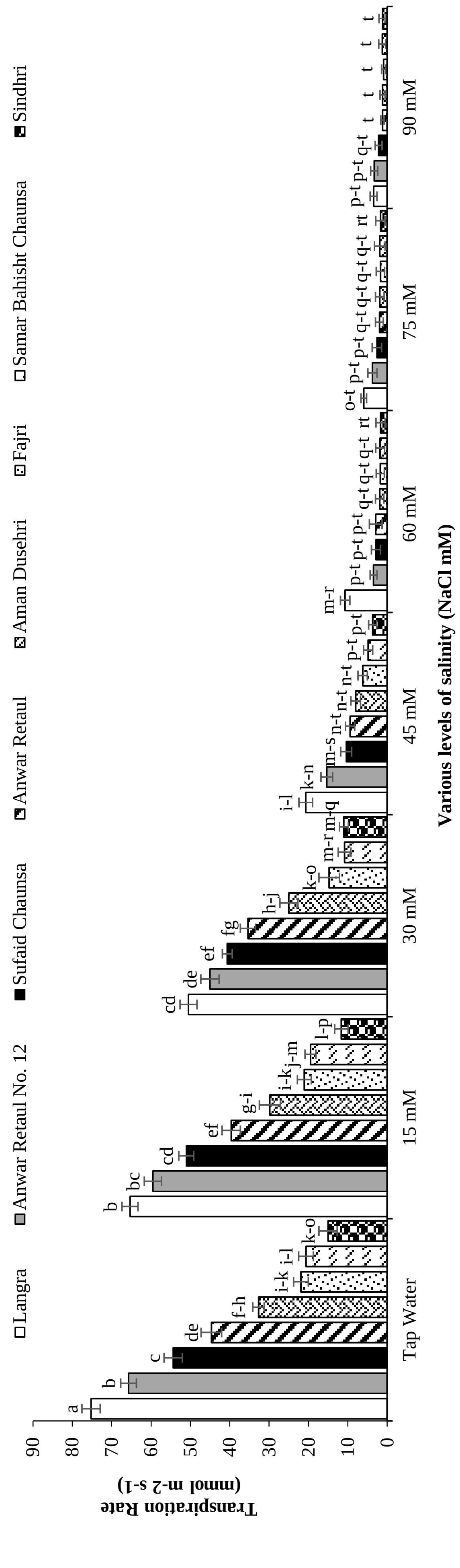

Fig. 11. Effect of various levels of NaCl induced artificial salinity stress on transpiration rate in different mango cultivars.

Both main and interactive effects of cultivars and salinity levels were found statistically significant for electrolyte leakage (ELL) (Fig. 7) and relative water content (RWC) (Fig. 8). It was observed that electrolyte leakage was significantly greater in Fajri, Samar Bahisht Chaunsa and Sindhri as compared to Langra, Anwar Retaul No. 12 and Sufaid Chaunsa where irrigation was done with tap water. The increasing level of salinity (15 to 90 mM NaCl) also enhanced ELL in all the cultivars. However, at all salinity levels ELL was significantly greater in Sindhri from Langra. A significant reduction of 50.5, 43.6, 34.8, 23.3, 33.1, 25.3 and 33.7% in ELL was noted in Langra as compared to Sindhri where irrigation was done with tap water and salinity levels 15, 30, 45, 60, 75 and 90 mM NaCl respectively. In case of RWC, all the cultivars remained statistically similar to each other where irrigation was done with tap water. For RWC at salinity levels 15, 30, 45, 60, 75 and 90 mM NaCl Langra, Anwar Retaul No. 12, Sufaid Chaunsa, Anwar Retaul and Aman Dusehri performed significantly better from Fajri and Sindhri. Both Fajri and Sindhri remained statistically alike to each other at salinity levels 15, 30, 45, 60, 75 and 90 mM NaCl for RWC. Maximum increase of 72.3, 120.9, 143.3, 143.5, 172.3 and 176.9% in RWC was noted in Langra as compared to Sindhri at salinity levels 15, 30, 45, 60, 75 and 90 mM NaCl respectively.

Both main and interactive effects of cultivars and salinity levels were found statistically significant for photosynthetic rate (Fig. 9), stomatal conductance (Fig. 10) and transpiration rate (Fig. 11). For photosynthetic and transpiration rate, Langra performed significantly better as compared to all other cultivars where irrigation was done with tap water. However, for stomatal conductance Langra and Anwar Retaul No. 12 performed significantly better from Sufaid Chaunsa, Anwar Retaul, Aman Dusehri, Fajri, Samar Bahisht Chaunsa and Sindhri when irrigated with tap water TW. Increasing level of salinity decreases photosynthetic, transpiration rate and stomatal conductance in all mango cultivars. However, for photosynthetic rate, Langra performed significantly better from Sindhri at salinity levels 15, 30, 45, 60 and 75 mM NaCl. However, all cultivars remained statistically alike to each other at salinity levels 60, 75 and 90 mM NaCl for transpiration rate and stomatal conductance. Maximum increase of 1.36, 1.29, 0.51 and 3.92-fold in photosynthetic rate, 4.02, 4.61, 3.59, 4.60, 5.26, 2.53 and 1.94-fold in transpiration rate and 0.51, 3.92, 3.59 and 4.60-fold in stomatal conductance was noted in Langra as compared to Sindhri when irrigated with tap water, 15, 30 and 45 mM NaCl respectively.

Discussion

Results of the current experiment showed that increasing concentrations of NaCl in irrigation water significantly decreased the growth attributes of mango cultivars, might be due to stress generated by a higher concentration of soluble salts in potting media. Our findings are in agreement to those obtained by Ahmed & Ahmed (1997) in mango, Ferreira & Lima-Costa (2006) and Jyothi and Raijadhav (2004) in citrus. According to Grattan and Grieve (1992), it is nutritional imbalance that resulted in high ratios of Na^+/Ca^{+2}, Na^+/Mg^{+2}, Cl^-/NO_3^- and $Cl^-/H_2PO_4^-$ that played an imperative role in the reduction of plant height. Ebert (2000) argued that chlorides and sulphates of the Ca^{+2}, Mg^{+2} and Na^{+1} induced osmotic stress and toxicity in plants under saline condition. According to Munns (1993), higher sensitivity of plants towards salinity is due to the imbalance of ions in the xylem transport system that stimulates shoot system for osmotic adjustment to reduce turgor loss (Shalhevet *et al*., 1995). Results of the current study also showed that Sindhri which was more susceptible towards salinity stress showed a low number of leaves survival comparative to Langra. Munns (1993) also observed that a higher concentration of salt in plants induced a premature senescence of old leaves that hampered the supply of assimilates in growing regions. Accumulation of salts in sensitive cultivar beyond threshold level leads towards scorching of leaves and ultimately death of plant (Munns & James, 2003). It was observed that increasing level of salinity significantly decreased gas exchange attributes i.e. photosynthetic rate, transpiration rate and stomatal conductance in mango cultivars. Cheeseman & Lovelock (2004) suggested that due to reduction in water potential under saline conditions developed a water stress that resulted in stomata closure (low stomatal conductance). Low water availability inactivates RuBPCO that play an imperative role in the regeneration of RuBP. The reduction in the regeneration of RuBP ultimately decreased photosynthetic rate in plants under higher level of salinity stress (Suárez & Sobrado, 2000). Results of the current study showed a significantly higher RWC in Langra and low in Sindhri that validated the potential of Langra to grow under salinity stress. Similar kind of results had been documented by many researchers where low RWC depicts low potential of plants to survive under stress (Parida & Das, 2005). A significant increase in ELL of stressed plants was might be due to reduction in molar percentages of phospholipids and sterols in membrane under higher salts concentration (Wu *et al*., 1998) and sodium-induced nutrients imbalance in the membrane (Greenway & Munns, 1980).

Conclusion

It is concluded that Langra has potential to survive under the variable level of soil salinity thus, is a comparatively salinity tolerant mango cultivar. However, Sindhri has the minimum potential to survive under salinity stress that made it a salt-sensitive mango cultivar.

References

Ahmed, A.M. and F.F. Ahmed. 1997. Effect of saline water irrigation and Cycocel on growth and uptake of some elements of Taimour and Alphonso mango seedlings. *Ann. Agri. Sci. Moshtohor,* 35(2): 901-908.

Almeselmani, M., F. Abdullah, F. Hareri, M. Naaesan, M. Adel Ammar, O. ZuherKanbar and A. Alrzak Saud. 2011. Effect of Drought on Different Physiological Characters and Yield Component in Different Varieties of Syrian Durum Wheat. *J. Agri. Sci.,* 3(3): 127-133.

Anees, M., F.M. Tahir, J. Shahzad, N. Mahmood and M. Genetics. 2011. Effect of foliar application of micronutrients on the quality of mango (*Mangifera indica* L.) cv. Dusehri fruit. *Mycopath,* 9(1): 25-28.

Anonymous. 2013. FAOSTAT Database on Agriculture. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy.

Anonymous. 2005. (Pakistan Horticulture Development and Export Board). Mango Marketing Strategy. Pakistan.

Arnon, D.I. 1949. Copper enzymes in isolated chloroplasts. Polyphenoloxidase in Beta vulgaris. *Plant Physiol.,* 24(1): 1-15.

Ayers, R.S. and D.W. Westcot. 1985. Water Quality for Agriculture. Food and Agriculture Organization of the United Nations, Rome.

Baloch, F.S., S.S. Tahir, S.T.H. Sherazi, N.S. Jilani, A.L. Khokhar and M.T. Rajput. 2017. Evaluation of essential oil components from the fruit peelings of sindhri and langra varieties of mango (*Mangifera indica* L.). *Pak. J. Bot.,* 49(4): 1479-1484.

Cheeseman, J.M. and C.E. Lovelock. 2004. Photosynthetic characteristics of dwarf and fringe Rhizophora mangle L. in a Belizean mangrove. *Plant, Cell Environ.,* 27(6): 769-780.

Ebert, G. 2000. Salinity problems in (Sub-) tropical fruit production. In: II ISHS Conference on Fruit Production in the Tropics and Subtropics, 531: 99-105.

Ferreira, A.L. and M.E. Lima-Costa. 2006. Metabolic responses to salt stress in cell suspension cultures of sensitive and resistant Citrus. *J. Hort. Sci. Biotechnol.,* 81(6): 983-988.

Ghafoor, A., K. Mustafa, I. Zafar and K. Mushtaq. 2010. Determinants of mango export from pakistan. *J. Agri. Res.,* 48(1): 105–119.

Grattan, S.R. and C.M. Grieve. 1992. Mineral element acquisition and growth response of plants grown in saline environments. *Agri. Ecosyst. Environ.,* 38(4): 275-300.

Greenway, H. and R. Munns. 1980. Mechanism of salt tolerance in nonhalophytes. *Annu. Rev. Plant Physiol.,* 31(1): 149-190.

Heuvelink, E., M. Bakker and C. Stanghellini. 2003. Salinity effects on fruit yield in vegetable crops: A simulation study. In: *International Symposium on Managing Greenhouse Crops in Saline Environ*., 609: 133-140.

Hoagland, D.R. and D.I. Arnon. 1950. The water culture method for growing plants without soil. University of California, College of Agriculture, Agricultural Experiment Station. 2nd ed. Berkeley, CA. Circular. pp. 374.

Jindal, P.C., J.P. Singh and O.P. Gupta. 1979a. Effect of Salinity on the Mineral Nutrients in Mango Seedlings. *Ind. J. Agri. Sci.,* 49: 105-109.

Jindal, P.C., J.P. Singh and O.P. Gupta. 1979b. Mineral nutrient status of different mango cultivars under varying salt status in soil. *Haryana J. Hort. Sci.,* 8: 39-41.

Jyothi, H. and S. Raijadhav. 2004. Effect of salinity levels on leaf chlorophyll, proline and wax content in 'Rangpur' lime rootstock strain. *Karnataka J. Agri. Sci.,* 17: 891-892.

Kumar, P., A.K. Singh and S.C. Shankhdhar. 2017. Efficacy of Soil and Foliar Application of Macro and Micronutrients on Yield and Quality of Mango cv . "Dashehari." *Int. J. Curr. Microbiol. App. Sci.,* 6(10): 1855-1861.

Laxman, R.H., C.J. Annapoornamma and G. Biradar. 2016. Mango. In: (Eds.): *Abiotic Stress Physiology of Horticultural Crops*. Rao, N.K.S., K.S. Shivashankara and R.H. Laxman. 1st ed. Springer, India, pp. 169-266.

Lutts, S., J.M. Kinet and J. Bouharmont. 1995. Changes in plant response to NaCl during development of rice (*Oryza sativa* L.) varieties differing in salinity resistance. *J. Exp. Bot.,* 46: 1843-1852.

Maas, E.V. and S.R. Grattan. 1999. Crop yields as affected by salinity. In: (Eds.): Skaggs, R.W. and J. van Schilfgaarde. Agricultural Drainage, Agronomy Monograph 38. American Society of Agronomy, Madison. pp. 55-110.

Majumder, P.K. and D.K. Sharma. 1985. Mango. In: (Ed.): Bose, T.K. Fruits of India: Tropical and sub-tropical. Naya Prakash Publishers, Calcutta. pp. 125-128.

Munns, R. 1993. Physiological processes limiting plant growth in saline soils: Some dogmas and hypotheses. *Plant. Cell Environ.*, 16(1): 15-24.

Munns, R. and R.A. James. 2003. Screening methods for salinity tolerance: A case study with tetraploid wheat. *Plant Soil*, 253(1): 201-218.

Mushtaq, A., S. Rizwan, N. Jamil, T. Ishtiaq, S. Irfan, T. Ismail, M.N. Malghani and M.N. Shahwani. 2019. Influence of silicon sources and controlled release fertilizer on the growth of wheat cultivars of balochistan under salt stress. *Pak. J. Bot.*, 51(5): 1561-1567.

Pakistan Observer. 2017. Pakistan 5th largest producer of mangoes in world. Available at https://pakobserver.net/pakistan-5th-largest-producer-mangoes-world/.

Parida, A.K. and A.B. Das. 2005. Salt tolerance and salinity effects on plants: A review. *Ecotoxicol. Environ. Saf.*, 60: 324-349.

Samra, J.S. 1985. Sodicity tolerance of grapes with reference to the uptake of nutrients. *Ind. J. Hort.*, 42: 12-17.

Schaffer, B., A.W. Whiley and J.H. Crane. 1994. Mango. p. 188. In: (Eds.): Andersen, P.C. and B. Schaffer. Handbook of Environmental Physiology of Fruit Crops. Volume II. Subtropical and Tropical Crops. 1st ed. CRC Press.

Schmutz, U. and P. Ludders. 1994. Salt tolerance in mango (*Mangifera indica* L.) rootstocks. *Angew. Bot. Berichte*, 5: 189-193.

Silva, J.M., H.R. DaGheyi, P.D. Fernandes, F.H.T. Oliveira and F.A.L. DeSorare. 2004. Macro and micronutrient and sodium contents in leaves of Mango rootstocks irrigated with water with different levels of salinity. In: Proceedings of Interamerican Society for Tropical Horticulture. Fortaleza, Brazil. pp. 213-217.

Singh, L.B. 1976. Mango. In: Simmonds, N.W. (Ed.). Evolution of crop plants. Longman, London, UK. pp. 7-9.

Steel, R.G., J.H. Torrie and D.A. Dickey. 1997. Principles and Procedures of Statistics: A Biometrical Approach. 3rd ed. McGraw Hill Book International Co., Singapore.

Suárez, N. and M.A. Sobrado. 2000. Adjustments in leaf water relations of mangrove (*Avicennia germinans*) seedlings grown in a salinity gradient. *Tree Physiol.*, 20(4): 277-282.

Wu, J., D.M. Seliskar and J.L. Gallagher. 1998. Stress tolerance in the salt marsh plant *Spartina patens*: impact of NaCl on growth and root plasma membrane lipid composition. *Physiolo. Plant.*, 102: 307-317.

(Received for publication 9 January 2019)