International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(3): 3333-3336

Received: 21-03-2019
Accepted: 25-04-2019

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Effect of various salt levels on leaf gas exchange parameters of ten polyembryonic mango rootstocks

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Abstract
A pot culture experiment was conducted to screen the polyembryonic mango rootstocks Muvandan, Manipur, Peach, Prior, Mylepelian, Nekkare, Vattan, Chandrakaran, Sundarimanga and Kolambe against different salt levels (50 mM NaCl, 100 mM NaCl and 150 mM NaCl) along with control (0 mM NaCl) based on the leaf gas exchange parameters. The experiment was conducted under Completely Randomized Design with three replications. Irrespective of different polyembryonic mango rootstocks, the leaf gas exchange parameters were found to be decreasing with increase in the level of salinity. The minimum per cent reduction of photosynthetic rate (7.65%), transpiration rate (20.85%) and stomatal conductance (32.79%) were recorded at higher salt level of 150 mM NaCl in Nekkare rootstocks.

Keywords: gas exchange parameters, nekkare, photosynthetic rate, transpiration rate

Introduction
Salinity is one of the most important abiotic stress factors which limit the crop production to greater extent at world level by altering the plant mechanisms and nutrient uptake (Willenborg *et al*., 2004) [12]. Mango, considered as one of the most important fruit crops in India and occupying a prime position in the markets is very sensitive to soil salinity (Gupta and Sen, 2003) [7]. Photosynthesis is an essential parameter used to monitor the plant response to abiotic stress. Salinity can induce the absorption of excessive mineral nutrition, causing an ionic imbalance as a result of the accumulation of particular salts within the plant. As a consequence, restriction of photosynthesis, stomatal conductance and transpiration rate occurred in the plant system (Hannachi and Van Labeke, 2018) [8]. As salinity causes a disturbance in the plant physiological activities, this in turn affects the photosynthesis a major factor of energy absorption (Chaves *et al*., 2009) [3]. The stomatal closure is induced by abscisic acid and occurrence of adverse effect on the chloroplasts (especially electron transport and secondary processes) and photosynthesis is disrupted during salinity (Bray *et al*., 1994) [2]. Finally reduction of photosynthetic activity under salinity conditions leads to decrease in the stomatal conductance and transpiration rate (Da Silva *et al*., 2008) [4]. The present study was conducted to understand the effect of salinity on leaf gas exchange parameters *viz*. photosynthetic rate, transpiration rate and stomatal conductance of ten polyembryonic mango rootstocks.

Materials and Methods
The pot culture experiment was conducted under semi-protected condition at Tamil Nadu Agricultural University, Coimbatore during 2018-2019. The polyembryonic mango rootstocks such as Muvandan, Manipur, Peach, Prior, Mylepelian, Nekkare, Vattan, Chandrakaran, Sundarimanga and Kolambe were subjected to three different salt levels (50 mM NaCl, 100 mM NaCl and 150 mM NaCl) along with one control (0 mM NaCl). The experiment was laid out under Completely Randomized Design with three replications for each salt treatment was maintained. The nucellar mango seedlings were transplanted from raised nursery beds to polybags of size 40 cm x 24 cm x 24 cm. The polybags were filled with 10 kg potting mixture containing sand, soil and FYM in the ratio of 1:2:1. Polybags were provided with punched drain holes at the bottom for drainage. The control plants were irrigated with water without

any added NaCl (EC = 0.5 dSm^{-1} and pH- 6.9). Based on the moisture content, the polybags were irrigated at regular intervals depending on the treatments for about three months.

Leaf gas exchange activities (photosynthetic rate, transpiration rate and stomatal conductance) were measured using Portable Photosynthesis System (PPS) (Model LI-6400 of LICOR inc., Lincoln, Nebraska, USA) equipped with a halogen lamp (6400-02B LED) positioned on the cuvette. Totally, three measurements were taken in the same leaf. Leaves were inserted in a 3 cm^2 leaf chamber and PPFD (Photosynthetic Photon Flux Density) at 1200 µmol photons m^{-2} s^{-1}, and relative humidity (50-55%) were set. The readings were taken between 11 a.m. to 12.30 p.m. The data were analysed using the STAR package (Statistical Tools for Agricultural Research developed by IRRI, Philliphines) to calculate the significant differences among the treatments.

Results and Discussion

The effect of salt stress on the photosynthetic rate of ten rootstocks were analysed and compared statistically (Table 1). No significant difference was recorded in control and 50 mM NaCl treatments for photosynthetic rate. Comparing with respective control, the least per cent reduction was recorded in Nekkare (4.56%) which was on par with Manipur (5.00%) rootstocks at 100 mM NaCl. In the same salinity level, the highest per cent reduction (11.83%) was observed in Chandrakaran which was on par with Sundarimanga rootstocks (11.40%). At higher salt stress level (150 mM NaCl), higher photosynthetic rate (6.88 µmol CO_2 m^{-2} s^{-1}) was recorded by Nekkare rootstocks and the least was observed in Chandrakaran (5.36 µmol CO_2 m^{-2} s^{-1}) which is on par with Sundarimanga (5.38 µmol CO_2 m^{-2} s^{-1}) rootstock. When irrigated with saline water, plants usually accumulate inorganic ions in vacuoles, decreasing the cell water potential. Reduction in photosynthetic rate might be mainly due to the entering of excessive amounts of toxic ions into the plant (Yang *et al*., 2009). The results obtained in the experiment are in line with reports by Qiu *et al*. (2018) [10] in hot pepper.

Under salinity stress, leaf transpiration rate was reduced significantly (p = 0.05) as NaCl concentrations increased (Fig. 1). Significant reduction in transpiration rate was observed even at low salinity level (50 mM NaCl). Transpiration rate decreased by 20.85 % only in Nekkare rootstocks whereas in Sundarimanga, Chandrakaran and Prior rootstocks, the transpiration rate decreased by about 47.45%, 47.63% and 45.57% respectively as compared to concern control rootstocks at 150 mM NaCl. These results are in agreement with the report by De Lucena *et al*. (2012) [5] in mango and Azizi *et al*. (2018) [2] in pinus.

In this study, after 90 days of salt stress imposement, significant reduction in the stomatal conductance was observed in all the salinity levels (Fig. 2). In Nekkare rootstock, the least per cent reduction of about 2.46% was recorded which was statistically on par with Manipur (2.48%) as compared with respective control in 50 mM NaCl. The higher per cent decrement (13.22%) was recorded by Sundarimanga in the above mentioned salt level. At both 100 and 150 mM NaCl, higher stomatal conductance was recorded by Nekkare rootstocks (1.02 and 0.82cm s^{-1} respectively). In contrast, lower stomatal conductance was observed in Sundarimanga (0.42 and 0.06 cm s^{-1}) and Chandrakaran rootstocks (0.45 and 0.08 cm s^{-1}). Under salt stress, as instant response in plants, a reduction in stomatal opening occurred to reduce water loss through leaves, as induced by osmotic potential reduction in soil solution (Taiz and Zeiger, 2013) [11]. The accumulation of salt ions in the leaves may also affect significantly, the essential physiological processes including stomatal conductance (Hussain *et al*., 2012) [9]. In Nekkare rootstocks, the salt ion accumulation on the upper leaves might be low which leads to tolerance for stress situation with least reduction in stomatal conductance. The highest per cent reductions in Chandrakaran and Sundarimanga rootstocks might be due to the perturbation in the water relations and subsequent synthesis of ABA. The decrement in stomatal conductance by salinity was also recorded by Dias *et al*. (2018) [6] in West Indian Cherry. Based on the gas exchange parameters, finally, it is concluded that Nekkare showed a better salt tolerance mechanism among the various tested polyembryonic mango rootstocks studied.

Table 1: Effect of salt stress on photosynthetic rate (µmol CO_2 m^{-2} s^{-1}) of polyembryonic mango rootstocks

Salt levels/ Rootstocks	Control	50 mM NaCl	100 mM NaCl	150 mM NaCl
Muvandan	7.52	7.41 (1.46)	7.07 (5.98)	6.54 (13.03)
Manipur	7.40	7.32 (1.08)	7.03 (5.00)	6.43 (13.11)
Peach	7.32	7.21 (1.50)	6.89 (5.87)	6.15 (15.98)
Prior	7.31	7.05 (3.56)	6.62 (9.44)	5.81 (20.52)
Mylepelian	7.38	7.27 (1.49)	6.94 (5.96)	6.25 (15.31)
Nekkare	7.45	7.42 (0.40)	7.11 (4.56)	6.88 (7.65)
Vattan	7.35	7.17 (2.45)	6.77 (7.89)	6.06 (17.55)
Chandrakaran	7.27	6.98 (3.99)	6.41 (11.83)	5.36 (26.27)
Sundarimanga	7.28	7.02 (3.57)	6.45 (11.40)	5.38 (26.10)
Kolambe	7.33	7.12 (2.86)	6.72 (8.32)	5.98 (18.42)
Mean	7.36	7.20 (2.24)	6.80 (7.63)	6.08 (17.39)
S.Ed	-	- (0.07)	0.25 (0.24)	0.22 (0.54)
C.D. (p=0.05)	NS	NS (0.15*)	0.55* (0.48*)	0.44* (1.10*)

The values in the parentheses indicated that per cent reduction as compared with concerned control.

* - Significant at 5% level

NS – Non-significant

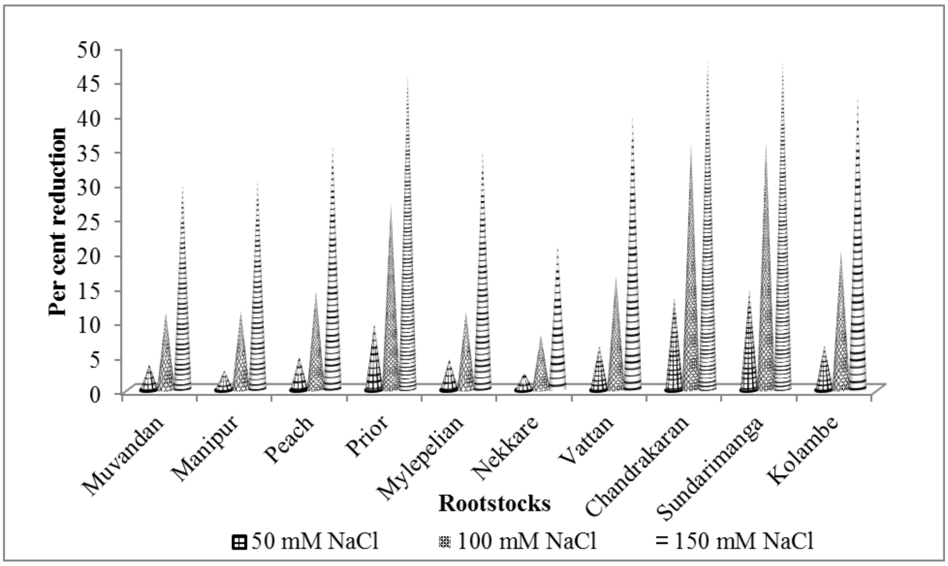

Fig 1: Per cent reduction of transpiration rate in polyembryonic mango rootstocks under different salt stress

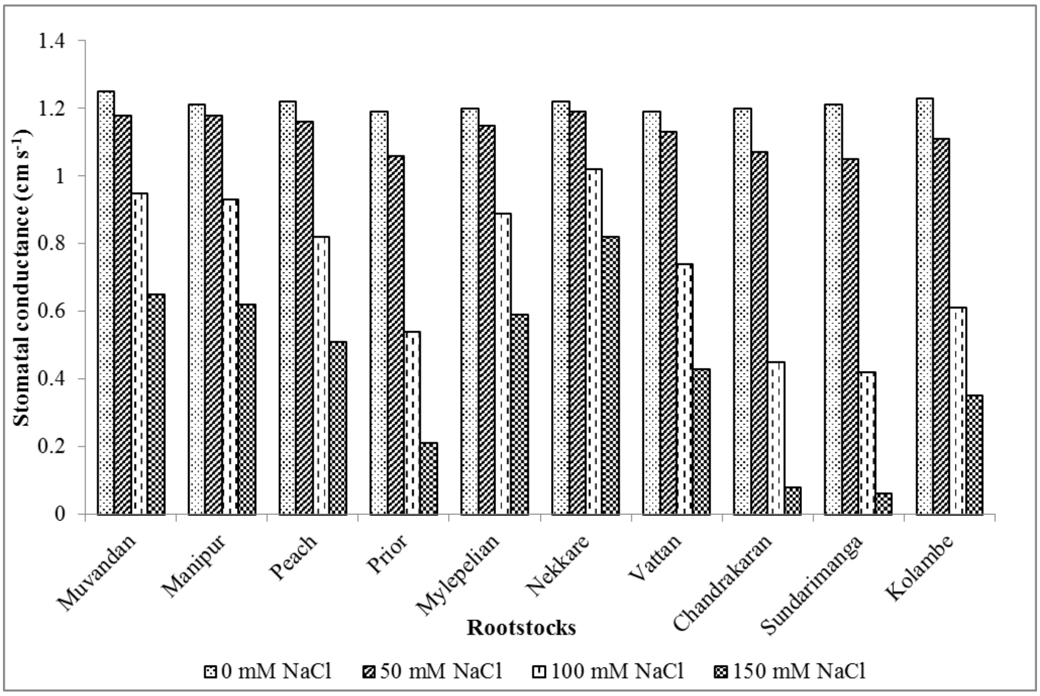

Fig 2: Effect of salt stress on stomatal conductance (cm s^{-1}) of polyembryonic mango rootstocks

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