

## SALT STRESS STUDIES IN MANGO- A REVIEW

A.K. Dubey, A.K. Singh and Manish Srivastav

Division of Fruits and Horticultural Technology  
Indian Agricultural Research Institute, New Delhi-110 012, INDIA

### ABSTRACT

Soil salinity is now considered as the frontier area of the Indian agricultural research. In India problem of soil salinity is causing concern over 8.5 m hectare area and the potential soil salinity hazard is threatening another 27% land area. This problem is more pronounced in Haryana, Uttar Pradesh, Orissa, Gujrat, Punjab, Rajashthan, West Bengal, Maharashtra, Andra Pradesh, Karnataka and Tamil Nadu. Mango is the most important fruit crop of India and it is grown on 1.401 million hectare land with total production of 9.782 million tones. It is more sensitive to soil salinity at younger stage. Northern India is the largest belt of mango cultivation contains appreciable amount of salts due to introduction of canal irrigation. It has now become serious problem for the establishment of new mango orchards. In irrigated areas, salinity is almost a universal threat because irrigation water normally contains hundred or thousands mg salts per liter of irrigation water. Little efforts have been made to study the effect of salts in systematic manner. Emphasis must be given to find out the physiology of salt stress in mango and its impact on the different plant growth functions. There are two-three mango genotypes having some degree of tolerance to salt but studies on the exact mechanism and level of salt tolerance in those mango genotypes still lacking. Identification of salt tolerant rootstocks and performance of scion cultivars on those rootstocks in saline conditions will determine the success and expansion of mango area in salt affected soils.

In India, salt affected soils are causing concern over 8.5 m hectare area and the potential soil salinity hazard is threatening another 27% land area (Survey of Indian Agriculture, 2004). Saline soils extensively occur in Punjab, Haryana, Uttar Pradesh, Gujrat, Rajashthan, West Bengal, Maharashtra, Orissa, Andra Pradesh, Karnataka and Tamil Nadu. The salt affected soils have higher amount of chlorides and sulfates of the calcium, magnesium and sodium. Once deposited or released in the soil, these salts are brought to or near the surface by upward moving water, which evaporates, leaving the salt behind. Unfortunately, high levels of these salts cannot be tolerated by most of the crop plants, a fact that severely limits the use of salt affected soils. When the soil solutions containing a relatively large amount of dissolved salts and brought into contact with a plant cell the cell than collapses. The kind of salt, the plant species and the rate of salinization are major factors that determine the concentration at which cell succumbs. Under the situation of salinity, plant growth is suppressed when the salt

concentration exceeds thresh hold value, growth rate and size of the plant progressively decreased with increased salinity. Constituents of salts accumulate in toxic amount in leaves of mango, which in term inhibit growth, causes leaf injury, nutrients imbalance and reduce uptake of major nutrients. Plant height and leaf area are drastically reduced due to salinity. Mango generally accumulates 2.5 to 3.0 times more than guava and *ber*. This creates bearing problem and thus results reduction in fruit yield. Some polyembryonic varieties are found to be tolerant to salinity. Therefore, mango should be grafted on salt tolerant rootstocks like Kurukkan for cultivation in salinity affected area.

Mango is the most important fruit crop of India. It is grown on 1.401 million hectare land with total production of 9.782 million tones (Survey of Indian Agriculture, 2004 ). Mango is very sensitive to soil salinity at younger stage. Northern India, which is the largest belt of mango cultivation, contains appreciable amount of salts which has been aggravated due to introduction of canal

irrigation. It has become serious problem for the establishment of new cultivars. In groundwater irrigated areas, salinity is almost a universal threat because irrigation water normally contains hundred or thousands of mg/liter of salts. The available information on growth inhibition of mango by salts has been compiled and discussed under following heads.

### Growth inhibition

If growth reduction can be correlated with the reduction in substrate water potential and similar responses occur with isosmotic concentrations of different salts, the salinity has an osmotic effect. If the response is more pronounced for one salt than for isosmotic concentrations of other salts, there is a specific (toxicity) effect. Although salinity affects plants physiologically in many ways the predominant influence of salt stress is of growth suppression. Typically growth decreases more or less linearly as salinity increases beyond a threshold level and the effect is similar for a range of different salts i.e. an osmotic effect (West, 1986).

The constituents of salt ions accumulate in toxic amounts in leaves of mango which in turn inhibit growth, causes leaf injury, nutrient imbalance and reduce uptake of major nutrients (Rao, and pathak 1989). Schmutz *et al.* (1993) observed that reduction in vegetative growth was greater with NaCl than with  $\text{Na}_2\text{SO}_4$  in mango rootstock 13-1. However, at low salt concentrations, leaf area was reduced but the number of leaves increased. Ahmed and Ahmed (1997) found reduction in all growth characters (height, number of leaves, leaf area and stem thickness) with increasing levels of salinity. Turpentine grafted on 13-1 rootstock exhibited higher reduction in shoot growth. It was also found that 13-1 was not able to protect the salts sensitive scion Turpentine from the detrimental effects of salinity (Schmutz and Ludders, 1999).

### Effect on yield

Hoult *et al.* (1996) suggested that salt toxicity limited mango productivity in arid environments. Mango trees grafted with Osteen and similar varieties on small three year old trees using different rootstocks (Gomera-1 and Gomera-3), the Gomera-1 rootstock had greater tolerance to higher concentration of chlorides and a higher productivity than Gomera-3 rootstocks, however yield decreased with increasing salinity (Martinez, *et al.*, 1999).

### Toxicity and injury

Cultivars differ in their ability to exclude or accumulate chloride, sodium and sulphate constituents of salinity. Symptoms of sodium injury in fruit crops include appearance of mottle or chlorotic areas in leaves, which usually end up in necrotic areas on tips, margins and even in stem. Jindal and Makhija (1983) studied the accumulation of  $\text{Na}^+$ ,  $\text{Cl}^-$  and  $\text{SO}_4^{2-}$  in young and fully grown trees of 5 varieties of *Mangifera indica*. Langra and Bombay Green accumulated the ions in toxic amounts while Dashehari and Chausa appeared to have some ability to exclude them. Fully grown trees accumulated more salts than did young trees. Samra (1985) reported leaf scorching was common in mangoes and all scorched mango leaves had high Na concentrations. Sodium toxicity exhibited itself as scorching of older leaves, which had the lowest leaf K: Na ratio was found most sensitive to sodium scorching (Samra, 1989). Hoult *et al.* (1997) reported scorching of leaf margins, a typical response to saline water uptake, varied between cultivars. Non-significant correlation was observed between sodium or chloride concentrations in leaf and the area of leaf margins showing scorching. Wang *et al.* (2000) reported that soil pH and the total N, P, K and Na contents were not related to the leaf scorching in mango in 'Xiamen' cultivar but the degrees of injury caused by leaf scorching were positively related

to the concentrations of chloride and potassium in leaves.

### Nutritional imbalance

Salt dominated soils having the higher side of the pH significantly affect the availability of various macro and micro-nutrients to the plants and creating nutrient imbalance. Nutritional imbalance may be caused by an excess of a particular ions like sodium, magnesium and calcium and anions like chloride, sulphate and nitrates.

More reduction in nitrogen content of mango leaves was observed (Jindal *et al.*, 1979a, b) due to higher chloride ion concentration in soil than by  $\text{SO}_4$  ions that may be due to their specific effect on inhibition of  $\text{NO}_3$  absorption and more absorption of ammonium. Pandey *et al.* (1971) assigned the mango decline to cation or anion imbalance under varying situations. Ahmed and Ahmed (1997) observed adverse effects on the uptake of N, P, K, Ca, Mg, Zn and Fe with increasing levels of salinity, the salinity level more than 0.2% adversely influenced the uptake of nutrients. Schmutz and Ludders (1994) reported leaf sodium and chloride concentrations were higher in 13-1 than Turpentine after 29 days of NaCl treatment. Schmutz and Ludders (1999) also found lower  $\text{Na}^+$  and  $\text{Cl}^-$  contents but higher  $\text{K}^+$  content in roots and higher  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  contents in leaves of *Mangifera zeylanica* compared to *Mangifera indica* 13-1. Further, higher K: Na ratio was found in all plant parts especially in roots of *Mangifera zeylanica*.

Genotype '13/1' was tested to characterize the morphological and physiological reactions to increasing saline stress conditions. Rooted cuttings were grown in the greenhouse and treated with 20, 40, 60 mM/l  $\text{Na}^+$  as NaCl and  $\text{Na}_2\text{SO}_4$ . The reduction of vegetative growth was stronger in NaCl treatments than in  $\text{Na}_2\text{SO}_4$  treatments. Salt symptoms occurred later with  $\text{Na}_2\text{SO}_4$

treatment. Salinity significantly reduced the average leaf area, but the leaf number was increased at lower salinity levels. Mineral analysis in roots, stem, old leaves, shoots and young leaves showed high  $\text{Na}^+$  contents in young plant parts. The  $\text{Na}^+$  contents in roots with  $\text{Na}_2\text{SO}_4$  treatment were significantly higher than with NaCl. The uptake of  $\text{SO}_4^{2-}$  was half that of  $\text{Cl}^-$  and the translocation of  $\text{Na}^+$  in the upper plant parts was reduced with  $\text{SO}_4^{2-}$  as anion. In both salt treatments transpiration was significantly reduced during 8 weeks of saline conditions. The reduction was stronger with NaCl than with  $\text{Na}_2\text{SO}_4$  treatment (Schmutz and Ludders, 1993).

### Accumulation of salts

Salinity tolerance is often related to the degree to which  $\text{Na}^+$  is excluded from the shoot.  $\text{Na}^+$  exclusion reduces  $\text{Na}^+$  accumulation in older leaves, increasing their longevity and thus net productivity. Therefore, salinity tolerance of a whole plant is not a property of all cells within a plant, but requires more subtle properties than simply  $\text{Na}^+$  tolerance of individual cells. It requires particular characteristics of specific cells. Most notably, to facilitate  $\text{Na}^+$  exclusion from the shoot,  $\text{Na}^+$  would need to be pumped out of cells in the outer part of the root, but into cells in the inner part of the root, adjacent to the xylem to maintain low  $\text{Na}^+$  in the xylem and thus low delivery to the shoot.

Samra (1985) reported that mango generally accumulated 2.5 -3.0 times more sodium than other species in both old and young leaves. Plant analysis in mango rootstock 13-1 revealed higher  $\text{Na}^+$  concentrations in young than old plants in different salt stress (Schmutz *et al.*, 1993). In the influence of salinity in combination with different root zone temperature in mango rootstock 13-1 and Turpentine, it was reported that 13-1 stored significantly higher  $\text{Na}^+$  content and lower  $\text{Cl}^-$  content (Schmutz and Ludders, 1998).

Schmutz *et al.* (2000) reported that 13-1 had Higher Na<sup>+</sup>, Cl<sup>-</sup> and Ca<sup>2+</sup> contents in leaves while significantly lower Na<sup>+</sup> contents were found in roots and young leaves of *Mangifera zeylanica* as compared to rootstock 13-1. The K<sup>+</sup> contents and K: Na ratios were significantly higher in roots of *Mangifera zeylanica*. The potassium, sodium and sulphur contents of leaves, stem and roots increased in Dudhia Langra, Guruivari, hybrid 15/1, Kala Hapus, Kurth, Kolumban and Nariyal with the increase in salinity and hybrid 15/1 had the highest potassium and sodium contents in leaves and stems. Which indicates its tolerance to potassium and sodium salts as compare to other evaluated cultivars (Nigam *et al.*, 2002).

### Cultivars tolerant to salt

Jindal *et al.* (1975) reported wide variation in growth and vigour among selected tolerant rootstock types from large population of sucking type mango seedlings. Bhambota *et al.* (1963) reported death of grafted mango seedlings at salinity level as low as 1.9 dS/m, however, Jindal *et al.* (1976) found Langra as the most sensitive variety. Vijyan and Bedi (1989) observed that jamun and sapota performed better than mango under same salinity level. Among mango rootstocks, Bappakai, Olour (Anonymous, 1989) and Kurukkan (Singh, 1985) were rated moderately tolerant to salt stress.

### REFERENCES

- Ahmed, A.M. and Ahmed, F.F. (1997). *Ann. Agric. Sci.* **35**: 901-908.
- Anonymous (1989). *IIHR, News* **10** (4): 1-3
- Anonymous (2004). Survey of Indian Agriculture, 2004.
- Bhambota, J.R. *et al.*, (1963). *Punjab Hort. J.* **8**: 164-170.
- Hoult, M.D. *et al.*, (1997). *Acta Hort.* **455**: 455-458.
- Jindal, P.C. *et al.*, (1979a). *Haryana J. Hort. Sci.* **8**:39-41.
- Jindal, P.C. *et al.*, (1975). *Haryana J. Hort. Sci.* **4**: 112-15
- Jindal, P.C. *et al.*, (1976). *Haryana J. Hort. Sci.* **5**:13-14.
- Jindal, P.C. *et al.*, (1979b). *Indian J. Agric. Sci.* **49**:105-109
- Jindal, P.C. *et al.*, (1983). *Prog. Hort.* **15** (3):226-228.
- Jindal, P.C and Makhija, M. 1983. *Progressive Horticulture* **15**(3): 226-228.
- Martinez *et al.*, (1999). Irrigation Under Conditions of Water Scarcity Vol. IG 17<sup>th</sup> International Congress on Irrigation and Drainage, Granada, Spain. Published In *Commission on Irrigation and Drainage*. pp 61-71.
- Nigam J.K. *et al.*, (2002). *Indian J. Hort.* **59** (1): 17-23.
- Pandey, R.M. *et al.*, (1971). *Curr. Sci.* **40** : 356-57
- Rao and Pathak (1989). *Indian J. Hort.* **6**(2): 99-102.
- Samra, J.S. (1985). *Indian J. Hort.* **42**(3-4): 178-183.
- Samra, J.S. (1989). *Acta Hort.* **231**:306-311.
- Schmutz, U. and Ludders, P (1993). *Acta Hort.* **341**:160-167
- Schmutz, U. and Ludders, P (1994). *Angewandte- Botanik Berichte* **5**: 189-193.
- Schmutz, U. and Ludders, P (1998). *Angewandte- Botanik*, **72**: 131-135.
- Schmutz, U. and Ludders, P (1999). *Gartenbauwissenschaft* **64**(2) : 60-64.
- Schmutz, U. and Ludders, P (1999). *Plant Genetic Resource News letter* **119**: 7-11.
- Schmutz, U. *et al.* (2000). *Acta Hort.* **509**: 269-276
- Schmutz, U. *et al.*, (1993). *Acta Hort.* **341**:160:167.
- Singh, A.K. ( 1985). M.Sc. Thesis IARI, New Delhi
- Wang, W.R. *et al.*, (2000). *J. Trop. Subtrop. Bot.* **8**: 333-338.
- West, D.W. (1986). *Acta Hort.* **175**:321-332.