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Review Article

SALINITY INFLUENCE IN TROPICAL FRUIT CROPS

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Abstract

Salinity remains one of men's oldest environment and horticultural problems and challenging to scientist for production and productivity in our country. Fruit crops are moderately to highly susceptible to salt stress and their production adversely affected due to accumulation of salt. Salinity is caused by various factors such as mineral weathering, use of faulty irrigation water, poor rainfall, high evaporation rates, etc. but canal irrigation has been held more responsible Salinity affects plant growth and development in various ways through its impact on photosynthesis, water relations and nutrient absorption. The ability of plants to tolerate salts is determined by many biochemical pathways which enable acquisition of water, protect chloroplast functions and maintain ion homeostasis. The present review focuses on effect of salinity levels on growth, physiological, biochemical response and nutrient accumulation with mechanisms of salinity stress tolerance in tropical fruit crops.

Key words : Fruit, salinity, salt, stress

Introduction

The excess of soluble salts present in the irrigation water and in the soil solution is one of the major abiotic stresses that affect crop yield and the distribution of plant species in natural environments (Boyer, 1982). This problem reaches 20% of the irrigated areas of the world, occurring especially in the arid and semiarid regions, where about 25% of the irrigated land is affected by salts (FAO, 2005). In India, 4.10 M ha. lands have been reported to be saline soil (Anon., 2011). Salt affected soils are spread widely covering the Indo-Gangetic plains, arid regions and coastal areas. The malady continues to increase due to the mismanagement of canal irrigation as well as due to brackish ground water irrigation.

Salt stress induces various morphological, physiological and biochemical responses from plants, depending on the genotype and the stage of plant development (Willadino and Camara, 2003). Plant growth is retarded by physiological processes, such as photosynthesis, stomatal conductance, osmotic adjustment, ion uptake, protein synthesis, nucleic acid synthesis, enzymatic activity, and hormonal balance (Parés *et al*., 2008). It also affects the transport process of water and ions, resulting in ion toxicity and nutritional imbalance (Larcher, 2003) and consequently vegetative growth variables such as dry mass, plant height, and leaf area are severely affected (Parés *et al.,* 2008).

Although plant tolerance to salinity can be described to several biochemical and physiological mechanisms, there is an increasing body of evidences suggesting the existence of a general stress response system in plants mediated by common cellular signal transduction pathway (Thomas and Bohnert 1993, Yeo, 1998). Biochemical studies have shown that plants under salt stress accumulate a number of metabolites, which are termed compatible solutes because they do not interfere with the plant metabolism (Kuznetsov and Shevyakova, 1997). Proline accumulation is one of the most frequently reported modifications induced by water deficit and salt stresses in plants, and it is often considered to be involved in stress resistance mechanisms (Lutts *et al.,* 1999).

Mango

The mango is of great economic and social importance for India, usually affected by water and soil

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salinity. Pandey *et al.* (2014) conducted experiment on six-month-old seedlings of seven mango (*Mangifera indica* L.) rootstocks namely Moovandan, Bappakai, Nekkare, Kurukkan, Olour, Terpentine and Chandrakaran with water containing 0, 50, 100, and 150 mM NaCl for 90 days. The decrease in growth was greatest in the salt-susceptible Chandrakaran rootstock (32.02%) at higher levels of salinity. However, in the salt-tolerant Olour and Nekkare, NaCl caused only a slight decrease in numbers of leaves and leaf area per plant. The concentration of Na+ ions in leaf tissues increased to a maximum (123.53%) in Chandrakaran and in root tissues Bappakai had the highest Na+ ions (77.27%) content. The maximum increase (109.09%) in leaf Cl- ions level occurred in Moovandan and Chandrakaran had the highest (139.29%) root Cl ions content at 150 mM NaCl. Based on overall performance and leaf scorching, they conculuded that that salinity tolerance increased in the following order Chandrakaran < Moovandan < Bappakai < Nekkare < Kurukkan < Terpentine < Olour.

Two polyembryonic, Olour and Kurakkan and one monoembryonic *viz*., non-descript seedling (common mango rootstock) grafted with the scion Amrapali were tested under NaCl stress (Dayal *et al*., 2014). Grafted plants were irrigated with water containing 0.0 or 50 mM NaCl at four days interval for 90 days. In the tested rootstock-scion combinations, minimum reduction in plant height and leaf numbers under salinised condition was found in graft with non-descript seedlings and Olour rootstocks, respectively. The higher peroxidase activity (213.43 Ab560 U g-1 leaf fresh weight) and proline accumulation (215.98 ìg g-1 of fresh weight) was observed in plants grafted with Olour rootstock. Olour seems to be good Cl- excluder rootstocks while non-descript seedling could effectively exclude Na+ from leaf tissues of scion cultivar.

Morsy (2006) reported that water salinity caused a significant reduction in stem thickness, number of leaves /plant and average leaf area. Root and shoot dry weight was decreased with increasing salinity in all cvs., while root:shoot ratio was not affected. Negative salinity effects on growth of all the studied mango cvs. were appeared at a concentration of 30 mM or more. Some of tested growth parameters of 'Alphonso' cv. were obviously affected with the least concentration (15 mM) of salinity, while salt symptoms occurred later (45mM) with cv. 'Zebda'. He concluded that mango plants cv. 'Zebda' are the most tolerant to salinity, while those of 'Alphonso' are the most sensitive. Vanichkul *et al*. (1999) evaluated the effect of sodium chloride on growth and transpiration of Kaew mango (Mangifera indica L. cv. Kaew) seedlings. They found that NaCl decreased leaf area, elongation of new shoot, plant dry matter, root to shoot ratio and reported higher leaf damage accompanied with growth reduction with increasing concentration of salts. Schmutz (2000) reported that 13-1 had Higher Na+, Cl- and Ca2+ contents in leaves while significantly lower Na+ contents were found in roots and young leaves of *Mangifera zeylanica* as compared to rootstock 13-1. The K+ 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 it's tolerance to potassium and sodium salts as compare to other evaluated cultivars (Nigam et al., 2002).

Dubey *et al.* (2006) revealed that genotypes Kurukkan and Olour were more salt tolerant than genotypes Kerala 1 and Kerala 2. Both Kurukkan and Olour survived 4.23 dS/m salinity, whereas Kerala 1 and Kerala 2 did not survive beyond 1.29 dS/m salinity. Srivastav *et al*. (2007) studies the effect of graded levels of artificially developed soil salinity dominated by chloride, sulphate and carbonate ions on survival, growth and chlorophyll contents of Kurukkan plants. Seedlings of 'Kurukkan' survived up to 60 days of salinization in sulphate (6.21 dS/m) and carbonate (6.43 dS/m) dominated salts. However, in chloride dominated salts, seedlings could not survive at 6.28 dS/m after 40 days of salinization.

Table 1: Salt tolerance level of tropical fruit crops

Crop	Salt tolerance		Rating
	Threshold (*ECe*)	Slope (*ECe*)	
Banana	-	-	Susceptible
Cherimoya	-	-	Susceptible
Coconut	-	-	Moderately tolerant
Date-palm	4.0	3.6	Tolerant
Grape	1.5	9.6	Moderately susceptible
Guava	4.7	9.8	Moderately tolerant
Grape fruit	1.2	13.5	Susceptible
Lemon	1.5	12.8	Susceptible
Kime	-	-	Susceptible
Mango	-	-	Susceptible
Orange	1.3	13.1	Susceptible

Tanji and Kielen (2002)

Banana

Banana is nutrient loving crop with high requirement of potassium. Salinity induced stress in banana is chiefly due to replacement of sodium ions with potassium which malfunctions the physiology and fruit development. Ikram-ul Haq *et al.* (2011) reported that salinity reduced the number of plantlets per explants and plant biomass significantly. A proportional relationship was observed for Na+ and Cl- but K+, Ca2+ and NO3- were observed to be inversely proportioned with NaCl stress. Similarly, total proteins as well as carbohydrate contents were decreased significantly. Increasing mode of secondary metabolites (proline, betaine contents and reducing sugars) were showing a negative relationship of saline stress with plant micro-propagation efficiency. Among photosynthetic pigments, total carotenoids were increased while chlorophyll contents (Chl a & b) decreased. Similarly, nitrate reductase activity also reduced. Overall, vegetative propagation of banana was affected significantly by NaCl stress under in-vitro conditions. Willadino *et al.* (2011) reported that PA 42-44 genotype was pointed out as the most sensitive one because it showed the highest Na + contents in both leaf blade and roots and rizome, besides a 18.5% reduction of dry matter production. The high Na + contents found for PA 42-44 tissues suggest a low efficacy to extrude and to prevent the Na + translocation to leaf blade. On the other hand, the Preciosa genotype showed both the lowest Na + contents and the smallest reduction for dry matter production (0.2%) as well as a low Na +/K + ratio indicating a salt tolerance strategy by Na + extrusion. Belfakih *et al.* (2012) revealed that the reduction of biomass and root accumulation of potassium in the shoot and sodium in the root due to increase in NaCl levels. There was reduced absorption of calcium and magnesium and a slight variation from the nitrogen concentration of 4g / l. Some salt tolerance was noted in the Grande Naine compared to the petite Naine variety. This tolerance may be associated with a good selectivity towards potassium.

Citrus

Citrus is ranked among the most sensitive crops to salinity. This constraint affects plant morphophysiology and may lead to yield declines. Singh *et al.* (2014) reported that the highest Membrane injury index (0.159) was recorded in *Jatti khatti* under 50 mM salinity followed by Attani-2 and Attani-1. The highest SOD (45.67 units mg-1 protein min-1) and CAT (5.34 ì moles H2O2 hydrolized mg-1 protein min-1) activities were recorded in the *Jatti khatti* under 50 mM NaCl salinity followed by Attani-2 and Attani-1. Based on observations they concluded, the relative salt tolerance of citrus rootstocks was adjudged to decrease in the following order: Attanni-1>Attanni-2> *Jatti khatti*.

Khoshbakht *et al.* (2015) observed ion concentrations of Cl- and Na+ increased by salinity treatments. Salinity also increased Mg2+ content in roots and reduced Ca2+ and Mg2+ concentrations in leaves. The K+ concentration in leaves was enhanced at low salinity (25 mM NaCl), whereas it decreased with increasing salinity stress. Salinity caused a decline in K+ contents in roots. Higher tolerance of rootstocks to salinity could be associated with the reduction of Cl- and Na+ uptake and transport to leaves, ability to keep higher Chl, gs, P N, and better maintenance of nutrient uptake even under high salinity. They found that Sour orange and Cleopatra mandarin were the rootstocks most tolerant to salinity of all nine studied. In addition, Trifoliate orange, Carrizo citrange, and Swingle citrumelo were the rootstocks most sensitive to salt stress followed by the Rough lemon and Macrophylla that showed a low-to-moderate tolerance, and Rangpur lime and Bakraii, with a moderate-to-high tolerance to high salinity. Aouad *et al.* (2015) reported that high salt concentrations caused a considerable reduction of growth parameters such as fresh and dry weights of shoots and roots, especially in citrumelo 57-98-502, Swingle citrumelo swingle F9-22-55 (80-11), Carrizo citrange 28608 and citrumelo 4475 BB6A5. In addition, they noted a significant accumulation of proline in the leaves of rootstocks as the salinity of the irrigation solution increased, particularly in citrumelo 4475 A B6A4 and citrumelo Sacaton 30057.

Cashewnut

Carneiro *et al.* (2004) observed growth variables were found to be affected by ECw and the effects varied among clones; however, no significant interactive effects were observed.. The value of ECw = 1.39 dS m^{-1} was considered as a threshold tolerance for the precocious cashew rootstocks used in their study. Clones EMBRAPA51 and EMBRAPA50, respectively, the having the best development indexes. Whereas, Ferreira-Silva *et al.* (2008) reported that CCP 09 genotype showed better growth performance after two weeks under a large range of NaCl salinity. The NaCl treatments induced a significant drop in transpiration as a consequence of an increased stomatal resistance. The genotype exhibited lower relative water content and less negative leaf osmotic potential and also showed greater ability to accumulate compatible organic solutes (amino acids, proline and soluble sugars) in leaves in addition to maintaining the soluble sugar concentration in roots as compared with the sensitive rootstock. Viégas *et al.* (2001) reported that K+ tissue concentrations were substantially decreased, particularly in roots on long term application of NaCl. In response to time and increasing levels of salinity, Na+ and Cl- ions concentrations reached toxic levels in leaves.

Papaya

Papaya, although exhibits different sensitivities to salinity, has great potential to be cultivated in semi-arid regions of India. Pares and Basso (2013) showed that the presence of NaCl in the irrigation water caused inhibition of growth in young plants and significant reduction in contents of chlorophyll. Tissue concentration of N and Na increased with increasing levels of NaCl, while K, Zn, Cu and Fe decreased hoowever Ca, Mg, P and Mn, were not affected.

Beniwal and Laura (2010) revealed that The recovery percentage of payaya plantlets decreased with the increase in the NaCl concentration (1.5%) under in vitro conditions. The ranking cultivars for their in vitro screening revealed 'Ranchi Dwarf' and 'Farm Selection' as susceptible/sensitive, 'Honey Dew' as moderately tolerant and 'Local' comparatively tolerant to salt (NaCl).

Passion fruit

Montana *et al.* (2014) revealed that seedling emergence was significantly higher in the 0 (0.05 dS m^{-1} of the substrate) and 30 mM NaCl (0.71 dS m^{-1}) treated seeds when compared with 60 mM (1.25 dS m^{-1}), 90 mM (1.69 dS m^{-1}) and 120 mM NaCl (2.30 dS m^{-1} of the substrate). There was a decline in the chlorophyll contents of the seedling cotyledons and an increased substrate EC with increasing NaCl concentrations.

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