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Salinity Tolerance in Fruit Crops

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Environmental stresses, such as salinity, drought, flood and heat, are impacting the production of fruit crops globally in the context of climate change. Salinity is one of the crucial variables that can be alleviated by leveraging the salt tolerance of fruit varieties. Salt-affected soils are characterised by a high concentration of salts (NaCl, $MgSO_4$, KNO_3, and $NaHCO_3$), which have an impact on the growth and development of plants, the structure of the soil, the quality of the water and the other uses of land and soil resources. Salt-affected soils (including coastal) occupy nearly 6.75 million hectares (mha) of land in India with 1.71 mha of land under saline soils and 3.79 mha of land under alkali soils (ICAR-CSSRI, 2016). The area covered by salt-affected soils is comparatively more extensive in semi-arid and arid regions than in humid areas. Salts of several cations, including sodium (Na^+), magnesium (Mg^{2+}) and calcium (Ca^{2+}), are among the several salts that are active in soil salinization. These salts significantly increase soil salinity. However, sodium is the main salt that causes the soil's physical structure deterioration. Plants can evolve numerous methods for salt tolerance, including salt avoidance, Na^+ exclusion from leaf blades, Cl^- excluder from roots or leaves tissue and osmotic adjustment. Osmotic tolerance involves the capacity of plants to resist the drought aspect of salinity stress by controlling stomatal conductance and leaf expansion. The wasteland can be exploited to boost productivity and ensure food and nutritional security for the people of India. The information on the tolerance to salt mechanism helps identify and produce varieties and rootstocks that raise the potential of adaptability to saline circumstances and may be further utilised to increase fruit crop production under saline conditions. Moreover, the selection of salt-tolerant rootstocks and the performance of scion cultivars on those rootstocks in saline environments will affect the success and growth of the area of fruits.

Potential issues addressed by producing plants under over-salinity involve osmotic control, ion transport and toxicity. Many researchers have reported that salinity over a specific level accelerates water stress, ion toxicity, nutritional problems, oxidative stress, change of metabolic processes, membrane disintegration, genotoxicity, diminished cell division and expansion. All these factors together affect the plant's development, growth and survival. Osmotic stress caused by the physiological drought lowers the osmotic potential. It thus leads to a reduction of cell development, root growth and shoot growth, which also results in the inhibition of cell expansion and the reduction of cell wall production. The toxicity of ions (Na^+ and Cl^-) impairs the function of nutritional balance and disrupts the cell organelles and their metabolism. The effect of salinity into two phases in the first phase is osmotic stress, which results in a rapid and severe response of an increase in external osmotic pressure caused by an increase in NaCl levels in the medium, contributing to a sharper loss in growth. The second phase is the ionic phase, leading to a slower reaction due to harmful ion accumulation in tissues. Such a scenario generates significant toxicity in leaves, reflected by chlorosis and the appearance of necrosis in these tissues. The excessive salt concentration likely causes leaf injury and death. This occurs when the cells exceed the capacity to store salt in the vacuoles, accumulating salt in the cytoplasm of the toxic leaves.

The mechanism for salt tolerance is genetically controlled and varies from plant to plant and species to species. Techniques for salinity tolerance are salt avoidance, salt exclusion, salt extrusion, salt dilution, and ion compartmentalization etc. Salt avoidance is the systematic method of eliminating harmful salt ions from plant components. The ability of plants to exclude salt is supported by low net Na^+ absorption by cells in the root cortex, which results in the removal of Na^+ ions from the leaf area. The exclusion of Na^+ from the roots ensures that Na^+ does not accumulate at hazardous levels within leaf blades. This exclusion method prevents salt entry, permitting the water to pass through and improving maximal salt removal. Under extreme salinity stress, the concentration of Na^+ appears to reach a lethal threshold before Cl^- does in plant tissue. The compartmentalisation of ions is a result of ion homeostasis. Restricting the intensity of ion concentrations throughout the plant to keep a steady environment inside the cell is termed as 'Ion Homeostasis'. Transportation of various ions inside the plant takes place via different ion-selective channels/transporters, symporters, antiporters and carrier proteins found in the plasma membrane of the root cells, which permits the movement of specific ions within the cell and manages the ionic balance under saline conditions. Various other strategies are involved in salinity tolerance in fruit crops, like the role of osmoprotectants, polyamines and hormones, ROS signalling and adaptation under stress conditions.

Strategies should be developed to overcome salinity stress, such as understanding the molecular mechanisms behind salt stress and improving and introducing new salt-tolerant cultivars of fruit plants into the environment. Genes for salinity stress should be identified and evaluated for their compatibility with fruit crops. Rootstock evaluation should be done at the field level, focusing on the yield and fruit quality attributed.