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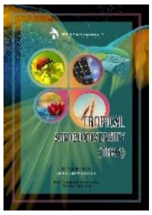

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REVIEW ARTICLE

SALT STRESS IN FRUIT CROPS AND ITS MANAGEMENT

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ABSTRACT

Due to the presence of excess soluble salt in the soil, soil salinity is a key abiotic stress and one of the major environmental issues affecting plant productivity, especially in arid and semi-arid areas. Salt damage typically shows up as leaf burn and defoliation and is linked to dangerous amounts of Na+ and/or Cl building up in leaf cells. The osmotic effect and/or excessive ion accumulation in the plant tissues, which may result in ionic toxicity and/or nutritional imbalance, are common causes of crop growth inhibition under saline circumstances. The degree to which any stress condition impacts a plant's growth or development depends on a number of variables, including the kind of plant, cultivar, and phenological stage, the composition of the soluble salts, the intensity and duration of the stress, and the edaphoclimatic conditions.

KEYWORDS

Soil Salinity, Leaf Burn, Plant Tissues, Ionic Toxicity and/or Nutritional Imbalance

1. INTRODUCTION

Land a non-renewable resource is primary center for production system. The sustainable production of agriculture and horticulture from the limited land resource is further threatened by the multiplexity of resource degradation problems in order to meet the food and nutritional requirement of ever-increasing population. Increased pressure on these scares land resources is led to further degradation problems like salinization with significant global dimension of about 1000 million hectares in more than 100 countries. Therefore, despite the fact that water logging and salinization are problems that affect most of the world, they are more severe in arid and semi-arid regions due to the limited salt leaching caused by insufficient precipitation and high evaporation. These issues also existed in coastal and cannel irrigated areas due to marine influence, which led to periodic inundation of tidal water.

Global salt affected area is 831million hectare, in India it is around 6.73million hectare and Gujarat is having highest salt affected area of 1.2million hectare. In those Sodic soils 3.77 million ha and Saline soils: 2.96 million ha according to CSSRI (2014). In 2018 global salt affected area is around 953 m ha. It was increased drastically and in Gujrat also it is around 2.2m ha. So salinity remains one of the men's oldest environment and agriculture problem which is challenging to agriculture scientist for production of fruit crops.

1.1 Salt stress (salinity)

The presence of electrolytic mineral solutes in soil and water at amounts that are detrimental to many fruit crops is referred to as salinity One of the main pressures, particularly in dry and semi-arid environments, is salinity in the soil or water, which can seriously harm the production of fruit crops. Low osmotic potential of the soil solution (water stress), nutritional imbalance, a particular ion action (salt stress), or a combination of these factors all contribute to salinity's harmful effects on plant growth (Ashraf et al., 2004).

1.2 Salinization of soil

- **Main cation** : Na^+, Ca^{2+}, Mg^{2+}, K^+
- **Main anion** : Cl^-, SO_4^{2-}, HCO_3^-, CO_3^{2-}, NO_3^-
- **Saline soil** : NaCl, Na_2SO_4
- **Alkaline soil** : Na_2CO_3, $NaHCO_3$

Saline soils - soils with an amount of neutral soluble salts like sodium chloride and sodium sulphate that is adequate to hinder the growth of the majority of crop plants. It also contains appreciable quantities of chlorides and sulphates of calcium and magnesium.

Sodic soils - Soils containing sodium salts capable of alkaline hydrolysis, mainly Na_2CO_3, these soils have also been termed as 'Alkali' in older literature.

Conditions that are saline-sodic may be present due to an excess of soluble salts and exchangeable sodium (Nimbolkaret al., 2020).

1.3 Causes of Salinity

I. Natural or primary salinity

Primary salinity is the result of salts building up over time in the soil or groundwater due to natural processes. It results from two organic processes. The first is parent materials that contain soluble salts weathering. Weathering processes break down rocks and release soluble salts of various types mainly chlorides of sodium, calcium, and magnesium, and to a lesser extent, sulphates and carbonates. The salt that is most soluble is sodium chloride. The second is the deposit of oceanic salt brought ashore by wind and precipitation. Ocean salts known as "cyclic salts," which are primarily sodium chloride, are transported inland by wind and deposited by rainfall.

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II. Secondary or human induced salinity

Human actions that alter the hydrologic balance of the soil between water applied (via irrigation or rainfall) and water utilised by crops lead to secondary salinization (transpiration; Garg and Manchanda 2008). The most frequent reasons are (a) clearance of land and planting of annual crops in place of perennial vegetation, and (b) irrigation systems that use salt-rich irrigation water or have inadequate drainage.

2. Types of Soil Salinity

2.1 Based on Their Resiliency to Salt Stress, Plants Are Divided Into Two Categories

Halophytes: Plants that thrive in environments with a lot of salt are known as halophytes. On the basis of their great tolerance, they are once more separated into two groups.

- Euhalophytes: Can tolerate extreme salt stress
- Oligohalophytes: Can tolerate moderate salt stress

Glycophytes: The plants that cannot grow under high salt concentration.

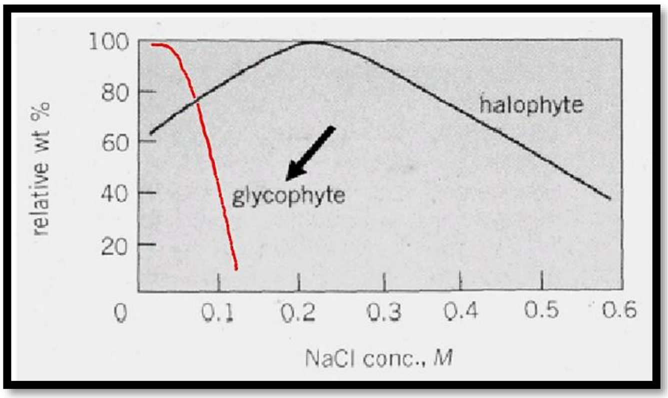

Figure 1: Relationship between growth and NaCl concentration for halophyte and glycophyte

Glycophtes are very sensitive salt they show decreased growth even with the 0.1-0.2M concentration of NaCl, Halophytres can tolerate 0.3-0.4M NaCl concentration (Parihar et al., 2015).

Table 1: Salt tolerance grades and threshold levels of different fruit crops

Sl. no.	Fruit crops	EC (dS/m)	Salt tolerant grades
1	Date palm, Ber, Jamun, Tamarind and Wood apple	4.0	High tolerant (8-16 dS/m)
2	Sapota, Pomegranate, Fig, Olive, Guava, Aonla, Bael,	2.5	Tolerant (6-8 dS/m)
3	Peach, Papaya, Banana, Grape, Mango, Custard apple and Phalsa	1.9	Mod. Tolerant (4-6 dS/m)
4	Plum, Pear, Lemon, Lime and Straw berry	1.8	Sensitive (0-4 dS/m)
5	Grape fruit	1.7	-
6	Orange, Mandrin	1.5	-
7	Almond	1.5	-
8	Black berry	1.5	-
9	Rasp berry	1.6	-

3. Effects of Salinity

3.1 Physiological Effects of Salt Stress

- Cell membrane damage: excuses salts triggers electrolyte leakage mainly K^+ efflux from the plant cell by membrane depolarization-activated outward rectifying K channels and leakage of solutes.
- Oxidative stress: Stress from salt causes plants to produce hazardous active oxygen species (AOS) or reactive oxygen species (ROS) quickly, including super oxide radicals, singlet O2, hydrogen peroxide, and hydroxyl radicals. Under salt stress, the ability to scavenge AOS is significantly decreased.
- Alteration in leaf water relations: Osmotic potential of soil water increases making it difficult for roots to absorb water.
- Gas exchange characteristics: Stomatal and non-stomatal factors affect photosynthetic assimilation in salt treated plants, which limits Co_2 supply to chloroplast cells, by cell membrane leakage, alteration in structure of intercellular spaces and biochemical regulations.
- Nutritional imbalance: Uptake of ions affects the membrane permeability, transport kinetics and selectivity. Antagonistic effects lead to decreased uptake of K, Ca and Mg.
- Loss of leaf pigments: Due to changes in the lipid protein ratio, which increases the chlorophylase activity.
- Osmotic stress and ion toxicity: Salinity diminishes the matrices, osmotic potential lowers the water intake capacity, and the presence of too many salts produces physiological drought (Grattanand Grieve, 1998).

3.2 Morphological Effects of Salinity

- Seed germination: NaCl accumulations to toxic levels leads to poor reserve mobilization in seed cotyledons, hampers seed metabolism. Decrease in osmotic potential of substrate further decrease in water imbibition by seeds resulting in embryo injury.

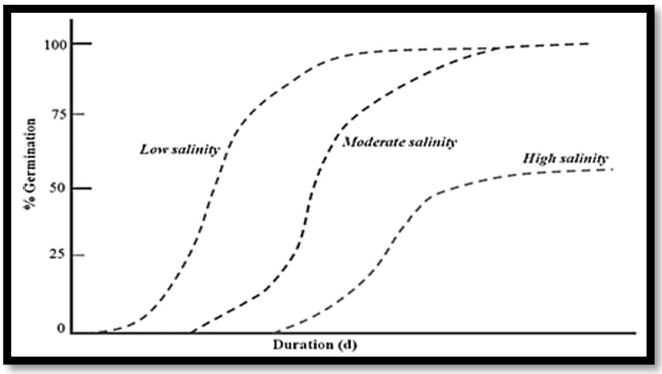

Figure 2: Relationship between the period after sowing and the rate of germination at various salinity levels.

- Growth stages: Reduced plant height, stem diameter, leaf area, and dry matter production in leaves are all effects of salinity. increased leaf abscission, which slowed the growth of the shoot.

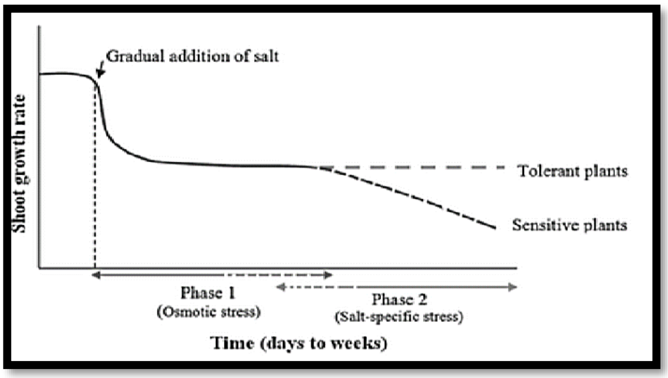

Figure 3: Overview of the twophase growth response to salinity for plant differing in salt sen itivity (Parihar et al., 2015).

- Visible symptoms: Marginal chlorosis, necrosis of leaves, necrotic lesions, heavy defoliation, leaf tip burning later dead leaf symptoms, further it reduces the flowering and fruiting.

Figure 4: Salt stress symptoms in guava cv. Allahabad Safeda planted under shallow water table saline conditions at Nain Experimental Farm, Panipat. The progressive loss of leaves, sparse growth, reduced fruiting and plant mortality with increasing salinity (Sharmaand Singh, 2017).

Figure 5: Salinity-induced Kinnow decline in Fazilka district of Punjab, India

- Enzymatic and non-enzymatic response: Salinity enhance the antioxidant molecules in fruit crops, mainly SOD and several SOD isozymes being Mn SOD, Cu/Zn SOD, Fe SOD. SOD is a metalloprotein that catalases the conversion of superoxide radical into Hydrogen peroxide (more damaging than superoxide radical) this activates catalases (CAT), Ascorbate peroxidase (APX) glutathione peroxidase (GPX).

Proline for stabilization of subcellular structure and eliminate free radicals, also produce Polyols like Mannitol and Sorbitol and Quaternary amines like Glycine – Bitanine which show antioxidant property.

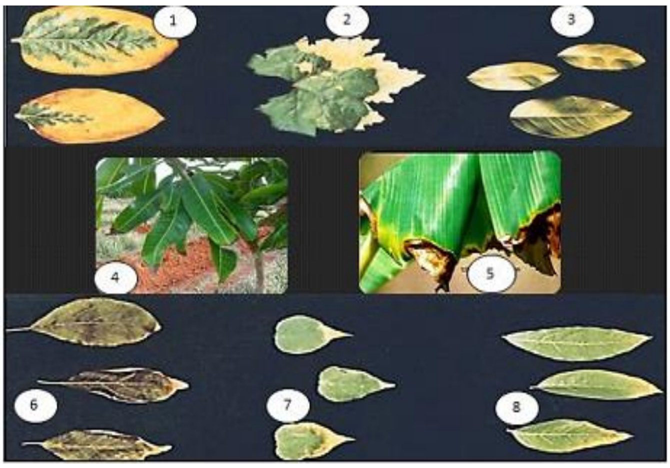

Figure 6: Salt injury symptoms on leaves of different fruit crops: 1-Apple; 2-Grape; 3-Grape fruit 4-Mango; 5- Banana; 6- Plum; 7-Apricot; 8-Avocado (Nimbolkar et al., 2020)

3.3 Salt Resistance in Plants

A. Avoidance mechanism

a. Salt Exclusion

Plant can exclude the salts passively due to low salts permeability.

Na ions can enter roots passively, whereas by contrast, Cl^- is excluded by the low permeability of root plasma membranes.

On the surface of the leaves of some plants are salt glands.

b. Salt Extrusion

It can extrude the salts actively by an active ion extrusion pump and plant avoid the salts stress.

The presence of salt-excreting glands, which lower salt concentration.

c. Salt Dilution

Plant can dilute the salts depending upon a high plastic extensibility of cell walls e.g. Succulence that may lead to dilution of intracellular salt.

B. Tolerance mechanism

The word "salt tolerance" refers to a plant's ability to grow relatively well in the presence of saltwater. There are two methods that could be used,

1. Excreting or secreting the absorbed salts into the vacuole.

2. Tolerate the ion balance strain by requiring protoplasmic substances.

C. Osmoregulation or Osmotic adjustment

Osmoregulation is process in which the ions have to be accumulated at levels optimal for adjustment of water potential in the plant. Mostly the excluding ions are used.

- It allows plant organs to adjust osmotically and maintain turgor.
- It also maintains stomatal opening and maintain the conc. of CO_2.
- Cl ions contribute more to an osmotic adjustment than the sulphate ions because chloride is more rapidly absorbed.

D. Nutrient deficiency stress: Replacementof K^+ by Na^+ during the salt stress but plants tent to exclude Na by Na^+ extrusionpump.

E. Morphological adjustments with salinity

1. Increase succulence
2. Decrease leaf number and size
3. Reduce stomata number and alternative stomata distribution
4. Thickening of leaf cuticle

Deteriorated or undeveloped xylem system(Abou El-Nourand El-Fouly, 2006).

3.4 Agronomical Practices to Overcome Salinity

a. Selection of tolerant cultivars and rootstocks

Selection of tolerant varieties is the most important tools.

Fruit crops can be evaluated by the capacity of the seed to germinate or cuttings to root in the salt affected soil or the capacity of particular fruit crops to survive in the saline media or the relative performance in saline and non-saline soils with respect to reduction in growth.

b. Tillage: To remove the top layer and shatter the salty layer closer to the root surface.

c. Planting methods and techniques: Pit method, auger Hole method, Ridge and Trench method.

Tractor operated auger used for pit preparation in saline soils specially in fruit crops.

d. Mulching: Wetzone in the rhizosphere helps in dilution of salts.

e. Nutrient management: Gypsum, Silicon, are good amendments, Application of 40 kg FYM, 2 kg urea while planting in saline soils, Spray of 2%DAP etc.

f. Use of microbial inoculants: Arbuscular mycorrhizal fungus aids in ion control, the buildup of suitable solutes to prevent cell dehydration, and improved root water uptake.

AMF *Rhizophagusirregularis*– Carrizo citrange

Glomus interradius –Olive

BurkholderiaPhytofirmans – Grape

Glomus mosseae- Red tangerine

Paraglomusoccultum – Citrus

g. PGR'S and other Chemicals: Humic acid (Pottasium humate @0.2-0.4g/plant), Salicylic acid 100ppm, NAA40ppm, polyols, polyamines, triazole compounds,Nitric oxide triggers the expression of many redox regulated gens.

h. Irrigation practices

Drip irrigation: Application of water directly to root zone help in better absorption of water.

Sub surface irrigation: Water is delivered through emitters below the soil's surface, which nearly eliminates surface runoff while reducing water loss from evaporation and deep percolation.

Partial root zone drying technique: It is the technique of irrigating half of the roots and another half kept dried, dried roots produce ABA which regulates the stomatal conductance and decrease the transpiration.

Deficit irrigation: Application of irrigation water below the crop evapotranspiration requirement resulting in enhanced uptake of water (Biswas and Biswas, 2014).

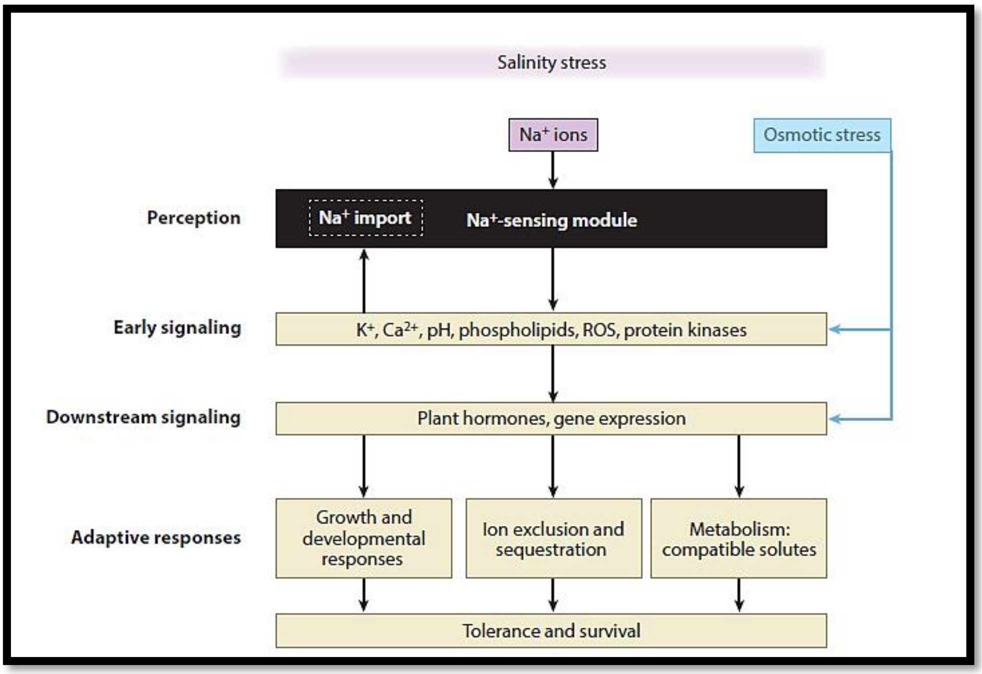

Figure 7: Osmotic and salt stressors significantly influence both early and downstream signalling (Zelm et al., 2020).

Salt stress reactions' "black box" is sodium sensing and import. Although Na+ causes particular downstream reactions, the method by which plants sense sodium is yet unknown. Intercellular or extracellular sensing could take place before or after Na+ import. Early signalling reactions, including as K+ transport, Ca2+ signalling, H+ transport, phospholipid modifications, reactive oxygen species (ROS) production, and protein kinase activity, are induced after the initial observation. These first Na+-induced signals then decrease sodium import. Phytohormone levels fluctuate downstream of the early signalling phase through production and transport, and gene expression levels are altered in a way that depends and does not depend on phytohormones.. The adaptive responses that the salt-induced signalling cascade produces, such as modifying growth and development, ion transport, and producing suitable solutes to counteract the osmotic pressure of Na+, are the last step in the process. A proper reaction to salinity and, ultimately, survival on salty soils depend on each link in the signalling chain. Part of the early signaling and downstream signaling response overlaps with osmotic stress–induced pathways (Ahmad and Anjum, 2020).

3.5 Genetic Engineering

In genetic engineering, genetic manipulation to bypass the sexual cycle is done to establish an individual during a new combination of inherited properties. It presently follows two major approaches.

I. The cellular approaches involve *in vitro* culturing of cells and the hybridization of somatic cells.

II. The molecular approaches involve the direct manipulation of nucleic acid.

Genetic transformation for developing salt tolerant genotypes (Singh et al., 2018).

Crop	Genetic transformation
Apple	Vacuolar Na+/H+ antiporter *MdNHX1* from the salt tolerant rootstock Luo-2 was introduced into rootstock M.26 by *Agrobacterium*-mediated transformation
Banana	Because of the increased buildup of proline and decreased levels of malondialdehyde, transgenic plants overexpressing MusaDHN1 showed greater salt tolerance.
Carrizo citrange	Yeast gene *HAL2* implicated in salt tolerance was integrated through *Agrobacterium*-mediated transformation
Mulberry	Stable transformation with barley *hva1* gene resulted in better physiological relations of transgenic lines under salinity
Pear	*MdSPDS1*-over-expressing transgenic plants were obtained by *Agrobacterium*-mediated transformation; selected transgenic lines produced spermidine synthase and exhibited tolerance to 150 mmol L^{-1} NaCl
Strawberry	Stable expression of osmotin gene in cv. Chandler through cocultivation with *Agrobacterium tumefeciens*

4. Conclusion

Bringing chemically degraded regions under crop and tree cover will help India's rising food demand and nutritional security issues. Although majority of the fruit crops are sensitive to salinity, yet their commercial cultivation is possible in saline and sodic soils by Several techniques such as selecting salt tolerant scion cultivars and rootstocks, planting techniques, spot soil amelioration, and novel irrigation techniques and by application of PGR and chemicals that can help to successfully raise fruit plantations in salt-affected soils. additionally enhance the health of the soil and ecology and guarantee long-term economic security to farmers who own such marginal properties.

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