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Review Article

Impact of Salt Stress on Fruits and Its Mitigation Strategies; A Review

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Abstract

Fruit crops are currently facing problems due to the different biotic and abiotic stress. Among these stresses, salinity stress is one of the most deleterious environmental threats that often limit crop production by disturbing the ecophysiology of fruit crops to a great extent. Salinity up to some extent is bearable by the crops, but when its level extends above the threshold value, growth rate and size of the plant decreases, restricts lateral shoot development, reduces leaf and fruit size and fresh and dry weight of different plant parts and ultimately could lead to death of the plant. The objective of this article is to analyze that how plant responses to the salt stress and affects the physiological and agronomic behaviour. This review focuses on adverse effects of salts stress on different fruits crops viz; changes in morphology, physiology, scion rootstocks interactions, nutritional imbalance, biochemical response and phytoharmones. In addition to the ecophysiological studies of fruit crops, mitigation strategies has also been focused. There are many strategies to cope with salinity stress which are the development of salinity tolerant crop and cultivars by using genetic and molecular techniques, plant hormones signaling, and reclamation of soils and stress elevation by bacteria. Thus, this chapter will gives a brief idea to the scientists, students and researchers to understand the effects of salinity on fruit crops and their management strategies.

Keywords: *Salt stress, fruit crops, physiology, phytoharmones, tolerance, melatonin, management strategies*

Introduction

Stress can be defined as any unfavourable condition that disturbs the physiology of plants and decreases the ability of plants to convert energy to biomass (Grime. 1977). It may be of two types; abiotic (salinity, heat, water, etc.) and biotic (bacteria, fungi, parasites, harmful and beneficial insects, weeds, etc). Various abiotic stresses like drought, high salinity, cold and heat waves, flood, etc lower the crop productivity and negatively influence the biomass production, survival, and yield of major crops (Vorasoot. *et al*., 2003; Kaur. *et al*., 2008; Mantri. *et al*., 2012; Ahmad. *et al*., 2012). Among these stresses, salt stress is major abiotic stress, affecting approximately 20% of irrigated land (Qadir. *et al.,* 2014), that often limits crop production to a great extent, and alters the physiological processes of plants by decreasing photosynthesis, nitrogen assimilation and cell division, thus ultimately arresting the plant growth (Anjum *et al*., 2011). High concentration of salt applied exogenously leads to the decrease in leaf growth, reduces conductance of stomata, causes disproportion of ion ratio, and inhibits photosynthesis (Wani. *et al*., 2013) and have a harmful outcome on plant metabolism, interrupting cellular homeostasis and disconnecting key physiological processes. The direct consequence of salt stress causes an increased accumulation of ROS, and ultimately an oxidative stress (Hasegawa. *et al.,* 2000; Chaves. *et al*., 2009). Soluble salts such as Na^+ and/or Cl^- present in the soil in excess quantity affects the crop growth and

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development adversely (Munns. 2005). (Szabolcs. 1974) reported depending upon the nature, characteristics, and plant growth relationships with salts, two types of salt-affected soils; saline soils (having NaCl and Na_2SO_4 as the soluble salts and sometimes considerable amount of Cl^- and SO_4^{-2} of Ca^{2+} and Mg^{2+}) and sodic soils (having Na^+ as salts). However, (Rengasamy. 2006) based on the soil and groundwater process, categorized three types of salinity; ground associated salinity, non-ground water associated salinity, and irrigation associated salinity. In arid and semi-arid regions, salinity reduces crop production because of the high rate of evaporation and insufficient precipitation for leaching (Zhao. *et al*., 2007). In this review, we described the effect of salinity stress on different attributes of fruit crops and their management strategies to cope with salinity stress on several physiological traits.

Effect of Salinity Stress on Different Attributes of Fruit Crops

Cations and anions are the basic circulatory system of the soil that helps the flow of minerals in the plants and soils as well. It plays a considerably basic role in maintaining the balance among physiological, morphological, nutritional and hormonal biology of the fruit crops. Any disturbance in the concentration of these anions in the soils may lead to hindrance in normal adsorption of mineral and causes several spontaneous changes in plants system. Salinity is a major environmental stress that limits plant growth and productivity (Zhu. 2001; Sah. *et al*., 2016) and affects critical processes like photosynthesis, protein synthesis, enzyme activities and lipid and hormone metabolisms (Li. *et al*., 2012). Excess salinity causes ion toxicity, osmotic stress, elicits oxidative stress, with different reactive oxygen species (ROS) and ultimately cell death (Qureshi. *et al*., 2013; Julkowska and Testerink. 2015). Salinity also affects the yield and quality of crops by decreasing the uptake of water and nutrients and increasing the concentrations of Na and Cl (Tulipani. *et al*., 2008; Machado and Serralheiro. 2017).

Effect of Salt Stress on the Morphology of Fruit Crop

Salinity up to some extend is bearable by the crops, but when its level extends above the threshold value, growth rate and size of the plant decrease and ultimately could lead to death. Plant responses due to salinity are, stunting of the plant, apical growth is checked with restricted lateral shoot development, leaf and fruit size is reduced and reduction in fresh and dry weight of different plant parts. The number of leaves reduces which attributes to low yield. In mango, yield and mean leaf area of mango were reduced due to chlorine pollution in the industrial belt around Vadodara in Gujarat (Vijayan and Bedi. 1989). In citrus, the decline is correlated to salinity in the Bathinda district of Punjab (Singh, 1966). In Anabe-e-Shashi, Selection-7, and Bangalore purple grapes, dry weight of roots and shoots, reduced due to chloride, sulfate, and carbonate salinity (Nauriyal and Gupta. 1967; Gupta and Nauriyal. 1973). Shoot length in Pusa seedless, Anab-e-shahi, and Beauty Seedless grape cultivars reduced considerably due to salt concentration (Pandey and Divate. 1976). Similar findings were observed in guava with the reduction in leaf area, dry matter, plant height, and yield (Desai and Singh. 1980). Both osmotic and toxic effects produced due to exposure to high salinity result in growth inhibition (Banon. *et al*., 2005). When plants were subjected to salt stress, top growth is suppressed more than root growth results in a reduction in shoot: root ratio (Bernstein and Kafkafi. 2002; Khayyat. *et al*., 2009). However, the response of salinity varies from soil to soil, plant to plant, family to family, within a genus, and even within species also. For example, (Khayyat. *et al*., 2009), in an experiment on strawberry reported that, high NaCl, harmed the dry weight of roots in *Fragaria x ananassa* cv. Selva, whereas, (Turhan and Eris. 2005) reported that NaCl increased root dry weight in the strawberry cv. Camarosa. The salinity has its contributory impact on plant morphology and yield as per the documented data recorded in different studies.

Effect of Salt Stress on Physiology of Fruit Crop

Salinity affects the physiology and metabolism of the cell in several ways. Salinity response had been studied at different levels i.e., at transcriptional (Ouyang. *et al.,* 2007; Beritognolo. *et al.,* 2011), proteomic (Ma. *et al.,* 2012; Cui. *et al.,* 2015), or metabolomic (Widodo. *et al.,* 2009). An experiment (Claeys. *et al.,* 2014) on arabidopsis showed that low concentrations of salt had little effect on growth, but at higher concentrations quickly decreases the relative growth rate which showed that water plant relationship is also affected by salinity stress (Nobel. 1991). Under high salinity conditions, the ability to control water potential and hydraulic conductivity, are important criteria for plants. Water potential (the potential energy of water per unit volume relative to pure water) determines the direction of movement of water from higher water potential to lower water potential, whereas, hydraulic conductivity refers, how easily water can flow and therefore, it is very necessary to know, and study these two attributing factors, affecting the rate of water movement under saline conditions. It has been observed that plants shows less hydraulic conductance in roots, thereby reduces the delivery of salt to the shoot (Vysotskaya. *et al.,* 2010) which, their by, reduces the water potential in leaves (Gama. *et al.,* 2009). Plants often under stress, lose water from their tissues, which reflex its effects on cell division, cell expansion, stomata opening, abscisic acid (ABA) accumulation, etc. (Hsiao and Xu. 2000). Anions or cations accumulation in the plants may be due to the response of salinity in the soil. Yield losses of fruit and nuts are generally greater due to specific ion toxicity rather than due to osmotic effects. Woody species accumulate more chloride or sodium which leads to leaf burn, necrosis, and defoliation when chloride limit cross 0.5% and sodium above 0.2% on a dry weight basis (Palaniappan. *et al.,* 1993). Wilting of leaves and dieback of shoots were also reported at high concentration of salts which ultimately caused the death of the plant (Joolka. 1976; Jindal. 1974). Salinity stress increased the amino acids, proline content, total organic acid, and hydrolytic enzymes in guava (Kaul. 1981). Salinity also alters the hormonal balance which mediates the adjustment of plants to salinity by reducing stomatal aperture and water loss, and in case, the stress continues, may leads to the death of the plant. (Pandey. 1982) found that growth was retarded in grapes due to diversion of nutrients towards respiring tissues damaged by salt. Salinity may also affect the chlorophyll content in Jamun (Patil and Patil. 1983b). These metabolic changes in the plant could be judged before the injury symptoms clearly seem on the plants.

Effect of Salt Stress on Scion Rootstock Interaction

The tradition of grafted plant cultivation is expanded greatly in recent years, due to the discovery, that the same variety can be grafted to different rootstocks, to create tolerance in the plant. Plant resistance offers the possibility to develop and use rootstocks, resistant to different soil pathogens, and offers promising advantages of cultivating grafted fruit crops. A number of works had been done to study the behavioural interactions of rootstock and scion in respect to salt stress and concluded that rootstocks restrict the translocation of salt to the scion. Clementine (Citrus *clementine* Hort. Ex Tan.) and Navel orange [*Citrus sinensis* (L.) Osb] were grafted on Cleopatra mandarin (*Citrus reticulat* Blanco.) and Troyer citrange (*C. Sinensis* × *Poncirus trifoliata*) rootstocks respectively (Banuls. *et al.,* 1995) and exposed to the high level of NaCl, result showed that Cleopatra mandarin scion accumulates less Cl^- in their leaves than Troyer citrange scions, and Cl^- levels in leaves of Clementine scions were lower than in Navel orange when both were grafted on the same rootstock. But the concentration of sodium was low in Troyer citrange scion than Cleopatra mandarin. It has also been assessed that salt-treated navel orange grafts showed more reduction in physiological processes than Clementine grafted plants. (Banuls. *et al.,* 1995) reported that the reduction in physiological process depends more on the scion type than on Cl^- or Na^+ concentration in leaves, but leaf injury and defoliation were related to Cl^- concentration. In avocado, which is considered as one of the most salt-sensitive crops (Grieve. *et al.,* 2012), an experiment conducted at the University of California by (Celis. *et al.,* 2018) on different rootstocks, treated with saline irrigation water, where, rootstock with a high concentration of cl^- and Na^+ in leaves show 100% mortality whereas, rootstocks with concentrations of Cl^- in leaves, were least affected by salinity and have the greatest yields, largest trunk diameters, and greatest survival percentages in the saline treatment. These studies reveal how rootstock influences scion behaviours.

Effect of Salt Stress on Nutritional Imbalance

Salt stress creates nutrient imbalances in plants in various ways like by affecting nutrient availability, competitive uptake, transport or by triggering physiological inactivation of a given nutrients (Grattan and Grieve. 1994). The uptake and availability of nutrients by the plants are ruled by several factors. The most important one is accumulation of cations (Na^+, Ca^+) and anions (Cl^-, SO_4^- and NO_3^-), which causes change in soil pH, leads to a limitation of many nutrients like nitrogen, zinc, phosphorus, molybdenum, magnesium, potassium, etc. In most of the cases, it has been studied that saline soils are deficient in (N. Jindal. *et al.,* 1976; 1979a; 1979b) observed that, reduction in N in mango leaves is more due to chloride salinity than sulphate, and probably, the chloride salinity inhibits nitrate absorption and which induce a large amount of ammonium absorption. Likewise, citrus species are most sensitive to soil salinity (Maas. 1993), however, the capacity of citrus trees to tolerate salinity varies among different species and even among different strains within a species (Newcomb. 1978; Singh. *et al.,* 1997). Sweet orange, when, budded on rough lemon (*Citrus x jambhiri* Lush.) shows marked depression in leaf potassium contents in high salinity conditions (Bhambota. 1965), but the effect was reversed in case of calcium. Major vineyard problem in Maharashtra (showing incident of the bunch and stalk necrosis) occurs due to impaired calcium nutrition in saline soil (Palaniappan. 1990) and due to such nutritional imbalance plant metabolism is adversely affected which cause hindrance in growth and development of fruit crops. With an increase in salinity micronutrients like copper and boron decreases and zinc and iron increase in different citrus rootstock (Chundawat. *et al.,* 1977). Increased NO^{-3} decreases the uptake and accumulation of cl^- in many annual horticultural crops (Bernstein. *et al.,* 1974; Kafkafi. *et al.,* 1982; Feigin. *et al.,* 1987; Martinez. *et al.,* 1987). However, P accumulation may depend on plant's growing conditions; plant types and even cultivar play a large role (Grattan and Grieve. 1994). In case of potassium, many studies showed that K concentration in plant tissue declines as the Na-salinity in root media increase (Francois. 1984; Izzo. *et al.,* 1991; Graifenberg. *et al.,* 1995; Pearez-Alfocea. *et al.,* 1996). Decreased K uptake with increased root-zone salinity has been noted in other subtropical or tropical fruit crops, such as guava (Makhija. *et al.,* 1980) and citrus (Patil and Bhambota. 1980). In mango, it has been reported that the accumulation rate and concentration of anions and cations were variety-specific i.e chloride accumulation was maximum in seedling mango leaves (0.29%) and least in Dashehari (0.14%) and sodium accumulation was high in Langra (0.36%) and low in Chausa (Jindal and Makhija. 1983). Likewise, Gomera-1 and Gomera-3, when grafted with the Osteen cultivar and thereafter, exposed to salinized irrigation waters, (electrical conductivity (1.02, 1.50, 2.00 and 2.50 dS m^{-1}). Results indicated, differences in retaining toxic elements in different organs (roots, stem, or leaves) of both the rootstocks, and Gomera-3 found more sensitive and took up higher amounts of Cl^- and Na^+ than Gomera-1. Hence, Gomera-1 found more tolerant, due to capacity of this rootstock to restrict the uptake and transport of Cl^- and Na^+ ions from the root system to the above ground parts (Duran. *et al.,* 2003).

Effect of Salt Stress on Biochemical Response

Salt stress enhances the antioxidant activity in fruit crops in response to oxidative damage (Ruiz-Lozano *et al.,* 2012). Superoxide dismutase (SOD) is the main antioxidant released in response of salinity stress, which catalyzes the conversion of superoxide radical into hydrogen peroxide. To avoid the accumulation of hydrogen peroxide a compound even more damaging than superoxide radical, enzymes catalase (CAT) and ascorbate peroxidase (APX) are activated (Arbona. *et al*., 2003; Hossain. *et al* ., 2009). Antioxidant acts very fast in neutralizing any molecule which have the potential of develop free radical and act as first line of defence (Ighodaro and Akinloye. 2017). When salt affected mango cv Olour seedlings were treated with 1500 ppm paclobutrazol, showed higher SOD (24%), CAT (46%) and POD (163%) activities (Srivastav. *et al.,* 2010). In Carrizo citrange under salinity (30, 60, or 90 mmol L^{-1} NaCl) activities of antioxidant enzymes (SOD, CAT, APX, and GR) increased in leaves of plant (Arbona. *et al.,* 2003).The plants under salinity stress also produce polyamine like proline (Viegas. *et al.,* 1999) and spermine to overcome the osmotic stress and cellular dehydration. *An Arabidopsis* double knockout mutant plant (*acl5/spms*) showed higher sensitivity to high salt than wild type plants due to incapable of producing spermine. But when exogenously spermine was applied it had showed salt tolerance (Yamaguchi. 2006). Whereas in Aonla cultivars (NA-6, NA-7, NA-10, NA-18, Chakaiya, and Anand 1) proline and total free amino acid contents increased with increasing salinity (Rao. *et al.,* 2009).

Effect of Salt Stress on Phytohormones

Phytohormones profoundly regulate many aspects of plant growth and developme in response to biotic and abiotic stress. These are internally secreted signaling molecules produced by the plants in extremely low concentrations, which plays, a vital role in plants' adaptation to varying abiotic stress, by modulating source/sink regulation, growth, development and nutrient allocation. In adverse environmental conditions, the role of phytohormones has been illuminated the responses of plant by regulating hormonal synthesis, signaling, and molecular level action. Change in levels of several phytohormones relates to changes in the expression of genes involved in hormonal biosynthesis and their mode of action. In different stages of the plant life cycle, ABA (abscisic acid) plays a vital role like from seed development to seed dormancy, and helps in mediating environmental stress in plants (Eyidogan. *et al.,* 2012; Devinar *et al.,* 2013), and hence, ABA is well known as plant stress signaling hormone (Mahajan and Tuteja. 2005), which regulate the expression of salt-responsive-genes under salinity (Narusaka. *et al.,* 2003). An increase in salinity, increases ABA concentration in different plant parts, as in leaves (Zhang. *et al.,* 2006) and roots (Jia *et al.,* 2002). The ABA reduces water losses by limiting transpiration as a result of stomatal closure (Wilkinson and Davies. 2010). In response to reactive oxygen species (ROS) generation under salt stress conditions, ABA promotes, synthesis and accumulation of osmoprotectants like proline (Iqbal. *et al.,* 2014) and dehydrins (Szabados and Savoure. 2009; Hara. 2010). In response of protective mechanisms, plants rapidly accumulate ABA under salinity condition (Shakirova. *et al.,* 2010). It has also been studied that, salt-induced ABA restricts Na^{+} and Cl^{-} in leaves and reduces leaf expansion (Cabot. *et al.,* 2009). There is an antagonistic relationship between ABA and auxin. (Nilsen and Orcutt. 1996) reported that on exposure to salinity stress a significant reduction in IAA levels over an incubation period of 5 days in rice. Gibberellic acid (GA) is also one of the most actively involved hormones in regulating plant responses to the external environments (Chakrabarti and Mukherji. 2003), which regulates all physiological developments in plants, improve photosynthetic efficiency, leaf area index, light interception, enhanced efficiency of nutrients and play an important role in modulating diverse processes throughout plant development (Khan. *et al.,* 2007). GA also influences the processes of germination, leaf expansion, stem elongation, flower initiation and fruit development (Yamaguchi. 2008).

Mitigation Strategies to Combat Salt Stress in Fruit Crops

Plant Hormones Signaling

Many pieces of literature have been cited on the action of biostimulants in fruit crops under salt stress conditions. Plant hormones are known to play an important role in the adaptation of plants under varying climatic conditions by manipulating growth, development, source/sink transitions, and nutrient allocation. Hormones act as a signaling factor in different stress conditions and help in the adaptation of the plant to stress (Sharma. *et al.,* 2005; Shaterian. *et al.,* 2005). Decline in endogenous levels of phytohormones such as indole-3-acetic acid (IAA), salicylic acid (SA), but increased in ABA, JA (Jasmonic Acid) in response to salinity (Wang. *et al.,* 2001), which, could restrict seed germination and plant growth (Zholkevich and Pustovoytova. 1993; Jackson. 1997; Debez. *et al.,* 2001). Exogenous application of plant hormones helps in alleviating adverse effects of salinity and to cope with salt stress problems (Sharma. *et al.,* 2013; Iqbal and Ashraf. 2013a; 2013b; Amjad. *et al.,* 2014). Biostimulants have a specific role in the modulation of plant cellular response to stresses. Brassinosteroids (BRs) a steroidal hormone play a critical role in monitoring the developmental processes of plants, and recent studies discovered that, BRs also play a critical role in establishing immunity in plants (Hauvermale. *et al.,* 2012; Zhu. *et al.,* 2013a). Salicylic acid (SA) was found to protect seedlings of pistachio from the injurious effects of salt stress by improving chlorophyll content and photosynthetic rate of the seedlings (Bastam. *et al.,* 2013). Whereas, polyamines like methylglyoxal-bis (guanylhydrazone) (MGBG), S-adenosyl methionine decarboxylase (SAMDC) found to enhance the salt stress effect in grapevine plantlets, triggers the accumulation of lipid peroxidase & ROS but reduces the APX activity and glutathione which helps to sustain stress (Ikbal. *et al.,* 2014). Other plant hormones such as jasmonic acid (JA), ethylene (ET), and salicylic acid (SA) are also playing a key role in regulating plant immune responses in fruit crops (Cao. *et al.,* 2011; Pieterse. *et al.,* 2012; Abdelrahman. *et al.,* 2018c; Jogaiah. *et al.,* 2018). Recently, the application of melatonin which is currently considered as a phytohormone, involved in the responses to a variety of biotic and abiotic stresses in plants (Zhao. *et al.,* 2019), and when sprayed repeatedly at concentrations of 100–200 μM were able to alleviate the deleterious effects of salinity in strawberry, not only in the leaves, but also in fruits, whose yield and quality was much better (Zahedi. *et al.,* 2020).

Salt Tolerance

Salt tolerance is expected low in fruit crops, but due to high genetic variability (not only among the species but among cultivars also) offers breeding and selection opportunity in fruit crops to develop salt tolerant traits. Much research had been done till now to develop tolerance mechanisms in crops. Another promising approach is the introduction of some important traits of salt tolerance from wild relatives. In many crops, rootstock is developed which imparted salt tolerance to the crop propagated on them. At IIHR Bangalore, Cleopatra mandarin and Rangpur lime rootstock could tolerate 6.8 dSm-1 salinity (Anon. 1983), and is therefore, observed as highly tolerant against salinity (Joolka and Singh. 1979). Soil contains more than 0.3% salt should not be selected for vine irrigation (Nauriyal and Gupta. 1967; Pandey and Divate. 1976), whereas, (Praeek. 1977) suggested most of the grapes can tolerate high concentration of lime in arid zone soil. Similarly, mango cultivars have different abilities to tolerate and accumulate salt and differ in their response to salinity injury (Nemat. 1991). Salt tolerance features of Gomera-1 mongo rootstock is related to its capacity to restrict the uptake and transport of Cl^- and Na^+ ions from the rootstock to the above ground parts (Duran. *et al.,* 2003). Langra was to be the most sensitive mango cultivar to salt stress (Jindal. *et al.,* 1976) while, rootstocks 13/1 and Gomera-1 demonstrated tolerance to saline water (Kadman. *et al.,* 1976). Recent studies showed that salinity tolerance in plant was due to their resistance to oxidative stress (Gueta. *et al.,* 1997). There are different plant defense mechanisms including antioxidant enzymes such as catalase, peroxidase, glutathione reductase, and polyphenol oxidase, and non-enzymatic antioxidant and cellular osmoregulation are involved against salinity (Niknam. *et al*., 2003; Asada. 2006). Likewise, several other horticultural crops, such as guava (*Psidiurnguajava* L), pomegranate (*Punicagranatum* L), aonla (*Phyllanthusemblica*) varying in salt tolerance, have been tested in the past using different establishment techniques (Singh. *et al.,* 1998, Dagar. *et al.,* 2001). Litchi (*Litchi chinensis* Sonn.) is known to grow well in a wide variety of soils with pH in the range of 5.5 - 6.5 (Maity and Mitra. 2002). As, roots of litchi plants establish a symbiotic association with arbuscular mycorrhizal fungi (AMF) (Parniske. 2008; Smith and Read. 2008), which in mycorrhizosphere, produces lots of physiological effects on stress tolerance, nutrient absorption, tree growth, and fruit quality in fruits. In recent years, as a biofertilizer and bio protector, AMF has attracted attention from agronomists and horticulturists in salt-stress mitigation.

Reclamation

Agricultural productivity in many arid and semiarid regions of the world is threatened by the occurrence of salt-affected soils and, hence, improved management practices are needed to maintain or increase the productivity of saline-sodic and sodic soils (Qadir. *et al.,* 2001; Suarez. 2001; Barrett-Lennard. 2002). Methods employed in reclaiming saline soils can be broadly grouped under three heads viz., mechanical methods, use of water, and application of amendments. Excess salinity in the root zone can be effectively controlled by leaching and drainage of soluble salts either by surface or sub-surface drainage (Robbins. 1986a; Qadir. *et al.,* 1996). Leaching is another way of treating salt-affected soils in which, the fraction of infiltrated water that must pass through the root zone to keep soil salinity from exceeding a level that would significantly reduce crop yield under steady-state conditions with associated good management and uniformity of leaching (Rhoades. 1974), and hence, adequate leaching is considered best method of controlling soil and water salinity. The saline soils treated with gypsum and subsequent leaching to remove Na^+. Application of gypsum considerably increases salt tolerance by improving soil structure, aeration, and increased Ca^{2+}/Na^+ influx (Oster and Frenkel. 1980; Suarez. 2001). The addition of organic matter and to supply N, P, Cu, and Fe through acidic fertilizers is necessary for the successful cultivation of fruit crops under saline soils and ammonical and acid-forming fertilizers are better than calcium ammonium nitrate. Excess chloride are major cause of poor vine growth of grape, and it continues to accumulate mainly in petioles even though toxicity symptoms appear in blades, and when its levels exceeds 1.5% in petiole and/or 2.0% in blades are considered to be toxic (Sharma. 2005). Besides, these, mulching of soils, frequent irrigations, adequate leaching, drainage, maintaining water table depth, improving irrigation efficiency by drip, pitcher irrigation, use of mycorrhiza, and green manuring help in reclaiming saline soils.

Molecular Biology

Recent improvement in molecular biology has expanded the possibilities for gene manipulation at the level of cell cultures and higher organizational unit. Improving salinity and drought tolerance of crop plants by genetic means has been an important but largely unfilled aim of modern agricultural development. The major bottleneck in the use of these techniques to develop salt-tolerant crops is that, salt tolerance is a complex, multigenic/quantitative trait (Foolad and Jones. 1993) and is often a mixed response of the rationally mixed system biology. The QTLs related with salt tolerance have significant role in understanding the stress response and generating stress-tolerant plants (Gorantla. *et al*., 2005). The rapidly expanding base of information on molecular strategies in plant adaptation to stress is likely to improve experimental strategies to achieve improved tolerance. Approaches, like microarray based transcriptional profiling of differential gene expression (Walia. *et al.,* 2007) and/or combination of genetic mapping and expression profiling (Marino. *et al.,* 2009; Pandit. *et al.,* 2010) are being used for identifying genes linked with QTLs, involved in the salt stress responses. Identification and manipulation of such genes, enzymes, or compounds through transgenic approaches had made possible, the development of plants with enhanced salt tolerance (Thomas. *et al*., 1995; Xu. *et al*., 1996). Many approaches in tomato has been taken to develop transgenic salt tolerance through the ontogeny of plant by QTLs pyramiding through marker-assisted selection (Foolad. 2004). In strawberry, an osmatin gene extracted from *Agrobacterium tumefaciens* strain GV2260 was inserted in in-vitro grown plantlets of strawberry (cv. Chandler), the transgenic lines so developed, showed osmotic gene expression, and biochemical analysis of these transgenic plants revealed enhanced levels of proline, total soluble protein and chlorophyll content as compared to the wild plants (Husain and Abdin. 2008).

Stress alleviation by Bacteria

Abiotic changes in nature leads to unique and complex aberration at the morphological and physiological level and ultimately become receptive to pathogen interference. In many studies, role of bacteria in the alleviation of salt stress complex aberration at different levels proven as an important tool for mitigation. Different strains of PGPRs; *Staphylococcus kloosii* EY37 and *Kocuria* species with the highest efficiency to alleviate salinity stress on the yield of strawberry and nutrient uptake was recorded. PGPR inoculations could alleviate the deleterious effects of salinity conditions in soil by increasing plant growth, chlorophyll content, and altering mineral uptake, and therefore, enhancing salt tolerance in strawberry plants (Karlidag. *et al.,* 2013). Salt-tolerant bacterial inoculants may be useful in developing strategies to facilitate plant growth in salinity conditions (Bacilio. *et al.,* 2004). The PGPRs have been reported to ameliorate the negative effect of salt stress on the plant growth of vegetable crops such as tomato (Mayak. *et al.,* 2004). (Karlidag. *et al.,* 2011a) determined that PGPR root inoculations could mitigates the deleterious effects of salinity conditions on plant growth of strawberry in pot experiments.

Conclusions and Future Perspectives

Salt stress is a growing concern for fruit cultivation due to less rainfall, several anthropogenic factors like excess use of fertilizer, use of faulty irrigation water etc. As fruit crops are extremely sensitive to different climatologically factors, salt stress is hampering productivity in direct and indirect ways. Salinity remains one of the farmers' oldest environmental disturbances in path of fruit crops production and productivity and challenging scientist for research in the field of salt stress. Several traditional mitigation strategies viz: soil, water, and nutrient management, plant harmone signaling, tolerance, reclamation has been adopted to combat salinity stress as well. But using PGPRs, genetic modification and by using molecular breeding tools are important new approach in future perspectives for the alleviation of salt stress.

References

1. Abdelrahman, M., Mai, M., Takao, I., Mitsutaka, M., Kyoko, M., Yukio, O., Masaru, M., Atsuko, U. and Akira, K. "Differential gene expression analysis and SNP/InDel marker discovery in resistant wild Asparagus kiusianus and susceptible A. officinalis in response to Phomopsis asparagi infection." *Data in brief* 21 (2018) c: 2117-2121.
2. Ahmad, P., Ashwani, K., Muhammad, A. and Nudrat, A. A. "Salt-induced changes in photosynthetic activity and oxidative defense system of three cultivars of mustard (Brassica juncea L.)." *African Journal of Biotechnology* 11.11 (2012): 2694-2703.
3. Anjum, S. A., Xiao, Y. X., Long, C. W. "Morphological, physiological and biochemical responses of plants to drought

stress." *African journal of agricultural research* 6.9 (2011): 2026-2032.
4. Anonymous. IIHR Anunual report, Bangalore (1983).
5. Arbona, V., Victor, F., Josep, J., Pilar, G. A. and Aurelio, G. C. "Enzymatic and non-enzymatic antioxidant responses of Carrizo citrange, a salt-sensitive citrus rootstock, to different levels of salinity." *Plant and cell physiology* 44.4 (2003): 388-394.
6. Asada, K. "Production and scavenging of reactive oxygen species in chloroplasts and their functions." *Plant Physiol* 141(2006):391-396.
7. Bacilio, M., Hilda, R., Manuel, M., Juan, P. H. and Yoav, B. "Mitigation of salt stress in wheat seedlings by a gfp-tagged Azospirillum lipoferum." *Biology and Fertility of Soils* 40.3 (2004): 188-193.
8. Banon, S., Fernandez, J. A., J. Ochoa. and Sanchez-Blanco, M. J. "Paclobutrazol as an aid to reduce some effects of salt stress in oleander seedlings." *European Journal of Horticultural Science* 70.1 (2005): 43-49.
9. Banuls, J. and Eduardo, P. M. "Effects of salinity on some citrus scion-rootstock combinations." *Annals of Botany* 76.1 (1995): 97-102.
10. Barrett-Lennard, E. G. "Restoration of saline land through revegetation." *Agricultural Water Management* 53 (2002): 213-226.
11. Bastam, N., Bahram, B. and Cyrus, G. "Improving salt tolerance by exogenous application of salicylic acid in seedlings of pistachio." *Plant growth regulation* 69 (2013): 275-284.
12. Beritognolo, I., Antoine, H., Federico, B., *et al*. "Comparative study of transcriptional and physiological responses to salinity stress in two contrasting Populus alba L. genotypes." *Tree Physiology* 31 (2011): 1335-1355.
13. Bernstein, L. "Crop growth and Salinity." *Drainage for agriculture* American Society Agronomy, Madison, Wisconsin 17 (1974): 39-54
14. Bernstein, N. and Uzi, K. "Root growth under salinity stress." *Plant Roots: The Hidden Half*. 3rd Edition. (Waisel, Y., Eshel, A. and Kafkafi, U., Eds.). *Marcel Dekker, New York, NY, USA* (2002) 787–805.
15. Bhambota, J. R. "Study on the effect of water table, Salt Concentration and nutrients on sweet orange (*Citrus sinensis L).*Osbeck under Punjab conditions." *Ph.D thesis, Punjab University* (1965).
16. Cabot, C., John, V. S., Joan, B. and Charlotte, P. "Abscisic acid decreases leaf Na^+ exclusion in salt treated *Phaseolus vulgaris* L." *Journal of Plant Growth Regulator* 28 (2009):187-192.
17. Cao, F. Y., Keiko, Y. and Darrell, D. "The roles of ABA in plant–pathogen interactions." *Journal of Plant Research* 124 (2011): 489-499.
18. Celis, N., Donald, L. S., Laosheng, W., Rui, L., Mary, L. A. and Peggy, M. "Salt Tolerance and Growth of 13 Avocado Rootstocks Related Best to Chloride Uptake." *Horticultural Science* 53.12 (2018): 1737-1745.
19. Chakrabarti, N. and S. Mukherji. "Alleviation of NaCl stress by pre-treatment with phytohormones in *Vigna radiata*." *Biologia plantarum* 46 (2003): 589-594.
20. Chaves, M. M., Flexas, J. and C. Pinheiro. "Photosynthesis under drought and salt stress: regulation mechanisms from whole plant to cell." *Ann. Bot.* (2009).
21. Chundawat, B. S., Arora, R. K., Kher, A. P. and Gupta, O. P. "Macronutrient level in various stionic combinations in sweet orange (*C. sinensis L*).*Osbeck*. Proc. Intern. Citrus Symposium." *Horticultural society of India IIHR*, Banglore (1977): 201-204.
22. Claeys, H., Sofie, V. L., Marieke, D., Katrien, M. and Dirk, I. "What is stress? Dose-response effects in commonly used in vitro stress assays." *Plant Physiology* 165 (20114): 519-527.
23. Cui, D. Z., Dandan, W., Jie, L., *et al*. "Proteomic analysis of seedling roots of two maize inbred lines that differ significantly in the salt stress response." *PLOS ONE* (2015).
24. Dagar, J. C., Gurbachan, S. and Singh, N. T. "Evaluation of forest and fruit trees used for rehabilitation of semiarid alkali-sodic soils in India." *Arid Land Research and Management* 15.2 (2001):115-133.
25. Debez, A., Chaibi, W. and S. Bouzid. "Effect du NaCl et de regulatoeurs de crois-

sancesur la germination d' Atriplex halimus L." *Cahiers Agricultures* 10.2 (2001): 135-138.
26. Desai, V. T. and Singh, R. N. "Growth of guava plants (Psisiumguavajava L.) as affected by salinity." *Indian Journal of Horticulture* 37 (1980): 3-9.
27. Devinar, G., A. Llanes., Masciarelli, O. and V. Luna. "Different relative humidity conditions combined with chloride and sulfate salinity treatments modify abscisic acid and salicylic acid levels in the halophyte *Prosopis strombulifera*." *Journal of Plant Growth Regulator* 70 (2013): 247-256.
28. Dubey, R. S. "Photosynthesis in plants under stressful conditions." *Handbook of photosynthesis* (1996): 859-875. Duran, V., Martinez, R. A. and J. Aguilar. "Salt tolerance of mango rootstocks (*Magnifera indica* L. cv. Osteen)." *Spanish Journal of Agricultural Research* 1.1 (2003): 68-78.
29. Eyidogan, F., Oz, M. T., Yucel, M. and Oktem, H. A. "Signal transduction of phytohormones under abiotic stresses." *Phytohormones and abiotic stress tolerance in plants*. *Springer*, Berlin (2012): 1-48.
30. Feigin, A., Irena, R., Meiri, A. and J. Shalhevet. "Response of melon and tomato plants to chloride-nitrate ratios in saline nutrient solutions." *Journal of Plant Nutrition* 10 (1987): 1787-1794.
31. Foolad, M. R. "Recent advances in genetics of salt tolerance in tomato." *Plant Cell, Tissue and Organ Culture* 76 (2004): 101–119.
32. Foolad, M. R. and Jones, R. A. "Mapping salt-tolerance genes in tomato (*Lycopersicon esculentum*) using trait-based marker analysis." *Theoretical Applied Genetics* 87 (1993): 184-192.
33. Francois, L. E. "Salinity effects on germination, growth, and yield of turnips." *Horticulture Science* 19 (1984): 82-84. Gama, P. B. S., Kiyoshi, T., Antony, E. E., Amin, E. E. and Kamal, E. S. "Salt-induced stress effects on biomass, photosynthetic rate, and reactive oxygen species-scavenging enzyme accumulation in common bean." *Journal of Plant Nutrition* 32 (2009): 837-854.
34. Gorantla, M., Babu, P. R., Reddy, V. B. L., Feltus, F. A., Andrew, H. P. and Arjula, R. R. "Functional genomics of drought stress response in rice: transcript mapping of annotated unigenes of an indica rice (*Oryza sativa* L. cv. Nagina 22)." *Current Science* 89 (2005): 496-514.
35. Graifenberg, A., L. Giustiniani., Temperini, O. and Lipucci, d. P. M. "Allocation of Na, Cl, K and Ca within plant tissues in globe artichoke (*Cynara scolymus* L.) under saline-sodic conditions." *Science Horticulture* 63 (1995): 1-10.
36. Grattan, S. R. and Grieve, C. M. "Mineral nutrient acquisition and response by plants grown in saline environments." *Handbook of Plant and Crop Stress*. Marcel Dekker, New York (1994): 203-226.
37. Grieve, C. M., Grattan, S. R., and Maas, E. V. "Plant salt tolerance." *Agricultural salinity assessment and management*. 2nd ed. American Society of Civil Engineers, Reston, VA (2012): 405–459.
38. Grime, J. P. "Evidence for the existence of three primary strategies in plants and its relevance to ecological and evolutionary theory." *The American Naturalist* 111.982 (1977): 1169-1194.
39. Gueta, D., Yardena, Z. Y., Barbara, A. Z. and Gozal, B. H. "Salt and oxidative stress: similar and specific responses and their relation to salt tolerance in Citrus." *Planta* 203 (1997): 460-469.
40. Gupta, O. P. and Nauriyal, J. P. "Studies on salt tolerance of grapes. II. Effect of high levels of chloride/sulphate and carbonate." *Haryana Journal of Horticulture Sci*ence 2 (1973): 14-22.
41. Hara, M. "The multifunctionality of dehydrins." *Plant Signal and Behaviour* 5 (2010): 503-508.
42. Hasegawa, P. M., Ray, A. B., Jian-Kang, Z. and Hans, J. B. "Plant cellular and molecular responses to high salinity." *Annual Review of Plant Biology* 51.1 (2000): 463-499.
43. Hauvermale, A. L., Tohru, A. and Camille, M. S. "Gibberellin signaling: a theme and variations on DELLA repression." *Plant Physiology* 160 (2012): 83-92.
44. Hossain, Z., María, F. L. C., Vicent, A., Rosa, M. P. C. and Aurelio, G. C. "Modulation of the Antioxidant System in Citrus Under Waterlogging and Subsequent

Drainage." *Journal of plant physiology* 166 (2009): 1391-1404.
45. Hsiao, T. C. and Liu-Kang, X. "Sensitivity of growth of roots versus leaves to water stress: Biophysical analysis and relation to water transport." *Journal of Experimental Botany* 51 (2000): 1595-1616.
46. Husaini, A. M. and Malik, Z. A. "Development of transgenic strawberry (Fragaria x ananassaDuch.) plants tolerant to salt stress." *Plant Science* 174 (2008): 446–455.
47. Ighodaro, O. M. and Akinloye, O. A. "First line defense antioxidants superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPX): Their fundamental role in the entire antioxidant defence grid." *Alexandria Journal of Medicine* 54.4 (2018): 287-293.
48. Ikbal, F., José, A. H., Gregorio, B. E., Tayeb, K., Aziz, A., Mohamed, F. and Pedro, D. V. "Enhanced salt-induced antioxidative responses involve a contribution of polyamine biosynthesis in grapevine plants." *Journal of Plant Physiology* 171 (2014): 779-788.
49. Iqbal, M. and Muhammad, A. "Gibberellic acid mediated induction of salt tolerance in wheat plants: growth, ionic partitioning photosynthesis, yield and hormonal homeostasis. *Environmental and Experimental Botany* 86 (2013) a: 76-85.
50. Iqbal, M. and Muhammad, A. "Salt tolerance and regulation of gas exchange and hormonal homeostasis by auxin-priming in wheat." *Pesquisa Agropecuaria Brasileira* 48 (2013) b: 1210–1219
51. Iqbal, N., Shahid, U., Nafees, A. K. and Khan, M. I. R. "A new perspective of phytohormones in salinity tolerance: regulation of proline metabolism." *Environmental and Experimental Botany* 100 (2014): 34-42.
52. Izzo, R., Flavia, N. I. and Mike, F. Q. "Growth and mineral absorption in maize seedlings as affected by increasing NaCl concentrations." *Journal of Plant Nutrition* 14 (1991): 687-699.
53. Jackson, M. "Hormones from roots as signals for the shoots of stressed plants." *Elsevier- Trends in plant science* 2 (1997): 22-28.
54. Jia, W., Youqun, W., Shuqiu, Z. and Jianhua, Z. "Salt -stress-induced ABA accumulation is more sensitively triggered in roots than in shoots." *Journal of Experimental Botany* 53 (2002): 2201-2206.
55. Jindal, P. C. and M. Makhija. "Salt accumulation in different mango cultivars." *Progressive Horticulture* 15 (1983): 226-28.
56. Jindal, P. C., Singh, J. P. and Gupta, O. P. "Salt tolerance of mango: A note on phosphorus and magnesium deficiency caused by sodium sulphate." *Haryana Journal of horticulture science* 5 (1976): 13-14.
57. Jindal, P. C., Singh, J. P. and Gupta, O. P. "Mineral nutrient status of mango cultivars under varying salt status in soil." *Haryana Journal of horticulture science* 8 (1979) a: 39-41.
58. Jindal, P. C., Singh, J. P. and Gupta, O. P. "Effect of salinity on mineral nutrients in mango seedlings." *Indian Journal of Agriculture science* 49 (1979) b: 105-9.
59. Jindal, P. C. "Studies on salt tolerance of mango (*Mangifera indica L.*)." *Ph.D. thesis, HAU*, Hisar
60. Jogaiah, S., Mostafa, A., Lam-Son, P. T. and Shin, I. I. "Different mechanisms of Trichoderma virens mediated resistance in tomato against Fusarium wilt involve the jasmonic and salicylic acid pathways." *Molecular Plant Pathology* 19 (2018): 870-882.
61. Joolka, N. K. "Effect of saline water on the growth of citrus plants." *Ph.D. thesis, HAU*, Hisar (1976).
62. Joolka, N. K. and Singh, J. P. "Effect of soil salinity on the growth of citrus rootstock." *India journal of agriculture science* 49 (1979): 858-61.
63. Julkowska, M. M., Christa, T. "Tuning plant signaling and growth to survive salt." *Trends in plant science* 20 (2015): 586-594.
64. Kadman, A., Gazit, S. and G. Ziv. "Selection of mango rootstock for adverse water and soil conditions in arid areas." *Acta Hortic.* 57 (1976): 81-88.
65. Kafkafi, U., Valoras, N. and J. Letey. "Chloride interaction with nitrate and phosphate nutrition in tomato (Lycopersi-

cone sculentum L.).” *Journal of Plant Nutrition* 5 (1982): 1369-1385.

66. Karlidag, H., Ahmet, E., Ertan, Y., Donmez, M. F. and Metin, T. "Effects of plant growth promoting bacteria on yield, growth, leaf water content, membrane permeability, and ionic composition of strawberry under saline conditions." *Journal of plant nutrition* 34 (2010): 34-45.
67. Karlidag, H., Ertan, Y., Metin, T., Mucahit, P. and Figen, D. "Plant growth-promoting rhizobacteria mitigate deleterious effects of salt stress on strawberry plants (Fragaria× ananassa)." *HortScience* 48.5 (2013): 563-567.
68. Kaul, M. K. “Studies on salt tolerance in guava.” *Ph.D. thesis, HAU, Hisar* (1981).
69. Kaur, G., S. Kumar., Nayyar, H. and Upadhyaya, H. D. "Cold stress injury during the pod-filling phase in chickpea (*Cicer arietinum* L.): Effects on quantitative and qualitative components of seeds." *Journal of agronomy and crop science* 194.6 (2008): 457-464.
70. Khan, N. A., Sarvajeet, S., Rahat, N. and Pervez, M. L. “The source-sink relationship in mustard.” *The Asian and Australian Journal of plant science and biotechnology* 1 (2007):10-18
71. Khayyat, M., Soheila, R., Saied, E. and Enayatollah, T. "Calcium effects on changes in chlorophyll contents, dry weight and micronutrients of strawberry (Fragaria× ananassa Duch.) plants under salt-stress conditions." *Fruits* 64 (2009): 53-59.
72. Li, C., Ping, W., Zhiwei, W., Dong, L., Changhai, L., Lihua, Y., Dongfeng, J., Mingyang, F. and Fengwang, M. “The mitigation effects of exogenous melatonin on salinity-induced stress in *Malus hupehensis*.” *Journal of pineal research* 53 (2012): 298-306.
73. Ma, H. Y., Liru, S., Yingjie, S., Shuang, W., Juan, N., Zhankui, W., Tian, Y., Weihong, G. and Hao, M. "Comparative proteomic analysis of seedling leaves of different salt tolerant soybean genotypes." *Journal of Proteomics* 75 (2012): 1529-1546.
74. Machado, R. M. A. and Ricardo, P. S. “Soil salinity: Effect on vegetable crop growth. Management practices to prevent and mitigate soil salinization.” *Horticulturae* 3 (2017):30.
75. Maas, E. V. “Salinity and citriculture” *Tree physiology* 12 (1993): 95-116
76. Mahajan, S. and Narendra, T. "Cold, salinity and drought stresses: an overview." *Archives of biochemistry and biophysics* 444 (2005): 139-158.
77. Maity, S. C. and Mitra, S. K. “Litchi.” Fruits: Tropical and Sub-tropical, 1 (2002): 556-608. Bose, T. K., Mitra, S. K. and Sanyal, D. (Eds). NayaUdyog, Bidhan-Sarni, Kolkata.
78. Makhija, M., Dhankhar, O. P and Singhrot, R. S. “Effect of soil salinity levels on growth and leaf mineral composition of guava (*Psidium guajava* L.).” *Haryana J. Hort. Sci.* 9.1-2 (1980): 21-25.
79. Mantri, N., Vikas, P., Suprasanna, P., Rebecca, F. and Edwin, P. "Abiotic stress responses in plants: present and future." *Abiotic stress responses in plants*. Springer, New York, NY (2012): 1-19.
80. Marino, R., Maharajah, P., Pawel, K., Carla, F., Luca, G., Pè, M. E. and Mirella, S. G. "Addressing drought tolerance in maize by transcriptional profiling and mapping." *Molecular Genetics and Genomics* 281 (2009): 163-179.
81. Martinez, V., Cerda, A. and Fernandez, F. G. “Salt tolerance of four tomato hybrids.” *Plant Soil* 97 (1987): 233-242. Mayak, S., Tsipora, T. and Bernard, R. G. "Plant growth-promoting bacteria that confer resistance to water stress in tomatoes and peppers." *Plant Science* 166 (2004): 525-530.
82. Munns, R. “Genes and salt tolerance: bringing them together.” *New phytologist*, 167.3 (2005): 645-663.
83. Narusaka, Y., Kazuo, N., Zabta, K. S., Yoh, S., Takashi, F., Hiroshi, A., Mari, N., Kazuo, S. and Kazuko, Y. S. "Interaction between two cis-acting elements, ABRE and DRE, in ABA-dependent expression of Arabidopsis rd29A gene in response to dehydration and high-salinity stresses." *The Plant Journal* 34 (2003): 137-148.
84. Nauriyal, J. P. and Gupta, O. P. “Studies on salt tolerance of grape. I. Effect of total salt concentration.” *PAU Agricultural Research Journal*, Ludhiana 4 (1967): 197-205.

85. Nemat, Y. A. "Studies on the effect of salinity on mango seedlings." *Ph.D. Thesis, Fac. Agric*. Cairo Univ. Egypt (1991).
86. Newcomb, D. A. "Selection of rootstocks for salinity and disease resistance." *Proc. Intern. Soc. Citriculture* (1978): 117-120.
87. Niknam, V., N. Razavi, H. Ebrahimzadeh, and B. Sharifizadeh. "Effect of NaCl on biomass, protein and proline contents, and antioxidant enzymes in seedlings and calli of two Trigonella species." *Biol. Plant* 50 (2003): 591–596. Nilsen, E. T. and David, M. O. "The physiology of plants under stress abiotic factors." *Wiley*, New York (1996): 118-130.
88. Nobel, P. S. "Physicochemical and environmental plant physiology." *London: Academic Press* (1991).
89. Oster, J. D. and H. Frenkel. "The chemistry of the reclamation of sodic soils with gypsum and lime." *Soil Science Society of America Journal* 44 (1980): 41–45.
90. Ouyang, B., Ting, Y., Hanxia, L., Liang, Z., Yuyang, Z., Junhong, Z., Zhangjun, F. and Zhibiao, Y. "Identification of early salt stress response genes in tomato root by suppression subtractive hybridization and microarray analysis." *Journal of Experimental Botany* 58 (2007): 507–520.
91. Palaniappan, R. and Chadha, K. L. "Advances in Horticulture." *Malhotra Publishing House* 2 (1993): 1073-1090.
92. Palaniappan, R. "Grapes disoders." Report submitted to MRDBS, Pune (1990): 6.
93. Pandey, R. M. "Physiological studies on "Salt tolerance in grapes.var. perlette. Research Report." *ICAR Fruit Research Workshop* (Nagpur) (1982): 414-16.
94. Pandey, R. M. and Divate, M. R. "Salt tolerance in grapes. I. Effect of sodium salt singly and in combination on some of the morphological characters of grapes varieties." *Indian Journal of plant physiology* 19 (1976): 230-39.
95. Pandit, A., Vandna, R., Subhashis, B., *et al.* "Combining QTL mapping and transcriptome profiling of bulked RILs for identification of functional polymorphism for salt tolerance genes in rice (Oryza sativa L.). *Molecular Genetics and Genomics* 284 (2010): 121-36.
96. Pareek, O. P. "Horticulture in the arid zone eco-system." *Desert Ecosystem and its improvement. CAZRI*, Jodhpur (1977): 14.
97. Parniske, M. "Arbuscularmycorrhiza: the mother of plant root endosymbioses." *Nature Reviews Microbiol*ogy 6 (2008): 763-775.
98. Patil, P. K. and Patil, V. K. "Effect of soil salinity levels on growth and chemical composition of *Syzygium Cumini* L. (jamun)." *Journal of Horticultural Science* 58 (1983) b: 141-45.
99. Patil, P. K. and Bhambota, J. R. "Salinity studies in citrus. I. Effect of various levels on the macronutrient status of seedling rootstock." *Journal of Indian society of soil science* 28 (1980): 72-79.

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