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**Hafiz Muhammad Bilal**
Department of Horticulture,
College of Agriculture,
University of Sargodha, Pakistan

**Rabia Zulfiqar**
Department of Horticulture,
College of Agriculture,
University of Sargodha, Pakistan

**Muhammad Adnan**
Department of Agronomy,
College of Agriculture,
University of Sargodha, Pakistan

**Muhammad Shakeeb Umer**
Department of Horticulture,
College of Agriculture,
University of Sargodha, Pakistan

**Haseeb Islam**
Department of Horticulture,
College of Agriculture,
University of Sargodha, Pakistan

**Hamza Zaheer**
Department of Horticulture,
College of Agriculture,
University of Sargodha, Pakistan

**Wazir Mohsin Abbas**
Department of Horticulture,
Crop and Food Sciences Pir Mehr
Ali Shah Arid Agriculture
University, Rawalpindi,
Pakistan

**Fateen Haider**
Department of Horticulture,
College of Agriculture,
University of Sargodha, Pakistan

**Rai Ikhlaq Ahmad**
Department of Horticulture,
College of Agriculture,
University of Sargodha, Pakistan

**Corresponding Author:**
**Muhammad Adnan**
Department of Agronomy,
College of Agriculture,
University of Sargodha, Pakistan

# Impact of salinity on citrus production; A review

**Hafiz Muhammad Bilal, Rabia Zulfiqar, Muhammad Adnan, Muhammad Shakeeb Umer, Haseeb Islam, Hamza Zaheer, Wazir Mohsin Abbas, Fateen Haider and Rai Ikhlaq Ahmad**

## Abstract
Citrus is one of the important horticultural fruit crop growing all over world. However, it is sensitive to many environmental stresses such as drought, excessive watering (water logging), extreme temperatures (cold, frost and heat), salinity and mineral toxicity, among all these stresses salinity stress is one of them. Salinity is abiotic factor that decrease the vegetative growth and yield by causing hyperosmotic and hyperionic effects on soil rhizosphere. Citrus is a crop susceptible to salt because citrus growth and yield is more significantly reduce in salt stress condition as compared with other fruit crops. There are many ways to combat the negative effect of salinity like alternate irrigation or selection of resistant root stocks. Therefore, this review focuses on the effect of salinity on citrus production and possible measures to reduce the losses.

**Keywords:** Citrus; stresses; salinity; rootstocks; losses

## 1. Introduction
Citrus is a subtropical crop and grown in almost all over of the world. It is susceptible to low temperature and poor soils. Major portion of citrus comes from northern hemisphere, Mediterranean countries and from United States, while largest citrus producer is Brazil. Citrus production is more successful in such type of areas where climatic condition is warm and have well drained soils. It requires supplemental irrigation and better irrigated water quality. The use of chemical product and fertilizers also boost salt reinforcement with soil which causes salt stress (Syvetrsen 1989) [23]. River water that used for irrigation purpose having negative effect on citrus plant due to presence of higher amount of soluble salt and also higher electrical conductivity > 3 dS $m^{-1}$ (García-Sánchez *et al*. 2002) [8]. Citrus is a crop susceptible to salt because citrus growth and yield is more significantly reduce in salt stress condition as compared with other fruit crops (Maas 1993; Storey and Walker 1998) [15, 20]. Soil salinity is one of the most important abiotic factors that adversely effect on plant growth. In addition, nursery and greenhouse industry is under pressure to recover and recycle fertilizer solution and wastes. Most of these contains significantly higher salt concentrations that could cause harm to susceptible species of plants (Bilal *et al*., 2020) [6]. Salt stress is depending upon climatic conditions, quality of irrigation water, soil condition (Grieve and Bevington 2007; Prior *et al*. 2007) [12, 17]. It occurs due to poor drainage of soil, toxicity of boron, imbalance or deficiency of nutrients and flooding. Salt stress negatively influence all plants (Camara-Zapata *et al*. 2004) [7]. Therefore, this review focuses on the effect of salinity on citrus production and possible measures to reduce the losses.

## 2. Salinity Impact on Citrus Growth and Production
Salinity is the main abiotic factor that decrease the vegetative growth and yield by causing hyperosmotic and hyperionic effects on soil rhizosphere. Syvertsen and Garcia-Sanchez (2014) [21] reported that salts stress through cause on roots predisposing trees to the biotic environmental stresses, also include effect by nematodes, bacterial disease and root rot. Balal *et al*. (2011) [5] study the influence of salt stress on plants. Results showed that maximum salt application gives rise to excessive reduction in the growth parameters, i.e., dry and fresh weight of root and shoot and also declared that through rise in salinity concentration sugar and proline contents were also improved. Wei *et al*. (2013) [25] investigated the influence salt

tolerance of citrus. The NaCl concentration decrease dry mass (DM), respiration levels and leaf area, but the loose-skin mandarins lower the leaf transpiration rate (Tr) than sweet oranges. The variation in basic nutritional value ranged between the salted cultivars and loose mandarins of the skin to indicate less leaf decline $Mg_2^+$ and $Ca_2^+$. The increased salt Beranium demonstrated weak- skin mandarins might well be associated with the ability to exclude $Na^+$ and $Cl^-$ from leaf in particular $Mg^+$ and $Ca^{2+}$ in their leaf. Gimeno *et al*. (2009) [10] conducted a research trail to study the effect of irrigation by salty water in semi-arid and arid areas. Fertilization and rootstocks show the central role in citrus salts tolerance. The salinity decreases; the growth of leaf was identical in S + N and S trees. The reason was the osmotic impact and the sensitivity of $Cl^-$ and $Na^+$ leaves played a key part in a growth response to salt stress of fino 49 lemons. They also reported that foliar spray of the concentrations of the $Cl^-$ leaf of nitrogen in S + N treatment was also lower relative to the S therapy, but the leaf growth was lowest for the treatment of N trees. Salt reduced water from leaves and osmotic potential to increase leaf turgor.

García-Sánchez *et al*. (2006) [9] conducted a research trail to evaluate the effect of different salinity concentrations on citrus and noted decrease in leaf gas exchange and leaf growth. They observed that shade reduced applications in salinized tree leaves but did not affect the root or leaf Cl- of trees in Cleo. In the leaf gas exchange parameters of shaded and un-shaded salinized plants there are no major variations. The growth has also been decreased by the salinity which has been documented to be superior to un- shaded trees. The damaging effects of salinity for accumulation and growth of $Na^+$ were not overcome by shading. Thy also reported that growth is reduced from salinity stress is superior for shaded than for un-shaded trees. Shading did not overcome the harmful effects of salinity on $Na^+$ accumulation and growth. (Adnan 2004) [3] reported that water salinity is the main issue due to its adverse impact on the yields of numerous horticultural crops. It inhibits the growth of citrus trees and often induces physiological issues. In addition to the accumulation of the extreme concentration of chloride or sodium in the leaves the salt stress mainly reduces net carbon dioxide integration, transpiration rate and water prospective citrus leaves. They observed that the best research tells that the citrus is genetically sensitive to salt.

Zekri and Parsons (1992) [26] conducted the experiment to check the effect of sodium chloride (NaC1) on the different citrus rootstocks at greenhouse. Increasing the levels of sodium chloride in the nutrition solution decreases the leaf and root mineral levels of the seven citrus rootstock grow substantially and distinct. It was noted that substantial variations across all leaf and root concentrations were also discovered in adverse condition by many citrus rootstock. They also reported that the sodium chloride sensitivity of different citrus rootstocks in the phrase of leaf burning symptoms observed and growth reducing could be assigned more $C1^-$ than to $Na^+$. Sodium and $CI^-$ concentrations were higher in the leaves as compared with the roots of seven citrus rootstocks. (Zekri 1993) [27] conducted an experiment in order to examines the impact of greenhouse experiment NaCl induced pressure on early development and the emergence of citrus rootstock cultivars, i.e. Citrumelo, Rough lemon, Volkamer lemon, Rangpur lime, Swingle citrumelo. Seeds were irrigated with a solution containing NaCl at different concentrations. The results showed remarkable effects of salinity on the growth of seedlings and emergence but no impact on the final emergence rate. They also observed that little tolerance results were found in sour orange, and rough lemon while highest in Rangpur lime and Swingle citrumelo.

## 2. Salinity Impact on Production and Efficiency of Crop Citrus

The citrus crop is sensitive to salt stress. Irrigation of saline water decreases the yield of the citrus crop. (Hepaksoy 2000) [13] conducted a research trail to check the yield and quality of rootstocks in saline conditions. They observed that fruit yield of citrus crop was reduced by approximately 13 %, 1.0 dS /m higher in electrical conductivity of the saturated soil extract when soil salinity is overshot a threshold electrical conductivity of 1.4 dS $m^{-1}$. The accumulation of high $Cl^-$ and $Na^+$ can effect particular ion toxicities, but this issue can be overcome by the selection of different rootstocks. Ashutosh *et al*. (2005) [24] investigated the harmful consequences of salt stress and reported depletion in fruit quality and yield. They observed that the feasible process (nutritional, biochemical, physical), which plants modify to assist salt stress, might give a sign to biotechnologists, and plant breeders to begin further in crop development.

Sharma *et al*. (2013) [19] in-vitro work has been carried out in order to examines the impact of salt stress on raw lemon seed production. The seed were treated with sodium salt in different concentrations. Results indicated that the tolerance index was found highest in NaCl treatments and the slightest in control. Syvertsen and Levy (2005) [22] conducted a research trail in citrus to study indirect and direct connections among salinity and other physical abiotic stresses like irradiance, drought, poor soil drainage, leaf atmospheric evaporative demand and leaf temperature. In accumulation, salinity relates to biotic pests and diseases containing Nematodes, root rot (*Phytophthora* spp), and mycorrhizae. Refining tree water association through ideal irrigation management lessening evaporative claim, and sustaining nutrient balances can improve salt injury and decline noxious ion accretion. They reported that salinity can also dispose of citrus rootstocks to ambush by nematodes, and root rot. Not all properties of salinity are negative, though, as modest salinity stress can lessen growth and physiological activity, permitting citrus seedlings survive under cold exposure and may also boost vegetation after the release of salt stress.

Abad *et al*. (2002) [1] carried out a research to check the impact of salts and observed that salinization decreases the plant dry weight higher in Sour orange as compare to in Cleopatra mandarin plants of citrus. They also reported that there is no correlation among $Na^+$ and $Cl^-$concentration in shoot fresh weight and leaves lessening. Salinity influence the overcome $Ca_2^+$, $K^+$ and total nitrogen in Cleopatra mandarin leaves and higher $K^+$ in Sour orange leaves of citrus cultivars. Gregorio *et al*. (2003) [11] determined the effects of salinity on uptake, growth, accumulation of $Na^+$ and $Cl^-$ ions and transport in the stem, leaves and root of two rootstocks, i.e., Sour orange and C. macrophylla. The results showed that in response to escalate salinity, shoot and root attentiveness of $Na^+$ and $Cl^-$ improve in sour orange, but not in *C. macrophylla* and also suggest that *C.* macrophylla and sour orange have the dissimilar structure for transport and uptake of $Cl^-$ and $Na^+$.

### 3. Approaches to Combat Salinity Stress in Citrus Species

The citrus crop is very sensitive to salts. Aboutalebi and Hasanzadeh (2014) [2] reported that inters tock between rootstock and scion can not only enhance production, durability, productivity and fruit quality but can also improves salinity tolerance. Murkute *et al*. (2006) [16] conducted a research trail to evaluate the response of citrus cultivars under the salinity. Mycorrhizal fungi, a symbiotic relationship among beneficial fungi and plant roots are supposed to impart the salts stress bear in the host plants. They observed that the salts stress improved due to Arbuscular Mycorrhizal fungi (AM fungi) colonization can be attributed to enhanced mineral nutrition. They also reported that the proline accumulation increases while the chlorophyll, calcium, and magnesium contents decrease significantly with increasing salinity. In general, the reduced Arbuscular Mycorrhizal colonization did not show any significant effects under salt stress. Anjum *et al.* (2001) [4] conducted a trail to check the effect of salinity. They select some citrus rootstocks, i.e., Yuma citrange, Cleopatra mandarin, Jatti khatti, Kharna khatta, Gada dehi, were assessed with different salinity levels. They were flourished by combining NaCl, $MgSO_4$, $Na_2SO_4$ and $CaCl_2$ salts in the soil. The results manifested that a higher number of leaves, minimum toxicity symptoms and more plant height were observed in these rootstocks at the highest ECe level and also showed that Kharna khatta proved to be minimum tolerant rootstock and Gada dehi determine the most tolerant rootstock.

Ruiz *et al.* (1997) [18] conducted an experiment to evaluate the salinity effect on relative growth rate (RGR), net assimilation rate on a leaf weight basis (NAR), leaf weight ratio (LWR), and nutrient uptake and utilization of citrus. They used four citrus rootstocks (Sour orange, Cleopatra mandarin, Carrizo citrange, and *Citrus macrophylla* with nutrient mixture and sodium chloride (NaCl) for the 20, 40 and 60 days. They observed that the relative growth rate declined with the time after applying all the concentrations of salts on rootstocks. After 60 days, salinity shows a significant effect on the leaf concentrations of Cl, Na, K, Ca, Mg, P, Fe, Mn and Zn and on the SAR and SURL of many elements. They also reported that the imbalance use of essential nutrients may also cause the disorder in plant growth at varying salinity levels. Iglesias *et al.* (2004) [14] conducted the research trail and they observed that salt effect decreases the total biomass of plant 27–38%; however, potassium nitrate supplementation relatively counteracted the influence by an increased dry matter of plant, and fresh leaf area. They also reported that the nitrogen and photosynthetic activity, and chlorophyll contents are also improved in leaves of the nitrate supplemented salinized plants. In salinized crop nitrate supplementation, decrease the leaf abscission, stimulated photosynthetic movement and enhance the growth rate of fresh leaves. The nitrate action did not respond to chloride concentration in the leaves, but it compact chloride absorptions in Carrizo and Macrophyll roots.

### 4. Conclusion

It is concluded from the review that citrus production is negatively affected due to salinity but proper measures and uses of salt tolerant root stock can reduce some losses. Moreover, more salt tolerant rootstocks need to be identified and selected for cultivation in saline areas. Additionally, water and nutrient management may be used to alleviate some aspects of salt stress.

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