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Abiotic stress and citriculture

Abstract

Salinity stress affects the growth and productivity of various fruit crops, furthermore, salinity is considered one of the main determining factors for cultivation. Under fluctuation in climate conditions, citrus growers must use various techniques to deal with increasing salinity levels to alleviate injuries, such as grafting with resistance rootstocks, canopy management, the Shading net technique, and using plant growth substances to sustain citriculture.

Keywords: citrus, climate conditions, grafting, rootstocks, salinity

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Abbreviations: UV, ultraviolet; PGR, plant growth regulators; HLP, citrus greening; PHs, protein hydrolysates; AMF, arbuscular mycorrhizal fungi

Background

Citrus trees (*Citrus spp.*) are subjected to numerous biotic and abiotic stresses which act simultaneously and affect tree growth and productivity. Environmental stress is the main determining element for the economic cultivation of citrus orchards. In addition, to global warming, there are different challenges facing citrus production worldwide. Unfavorable climate conditions, like rising temperature, saline soil, drought, flooding, increasing ultraviolet (UV) radiation, or high solar radiation among others.

Increasing soil salinity because of water scarcity is expected to affect various glycophytes growing areas in the next decade. Citrus varieties are considered very sensitive to saline conditions compared with other fruit plants.[1] Therefore, soil salinity is one of the major abiotic stresses restricting citrus growth and productivity, which are accountable for limiting tree growth and yield loss. Consequently, citrus growing had to deal with various abiotic stresses and nutrient deficiency, which lead to various morphological, physiological, biochemical, and molecular responses of various plants, to minimize adverse effects on citrus tree productivity.[2,3]

Different physiological, hormonal, and molecular responses of the citrus tree are subjected to abiotic stress. In addition, trees use biochemical mechanisms like osmotic adjustment, by reducing the water potential and preserving the turgor of the cell by increasing organic solute concentrations in the plant cells.[2,3] There are different methods used to improve salinity tolerance, such as grafting with resistance rootstocks, different practices to improve tree growth and productivity under salinity stress are required. In addition, elevated CO_2,[4,5] shade screen under field conditions, and using various substances such as plant biostimulants, Plant growth regulators (PGR) is considered an essential practice to enhance a tree's tolerance for various abiotic stresses, increase yield crop, and improve fruit quality.[6] This review focuses on the impact of salinity on citriculture and the main practice required maintaining citrus growth and productivity.

Citrus and climate change

Commercial citrus cultivars belong to genera of citrus, while, most rootstocks from Citrus, Poncirus, and Hybrids of the two genera.[7] Currently, the citrus industry is subjected to different threats worldwide, particularly, because of climate change, for instance, high temperature, increase soil salinity, and low rainfall, in addition to more spreading of pests and diseases like citrus greening (HLP), dry root rot, citrus canker, citrus tristeza virus,…. Etc.[8] Therefore, researchers provide more efforts to adapt citrus orchards to these threats to maintain productivity and improve fruit quality.

Citriculture and salinity

Citrus is one of the salt-sensitive trees, currently, due to scarce water in different citrus production regions particularly in arid and semi-arid regions, citrus growers had to use low-quality water to irrigation citrus orchards. Furthermore, irrigated soils in arid and semi-arid regions are containing more salt ions that affect citrus growth. Whereas citrus trees could sustain growth under moderate salinity for short period.[9]

Salinity causes adverse impacts and decreases plant growth and productivity because of the harmful effects of increased salts on the ionic balance in the cell, water balance, nutrients, carbon dioxide absorption rate, and various metabolic processes.[10] Furthermore, closing stomatal is considered the chief response of plants that are subjected to salinity stress, which leads to a reduced average of transpiration, consequently, minimizing photosynthesis due to low CO_2 available.[11,12]

Salinity causes various negative impacts on citrus trees like decay tree (Figure 1), abortion fruit set, reduction in fruit yield, and poor fruit quality, in addition, to limiting the expansion of this tree in new regions. Furthermore, salinity causes direct effects on the root system, which predisposes trees to different pathogens such as attacks by fungi, bacteria, and nematodes, which inhibit the whole tree growth.

The main adverse effects of salinity on citrus

1. Leaf injury (Figure 2).
2. Reducing net CO_2 assimilation.
3. Affect stomatal conductance.
4. Decreasing leaves water potential.
5. Accumulate higher concentrations of toxic ions in leaves, particularly sodium and chloride.
6. Reduction in NO_3 absorbed.
7. Imbalance concentrations of various nutrients.
8. Inhibiting growth.
9. Yield losing.

Figure 1 Field image of Lemon trees affected by salinity (Photo by Dr. Abobatta 2021).

Figure 2 Field image of impact of salinity on citrus leaves (Photo by Dr. Abobatta 2021).

The previous studies showed that citrus trees could continue growing and produce economic yield with fitting management practice at moderate salinity levels for short time.[13] The response of the citrus trees to salinity stress differs depending on various factors that include rootstocks, the intensity of salinity, phenological stage, time of exposure, soil type, Calcium/ Sodium ratio in soil, irrigation water quality, and other environmental conditions.[13]

Improve citrus tolerance to salinity

Several reports have shown that there are various techniques could improve salinity tolerance in citrus that including:

1. **Grafting with resistance rootstocks:** Like Cleopatra mandarin, Volkameriana, and Sacaton citrumelo.[14] In addition to the use of interstocks, which could be preventing plants from the toxicity of salinity and considered one of the effective methods to enhancing salinity tolerance and stimulate growth and productivity.[12,15]
2. **Canopy management:** Under abiotic stress, there are numerous benefits of the controlled canopy and using of dwarfing rootstocks to reduce harmful effects on the growth and productivity of trees.[16,17]
3. **Exogenous application of biostimulants substances:** Plant biostimulants used in the agricultural sector to improve crop performance, play important roles in increasing tolerance and improving plant growth under environmental stress.[18] Biostimulants act by enhancing salinity adaptation, improving nutrient absorption, stimulating growth recovery, and enhancing total yield.

There are many diverse bioactive substances are cataloged as plant biostimulants based on their agricultural function claims, including:

I. Humic and Fulvic acids,

II. Animal and vegetal protein hydrolysates (PHs),

III. Macroalgae seaweed extracts.

IV. Silicon

V. Arbuscular mycorrhizal fungi (AMF)

VI. Nitrogen-fixing bacteria of strains belonging to the genera Rhizobium, Azotobacter, and Azospirillum.

Plant growth regulators (PGRs)

The plant growth regulators (PGRs) are one of the important substances that improve plant growth under various stress, (PGRs) improve salinity tolerance, reduce salinity hazards, stimulate plant growth, induced yield, and improve fruit quality.[19] Moreover, under field conditions, PGRs are used as practical treatments or growth substances to improve tree performance and yield under saline conditions.[20]

Benefits of PGRs

PGRs have essential impacts on plant tolerance for abiotic stress and alleviating hazards of salinity, drought, and rising temperature.

PGRs causes a wide range of alteration in plant metabolism, such as increasing the physiological availability of water and essential nutrients and reducing toxic salt load.

The main benefits of PGRs are as follows:

a. Enhancing activation of the antioxidant enzyme.

b. Induce salt tolerance by reserving nontoxic levels of the reactive oxygen species (ROS).[21]

c. Regulate metabolism activities in plants.

Conclusion

Salinity conditions affect citrus trees negatively and cause a reduction in vegetative growth and productivity. Different practices could be used to alleviate the adverse impacts of salinity such as using resistance rootstocks, controlled tree size, using 50% net shading under field conditions, and Exogenous application of anti-stress substances and plant stimulators.

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Conflicts of interest

The authors declare there is no conflict of interest.

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