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A review article: Citrus as salt tolerance under plant tissue cultures

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Abstract: *Citrus, one of the significant natural product yields of the tropics and subtropics is gathered as a glycophyte. The malicious impacts of salt pressure lead to decrease in organic product yield and quality. The reaction of various citrus species to various salt(s) further brings differential reactions, at the point when organic product quality is concerned. The potential components (physical, dietary, biochemical), which plants adjust to continue salt pressure, might give a sign to plant reproducers and biotechnologists to continue further in crop improvement. The current examination is an endeavor to audit the writing and investigate the potential instruments of salt resilience on manageability of saltiness by citrus. The job of endomycorrhizal parasites in citrus under salt pressure is likewise examined.*

Keywords: *Abiotic stress, Citrus, Plant Tissue culture, Salinity.*

I. INTRODUCTION

In India, of the land territory of around 329 m ha, the developed region is just 156 m ha. The per capita accessibility of land has declined from 0.89 ha in 1951 to 0.37 ha in 1991, and is anticipated to slide down to 0.19 ha in 2035 (Singh S et al., 2000). The sizable rich territories are leaving development because of saltiness and sodicity (pH). In India, 10.1 m ha territory is accounted for to be salt affected (Yadav J. S. P., 2000), where development of salt lenient plant species could be the most appropriate other option. Citrus, one the most significant organic product harvests of India. Aside from defenseless to a few biotic burdens (creepy crawly bugs, pathogens like *Phytophthora* root decay, citrus tristeza infection and nematodes), citrus is exceptionally delicate to soil saltiness and pH. Around 13 percent reduction of citrus yield per every 1 dS m-1 increment in saltiness above 1.4 dS m-1, the edge estimation of electrical conductivity of immersed soil extricate, has been reported (Shalhevet J et al., 1990). Chloride harmfulness seems, by all accounts, to be the fundamental explanation behind decrease in its natural product yield in spite of the fact that the chance of osmotic part can't be prohibited. Likewise, the conceivable supplement irregularity because of saltiness can prompt physiological and biochemical unsettling influences which inevitably may prompt debilitate yield or potentially natural product quality (Nieves M. et al., 1992). Industrially, citrus is proliferated by shield maturing on the rootstocks of wanted characters. Rootstocks impact tree life, water relations, cold strength, mineral nourishment, hormonal equalization and natural product yield and quality. In this manner, the investigation on contrasts in capability of rootstocks to ship water and supplements becomes significant particularly in sprouted trees (Shrivastava A. K. et al., 1999). The plant development in saline condition is influenced because of: (I) Water deficiency; (ii) Effects on plant digestion; and (iii) Ion harmfulness and nourishing lopsidedness. The tree development and natural product yield are hindered at a dirt saltiness of around 2 dS m-1 with no associative articulation of leaf symptoms (Bingham F. T. et al., 1974; Cerda A. et al., 1999). However, citrus is profoundly salt delicate yield, contrasts in resistance do exist among species (Mass E. V. et al., 1993). The current endeavor attempts to accumulate the data on work done as such far on different citrus genotypes and their exhibition under saltiness conditions to comprehend the potential components for salt pressure resistance.

II. Seed Germination under Salinity

Seed germination is incredibly influenced by saltiness (Shannon M. C., 1979). Soil saltiness may demonstrate negative to seed germination because of decreased water take-up and over the top ingestion of particles till their harmfulness endures. It influences the development either by diminishing the osmotic capability of the dirt answer for a point, which will hinder or forestall the admission of water or become harmful to undeveloped organism and seedling (Zekri M., 1993). Salt resilience is anything but a consistent character in citrus rootstocks yet changes with the phases of seedling development (Zekri M., 2003). The existed decrease or complete restraint of germination potential under salt pressure could be ascribed to the saltiness that continuously lessens the endogenous phytohormones (gibberellins, auxins, cytokinins), the principle factors for controlling germination. Additionally, saltiness builds the degree of normal inhibitors (El-Desouky S. A. et al., 1998).
Taking all things together, the impact of salt weight on the development boundaries might be viewed as decreased plant stature, stem diam, leaf region, root length, new and dry weight and senescence, if saltiness increments past resilience limit.

Be that as it may, the resilience may change as indicated by species (Patil V. K. et al., 1978; Mobayen R. G. at al., 1980) salt mix and focus and seedling age (Patil V. K., et al 1978; Joolka N. K. et al., 1980; Walker R. R., et al., 1983). Decrease in development boundaries at expanding saltiness levels can, in certain occurrences, be credited to saltiness prompted unfavorable change in leaf water connection diminishing photosynthesis, lack of hydration of proteins and cellular material to a lower extent (Nieves M. et al., 1991). The diminished development may likewise be a direct result of osmotic impact of salt on root and poisonous impact of aggregated particles in the plant tissues (Lea-Cox J. D. et al., 1993; Storey R., 1995). The decrease in relative development was accounted for to be increasingly subject to scion, while the defoliation was more rootstock dependent (Banuls J. et al., 1990). The expansion of calcium ($CaSO_4$) to saline arrangement essentially diminished the antagonistic impact of NaCl on shoot growth (Zekri M. et al., 1990) and the treatment of Paclobutrazol repaid the pernicious impacts of saltiness on root development (root size, number of parallel roots, dry load of roots) (El-Desouky S. A. et al., 1998)

III. Nutritional Aspects

In general, the mineral accumulations either increase or decrease because of salt stress (Zekri M. et al., 1990; Nieves M. et al. 1990). In any case, the impact was discovered reliant on scion-rootstock combination ((Banuls J. et al., 1990). The NaCl expansion in development media expanded N, P and K furthermore, diminished Ca and Mg in the greater part of the rootstocks, while the expansion of $CaSO_4$ in saline medium didn't influence the N, P, K and Mg yet evident increment in Ca in certain rootstocks uncovered that the salt quality and amount additionally influence the dietary imbalance (Zekri M., 1993). The mineral focuses in the plant organs (leaf, stem, root) broke down in two citrus genotypes (Sharp orange, Macrophylla) demonstrated that the mineral collection shifts in the various organs of the plant (Ruiz D. et al., 1999) separated from species and salt focus. There was no straight pattern found in aggregation of micronutrients; be that as it may, higher saltiness (≥60 mM) diminished just Cu and Mn gathering at the entire plant level (Tozlu I. et al., 2000).

IV. Na^+ and Cl^- Accumulation and K^+ Substitution

Some citrus species while developing on saline conditions retain enormous amounts of chloride and sodium in their leaves. The convergence of Cl^-, Na^+ and K^+ in leaves on salt rewarded plants of all rootstocks changed by age or position of leaves on the plant (Grieve A. M. et al., 1983). The higher leaf Cl^- in salt rewarded plants than control of trifoliate orange gave off an impression of being adjusted to a great extent by the going with higher groupings of gathered K, in any case, in sweet orange, K focus didn't increment altogether in salt rewarded plants. Walker and Douglas (Walker R. R. et al., 1983) uncovered the decrease in K^+ with increment in saltiness and along these lines; there was proof of constrained Na/K trade and conceivable sequencing of Na^+. Additionally, expanding Ca (2-8 mM) in development medium didn't adjust either shoot development or levels of Cl^-, Na^+ and K^+ in all rootstocks tried. The salt incited loss of K^+ and increment in Na^+ with expanding saltiness couldn't be forestalled by expansion of Ca. pH (5-8) couldn't influence the shoot development and particle uptake in Rangpur lime (Walker R. R. et al., 1983).

Leaf chloride examination showed that Rangpur lime and Cleopatra mandarin rootstocks confined the take-up or potentially transport of Cl^- to shoots (Walker R. R. et al., 1983). In any case, similarly high groupings of Na were gathered in develop leaves of all rootstocks during salt treatment and the leaf K^+ didn't modify by saltiness and stayed same as that of control. Rootstocks (Cleopatra mandarin and Rangpur lime), which kept up capacity for chloride prohibition during treatment with 150 mM NaCl, couldn't limit Na^+, demonstrated that obviously discrete instrument existed which control the take-up and additionally transport of Cl^- and Na^+ in citrus. Subsequently, this evident failure of rootstocks developed on saltiness to agreeably reject sodium speaks to the most probable constraint to the degree to which salt resilience can be improved. The maximum furthest reaches of Cl^-focus in underlying foundations of citrus united plants appears to vary from every scion-rootstock mix, since Cl^- amassing in leaves and Cl^- transport to scion could influence Cl^- fixation in roots (Banuls J. et al., 1990). Be that as it may, appropriation of Na+ between plant organs was discovered scion–rootstock subordinate with constrained vehicle from root to shoot.

Leaf chloride focuses diminished with seedling age and were adversely co-related with seedling dry load inside same cultivars yet expanded basipetally in all cultivars (Sykes S. R., 1985). Walker (1986) uncovered that the Na prohibition and K-Na selectivity in salt rewarded rootstocks seemed to have a more prominent capacity to pull back sodium from the xylem in the proximal root and basal stem and sequester it in both the wood and the bark of these locales recommending that the lower substance of salt rewarded plants came about because of overall deficit of K from plant as opposed to decreased uptake. Arrival of K into the xylem in return for Na is inferred by the noteworthy increment in K focus. In any case, reports likewise show that the scion-rootstock blend didn't influence Na and K fixations in leaves (Nieves M. et al., 1990).

The addition of $CaSO_4$ (5 mol m^{-3}) to the saline solution (50 mol m^{-3}) reduced Na and/or Cl concentration in shoots of Sour orange, Troyer citrange, Swingle citrumelo, Ridge pineapple sweet orange and Rough lemon but did not affect Na and Cl contents in roots of any of the rootstocks (Zekri M., 1993). Also, none of the several rootstocks tested could exclude Na or Cl from its shoots. However, Na and Cl exclusion capacities of some citrus rootstocks were lost at the saline solution having osmotic potential of -0.20 MPa (~50mol m^{-3}) or higher (Ruiz D. et al., 1999)

The relative rates of mineral accumulation by shoot and the relative rates of mineral transport from the root to shoot of Cl and/or Na, increased in seedlings of Sour orange and Macrophylla grown in Cl and/or Na treatment (Ruiz D. et al., 1999). Na stressed seedlings decreased accumulation of Ca in Sour orange and Ca and K in Macrophylla compared to control. Also, leaf injury symptoms associated with Na in both genotypes may be due to reduced uptake and transport of Ca. The K deficiency, caused due to Na stress, could be the reason of reduced CO_2 assimilation rates (Ruiz D. et al., 1999). The 'Fine Root Turnover' phenomenon in which continuous root formation in plants apparently used by the plants to remove the excess ions and delay onset of accumulation in this tissue has been well established in *Poncirus trifoliate* (Tozlu I. et al., 2000). The high Cl accumulation was more toxic than Na in leaves whereas the latter is more toxic to fine roots and limited K substitution. It is proposed that the accumulation of Na or/and Cl in plant organs is also a species dependent phenomenon (Garcia S. F. et al., 2003)

V. Physiological Aspects: Water Relation / Stomatal Conductance and Gas Exchange

Physiological aggravations because of salt treatment at times may be ascribed to saltiness actuated changes in water relations. In particular, turgor subordinate procedures (photosynthesis) are probably going to be influenced if the osmotic change is deficient. Stomata of develop citrus leaves can stay open at low leaf water possibilities by keeping up higher turgor in monitor cells than mesophyll cells (Syvertsen J. P. et al., 1982). In any case, the citrus genotypes seemed to have diverse capacity for turgor upkeep during salt stress (Walker R. R. et al., 1982; 1983;).

Osmotic potentials decreased as leaves matured and responses to salinity were found rootstock dependent (Syvertsen J. P. et al., 1988). The net gas trade qualities of develop leaves were unaffected by saltiness yet full grown leaves had lower stomatal conductance and interior CO_2 focus, bringing about higher water use proficiency than youthful leaves, paying little heed to saltiness. Despite what might be expected, Nieves et al (1991) announced that the salt rewarded plants had fundamentally lower stomatal conductance than control and there was no distinction identified with rootstock or scion. The leaf stomatal thickness was influenced by the rootstocks under salt stress (Hepaksoy S. et al., 2002).

Leaf water potential, stomatal conductance and photosynthesis were decreased more in united plants and selection of rootstocks (Cleopatra mandarin, Troyer citrange) had little impact on salt prompted parameters (Banuls J. et al., 1995). In this manner, the decrease in gas trade boundaries and development at expanding saltiness levels relied more upon the scion type than on Na^+ and $Cl^–$ focuses in leaves. Something else, leaf injury and defoliation were firmly related to leaf $Cl^–$ concentration (Garcia S. F. et al., 2002)

VI. Biochemical Aspects

Biochemical pointers (proline, plant colors, sugars) demonstrated changed reaction to saltiness. Nolte et al (1997) examined 55 developed and wild types of Aurantioideae for proline and betaine investigation and found that a few animal types aggregated proline alone and some collected proline and proline-betaine (20-100 µmol g^{-1} dry mass) under salt pressure. Proline level expanded during winter (Syvertsen J. P. et al., 1983; Yelenosky G., 1979) and was seen as species dependent (Nieves et al., 1991). The plant shade substance decline in light of salt worry in a few citrus rootstocks (Patil V. K. et al., 1978; Syvertsen J. P. et al., 1998). Zekri (1991) revealed the loss of chlorophyll because of $Cl^–$ aggregation. The diminished photosynthetic capacity under saltiness is expected to stomata conclusion and concealment of explicit proteins that are answerable for the union of photosynthetic colors. The decrease of chlorophyll substance is predominantly because of devastation of chlorophyll biosynthesis and decrease in magnesium, iron and manganese (El-Desouky S. A. et al., 1998). The helpful impact of Paclobutrazol (PP_{333}) under saltiness on the aggregation of chlorophyll, carotenoids and phytohormones has additionally been documented (El-Desouky S. A. et al., 1998).

Impressive varieties in gathering of solvent sugars because of salt pressure are additionally obvious at entomb explicit, intra-explicit and even among all lines, which are salt tolerant (Thanaa E. et al., 1994).). Lower osmotic potential of plant cells would build the ability of plants to retain saline substrates. Consequently, expanded centralization of decreasing and all out sugars in light of salinity could be ascribed as osmotic acclimation to let down the osmotic capability of plant cells (Thanaa E. et al., 1994).

VII. Salinity and Mycorrhizal Fungi

Mycorrhizal symbioses have been found to improve the capacity of stress resistance in certain plant species. Duke et al (1986) announced the gathering of phosphorus, dry issue and betaine during NaCl weight on Carrizo citrange colonized with mycorrhizal growths (*Glomus intraradices*). High root-contamination (77-83%) was seen with control and qualities dropped (53%) at 100 mM NaCl. Shoot and root dry load of AM plants was fundamentally high over non-rewarded plants at all salt medicines. Proline-betaine was found directly identified with high NaCl focuses paying little mind to plant mycorrhizal status. Toll et al (1983) announced decreased VAM contamination in profound layers because of expanding the saltiness of the water system water (EC=1.1-2.7 dS m^{-1}). Harmond et al (1987) announced that the mycorrhizal colonization stayed unaffected under saltiness stress and diminished the pressure driven conductivity of roots, leaf water potential, stomatal conductance and net digestion of CO_2 of AM and non-AM seedlings to a comparable degree in pineapple sweet orange, Carrizo citrange and Sour orange. AM plants of Carrizo citrange and Sour orange amassed more chloride in leaves than non-AM plants. The watched decrease in N and P substance because of saltiness was at standard in AM and non-AM plants.

Graham and Syvertsen (1989) affirmed that saltiness (30, 60 mM NaCl) didn't influence the mycorrhizal colonization however decreased the development of non-Mycorrhizal plants, however not essentially, than AM vaccinated plants of Sour orange and Sweet orange. Mycorrhiza didn't influence the development of either species significantly under non-stress condition. Despite the fact that the centralization of N, Ca and Mg diminished, Na and Cl expanded because of salt pressure and stayed at standard with VAM plants aside from Cl. The absolute chloride was more noteworthy in VAM plants at control and 30 mM NaCl focus. The leaf Cu focus was essentially higher in AM plants. Mycorrhiza expanded Cl and Zn and diminished Mn in underlying foundations of both the species independent of saltiness. The root Cu of either species was expanded by mycorrhiza under non-stress condition however salinization decreased it in mycorrhizal roots. Mycorrhizal organisms seemed, by all accounts, to be working in P take-up under saltiness worry, as moderate degrees of NaCl didn't lessen P focus in AM plants. Likewise, the diminished water powered conductivity of roots and transpiration of shoots was regardless of mycorrhization and comparable in either species.

Salinity treatments would in general decrease the action of peroxidase, while it didn't influence the polyphenol oxidase. Despite what might be expected, mycorrhizal disease didn't essentially modify the peroxidase movement however apparently expanded the leaf polyphenol oxidase in Sour orange (Thanaa E. et al., 1994). A stamped decline in starch and all out sugars and critical increment in diminishing, non-decreasing and complete dissolvable sugars, with expanding saltiness ($NaCl^{+}CaCl_2$, 1:1) was additionally watched. The all out chlorophyll and chlorophyll-a reacted adversely to saltiness yet chlorophyll-b was not significantly influenced. Nonetheless, altogether expanded complete chlorophyll and chlorophyll-b because of mycorrhizal vaccination leveled out couldn't be held under salinity (Thanaa E. et al., 1994).

Salinity eventually influences the natural product quality and yield. The yield decrease because of saltiness stress could be comprehended as decrease in the quantity of natural products per tree and the ion toxicity was substantiated for the deterioration of nature of fruits (Francois L. E. et al., 1980). Bielorai et al (1983) uncovered that high sodium ingestion proportion (SAR) and high Cl diminished the yield (9%) of Marsh Seedless grapefruit and high ESP (interchangeable sodium percent) didn't explicitly influence yield. The salinity affected changes in strip characters could be related with the loss of water in the albedo through diminished osmotic potential (Sinclair W. B. et al., 1984). Regardless of unaffected juice content, all out solvent solids, thickness and titrable acidity expanded in a few citrus animal varieties as a reaction to expanding salinity (Nieves M. et al., 1991); in any case, the determination of rootstocks impacted the quality natural products in an unexpected way.

VIII. Salinity and Tissue Culture

The utilization of plant tissue culture to incorporate disease resistance into crop plants and to select mutants that are tolerant to toxins, herbicides, salinity and environmental stresses has been proved (Spiegel-Roy P. et al., 1976). The advancement in choice of NaCl resistance in C. sinensis of ovular callus edified the utilization of cell line determination for saltiness resistance in citrus, an exceptionally salt touchy organic product crop (Kochba J. et al., 1980). Gamma lighted (8-16 kR) callus performed well when contrasted with non-illuminated when exposed to saltiness (0.2 M NaCl), however the thing that matters was non-critical and discovered stable after evacuation of determination pressure. A few callus lines of Shamouti sweet orange and one cell line of Sour orange have been accounted for to develop within the sight of NaCl by dull presentation to the medium containing salt (Kochba J. et al., 1982). The NaCl open minded cells likewise found to perform well on the choice weight of Na_2SO_4 and K_2SO_4, however performed inadequately with KCl.

Ben-Hayyim and Kochba (1982) uncovered development qualities and steadiness of resilience of citrus callus cells exposed to NaCl stress. The non-tolerant selected callus cell lines didn't show any put on in weight and development when presented to 0.2 M NaCl, in contrast to lenient line. Cells, which performed well in NaCl stress, had ability to withstand within the sight of different Na^{+} salts with different cations (Na_2SO_4, $NaNO_3$, NaBr). Despite what might be expected, supplanting Na^{+} with different cations offered ascend to different degrees of development hindrance, demonstrating that the idea of cation in the protection from salt pressure is fairly significant factor.

To introduce salt tolerance, selection for salt tolerant genetic variants in tissue culture (unconstrained or initiated change), which have regenerative limit, may give helpful beginning material to ordinary reproducing. Ben-Hayyim and Kochba (1983) examined the parts of salt resilience in NaCl open minded chosen stable cell lines of *C. sinensis.* NaCl lenient callus line when expelled from choice weight for at any rate four sections held a similar limit of resilience to 0.2 M NaCl. The recorded Na^{+} and Cl^{-} uptake were additionally discovered low than the salt touchy cell line. KCl again demonstrated as development smothering when subbed to NaCl. The utilization of Na_2SO_4 and K_2SO_4 uncovered that the poisonous impacts were that of collected chloride as it were. The presence of Ca^{2+} in growth medium was also essential for proper growth. The electron micrographs demonstrated that the salt lenient cells had large vacuoles when contrasted with salt touchy cells. It was presumed that the resistance of cells to NaCl stress was because of fractional evasion of harmful components by variations.

The presence of NaCl during embryogenesis influences the development growth regulators balance. It additionally improves the prerequisite of gibberellic corrosive for the typical heart molded incipient organism development. However, the interactions of NaCl with cytokinins or gibberellins are not yet clear (Ben-Hayyim G. et al., 1989). The perfect system for the improvement of salt lenient saplings in vitro was to keep the chose worry all through the recovery process (Ben-Hayyim G. et al., 1989). The NaCl open minded cell line required same salt to create green undeveloped organisms that was not acquired without NaCl. The greening of white incipient organisms should be possible by the expansion of cytokinins (BAP 0.2 mg^{-l}) or abscisic corrosive (0.1 mg^{-l}) in the strong glycerol medium. The expansion of NaCl into development medium brought about callus multiplication and demise of undeveloped organisms. With a few exchanges of typical incipient organisms to kinetin medium (0.1–1 mg L^{-l}) gave the plantlets. Without kinetin, a few incipient organisms created roots immediately and shoot advancement was captured totally. The saplings created within the sight of NaCl (0.2 M) yielded some typical looking leaves, however no internodes. NAA could instigate just establishing yet further shoot improvement didn't happen. Beloualy and Bouharmont (1992) could separate the plantlets from salt open minded cell lines of *Poncirus trifoliata*.

A few cytological changes related with the salt resistance happen in the embryogenic callus. Electron microscopy perceptions of salt lenient (0.17 M NaCl) embryogenic calli of *Citrus limon* uncovered the salt open minded calli had thick cell dividers, ring formed mitochondria, expanded substance of lipid bodies and equal collection of harsh endoplasmic reticulum (Piqueras A. et al. 1994). The thick cell dividers might be as a component to save water capability of the cell dividers against high saline outer medium. The huge increment in the proline and sugar substance in C. aurantium callus saltiness (137 mM NaCl) would be a marker of the affectability to saline stress (Atmane-Rochdi et al., 2003).

The plant survival against cytotoxic effects depends upon the presence of reduced mineral molecules and antioxidant enzymes. Reception of cells is related with diminished cell development despite the fact that the turgor weight of cells is kept up. Piqueras et al (1996) uncovered that the development of salt open minded cells was decreased to five creases when contrasted with control. In the salt open minded cells, Na^+ and Cl^- focus were higher than control cells. However, Ca^{2+}, Mg^{2+}, K^+ substance were decreased in salt tolerance cells. The convergence of all out sugars, proline and betaine expanded two creases in the salt open minded cell mass over the control. While assessing the saline pressure and cell harmfulness utilizing cell suspension culture Carvalhal, Lima-Costa et al (2002) revealed no extraordinary contrasts in protein substance during cell development. This can be attributed as a strong indication that the protein metabolism has not been changed by different salt shock.

Table: 1 Effect of salinity on seed germination in vivo, nutritional parameters, physiological parameters, biochemical parameters, fruit yield and quality

Citrus species	Salt(s)/ Magnitude of salinity	Effect of salinity
Trifoliate orange, Cleopatra and Bakraie mandarin	NaCl, Na2SO4, PEG (0, 250, 500, 750 J/kg water potential)	Germination rate reduced; however, final germination not affected.
Citrus aurantium, *C. volkameriana*, *C. sinensis*, *C. reshni*, *C. jambhiri*, *C. sinensis x Poncirus trifoliata* and *C. paradis x P. trifoliata.*	NaCl (50, 100 mM) + $CaSO_4$ (5m*M*)	Salinity affected the emergence of first seedling, emergence spread and time to 50% emergence and final emergence.
Sour orange, Volkamer lemon, Rangpur lime and Cleopatra mandarin	NaCl (1000-9000 ppm)	Reduced seed germination as follows: Sour orange, 13; Volkamer lemon, 8.7; Rangpur lime, 3; and Cleopatra mandarin, 19%. The number of days for seed germination increased. Maximum tolerable salinity was: Volkamer lemon & Rangpur lime, 9000; Sour orange & Cleopatra mandarin, 600 ppm.
Troyer citrange, Volkamer lemon, Sour orange, Cleopatra mandarin and Flying Dragon	NaCl (50, 100 mM) in vitro seed germination	No germination at 100 mM. At 50 mM, germination was: Flying Dragon, 97.7; Troyer citrange, 98%.
C. grandis cv. Pingshanyou and *C. reticulata* cv. Fuju	NaCl (20-40 mM/l)	No effect on seed germination, sprout length and radical length. Germination time increased.
Navel orange and Clementine on	NaCl (0-60 mM)	Sharp decrease in N accumulation and

Troyer citrange and Cleopatra mandarin		dependent on scion rootstock combination. Little difference in P and significant decrease in Ca, Mg, and K contents in leaves and roots of all combinations.
C. aurantium	NaCl (0, 40 mM) + $CaSO_4$, $CaCl_2$ and KCl (1, 5, 7.5 m*M*)	Significantly reduced the leaf Ca, Mg and K and no significant differences were found in P, Fe, Mn, Zn and Cu contents.
Verna lemon trees on Macrophylla, Cleopatra mandarin and Sour orange	NaCl (6, 12, 20, 28 mol m^{-3} Cl)	Linear increase in P. Leaves from *Macrophylla* generally had higher total N under than those from other two combinations. No change in Mg but Ca decreased.
Cleopatra mandarin and Volkamer lemon	6.13 dS m^{-1} salinity	K, Ca and Mg in low range; Zn, Cu, Mn, and Fe in sufficient range and not affected by saline treatments. N increased with salinity.
C. aurantium, *C. volkameriana*, *C. sinensis*, *C. reshni*, *C. jambhiri*, *C. sinensis x P. trifoliata* and *C. paradise x P. trifoliata.*	NaCl (50, 100 mM) +$CaSO_4$ (5mM)	N, P, K, Ca and Mg reduced in most rootstocks; addition of $CaSO_4$ did not affect N, P, K and Mg but increase in Ca in some rootstocks.
Sour orange and Macrophylla	Na without Cl, Cl without Na and NaCl (40 mM)	Ca and Mg in leaves, K and Ca in roots and K in stem decreased and Mg in the root and stem increased. Cu and Mn in leaves; Ca, Mg, Cu, Mn, Zn in the stem; and Mg and Z in the roots increased; total N, P and Fe in general reduced.
P. trifoliata	NaCl (0, 30, 60, 90, 120 mM)	K and P increased in roots and leaves. No differences for Ca and P in stem and Mg in structural roots.
Valencia on Cleopatra mandarin, Rangpur lime, Sweet orange, Rough lemon, Trifoliate orange and Carrizo citrange	NaCl (0-150 mM)	Marked reduction in leaf water potential and also reduction in leaf osmotic potential. Stomatal resistance increased and showed only partial recovery after cessation of salt treatment.
Etrog citron (C. medica)	NaCl (0-150 mM)	Showed complete stomatal recovery when stress relieved.
Valencia grafted on Trifoliate orange and Sweet orange rootstocks	NaCl (10, 14, 20 mol m^{-3} Cl)	Osmotic potentials decreased. Responses to salinity found rootstock dependent. Net gas exchange remained unaffected but mature leaves had lower stomatal conductance and internal CO_2 concentration.
Verna and Fino lemon on Sour orange and *Macrophylla*	NaCl (2, 40 and 80 mM)	Stomatal conductance lowered than control and there was no difference related to rootstock or scion. Leaf water potential was higher than in control in all scion-rootstock combinations.
Sour orange and Cleopatra mandarin	NaCl (-0.10, -0.20, -0.35 MPa)	Root hydraulic conductivity, stomatal conductance and evapotranspiration significantly reduced.
Cleopatra mandarin and Volkamer lemon	NaCl +$CaCl_2$ 3:1 (6.13 dS/m)	Whole plant transpiration rate and photosynthetic rate reduced.
Navel orange Clementine on Cleopatra mandarin and Troyer citrange	NaCl (0, 20 40, 60 mM)	Leaf water potential, stomatal conductance and photosynthesis reduced. Reduction in gas exchange parameters at increasing salinity levels depended more on scion type than on Na and Cl in leaves.
Satsuma mandarin on Trifoliate orange and Troyer citrange	NaCl (2.0, 3.5, 5.0, 6.5 dS/m)	Stomatal density, photosynthetic rate and water use efficiency reduced.

Valencia orange (C. sinensis) on P. trifoliata and C. sinensis	NaCl (10, 14, 20 mol/m^3)	Total chlorophyll reduced.
Verna and Fino lemon (*C. limon*) on Sour orange (*C. aurantium*) and Macrophylla (*C. macrophylla*)	NaCl (2, 40, 80 mol/m^3)	Chlorophyll a, b and a+b reduced. Proline increased.
Sour orange (*C. aurantium*) and Cleopatra mandarin (*C. reticulata*)	NaCl (osmotic potential of soils -0.10, -0.20, – 0.35 MPa)	Total chlorophyll reduced by 56% in Sour orange and 11% in Cleopatra mandarin by first salinity level (-0.10 MPa).
Hamlin sweet orange (*C. sinensis*)	NaCl, KCl and $NaNO_3$ (0, 15, 45, 50, 60 mM)	NaCl and KCl increased proline; $NaNO_3$ did not affect proline.
Sour orange (*C. aurantium*), Volkamer lemon (*C. volkameriana*), Rangpur lime (*C. limonia*) and Cleopatra mandarin (*C. reticulata*)	NaCl (4000, 5000 ppm), NaCl 5000 ppm + PP333 (50, 100 ppm)	Chlorophyll a, b, a+b and carotenoids reduced. Cytokinins, gibberellins, auxins decreased.
Valencia orange	Cl and SO_4	Reduced fruit yield.
Valencia orange (*C. sinensis*)	1.7 dS/m (no salt), 3.8 dS/m (5mM each of $CaCl_2$ + Na_2SO_4 + $MgSO_4$), 5.7 dS/m (10mM each of $CaCl_2$ + Na_2SO_4 + $MgSO_4$)	Reduction in fruit number, not size. Rind thickness decreased and maturity delayed. Total soluble solids (TSS):Titrable acidity(TA) unaffected.
Marsh Seedless grapefruit (*C. paradisi*)	Salt combination, EC- (2.7dS/m), SAR-10.3 $(mol/m^3)^{1/2}$	Reduction in fruit yield (9%).
Shamouti orange	Cl (100, 250 and 450 mg/l)	Fruit yield decreased (13%) with increased salinity (100-450 mg/l Cl).
Verna lemon(*C. limon*) budded on *C. aurantium*, *C. reticulata*, *C. macrophylla*	Saline irrigation water with EC- 1.2, 2.2, 3.8 and 5.2dS/m	Peel thickness increased. TSS, density and titrable acidity of juice increased, juice content remained unaffected.
Fino-49 (*C. limon*) on *C. macrophylla*	NaCl 15 mM (EC- 2.5 dS/m, SAR- 4.5) and 30 mM (EC-4dS/m, SAR- 9) Control (1dS/m, SAR-1.6)	Fruits/tree, fruit juice and yield decreased. Peel and pulp increased. TA and TSS decreased but TSS:TA unchanged.
Star Ruby grape fruit (*C. paradisi*) on *C. reticulata* and *C. sinensis* x *P. trifoliata*	NaCl (3, 15 30 dS/m)	Reduced fruit yield.

Future Perspectives

Aside from thinking about the system for nutritional imbalance and their optimization, salinity ought to be handled by utilizing a few different methods. It is recommended that particle substance of leaf tissues, yet additionally particle substance and large scale manufacturing of all tissues ought to be viewed as when the saltiness resilience of citrus and related genera is to be characterized (Tozlu I. et al., 2002). Plants rewarded with Pachlobutrazol (PP_{333}) (Thanaa E. et al., 1994) and abscisic acid (Arbona-Mengual V. et al., 2003), indicated high decrease in injurious impacts of soil saltiness, and might be caught as plant development hormones yield some productive outcomes in saltiness tolerance (Arbona-Mengual V. et al., 2003). The outcomes propose that abscisic corrosive assumes a job in altering citrus physiological conduct because of saltiness and could be useful in their acclimatization to saline conditions. The new idea of utilizing interstock to diminish poisonous particle collections in leaves of grew citrus trees (Camara-Zapata J. M. et al., 2003) can possibly manage soil saltiness, yet the instrument is yet to be seen totally and needs more consideration. The plant cell and tissue culture and transgenics structure elective methods, which is yet left under misused similarly as salinity tolerance of enduring plant species are concerned and can give a good anticipated achievement.

Conflict of interest

The authors have no conflict of interest in preparing of this article.

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