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RESEARCH ON THE EFFECT OF SALINITY ON TOMATO (*Lycopersicon esculentum* Mill.) DURING THE SEED GERMINATION STAGE AND ON THE VEGETATION PERIOD: REVIEW

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Abstract

The tomato is a major annual crop that is grown all over the world for the nourishment of consumers. Since it is predicted that by 2050, over 50% of arable land will be saline, researchers have recently concentrated on understanding how tomato plants respond to different saline environments. The tomato is regarded as "moderately tolerant" of salinity because of its capacity to maintain ionic and water balance in the root zone at moderate salinity levels and because it is more vulnerable to salt stress than its wild equivalents. Some papers include information on how different cultivars behave under different salinity concentrations, analyse various parameters, and discuss the mechanisms regarding tomato salt tolerance. When the salt concentration increased, tomato seed germination was reduced, the time required for full germination was prolonged, plant growth and productivity were limited, and sometimes it led to plant death. Therefore, this review provides a synthesised understanding of the latest scientific findings about the impact of salinity on tomato fruit morphology (germination and seedling growth), physiological (transpiration), biochemical characteristics, as well as yield and fruit quality indicators.

***Key words**: genotypes, tomato seeds, salinity stress, germination.*

INTRODUCTION

Plants are always exposed to their surroundings due to their sessile nature. For plants to carry out vital processes like photosynthesis and to develop vegetatively and reproductively, they must adjust to their ever-changing surroundings (Mundaya Narayanan et al., 2023). A global issue, salt in the soil endangers crop growth and productivity while impeding the long-term viability of contemporary agriculture. Soil salinity is mostly caused by high salinity groundwater levels rising and by inadequate irrigation and drainage systems (Rengasamy, 2006). Currently, 632 million hectares of arable land, or one-fifth of all cultivable soil on Earth, are categorized as being damaged by salt.

In the context of agricultural production, saline and alkaline soils are commonly referred to as salt or salty soils. They cover roughly 250,000 hectares in our country, with the largest areas being found in the Danube Meadow, the Plain in the west of the country, the Romanian Plain, the Moldavian Plateau, the area around the Black Sea coast, and the meadows of several inland rivers (Olt, Jiu, Siret, etc.) in the Jijia-Bahlui Depression.

In general, saline soils with solution osmotic pressures greater than 10-12 atmospheres inhibit plant growth. The detrimental impact of salts on plants is reliant with the specific composition of the salts as well as their concentration in the solution. (Läuchli & Grattan, 2007; Covașă et al., 2023). The salinity of arable land is becoming a greater problem in many irrigated, semi-arid, and arid regions of the world where rainfall is insufficient to wash away salts from the root zone. This contributes significantly to decreased crop yield (Francois & Maas, 1999; Van Zelm et al., 2020). However, since salt destruction depends on species, variety, development stage, environmental factors, and the nature of the salts, it is difficult to define saline soils precisely. According to Ponnamperuma (1984), saline soils are those that have enough salt in the root zone to impede crop plant growth. In the Dictionary of

Environment and Conservation, saline soil is defined as soil that contains enough soluble salts (sulphates and chlorides of sodium and calcium) to reduce its fertility. According to Jamil et al. (2011), a saline soil is commonly characterized as one with an exchangeable salt content of 15% and an electrical conductivity (EC) of the saturation extract (ECe) at the root zone above 4 dS m^{-1} (about 40 mM NaCl) at 25°C. The presence of water-soluble salts such as sodium (Na^+), potassium (K^+), chloride (Cl^-), and sulphate ($SO4^{2-}$) constitutes salinity in soil. Some ions, such as K^+ and $SO4^{2-}$, are thought to be nutrients for plants, although Na^+ and Cl^- are not. As a result, Na^+ and Cl^- are frequently the focus of soil salinity (Stavi et al., 2021). Läuchli and Lüttge (2002) defined salinity as the "concentration of dissolved mineral salts presents in soils (soil solutions) and waters". To sum up, soil salinity is a measurement of the concentration of all soluble salts in soil water and is commonly given in decisiemens per metre (1 dS m) as the electrical conductivity (EC) of the saturation extract (ECe) (Hasanuzzaman et al., 2013).

A large amount of salt in the soil inhibits the plant's capacity to absorb water, resulting in osmotic stress and ion toxicity due to the excessive accumulation of Cl^- and Na^+ (Leyva et al., 2011; Parihar et al., 2015; Yang & Guo, 2018; Zulfiqar et al., 2022). Salinity has an indirect effect on plant development through the degradation of soil physical conditions (Driessen et al., 2001), but it also directly affects plant growth by influencing plant water uptake, and nutrient availability (Litalien & Zeeb, 2020). At the molecular and biochemical levels, plants have a few defence mechanisms against salinity stress (Shiozaki et al., 2005; Hauser and Horie, 2010).

Munns (1993), specifies that the reaction of plants to salinity takes place in three phases: the zero phase is characterized by the adaptation of plants to a short-term osmotic shock to the stress triggered by salts; in the second phase, there is a reduction in growth due to the osmotic stress caused by the salts in the external solution at the root level; and in the third phase, there is a change in the intensity of transpiration, which occurs depending on the genotype and the ionic toxicity at the foliar level. Thus, the increased concentration of salts reduces the osmotic potential of water around the root system, ultimately making it difficult for plants to absorb water (osmotic effect) and induces symptoms of toxicity (ionic effect), resulting from the metabolic balance and premature senescence of the leaves. During the three phases, a series of molecular and physiological changes can be observed, respectively: a decrease in stomatal conductivity and root water conductance, readjustment of the water balance by synthesizing some osmoactive compounds, readjustment of growth rate, nutritional disorders, as well as a change in the concentration of photoassimilating pigments (Munns & Tester, 2008).

The tomato, or *Lycopersicon esculentum* Mill., is a self-pollinating vegetable crop that is grown all over the world and is considered to be one of the most valuable crops in the vegetable family Solanaceae.

Tomatoes have been described as "moderately tolerant" of salinity because they are capable of preserving ionic and water balance in the root zone at moderate salinity levels. In addition to being a model plant for studies on stress tolerance, genetics, and fruit development, its fruits are extensively consumed in the fresh market (Rothan et al., 2019). It is essential for providing the human diet with an impressive amount of vitamins A and C. It also has a high lycopene content, which may help mitigate the negative effects of free radicals, which are believed to be linked to several cancers and age-related disorders.

The success of seedling establishment and subsequent development is dependent on seed germination, which is an essential and crucial stage in the plant's life cycle. It is a multi-stage, complex developmental process that is influenced by internal as well as external factors. Seed size, age, chromatin-associated elements, proteins, plant hormones (auxin), related genes (maturating and hormonal genes), non-enzymatic processes, and structural components (endosperm and seed coat) are examples of internal variables. In addition, the germination of seeds is influenced by external factors such as moisture, light, salinity, temperature, acidity, and nutrients (Finch-Savage & Leubner-Metzger, 2006; An & Lin, 2011).

Even though seed germination under salt stress is crucial, little is known about the mechanism(s) behind seeds' ability to tolerate salt. Salt stress in vegetative plants results in decreased rates of root and leaf elongation as well as decreased cell turgor, indicating that saline in the environment predominantly affects water intake (Fricke et al., 2006). Both the embryo and the endosperm interact in two ways throughout the germination process: the embryo controls the endosperm's deterioration, while the endosperm serves as an environmental sensor to control the embryo's growth (Yan et al., 2014). Furthermore, germination is regulated by a variety of interrelated hormonal and physical variables (Chahtane et al., 2017).

Tomato seed embryos are surrounded by endosperm and testa, acting as mechanical barriers for radicle protrusion. Endosperm weakening and testa degradation are necessary for germination. Germination of tomato seeds takes place only at temperatures above the threshold of 9-10ºC, but below 35, with the optimum occurring at temperatures between 20 and 25ºC. The lower the germination temperature, the longer the duration of this process, increasing the risk of seed disease (Munteanu, 2003; Inculet & Stoleru, 2021).

Numerous scientific studies have observed that the highest percentage of seed germination occurs in conditions with distilled water and that the rate decreases with increasing media salinity (Singh et al., 2012; Ratnakar & Rai, 2013; Rofekuggaman et al., 2020; Adilu & Gebre, 2021). Salt stress affects tomato seed germination by altering key enzyme activities and gibberellin levels, thereby delaying and reducing the germination rate (Singh et al., 2012; Tanveer et al., 2020). Tomato seeds were severely injured by salinity stress due to decreased germination and an elevated relative injury rate. Under salinity circumstances, the seedling vigor index and height also had a considerable decrease (Choudhury et al., 2023).

In addition, some authors suggested that moderate salinity enhances fruit quality by influencing the pH value and levels of soluble solids, such as sugars and acids; these are important variables in determining the quality of fruit offered in markets, and salt stress typically enhances fruit quality by raising the content of those components (Coban et al., 2020; Ladewig et al., 2021).

In the light of this circumstance, a review was carried out to determine the impact of sodium chloride stress on seed germination, the subsequent development of seedlings, but also on the entire vegetation period of tomato plants.

MATERIALS AND METHODS

This summary focuses on an in-depth investigation of the resources that are accessible through the international literature. The data for this analysis was collected from accessible resources on the internet, including Google Academic, Free Full PDF, Research Gate, Science Direct, MPDI, Frontiers, Web of Science, PubMed, and the International Society for Horticultural Science. To identify the content of our work, we searched for phrases and terms like "growth", "vigour index", "salt tress", "seed germination", and "screening of salinity effects".

In this study, only original scientific publications establishing the effects of individual salinity on morphology, physiology, yield, and fruit quality that were published in scientific journals with peer review during the last few years were included. When searching for scientific publications using the keyword "salinity effects on tomato", 106 000 results were retrieved on Google Academic; however, only 335 unique works were found in PubMed databases. After carefully reviewing the titles and abstracts, papers that were determined to be unrelated to the search topic were eliminated. The full texts of the remaining papers were then downloaded and evaluated in order to determine whether they fulfilled the established standards. Based on these criteria, 98 research papers and experiments had an influence on the morphology, physiology, and phytochemicals of tomatoes under salt stress.

RESULTS AND DISCUSSIONS

Currently, research has demonstrated that varying salinities in soil or irrigation water can alter plant morphology, physiology, and biochemistry, with specific implications for fruit quality and output. Excessive levels of salt may also cause imbalances in the absorption and utilisation of vital nutrients like magnesium, calcium, and potassium, which can affect the nutritional status of plants and their general health.

The effect of salinity on tomato morphology

Salinity has a profound effect on each aspect of a tomato plant's being, altering even its physical traits. Generally speaking, a plant's morphology provides information about its metabolic function by reflecting the environmental factors that affect it (Roșca et al., 2023). The cultivation of species in a saline environment depends on the capacity of plants to adapt to salty water during germination and the early phases of seedling development.

During the vegetative stage, the optimal EC range for tomatoes produced in soilless or hydroponic systems is usually 1.5 to 3.0 milli Siemens per centimetre (mS/cm). When the plants reach the fruiting and blooming stages, they may tolerate a small increase in EC, up to 2.0-4.0 mS/cm. These levels prevent excessive salt accumulation while offering a suitable balance of nutrient availability and absorption. The most vulnerable stage of a plant's life cycle is the seedling stage, and germination controls when and where seedling growth starts. Regarding the relative susceptibility of germination and seedling growth to salt stress, there are contradictory observations in the literature. Singh showed in a 2012 study carried out in New Delhi that tomato seed germination decreased at a relatively low salinity (1% NaCl). Germination percentages in parents dropped sharply from 77.60% (control) to 29.60% (at 3% NaCl) and in F1s from 75.82% (control) to 33.16% (at 3% NaCl) at higher salinity (3% NaCl). Shanika & Seran (2020) found that seed treated with NaCl above 40 mM had a germination percentage of less than 50%, with the lowest figure (18.3%) occurring at 80 mM salinity. Following a 12-day period of seeding, salt stress had a substantial ($P<0.001$) impact on the shoot and root lengths, dry and fresh weights of the shoots and roots, relative water content, and total dissolved salt content of the initial leaves (cotyledons).

According to Kaveh et al. (2011), there is a substantial negative link between salinity and the rate and percentage of germination in *Solanum esculentum*. This correlation causes delayed germination and a reduced germination percentage. Abdel-Farid et al. (2020) achieved the following results: the germination rate of tomato seeds was dramatically reduced at salinity levels of 50, 100, and 200 mM NaCl and entirely inhibited at 100 and 200 mM NaCl. The authors clarified that partially osmotic or ion toxicity may have impaired enzyme activity, which could account for the delay in seed germination. When compared to the control (0 mM), González-Grande et al. (2020) observed that the tomato cultivar Río Grande's seed germination rate decreased by 6.4% at 85 mM NaCl. The rate of germination was less than 2.8% at 171 and 257 mM NaCl, indicating a significant impact on the process.

Ahmed et al. (2022), in a study about five levels of salinity and four varieties of tomato (Binatomato-6, Binatomato-7, Binatomato-8, and Binatomato-9), found that after 11 days of sowing the seeds, the highest percentage of seed germination (81.33%) of tomato was recorded in the case of the control (0 mM NaCl) and the lowest percentage of seed germination (0%) was observed in the case of the 150 mM NaCl salt solution.

According to Adilu & Gebre (2021), a decline in the water potential gradient between seeds and the medium they are growing in can be the cause of the decrease in germination rate and percentage under salt stress. Moreover, gibberellin acid concentration and enzyme activation during seed germination are impacted by the osmotic and toxic effects of NaCl. In comparison to the untreated control condition, Chakma et al. (2019) found that the percentage germination, germination coefficient, radicle length, seedling vigour index, fresh weight of radicle, mean germination time, and germination index reduced as the salt concentration increased. Al-Harbi et al. (2008) demonstrated that for all cultivars, the germination percentage was higher and the germination rate was faster at the lowest level of salinity (0.5 dS m^{-1}). The final germination percentage decreased, and the germination rate was delayed as salinity increased. In a lab experiment, Mustafa et al. (2021) showed that salinity at 12 dS m^{-1} considerably lowered all indicators compared to salinity at 6 dS m^{-1}. The germination percentage, speed, mean germination time, mean daily germination, peak value of germination, and germination value were all decreased by 73.45%, 72.59%, 28.94%, and 87.58%, respectively, as compared to the control when salinity was applied at a 12 dS m^{-1} level. The highest salinity level (5 dS m^{-1} NaCl) resulted in the lowest germination percentage (11.67%) for variety Eshet. Increasing salinity levels from 1 to 5 dS m^{-1} NaCl significantly reduced the standard germination percentages compared with the control (Shamil et al., 2020).

Plant morphology can be affected by salt at any stage of growth. Variations may be seen in the height of the plant, the ratio of roots to shoots, the size of the leaves, the number of branches, or the quantity of leaves or flowers per plant. Research on the impact of salinity on tomato plants revealed that the degree of morphological alterations in plants is influenced by the salinity of the growing medium.

The first response of plants to salinity is to reduce leaf area, which leads to reduced growth. Based on the findings of Sardoei and Mohammadi's (2014) research, it can be inferred that root and shoot growth indices were the ones that were most rapidly impacted by salt stress. When Sanjuan et al. (2015) tested 48 native tomato lines and commercial controls in Mexico at five different electrical conductivity (EC) levels using NaCl in the nutrient solution, they discovered that salt decreased the number of leaves, stem diameter, leaf area, and plant height. Moreover, the Salinity Susceptibility Index (SSI $\leq$ 1) indicated that 75% of the materials assessed were tolerant to salinity. Albacete et al. (2008) found that tomato (*Solanum lycopersicum* L.) root fresh weight decreased up to 30% when exposed to 100 mM NaCl of salt stress. According to Kakar et al. (2019), salt stress adversely influenced the tomato plant growth rate and development, as well as the number of fruits, fruit weight, leaf number, leaf area index, fresh weight, dry weight, and maximum height of the tomato plant at harvesting. Additionally, Romero-Aranda et al. (2001) reported data indicating that salinity inhibits the expansion of leaves in two tomato varieties. Common findings showed that the tomato plant's leaf area index decreased when exposed to salt stress at concentrations of 40 and 60 mM (Hajiaghaei-Kamrani et al., 2013). Furthermore, the study of variability revealed that, in comparison to other treatments, salinity at 12 dS m^{-1} considerably decreased all growth indices, with the exception of the fresh and dry weight of the shoot, which didn't differ significantly from salinity at 6 dS m^{-1}. According to Mustafa et al. (2021), the salt treatment with 12 dS m^{-1} decreased the plant height, leaf area, shoot fresh weight, shoot dry weight, root fresh weight, and root dry weight when compared to the control treatment.

Tomato dry weight, leaf area, plant stem, and roots decreased when salt exceeded 4000 ppm (Omar et al., 1982). Al-Rawahy (1989) clarified that a combination of the osmotic and particular ion actions of Cl and Na may cause the reduction of dry weights brought on by elevated salinity.

The effect of salinity on tomato physiology

Plants under salinity stress have lower water potential or content, which promotes the closing of stomatal pores, preventing more water loss through transpiration (Zhang et al., 2009). In addition to reducing transpiration because of stomatal closure, salt stress lowers net photosynthesis by lowering chlorophyll content (Flexas et al., 2007; Zribi et al., 2009). Chlorophyll content (Chl) was shown to be strongly impacted by the NaCl and drought treatments. Plants grown at 150 mg NaCl and drought + 150 mM NaCl had total Chl levels that reduced from 12.8 mg/g^{-1} f.w. in the control to 10.9 mg/g^{-1} f.w. and 7.0 mg/g^{-1} f.w., respectively (Giannakoula & Ilias, 2013). Some varieties that were exposed to 200 mM NaCl showed signs of necrosis and wilting in their leaves after one week of NaCl treatments; other genotypes took longer than two weeks to reach these stages (at 150 or 200 mM NaCl); still other varieties just dried up and died in less than a week (Murillo-Amador et al., 2017).

Salinity reduces the concentration of photosynthetic pigments and, as a result of diffusion constraints, lowers CO_2 availability, which reduces tomato physiological efficiency (Ashraf and Harris, 2013). Habibi et al. (2019) observed that salinity treatments (50, 100, 150, and 200 mM) decreased plant height, root length, the number of flowers, photosynthetic rate, transpiration rate, and stomatal conductance, but increased leaf temperature.

Increasing salt levels have been linked in several studies to decreased chlorophyll content and features related to photosynthesis (Raza et al., 2017; Gharbi et al., 2018; Kalaji et al., 2018), increased proline accumulation (Gharsallah et al., 2016; Parvin et al., 2019), antioxidant metabolism activities (Soares et al., 2019; Parvin et al., 2019; Abdelaal et al., 2019), and K^+/Na^+ ratio (Raza et al., 2017; Ishikawa & Shabala, 2019).

In addition, salinity also represses the development of leaf, flower, and fruit by slowing cell division or elongation, hindering sugar metabolism, and reducing water input, respectively (Siddiqui et al., 2017; Pinedo-Guerrero et al., 2020). Moreover, Zhang et al. (2016) demonstrate that high concentrations also reduce leaf chlorophyll content, stomatal resistance, and photosynthetic activities. In an experiment carried out in Egypt during 2020-2021, it was demonstrated that salinity increased specific leaf weight, osmotic pressure in leaves, water use efficiency (WUE), leaf total sugar content, leaf proline content, and electrolyte leakage in leaves (Abdalla Hassan Radwan et al., 2023). As reported by Tomescu et al. (2017), all plants that were watered with saline solution showed a substantial reduction in the photosynthetic outcomes (assimilation rate and stomata water vapour conductance).

According to El-Hendaway et al. (2005), salinity can significantly reduce photosynthesis and increase transpiration rate, which leaves the growing organs with insufficient absorption and ultimately delays or stops growth. Furthermore, the physicochemical characteristics of planting soil may be negatively impacted by the addition of NaCl solution (Fontes & Ronchi, 2002). Due to the toxicity of salt and chloride ions at high concentrations in the plant and the reduction of soil moisture availability, salinity has a negative impact on crop plant output (Mallick et al., 2020).

The effect of salinity on tomato yield and quality

When soluble salts are present in the soil in "excessive" amounts or concentrations, whether naturally occurring or as a result of improperly managed irrigation water, salinity becomes a concern. Most of the research carried out with tomatoes suggested a positive or no impact of salinity on fruit quality. Research on tomato landraces showed that salt enhances the flavonoids and sugar content of the fruit (Moles et al., 2019). In addition, Hurtado-Salazar et al. (2018) showed that high levels of salinity and water stress favor the increase of soluble solids in cherry tomato fruits, with a decrease in production as abiotic stress increases. Saito et al. (2008) demonstrated that moderate salt stress (EC 8.0 dS m^{-1}) enhances the accumulation of citric and malic acids by 1.7- and 2.5-fold, respectively, compared to control conditions (EC 2.5 dS m^{-1}) at the red-ripe stage. In a study, Azarmi et al. (2010) demonstrated that salinity enhanced qualitative attributes. Above 3 dS m^{-1} EC, there was a significant ($P \leq 0.05$) increase in total soluble solid. Fruit dry weight rose by 8.7% at an EC of 6 dS m^{-1} over 2.5 dS m^{-1}. When compared to 2.5 dS m^{-1}, titratable acidity increased by 2.7, 9.9, 20.3, and 28.9% at EC of 3, 4, 5, and 6 dS m^{-1}, respectively. In accordance with Liu et al. (2014), tomato cultivars of Tainan ASVEG No. 19, and Taiwan Seed ASVEG No. 22 had greater percentages of total soluble solids (16.3%, and 50%) and titratable acid (50%, and 45.3%) under the 150 mM NaCl stress condition compared to those under the 0 mM NaCl condition. On the other hand, when a 200 mM NaCl solution was used as irrigation water, there were observed losses in the dry matter of 61% in leaves, 40% in stems, and 44% in roots (Zribi et al., 2009).

Zhang et al. (2016) also confirmed that both the total fruit sugar and total acid content of tomatoes increased as salinity increased; additionally, raising the salinity of the nutrient solution from 0.78 dS m^{-1} to 1.58 dS m^{-1} resulted in an increase in sugar and acid content to 14.3% and 28%, respectively.

Many research studies have established that excessive salt concentrations lead to metabolic imbalances that reduce plant productivity (Kusvuran et al., 2016). Total yield of tomato is significantly reduced at salinity equal to and above 5 dS m^{-1}, with a 7.2% yield reduction per unit increase in salinity (Zhang et al., 2016). Abdalla Hassan Radwan et al. (2023) demonstrated that salinity increased nonmarketable yield and fruit contents of TSS, Vit. C, TA, and fruit firmness. Also, salinity enhanced Na and Cl contents in both young and old leaves, but their concentrations were higher in older leaves than in younger ones.

Also, experiments have demonstrated that the salinity of irrigation water may result in a decrease in tomato output, particularly if the applied water's salt content is higher than the salt tolerance threshold (Kang et al., 2010, Li et al., 2019, Li et al., 2022). In 2021, Ladewig et al. examined the responses of four tomato landraces and one hybrid to four different NaCl concentrations (0, 30, 60, and 90 mM). When comparing plants exposed to 30, 60, and 90 mM to the control, they found that the cultivar "Campeche" performed lowest in response to salinity, showing the most significant yield reductions of 71.1%, 80.1%, and 89.6%, respectively. Del Amor et al. (2001) demonstrated that salinity reduces the growth rate of tomato (*Lycopersicon esculentum* Mill. cv. Daniela), primarily the number of fruits and also fruit size. Magán et al. (2008) found that tomato fresh yield is significantly decreased by salinity. Siddiky (2012) & Siddiky et al. (2014) revealed that there was a notable difference in fruit weight among various tomato germplasms and that plants treated with high concentrations of salt generally showed a significant loss in fruit yield when compared to controls. In a study conducted in Bangladesh, a significant decrease in tomato yield was found in all five studied BARI-T (1–5) varieties at 6 and 8 dS/m^{-1} salinity levels. A reduction in fruit number of 2.0% was reported with an increase of 1 $dS\ m^{-1}$ beyond the threshold value of 4.4 $dS\ m^{-1}$ (Magán et al., 2008). Sharma & Sachan (2023) noted that the application of a saltwater concentration at EC 8 $dS\ m^{-1}$ produced the lowest fruit yield of 145.59 g, while the application of no saltwater concentration (control) produced the highest fruit yield of 323.52 g. As salinity increased, there was a significant reduction in fruit output. The findings of Mou (2021), El-Mogy et al. (2018), Islam et al. (2011), and Mazumder (2016 a and b) were in agreement with this result. Zhang et al. (2022) found that tomatoes produced at salinities of 5 $dS\ m^{-1}$ and higher had a significantly lower total yield. Moreover, Ahmad et al. (2017) also showed that the yield of tomato cultivars (Pearl and MT1) was affected by salinity, reducing their productions by 84% at the highest concentration of salinity. Even at the medium level of NaCl (70 mM), both of the cultivars had lost 62% of their yield, indicating a moderate salinity-tolerance of the cultivar studied.

CONCLUSIONS

Salinity is one of the harshest environmental variables limiting crop productivity. Studying plant growth throughout the course of the growing season can reveal information about a crop's long-term salt tolerance. This review indicates that tomato varieties are more vulnerable to the adverse effects of salt in the form of NaCl solution during the seedling stage of growth than they are later in the life cycle. The study also highlights the fact that, although some salinity treatments have been shown to improve tomato quality, there have been reports of adverse effects of increased salinity on tomato yield.

Based on the prediction that over 50% of arable land will turn salty by 2050, researchers ought to concentrate more on finding techniques to desalinate soils, studying how to create fertigation plans that encourage better management of water and fertiliser applied in accordance with plant requirements, developing new salinity-resistant varieties, or enhancing already existing species.

However, further field research in salt-affected soils is needed to get a better understanding of how salinity affects tomato plants. This research should take into account the individual and cumulative interactions of the many components.

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