Research Article

Impact of Saline Irrigation Water on Yield and Quality of Tomato (*Solanum lycopersicum* L.)

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Abstract

Salinity is one of the most decisive environmental factors limiting the productivity of crop plants especially in arid and semi-arid regions. Water sources on earth contain 30 g of sodium chloride per litre, making earth been referred to as a salty planet. Due to inadequate availability of good quality surface water in different parts of the world, farmers have to use poor quality ground waters for irrigation. Tomato is a major vegetable crop grown throughout the world for its high agro- economic value and is moderately tolerant to salinity which therefore commonly cultivated in saline areas. A huge genetic variation of tolerance to salt level exists among tomato genotypes. Salt stress adversely impacts yield traits of tomato; however, has additionally a beneficial and positive effect in improving fruit flavour.

This paper provides comprehensive review of major research advances to illustrate the impact of saline irrigation water on yield and quality of tomato.

Keywords: salinity, yield, quality, tomato

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Introduction

Tomato is one of the most important horticultural crops in the world. Tomato fruit is a main part of dietary meals as it's a vital source of vitamins, minerals, and antioxidants. Owing to its high food value, the request and demand of tomatoes is rising day by day. Tomato plants require high temperatures and high photosynthetic active radiation for optimum production. As these conditions are typical of arid and semi-arid regions where irrigation water is usually limited and often saline. Tomato production has been limited due to high salinity level of the soil or of the irrigation water [1,2].

Salinity or salt stress is a serious environmental stresses causing global menace to crop production and agricultural sustainability as it significantly reduces once productive land to non-productive. With the increase in level of salinity over the years due to poor quality irrigation and chemical application to the soil, it's expected that by 2050, more than 50% of the land available for agriculture will be lost due of salinity [3]. Most of the tomato cultivars are sensitive to moderate salinity levels [4]. Indeed, all plant development stages, including seed germination, vegetative growth and reproduction, show salinity sensitivity, that leads to poor harvests and reduced economic yield [5]. As salinity stress involves changes in plants physiological and metabolic processes, depending on severity and duration of stress which ultimately restricts crop production. Plants grown under saline conditions are usually stressed under three ways. These are (a) reduction of water potential in the root zone and therefore causes water deficit, (b) phytotoxicity of ions viz., Na^+ and Cl^-, and (c) nutrient imbalance by depression in uptake and/ or shoot transport [6]. However, many researchers believe that tomato plants grown under saline conditions have increased level of fructose, glucose, total soluble solids, amino acids and organic acids [7] which helps in improving the quality of tomato fruits. The maximum level of soil salinity tolerated by tomato, on the basis of electrical conductivity of the saturation extract (ECe), is 2.5 dS m^{-1}, with decline of 9.9% in the production for each unit increase of salinity above this limit [8]. On the other hand, [9] reported that use of irrigation water with electrical conductivity of 1.7, 2.3, 3.4, and 5.0 dS m^{-1} declines tomato yield by 0, 10, 25 and 50%, respectively. Most commercial cultivars of tomato are sensitive to moderate levels of salinity up to 2.5 dS m^{-1}, without significant yield reduction. However, unfavourable growing conditions and improper crop selection by the farmers are some of the constraints which limits the growth and production of crop. Since tomato could act as a model crop for saline water use as its already grown in larger areas under saline conditions, and because there is a wealth of important knowledge regarding the physiology and genetics of this species [10]. However, correcting saline condition in field or greenhouse would be expensive and temporary

strategy while selection and breeding for salt tolerance can be a wise solution to minimize salinity effects as well as improve production efficiency.

Effect of saline irrigation water on yield and yield attributes of tomato

Salinity causes retardation in growth and development of tomato plants during both vegetative as well as reproductive phases. Higher concentrations of NaCl (50 and 100 mM) resulted in significant reduction in all vegetative growth parameters, including number of lateral shoots, fresh and dry weight of shoots and roots and stem diameter [11]. Shoot growth, as indicated by percentage reduction in dry weight, tended to be more affected than root growth. Similar observations were reported by several authors and reviewed by [10]. Salinity stress (5.4 $mScm^{-1}$) leads to reduced plant height by 10% -20% compared to the control as reported by [12]. The reduction in plant height with increased salinity is more linked with shortening of the stem internodes than with a reduction in the number of nodes. Salt stress significantly affects the morphology, physiology and fruit weight of tomato plant. A decrement in plant height, leaf number and number of branches per plant at 6 and 8 dS m^{-1} salinity level while reduced shoot dry weight, leaf area and fruit weight per plant at 8 dS m^{-1} [13]. These findings are in line with the observations informed by [14] who stated that salinity significantly decreased vegetative parameters (number of leaves, plant height, leaf area, root length and dry matter accumulation) with increase in salt concentration

Stressed plants produces flowers and fruits at a slower rate with smaller size fruits compared to the non-stressed plants [11]. The reduction in fruit yield with increased salinity stress is due to reduced fruit weight as well as fruit number. There was no significant reduction in fruit yield upto 2 dS m^{-1} but found significant decrease with increasing salinilty levels upto 8dS m^{-1} by [15] and also found more than 50% yield reduction at same level of salinity. These results were similar to the findings of [16] and [17] in tomato. While studying the effect of soil salinity on growth and yield of tomato, [18] reported that tomato fruit yield and vegetative growth were unaffected upto a soil salinity of 2.6 dS m^{-1} in two years while with each unit of increased salinity more than 2.5 dS m^{-1} reduces yield by 6.32% and vegetative growth by 5.35%. Reduction in total and marketable fruit yield with increased salinity was a result of reduced fruit weight [19]. Total fruit yield was reduced by 8.7, 21.7, 36 and 48.9% at salinity level of EC 3, 4, 5 and 6 dS m^{-1}, respectively, compared to 2.5 dS m^{-1} [20]. Threshold limit of salinity for tomato, up to which yield reduces very little or no reduction occur, is 2.5-3.0 dS m^{-1} and thereafter with every increase of 1.0 dS m^{-1} in ECe results in a yield reduction of about 9–10 % [4].

Effect of saline irrigation water on quality of tomato

Tomato crop duration can be divided into two stages, where the first stage is developmental stage, during which fruit size increases and other stage is the ripening stage which starts with the end of first stage and terminates at tissue breakdown. Application of saline water accelerates both of these stages and therefore reduces fruit lifespan. The beneficial effects of salinity stress on quality of tomato fruits got confirmed by different studies. As salinity causes osmotic stress inside the plants, thus in order to maintain the osmoticum inside the plant cell, secretion of compatible osmolytes mainly sugars, free amino acids *etc* takes place by the plant cell which increase the total soluble solids in the fruits. Accumulation of sugars and TSS in fruit was also due to reduced water flux to the fruit under salt stress caused by high EC. Total soluble solids (TSS) content of the fruit is one of the most important quality criteria for tomato paste processing. TSS of ripen fruit increases with increased salinity and hence the use of moderate saline irrigation water (3-6 dS m^{-1}) is recommended to improve fruit quality [10]. Sucrose content of mature fruits increases when plants are treated with NaCl during reproductive growth phase of plant. The results are in line with the observation that sucrose content of tomato leaves is increased in plants exposed to 50 or 100 mM NaCl as compared to the control plants [21], [22] also reported improved fruit quality as total sugars and total soluble solids (TSS) with increasing salinity. These results are in line with the findings of [15] who reported that the fruit quality i.e. TSS content was found improved from 6.93 to 9.33^0 Brix along with fruit firmness, ascorbic acid content and titrable acidity of tomato fruit with increasing salinity levels upto 6 dS m^{-1} and also specified that a mild salt stress is beneficial in order to enhance the quality of fruits and improve their market value. Fruit quality in terms of chemical constituents (sugars and acids), pigments and especially fruit taste was superior among treated one than the control plants which is due increased acids and sugars under salinity [23]. Serio *et al.* (2004) observed that higher NaCl content of nutrient solution improves the organoleptic quality and nutraceutical properties of tomatoes and also some intrinsic quality parameters, such us dry matter, total soluble solids, vitamin C, α-tocopherol and the antioxidative potential [24]. As per the findings of [25] total soluble solids, acidity and lycopene contents increased with increase in saline water level. However, the pH of fruit juice found declined with increased water salinity. After a three yearlong study conducted by [2], they reported that high salinity level (5.5 dS m^{-1}) treatment yields fruits with increased

soluble solids, total acid, vitamin C and sugar-acid ratio by 38.2-54.2%, 25.9-43.1%, 36.5-50.2% and 34.9-43.3%, respectively and hence, found a positive correlation between the tomato comprehensive quality and salinity of irrigation water.

Conclusion

As per the above discussion, it can be concluded that application of saline irrigation water is associated with decrement of total yield with increased levels of salinity while the quality parameter like total sugars, TSS were found increased with higher salinity levels enhancing flavour aspects and nutritional value. As salinity increases fruit quality by increasing fruit firmness, total sugars and total soluble solid. So, use of saline water for improving fruit quality can be an important aspect for increased market value with higher prices balancing yield losses. Moreover, judicious use of quality water with saline water can be proved as an efficient approach for improving yield as well as quality of tomato.

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