International Journal of Plant & Soil Science

Volume 35, Issue 20, Page 1076-1085, 2023; Article no.IJPSS.106590
ISSN: 2320-7035

Comparative Study of the Impact of Saline Water Irrigation on Tomato Yield, Quality and Growth in Andhra Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2023/v35i203904

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/106590

Original Research Article

Received: 24/07/2023
Accepted: 29/09/2023
Published: 07/10/2023

ABSTRACT

Tomato (*Lycopersicon esculentum Mill.*) belonging to the family Solanaceae, is one of the most important, popular, nutritious, and palatable vegetables grown in Andhra Pradesh. It plays a vital role in providing a remarkable quantity of vitamin-A and vitamin-C in human diet. Tomato is cultivated all over Andhra Pradesh due to its adaptability to wide range of soil and climate. Saline water resources are abundant in the most areas of India. Most of these resources still have not been effectively utilized. The present investigation was conducted on the effects of saline water irrigation on tomato yield, quality and growth at the Research Farm, Department of Agricultural Engineering, Aditya Engineering College, Surampalem, East Godavari district, Andhra Pradesh. Saline water differing in Electrical Conductivity (EC) 6ds/m and 4ds/m was supplied to the plant after the seedlings. The objective of this work is to compare the effect of tomato crop under drip

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irrigation by three different treatments. First treatment is of fresh water under drip irrigation. Second treatment is of Nacl+water with an EC of 6ds/m under controlled irrigation in the ratio 2.5:7.5. Third treatment is of Nacl+water with an EC of 4ds/m under controlled irrigation in the ratio 1.5:8.5 of the tomato variety Pusa F1 hybrid is used for the experiment. Growth of crop includes plant height, number of fruits, number of leaves, fruit length, fruit diameter and fruit weight. The healthy growth that is 69.4cm plant height, 26 leaves per plant, 34 fruits per plant, 7.8 cm fruit length, 5.4 cm diameter of fruit and 89.4 g of average fruit weight and maximum score (4.86 out of 5) in organoleptic test were obtained in (T-1) i. e. drip irrigation. Although salinized tomato fruits were smaller than non-salinized control fruits, they have increased soluble solids, high sugar content, which all are highly requested qualities by the processing tomato industry. Current research concludes that the fresh water irrigation T-1 recorded the high-water use efficiency and saline water irrigation treatments (T2&T3) having less water use efficiency may be due to the plants suffering with more soil moisture stress due to osmotic pressure build up by the saline water irrigation.

Keywords: Saline; NACL; tomato; drip irrigation; EC and pH; treatments; organoleptic.

1. INTRODUCTION

Tomatoes (*Solanum lycopersicum*) are a good source of phytochemicals and nutrients such as lycopene, potassium, iron, folate, and vitamin C. Besides lycopene and vitamin C, tomatoes provide other antioxidants, such as beta-carotene, and phenolic compounds, such as flavonoids, hydroxycinnamic acid, chlorogenic, homovanillic acid, and ferulic acid. It is originated in western South America and domestication is thought to have occurred in Central America. Because of its importance as food, tomato has been adopted to improve productivity, fruit quality, and resistance to biotic and abiotic stresses. Tomato has been widely used not only as food, but also as research material [1]. It occupies an area of about 4.73 million hectares with a production of 163.96 million tonnes in the world. The total global area under tomato is 46.16 lakh ha and the global production is to the tune of 1279.93 lakh tonnes. It is the world's 3rd largest vegetable crop after potato and onion. The biggest producer of tomatoes in 2016 was china by far with more than 50 million tons harvested, followed by India, USA, Turkey, and Egypt. As it is a relatively short duration crop and gives a high yield, it is economically attractive and the area under cultivation is increasing daily [2].

Fresh water is a (very) limited resource in the world. Most of the water available for irrigation comes from aquifers and lakes. The total amount of fresh water from these two resources only accounts for less than 1% of the total water supply. So, if saline water can be used as a resource, this can greatly reduce the amount of fresh water used by agriculture and decrease water stress in many areas. If all the world's saline water would be used for irrigation, it could double the amount of available water for agriculture. At the same time, saline agriculture limits the damage caused by salinization by employing sustainable practices for agriculture and water management, and by making use of salt-tolerant crop varieties. If salt-affected soils are put back into production, 70-120 million hectares of new arable land can be saved, along with their natural ecosystem and the associated biodiversity [3].

Therefore, selection of best method of saline water irrigation is governed by two points:

1. To avoid salt accumulation at the upper layer and to enhance salt leaching to the deep layers.
2. To avoid disturbance of water absorption by roots and to maintain plant water status at acceptable level.

- Soil salinity is a major environmental constraint to crop production, effecting an estimated 45 million ha of irrigated land and is expected to increase due to global climate changes because of many irrigation practices.
- People have long believed that salt-affected land was unusable. But as a result of in-depth research and years of testing, a practical solution was found Saline agriculture.
- If salt-affected soils are put (back) into production, 70-120 million hectares of new arable land can be saved, along with their natural ecosystems and the associated biodiversity.
- As to the tomato crop, consider it as moderately sensitive to the effects of salts.

- Andhra pradesh is one of the major tomato producing state in the country of yield of 20114 kg/ha. A large volume is coming from the Kurnool, Chittoor and Prakasam districts.

1.1 Objectives

1. To find the effect of different levels of EC and pH of saline water on growth of tomato crop.
2. To compare the yield with normal irrigation water to saline water of tomato crop- under drip system.

3. MATERIALS AND METHODS

3.1 Experimental Site

The experiment was conducted in the Department of Agricultural Engineering, Aditya Engineering College, Surampalem, East Godavari, Andhra Pradesh, India.

3.2 Experimental Details

Name of the crop: Tomato
Botanical name: *Lycopersicon esculentum Mill.*
Family: Nightshade
Crop Variety: Pusa hybrid
Number of treatments: 3
Dimensional area of each plot: 9 m×4.5m
Row to Row & plant to plant spacing: 0.6×0.6m

3.3 Design of Experimental Field

Randomized block design
The total area selected for experimental field is 121.5 m^2 and divided into three plots i.e.

T1-drip with Fresh Water
T2 -drip with Saline Water (EC 4ds/m)
T3 -drip with Saline Water (EC 6ds/m).

4. METHODS

The field was thoroughly ploughed and divided into plots of 9m×4.5m. As per the requirement of the research, two tanks were installed in the field nearer to experimental plots at the head of 5m and connected to the separate sub lines to maintain two salinity levels. Laterals with 16 mm diameter are provided with the online emitters at a spacing of 60cm directly joined to the mainline having size of 50 mm through lateral take-off.
As pure water which has no impurities was supplied from the source of filter point and drip system is operating by the gravity, so no filters were provided. The lateral lines were laid at the spacing of 60cm as per the crop spacing by adapting the paired row system. Totally, 21 lateral lines were connected to main line. To control the flow of water in laterals in accordance with the Crop Water Requirement, every lateral was provided with the control valve except the laterals which were designed for 100% of crop water requirement.

The control plot was provided with a provision of irrigation with fresh water through pump source connected to the submain and to the laterals. The other two plots were irrigated under saline water with a provision of two different containers connected to the sub main & to the laterals to maintain different EC levels [4]. The water requirement of the control plot is considered as 560 mm based on the Pan Evaporation data of 6 mm/ day. Farmyard manure was applied 10kg throughout the field and mixed with the help of rotavator.

4. RESULTS AND DISCUSSION

Plant height: The height was measured after 15 days from transplanting and followed with that interval.

The maximum height (i.e., 69.4 cm) of the plant was recorded in treatment-1 (Fresh water under drip irrigation) than that in the treatment-2 (NaCl+ water with an EC 6ds/m) & treatment-3 (NaCl+ water with an EC 4ds/m). This might be attributed to the adoption of drip irrigation system rather than the traditional methods and in efficient utilization of water for better growth and improvement in plant [5].

With 15 days interval from transplanting, the number of leaves counted for five observational plants separately for three treatments and average was recorded as shown in the table.

The maximum no. of leaves per plant was recorded in treatment-1 (Fresh water under drip system) than that in the treatment-2&3 with an EC of 6&4ds/m under controlled irrigation (NaCl+ water). This might be attributed to the release of essential nutrients from soil in comparison to other nutrient sources, efficient utilized for better growth.

Chart 1. Measurement of plant height

NO. OF DAYS	PLANT HEIGHT (in cm)		
	Treatment-1	Treatment-2	Treatment-3
After 15 days	10	6	8
After 30 days	20.5	13.2	16.5
After 45 days	38	26	30
After 60 days	49.2	35	41
After 75 days	56	42	48
After 90 days	69.4	50.8	56

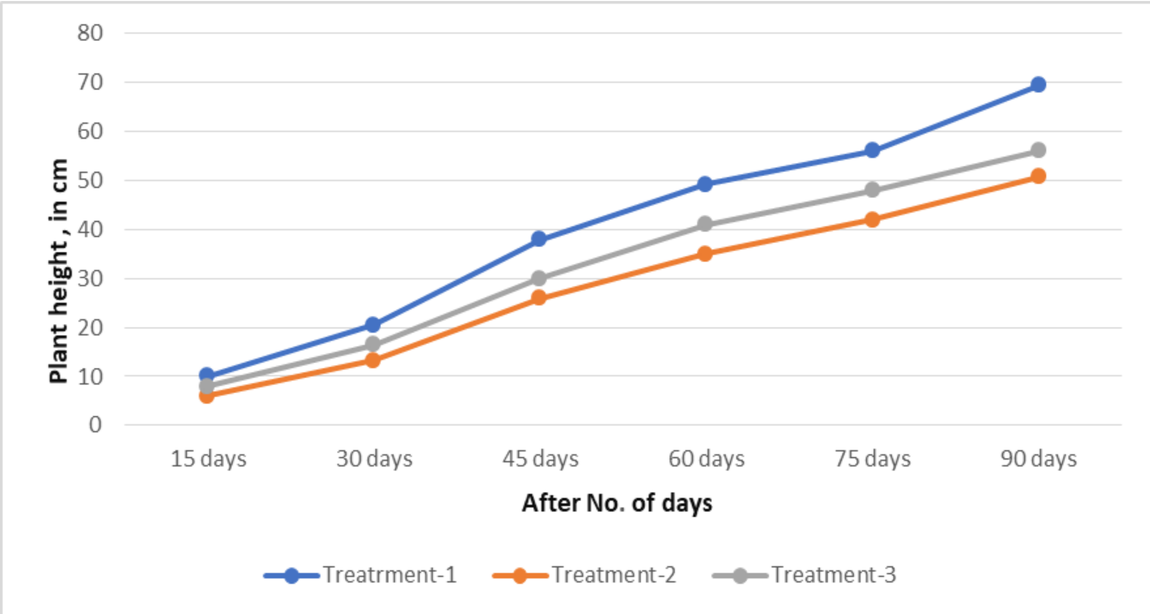


Fig. 1. Plant height (cm) of tomato as influenced by three different growing media.
Number of leaves per plant

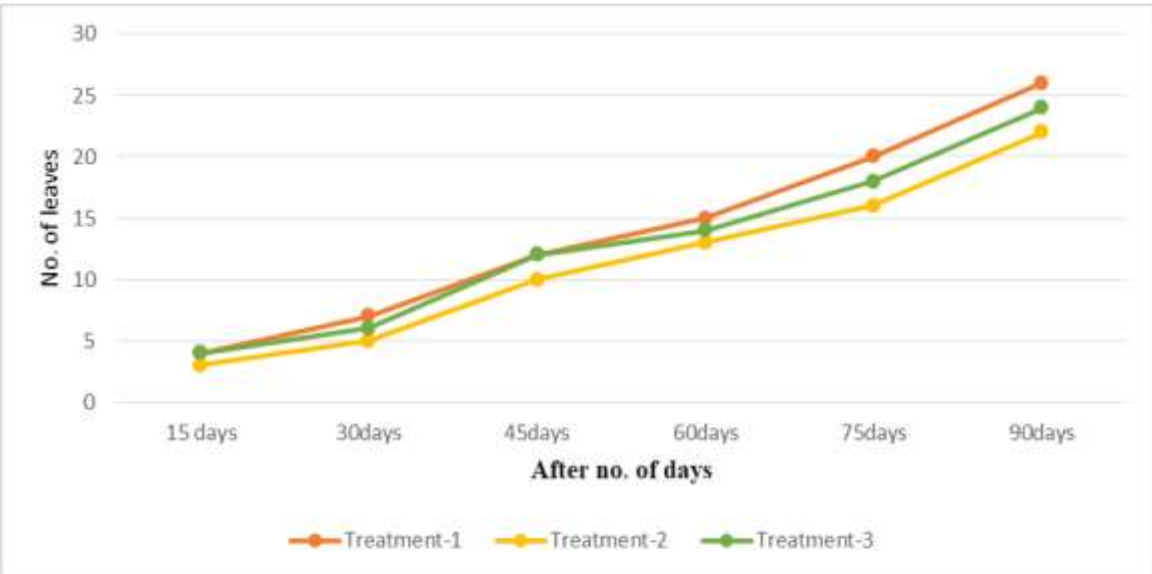


Fig. 2. No. of leaves per plant as influenced by three different growing media

Chart 2. Observations of Fruit length (cm), Fruit diameter (cm), No. of Fruit per plant and Average fruit weight (g)

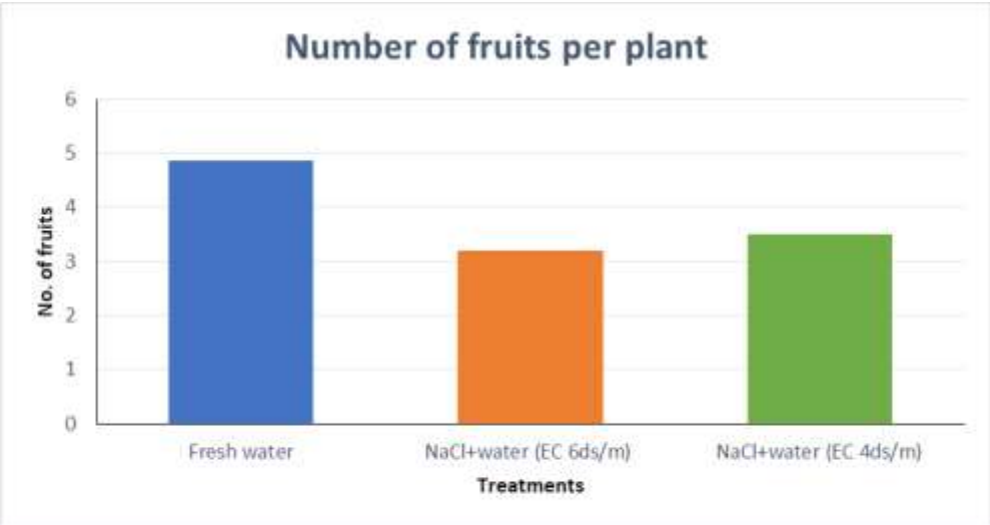
parameters	T1	T2	T3
Fruit length (cm)	7.8	5.9	6.4
Fruit diameter(cm)	5.4	3.7	4.2
*Average fruit weight (g)	89.4	48.2	67.5

Table 1. The number of leaves per plant in two treatments at 15 days interval

NO. OF DAYS	NO. OF LEAVES PER PLANT		
	Treatment-1	Treatment-2	Treatment-3
After 15 days	4	3	4
After 30 days	7	5	6
After 45 days	12	10	12
After 60 days	15	13	14
After 75 days	20	16	18
After90 days	26	22	24

Table 2. Observations recorded for number of fruits per plant, Yield per plant (kg)

Treatments	No. of fruits per plant	Yield per plant (kg)
Fresh water (T1)	32	3.78
Nacl+water (T2) (EC 6ds/m)	13	0.68
Nacl+ water (T3) (EC 4ds/m)	24	2.12



Picture 1. Bar graph showing yield of fruits per plant with various treatments

4.1 Yield Parameters

The data on yield per plant (kg), number of fruits per plant were statistically analysed and the average values are given in the table.

4.2 Number of Fruits Per Plant

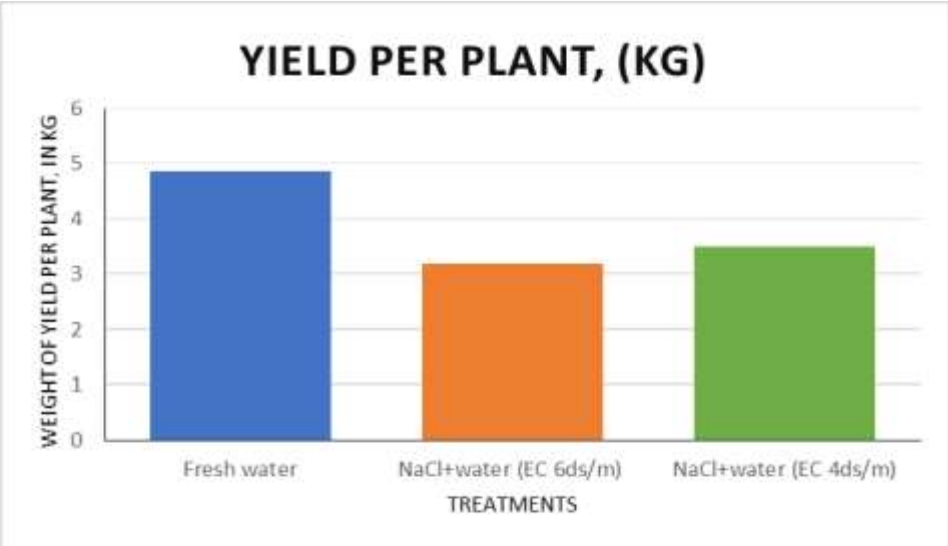
The harvesting is done at three times with an interval of ten days from the fruit maturity date. At each time of harvesting the number of fruits for five observational plants was counted and average was computed which was given in table. It is clear from table, that the maximum no. of fruits per plant (34) was observed in treatment (T-1) while the minimum no. of fruits per plant (13) in T-2 with EC 6ds/m & (24) were observed in the treatment (T-3) with EC 4ds/m [6].

4.3 Yield Per Plant (kg)

The tomatoes harvested from the five observational plants are weighed at each picking and the average weight of fruits per plant was calculated which are presented table 2. It is from the observations made that the highest yield per plant (3.78 kg) was recorded in the treatment-1 than the yield per plant (0.64 kg &2.12kg) in the treatment-2&3 [7]. This might be due to nutrient sources which helps in growth such as nitrogen, organic carbon, potassium, phosphorus, zinc, copper, etc., are present in the required amount in T-1 while in the T-2&3, the presence of sodium (30%) and magnesium (26.52%) in high concentrations which affects the growth of fruits.

4.4 Organoleptic Test

Data regarding scores obtained after evaluation of tomato plants of different treatments for Organoleptic test regarding different quality parameters like appearance, colour, size and weight, shoot as vegetable, pungency and average rating. The scoring was done for each character out of 5 marks, in which five score was given for excellent, four for better, three for good, two for average and one for poor and average ratings were converted to 5point scale. The maximum score (4.86) was obtained in treatment-1 While the lowest score (3.19 & 3.5) was observed in treatment of 2&3 with an EC of 6&4ds/m. The high score for colour character ranged 3.91 in T-1 than the score (2.69 & 3) observed in T-2&3. Regarding the size and weight character the score was ranged 4.78 which is the maximum value obtained in T-1. The values for pungency character ranged 4.34. The maximum value was obtained by T-1 while, the lowest value was observed in treatment T-2&3.



Picture 2. Bar graph showing yield per plant with various treatments

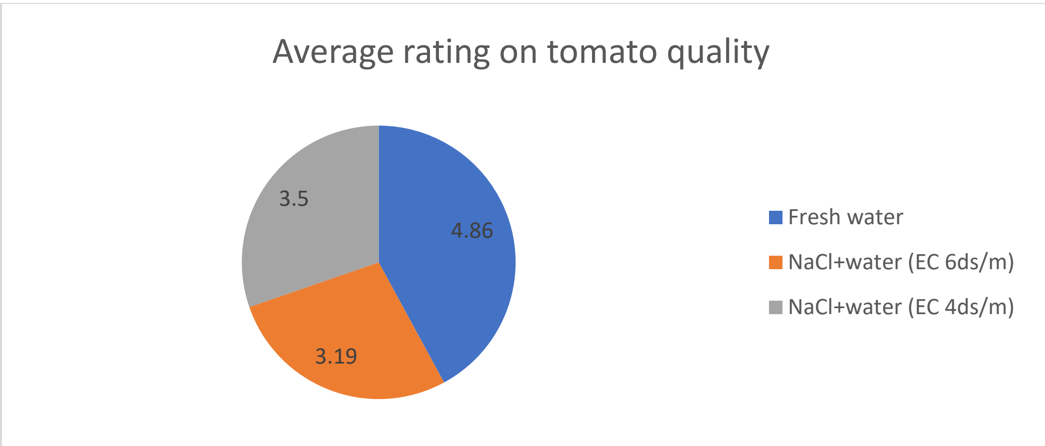


Fig. 3. Organoleptic test of tomato as influenced by three different growing media Photos related to research

Fig. 4. Installed drip system in field

Fig. 5. Transplantation of seedlings after 10days of germination

Fig. 6. Rock salt bag

Fig. 7. Adding of 250g of salt in 200L of water

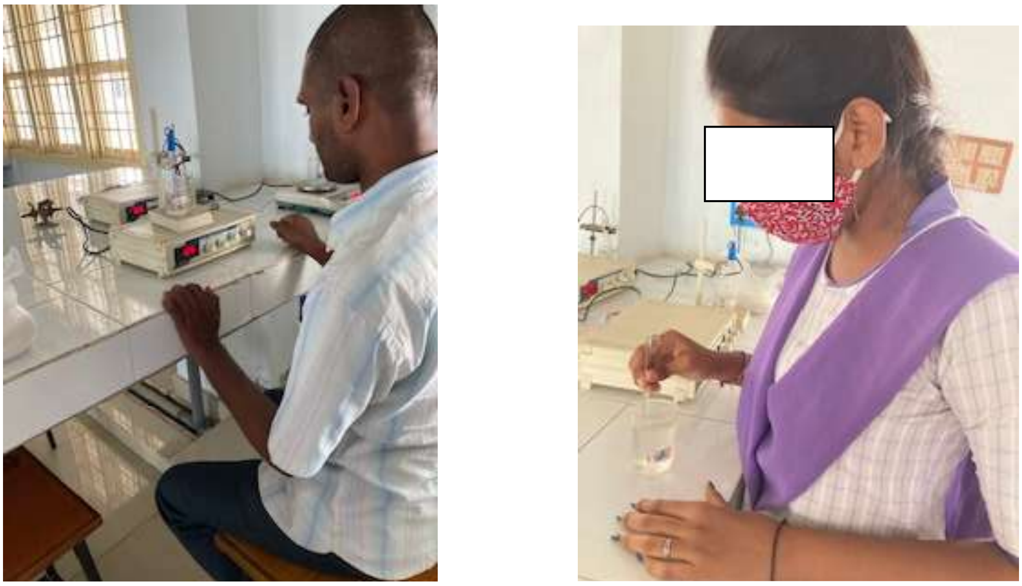


Fig. 8. Measuring of P^H and EC for two treatments

Fig. 9a. T1 | Fig.9b. T2 | Fig. 9c. T3

Fig. 9a-c. Field experiment

4.5 Cost of Cultivation

The total cost of cultivation required to cultivate the tomato crop in three different treatments with saline water and fresh water under drip irrigation system is the average cost Rs.6000 of cultivation which may be of because all the materials needed are easily available.

5. CONCLUSIONS

The tomato 'Pusa F1 hybrid' variety was used for this study. The experiment was done under drip irrigation system with three treatments of different EC levels (saline & normal). The statistical analysis of data was made, the important findings emerged out are summarized as under.

1. The results indicated that, the different treatments of fresh water significantly influenced the growth parameters of tomato like plant height, number of leaves per plant. The maximum plant height (69.4cm), number of leaves per plant (26) were recorded in treatment 1. Whereas, minimum plant height (59.8 & 62.1cm), number of leaves per plant (19 & 23) found in treatment of 2&3 with an EC of 6&4ds/m.
2. The variations in fruit weight (89.4g) were observed. It was maximum in treatment-1 and minimum fruit weight (48.2g&67.5g) was recorded in treatment -2&3with an EC of 6&4ds/m.
3. The organoleptic test had also shown variations for scores for different

characters. The treatment of fresh water (T-1) obtained maximum score (4.86) on average rating for all parameters, while the minimum score (3.19 & 4.2) was obtained in treatment of NaCl+ water (T-2&3) with an EC of 6&4ds/m as per the evaluation of six different people.

4. As stated above it shows the benefits of adoption of the drip irrigation system rather than the traditional methods and these results shows the possibility of drip irrigation with saline water having low salinity for higher yields(T-3).
5. The data from this experiment showed that the maximum yield of 3.78kg per plant was recorded in the treatment-1 which is related with fresh water.

The present investigation was undertaken to study the effect of saline water irrigation on growth and yield of tomato crop as concluded that the saline water irrigation leads to the reduction in the yield of 30% and 20% for the irrigation water salinity of 6ds/m and 4ds/m respectively as compared to the treatment irrigated with fresh water.

- C.M. Grieve's study concludes that salt tolerance data for vegetables has been condensed and presented in a uniform format based on the best available data. It also notes the existence of discrepancies and inconsistencies due to differences in cultivars, environments, and experimental conditions [8].
- Compare with C. M. Grieve’s study touch on the importance of salt tolerance in vegetable crops, they have different focuses. Our study provides specific experimental results regarding the effects of different irrigation treatments on tomato plants, while C.M. Grieve's study offers a broader perspective on salt tolerance in vegetable species.
- Yaming Zhai *et al.*, the study provides valuable insights into the effects of saline water irrigation on tomato crops. It emphasizes the importance of finding a balance between yield, quality, water use efficiency, and soil salinity when deciding on an irrigation scheme, especially in regions where saline water may be a significant water source. The optimal treatment identified (S1W3) serves as a practical recommendation for growers in northern China [9].
- Current research concludes that the fresh water irrigation T1 recorded the high-water use efficiency and the saline water irrigation treatments (T2&T3) having less water use efficiency may be due to the plants suffering with more soil moisture stress due to osmotic pressure build up by the saline water irrigation [10-15].

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
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