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# EFFECT OF SALINE AND SODIC WATER IRRIGATION ON NUTRIENT COMPOSITION OF *TALINUM FRUTICOSUM* (L.) JUSS

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**ABSTRACT**

*Talinum fruticosum* (L.) Juss. (Water leaf) is a perennial, nutritious leafy vegetable valued for its edible leaves, high protein, fiber, vitamins, minerals, fodder use, and medicinal properties. A pot experiment was conducted at Agricultural College and Research Institute, Killikulam, Tamil Nadu, to evaluate the influence of saline and sodic water irrigation on the nutrient composition of water leaf, grown in neutral soil (Inceptisol). Saline water with electrical conductivity ranging from 2 to 10 dS $m^{-1}$ and sodic water with soluble sodium percentage ranging from 20 to 80, alongside borewell water as control were utilized for irrigation. Plant samples were collected at different growth stages for nutrient analysis. Results revealed a increasing trend in green fodder yield up to moderate level of both salinity (T5-EC of 6 dS/m) and sodicity (T9–SSP 40) and significant decline in macro (N, P, K, Ca & Mg) and micro nutrients (Fe, Zn, Mn & Cu) with increasing salinity and sodicity, while sodium accumulation increased under sodic irrigation. The highest nutrient contents were observed at EC < 1 dS $m^{-1}$ and SSP < 10, and the lowest at EC 10 dS $m^{-1}$ and SSP 80. The decline in nutrient levels was attributed to ionic antagonism, osmotic stress, and reduced nutrient uptake. Overall, the nutrient balance and quality of *T. fruticosum* were negatively impacted by salty and sodic water; yet, yields reached moderate levels, suggesting that *Talinum fruticosum* is suitable for marginal lands and has the potential to provide both economic and nutritional support in salt affected areas.
***Keywords*** **:** Saline water, sodic water, *Talinum fruticosum*, yield, nutrient composition.

## Introduction

Twenty per cent of the world's irrigated farmland accounts for nearly 40% of worldwide agricultural production, demonstrating that irrigation and other management practices have more than doubled land productivity in arid conditions. The total salt-affected area in India is estimated at about 6.72 million hectares, accounting for roughly 2.1 % of the country's geographical area (Kumar and Sharma, 2020). Of this, approximately 2.95 million hectares are saline soils, while about 3.77 million hectares are sodic soils. Additionally, sodic or saline sodic groundwater makes up around 44% of the northern state's irrigation groundwater. Farmers are forced to use this poor-quality groundwater to meet crop irrigation needs because of the extreme lack of fresh water in dry and semi-arid regions (Makarana *et al.,* 2023). Nevertheless, freshwater resources for irrigation are shrinking in arid and semi-arid regions due to increasing urban water use. As a result, it is usual in those areas to irrigate agricultural land using lower quality water (e.g., treated wastewater, saline water, effluent, drainage, and groundwater).

To avoid secondary salinization in the soil and a more significant reduction in soil quality, irrigation water efficiency and quality must be taken into account. It is undisputed that salinity and alkalinity are the most accepted water quality parameters of concern. Saline water has higher proportion of total dissolved salts resulting in salt built up in the soil. Sodicity, on the other hand, is related to the higher proportion of Na in the irrigation water in comparison to calcium and magnesium. Sodic water irrigation has a negative impact on soil physical, chemical and biological properties and adversely affects crop productivity. The problem of sodicity becomes worse when the carbonate and bicarbonate associates with sodium. A low concentration of soluble salt is a characteristic of high RSC irrigation water. The proportion of calcium and magnesium are significantly lower than those of sodium salts. Typically, sodium carbonate is the predominant salt found in these waters. Long term usage of this type of water immobilizes the soils soluble calcium and magnesium by precipitating them as carbonates; as a result, the concentration of sodium in the soil solution and exchangeable complex increases, resulting in the formation of sodic conditions (Yadav *et al.,* 2022). Saline and sodic water affect plants by causing abiotic stressors such as reduced transpiration and a specific toxic ion impact.

*Talinum fruticosum* (L.) Juss. (Water leaf) is a perennial, non-conventional, herbaceous and glabrous plant (Ezekwe *et al.,* 2002) that belongs to the family Talinaceae. This is an edible leafy vegetable besides fodder utility. Cultivation of this leafy vegetable is common in Nigeria and Cameroon where it is propagated by both seed and cuttings. Talinum species produces heterogeneous population though it is self-pollinated due to the insect pollination (Nya and Eka, 2015).

Nutritionally, waterleaf has been proven to be high in crude-protein (22.1%), ash (33.98%) and crude fiber (11.12%). In addition, the essential nutrients viz., B-carotene, calcium, potassium, magnesium, pectin, vitamins and other minerals also present in sufficient proportion. It is eaten as a vegetable throughout the tropical regions, including many West and Central African countries. The leaves and young shoots are widely used in secondary agriculture especially thicken sauce (Ibeawuchi *et al.,* 2007). It also possesses medicinal values for specific human ailments. Biomass of this plant is used as feed (green forage) for rabbits (Ekpenyong, 1986; Aduku and Olukosi, 1990). In addition, waterleaf production provides a complementary source of income to small-scale farming households (Udoh, 2005).

Seedlings of *Talinum fruticosum* (L.) Juss. were observed to tolerate salinity levels from 0 to 560 mM NaCl (Bamidele *et al.,* 2007). It survives well in alkaline soil too (Lal *et al.,* 2008). This plant is often tested for phytoremediation of Iron (Fe) from contaminated soil (Owonubi *et al.,* 2022), metal ions such as Cobalt, lead and Zinc ion concentrations (Ebere *et al.,* 2016). But till date, the yield and nutrient composition under poor quality irrigation water for this plant is less attempted. Hence, an attempt is made to assess the yield and nutrient composition of *Talinum fruticosum (L.) Juss.* under varying level of saline and sodic water irrigation.

## Materials and Methods

The experimental design was carried out by adopting pot culture experiment using a completely randomized block (CRD) design with two replications. The pots were filled with the collected neutral soil (Inceptisol) except for the top 5 cm. For planting, uniform sized, single stem cuttings of *Talinum fruticosum* were used. The leaves and branches of the cutting were removed and buried in soil at a depth of 5-7.5 cm below the soil surface, with adequate watering. For irrigation, saline and sodic water with differing concentrations were utilized. Saline water having varying level of EC (2 to 10 dS $m^{-1}$) (T2 -T6) being artificially stimulated by taking into account the relationship between EC and total dissolved salt, which is expressed as TDS (mg/L) = EC x 640. To create saline water with the desired EC, a 4:2:1 salt mixture of $CaCl_2$-$MgCl_2$-NaCl was used. Taking into account the initial sodium content in the irrigation water, sodium carbonate was used to artificially create sodic water with seven levels of soluble sodium percentage (SSP (T7 -T13); 20, 30, 40, 50, 60, 70, and 80). Bore well water is considered as control (T1) for both salinity and sodicity as it has an EC and SSP values of < 1 dS/m and < 10, respectively.

The green fodder was harvested during each cut was weighed separately for each treatment and recorded. The first harvest took place at 90 days after planting whereas subsequent harvests were made at a interval of 25 days after the first cut. Fresh weight of leaf and stem taken separately for each treatment and the weight were recorded in gram. At each cutting, the plant samples were collected from the individual pots and were first air dried, then dried in hot air oven at $60^{0}$C and made into powder by using Willey Mill and analysed for nitrogen content using micro kjeldahl method by diacid extraction (Humphries, 1956). Phosphorus was measured using Vanadomolybdate yellow colour method by triacid extraction following Piper (1966). The potassium and sodium content were analysed using flame photometry method by triacid extraction, as outlined by Jackson (1973). The calcium and magnesium content were measured using versenate method by triacid extraction developed by Jackson (1973). Micronutrients including iron, zinc, manganese and copper were analysed using Atomic Absorption Spectrophotometer (AAS) method using triple acid extract, as detailed by Lindsay and Norvell (1978).

## Results and Discussion

### Yield parameter

The green fodder yield of *Talinum fruticosum* was significantly influenced by saline and sodic water irrigation (Table 1). In salinity irrigation, the highest green fodder yield of 131.5 g and 35.5 g was recorded in water leaf irrigated with water having a EC of 6 dS/m (T5) during the first and fourth harvest whereas the lowest green fodder yield of 92 g and 28 g was recorded in T6 (EC 10 dS/m). In case of sodic water irrigation, the highest green fodder yield of 108 g and 29.5 g was recorded in T9 (SSP 40) and the lowest green fodder yield of 65.5 g and 61 g was recorded in T13 (SSP 80) during the first and fourth harvest. Control observed for the green fodder yield of 95 and 30.50 g, respectively on first and fourth harvest. Among all the treatments, T4 (EC 6 dS/m) and T9 (SSP 40) both performed well when irrigated with saline and sodic water, respectively. Salinity and Sodicity hazard of irrigation water has a substantial impact on the production of green fodder of water leaf. In sodic water irrigation, the lowest green fodder yield obtained under water leaf irrigated with irrigation water having SSP of 80 and this is owing to the significant accumulation of Na and competitiveness of Na+ ions (Tuna *et al.,* 2007), associated quality detoriation of physical and chemical properties of the soil (Choudhary *et al.,* 2006). The decreased yied under higher salinity (EC 10 dS/m) was due to the reduced water absorption, (Dorai *et al.,* 2001) which leads to reduced nutrient absorption (Shannon *et al.,* 2000) and a reduction in the production of fodder (Thi *et al.,* 2021).

**Table 1 :** Effect of saline and sodic water on the green fodder yield of *Talinum fruticosum*

| Treatments | Green fodder yield (g/plant) | | | |
|---|---|---|---|---|
| | 1$^{st}$ harvest (90 DAP) | 2$^{nd}$ harvest (115 DAP) | 3$^{rd}$ harvest (140 DAP) | 4$^{th}$ harvest (165 DAP) |
| $T_1$- EC < 1 dS $m^{-1}$ & SSP < 10 | 95.00 | 90.50 | 77.00 | 30.50 |
| $T_2$- EC 2 dS $m^{-1}$ | 111.50 | 98.00 | 62.00 | 31.00 |
| $T_3$- EC 4 dS $m^{-1}$ | 115.00 | 96.00 | 71.00 | 30.00 |
| $T_4$- EC 6 dS $m^{-1}$ | 131.50 | 119.00 | 75.00 | 35.50 |
| $T_5$- EC 8 dS $m^{-1}$ | 129.00 | 114.00 | 73.00 | 32.00 |
| $T_6$- EC 10 dS $m^{-1}$ | 92.00 | 94.00 | 81.00 | 28.00 |
| $T_7$- SSP 20 | 98.00 | 95.00 | 82.00 | 27.00 |
| $T_8$- SSP 30 | 103.00 | 96.00 | 81.50 | 29.00 |
| $T_9$- SSP 40 | 108.00 | 100.00 | 83.00 | 29.50 |
| $T_{10}$- SSP 50 | 106.00 | 97.00 | 83.00 | 24.50 |
| $T_{11}$- SSP 60 | 85.00 | 70.00 | 51.00 | 16.00 |
| $T_{12}$- SSP 70 | 75.12 | 53.00 | - | - |
| $T_{13}$- SSP 80 | 65.50 | 61.00 | - | - |
| **SEd** | **2.12** | **1.83** | **1.43** | **1.17** |
| **CD (P=0.05)** | **4.58** | **3.97** | **3.09** | **2.52** |

*DAP – days after planting

### Nutrient composition

### Macronutrients

Saline and sodic water irrigation influenced the nitrogen content of water leaf appreciably. The highest nitrogen content of 17.05 g/ kg was recorded in water leaf grown with irrigation water having EC of < 1 dS / m (T1) and the lowest nitrogen content (15.82 g / kg) was found in water leaf irrigated with water having EC of 10 dS/m (T6), during the first harvest (Table 2). Under irrigation with sodic water, the highest nitrogen content of 17.05 g / kg was detected in water leaf grown with irrigation water having SSP of < 10 (T1) and the lowest nitrogen content of 15.52 g/kg was found from T13 (irrigation water SSP 80), during the first harvest. From second, third and fourth harvesting, a similar pattern of nitrogen with a declining tendency was noticed. Increasing salinity and sodicity hazard reduced the nitrogen concentration in water leaf. In similar fashion, nitrogen concentration in water leaf droped during successing harvest. Higher concentration of chloride from saline water restricts the absorption of $NO_3^-$ which might be reason for reduced N content with increasing salinity of irrigation water (Munns and Gilliham, 2015). Sodic water irrigation decreases the nitrogen content in plants due to the osmotic adjustment of the plants to sodic treatments or due to growth dilution (Al-Rawahy *et al.,* 1992).

Water leaf irrigated with salty water having a EC of < 1 dS/m (T1) recorded higher phosphorus content of 1.69 g/kg (Table 2), whereas the treatment T6 (EC 10 dS/m) registered the least phosphorus content (1.47 g/kg). In case of sodic water irrigation, treatment T1 (SSP < 10) and T7 (SSP 80) observed for the highest (1.69 g/kg) and least P content (1.48 g/kg) in water leaf. The phosphorus content showed a similar pattern with decreasing trend from first to fourth harvesting. Similar to nitrogen, phosphorus content of water leaf also decreased with increasing salinity and sodicity hazard of irrigation water as well as with progressive of harvesting. The higher availability of $Cl^-$ and $H_2SO_4^-$ restricts P availability to plants as these ions are antagonistic to phosphorous (Parihar *et al.,* 2015) and as a result, P content in water leaf plants reduced with increasing salinity and sodicity. P availability under alkaline environment is meagre due to increased P sorption in soil (Marschner, 2011) which leads to less availability and absorption of P by the plants. This might be the reason for the reduced P content of water leaf when irrigated with sodic water.

Salinity and sodicity of irrigation water affected the potassium content of water leaf notably. The highest (20.75 g/kg) and least K content (19.40 g/kg) was observed in water leaf irrigated with water having EC value of 2 dS/m (T2) and 10 dS/m (T6), respectively. In case of sodic water irrigation, treatment T2 and T13 registered for the highest (21.36 g/kg) and lowest (18.17 g/kg) potassium content, respectively in water leaf. With each harvest, the potassium content progressively declined (Table 2). The potassium content of water leaf significantly varies with saline and sodic water irrigation. Further, the potassium content of water leaf decreased as harvesting continues. The lowest potassium level under irrigation with saline and sodic water was found in EC 10 dS/m and SSP 80. Potassium content of water leaf decreased with sodic water irrigation due to the similarity of $K^+$ and $Na^+$ in physical and chemical properties at soil exchangeable sites. Further, potassium uptake in plants is primarily inhibited as higher concentration of Na have a greater tendency to compete with potassium in the major binding sites, including the regulation of enzymatic activity that takes place at unfavorable cytosolic $K^+/Na^+$ ratios, (Adams and Shin, 2014; Benito *et al.,* 2014). In case of saline water application, the amount of K that was readily available was decreased, limiting plant K absorption and crop yield (Moterle *et al.,* 2016).

**Table 2 :** Effect of saline and sodic water on the macro nutrient composition of *Talinum fruticosum* at different harvest

| Treatments | Nitrogen content (g/kg) | | | | Phosphorus content (g/kg) | | | | Potassium content (g/kg) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | I | II | III | IV | I | II | III | IV |
| $T_1$- EC <1 dS $m^{-1}$ & SSP < 10 | 17.05 | 16.80 | 16.55 | 16.30 | 1.69 | 1.64 | 1.59 | 1.54 | 20.94 | 20.60 | 20.26 | 19.92 |
| $T_2$- EC 2 dS $m^{-1}$ | 17.02 | 16.77 | 16.52 | 16.27 | 1.67 | 1.61 | 1.55 | 1.49 | 20.75 | 20.03 | 19.92 | 19.20 |
| $T_3$- EC 4 dS $m^{-1}$ | 16.89 | 16.64 | 16.39 | 16.14 | 1.59 | 1.54 | 1.49 | 1.44 | 20.14 | 19.94 | 19.13 | 18.93 |
| $T_4$- EC 6 dS $m^{-1}$ | 16.44 | 16.19 | 15.94 | 15.69 | 1.56 | 1.52 | 1.48 | 1.44 | 19.60 | 19.40 | 18.70 | 18.50 |
| $T_5$- EC 8 dS $m^{-1}$ | 16.18 | 15.93 | 15.68 | 15.43 | 1.53 | 1.50 | 1.47 | 1.44 | 19.50 | 19.20 | 18.50 | 18.20 |
| $T_6$- EC 10 dS $m^{-1}$ | 15.82 | 15.57 | 15.32 | 15.07 | 1.47 | 1.45 | 1.43 | 1.41 | 19.40 | 18.90 | 18.40 | 17.80 |
| $T_7$- SSP 20 | 16.49 | 16.24 | 15.99 | 15.74 | 1.66 | 1.62 | 1.58 | 1.54 | 21.36 | 20.02 | 18.68 | 17.34 |
| $T_8$- SSP 30 | 16.40 | 16.15 | 15.90 | 15.65 | 1.63 | 1.59 | 1.55 | 1.51 | 20.96 | 19.95 | 18.75 | 17.74 |
| $T_9$- SSP 40 | 16.31 | 16.06 | 15.81 | 15.56 | 1.60 | 1.57 | 1.54 | 1.51 | 20.45 | 19.45 | 18.20 | 17.20 |
| $T_{10}$- SSP 50 | 16.24 | 15.99 | 15.74 | 15.49 | 1.57 | 1.52 | 1.47 | 1.42 | 19.60 | 19.10 | 17.10 | 16.60 |
| $T_{11}$- SSP 60 | 16.15 | 15.90 | 15.65 | 15.40 | 1.53 | 1.49 | 1.45 | 1.41 | 18.78 | 17.37 | 15.96 | 14.55 |
| $T_{12}$- SSP 70 | 15.95 | 15.70 | - | - | 1.50 | 1.46 | - | - | 18.58 | 16.81 | - | - |
| $T_{13}$- SSP 80 | 15.52 | 15.27 | - | - | 1.48 | 1.44 | - | - | 18.17 | 16.03 | - | - |
| **SEd** | **0.24** | **0.19** | **0.14** | **0.10** | **0.06** | **0.04** | **0.03** | **0.01** | **0.25** | **0.22** | **0.18** | **0.15** |
| **CD (P=0.05)** | **0.51** | **0.42** | **0.30** | **0.22** | **0.12** | **0.09** | **0.06** | **0.03** | **0.54** | **0.50** | **0.40** | **0.33** |

*DAP – days after planting, SSP – Soluble Sodium Percentage
*I - 1st harvest (90 DAP), II – 2nd harvest (115 DAP), III – 3rd harvest (140 DAP), IV – 4th harvest (165 DAP)

The calcium content of water leaves was significantly impacted by the salinity and sodicity of irrigation water (Table 3). The water leaf watered with water having EC values of 1 dS/m (T1) and 10 dS/m (T6), respectively, had the highest (5.80 g/kg) and lowest (4.89 g/kg) calcium contents. Treatments T7 and T13 recorded the highest (5.90 g/kg) and lowest (4.03 g/kg) calcium contents in water leaf while using sodic water irrigation, during the first harvest. The calcium concentration decreased progressively with each harvest in water leaf. Calcium concentration of water leaf fluctuates dramatically when salinity and sodicity level rises. Subsequent harvesting results in the reduction of calcium content in water leaf. Sodium and calcium ions have antagonistic relationship and hence, availability of calcium ios reduced when soils irrigated with sodic water leading to the reduced uptake of Ca by plants (Kopittke, 2012). The higher and toxic effects ions under saline irrigation alters membrane characteristics adversely resulting to the reduced Ca uptake by plants (Rengel, 1992).

The magnesium content of water leaves was significantly altered by irrigation with saline and sodic water (Table 3). During the first harvest, water leaf with irrigation water having an EC of 1 dS/m (T1) had the highest magnesium content (7.24 g/ kg), and water leaf with irrigation water having an EC of 10 dS/m (T6) had the lowest magnesium content (5.73 g/ kg). The water leaf grown with irrigation water having an SSP of < 10 (T1) had the maximum magnesium content, which was 7.24 g/kg, and the leaf grown with irrigation water having an SSP of 80 (T13), which had the lowest magnesium content, which was 5.67 g/kg, was discovered during the first harvest. A similar pattern of magnesium with a falling level was seen during the second through fourth harvestings. The influence of saline and sodic water irrigation on magnesium concentration of water leaf was similar to that of calcium. followed similar pattern is considerably affected by irrigation with saline and sodic water. The magnesium level reduced as the harvesting process continues. The competition between Ca, Mg, and Na for uptake by the plant may be to held responsible for the decrease in magnesium concentration (Edelstein *et al.,* 2005). Further, $Na^+$ interferes with the absorption of $K^+$, $Ca^{2+}$, and $Mg^{2+}$ by plants in soil by competing with their ions (Pereira *et al.,* 2016).

Treatment T6 (EC 10 dS/m) recorded the least sodium content (1.72 g/kg) in water with saline water irrigation whereas control treatment (EC < 1 dS/m; T1) recorded a greater sodium content of 1.89 g/kg (Table 3). In case of sodic water irrigation, treatments T1 (SSP < 10) and T7 (SSP 80) observed for the lowest (1.72 g/kg) and highest (2.40 g/kg) sodium contents in the water leaf, respectively. With each harvest, the sodium content gradually decreased under saline water irrigation whereas it was gradually increased with sodic water irrigation. The sodium concentration of water leaves irrigated with saline water decreased as harvesting progressed, but it grew under sodic water irrigation. In addition to the built-in control mechanism in plants for Na ion regulation, saline water irrigation utilized for irrigation has a relatively lower sodium concentration than calcium and magnesium, which lowers sodium absorption (Allen and Cunningham 1983; Evelin *et al.,* 2009; Kapoor *et al.,* 2013). The increased availability of sodium ions and their cumulative impact on the amount of sodium in plants are the causes of the increased sodium buildup in water leaf as a result of the sodicity hazard (Tal *et al.,* 1991).

**Table 3 :** Effect of saline and sodic water on the mineral composition of *Talinum fruticosum* at different harvest

| **Treatments** | **Calcium content (g/kg)** | | | | **Magnesium content (g/kg)** | | | | **Sodium content (g/kg)** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **I** | **II** | **III** | **IV** | **I** | **II** | **III** | **IV** | **I** | **II** | **III** | **IV** |
| $T_1$- EC <1 dS $m^{-1}$ & SSP < 10 | 5.80 | 5.70 | 5.60 | 5.50 | 7.24 | 6.98 | 6.72 | 6.46 | 1.89 | 1.83 | 1.79 | 1.75 |
| $T_2$- EC 2 dS $m^{-1}$ | 5.74 | 5.68 | 5.62 | 5.56 | 6.98 | 6.75 | 6.52 | 6.29 | 1.87 | 1.81 | 1.74 | 1.67 |
| $T_3$- EC 4 dS $m^{-1}$ | 5.63 | 5.52 | 5.41 | 5.30 | 6.75 | 6.54 | 6.33 | 6.21 | 1.82 | 1.79 | 1.72 | 1.65 |
| $T_4$- EC 6 dS $m^{-1}$ | 5.46 | 5.29 | 5.12 | 4.95 | 6.54 | 6.43 | 6.32 | 6.12 | 1.78 | 1.74 | 1.68 | 1.62 |
| $T_5$- EC 8 dS $m^{-1}$ | 5.17 | 4.88 | 4.59 | 4.30 | 6.43 | 5.73 | 5.03 | 4.33 | 1.73 | 1.69 | 1.67 | 1.65 |
| $T_6$- EC 10 dS $m^{-1}$ | 4.89 | 4.61 | 4.33 | 4.05 | 5.73 | 5.53 | 5.33 | 5.13 | 1.72 | 1.69 | 1.66 | 1.63 |
| $T_7$- SSP 20 | 5.90 | 5.80 | 5.70 | 5.60 | 6.87 | 6.73 | 6.59 | 6.45 | 1.88 | 2.08 | 2.33 | 2.58 |
| $T_8$- SSP 30 | 5.78 | 5.66 | 5.54 | 5.42 | 6.73 | 6.57 | 6.41 | 6.25 | 1.93 | 2.13 | 2.38 | 2.63 |
| $T_9$- SSP 40 | 5.42 | 5.06 | 4.70 | 4.34 | 6.57 | 6.42 | 6.27 | 6.12 | 2.06 | 2.26 | 2.51 | 2.76 |
| $T_{10}$- SSP 50 | 5.13 | 4.84 | 4.55 | 4.26 | 6.42 | 6.14 | 5.86 | 5.58 | 2.15 | 2.35 | 2.60 | 2.85 |
| $T_{11}$- SSP 60 | 4.86 | 4.59 | 4.32 | 4.05 | 6.14 | 5.90 | 5.66 | 5.42 | 2.20 | 2.40 | 2.65 | 2.90 |
| $T_{12}$- SSP 70 | 4.42 | 3.98 | - | - | 5.90 | 5.67 | - | - | 2.34 | 2.54 | - | - |
| $T_{13}$- SSP 80 | 4.03 | 3.64 | - | - | 5.67 | 5.47 | - | - | 2.40 | 2.60 | - | - |
| **SEd** | **0.12** | **0.11** | **0.09** | **0.07** | **0.21** | **0.19** | **0.17** | **0.15** | **0.14** | **0.11** | **0.08** | **0.05** |
| **CD (P=0.05)** | **0.28** | **0.24** | **0.20** | **0.17** | **0.45** | **0.42** | **0.37** | **0.33** | **0.30** | **0.24** | **0.17** | **0.11** |

*DAP – days after planting, SSP – Soluble Sodium Percentage
*I - $1^{st}$ harvest (90 DAP), II – $2^{nd}$ harvest (115 DAP), III – $3^{rd}$ harvest (140 DAP), IV – $4^{th}$ harvest (165 DAP

## Micronutrients

Saline and sodic water irrigation influenced the iron content of water leaf appreciably. The highest iron content of 31.87 mg/kg was recorded in water leaf grown with irrigation water having EC < 1 dS/m (T1) and the lowest iron content (29.78 mg/kg) was found in water leaf irrigated with water having EC of 10 dS/m (T6), during the first harvest (Table 4). Under irrigation with sodic water, the highest iron content of 31.87 mg/kg was detected in water leaf grown with irrigation water having SSP < 10 (T1) and the lowest iron content of 31.87 mg/kg was found from T13 (irrigation water SSP 80), during the first harvest. From second, third and fourth harvesting, a similar pattern of iron with a declining tendency was noticed. Iron content of water leaf significantly decreased with increasing salinity and sodicity hazard in irrigation water. With successive harvesting, iron concentration in water lead declined sequentially. Least iron content in water leaf was observed from the T7 (EC 10 dS/m) and T13 (SSP 80). Reduced Fe content in the water leaf under saline irrigation was due to the precipitation of Fe as $Fe_2(SO_4)_3$ by the sulfate ions from saline water in addition to the reduced water absorption in association with reduced nutrient uptake (Hassan *et al.,* 1970). Sodicity stress restricted the plant's ability to absorb iron from soil (Rabhi *et al.,* 2007) and adverse influence of enhanced sodium on the soil solution might hinders the availability and absorption of Fe which might be probable reason for the reduced iron content in water leaf irrigated with sodic water. Bekmirzaev *et al.* (2021) reported a similar inference.

Salinity and sodicity of irrigation water affected the zinc content of water leaf notably. The highest (17.42 mg/kg) and least zinc content (15.02 mg/kg) was observed in water leaf irrigated with water having EC value of < 1 dS/m (T1) and 10 dS/m (T6), respectively. In case of sodic water irrigation, treatment T1 and T13 registered for the highest (17.42 mg/kg) and lowest (14.58 mg/kg) potassium content, respectively in water leaf. With each harvest, the zinc content progressively declined (Table 4). Zinc being a cationic nutrient noticed a similar trend as that of iron in plant composition of water leaf. Higher pH and more $HCO_3^-$ concentrations in soil solutions due to sodic water irrigation hinders root development and function and may result in a decline in the levels of zinc, iron, manganese, and copper (Rietz and Haynes, 2002; Romheld and Marschner, 1986). The reduced water uptake due to altered osmotic concentration of soil solution and imbalance of nutrients might be the reduced Zn content of water leaf irrigated with saline water.

The manganese content of water leaves was significantly impacted by the salinity and sodicity of irrigation water. The water leaf watered with water having EC values of < 1 dS/m (T1) and 10 dS/m (T6), respectively, had the highest (9.32 mg/kg) and lowest (8.14 mg/kg) manganese contents (Table 4). Treatments T1 and T13 recorded the highest (9.32 mg/kg) and lowest (8.02 mg/kg) manganese contents in water leaf while using sodic water irrigation, during the first harvest. The manganese concentration decreased progressively with each harvest in water leaf. As irrigation water's salinity and sodicity hazards increased, the iron content of water leaf considerably reduced. Iron concentration in water leaf sequentially declined with each harvest. Water leaf obtained from T7 (EC 10 dS/m) and T13 (SSP 80) had the least iron content. Lower manganese ion activity in solution, interference of Mn absorption by cations like sodium and calcium (Cramer *et al.,* 1991), manganese uptake and concentrations in leaves were significantly reduced (Cramer *et al.,* 1986; Shennan *et al.,* 1990) under saline and sodic water irrigation.

The copper content of water leaves was significantly altered by irrigation with saline and sodic water (Table 4). During the first harvest, water leaf with irrigation water having an EC of 1 dS/m (T1) had the highest copper content (2.13 mg/ kg), and water leaf with irrigation water having an EC of 10 dS/m (T6) had the lowest copper content (1.63 mg/ kg). The water leaf grown with irrigation water having an SSP of < 10 (T1) had the maximum copper content, which was 2.13 mg/kg, and the leaf grown with irrigation water having an SSP of 80 (T13), which had the lowest copper content, which was 1.71 mg/kg, was discovered during the first harvest. A similar pattern of copper with a falling level was seen during the second through fourth harvestings. The influence of saline and sodic water irrigation on copper concentration of water leaf followed similar pattern as like that of Fe, Mn and Zn. The reduced root development due to the salinity and sodicity hazard (Ma *et al.,* 2016) might be prominent factor for the reduced Cu absorption by water leaf plants in addition to the restricted mobility of copper in the soil (Hassan *et al.,* 1970) as well as low available copper in the soil solution.

**Table 4 :** Effect of saline and sodic water on the micronutrients composition of *Talinum fruticosum* at different harvest

| Treatments | Iron content (mg/kg) | | | | Zinc content (mg/kg) | | | | Manganese content (mg/kg) | | | | Manganese content (mg/kg) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **I** | **II** | **III** | **I** | **II** | **III** | **IV** | **IV** | **I** | **II** | **III** | **IV** | **I** | **II** | **III** | **IV** |
| $T_1$- EC <1 dS $m^{-1}$ & SSP < 10 | 31.87 | 31.76 | 31.59 | 9.32 | 17.42 | 17.25 | 17.08 | 16.91 | 2.13 | 1.96 | 1.92 | 1.88 | 9.32 | 9.15 | 9.03 | 8.91 |
| $T_2$- EC 2 dS $m^{-1}$ | 31.32 | 31.22 | 31.06 | 9.02 | 16.89 | 16.73 | 16.57 | 16.41 | 1.98 | 1.91 | 1.89 | 1.87 | 9.02 | 8.86 | 8.75 | 8.64 |
| $T_3$- EC 4 dS $m^{-1}$ | 30.91 | 30.82 | 30.67 | 8.85 | 16.32 | 16.17 | 16.02 | 15.87 | 1.86 | 1.80 | 1.78 | 1.76 | 8.85 | 8.70 | 8.62 | 8.54 |
| $T_4$- EC 6 dS $m^{-1}$ | 30.36 | 30.28 | 30.14 | 8.67 | 15.91 | 15.77 | 15.63 | 15.49 | 1.82 | 1.76 | 1.74 | 1.72 | 8.67 | 8.53 | 8.47 | 8.41 |
| $T_5$- EC 8 dS $m^{-1}$ | 30.02 | 29.95 | 29.82 | 8.39 | 15.36 | 15.23 | 15.10 | 14.97 | 1.72 | 1.69 | 1.65 | 1.61 | 8.39 | 8.26 | 8.18 | 8.10 |
| $T_6$- EC 10 dS $m^{-1}$ | 29.78 | 29.72 | 29.60 | 8.14 | 15.02 | 14.90 | 14.78 | 14.66 | 1.63 | 1.61 | 1.60 | 1.59 | 8.14 | 8.02 | 7.95 | 7.88 |
| $T_7$- SSP 20 | 31.24 | 31.14 | 30.98 | 8.94 | 16.78 | 16.53 | 16.46 | 16.39 | 2.01 | 1.98 | 1.96 | 1.94 | 8.94 | 8.78 | 8.67 | 8.56 |
| $T_8$- SSP 30 | 30.96 | 30.87 | 30.72 | 8.69 | 16.24 | 16.09 | 15.94 | 15.79 | 1.94 | 1.91 | 1.87 | 1.83 | 8.69 | 8.54 | 8.44 | 8.34 |
| $T_9$- SSP 40 | 30.47 | 30.39 | 30.25 | 8.46 | 15.96 | 15.82 | 15.68 | 15.54 | 1.86 | 1.83 | 1.81 | 1.79 | 8.46 | 8.32 | 8.23 | 8.14 |
| $T_{10}$- SSP 50 | 30.12 | 30.05 | 29.86 | 8.33 | 15.47 | 15.34 | 15.21 | 15.08 | 1.81 | 1.79 | 1.79 | 1.79 | 8.33 | 8.20 | 8.12 | 8.04 |
| $T_{11}$- SSP 60 | 29.94 | 29.88 | 29.76 | 8.27 | 15.12 | 15.00 | 14.88 | 14.76 | 1.76 | 1.75 | 1.74 | 1.73 | 8.27 | 8.15 | 8.08 | 8.01 |
| $T_{12}$- SSP 70 | 29.58 | 29.53 | - | 8.15 | 14.94 | 14.83 | - | - | 1.73 | 1.72 | - | - | 8.15 | 8.04 | - | - |
| $T_{13}$- SSP 80 | 29.12 | 29.02 | - | 8.02 | 14.58 | 14.48 | - | - | 1.71 | 1.69 | - | - | 8.02 | 7.92 | - | - |
| **SEd** | **0.28** | **0.25** | **0.20** | **0.21** | **0.18** | **0.15** | **0.14** | **0.16** | **0.27** | **0.24** | **0.18** | **0.16** | **0.21** | **0.18** | **0.15** | **0.14** |
| **CD (P=0.05)** | **0.61** | **0.54** | **0.44** | **0.45** | **0.39** | **0.33** | **0.30** | **0.36** | **0.59** | **0.51** | **0.39** | **0.36** | **0.45** | **0.39** | **0.33** | **0.30** |

## Conclusion

The present study revealed that *Talinum fruticosum* exhibited considerable tolerance to moderate levels of salinity and sodicity. The green fodder yield was significantly increased by irrigating the plants with sodic water of SSP level up to 40 and saline water of EC level up to 6 dS $m^{-1}$. Controlled salinity and sodicity levels dramatically decreased macro and micro nutrients (N, P, K, Ca, Mg, Fe, Zn, Mn and Cu) contents, and increased sodium accumulation in plant parts. The decline of nutrient concentrations in plant tissues was due to ionic imbalance, osmotic stress, and limited nutrient absorption under the conditions of impaired water quality.

The adverse effects of salinity and sodicity on the nutrient composition and quality of vegetables can to some extent be overcome by *T. fruticosum*, which is moderately productive and can be grown as a leafy vegetable on marginal lands and salt-affected soils and should be promoted for improved food and fodder security in water-scarce areas.

### Conflict of Interest/Competing Interest:

- The authors have no relevant financial or non-financial interests to disclose.
- The authors have no conflicts of interest to declare that are relevant to the content of this article.
- All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.
- The authors have no financial or proprietary interests in any material discussed in this article.

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