# EFFECT ON GROWTH PERFORMANCE AND BIOCHEMICAL CONTENTS OF *SALVADORA PERSICA* WHEN IRRIGATED WITH WATER OF DIFFERENT SALINITY

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## SUMMARY

**An experiment was conducted in pots to study the effects of saline water of different salinity on growth performance, salt-accumulation and biochemical contents in *Salvadora persica* at establishment stage using calcareous soil. The observations indicated that all the growth parameters such as height, stump diameter and plant biomass decreased with the increase in the salinity of irrigation water and a total reduction in dry biomass of the plant was 31.59% when irrigated with water of 16 dS $m^{-1}$ as compared to good quality tap water. Concentration of sodium in different parts of plant indicated that maximum retention was in root followed by stem, leaf and minimum in thin branches and it increased with the increase in salinity of irrigation water. Potassium content was maximum in leaf in all the treatments and almost evenly distributed in other parts. Its accumulation decreased with increase in salinity of irrigation water. Both calcium and magnesium contents were maximum in leaf followed by root. These were almost equal in stem and thin branches. In leaf samples, proline and other amino acids increased and chlorophyll, protein and sugar contents decreased with the increase in salinity of irrigation water.**

***Key words*: Electrical conductivity, halophyte, proline, *Salvadora persica*, soil salinity**

## INTRODUCTION

Worldwide the soil salinity has become a major agricultural threat. Substantial areas of earth's potentially productive lands are affected by salinity and alkalinity. In India out of 9.38 million ha salt-affected soils, 3.88 million ha are alkali soil and 5.5 million ha (including coastal sands) saline soils (IAB 2000). About 25 to 84% of total ground water in arid and semi-arid region of the country, are reported to be saline in nature (Minhas 1999). The use of saline soils and brackish groundwater for growing plants of varying economic utilities, thus assumes utmost importance in this region.

*Salvadora persica* Linn. (commonly known as Jaal) of family Salvadoraceae is much-branched, evergreen shrub or a tree found in dry and arid regions of India particularly on alkaline and saline lands and in coastal regions of Gujarat just above the high water mark. Its fodder is lopped for camels. The twigs are beneficial in dental care. The leaf decoction is used in asthma and cough and the poultice is applied to painful tumours and piles (CSIR 1990). The fruit is edible and yields 40-50% fat and is a good source of lauric acid. The purified fat is used for soap making. The oil is of commercial importance. Keeping in view the distribution of *S. persica* on highly saline soils and its economic importance particularly of

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seed-oil, the effects of saline water of different salinity on growth performance, salt-accumulation and biochemical contents at establishment stage were studied and reported in the paper.

## MATERIALS AND METHODS

The experiment was conducted in pot house at Central Soil Salinity Research Institute, Karnal (Latitude 29°43'N, Longitude 76°58'E, 245 m above the mean sea level) in Haryana. The climate is semi-arid with little or no water surplus, megathermic and monsoonic. Pots of 40 cm diameter and 40 cm height were filled with calcareous soil after bringing from Hisar and getting it uniformly prepared breaking the lumps into workable soil. The soil samples were collected for initial physico-chemical properties of the soil. Most of the natural saline waters contain chlorides and sulphates of sodium, magnesium and calcium. Therefore, the saline waters were prepared dissolving salts of NaCl, $MgSO_4$ and $CaCl_2$ in distilled water to make the water of desired salinity ranging from 4 to 16 dS $m^{-1}$. The sodium adsorption ratio (SAR) of water was maintained at 10. The treatment with tap water (EC 0.4 dS $m^{-1}$) was kept as control. For each treatment four replications were kept. Six months old seedlings (raised in nursery) were planted. Irrigation was given as and when required. Every time 5 liters of water was applied per pot. After one year, height, and both fresh and dry biomass were recorded. The salinity development in soil and ionic contents (Na, K, Ca and Mg) were observed in different parts of the plant. The mature fresh leaves from middle part of the branch were collected randomly and mixed thoroughly for analysis. The homogenized samples were analyzed for chlorophyll, sugar, protein, proline and other amino acids.

The soil saturated extract was obtained by subjecting the soil paste on the vacuum pump, as described in USDA Handbook No. 60 (Richards 1954). The electrical conductivity (ECe) was measured using conductivity meter and the pH of extract of saturation paste (pHs) was measured with the help of digital pH meter. Sodium and potassium were determined with the help of flame photometer as described by Richards (1954). Calcium and magnesium in soil samples were determined using Versenate methods of Cheng and Bray (1951). Oven dried (at 80° C for 24 hours) plant samples (root, stem, thin branch and leaf) were grinded and digested in a mixture of $HNO_3$: $HClO_3$ (3:1). The accumulation of Na and K were determined with the help of flame photometer (method 11a, USDA Handbook 60, Richards 1954). The calcium and magnesium were determined using absorption spectrometre (Models GBC 932 AA) as per standard procedure (Jackson 1967). Chlorophyll contents were estimated according to Arnon (1949). The estimation of sugar was carried out using a method proposed by Hedge and Hofreiter (1962). Protein contents in leaf samples were determined using method of Lowry *et al.* (1951). Proline was estimated following Bates *et al.* (1973) and other amino acids were estimated by a method described by Lee and Takahashi (1966).

## RESULTS AND DISCUSSION

The soil used in pots was calcareous ($CaCO_3$ 7.5% ) and had pH and EC 8.6 and 0.82 dS $m^{-1}$, respectively and cation exchange capacity 35 cmol (p+) $kg^{-1}$.

### *Growth performance*

The plant growth parameters such as height, diameter, root-length and total dry biomass of the plants indicated that all these parameters decreased with the increase in the salinity of irrigation water (Table 1). Root length ranged from 35.5 cm in control to 22.31 cm when irrigated with water of EC 16 dS $m^{-1}$. However, there was no significant reduction in root length among different saline water treatments. Total reduction in dry biomass of the plant was 31.59% when irrigated with water of 16 dS $m^{-1}$ as compared to the control (Table 1). Maliwal and Nadiadara (1990) reported that this species is lesser tolerant to salinity than sodicity. Rao *et al.* (1999a) proved the suitability of the species for highly saline black soils with salinity ranging from 30-70 dS $m^{-1}$ in the top 30 cm soil depth. They also reported that at high salinity, the axillary buds remain dormant for longer time and once the bud-dormancy is broken the growth was maintained with less variation in side branches. This was also observed in present study.

### *Accumulation of ionic contents*

Accumulation of sodium in different parts of plant indicated that maximum retention was in root followed by stem, leaf and minimum in thin branch especially when irrigated with water of high salinity (Table 2). Accumulation

**Table 1.** Growth parameters of *Salvadora persica* irrigated with water of different salinity.

| ECiw of irrigation water (dS $m^{-1}$) | Height (cm) | Diameter (cm) | Root length (cm) | Dry biomass (g per plant) of Root | Stem | Branch | Leaf | Entire plant |
|---|---|---|---|---|---|---|---|---|
| Control (Tap water) 0.4 | 170.75 | 2.00 | 35.50 | 24.23 | 36.25 | 23.87 | 4.62 | 88.97 |
| 4 | 146.25 | 1.45 | 27.75 | 18.10 | 34.05 | 31.46 | 4.46 | 88.07 |
| 8 | 127.50 | 1.45 | 27.50 | 19.53 | 28.35 | 26.84 | 4.02 | 78.74 |
| 12 | 96.25 | 1.35 | 25.25 | 22.96 | 17.27 | 24.65 | 3.20 | 68.08 |
| 16 | 77.44 | 1.23 | 22.31 | 20.55 | 16.11 | 22.10 | 2.10 | 60.86 |
| LSD (P=0.05) | 16.04 | 0.17 | NS | NS | 5.33 | 2.87 | 0.48 | 7.45 |
| CV (%) | 7.42 | 6.94 | 14.36 | 13.73 | 11.94 | 6.72 | 7.31 | 5.75 |

NS=not significant

of sodium in different parts of the plant increased with increase in salinity of irrigation water. Potassium accumulation was highest in leaf while in other parts it was almost evenly distributed. The contents decreased with increase in salinity of the irrigation water. Sodium: potassium ratio was higher in root and stem as compared to leaves. The ratio is low when irrigated with normal water but it gradually increased with increase in salt in irrigation water. Both calcium and magnesium contents were maximum in leaf followed by root. These were almost equal in stem and thin branch. Magnesium contents were highest in leaf while in other parts there was no clear trend except that the contents increased with increase in the salt of irrigation water (Table 2).

Rao *et al*. (1999a) pointed out that bark and senescing leaves act as potential sinks for toxic ions like sodium and chloride. This study indicates that after absorption of sodium by roots it reaches to stem and finally accumulates in leaf facilitating the dilution of salt with in the tissues.

**Table 2.** Sodium, potassium, calcium and magnesium contents in different parts of *S. persica* irrigated with water of different salinity (ECiw).

| Elements (mg $g^{-1}$ dw) | Plant parts | ECiw (dS $m^{-1}$) of irrigation water: Tap water (0.4) | 4 | 8 | 12 | 16 | LSD (P=0.05) | CV % |
|---|---|---|---|---|---|---|---|---|
| Na | Root | 14.31 | 17.73 | 24.27 | 29.58 | 35.31 | 0.461 | 1.13 |
| | Stem | 16.14 | 19.31 | 21.45 | 24.78 | 27.47 | 0.475 | 1.17 |
| | Branch | 12.44 | 13.71 | 14.55 | 15.08 | 16.41 | 0.341 | 4.33 |
| | Leaf | 9.26 | 12.68 | 14.36 | 24.16 | 29.11 | 0.399 | 1.32 |
| K | Root | 5.99 | 5.05 | 4.32 | 3.63 | 2.10 | 0.243 | 3.25 |
| | Stem | 5.93 | 4.67 | 3.39 | 3.24 | 2.05 | 0.188 | 2.83 |
| | Branch | 5.79 | 4.99 | 4.19 | 3.13 | 2.09 | 0.303 | 4.23 |
| | Leaf | 6.01 | 6.23 | 6.21 | 5.76 | 4.63 | 0.155 | 1.36 |
| Ca | Root | 6.38 | 8.61 | 12.11 | 13.27 | 15.12 | 0.472 | 2.35 |
| | Stem | 4.47 | 6.61 | 7.46 | 11.04 | 13.71 | 0.567 | 3.85 |
| | Branch | 6.41 | 7.83 | 9.61 | 11.54 | 13.62 | 0.377 | 2.14 |
| | Leaf | 23.69 | 27.46 | 28.21 | 29.41 | 30.32 | 0.505 | 0.93 |
| Mg | Root | 1.88 | 2.33 | 3.29 | 3.45 | 3.62 | 0.328 | 6.02 |
| | Stem | 1.54 | 2.05 | 2.33 | 3.11 | 4.09 | 0.140 | 3.12 |
| | Branch | 2.10 | 2.43 | 2.63 | 2.74 | 2.89 | 0.218 | 4.42 |
| | Leaf | 3.49 | 4.95 | 5.24 | 5.80 | 6.37 | 0.149 | 1.54 |



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These results clearly show that the leaves of *S. persica* are important sinks for salt accumulation. In one interesting study Rao *et al*. (1999a) found that in *S. persica*, the senescing leaves showed 40-48 % more salt during dry months and 25-26% in wet season. However, the bark showed 46-53% salt in dry season and 67-68% in wet season. The data clearly indicated that bark and senescing leaves act as potential sinks for toxic salts, thus lowering the hazards of salt toxicity. Leaves also showed succulence (more when irrigated with water of higher salinity), facilitating the dilution of salt within the tissues (Tiku 1976, Rao and Rajeswara 1982). This also favours water conservation.

### *Development of salinity in soil*

After harvesting of the plants, the salinity (electrical conductivity) of soil was found to increase proportionately with the increase in salinity of irrigation water (Table 3).

**Table 3.** Change in soil salinity (EC) due to irrigation with water of different salinity under *Salvadora persica*.

| Electrical conductivity of irrigation water ($dS\ m^{-1}$) | Change in soil salinity under *Salvadora persica* | |
|---|---|---|
| | Before starting the experiment | After harvesting the plant |
| 0.4 | 0.83 | 0.89 |
| 4.0 | 0.81 | 3.21 |
| 8.0 | 0.82 | 4.63 |
| 12.0 | 0.82 | 7.47 |
| 16.0 | 0.80 | 8.77 |

### *Biochemical contents in leaf*

The results of different treatments, clearly indicated that proline and other amino acids increased and chlorophyll, protein and soluble sugar contents decreased significantly with the increase of salinity of irrigation water (Table 4). Salinity induced the decrease in chlorophyll, which can be attributed to a weakening of pigment protein lipid complex (Strogonov 1964). The decrease in chlorophyll contents with increase in salinity also indicates the effect of salinity on productivity.

Increase in amino acids can be ascribed to increased proteolysis or inhibition of protein synthesis under salinity, which in turn favour osmotic adjustment (Hall and Flowers 1973, Stumpf and O'Leary 1985, Rao *et al*. 1999 b,c). Of all the amino acids proline content was found very high under higher salinity, therefore, in *Salvadora persica* it plays an important role in osmotic adjustment and turgor maintenance (Rao *et al*. 1999c, 2001). Plants under saline conditions were able to maintain water potential gradient (osmotic adjustment) by accumulation of inorganic ions and low molecular organic compounds in their tissues (Flowers 1985, Weretelinyk *et al*. 1982, Reddy *et al*. 1993). At very high salinity levels *S. persica* thrives well and maintains good growth in terms of height and canopy spread proving its potential for biosaline agriculture.

**Table 4.** Biochemical contents in leaf of *Salvadora persica* irrigated with water of different salinity.

| Electrical conductivity of irrigation water ($dS\ m^{-1}$) | Chlorophyll ($mg\ g^{-1}$ dw) a | b | Total | Proline ($mg\ g^{-1}$) | Other amino acids* ($mg\ g^{-1}$) | Soluble sugar ($mg\ g^{-1}$) | Protein ($mg\ g^{-1}$) |
|---|---|---|---|---|---|---|---|
| Tap water 0.4 | 1.62 | 3.29 | 4.91 | 389.5 | 199.0 | 86.3 | 9.11 |
| 4 | 1.06 | 2.72 | 3.78 | 404.3 | 261.0 | 79.8 | 8.53 |
| 8 | 1.01 | 2.44 | 3.45 | 455.0 | 374.5 | 53.7 | 7.00 |
| 12 | 0.87 | 1.56 | 2.43 | 582.3 | 377.8 | 49.4 | 6.62 |
| 16 | 0.44 | 1.13 | 1.57 | 601.0 | 388.8 | 39.7 | 5.85 |
| LSD (P=0.05) | 0.03 | 0.21 | 0.84 | 4.9 | 4.2 | 1.03 | 0.72 |
| CV(%) | 1.55 | 4.92 | 1.39 | 0.53 | 0.69 | 0.89 | 5.16 |

*excluding proline

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