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## Studies on the performance and phytoremediation effect of underutilized leafy vegetables in salt affected soils

**S Jeeva**DOI: <https://doi.org/10.22271/chemi.2020.v8.i2aa.9015>**Abstract**

Phytoremediation is a biological approach proving the efficiency of plants to desalinate the soil. Soil phytodesalination is based on the capacity of some halophytes to accumulate enormous sodium quantities in their shoots. The study on the evaluation of underutilized leafy vegetables along with amaranthus in salt affected soils for leaf yield and phytoremediation effect was carried out at HC&RI (W), Trichy from 2017-19. *Portulaca oleraceae* (Paruppukeerai), *Chenopodium album* (Chakravarthi keerai) *Sesuvium portulacastrum*, *Tetragonia tetragonioides* and *Amaranthus* (CO2 Mulai keerai and PLRI Sirukeerai) were utilized in the study. The leafy vegetables show significant difference in plant height, number of leaves and total biomass per plant. The leaf stem ratio showed no significant difference among the leafy vegetables. The leafy vegetables differ significantly for protein, fibre content and RWC. The yield per plot was significantly higher in *Chenopodium album*. The pH and EC of the soil at the start and end of the trial revealed that there was reduction in pH and EC content of the soil in the *Portulaca* and *Chenopodium* grown field indicating their phytoremediation effect. This indicated that the sodic soils can be utilized for growing the under utilized leafy vegetables like Paruppu keerai, Chakravarthi keerai, Newzealand spinach and Palak. The study also indicated that the crops *Portulaca*, *Chenopodium* and Palak are potential crops for mitigation of sodic soils. Repeated cropping of these crops until the soil reaches acceptable levels will help the farmers to utilize their lands for regular crops.

**Keywords:** Phytoremediation, leafy vegetables, salt affected soils, sodic soils**Introduction**

Salt affected soils adversely affect the livelihood security of the people in more than 100 countries, occupying about 831 million ha across the Globe. In the Indian context, salt affected soils occupy about 6.73 million ha area affecting production and productivity across a number of states. Salinity of soil and water resources is the most basic and oldest environmental problems that it can limit crop production in many parts of the world and is considered as serious danger for agriculture (Abrol *et al*, 1988; Munns, 2002) <sup>[1, 2]</sup>.

Salinity can limit plant growth and yield by reducing osmotic potential, ion toxicity creation, uptake disarrangement and ion imbalance and can cause disorders in enzyme activities and membrane and metabolic activities in plants (Islam *et al*, 2008) <sup>[3]</sup>. These processes could affect morphological parameters and plant growth and will reduce vegetative growth (Rogers *et al*, 2009) <sup>[4]</sup>, active leaf area, chlorophyll content (Saleh and Maftoun, 2008) <sup>[5]</sup>.

Sodicity-induced soil degradation is a major environmental constraint with severe negative impacts on agricultural productivity and sustainability in arid and semiarid regions. As an important category of salt-affected soils, sodic soils are characterized by excess levels of sodium ions (Na<sup>+</sup>) in the soil solution phase as well as on the cation exchange complex, exhibiting unique structural problems as a result of certain physical processes (slaking, swelling, and dispersion of clay) and specific conditions (surface crusting and hardsetting). Amelioration of saline and sodic soils has been predominantly achieved through the application of chemical amendments. However, amendment costs increased prohibitively over the past two decades. Since climate and cost are two vital factors in reclamation of saline land, hence, cultivation of salt-tolerant species could be an effective way to improve this situation. Recently, a new environmentally safe and clean technique known as phytoremediation has been introduced to address the salinity problem. This includes the introduction of salt (ion) removing species to control salinity and to maintain the sustainability of agricultural fields

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[Rabhi *et al.* 2009] <sup>[6]</sup>. Phytoremediation is defined as the use of plants to remove pollutants from the environment and to render them harmless [Salt *et al.* 1998] <sup>[7]</sup>. These plants not only remediate the salt-contaminated soils but also provide food, fodder, fuelwood, and industrial raw material and increase the income of the farmers owning salt-affected lands. Several halophytic plant species have been tried in the past for their possible use in reclamation of salt affected soils. Purslane (*Portulaca oleracea* L.) is the eighth most common plant distributed throughout the world, being a heat and drought tolerant important vegetable crop [Ana Anastácio and Carvalho, 2013] <sup>[8]</sup>. It is eaten fresh, cooked, or dried and interest in cultivating it as a food crop has polyunsaturated fatty acids and antioxidants. *Portulaca oleracea* is a halophytes with highest potential as vegetable crop for saline irrigation (Simopoulos, 2004) <sup>[9]</sup>.

The leaves and young shoots of *Chenopodium* may be eaten as a leaf vegetable. The leaves and young shoots of this plant are used in dishes such as soups, curries, and paratha-stuffed breads, especially popular in Punjab. Obligate halophytes grow only in salty habitats. They show sufficient growth and development under high saline condition. Many plant species belonging to *Chenopodiaceae* family fall in this category.

Rabhi *et al.* 2010 <sup>[10]</sup> reported that *Sesuvium portulacastrum* seedlings grown on a saline soil significantly reduced the soil salinity and EC by absorbing soluble salts mainly sodium ions and they also reported that *Sesuvium portulacastrum* was able to accumulate nearly 30% of Na<sup>+</sup> content in shoot over the 170 d. Wilson *et al.*, 2000 <sup>[11]</sup> proved the salinity tolerance of New Zealand spinach (*Tetragonia tetragonioides* Pall.)

With this background, this work was undertaken to evaluate the following underutilized leafy vegetables under sodic soil and to study their phytoremediation effect on sodic soils.

1. *Portulaca oleracea*
2. *Chenopodium album*
3. *Sesuvium portulacastrum*
4. *Tetragonia tetragonioides*
5. *Amaranthus sp.*

## Materials and Methods

The experiment was conducted at Horticultural College and Research Institute for Women, Trichy during 2016-19. The experiment was conducted for three seasons, during July-Nov 2016, April to August 2017 and January – March 2019. The trial was laid out with *Portulaca oleracea*, *Chenopodium album*, *Sesuvium portulacastrum* *Tetragonia tetragonioides* and *Amaranthus* CO2 Mulaikerai and PLR 1 Sirukeerai in Randomized block design with four replications. Soil pH and EC were measured at the start and end of the experiments. The growth and yield parameters were recorded.

The growth parameters viz., Plant height, number of leaves per plant, and leaf stem ratio were recorded.

## Biomass determination

Harvested plants were washed thoroughly in running tap water and rinsed twice with distilled water. They were then placed in paper bags and weighed after oven dried at 80°C for 72 hrs.

## Relative water content (RWC)

The fourth leaf of the plant representing each treatment were harvested and weighed to determine the fresh weight (FW). The leaves were submerged separately in distilled water for 24 hours in the dark. They were removed from water, mopped

dry using an absorbant and weighed to determine their saturated weight (SW). The leaves were then placed in envelopes and dried in oven at 80°C for 24 hours, weighed to get the dry weight (DW). The Relative water content was calculated using the formula:  $RWC = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Saturated weight} - \text{dry weight}} \times 100$

## Total chlorophyll

Plant leaves were ground in 80% Acetone in the dark. After centrifugation at 4000g for 5 minutes, the absorbance of the supernatant was read at 645 and 663 nm. The total chlorophyll content was calculated using the formula  $20.2(A_{645}) - 8.02(A_{663}) \times V/1000 \times W$

## Protein

The protein content was calculated by using the formula, Protein (mg/100g) = Nitrogen x 6.25. Estimation of nitrogen was done by Colorimetric method as suggested by Snell and Snell (1939) <sup>[12]</sup> using the Spectronic- 20.

## Fibre

Crude fiber was determined by following the AOAC (2005) <sup>[13]</sup> method. This was done by acid –alkali hydrolysis.

## Results and Discussion

The study on the evaluation of underutilized leafy vegetables along with amaranthus in salt affected soils for leaf yield and phytoremediation effect was carried out at HC&RI (W), Trichy from 2017-19 with the objectives to study the effect of sodicity on growth and yield of the green leafy vegetables, on physiological traits of the crops and quality of greens and to study the phytoremediation effect of the above greens in salt affected soil *Portulaca oleracea* (*Paruppukeerai*), *Chenopodium album* (*Chakravarthi keerai*), *Sesuvium portulacastrum* (*Sea purslane*), *Tetragonia tetragonioides* (*Newzealand spinach*), and *Amaranthus* (*CO2 Mulai keerai and PLR1 Sirukeerai*) were utilized in the study.

The leafy vegetables show significant difference in plant height, number of leaves and total biomass per plant. The leaf stem ratio showed no significant difference among the leafy vegetables. The leafy vegetables differ significantly for protein, fibre content and RWC. The yield per plot was significantly higher in *Chenopodium album*. (Table 1)

The pH and EC of the soil at the start and end of the trial revealed that there was reduction in pH and EC content of the soil in the *Portulaca* and *Chenopodium* grown field indicating their phytoremediation effect (Table 2).

The pooled analysis of three season data revealed that the evaluated underutilized leafy vegetables performed well under sodic soil condition, with yield potential ranging from 8.4 t/ha in *Amaranthus* PLR 1 to 12.6 t/ha in *Chenopodium album* and *Tetragonia tetragonioides*. This indicated that the sodic soils can be utilized for growing the under utilized leafy vegetables like *Portulaca*, *Chenopodium* and *Tetragonia*. Ravindran *et al.* 2007 <sup>[14]</sup> observed that *S. maritima* and *Sesuvium portulacastrum* exhibited greater accumulation of salts in their tissue and higher reduction of salts from the saline land. Hamidov *et al.* 2007 <sup>[15]</sup> reported that *Portulaca oleracea* accumulated highest salt uptake (497 kg ha<sup>-1</sup>) with biomass production of 3948 kg ha<sup>-1</sup>.

The study also indicated that the crops *Portulaca* and *Chenopodium* are potential crops for mitigation of sodic soils. Repeated cropping of these crops until the soil reaches acceptable levels will help the farmers to utilize their lands for regular crops.

## Conclusion

Salt affected soils adversely affect the livelihood security of the people in more than 100 countries, occupying about 831 million ha across the Globe. In the Indian context, salt affected soils occupy about 6.73 million ha area affecting production and productivity across a number of states. Sodicity is one of the major constraints in crop production.

Amelioration of saline and sodic soils has been predominantly achieved through the application of chemical amendments. However, amendment costs have increased prohibitively over the past two decades. Since climate and cost are two vital factors in reclamation of saline land, hence, cultivation of

salt-tolerant species could be an effective way to improve this situation.

The study on the evaluation of underutilized leafy vegetables along with amaranthus in salt affected soils for leaf yield and phytoremediation effect indicated that the sodic soils can be utilized for growing the under utilized leafy vegetables like Paruppu keerai, Chakravarthi keerai, Newzealand spinach and Palak. The study also indicated that the crops Portulaca, Chenopodium and Palak are potential crops for mitigation of sodic soils. Repeated cropping of these crops until the soil reaches acceptable levels will help the farmers to utilize their lands for regular crops.

**Table 1:** Growth, Yield, Quality and Physiological characters of leafy vegetables under salt affected soil

Treatments	Plant Height (cm)	No. of leaves	Total biomass/plant	Leaf/stem Ratio	Yield per plot (Kg/3 m <sup>2</sup> )	Estimated yield per ha	Protein (g)	Fibre (g)	RWC (%)	Chlorophyll (mg/g of fresh wt)
T1 <i>Portulaca oleraceae</i>	36.8	44.8	14.80	1.8	3.00	10.0	3.6	1.6	72.8	1.22
T2 <i>Chenopodium album</i>	37.0	25.4	16.45	2.2	3.80	12.6	2.6	1.4	65.6	1.26
T3 <i>Sesuvium portulacastrum</i>	36.6	20.6	13.15	2.0	2.68	8.9	2.0	1.6	68.4	1.22
T4 <i>Tetragonia tetragonioides</i>	39.4	23.6	16.45	1.8	3.78	12.6	2.2	0.8	68.4	1.24
T5 <i>Amaranthus</i> CO2 Mulaikeerai	34.5	36.4	11.82	2.0	3.06	10.2	4.8	1.8	62.5	1.30
T6 <i>Amaranthus</i> PLR 1 Sirukeerai	32.8	32.8	12.06	2.0	2.52	8.4	3.8	1.8	63.4	1.32
SEd	0.22	0.78	0.34		0.18		0.42		1.6	
CD(P=0.05)	0.46	1.45	0.66	NS	0.36		0.88	NS	3.4	NS

**Table 2:** Soil characters at the start and end of the experiment

Treatments		pH	EC (dsm <sup>-1</sup> )
T1 <i>Portulaca oleraceae</i>	Start	8.3	1.30
	End	8.2	1.24
T2 <i>Chenopodium album</i>	Start	8.3	1.30
	End	8.2	1.22
T3 <i>Sesuvium portulacastrum</i>	Start	8.3	1.30
	End	8.3	1.30
T4 <i>Tetragonia tetragonioides</i>	Start	8.3	1.30
	End	8.3	1.30
T5 <i>Amaranthus</i> CO2 Mulaikeerai	Start	8.3	1.30
	End	8.3	1.30
T6 <i>Amaranthus</i> PLR 1 Sirukeerai	Start	8.3	1.30
	End	8.3	1.30

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