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Assessing the prospective of *Jatropha curcas* in Reclamation of Sodic Soil

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Abstract

Uttar Pradesh, India has more than 1.2 million hectares of salt affected soil. Out of which mostly are sodic soil. Gypsum, a chemical amendment for sodic soil is widely used for reclamation. This paper discusses application of Jatropha curcas for reclamation of sodic soil. Without applying any chemical amendment, Jatropha was planted on soil having an exchangeable sodium percentage (ESP) of 51 and pH 11.9. The result indicates that plantation of Jatropha reduces ESP, pH and Na^+ significantly and increases soil organic carbon and exchangeable Ca^+. It could deduce that Jatropha mainly works upon the principle of increased CO_2 partial pressure existing. The interaction of roots and micros, the respiration probably amplifies the solubility of calcites and improves soil physical properties because of the vertical growth of taproot. It is concluded that Jatropha is efficient for sodic soil reclamation but takes a longer duration, because plant requires time for stabilization. Presently, at partial reclamation, other crops can be planted along with Jatropha to diversify the waste land use.

Keywords: Jatropha curcas, reclamation, sodic soil, gypsum.

Introduction

The excessive use of Agrochemicals has deteriorated the soil health. Farmers use excessive chemical fertilizer to augment their productivity but ultimately, these excessive uses ruined the important nutrients within the soil, and ultimately soil become sodic. Consequently, the shortage of nutrients affects the growth of plant. The globally, sodicity problem is one of the important challenges. In India, the areas affected by sodic soil are 3.88 million hectares[1]. It generally has a pH value above 8.5 and ESP more than 15 and exhibit dispersion of clay, surface crusting, hard settings[2,3]. Conventionally, sodic soil management has aimed to displace excess Na^+ by calcium and thus reduce sodicity. The use of gypsum is a common practice as an external source of Calcium[4]. Gypsum based reclamation is an expensive methodology. In this paper, an attempt is made to assess the potentials of Jatropha in reclamation of sodic soil as it can prove to be a cost-effective way to manage land sodicity. Thus, the objective of this paper is to monitor and assess the reclamation potentials of Jatropha. This work was experimenting in a farmer's field at Village- Chandesaua, District-Sitapur, Uttar Pradesh, India by means of financial assistance of the Department of Science and Technology (DST), Government of India.

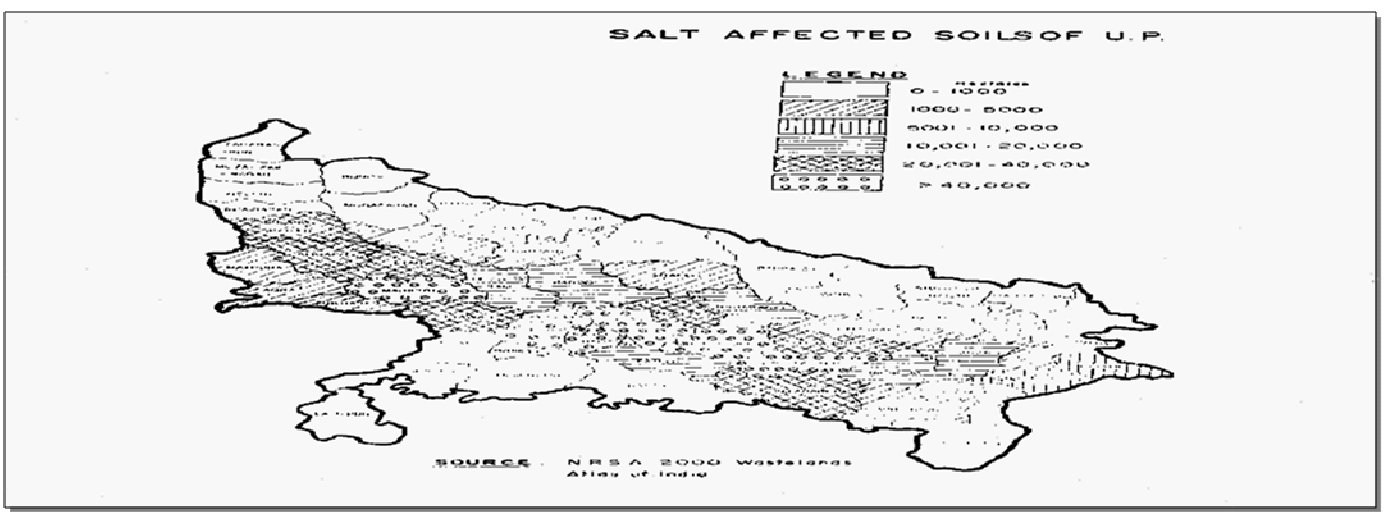

Figure-1
Salt affected soils of Uttar Pradesh. Source: NRSA, India

Material and Methods

The field experiment was conducted over three years at village-Chandesua, Sitapur, Uttar Pradesh, India. Before initiating the reclamation program, runoff from the surrounding area was checked. Fields were divided into three equal plot sizes. Soil Samples were collected from depth intervals of 0-15cm, 15-30 cm and 30-45 cm with an auger of 4cm in diameter during pre and post plantation and analyzed. It was air dried and ground to pass through a 2mm sieve. Soil pH, EC and ESP of soil samples were determined. The ESP was determined according to USDA Handbook[5] 60 whereas organic carbon was determined by Walkley and Black[6]. The $Na^{+,}$ Ca^{+}, K^{+} were determined using flame photometer. The chemical properties of sodic soils before and after the plantations of Jatropha are indicated in table-1.

Saplings of Jatropha were planted at 60 X 60 X 60 cm deep pits at a spacing of 2.5 X 2.5 m in 1000 sq m plot size. Chemical fertilizer was not applied during refilling of the pits. Regular monitoring of the field was conducted to study the impact of Jatropha on sodic soil. Statistical method and test of significance appropriate for the design were applied in the data for discriminating against the treatment effects from chance effects.

Results and Discussion

After twenty months of plantation of Jatropha, it was found that ESP was lessened. Table 2, depicted that plant growth and biomass of Jatropha plant at different ESP indicates decreases in dry weight of the root, shoot and leaves accompanied by a significant decrease in the total biomass increase in soil ESP.

Table 3 shows that the concentration of Na was significantly augmented in all plant parts, that is roots, stem and leaf on increasing soil ESP while K, Ca and Mg was decreased. Maximum concentration of Na was noticed in leaves. Accumulation of Na was at a maximum in the stem. The Na/K ratio was also increased on increasing soil ESP. However, a significant increase in the Na/K ratio was noticed above 47 ESP.

Table-1
Chemical properties of the soils collected before and after the plantation of Jatropha

Soil Depth	(BR) S_1	(AR) S_1	(BR) S_2	(AR) S_2	(BR) S_3	(AR) S_3
Chemical Properties						
pH (1:2 soil)	11.9 ±0.11	9.9 ± 0.08	11.2 ± 0.12	10.1 ± 0.21	11.2 ± 0.1	9.1 ± 0.1
EC(dSm^{-1})	1.1 ± 0.08	0.9 ± 0.06	0.9 ± 0.10	1.0 ± 0.04	1.1 ± 0.15	1.0 ± 0.15
Org. C (%)	0.24 ± 0.16	0.45 ± 0.05	0.45 ± 0.07	0.51 ± 0.05	0.43 ± 0.09	0.50 ± 0.09
Exch. Na (c mol kg^{-1})	7.45 ± 0.12	7.43 ± 0.11	7.42 ± 0.80	7.40 ± 1.01	6.45 ± 0.43	6.41 ± 0.43
Exch. K (c mol kg^{-1})	0.59 ± 0.30	0.60 ± 0.15	0.58 ± 0.09	0.59 ± 0.07	0.59 ± 0.06	0.60 ± 0.06
Exch. Ca (c mol kg^{-1})	11.0 ± 1.0	11.0 ± 1.0	10.0 ± 1.0	10.0 ± 1	10.0 ± 0.8	10.0 ± 0.8
Exch. Mg (c mol kg^{-1})	2.09 ± 0.03	2.09 ± 0.01	2.09 ± 0.03	2.08 ± 0.13	2.08 ± 0.03	2.08 ± 0.03
CEC (c mol kg^{-1})	16.77 ± 0.50	16.71 ± 0.45	16.73 ± 0.34	16.72± 0.34	16.71± 0.22	16.71± 0.22
ESP (%)	51.46 ± 0.34	47.80 ± 0.53	50.05 ± 4.03	45.58± 5.42	50.33± 1.89	44.33± 1.89

S indicates levels of depth S1= 0-15cm (BR), (AR); S2=15-30cm (BR), (AR); S3= 30- 45cm (BR),(AR); [BR-Before Reclamation; AR-After Reclamation]; CEC- cation exchange capacity; ESP- exchangeable sodium percentage.

Table-2
Status of plant growth and biomass of Jatropha plant at different ESP levels (Data collected after periodic monitoring)

Soil sodicity (ESP)	Plant height (cm)	Root (g $plant^{-1}$)	Shoot (g $plant^{-1}$)	Leaf (g $plant^{-1}$)	Total biomass (g $plant^{-1}$)
44	94.4	1.03	7.03	1.51	13.47
45	86.9	0.82	4.65	1.33	9.40
47	81.8	0.70	3.35	1.30	7.45
50	75.6	0.63	2.73	0.98	5.74
51	70.2	0.61	2.43	0.95	5.09
CD at 5%	9.7	0.35	0.96	0.12	1.27

Table-3
Effect of Soil Sodicity on concentration of cation in different plant parts of Jatropha

Cations	Plant Parts	Soil Sodicity (ESP)					CD at 5%
		44	45	47	51	50	
		Concentration (%)					
Na	Root	0.76	1.26	2.00	2.30	2.50	0.43
	Stem	0.67	1.82	2.23	2.81	3.10	0.41
	Leaf	1.32	1.85	2.46	2.89	3.27	0.28
K	Root	2.10	1.58	1.46	1.24	1.16	0.32
	Stem	3.24	2.56	2.08	1.90	1.32	0.53
	Leaf	4.04	2.73	2.43	1.23	1.23	0.65
Ca	*Root*	3.05	2.87	2.15	2.18	1.64	0.67
	Stem	2.20	2.18	1.49	1.32	1.46	0.69
	Leaf	3.39	3.00	2.75	2.43	1.63	0.78
Mg	Root	0.35	0.31	0.34	0.31	0.24	NS
	Stem	0.20	0.15	0.16	0.15	0.12	NS
	Leaf	0.55	0.53	0.51	0.33	0.31	0.11
Na/K Ratio	Root	0.36	0.80	1.37	1.85	2.16	0.64
	Stem	0.21	0.71	1.07	1.48	2.35	0.77
	Leaf	0.33	0.68	1.01	2.35	2.66	0.43

Jatropha can survive harsh environments of semi-arid agro climatic conditions, wastelands[7-10] and grows fast with little maintenance. Jatropha mainly works upon the principle of enhanced CO_2 partial pressure in the root zone because of interacting root and microbial respiration, which probably increases the solubility of calcite and improved soil physical properties because of its tap root. The exact mechanism is still to be determined.

Mention several comparative studies of sodicity, the ameliorative affect of gypsum are first confined to the zone into which the amendment was incorporated[11,12]. In the Phytoremediation treatment study, amelioration occurred through the rooting depth of the crops. Qadir and coworkers[13] reported that Phytoremediation treatment decreased soil sodicity and suggest that plant roots affect the chemical environment of the soil by increasing calcium presents in the soil solution. In calcareous sodic soil this affect is partially of a consequence to the fact the growing roots of plants increase the partial pressure of CO_2 (P_{CO2}), so enhancing the dissolution of calcite[14]. The P_{CO2} effect reduces the sodicity of calcareous sodic soil, under cropping condition[12]. Thus, the P_{CO2} effect generates H^+ through H_2CO_3 dissociation in the root zone. However, the H^+ released by crops may react with calcite in a similar way, so increasing Ca^{2+} levels in a sodic soil[15].

In sodic soil, Jatropha plants are found to respond better to organic manure. At the initial stage, ESP of soil was found to be at 51. But after twenty-five months of plantation, ESP and pH gradually reduced to 44 and 9.1 respectively without application of gypsum. By application of gypsum, it can be reclaimed faster but gypsum reclaimed soil reverses back to sodicity. Bhargava and Kumar[16] reported that the soil which was once severely sodic up to 2 meter soil depth had become non-sodic in the upper 40-50 cm depth over the past 20-30 year period since their reclamation commenced. Nevertheless, the soil below 40-50 cm depth still had ESP values greater than 15, which prove harmful to several plant species intended to be grown in the reclaimed soil. Therefore, the reduction done by Jatropha is significant as it shows the impact and potential to reclaim sodic soil. Increase of Na in the plants is inevitable when exposed to salt stress. In the present experiment, the Na concentration and accumulation were higher and can be taken as an index for its tolerance and reclamation of soil. Plants growing under sodic condition often show an increase in Na contents in shoots and are accompanied by a decrease in other essential elements[17, 18.] The maximum accumulation of Na was observed on the stem. This could probably be a part of the protective mechanism to deposit excess of ions in the sink with ion metabolic activity. Similar findings were observed by Garg and Shrivastava[19,] Singh and Singh[20] in plants. The uptake of Ca, K and Mg were decreased while Na uptake increased with increasing the soil ESP. The observed results are in agreement in the findings of Bhatnagar and Yadav[21].

Conclusion

The study indicates that *Jatropha curcas* could reclaim sodic soil without applying chemical amendment. The speed of reclamation is slow that could potentially be increased by the use of genetic engineering. This study is based on three-year experiment on Jatropha, and thus the results have shown a marginal decrease in soil sodicity. However, it has been observed that Jatropha matures after three years. It could be inferred that Jatropha could reclaim sodic soil completely in a long run. This drawback can be further tackled by intercropping with Jatropha to diversify land use system. Cultivation of *Jatropha curcas* is an effective and more sustainable way to manage sodicity and issues arising due to gypsum applications and economic crunches.

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