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Influence of fruit tree based cropping system on chemical properties of salt affected soil

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Abstract
The present investigation entitled "Effect of tree cropping systems on chemical properties of salt affected soil" was carried out at wasteland management farm Akma, Department of Horticulture, Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Faizabad, U.P. during the year 2010-11. All the tree cropping systems *viz*. Aonla + Ber, Aonla + Guava, Ber + Guava + Phalsa, Aonla + Karonda and Aonla + Subabool improved the chemical properties of soil as compared to control (barren site). Decrease in pH, ECe, ESP and increase in CEC indicated considerable improvement in chemical properties of soil. Improvement was noticed more in upper depth as compared to lower depth as well as more under inside canopy as compared to open side canopy of plants.

Keywords: Fruit trees, aonla, Ber, guava, phalsa, subabool, EC, pH, ESP and CEC, canopy

Introduction
Land is one of the limited and inelastic resources, which is reached to the state of high degree of degradation and shrinkage due to over exploitation and subsequent incensement of population growth and consequential anthropogenic pressure. Out of the total geographical area of 329 million ha, nearly 175 million ha area is suffering from different levels of degradation. Among degraded wastelands (173.08 million ha.), 7.0 million ha is adversely affected with excessive soluble salts/exchangeable sodium salts, which is unsuitable to profitable crop production. In Uttar Pradesh, out of 135.25 lakh ha degraded lands (46% of total geographical area), 12.0 lakh ha area is under sodic lands, which is difficult to manage for cultivation of agronomical crops with optimal crop harvest (Agrawal & Gupta, 1968) [2]. The majority of such lands is lying barren and has become ecologically and economically unproductive due to chronic degradation and denudation. The presence of excessive salt in soil decreases its productivity as the salt inhibits not only the plant growth, but also deteriorates physical and chemical properties of soil. The absorption of sodium salt in such soil results into compact soil structure, low availability of essential plant nutrients and reduced microbial activities in soils, which inhibits the growth activities of most of the corps/plants. The utilization and management of such categories of waste lands needs a systematic approach of land and crop management for effective and selective crop planning. Vegetation exerts a decisive influence on physical and chemical characteristics and content of organic matter through their deep root system and addition of organic matter from biomass (Nandagouthar *et al*.) [9]. The research work carried out earlier has shown that the reclamation of salt affected soils for cultivation of agronomical crop is not only expensive but management of such soil further becomes more complicated. A number of fruit trees species have been identified to have tolerance to sodic soil. The degree of tolerance to different levels of sodicity have been worked out in aonla, ber, bael, citrus, grape, guava, karonda, phalsa, and other horticultural crops by several scientist at different places. The effect of combined plantations of the selective fruit tree species at specific age (12 year old plantation) for improvement of salt affected and poor fertile soils has not been worked out so far. Therefore, there is great importance to study in systematic manner for improvement of chemical properties of salt affected soils through tree plantation as efficient and effective methods of land reclamation. The present investigation has been undertaken with objectives to study the changes in chemical properties of soil and to find out the most suitable and potential cropping model for reclamation of salt affected soil.

Material and Methods

The present investigation was undertaken at the Wasteland Management Farm, Akma, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) during the year 2010-11. The 12 year old five selective tolerant fruit species *viz*. Aonla, Ber, Guava, Phalsa, Karonda and one fodder species subabool planted in different cropping models in an area of 0.5 ha each under wasteland conditions having alkali/sodic soils and poor soil fertility status were taken under study. The plant spacing was kept 8 meter for Aonla, Guava, Ber and Phalsa and 4 meter for Karonda and Subabool. The pit size was 1 m^3 and filling mixtures were applied as per recommendations for sodic land plantation. The cultural practices were followed as per recommendations. The details of treatment are given below:

(1) Treatments

(a) The tree cropping systems – 5

i. Aonla + Ber (C_1)
ii. Aonla + Guava (C_2)
iii. Aonla + Karonda (C_3)
iv. Ber + Guava + Phalsa (C_4)
v. Aonla + Subabool (C_5)

(b) Sampling sites – 2

i. Inside tree canopy (Basin)
ii. Outside tree canopy (Centre)

(c) Control – 1 (bare site)

(2) Total treatment = 5 x 2 + 1 =11

(3) Design – Randomized Block Design (RBD)

(4) Replication – 4

(5) Plot size – 0.5 ha each.

Table 1: Details of the cropping systems and plant population

S. No.	Tree cropping systems	Plot size (ha)	Total No of Plants per plot	Plant density /ha.
1	Aonla + Ber (C_1)	0.5	Aonla = 72	144
			Ber = 50	100
2	Aonla + Guava (C_2)	0.5	Aonla = 72	144
			Guava = 50	100
3	Aonla + Karonda (C_3)	0.5	Aonla = 72	144
			Karonda = 110	220
4	Ber + Guava + Phalsa (C_4)	0.5	Ber = 50	100
			Guava = 72	144
			Phalsa = 60	120
5	Aonla + Subabool (C_5)	0.5	Aonla = 72	144
			Subabool = 110	220
6	Control (C_0)	0.5	Nil	Nil

Collection of soil samples

The soil samples were collected from each plot of cropping model and control plot (barren site). The soil samples were taken randomly from the basin (inside canopy) of each tree species and between the Centre of rows and plants from 4 selected spots of each model at the depth of 0-15, 15-30, 30-45 and 45-60 with the help of spade, Khurpi, and soil Serew auger after offset of Mansoon i.e. in the month of October – November. The soil samples were collected from the inner rows of tree species by covering 4 trees (2 +2) of Aonla + Ber, Aonla + Guava, 8 trees (2 + 2 + 4) of Ber + Guava + Phalsa, 8 trees (2 + 6) of Aonla + Karonda and Aonla + Subabool.

Preparation of soil samples

The samples collected from the plots of different models were brought to the laboratory and fresh weight was taken. The samples were dried in the shade at room temperature as well as in oven at 105^0C temperature for 24 hours till the constant weight. Thereafter, each sample was grinded and sieved with 20 meshes and used for analysis of chemical properties soil as influenced by different cropping models.

Observations recorded

Chemical characteristics of soil samples were determined to find out the changes in chemical properties of soil as affected by each cropping models. The methods employed for estimation of changes in chemical properties of soil is mentioned below:

Table 2: Methods used in analysis of chemical properties of soil.

Soil properties	Methods adopted
(Chemical properties)	
(i) Electrical conductivity (ECe)	Digital conductivity meter
(ii) pHs (1:2.5)	Digital pH meter
(iii) Exchangeable Sodium Percentage (ESP)	By formula given as $ESP = \frac{\text{Exchangeable } Na^+}{\text{Cation exchange capacity}} \times 100$
(iv) Cation Exchange Capacity (CEC)	Determined by following formula as given by Bourer *et al.* (1962) $\text{CEC (me/100 gm soil)} = \frac{\text{Na conc. of extract in me/l}}{\text{Weight of sample (gm)}} \times 100$

The data was analyzed statistically as per method given by Panse and Sukhatme (1989) [11] and results were evaluated at 5 per cent level of significance.

Result and Discussion

Effect of tree cropping systems on chemical properties of salt affected soil

pH

Studies indicated that pH of the soil decreased significantly in areas under influence of different tree crop combinations at all the depths as compared to control (barren site), however, it was recorded minimum with Ber + Guava + Phalsa cropping system. Reduced pH in basins as compare to centres and increased pH with progressive depths of soil was also noted. Increase in organic carbon in the present investigation is the main cause of reduced pH in different cropping models. It was based on the fact that decomposition of leaf litter and other biomass in soil resulted in production of carbonic acid which ultimately decreased the soil pH. The findings of Grewal (1984) [5], Basu and Mandi (1987) [3], Sharma and Gupta (1989) [12], Singh (1989) [13], Singh (1990) [14], Singh *et al.* (1990) [14] and Malviya and Singh (1998) [7] also supported the contention that there is reduction in pH of soil by afforestation and planting of different crop plants as compared to bare sites.

Electrical Conductivity (ECe)

All the cropping systems showed significant reduction in respect of their ECe at each depth over control (barren site). The minimum ECe was noted from the area planted with Ber + Guava + Phalsa followed by Aonla + Ber cropping system. Reduction in ECe of the soil is beneficial for its reclamation. Our findings are in the same line of those reported by Mishra *et al.* (1988) [8], Singh (1989) [13], Yadav (1990) [18], Nath and Banerjee (1992) [10] and Singh Gurubachan (1995) [15] that the tree association considerably reduces the ECe of soil. Reduction in ECe might be due to leaching of salts, increased hydraulic conductivity, and decreased upward movement of salts under tree canopy of different models. In case of control, salt concentration was higher at upper surface due to upward movement of salt with increased rate of evaporation.

Exchangeable sodium percentage (ESP)

Exchangeable sodium percentage of soil was observed to be reduced significantly in planted area of different models over unplanted ones (barren land). The reduction was comparatively faster in Ber + Guava + Phalsa cropping model than others. Reduction in ESP is one of the most important parameters for improving the chemical properties of soil. Increase in porosity, hydraulic conductivity, exchangeable calcium and magnesium as well as reduced pH of the soil as observed in our studies may be possible reason for reduction in ESP under different tree crop combinations. The production of organic and inorganic acids from tree biomass helps in liberating calcium for replacing harmful sodium in the exchange complex (Srivastava *et al.*, 1988) [17]. Findings of Arya *et al.* (1973) [1], Singh (1989) [13], Singh (1990) [14], Jain and Singh (1998) [6], Malviya and Singh (1998) [7] also supported the fact that ESP of the soil is reduced by plantation/afforestation in comparison to open area.

Cation Exchange Capacity (CEC)

It is evident from the results obtained from present investigation that cation exchange capacity of soil improved appreciably under different cropping models over control (barren site) and was found to be decreased with increasing depths of soil. It was maximum in area planted with Ber + Guava + Phalsa tree crops. Cation exchange capacity of soil have negative correlation with pH and exchangeable sodium percentage (ESP), whereas positive with organic carbon of soils. In our findings, reduced pH, ESP and increased organic carbon status of soil with different cropping system may be the possible reason for improvement in CEC under plantation areas of different models. Improvement in CEC level under plantation area has been noticed by Basu and Mandi (1987) [3], Singh *et al.* (1969) [16] reported that cation exchange capacity was higher under legume than cultivated crop in the soil. Campbell (1994) [4] stated that organic matter content is the prime determinant of exchange capacity of soils.

Table 3: Effect of various tree cropping systems on $pH_{(s)}$ of soil.

S. No.	Treatment / Tree cropping systems		$pH_{(s)}$ at different depth (cm)				Mean value (0-60 cm)	Average value of basin and centre
			0-15	15-30	30-45	45-60		
1	Aonla + Ber	Basin	8.65	8.83	9.42	9.54	9.11	9.23
		Centre	8.94	9.20	9.56	9.68	9.35	
2	Aonla + Guava	Basin	8.72	8.93	9.50	9.62	9.19	9.28
		Centre	8.97	9.15	9.58	9.74	9.36	
3	Aonla + Karonda	Basin	9.15	9.40	9.72	9.88	9.54	9.64
		Centre	9.42	9.74	9.80	9.97	9.73	
4	Ber + Guava + Phalsa	Basin	8.50	8.70	8.98	9.40	8.90	8.99
		Centre	8.85	8.97	9.08	9.45	9.08	
5	Aonla + Subabool	Basin	9.10	9.27	9.45	9.62	9.36	9.46
		Centre	9.30	9.43	9.64	9.84	9.55	
6	Control		10.09	10.33	10.40	10.68	10.38	10.38
	CD at 5%		0.15	0.15	0.16	0.16		

Table 4: Effect of various tree cropping systems on ECe (dSm^{-1}) of soil.

S. No.	Treatment / Tree cropping systems		ECe at different depth (cm)				Mean value (0-60 cm)	Average value of basin and centre
			0-15	15-30	30-45	45-60		
1	Aonla + Ber	Basin	6.80	7.32	7.92	8.80	7.71	8.14
		Centre	7.86	8.25	8.62	9.50	8.56	
2	Aonla + Guava	Basin	7.30	7.56	8.03	8.82	7.93	8.28
		Centre	7.95	8.27	8.54	9.75	8.63	
3	Aonla + Karonda	Basin	7.80	8.42	9.30	10.08	8.90	9.32
		Centre	8.90	9.70	9.95	10.40	9.74	

4	Ber + Guava + Phalsa	Basin	6.40	7.10	7.86	8.92	7.57	8.04
		Centre	7.82	8.20	8.70	9.30	8.51	
5	Aonla + Subabool	Basin	7.65	8.40	9.15	9.90	8.78	9.21
		Centre	8.84	9.65	9.82	10.20	9.63	
6	Control		14.02	13.56	12.80	12.30	13.17	13.17
	CD at 5%		0.44	0.42	0.45	0.46		

Table 5: Effect of various tree cropping systems on ESP (%) of soil.

S. No.	Treatment / Tree cropping systems		ESP at different depth (cm)				Mean value (0-60 cm)	Average value of basin and centre
			0-15	15-30	30-45	45-60		
1	Aonla + Ber	Basin	32.80	36.84	45.20	54.30	42.29	45.41
		Centre	41.70	44.60	50.10	57.70	48.53	
2	Aonla + Guava	Basin	33.70	37.70	46.60	55.74	43.44	46.39
		Centre	40.98	45.56	51.50	59.30	49.34	
3	Aonla + Karonda	Basin	40.60	44.40	50.20	60.70	48.98	52.71
		Centre	49.80	52.98	57.04	65.90	56.43	
4	Ber + Guava + Phalsa	Basin	31.60	35.90	42.00	54.50	41.00	44.13
		Centre	40.36	44.00	48.60	56.10	47.27	
5	Aonla + Subabool	Basin	39.04	43.98	49.90	58.10	47.76	51.07
		Centre	46.10	51.40	56.60	63.40	54.38	
6	Control		71.50	75.70	80.30	85.20	78.18	78.18
	CD at 5%		2.09	2.38	2.54	2.92		

Table 6: Effect of various tree cropping systems on CEC [Cmol (P^+) kg^{-1}] of soil.

S. No.	Treatment / Tree cropping systems		CEC at different depth (cm)				Mean value (0-60 cm)	Average value of basin and Centre
			0-15	15-30	30-45	45-60		
1	Aonla + Ber	Basin	17.80	17.10	15.92	14.70	16.38	15.95
		Centre	16.30	16.00	15.60	14.15	15.51	
2	Aonla + Guava	Basin	17.50	17.04	16.30	14.54	16.35	15.93
		Centre	16.40	16.02	15.56	14.00	15.50	
3	Aonla + Karonda	Basin	16.52	16.20	15.75	14.50	15.74	15.29
		Centre	15.35	15.10	14.90	13.95	14.83	
4	Ber + Guava + Phalsa	Basin	18.10	17.40	16.80	15.00	16.83	16.32
		Centre	16.60	16.15	16.04	14.50	15.82	
5	Aonla + Subabool	Basin	16.70	16.10	15.90	14.80	15.88	15.52
		Centre	16.05	15.30	15.02	14.30	15.17	
6	Control		14.10	13.60	13.05	12.80	13.39	13.39
	CD at 5%		0.77	0.74	0.72	0.66		

Conclusion

Based on the results obtained from the present investigation, it is concluded that all the cropping systems improved the soil as compared to control (barren site). Decrease in pH, ECe, ESP, and increase in CEC indicated considerable improvement in chemical properties of soil. Among various tree cropping systems, Ber +Guava + Phalsa emerged most superior in improving the soil characteristics and availability of nutrients. Aonla + Ber tree cropping system was found the next best combination in this respect.

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