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APPRAISAL OF SOME SALT AFFECTED SOILS OF D. I. KHAN DISTRICT (N.W.F.P.)

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Abstract. Salt-affected soils of D.I. Khan were appraised by collecting eighteen composite samples from 0 — 15, 15 — 45 and 45 — 90 cm depth. Four samples were found to be saline and fourteen saline-alkali. The values of electrical conductivity ranged from 5.83 to 20.87mmhos/cm at 25°, pH from 7.80 to 8.40 and ESP from 13.15 to 28.08. Sodium and chloride were dominant soluble ions. These soils were from medium to fine in texture and strongly calcareous having low contents of organic matter, total nitrogen, and available phosphorus. Available potassium was adequate. Significant correlations were found between clay content and CEC, ESP and gypsum requirements and pH and organic matter.

The economy of Pakistan is predominantly agrarian and prosperity of the people depends upon the culturable land. Of * the total 47.64 million acres of culturable land, 17.41 million acres are affected by salinity and water logging which has caused a great set back to economy of the country.

Keeping in view the seriousness of this acute problem, an accelerated programme for water logging and salinity control has been prepared which is estimated to incur over Rs. 3,000 crores and will be implemented during the next 20 years under the direct responsibility of the Federal Government in coordination with the department concerned. Like other parts of the country, salt affected soils are also common in D.I. Khan region both in irrigated and unirrigated areas. Realising the vital importance of the problem, this research project of salinity appraisal was undertaken in order to obtain detailed information regarding the physicochemical characteristics of these soils. The findings of this research project will be of great help in the improvement and management of these salted soils and will be useful in the maximum possible exploitation of the agricultural potentialities of this region.

Materials and Methods

Research was carried out from July, 1974 to September 1975. Eighteen soil samples were collected from representative salt affected areas of Kurai, Rakh Zindani, Shor Kot, Ratta Kulachi, Kut Shahani and Rakh Bibi in D.I. Khan district (location depicted in Fig. 1). Composite samples from these profiles were taken from 0 – 15, 15 — 45 and 45 — 90 cm depth. Field observations involving the study of native vegetation, crops grown, irrigation, drainage and relief were made during soil sampling. The samples were air dried, ground and sieved through 2 mm sieve.

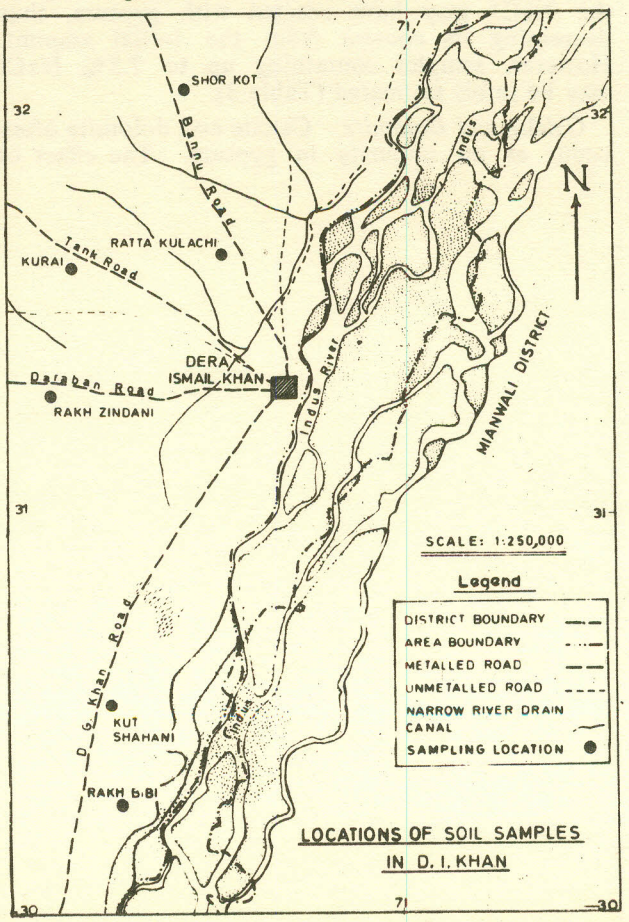

Fig. 1. Map showing location of soil samples in D. I. Khan.

*Yearbook of Agriculture Statistics (1973-74). Government of Pakistan, Ministry of Food, Agriculture and Rural Development, Agriculture Wing (Planning Unit), Islamabad, p. 4.

Analysis of particle size distribution was carried out by the method of Moodie *et al.*[3] Saturation percentage, pH of the saturated paste, electrical conductivity of saturation extract, water soluble cations and anions, sodium adsorption ratio, cation exchange capacity, exchangeable cation, ESP, gypsum requirements and alkaline earth carbonate and organic matter were determined according to the methods given by Richards.[6] The total nitrogen was determined as given in AOAC.[1] Available phosphorus was determined as described by Olsen *et al.*[5] Available potassium was calculated by adding exchangeable and soluble potassium.

Results and Discussion

The character of native vegetation and the unfavourable response of crops plants in some areas of D.I. Khan emphasized the need for salinity survey. In general the problem areas are characterized by the presence of barren spots and alkali or salt tolerant native or crop plants which show symptoms of injury or growth abnormalities.

Native plants and weeds found in these areas included *Saueda fruticosa* (Lani*), *Capparis aphylla* (Karir*), *Acacia arabica* (Babul*), *Calotropis procera* (Ak) and *Cynodon dactylon* (Khabal). Crops commonly grown were wheat, sorghum, maize, rice, cotton and sugar cane. The sources of irrigation were commonly tube-wells. Drainage of the areas was poor. The water table in the area was varied from about 40 — 60 m.

The textural class of Kurai and Rakh Zindani was from silt loam to clay and that of Shor Kot and Ratta Kulachi was silty clay and silty clay loam whereas that of Kut Shahani and Rakh Bibi was from silty clay to clay. The average contents of clay and silt were higher than sand. The ratios of clay to sand and clay to silt were non-consistent showing no illuviation of clay in these soils (Table 1).

Saturated percentage of these soils was high and showed an increase with corresponding increase in clay content. These soils were strongly calcareous and alkaline in reaction with the range of calcium carbonate equivalent from 18.25 to 28.85% and pH of saturated paste from 7.80 to 8.40. The alkaline reaction and calcareousness of these soils could be attributed to high concentration of bases and calcareous parent material. Soluble salts were distributed throughout the profiles and values of electrical conductivity of saturation extract ranged from 5.83 to 20.87 mmhos/cm at 25°. The high values of electrical conductivity might be due to imperfect leaching of soluble salts, use of poor quality irrigation water and poor management practices. All these soils contained fairly high concentration of soluble cations and anions except carbonate which was detected in traces (Table 2).

Sodium and chloride ions were dominant among cations and anions. Sodium content varied from 28.04 to 110.76 me/L while calcium ranged from 12.82 to 40.60 me/L whereas magnesium and potassium ranged from 6.05 to 22.54 and 1.02 to 6.19 me/L respectively. Chloride was the most prominent anions, sulphate was next, bicarbonate was the least prevalent of all. The distribution of bicarbonate and chloride was uniform with depth, but the sulphate increased with depth in all the soils except that of Ratta Kulachi wherein a reverse pattern was observed. Variation in the amount of anions within profiles could be ascribed to the differences in quality of irrigation water, amount of irrigation water applied and the type of parent material of the soils.

The cation exchange capacity of these soils ranged from 13.78 to 33.33 me/100 g soil (Table 3). The values of CEC showed positive correlation with clay

*local names of the vegetation.

TABLE 1. PARTICLE SIZE DISTRIBUTION AND SATURATION PERCENTAGE OF REPRESENTATIVE SALT AFFECTED SOIL SAMPLES FROM D. I. KHAN.

Location of soils	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Clay/sand	Clay/silt	Texture class	Saturation (%)
Kurai	0-15	7.20	26.16	66.20	9.19	2.53	Clay	74.97
	15-45	5.80	55.00	39.20	6.76	0.71	Silty clay loam	47.47
	45-90	12.80	68.00	19.20	1.50	0.28	Silt loam	36.39
Rakh Zindani	0-15	13.20	42.00	44.80	3.39	1.07	Silty clay	56.75
	15-45	13.20	41.00	45.80	3.47	1.12	Silty clay	54.64
	45-90	18.80	46.00	35.20	1.90	0.77	Clay loam	48.55
Sher Kot	0-15	10.80	44.00	45.20	4.19	1.03	Silty clay	58.74
	15-45	8.80	42.00	49.20	5.59	1.17	Silty clay	59.00
	45-90	2.80	54.00	42.00	15.36	0.79	Silty clay	56.02
Ratta Kulachi	0-15	7.20	56.00	36.80	5.11	0.66	Silty clay loam	55.36
	15-45	7.20	42.00	50.80	7.05	1.21	Silty clay	58.67
	45-90	7.20	64.00	28.80	4.00	0.45	Silty clay loam	53.00
Kot Shahani	0-15	4.00	42.00	54.00	13.50	1.29	Silty clay	63.93
	15-45	6.00	56.00	38.00	6.33	0.68	Silty clay	55.04
	45-90	3.60	20.00	76.40	20.11	3.82	— clay	74.10
Rakh Bibi	0-15	4.00	28.00	65.80	10.77	2.35	— clay	69.21
	15-45	3.60	18.00	78.40	21.78	4.36	— clay	79.85
	45-90	5.20	26.40	68.40	13.15	2.59	— clay	76.26

content, i. e. *r* 0.7184, *t* 4.04 (Fig. 2). Arshad and Pawluk[2] and Sarir[7] also reported similar results. Exchangeable calcium plus magnesium was the predominant cations on exchange complex and ranged from 9.99 to 25.93 me/100 g. The high degree of saturation of exchange complex with calcium plus magnesium might be due to the nature of soluble salts and calcareous parent material.

Exchangeable sodium was the second dominant cations on the exchange complex and ranged from 2.60 to 7.12 me/100 g. Exchangeable sodium percentage varied from 13.15 to 28.08. Exchangeable potassium was the least dominant of all exchangeable cations and ranged from 0.84 to 1.81 me/100 g of soils.

The soils having ESP above 15 showed gypsum requirements varying from 1.55 to 19.93 ton ha. The soils of Kurai, Shor Kot, Ratta Kulachi, Kut

TABLE 3. CHEMICAL CHARACTERISTICS OF REPRESENTATIVE SALT AFFECTED SOIL SAMPLES FROM D. I. KHAN.

Location of soils	Depth (cm)	pH	C.E.C. (me/ 100 g)	Exchangeable cations			E.S.P.	S.S.P.	G.R. (ton/ ha)	Lime	Organic matter	N (%)	Available P ppm	Available K ppm
				Na^+	K^+	$Ca^{++}+Mg^{++}$								
Kurai	0-15	8.00	24.63	3.24	1.18	20.21	13.15	59.83	0.00	22.00	0.603	0.058	2.52	499.20
	15-45	7.95	22.18	3.90	1.36	17.92	16.82	66.49	1.55	24.78	0.507	0.046	3.50	556.92
	45-90	7.90	13.78	2.60	1.19	9.99	18.89	50.18	3.45	28.85	0.464	0.032	2.04	478.92
Rakh Zindani	0-15	7.80	24.40	3.54	1.81	19.05	14.68	57.64	0.00	25.53	0.776	0.057	2.53	748.02
	15-45	8.00	26.08	3.67	1.22	21.19	14.07	60.32	0.00	25.67	0.517	0.046	5.24	499.20
	45-90	7.90	20.04	3.68	1.55	14.81	14.02	55.09	0.00	27.90	0.310	0.031	2.16	628.00
Sher Kot	0-15	8.15	29.71	5.99	1.66	22.15	20.16	61.66	3.51	26.30	0.845	0.070	9.00	768.30
	15-45	8.10	23.18	5.39	1.47	16.32	23.25	57.63	4.67	25.30	0.620	0.052	5.24	631.80
	45-90	8.40	24.63	4.50	1.15	18.98	18.63	59.61	0.00	25.25	0.414	0.038	2.16	498.42
Ratta Kulachi	0-15	8.10	26.08	5.66	0.94	19.48	21.70	66.18	1.78	19.45	0.362	0.038	9.00	499.22
	15-45	8.05	32.53	4.94	1.66	25.93	15.18	56.10	0.00	19.66	0.156	0.014	5.60	748.02
	45-90	8.00	22.10	5.36	1.11	15.63	24.25	55.60	11.69	21.19	0.172	0.014	3.50	495.30
Kut Shahani	0-15	7.90	25.36	4.97	1.13	20.26	23.38	36.64	5.46	22.75	0.966	0.092	10.12	502.32
	15-45	7.95	22.36	6.20	1.50	14.66	28.08	42.43	19.93	22.48	0.569	0.048	2.58	609.96
	45-90	7.90	29.09	6.26	0.96	21.87	23.12	41.80	4.35	21.13	0.304	0.022	3.56	415.74
Rakh Bibi	0-15	8.10	23.35	5.46	0.84	17.05	19.59	62.91	8.17	20.14	0.741	0.055	10.60	416.13
	15-45	8.05	33.33	6 92	1.45	24.96	20.76	52.07	11.76	18.25	0.582	0.036	6.44	627.90
	45-90	7.05	30.79	7.12	0.97	22.70	21.58	51.79	9.60	20.10	0.448	0.031	8.12	417.30

TABLE 2. CHEMICAL CHARACTERISTICS OF REPRESENTATIVE SALT AFFECTED SOIL SAMPLES FROM D. I. KHAN

Location of soils	Depth (cm)	$EC \times 10^3$ of saturated paste	Salt (%)	Soluble cation				Soluble Anions				SAR
				Na^+	K^+	Ca^{++}	Mg^{++}	CO_3''	HCO_3'	Cl'	SO_4''	
				me/l				me/l				
Kurai	0-15	5.83	0.277	30.21	1.41	12.82	6.05	0	8.25	22.40	19.84	9.84
	15-45	9.64	0.294	56.32	1.32	18.03	9.03	0	7.75	44.25	32.70	15.30
	45-90	10.62	0.247	46.48	1.23	24.30	21.01	0	6.25	48.50	38.67	9.86
Rakh Zindani	0-15	9.41	0.341	49.41	1.91	23.00	11.40	0	6.00	57.75	22.03	11.90
	15-45	6.94	0.239	37.86	1.15	16.52	7.23	0	7.25	30.50	25.00	10.97
	45-90	8.04	0.247	39.58	1.02	16.74	14.50	0	7.50	40.00	26.34	9.99
Sher Kot	0-15	18.85	0.708	106.65	5.24	40.60	20.46	0	14.50	129.00	29.45	19.32
	15-45	10.63	0.401	58.42	2.62	31.14	7.72	0	10.10	50.00	37.80	12.82
	45-90	11.45	0.388	65.26	2.17	27.16	14.14	0	8.00	35.40	65.93	14.24
Ratta Kulachi	0-15	18.32	0.749	108.58	6.19	28.83	20.47	0	6.00	98.00	60.40	21.89
	15-45	12.01	0.423	62.17	4.28	23.86	20.05	0	6.50	50.60	53.69	14.96
	45-90	11.44	0.542	48.90	3.07	22.57	20.09	0	6.00	38.50	52.13	10.36
Kut Shahani	0-15	8.14	0.333	28.04	1.80	32.15	14.45	0	7.50	35.40	33.63	5.80
	15-45	8.36	0.229	30.56	1.77	25.50	14.19	0	7.00	38.50	26.64	6.86
	45-90	8.44	0.405	37.67	1.54	30.52	20.38	0	5.50	42.00	42.61	7.45
Rakh Bibi	0-15	20.87	0.924	110.76	3.19	39.55	22.54	0	6.50	193.00	27.54	19.77
	15-45	9.63	0.492	41.86	2.04	24.52	11.97	0	6.00	38.50	35.89	9.80
	45-90	8.28	0.404	38.70	1.53	23.43	11.06	0	6.00	24.50	44.22	9.32

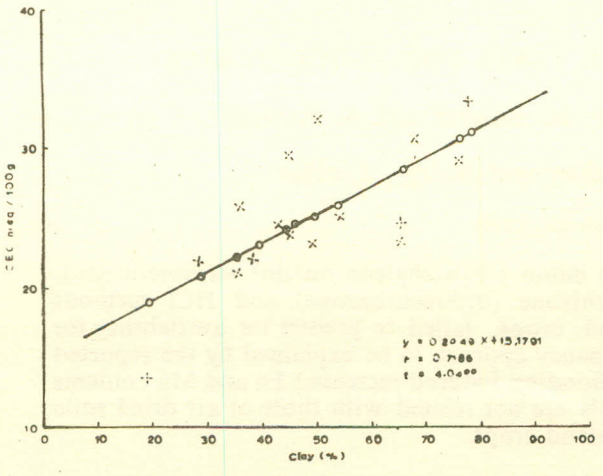

Fig. 2. Relationship between % clay and CEC.

Shahani and Rakh Bibi gave gypsum requirements of 2.50, 4.09, 8.73, 9.91 and 9.91 and 9.54 ton/ha, respectively. Kut Shahani soils indicated the highest gypsum requirements as these soils had maximum ESP whereas Rakh Zindani soils gave negative gypsum requirements which might be due to the presence of gypsum in these soils. It was found that significant correlation existed between ESP and gypsum requirement i. e. r 0.798, t 5.304** (Fig. 3).

These soils were low in organic matter, nitrogen and available phosphorus, but high in available potassium. The organic matter and nitrogen content decreased with depth while phosphorus followed no regular trend of increase or decrease. The values of organic matter, total nitrogen and available phosphorus ranged from 0.156 to 0.966% from 0.014 to 0.092% and from 2.16 to 10.60 ppm, respectively. The low content of organic matter was due to the arid climatic condition of this region which was responsible for poor production, and simultaneous decomposition of organic matter. Besides this the factor of high salinity and alkalinity could also cause an adverse effect on the accumulation of organic matter through their injurious effect on the growth of native vegetation. Organic matter and pH showed a negative relationship with r 0.6789 and t 5.0372** (Fig. 4). The low content of phosphorus could be attributed to

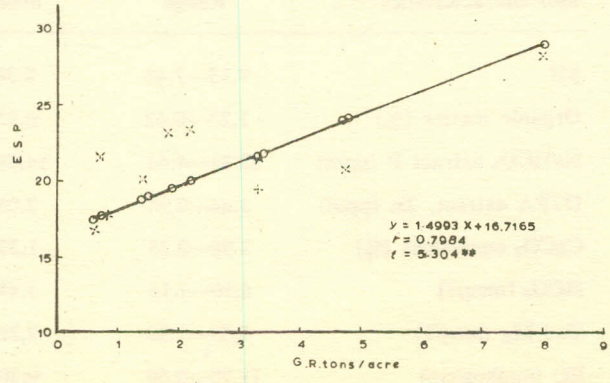

Fig. 3. Relationship between ESP and gypsum requirements.

the calcareousness of these soils. High content of potash, ranging from 416.13 to 768.30 ppm, could be ascribed to the presence of potassium bearing clay minerals as reported by Nawaz.[4]

According to the classification of Richard[6] these salted soils were classified into saline-alkali and as such four samples were saline and fourteen-saline-alkali and no sample was found normal.

It could be concluded from these results that the saline soil of Rakh Zindani could be improved by leaching with good quality of irrigation water while the saline-alkali soil could be improved through the application of suitable chemical amendments, preferably gypsum along with leaching. The gypsum requirements were found to be 2.50, 4.09, 6.75, 9.91 and 9.84 ton/ha for Kurai, Shor Kot, Ratta Kulachi, Kut Shahani and Rakh Bibi, respectively.

Provision of poor drainage system such as tile drainage, growing of salt resistant crops like sugar cane, rice, barley, cotton berseem, deep plowing and proper crop rotation could improve these salted soils.

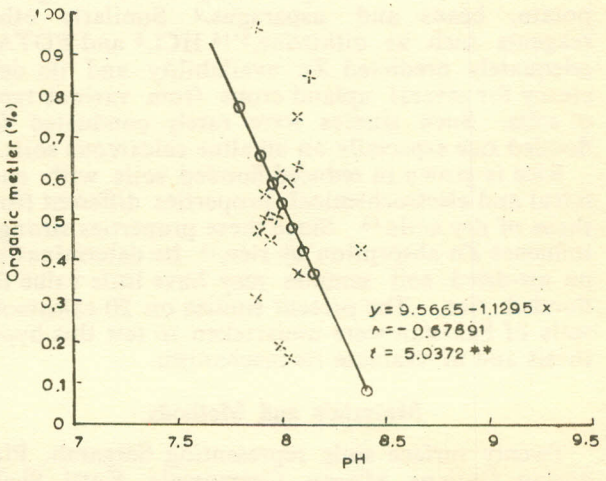

Fig. 4. Relationship between pH and organic matter.

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