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Research Paper

CHLORIDE STATUS IN SOILS OF DRYLAND AREAS IN MIRZAPUR DISTRICT, UTTAR PRADESH, INDIA

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Abstract

A study was conducted to determine chloride status in soil of Mirzapur district, at Department of Soil Science and Agricultural Chemistry, Banaras Hindu University Varanasi, Uttar Pradesh. To evaluate the status of chloride in soils, the surface soil samples were collected in dryland areas of Mirzapur district, Uttar Pradesh during pre monsoon period. After processing the soil samples, the soils were extracted by water (plant available Cl^-) and sodium carbonate (total Cl^-).The chloride of the extractants is determined by spectrophotometric method using ferric nitrate monohydrate and mercury (II) thiocyanate. The mean chloride content of the soils in Mirzapur district was 86.5 kg ha^{-1}. In Mirzapur District 57.2 % soils were found low category (Category of soil chloride, kg ha^{-1} : Low ≤34, Medium 35-67 and high >67) chloride content in soils.

Key words: Soil, available chloride, total chloride, dryland.

INTRODUCTION

The chloride ion is present in abundance almost everywhere in the world. It is required as a micronutrient for optimal plant growth, at a rate only 0.3-1 mg/g dry matter in most plants (Marschner, 1986). Broyer *et al*. (1954) offered sufficiently evidence to cause general acceptance of Cl^- as plant essential element. Cl has a number of essential biochemical functions in plants (Fixen, 1993). It operates as a counter ion for cation transport and as an osmoticum (Flowers, 1988). Plants take up Cl as the Cl^- ion from soil solute and the primary form of Cl in plants is Cl^-. Like nitrate (NO_3^-), Cl^- acts as a counter ion for the transport and uptake of essential cation, such as, Ca^{2+}, Mg^{2+}, K^+ and NH_4^+. Chloride is also involved in several other processes taking place in the plant, *viz.*, photosynthesis by evolution of oxygen in photosystem II, enzyme activation and transportation of other plant nutrients(Grant Lamond and Mohr, 2003), plant development, lodging prevention and disease suppression (Engel *et. al.*, 1994). Chloride fertilization based on soil testing is gradually becoming an established practice in

dryland wheat, sorghum and corn production in Kansas, North America (Mengal *et al*., 2009). The chloride showed significant responses of dryland winter wheat and barley (Petrie, 2005) in eastern Oregon. Chloride concentrations of 20-50 g m^{-3} have been found in rain water close to sea share, diminishing rapidly with distance from the ocean. In inner continental areas, the corresponding concentrations are 2-6 g m^{-3}. Thus, in dry land areas (rainfall 375-1125 mm with high evapotranspiration), Cl is generally deficient in soil as well as in ground water.

According to India's Fourth Five Year Plan areas with an annual rainfall of less than 375 mm are classified as arid (desert) and those receiving 375-1125 mm are dry land. Dry lands contribute 42% of the total food grain production (Shivanappan, 1995) of the country. India has about 47 million hectares of dry lands out of 108 million hectares of total rainfed area. Those areas produce 75% of pulses and more than 90% of sorghum, millet and groundnut. Thus, dry lands and rainfed farming will continue to play a dominant role in agricultural production. Despite all the improvements in agriculture in present scenario, we have yet not been able evolve an appropriate package of practices for our dry land areas.

This study was carried out to examine the chloride status in soil of dryland areas in Mirzapur district, Uttar Pradesh for the enhancement of the productivity of the dryland through appropriate doses of chloride fertilizers.

MATERIALS AND METHODS

Study area

Mirzapur district is situated in between the parallels of 24˚34' & 25˚16' North latitude and 82˚05' and 83˚11' East longitude. Mirzapur is situated in eastern part of Uttar Pradesh, India and physiography of the site is piedmont plains at foothills of Vindhyan range. The climate is predominantly dry (sub-tropical to dry), winter season is short (November to February) but summer is long (March to October). The temperature rises up to 40˚C or more during summer and drops 4˚ C during December to January. The average annual rainfall of Mirzapur is 1060 mm. The normal period of onset of monsoon in this district is third to fourth week of June, which lasts up to end of September. About 90 % of annual rainfall is received during monsoon season but it is highly erratic and unpredictable, at time cause drought spells of varying degree and duration.

Soil sampling and laboratory analysis

Surface soil of the cultivated dry lands of Mirzapur district was sampled randomly to a depth of 0-15 cm in triangular shape by the help of *khurpi* from 21 different sites of different geomorphological locations. Soil samples collected from different geomorphological locations were air dried at room temperature under shade. Air dried samples were grinded manually by wooden grinder and passed through a 2 mm sieve. The soil samples were then stored in capped plastic containers. The homogenized soil samples were analysed for selected physical and chemical properties by standard procedures.

Bulk and particle density were determined using pycnometer in laboratory in disturbed soil sample. Keen's box method was applied for measurement of water holding capacity (Black, 1965). The soil particle size analysis was done mechanically by using the hydrometer method of Bouyoucos(1927) with sodium hexameta- phosphate as the dispersing agent. The pH and electrical conductivity (EC) of the Soil and water samples were measured by using digital pH and EC meter, respectively. Organic carbon was estimated by Walkley-Black wet digestion method (1934).Macronutrients also determined following the standardized protocols described in Page (1991).Water

soluble and total chloride were estimated with colourometric method developed by Fixen *et al*.(1987).

Statistical analysis Data obtained from all the observations were statistically analysed. The correlation of soil parameters with chloride content in soil were statistically calculated.

RESULTS AND DISCUSSION

In Mirzapur district 52% soils were sandy clay loam, 33% clay loam others were clay. The range of sand, silt and clay content varied from 24.96-74.96%, 6-30% and 19.04-45.04%, respectively. Thus, the texture of the dryland regions varied from mostly sandy clay loam to clay loam. The bulk and particle density ranged from 1.27 to 1.49 Mg m^{-3} and 1.95 – 2.79 Mg m^{-3}, respectively. Porosity of the collected soil samples of Mirzapur district ranges from 31.79 to 51.56%. Wide variation of WHC was found in the cultivated dryland soils of Mirzapur district. The WHC varied from 33.70-51.59% in Mirzapur district (Table 1). These variations are due to organic matter content, soil particles content, as well as tillage practices for different cropping system.

The soil pH varied between 7.1 to 9.5 .Fifty per cent dryland soils of Mirzapur district were strongly alkaline in reaction, 35% were mildly alkaline and approximately 5% were very strongly alkaline and rests (10%) were neutral in reaction (Table 2). Thus, dryland soils in Mirzapur district were mostly alkaline nature.

Electrical conductivity of the soils in cultivated dryland in Mirzapur district varied from 0.57 to *2.*88 dSm^{-1}. The mean EC values in all the soils were found below 4 but the mean pH was 8.23. Thus, the cultivated dryland soils of Mirzapur district were on an average categorized as alkali (EC < 4 & pH > 8.5) to saline-alkali in nature (EC > 4 & pH < 8.5). The mean of SOC in Mirzapur was 5.88 g kg^{-1}. Thus, considering the district in dryland areas of eastern Uttar Pradesh, the organic matter content on an average was found medium. But, 24% in Mirzapur district were found low organic matter content. Plant available nitrogen content in dryland soils of Mirzapur district varied from 50.67-231.24 kg ha^{-1} with an average of 172.47 kg ha^{-1}. The plant available nitrogen content in dryland soils of Mirzapur district was low (< 272 kg ha^{-1}). As the organic matter content in the dry land areas of Mirzapur district was low to medium range, the plant available nitrogen content in soils was observed consequently low.

Plant available phosphorus contents in cultivated dryland soils of Mirzapur district varied 2.65 to 108.68 kg ha^{-1}. According to soil fertility index, more than 71% analyzed soil samples in Mirzapur district are medium to high grade phosphorus while 29% are in low category (<22.5 kg ha^{-1}).

Potassium is one of the three major plant nutrient elements. In Mirzapur district 57% soils were in medium range and 43% in high range category. The average plant available soil potassium content in dryland region was medium range. Thus, available potassium in soil is not a serious problem in this region for crop cultivation.

The critical limits of exchangeable Ca and Mg vary widely among soils, average values are less than 2.0 meq/100 g for exchangeable Ca and less than 0.5 meq/100 g exchangeable Mg. Critical limit of $CaCl_2$ (0.15%) extractable Sulphur in soils is about 10 mg kg^{-1}.In Mirzapur district 80% soil samples were found below the critical level. Thus, plant available of sulphur content in Mirzapur district were lower (mean18.11 kg ha^{-1}) due to low SOM content in soils.

The mean of the plant available calcium and magnesium in Mirzapur 8.74 and 4.71 meq/100g of soils. The plant available calcium and magnesium content in all analysed soil samples were above critical limits, i.e. 2 meq/100g and 0.5 meq/100g of soils,

respectively. As Ca and Mg were present in sufficient in the dryland region of Uttar Pradesh, the minerals i.e. Calcite, olivine, magnesite and chlorite etc. may present in the soils of the Mirzapur.

The mean content of water extractable, potassium sulphate extractable, calcium oxide extractable and total chloride in the soils of 21 different locations of Mirzapur district was estimated as 38.64 and 281.37 mg kg^{-1}, with ranges from 2.50-222.50 and 240.7-373.5 mg kg^{-1}, respectively (Table 3). The highest value of both the water extractable chloride (i.e. plant available form) and total chloride was obtained in Bharwan Chauraha. Similarly, the lowest value of water extractable chloride (i.e. plant available form) and total chloride was obtained in Bahgum and Esherpati (Gurkholi and Devri) village of Mirzapur district, respectively. An examination of the data clearly showed a wide range of chloride content in the dry land soils. The wide variations in the chloride content might be due to the nature of the parent materials from which the soils would be derived. Because of its mobility in the soil with moving water in the soil, the chloride content of soil is not an intrinsic property of the soil but rather a result of soil management.

Moreover, Fixen et al. (1987) established the calibration of chloride based on the soil test in a specific geographic area (South Dakota), crop species (spring wheat) and cultivars. According to this calibration data more than 80% soils of the dry land areas of Mirzapur district was observed low to medium category (67% in low).

Correlation of the chloride content with soil properties

The data on correlation of the water extractable chloride (WE-Cl^-) and total chloride (Total Cl^-) in soils with the properties of soils of Mirzapur district have been presented in Table 5. The WE-Cl^- in Mirzapur was significantly correlated with Mg^{2+} content in soils. Due to low organic matter contents in the dry lands areas of Mirzapur district, Cl^- leaching is not significantly controlled by low amount of organic matter in soils. The soil bases (i.e. Ca^{2+} & Mg^{2+}) are governed the Cl^- leaching to lower profiles in dry land areas of Mirzapur.

CONCLUSIONS

The soils of the dry land areas were mostly clay loam to sandy clay loam in texture with the clay content more than 30% and contents low organic matter. The WHC and porosity of soils in the district were in an average more than 40%, suitable for good crop cultivation. The pH of most of the dry land soils were alkaline and EC were found in higher range (more than 1.0 dSm^{-1}). As the organic matter content in the dry land areas of these regions was low to medium, the plant available nitrogen in soils was observed consequently low; whereas phosphorus and potassium content ranged from low to medium. The plant available calcium and magnesium in dry land regions of Mirzapur district were above the critical limits. According to Fixen *et al.* (1987) calibration index, more than 80% soils of the dry land areas of Mirzapur district were observed the chloride content, low to medium category.

Worldwide Cl calibration data on specific geographical location for specific crop still have not developed widely for crop cultivation purpose. The chloride calibration data are particularly needful for dryland areas for enhancement of water use efficiency and land productivity.

Table 1: Physical property of the dryland soils of Mirzapur district, Uttar Pradesh

S. No.	Location (Village)	Bulk density ($Mg\ m^{-3}$)	Particle density ($Mg\ m^{-3}$)	Porosity (%)	WHC (%)	Sand (%)	Silt (%)	Clay (%)	Textural Class (USDA)
1.	Esherpati	1.32	2.59	49.03	42.21	74.96	6	19.04	Sandy Loam
2.	Rambagh	1.33	1.95	31.79	42.45	46.96	20	33.04	Clay Loam
3.	Smspur	1.42	2.79	49.10	49.62	62.96	12	25.04	Sandy Clay Loam
4.	Smspur	1.35	2.46	45.12	33.70	54.96	16	29.04	Sandy Clay Loam
5.	Dhrara	1.29	2.48	47.98	45.57	64.96	10	25.04	Sandy Clay Loam
6.	Barurahi	1.37	2.63	47.90	42.99	59.96	20	20.04	Sandy Clay Loam
7.	Pusaya Dagmagpur	1.26	2.30	45.21	45.37	44.96	22	33.04	Clay Loam
8.	Persunpur	1.33	2.29	41.92	45.05	34.96	24	41.04	Clay
9.	Gurkholi	1.31	2.71	51.66	44.79	54.96	14	31.04	Sandy Clay Loam
10.	Puthrahan	1.34	2.42	44.62	44.52	50.96	16	33.04	Sandy Clay Loam
11.	Kapsaur	1.35	2.20	38.63	46.80	38.96	26	35.04	Clay Loam
12.	Bharwan Chauraha	1.32	2.15	38.60	46.74	36.96	30	33.04	Clay Loam
13.	Bahrgum	1.30	2.54	48.81	51.18	24.96	30	45.04	Clay
14.	Dhorapur	1.30	2.36	44.91	50.35	46.96	20	33.04	Clay Loam
15	Gautam Luholi	1.30	2.41	46.05	48.77	50.96	20	29.04	Sandy Clay Loam
16	Rajpur	1.49	2.46	39.43	42.13	50.96	20	29.04	Sandy Clay Loam
17	Aamghat	1.27	2.29	44.54	49.80	58.96	16	25.04	Sandy Clay Loam
18	Gurwa	1.29	2.46	47.56	50.04	52.96	18	29.04	Sandy Clay Loam
19	Hurwa	1.30	2.59	49.80	48.69	52.96	18	29.04	Sandy Clay Loam
20	Devri	1.33	2.32	42.67	50.41	44.96	24	31.04	Clay Loam
21	Devri	1.30	2.53	48.61	51.59	46.96	20	33.04	Clay Loam
	Range	1.26 – 1.49	1.95 – 2.79	31.79 - 51.66	33.70 - 51.59	24.96 – 74.96	6 -30	19.04 – 45.05	
	Mean	**1.33**	**2.42**	**44.95**	**46.32**	**50.34**	**19.14**	**30.51**	
	±S.D.	0.05	0.19	4.77	4.25	11.14	5.95	6.01	
	C.V.	3.90	8.04	10.61	9.18	22.14	31.09	19.70	

Table 2: Chemical properties of the dryland soils of Mirzapur district, Uttar Pradesh

S. No.	Location (Village)	pH	EC (dSm^{-1})	O.C. ($g\ kg^{-1}$)	Available N ($kg\ ha^{-1}$)	Available P (P_2O_5) ($kg\ ha^{-1}$)	Available S ($kg\ ha^{-1}$)	Available Na^+ ($kg\ ha^{-1}$)	Available K (K_2O) ($kg\ ha^{-1}$)	Ca^{+2} (me/100g soil)	Mg^{+2} (me/100g soil)
1.	Esherpati	8.2	1.96	1.95	50.17	25.55	37.24	144.48	192.19	5.5	7.1
2.	Rambagh	8.6	1.64	2.92	150.52	23.95	75.32	142.24	451.58	7.5	13
3.	Smspur	8.4	0.92	2.92	213.24	23.95	21.28	107.52	274.17	7.9	1.1
4.	Smspur	8.8	1.06	6.24	188.16	3.32	6.44	221.76	338.68	7.0	9.5
5.	Dhrara	8.6	1.27	4.29	175.61	18.66	6.44	206.08	282.24	9.0	5.4
6.	Barurahi	8.5	1.47	5.26	188.16	19.99	9.80	129.92	475.77	8.8	6.0
7.	Pusaya Dagmagpur	9.5	3.27	6.82	175.61	72.68	13.16	108.64	215.45	12.6	5.4
8.	Persunpur	8.8	1.63	7.80	188.16	11.79	11.76	114.24	681.40	10.5	10.5
9.	Gurkholi	8.0	1.01	4.87	213.24	2.65	5.32	112.00	420.91	8.6	1.4
10.	Puthrahan	7.3	0.59	7.60	150.52	36.66	3.08	119.84	327.93	8.1	0.7
11.	Kapsaur	8.5	2.28	5.85	163.07	19.99	98.00	170.24	802.42	19.0	1.0
12.	Bharwan Chauraha	7.1	1.31	7.41	175.61	52.00	2.52	134.40	420.62	6.5	11.0
13.	Bahrgum	7.9	1.21	6.82	188.16	52.05	9.24	134.28	309.12	7.7	4.3
14.	Dhorapur	8.6	1.63	9.16	200.70	47.33	1.12	211.68	148.43	8.8	6.4
15	Gautam Luholi	7.5	0.80	4.87	213.24	86.01	3.08	117.60	170.68	6.4	1.9
16	Rajpur	8.6	1.31	5.65	150.52	63.34	1.12	144.48	172.50	11.0	0.4
17	Aamghat	7.8	1.00	5.85	188.16	69.34	33.32	478.24	431.42	7.5	2.8
18	Gurwa	7.7	1.72	4.87	200.70	33.54	9.80	114.24	244.60	6.0	3.5
19	Hurwa	7.9	2.88	7.21	125.44	86.01	5.88	124.32	283.58	7.0	4.0
20	Devri	8.0	1.73	8.75	150.52	108.68	8.40	135.52	407.20	9.3	3.2
21	Devri	8.6	0.57	6.43	150.52	15.98	3.08	155.68	213.69	9.0	0.5
	Range	7.1 - 9.5	0.57 - 2.88	1.95 - 9.16	50.17 – 231.24	2.65 – 108.68	1.12 – 98.00	107.52 – 478.24	148.43 – 802.42	5.5 – 19.0	0.4 – 11.0
	Mean	**8.23**	**1.48**	**5.88**	**172.47**	**41.59**	**18.11**	**158.58**	**345.93**	**8.74**	**4.71**
	±S.D.	0.57	0.68	1.88	53.28	29.88	25.32	88.11	166.47	2.90	3.75
	C.V.	6.97	46.11	32.01	30.89	71.84	139.77	55.56	48.12	33.19	79.57

Table 3: Chloride content in the dry land soils of Mirzapur district, Uttar Pradesh

S.No.	Location (Village)	Soil	
		Water extractable chloride (mg kg^{-1})	Total chloride (mg kg^{-1})
1.	Esherpati	37.50	240.7
2.	Rambagh	5.00	232.4
3.	Smspur	2.75	282.2
4.	Smspur	45.00	256.6
5.	Dhrara	17.5	315.4
6.	Barurahi	67.5	290.5
7.	Pusaya Dagmagpur	5.00	315.4
8.	Persunpur	140.00	232.4
9.	Gurkholi	2.50	240.7
10.	Puthrahan	10.00	332.0
11.	Kapsaur	15.00	282.2
12.	Bharwan Chauraha	222.50	373.5
13.	Bahrgum	2.50	282.2
14.	Dhorapur	3.25	315.4
15	Gautam Luholi	5.75	340.3
16	Rajpur	10.00	290.5
17	Aamghat	4.25	240.7
18	Gurwa	17.50	249.0
19	Hurwa	115.00	273.9
20	Devri	77.50	282.2
21	Devri	5.50	240.7
Range	Range	2.50 – 222.50	240.7 – 373.5
Mean		**38.64**	**281.37**
±S.D.		57.51	39.55
C.V.		148.84	14.05

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