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Distribution of Available S in Some Soil Series of West Bengal Growing Rice and Pulses

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Abstract

Laboratory experiment was conducted to study the distribution of available S and to find out influence of different soil characteristics on the predictability of available S status in sixteen different soil series of West Bengal growing rice and pulses. Available ($CaCl_2$ extractable) S content of soils under study showed wide variation ranging from 16.66 to 51.57 with an average of 35.60 mg kg^{-1} soil and considering the availability index (viz., available S<10 ppm (low); between 10-20 ppm (medium) and >20 ppm (high), 13% of the soils could be classified under medium and 87% under high available S status. The variation of available S status in soils of different series was due to variation in different soil properties, soil and crop management practice and fertilizer use, etc. Correlation coefficient values among different soil properties revealed significant influence of clay, total P, total S and amorphous Al content of the soils with their respective relative contributions of 58, 13, 6, 5 and 2% in the variation in available S status in soils.

1. Introduction

As essential nutrient, sulphur ranks fourth in the mineral composition of plants. It plays an important role in the formation of proteins (particularly sulphur containing amino acids) and is involved in the metabolic and enzymatic processes of all living cells. As the requirement of sulphur is high, it plays a vital role in the nutrition of oil seed and pulse crops. Status of other major nutrients, particularly of nitrogen and phosphorus, play an important role in determining the amount of sulphur absorbed by crops. Sulphur occurs in soil in inorganic as well as in organic forms but organic forms of sulphur provides the major sulphur reservoir (Reisenauer et al., 1973; Scott and Anderson, 1976) in most soils. The inorganic form of sulphur consisting mainly of sulphate in soil solution and is in equilibrium with the solid phase viz., sesquioxides and clay minerals, to which it is also adsorbed. Sulphate sulphur constitutes only a small fraction of total sulphur (1.25 to 17.7%), particularly in coarse textured soils, because of its loss by leaching (Sing et al., 1993). Much of the information on sulphur content and its distribution in different forms in Indian soils is confined to a few states where magnitude of sulphur problems in soils and crop production has come up to a high extent. The amount of sulphate sulphur rather than representing a discrete chemical entity, as available sulphur is sometimes made out to be, is more of an indicator of the pool of available sulphur on which a crop can hopefully bank upon and thus is dependent on the donor fractions plus fertilizer input. This form of sulphur (extracted by 0.15% $CaCl_2$) is used as an index of sulphur availability in many soils. The amount of total sulphur and also that in different fractions depends on a large number of factors such as parent material, organic matter, temperature and moisture regimes, texture, type and level of management. A laboratory experiment was conducted to study the distribution of available S and to find out influence of different soil characteristics on the predictability of available S status in sixteen different soil series of West Bengal growing rice and pulses.

2. Materials and Methods

2.1. Collection of soil

Surface (0-15 cm) soil samples, two each, from typical rice and pulse growing fields belonging to 16 identified soil series of the dominant soil groups in seven districts of West Bengal were collected for the study (Table 1). The composite soil samples were dried on polythene sheets under shade, sieved (0.2 mm) on nylon mesh and preserved in polythene containers for chemical analyses.

2.2. Soil analysis

Processed soil samples were analysed for pH (soil and water ratio of 1:2.5) with a glass electrode pH meter (Systronics model 335) [Jackson (1973)]; Organic Carbon by the method of Walkley and Black as outlined by Jackson (1973); mechanical analysis by International pipette methods (Kilmer and Alexander 1949) as outlined by Jackson (1973); cation Exchange Capacity (by saturating the soil with neutral normal ammonium acetate and then by distilling the NH_4^+ saturated soil with magnesium oxide., absorbing the liberated ammonia gas in boric acid and titrating with standard HCl) by Baruah and Barthakur, (1997); total Nitrogen by modified Kjeldahl digestion method (Bremner, 1960); total Phosphorus [after digesting a suitable amount of soil in a mixture of nitric acid and perchloric acid (9:4)]; by the vanado-molybdate yellow colour method (Page et al., 1982 total Sulphur [after digesting the soil with HNO_3: $HClO_4$ (2:1) and HCl ; free oxides of iron and aluminium were extracted using citrate-bicarbonate-dithionite extractant] by the method described by Tabatabai et al. (1982) (Mehra and Jackson, 1960). Iron in the extract was determined colorimetrically using orthophenanthrolein and aluminium by aluminon reagent (Page et al., 1982). Amorphous aluminium was determined by shaking the soil samples for a period of 4 hrs in dark after adding 0.2 M acidic ammonium oxalate (pH 3.0), followed by digestion of an aliquot from this extract by di-acid mixture (HNO_3 and $HCIO_4$) (McKeague and Day, 1966) and then determined the aluminium in the extract colorimetrically by using aluminium method (Black,1965). Amorphous Iron was extracted by shaking the soil with 0.2M acidic ammonium oxalate (pH 3.0) for 4 hours in dark. The aliquot from the extract was first digested with di-acid-mixture (McKeague and Day, 1966).

Table 1: Selection of sites for sampling

Soil No.	Name of soil series	Belonging	
		Police station/ sub-division	District
S_1	Kusmi	Taldangra	Bankura
S_2	Sirkabad	Arsha	Purulia
S_3	Sukhnibasa	Hura	Purulia
S_4	Patapahari	Manbazar	Purulia
S_5	Rangamati	Arsha	Purulia
S_6	Diknagar (Digragan)	Raghunanthpur	Purulia
S_7	Dakshinbahal	Purulia	Purulia
S_8	Hijalgara	Jamuria	Bardwan
S_9	Gopalpur(Chamtibagan)	Nalhati	Birbhum
S_{10}	Sadaipur	Dubrajpur	Birbhum
S_{11}	Barakadra	Goaltore	Mednipur
S_{12}	Teltaka (Faringdanga)	Garbeta	Mednipur
S_{13}	Narayanpara	Polba-dadpur	Hugli
S_{14}	Shyampur	Bagnan	Howrah
S_{15}	Baneswarpur	Amta	Howrah
S_{16}	Bankul	Jagadballavpur	Howrah

3. Results and discussion

3.1. Physico chemical properties of experimental soils

The results of some of the important physico chemical properties of soils studied are presented in Table 2. Careful appraisal of the results revealed that soils varied in their pH values within the range between 5.26 (Patapahari) to 6.65 (Sukhnibasa) with a mean of 5.97±0.33. Among the soil series, most of them (nearly 63%) had slightly acidic (pH>6.0) ; 4 soil series (25%) moderately acidic (pH; 5.52- 6.0) and only 2 soil series (about 13%) exhibited strongly acidic soil reaction (pH<5.5).

The organic carbon content of soils also varied from 0.41 (Patapahari) to 0.59 (Baneswarpur) with average value of 0.48±0.13%. Of the 16 soil samples, 9 (nearly 56%) soil series had organic carbon content of <0.5% and thus could be grouped as low organic carbon containing soils whereas; about 45% belonged to medium category. Higher temperature in Purulia district as compared to Howrah district might have resulted in higher loss of carbon from soil in Patapahari series leading to the observed values of organic carbon content. Cation exchange capacity values of the soil samples varied between 5.21 (Shyampur) to 7.57 (Hijalgara) with a mean of 6.24±0.61 Cmol (P +) kg^{-1} soil. Lower values of CEC could be attributed to the lower organic carbon as well as clay content in these soil series. Marked variation in clay content, ranging from 15.76 to 22.76, with a mean of 19.32±2.32% was observed in the soils. Silt fraction of the experimental soil samples ranged from 21.00 to 35.00 with average value of 27.69±4.60%. With proportion of clay and silt taken together, soil samples were rated as silty loam in texture. Total nitrogen (N) content of samples ranging from 0.05 to 0.08 with a mean value of 0.07±0.02% indicated that the soils under this study, in general, had low total N content. While the total phosphorus (P) content of the soils appeared to vary from 59.19 to 79.46 with an average value of 160.85±64.50 mg kg^{-1} soil. Similar results were also obtained by other researchers (Mishra et al., 2007; Kour et al., 2007). The dithionate extractable aluminium (CBD-Al) and iron (CBD-Fe) fractions, which consisted of organically bound, inorganic amorphous and nonsilicate crystalline Al, Fe forms, showed high extent of variations in their values ranging from 0.26 to 1.17 and 0.67 to 2.34 with respective means of 0.82±0.32 and 1.27±0.62%. The acidic ammonium oxalate (0.2 M; pH 3.0) extractable Al (amor- Al) and Fe (amor-Fe) fractions primarily comprised amorphous and organically bound together with some amount of crystalline forms of Al and Fe, were found to maintain glaring differences in soils

Table 2: Some physico chemical properties of soils under study

Soil no.	Soil series	pH	O.C (%)	CEC Cmol (P+)kg^{-1}	Texture			Total N (%)	Total P (g/kg)	Total S (g/kg)	CBD Al (%)	CBD Fe (%)	Amor. Al (%)	Amor. Fe (%)	Avai. S (g/kg)
					Sand %	Silt %	Clay %								
S_1	Kusmi	5.96	0.41	5.39	57.76	25.00	17.24	0.07	88.25	140.00	0.65	1.03	0.22	0.32	21.42
S_2	Sirkabad	6.03	0.44	6.04	55.76	27.00	17.24	0.05	59.19	190.00	0.78	1.10	0.27	0.46	17.06
S_3	Sukhni-basa	6.65	0.45	5.97	55.24	29.00	15.76	0.06	129.17	240.00	0.39	1.07	0.26	0.46	25.78
S_4	Patapahari	5.26	0.41	5.87	61.76	21.00	17.24	0.05	181.74	190.00	1.04	1.35	0.31	0.56	36.49
S_5	Ranga-mati	5.37	0.43	7.11	52.24	31.00	16.76	0.07	113.29	200.00	0.26	1.10	0.25	0.37	22.21
S_6	Diknagar	6.24	0.51	5.83	56.76	25.00	18.24	0.06	70.81	200.00	1.17	0.67	0.27	0.32	16.66
S_7	Dakshi-nbahal	6.03	0.53	6.07	51.24	27.00	21.76	0.06	154.66	400.00	1.03	0.67	0.39	0.69	50.38
S_8	Hijalgara	6.13	0.46	7.57	48.76	29.00	22.24	0.07	151.84	421.00	0.69	1.01	0.35	1.11	47.60
S_9	Gopalpur	5.98	0.44	6.21	51.24	27.00	21.76	0.07	121.70	300.00	0.52	1.02	0.36	0.6	22.61
S_{10}	Sadaipur	5.71	0.51	6.26	55.24	25.00	19.76	0.08	157.14	200.00	0.62	1.08	0.57	0.46	45.62
S_{11}	Barakadra	6.05	0.43	6.90	61.76	21.00	17.24	0.06	181.48	200.00	0.74	1.35	0.24	0.51	37.68
S_{12}	Teltaka	6.01	0.41	5.87	57.76	24.00	18.24	0.07	159.38	300.00	0.98	1.09	0.29	0.18	48.39
S_{13}	Narayan-para	5.93	0.55	6.56	47.76	31.00	21.24	0.07	215.63	300.00	1.03	1.19	0.81	0.56	38.08
S_{14}	Shyampur	6.07	0.57	5.21	42.24	35.00	22.76	0.08	279.46	400.00	1.06	2.34	0.95	0.42	51.57
S_{15}	Bane-swarpur	6.12	0.59	6.21	49.24	31.00	19.76	0.08	244.55	300.00	1.08	2.19	0.96	0.46	43.63
S_{16}	Bankul	6.05	0.55	6.76	43.24	35.00	21.76	0.07	265.23	295.15	1.09	2.07	0.75	0.51	44.43
Range		5.26-6.65	0.41-0.59	5.21-7.57	42.24-61.76	21.00-35.00	15.76-22.76	0.05-0.08	59.19-279.46	140.00-421.00	0.26-1.17	0.67-2.34	0.22-0.96	0.18-1.11	16.66-51.57
Mean		5.97	0.48	6.24	53.00	27.69	19.32	0.07	160.85	267.26	0.82	1.27	0.45	0.49	35.60

ranging from 0.22 to 0.96 and 0.18 to 1.11 with mean values of 0.45±0.20 and 0.49±0.27%, respectively.

3.2. Sulphur (S) availability in soils

3.2.1. Available S

Wide variation in available S content ranged from 16.66 to 51.57 with an average of 35.60±12.40 mg kg^{-1} soil was observed in the experimental soil (Table 2). The highest amount of available S (51.6 mg kg^{-1}) was observed in Shyampur series, while the Diknagar series soil had the lowest amount of available S (16.70 mg kg^{-1}).Based on rating commonly used to broadly classify different soil groups on the basis of $CaCl_2$ extractable S (mg kg^{-1} soil) into low (<10) medium (10-20) and high (>20) category, among 16 soil series only two Diknagar and Sirkabad (13%) fell under medium category and the remaining 14 soils (87%) could be classified as high category (Table 2). The observed variation in the available S status in soils of different identified series considered in this experiment might be due to presence of variable amounts of organic matter with soil and crop management practices followed; fertilizer use and some other basic soil properties. These results were in conformity with those reported by (Mishra et al., 1990).

3.2.2. Total S

The total S content, being the reserve pool of this nutrient element in soil, was found to vary widely from 140.00 to 421.00 with an average of 267.26±84.59 mg kg^{-1} soil (Table 2). The lowest amount of total S was obtained in the soil collected from Kusmi series (soil no. 1) while the highest value was observed in the sample collected from Hijalgara series (soil no. 8). Since the main domain of most of total S content of soil is the organic matter, low organic matter content in the former soil as compare to high amount in the latter one might have resulted in such wide variation in total S content. Similar result on the distribution of total S in soil was also reported by (Kumar et al., 2002).

3.3. Relationship of available S with some important physicochemical properties of soils

3.3.1. Simple correlation study

Simple correlation ® values of available S and total S with soil properties were worked out to assess the influence of individual soil property on S availability in the soils. Appraisal of the results revealed significant and positive correlation of available S with total P content (r=0.77**), total S (r=0.70**) content, clay content (r=0.60**), amorphous Al (r=0.54**), and CBD Fe (r=0.34*) and Al (r=0.37*) contents of the soils. Sand fraction of the soil showed significant, but negative correlation (r=-0.41*) with available S status of the soils. Significant positive correlations of available S with amorphous Al (r=0.54**), and CBD Fe (r=0.34*) and Al (r=0.37*) contents of the soils might be attributed to more retention of $SO4^{-2}$ ions with increases in the amounts of amorphous and crystalline Fe and Al fractions. Similar results of high correlation between sulphate S and crystalline as well as amorphous Fe and Al fractions were reported by (Reddy et al*.,* 2001). Significant and positive correlation of total S with total P content (r=0.52**), available S (r=0.70**) content, clay content (r=0.81**), silt (r=0.47**), amorphous Fe (r=0.56**), and amorphous Al (r=0.46**) contents of the soils. Sand fraction of the soil showed significant, but negative correlation (r=-0.70*) with total S status of the soils.

3.3.2. Contribution of soil property on variability of available S status in soils

Step-wise regression equations worked out to evaluate the contribution of soil properties on the variability of available S status in soils are presented in Table 4. Results showed that total P alone exhibited to explain nearly 59% variation in available S status of soils. Inclusion of CBD- Al as another soil property improved the predictability by nearly 72%resulting into its individual contribution of about 13%. While these two soil characteristics together with total S, silt and total N content collectively accounted for the maximum 84.49% variations of available S in soils.

4. Conclusion

Due to wide variation in soil physico-chemical properties, soil and crop management practices and fertilizer use, soils of different soil series differed in their available S content. Variations in total P, dithionate extractable aluminium, total S, silt and total N content of the soils collectively accounted for the maximum variations in available S in soils.

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