

## Forms and Status of Sulfur in Some Soils of Terai Region of West Bengal

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### Abstract

Twenty one surface soil samples were collected from terai region of West Bengal (Lotafela, Balorampur, Rajpur, Matiarkuthi, Berubari soil series and benchmark sites like Kharibari, Pundibari, Islampur, Dhupguri) and were analyzed to evaluate different forms of S status. The range of total S, organic S, adsorbed S, available S and water soluble S were 178.57 to 433.09 (mean 264.63), 150.27 to 372.73 (mean 229.57), 3.19 to 42.91 (mean 1837), 13.73 to 30.38 (mean 20.67) and 6.91 to 26.23 (mean 16.69) ppm, respectively. All the forms of S were positively correlated to pH, organic C, cation exchange capacity and total N. Clay content was negatively correlated to water soluble S and available S but silt + clay content was positively correlated. Silt + clay content was negatively correlated to adsorbed S content of the soil. C : N and C : S ratio varied from 3.86 to 10.54 (mean 6.28) and 52.01 to 131.46 (mean 79.83) in the soils.

**Key words : Physico-chemical properties, Forms and status of S, Terai soil.**

Intensive multiple cropping system with high yielding varieties, high sulfur requiring crops and continuous use of sulfur free fertilizers as a great endeavor for boosting food production, is causing a marked depletion of inherent nutrient reserves of soil including sulfur. Consequently, besides N, P, and K the deficiency of sulfur is frequently reported in Indian soils. Inadequate sulfur supply seriously retards the growth of plants. Visual symptoms of sulfur deficiency have been reported recently from various locations of West Bengal. No information is available on the sulfur status of the soils of terai region of West Bengal except a couple of reports on the response of some crops to sulfur application. Soils of terai agro-climatic region of West Bengal, in general, are considered to be low productivity and characterized as coarse textured, acidic in reaction, with multinutrient deficiency problems. Apart from the micronutrient element, there is an emerging trend of sulfur response in some crops particularly in oilseeds and legumes. Several field trails demonstrated the sulfur response to a variety of crops due to its addition.

### Methods

Twenty one surface (0—15 cm) soil samples were collected from some identified soil series of Cooch

Behar and Jalpaiguri districts namely Lotafela, Balorampur, Rajpur, Matiarkuthi, Berubari soil series (NBSS and LUP 2001) and from some benchmark sites viz. University Research farm at Pundibari, Kharibari, Islampur, State Government Block Seed farm at Dhupguri, together representing the terai agro-climatic zone. The soil samples were collected and prepared by drying, crushing and sieving through 2 mm sieve and analyzed for pH (soil : water :: 1:2.5) with the help of pH meter; organic carbon by Walkley and Black's chromic acid digestion method (Walkley and Black 1934); CEC and total N were measured by using standard procedures (Jackson 1973), mechanical analysis by Bouyoucos hydrometer method (Day 1965).

Total sulfur (Tabatabai 1982), water soluble sulfur and available sulfur (Williams and Steinberg 1959), were extracted and sulfate in the extracts were determined by turbidimetric method (Chesnin and Yien 1951). Adsorbed S was calculated from the difference between phosphate extractable S (Fox et al. 1964) and CaCl<sub>2</sub> extractable S and also organic S were calculated by the difference between total S and phosphate extractable S.

### Results and Discussion

Soil pH, organic carbon, CEC, soil texture, total

**Table 1.** Physico-chemical properties of the studied soil.

Soil properties	Mean	Range
pH	5.54	4.11–7.13
Organic carbon (%)	1.21	0.64–2.24
CEC [Cmol (+)/kg]	12.73	8.71–18.46
Clay (%)	19.08	14.40–23.76
Silt + Clay (%)	41.27	31.40–52.32
Total N (%)	0.17	0.08–0.31
C : N	6.28	3.86–10.54
C : S	79.83	52.01–131.46

nitrogen content of the soils are presented in Table 1. Results showed that the pH of the soil ranged from 4.11 to 7.13 (mean 5.54), organic C content varied from 0.64 to 2.24 with a mean value of 1.21%. CEC content of the soil varied from 8.71 to 18.46 (mean 12.73) Cmol (+)/kg, and clay content varied from 14.40 to 23.76 (mean 19.08) % whereas silt + clay content varied between 31.40 and 52.32 (mean 41.27% of the soil mass).

The total S content of the soils ranged from 178.57 to 433.09 with a mean value of 246.63 ppm. The total S in the soils was significantly and positively correlated with pH ( $r=0.61^{**}$ ), organic C ( $r=0.50^{*}$ ),

CEC ( $r=0.74^{**}$ ) and total N ( $r=0.054^{*}$ ). Organic C content of the soil influences the total S, total N and CEC content of the soil. Similar findings were also recorded Singh et al.(1993).

Organic S content varied from 150.27 to 372.73 with an average of 229.57 ppm accounting 86.7% of the mean total S content of the soil. Similar proportion of the organic S out of total S was reported in Himachal Pradesh (Kanwar and Takkar 1964). A significant and positive correlation was found with pH ( $r=0.52^{*}$ ), CEC ( $r=0.71^{**}$ ) and total N ( $r=0.55^{**}$ ). The variation in the organic S content was largely due to wide variability in the organic matter status of experimental soils as evidenced by positive and significant correlation ( $r=0.50^{*}$ ) between these two parameters. Since most of the soil S is an integral part of soil organic matter, this relationship was anticipated (Singh et al. 2006, Mukhopadhyay and Mukhopadhyay 1980).

Adsorbed S content in the soil ranged from 3.19 to 42.91 ppm with an average of 18.37 ppm. This wide variation in results might be due to the differential amount of clay content in the soils that absorb various amounts of S. Most of the soils primarily con-

**Table 2.** Different forms of sulfur in soil.

Places	Water sol S (ppm)	Available S (ppm)	Adsorbed S (ppm)	Organic S (ppm)	Total S (ppm)
Berubari-1	8.97	17.53	27.62	229.40	265.99
Berubari-2	7.70	16.41	31.34	257.10	296.14
Balorampur-1	20.50	21.59	8.36	229.76	258.62
Balorampur-2	14.00	15.75	13.16	249.93	277.09
Balorampur-3	17.81	18.67	13.50	297.10	328.41
Balorampur-4	26.22	30.38	42.81	328.11	397.14
Balorampur-5	24.97	26.29	20.49	250.11	295.57
Dhuppuri	16.60	21.61	18.67	250.03	285.30
Islampur	19.71	22.39	42.91	150.27	212.89
Kharibari	21.80	22.20	8.38	263.91	294.09
Lotafela-1	15.39	22.00	11.21	221.19	247.78
Lotafela-2	22.65	23.32	3.19	275.88	301.72
Lotafela-3	19.71	20.78	11.79	192.23	223.73
Lotafela-4	16.53	17.98	5.35	176.43	198.31
Matiarkuthi-1	7.95	19.67	19.02	151.60	178.57
Matiarkuthi-2	8.72	17.33	21.83	164.43	194.99
Pundibari-1	9.51	18.60	15.39	206.46	231.36
Pundibari-2	17.63	19.19	9.34	188.12	215.09
Pundibari-3	26.23	27.09	34.13	372.73	433.09
Rajpur-1	6.91	13.73	22.14	176.30	205.35
Rajpur-2	21.09	21.57	5.12	189.87	216.09
Mean	16.69	20.67	18.37	229.57	264.63
Range	6.91-26.23	13.73-30.38	3.19-42.91	150.27-372.73	178.57-433.09

tained water soluble sulfates, but also had significant amounts of adsorbed sulfates which are considered to be available to plant. This might be expected due to presence of Fe and Al oxides in surface soils. Similar result was also reported by Chao et al. (1962), (1), Singh et al. (2006). Adsorbed S was positively correlated with pH ( $r = 0.46^*$ ). It was also positively correlated to clay content of the soils but maintained negative correlation with silt + clay content soil.

Available S extracted by 0.15%  $\text{CaCl}_2$  and water soluble S content ranged from 13.73 to 30.38 (mean 20.67) and 6.91 to 26.23 (mean 16.69) ppm of soil. These two forms of S constituted 7.8 and 6.3% of the total S. Similar observations were also reported by Kumar et al. (2002). Positively and significant correlations of these two forms of S with pH ( $r = 0.75^{**}$ ,  $r = 0.71^{**}$ ), CEC ( $r = 0.51^*$ ,  $r = 0.84^*$ ) and total N ( $r = 0.45^*$ ,  $r = 0.44^*$ ) content of the soil were recorded. These were also negatively correlated with clay content ( $r = -0.24$ ,  $r = -0.43$ ) of the soil and positively correlated to organic C ( $r = 0.31$ ,  $r = 0.29$ ) and silt + clay content ( $r = 0.29$ ,  $r = 46^*$ ) respectively, but the water soluble S was significantly correlated which suggested that organic C and silt content of the soil might have played an important role to supply the readily available S to plant. Similar findings were also reported by Mishra et al. (1990) and Kumar et al. (2002).

C : N ratio varied from 3.86 to 10.54 with an average value of 6.28 in these soils. This narrow range of C : N ratio indicated that mineralization of nitrogen took place in soils. The C : S ratio of soils ranged from 52.01 to 131.46 with an average value of 79.83. The wide variation might probably be due to diverse nature of the organic matter.

From this study, it is suggested that organic matter plays an important role in supplying available S content in the soil which implies that increase of organic pool in soil would help for better crop nutrition.

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