International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(4): 2920-2925

Received: 28-05-2019
Accepted: 30-06-2019

Dipa Kundu
Department of Agricultural Chemistry and Soil Science, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Umalaxmi Thingujam
Department of Agricultural Chemistry and Soil Science, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Gora Chand Hazra
Department of Agricultural Chemistry and Soil Science, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Himadri Saha
Department of Agricultural Chemistry and Soil Science, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Correspondence
Dipa Kundu
Department of Agricultural Chemistry and Soil Science, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Nutrient indexing of sulphur and its correlation studies with soil organic carbon and pH in the soils of Murshidabad and Purulia districts of West Bengal

Dipa Kundu, Umalaxmi Thingujam, Gora Chand Hazra and Himadri Saha

Abstract
Keeping in consideration of the importance of sulphur as an essential plant nutrient and its occurrence of widespread deficiency in Indian soils, the present experiment was carried out in 2015-2016 with the objective of nutrient indexing of sulphur in soils of Murshidabad and Purulia districts of West Bengal and to study the correlation between the available soil sulphur and soil organic carbon as well as soil reaction. Results of available sulphur showed that 30.05, 27.78, 37.30 and 3.97 per cent of soil samples of Murshidabad were under deficient (<10 mg kg^{-1}), low (10.0-20.0 mg kg^{-1}), medium (20.0-40.0 mg kg^{-1}) and high (>40.0 mg kg^{-1}) category, respectively. In Purulia soils, 56.71, 34.62 and 9.52 per cent of soil samples fell under deficient, low and medium category, respectively. The available sulphur status of Murshidabad and Purulia soils were categorised as medium and low as evident from their nutrient index values (NIV) of 1.46 and 1.04, respectively. A significantly negative correlation was recorded between available soil sulphur and soil pH in both the districts of Murshidabad (r = -0.471**) and Purulia (r = -0.526**). Significantly positive correlation was observed between available soil sulphur and organic carbon content of soil for Murshidabad (r= 0.625**) as well as Purulia soils (r= 0.506**).

Keywords: Available soil sulphur**,** nutrient index value, correlation, soil organic carbon**,** soil pH

Introduction
Sulphur is considered as the fourth major plant nutrient element after nitrogen, phosphorous and potassium (Patel *et al.* 2013a) [14] due to its positive impact on quality as well as yield attributing characters of crops (Choudhary *et al.* 2014) [6]. Sulphur deficiency, which is gradually becoming widespread in, on an average of, forty one per cent of Indian soils (Singh 2000) [21] is attributed to the continuous use of sulphur-free fertilizers, high yielding varieties and adoption of intensive multiple cropping system including high sulphur requiring crops (Das *et al*. 2012) [7]. The area speculated as sufficient in sulphur has already started showing sulphur deficiency. The most alarming fact is that even without visible symptoms, sulphur deficiency can reduce crop yield by 10-34 per cent (Tandon 1986) [22]. Sulphur deficiency has been reported at alarming frequency for cereals, pulses, oilseeds (Mathew *et al*. 2013) [13] and bulb crops (Chandel *et al.* 2012) [2]. A timely and precise appraisal of sulphur deficiency is necessary for monitoring and identifying deficient areas for taking prompt and appropriate corrective measures to augment the productivity of crops. Under the above backdrop with the objective of delineating the deficient areas of sulphur in West Bengal, two districts, namely Purulia and Murshidabad, were selected for its nutrient indexing in the present study.

Materials and Methods
To carry out the present study, two hundred and fifty two and two hundred and thirty soil samples from twenty four blocks and eighteen blocks of Murshidabad and Purulia were collected, respectively, according to grid sampling pattern maintaining approximately 3.7 km grid for Murshidabad and 4 km grid for Purulia district using global positioning system (GARMIN GPS Version *etrex*). The soil samples immediately after collection were air dried, grounded, screened through 2 mm nylon sieve and stored in the air tight plastic containers for further analyses. The processed soil samples were analyzed following the standard procedures

for the parameters, viz., soil pH (Jackson 1973) [9], oxidizable organic carbon (Walkley and Black, 1934) [23] and available sulphur (Chesnin and Yien 1951) [5] using 0.01 M Ca $(H_2PO4)_2$. $2H_2O$ solution as extractant (soil: extractant: 1:5). Finally, the data were statistically analyzed by using the software SPSS 16.0 for windows. Soil samples were categorized as deficient, low, medium and high on the basis of their available sulphur in soils. Finally, nutrient index value (NIV) for soil samples of each district was calculated (Ramamurthy and Bajaj, 1969) [15]. Correlation studies between available soil sulphur and soil organic carbon as well as soil pH was worked out of the experimental soils by standard statistical methods.

Results and Discussion

The data regarding soil pH and oxidizable organic carbon of Murshidabad and Purulia districts have been furnished in Table 1 and 2, respectively. The data of available sulphur and nutrient index value (NIV) of Murshidabad and Purulia district have been presented in Table 3 and 4, respectively.

Soil properties

Soil pH

Results (Table 1) showed that soil pH of the Murshidabad district ranged from 4.7 to 7.4 with a mean value of 5.96. Nearly 28.97 percent, 41.62 percent and of 23.02 percent of soil samples were recorded the pH in the range of below 5.5 (acidic), 5.5-6.5 (slightly acidic), and 6.5-7.5 (neutral), respectively. Soil pH of Purulia district (Table 2) ranged from 4.21-6.78 with a mean value of 5.57. Nearly 43.48 percent, 52.17 per cent and 4.34 per cent of soil samples were recorded the pH in the range of below 5.5 (acidic), 5.5-6.5 (slightly acidic) and 6.5-7.5 (neutral), respectively. Occurrence of such low pH values in the soils of Purulia could be due to the leaching of bases from the upper topographic position leaving behind the oxides of iron and aluminium which might be attributed to the lower pH values of the soils (Sehgal, 2012) [18]. Similar reports were also reported by Satpathy *et al.* (2015) [17].

Soil organic carbon (SOC)

The soil organic carbon content of Murshidabad district soils (Table 1) were found to be of medium status. It ranged from 0.367-1.06 per cent with a mean value of 0.55 per cent. Results revealed that 15.87 per cent, 23.06 percent and 61.07 percent of soil samples were found in low (<0.5 per cent), medium (0.5-0.75 per cent) and high category (>0.75 per cent), respectively. The observation of predominance of medium range of organic carbon content in Murshidabad soils might be due to intensive cultivation with little deposition of organic residues and greater oxidation of organic matter caused by hotter climate. Results also showed that organic carbon content was found in a significantly negative correlation (r= -0.421**) with soil pH of Murshidabad soil. This negative correlation of organic carbon with pH might be related to the greater activities of microorganisms, particularly bacteria, at high pH soils (Rousk *et al*. 2009) [16].

Available sulphur status of soil

The values of available sulphur in Murshidabad soils ranged from 2.24-64.43 mgkg^{-1} with a mean value of 18.38 mg kg^{-1} (Table 3). Data revealed that 30.05 per cent, 27.78 per cent, 37.30 per cent and 3.97 per cent of soil samples fell under deficient (<10 mg kg^{-1}), low (10.0-20.0 mg kg^{-1}), medium (20.0-40.0 mg kg^{-1}) and high category (>40.0 mg kg^{-1}) of available soil sulphur content (Figure 1). Several workers supported this result [(Singh, 2001) and Chattopadhyay and Ghosh (2006)] [20, 3]. The predominance of medium sulphur status of Murshidabad soils might be related to the intensive cultivation.

Available soil sulphur content in soils of Purulia district (Table 4) showed that it ranged from 3.06-37.21 mg kg^{-1} with a mean value of 11.16 mg kg^{-1}. About 56.71 per cent, 34.62 per cent and 9.52 per cent samples were found under deficient, low and medium category with respect to available sulphur content (Figure 4). The maximum deficiency was observed in Jhalda-1 block as compared to other blocks while maximum sufficiency was observed in Bundwan and Kasipur block. This was probably due to leaching losses of sulphate-sulphur in these coarse textured soils (Cheema and Arora, 1984) [4].

The available sulphur status of Murshidabad and Purulia soils were categorised as medium and low as evident from their nutrient index values (NIV) of 1.46 (Table 3) and 1.04 (Table 4), respectively.

Relationship between soil characteristics and available soil sulphur

The relevant data on correlation studies have been furnished in Figure 2 and 3 (Murshidabad soils), Figure 5 and 6 (Purulia soils) and Table 5. Results of correlation study showed that there was a significantly negative correlation between available soil sulphur and soil pH in both the districts of Murshidabad (r=-0.471**) [Figure 3 and Table 5] and Purulia (-0.526**) [Figure 5 and Table 5]. The results indicated that available soil sulphur increased with decrease in pH value. Similar results were also supported by Jat and Yadav (2006) [10] and Kumar *et al*. (2014) [12]. Such correlations in Purulia soils might be due to strongly weathered acid Alfisols rich in Fe and Al oxides that caused more adsorption of sulphur from soil solution (Biswas *et al*., 2003) [1] while the solution pH which controls the polarity and surface density of adsorption plane like Fe and Al oxides in such a way that their magnitude increased with drop in pH, resulting in enhancement of SO_4^{2-} adsorption with decrease in pH and *vice versa*. These results are in accordance with Kumar *et al*. (2014) [12].

Significantly positive correlations of r= 0.625** for Murshidabad soils (Figure 2 and Table 5) and r= 0.506** for Purulia soils (Figure 6 and Table 5) were observed between available sulphur and organic carbon content of soil. The positive correlations might be attributed to the fact that organic matter could be a good reservoir of sulphur. Such findings were corroborated by the studies of several workers Sharma and Gangwar (1997) [19], Ghosh *et al*., 2005) [8] and Kour and Jalali (2008) [11].

Conclusion

It can be concluded from the findings of the experiment that the external application of sulphur containing fertilizers along with the organic manures are to be recommended for the soils of both the districts because the available sulphur contents are low and medium in the soils of Purulia and Murshidabad, respectively.

Table 1: Status of soil pH and oxidizable organic carbon of different blocks in Murshidabad districts of West Bengal

Blocks		pH			SOC (%)		
	No. of samples	Range	Average	SD(±)	Range	Average	SD(±)
Sagardighi	12	4.7-6.82	6.13	0.55	0.43 - 0.70	0.55	0.11
Bharatpur	12	5.17-6.79	5.75	0.55	0.47-0.87	0.63	0.11
Farakka	6	5.1- 6.4	5.68	0.44	0.47-0.81	0.67	0.13
Samsherganj	10	5.1-7.4	6.03	0.64	0.42-0.78	0.59	0.13
Raghunathganj I	10	5.40-6.67	5.82	0.55	0.40-0.78	0.60	0.15
Raghunathganj II	10	5.02-6.9	5.81	0.55	0.43-0.87	0.69	0.17
Khargram	10	5.4-7.12	6.00	0.61	0.49-0.85	0.61	0.14
Kendi	12	5.1-7.24	5.93	0.75	0.45-0.90	0.70	0.16
Bhagwangola I	11	5.12-6.7	5.84	0.54	0.48-0.88	0.67	0.14
Bhagwangola II	12	5.02-7.1	5.76	0.67	0.47-0.81	0.64	0.11
Hariharpara	12	5.18-7.05	6.05	0.72	0.51-0.82	0.62	0.11
Nabagram	12	5.1-7.2	6.14	0.72	0.48-0.93	0.67	0.16
Nawda	12	5.31-7.1	6.07	0.65	0.52-0.90	0.67	0.14
Jiaganj	12	5.03-7.16	5.93	0.66	0.48-0.78	0.67	0.13
Jalangi	11	4.99-6.82	6.25	0.69	0.39-1.06	0.67	0.18
Domkal	12	4.88-7.14	6.16	0.80	0.56-0.97	0.71	0.11
Lalgola	12	4.98-6.8	5.93	0.63	0.41-0.98	0.68	0.15
Raninagar I	11	5.3-6.71	5.91	0.65	0.37-0.74	0.60	0.11
Raninagar II	8	5.1-7.3	6.02	0.74	0.47-0.76	0.62	0.10
Suti I	5	5.23-6.2	5.56	0.46	0.61-0.87	0.73	0.11
Suti II	5	5.28-6.78	6.02	0.55	0.45-0.82	0.64	0.13
Beldanga I	12	5.1-6.95	5.68	0.54	0.49-0.73	0.60	0.09
Beldanga II	12	4.91-6.79	5.87	0.53	0.41-0.81	0.65	0.13
Berhampore	12	4.9-7.22	6.30	0.65	0.38-0.79	0.61	0.13

Table 2: Status of soil pH and oxidizable organic carbon of different blocks in Purulia districts of West Bengal

		pH			SOC (%)		
Blocks	No. of samples	Range	Average	SD(±)	Range	Average	SD(±)
Puncha	12	4.9-6.2	5.54	0.64	0.22-0.59	0.47	0.13
Bundwan	10	4.92-6.28	5.33	0.55	0.24-0.58	0.40	0.13
Manbazar l	10	4.58-6.34	5.49	0.65	0.25-0.69	0.46	0.12
Manbazar II	10	4.34-6.16	5.32	0.76	0.19-0.73	0.46	0.17
Hura	10	4.41-6.78	5.54	0.90	0.24-0.52	0.40	0.11
Borobazar	10	5.02-5.91	5.48	0.41	0.23-0.67	0.47	0.13
Bolorampur	10	4.33-6.42	5.64	0.56	0.29-0.64	0.49	0.11
Kasipur	15	5.1-6.32	5.55	0.67	0.27-0.69	0.48	0.11
Santuri	10	5.05-6.13	5.56	0.47	0.36-0.63	0.54	0.09
Jaipur	12	5.32-6.2	5.38	0.64	0.38-0.75	0.54	0.10
Raghunathpur I	15	4.21-6.45	5.49	0.60	0.21-0.74	0.48	0.13
Raghunathpur II	12	4.67-6.03	5.58	0.71	0.35-0.59	0.47	0.08
Jhalda I	16	5.01-6.62	5.58	0.55	0.21-0.71	0.50	0.11
Jhalda II	15	4.81-6.02	5.50	0.54	0.22-0.67	0.46	0.12
Purulia II	15	4.45-6.53	5.46	0.55	0.22-0.76	0.49	0.14
Para	16	4.75-6.32	5.58	0.66	0.44-0.86	0.54	0.11
Purulia I	16	5.17-6.53	5.45	0.53	0.24-0.67	0.48	0.13
Arsha	16	5.17-6.58	5.59	0.66	0.25-0.59	0.38	0.13

Table 3: Block wise available soil sulphur content (mg kg^{-1}) of soil samples as well as NIV of sulphur in Murshidabad district of West Bengal

Name of the block	Sulphur				
	No. of samples	Range (mg kg^{-1})	SD(±)	Average (mg kg^{-1})	NIV
Sagardighi	12	5.61-21.25	5.98	13.97	1.33
Bharatpur	12	4.46-55.20	15.12	16.38	1.42
Farakka	6	6.80-27.84	7.87	17.51	1.5
Samsherganj	10	4.83-22.63	6.28	11.70	1.2
Raghunathganj I	10	6.68-44.20	14.08	21.48	1.6
Raghunathganj II	10	7.80-54.20	16.49	26.03	1.8
Khargram	10	8.13-58.16	16.61	21.12	1.4
Kendi	12	8.9-23.63	6.12	16.55	1.42
Bhagwangola I	11	5.13-37.19	11.83	21.03	1.46
Bhagwangola II	12	7.03-42.98	10.92	19.52	1.58
Hariharpara	12	6.97-29.53	8.48	15.01	1.33
Nabagram	12	9.14- 41.86	9.91	20.44	1.58
Nawda	12	5.18-64.43	12.23	21.10	1.5
Jiaganj	12	6.80-34.85	9.22	19.12	1.42

Jalangi	11	4.25-51.86	13.03	16.48	1.36
Domkal	12	6.77-31.18	7.87	19.43	1.50
Lalgola	12	5.22-28.49	7.21	17.58	1.42
Raninagar I	11	5.96-61.20	14.79	22.35	1.63
Raninagar II	8	6.58-27.84	7.68	17.86	1.38
Suti I	5	16.15-31.34	6.36	22.13	1.60
Suti II	5	9.22-28.64	8.03	7.63	1.40
Beldanga I	12	6.13-33.21	11.89	7.69	1.08
Beldanga II	12	2.24-37.66	13.77	22.13	1.83
Berhampore	12	6.57-23.72	6.33	15.23	1.33
		Mean	10.34	18.01	1.46

Table 4: Block wise available soil Sulphur content (mg kg^{-1}) of soil samples as well as NIV of Sulphur in Purulia district of West Bengal

Name of the block	Sulphur				
	No. of samples	Range (mg kg^{-1})	SD(±)	Average (mg kg^{-1})	NIV
Puncha	12	4.93-27.86	6.46	10.96	0.83
Bundwan	10	6.57-37.21	10.58	13.45	0.7
Manbazar l	10	3.29-18.9	5.72	10.73	1.1
Manbazar II	10	4.46-23.16	5.47	11.38	1.1
Hura	10	4.70-23.16	6.80	9.75	1.30
Borobazar	10	3.13-21.76	7.10	10.91	1
Bolorampur	10	3.06-25.97	6.67	10.21	1.10
Kasipur	15	6.80-33.55	9.50	12.52	1.2
Santuri	10	4.46-19.89	4.60	10.85	1
Jaipur	12	4.92-18.49	4.49	9.91	0.83
Raghunathpur I	15	3.08-21.76	5.27	9.98	1.06
Raghunathpur II	12	4.35-16.15	4.30	10.48	1
Jhalda I	16	4.46-18.02	4.26	9.00	1
Jhalda II	15	4.13-23.86	5.35	11.60	1.07
Purulia II	15	5.16-27.84	5.71	11.51	1.07
Para	16	4.46-25.50	5.79	12.45	1.06
Purulia I	16	5.46-25.73	7.33	14.76	1.31
Arsha	16	4.21-21.99	6.08	10.05	1.12
		Mean	6.16	11.14	1.04

Table 5: Correlation coefficient between soil characteristics and available soil sulphur (mg kg^{-1})

		pH	OC	S
Murshidabad	pH	1		
	OC	-0.421**	1	
	S	-0.471**	0.625**	1
Purulia	pH	1		
	OC	-0.311**	1	
	S	-0.526**	0.506**	1

**Correlation is significant at the 0.01 level (2-tailed)

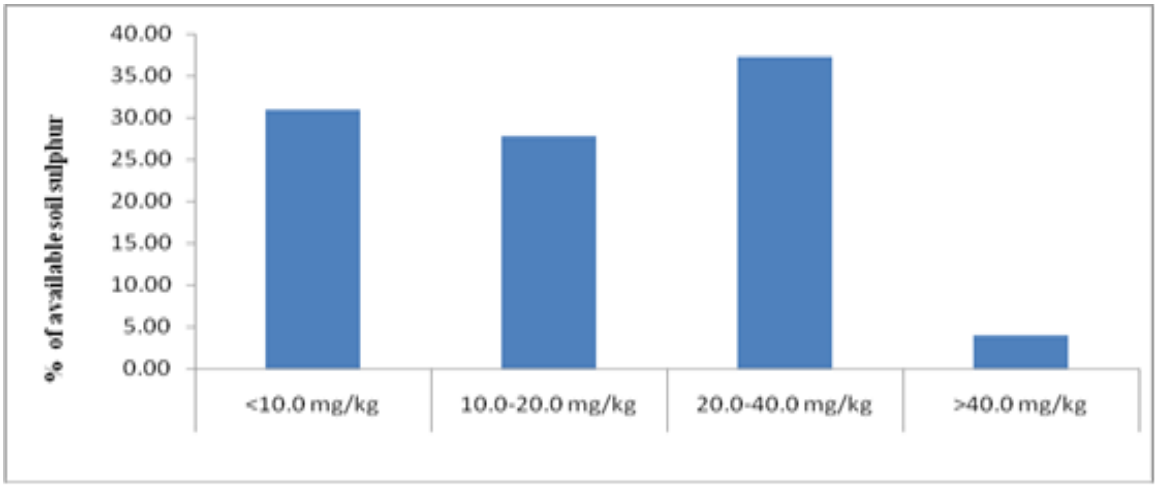

Fig 1: Graphical representation of the deficient, low, medium and high content of available soil sulphur (mg kg^{-1}) in soil samples of Murshidabad district

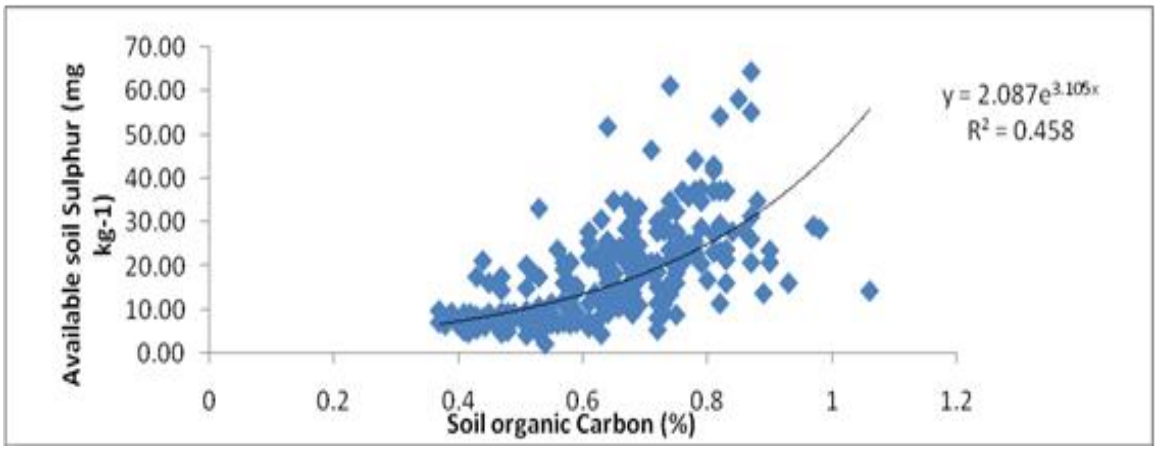

Fig 2: Graphical representation of the relationship of available soil sulphur with organic carbon content (%) in soils of Murshidabad district

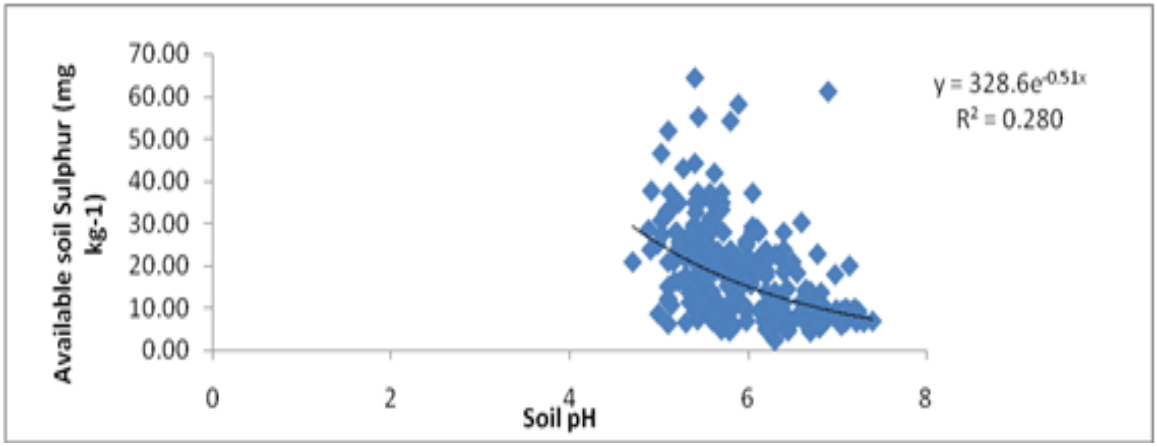

Fig 3: Graphical representation of the relationship of available soil sulphur with pH in soils of Murshidabad district

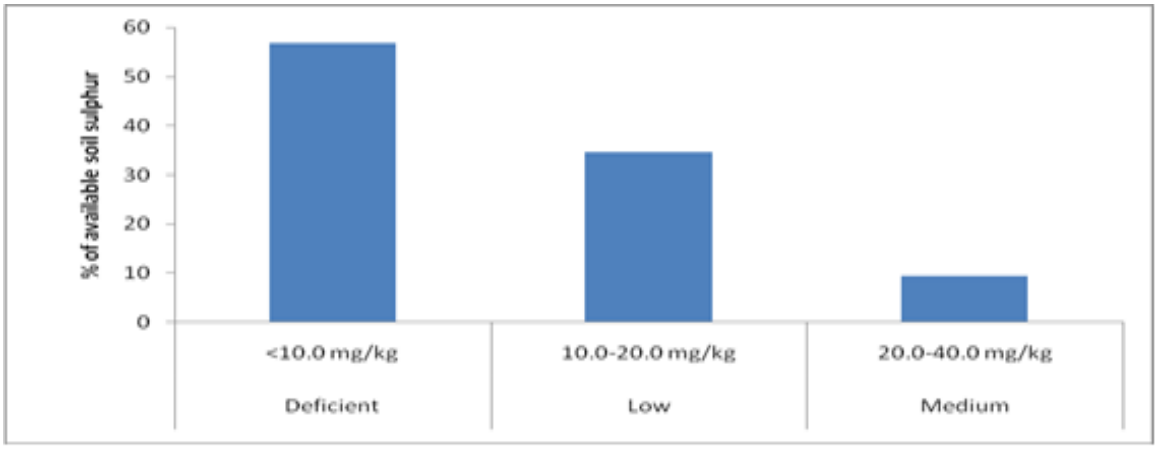

Fig 4: Graphical representation of the deficient, low and medium content of available soil sulphur (mg kg^{-1}) in soil samples of Purulia district

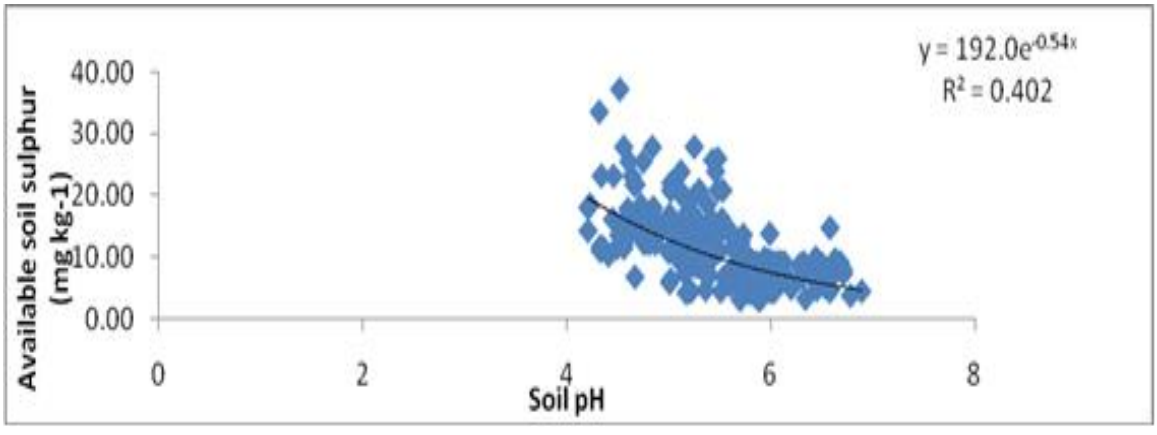

Fig 5: Graphical representation of the relationship of available soil sulphur with pH in soils of Purulia district

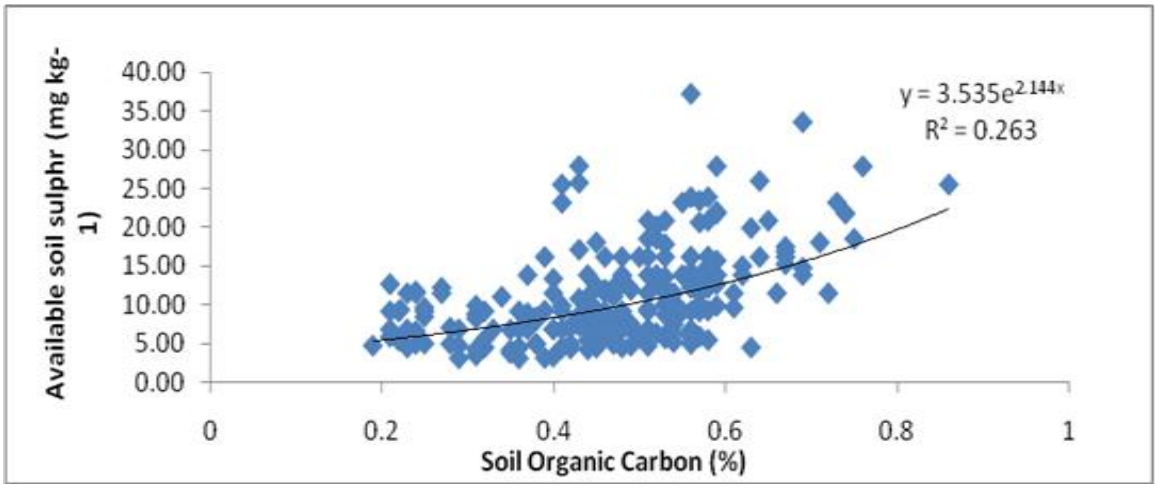

Fig 6: Graphical representation of the relationship of available soil sulphur with organic carbon content (%) in soils of Purulia district

References

1. Biswas H, Rattan RK, Datta SP, Singh AK. Adsorption and translocation of sulfur in some tropical acid soils. Journal of Plant Nutrition and Soil Science. 2003; 166:519-524.
2. Chandel BS, Thakur P, Ali J, Singh H. Soil sulphur status and response of garlic to sulphur in relation to phosphorous. Annals of Plant Research. 2012; 14:156-158.
3. Chattopadhyay S, Ghosh GK. Sulphur status in some red and laeritic soils of Birbhum district of West Bengal. Indian Journal of Fertilizers. 2006; 2:35-38.
4. Cheema HS, Arora CL. Sulphur status of soils, tube well waters and plants in some areas of Ludhiana under groundnut-wheat cropping pattern. Fertilizer News. 1984; 29:28-31.
5. Chesnin L, Yien CH. Turbidimetric Determination of Available Sulphur. Proceedings of Soil Science Society of America. 1951; 15:149-151.
6. Choudhary P, Jhajharia A, Kumar R. Influence of sulphur and zinc fertilization on yield, yield components and quality traits of soybean (*Glycine max* L.). The Bioscan. 2014; 9(1):137-142.
7. Das I, Mukhopadhyay PK, Ghosh SK, Roy SC. Status, distribution *vis* a *vis* taxonomic class distribution and availability indices of sulphur in some Entisols of West Bengal, India. Indian Journal of Agricultural Research. 2012; 47(2):144-150.
8. Ghosh GK, Chattopadhyay GN, Chattopadhyay S. Availability and forms of sulphur in red and lateritic soils of Birbhum district of West Bengal. Journal of the Indian Society of Soil Science. 2005; 57:464-466.
9. Jackson ML. Soil chemical analysis. Prentice Hall of India Ltd. New Delhi, India, 1973.
10. Jat JR, Yadav BL. Different forms of sulphur and their relationship with properties of Entisols of Jaipur District (Rajasthan) under Mustard cultivation. Journal of the Indian Society of Soil Science. 2006; 54(2):208-212.
11. Kour S, Jalali VK. Forms of sulphur and the relationships in soils of different agroclimatic zones of Jammu region. Journal of the Indian Society of Soil Science. 2008; 56:309-312.
12. Kumar H, Sahu KK, Kurre PK, Goswami RG, Kurrey CD. Correlation studies on available sulphur and soil properties in soils of Dabhra block under Jangir-Champa district in Chhattisgarh. An Asian Journal of Soil Science. 2014; 9(2):217-220.
13. Mathew J, Geoge S, Indira M. Effect of sulphur and boron on the nutrient release pattern in a typical Entisol of Kerala. Indian Journal of Fertilizers. 2013; 9:16-20.
14. Patel HR, Patel HF, Maheriya VD, Dodia IN. Response of kharif greengram (*Vigna radita* L. Wilczek) to sulphur and phosphorus fertilization with and without biofertilizer application. The Bioscan. 2013; 8:149-152.
15. Ramamurthy B, Bajaj JC. Available nitrogen, potassium and phosphorous status of Indian soils. Fertilizer News. 1969; 14:25-36.
16. Rousk J, Brookes PC, Baath E. Contrasting soil pH effects on fungal and bacterial growth suggest functional redundancy in carbon mineralization. Applied and environmental microbiology. 2009; 75(6):1589-1596.
17. Satpathy S, Mishra A, Saren S, Acharya BP. A study on soil fertility status of some villages in Nimapara block of East and South-Eastern coastal plain agroclimatic zone of Odisha. International journal of chemical and pharmaceutical review and research. 2015; 1(1):18-23.
18. Sehgal JL. Soil classification. Fundamental of Soil Science. Indian Society of Soil Science Cambridge printing Works, New Delhi, India. 2012: pp.50.
19. Sharma YK, Gangwar MS. Distribution of different forms of sulphur and their relationship with some soil properties in Alfisols, Inceptisols and Mollisols of Moradabad district, Uttar Pradesh. Journal of the Indian Society of Soil Science. 1997; 45(3):480-485.
20. Singh MV. Importance of sulphur in balanced fertilizer use in India. Fertilizer News. 2001; 46:31-35.
21. Singh SK. Effect of different sources of sulphur on rice under rain fed lowlands. Oryza. 2000; 37(1):81-82.
22. Tandon HLS. In sulphur research and agriculture production in India (Tandon, H.L.S. ed) fertilizer development and consultation organization, New Delhi, 1986.
23. Walkley AJ, Black IA. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science. 1934; 37:29-38.