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## Status of Sulphur in soils and plants of mixed red and black soils in Rewa district of Madhya Pradesh, India

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**Abstract**

The study was carried out status of sulphur in mixed red and black soils of Riwa district (M.P.) having 204 surface soil samples (0-15 cm) GPS based and 50 plant samples were collected from rice based cropping zone of Rewa district using Geo Positioning System (GPS). Sample was collected from eight blocks (Rewa, Gudh, Sirmor, Raipur Karchuliyan, Teonther, Mouganj and Hanumana) of Rewa district. The district spread between latitude-24°21'59.9" N to 24°48'40.9" N and longitude-81°09'21.8" E to 82°02'02.2" E. The mean value of pH, electrical conductivity (EC), organic carbon and CaCO<sub>3</sub> in soil were 7.45, 021 dSm<sup>-1</sup>, 5.03 g kg<sup>-1</sup> and 2.83 g kg<sup>-1</sup>, respectively. The average of available sulphur (S) content was observed 12.38 mg kg<sup>-1</sup>. The S concentration in rice grain and straw 0.055%, and 0.096 %, respectively. Sulphur was found to be positively correlation and statistically not-significant with pH and positively and significant correlation with organic carbon. The available sulphur show negative correlation with CaCO<sub>3</sub>. The results of the study indicated that 45.10 % sulphur deficiency is the major disorder in mixed red and black soils of Rewa district of Madhya Pradesh, India.

**Keywords:** Sulphur status, GPS technique, mixed red and black soils, Rewa district of Madhya Pradesh, and Physico-chemical property.

### 1. Introduction

Sulphur is one of the most important elements, which is categorized as a secondary nutrient is needed by the plant in about the same quantities as P. It plays an important role in the formation of sulphur containing amino acids like cystine (27% S), cystein (26% S), methionine (21% S), which act as building blocks in the synthesis of protein. It has a role to play in increasing chlorophyll formation and aiding photosynthesis. Sulphur also plays a role in activation of enzyme, nucleic acids and forms a part of biotin and thiamine. It is also required for the formation of glucoside and oils found in onion, garlic, cruciferous plants and certain disulphide linkage that has been associated with structural characters of protoplasm. Sulphur is known to stimulate root growth, seed formation, nodule development and also helps in chlorophyll synthesis, elemental sulphur and its compound are also used in the reclamation of salt affected soils and thus it increase the availability of phosphorus and certain micronutrients like zinc, iron, manganese and copper in these soils. Sulphur is a key element for plant and animal life and its insufficient supply to the plant, adversely affects both the quantity and quality of crops. Sulphur is the fourth major nutrient after nitrogen phosphorus and potassium. At present sulphur deficiency in soils of various Indian states varies from 5 to 83 with a mean of 41% (Singh 2001) [8]. The deficiency of sulphur in soils of Madhya Pradesh is observed to be in 44 % samples. Information about the extent of sulphur deficient area is necessary for the scientists, administrators, farmers and fertilizer manufacturers to determine the kind and quantity of fertilizer required for the particular region. There is a need to blend the traditional knowledge with frontier technologies. Geo-positional system is the tool of such frontier technology which, would help in generation of agricultural management system and formulating plans for sustainable agricultural development. The geo referenced sampling sites can be revisited with the help of GPS, which helps in monitoring the changes in the status of sulphur over a period of time, which otherwise is not possible by traditional methods of sampling. This study was conducted to assess the status of sulphur content in mix red and black soils of rice –wheat growing region of Rewa district, Madhya Pradesh, India.

## 2. Methods and Material

The study area is located in Rewa district of Madhya Pradesh. This district is situated between latitude-24°21'59.9" N to 24°48'40.9" N and longitude-81°09'21.8" E to 82°02'02.2" E. Climate of this region is semi-arid and sub-tropical. GPS based 204 surface soil samples and 50 plant samples were collected after harvesting of crop during the month of November 2010. Tehsil wise details of soil and plant sample of Rewa district were given Table -1. The collected soil samples were physico-chemical processed and analyzed pH (Govindrajan, 1970) [4], EC (Jackson, 1965) [5], organic carbon (Walkley and Black) and calcium carbonate (Jackson, 1965) [5] and available S by extracting with 0.15% CaCl<sub>2</sub> solution was determined by turbidimetric method (Chesnin and Yien 1951) [2]. The plant sample (grain and straw) were digested with di-acid mixture of HNO<sub>3</sub>: HClO<sub>4</sub> in 9:3 ratio and total S was determined by turbidimetric method (Chesnin and Yien 1951) [2] and estimated by using spectrophotometer. Further, data were processed statically to obtain the proposed objectives. The Limits of Sulphur content (mg kg<sup>-1</sup>) were used for various categories (low, medium and high) as suggested by Rathore *et al.* are given as:

Particularly	Low	Medium	High
S	<10	10-15	>15
NI:	<1.67	1.67-2.33	>2.33

## 3. Results

### 3.1 Physico-chemical properties of soils

Range of mean values of physico-chemical properties of Rewa district as Indicated in the Table 2. The pH status soil range between 5.50 to 8.10 with the average value is 7.45. The pH value is maximum (6.30-8.10, mean 7.66) and minimum (6.20-7.70, mean 6.93) in Rewa and Hanumana tehsil, respectively. The EC status soil range between 0.10 to 0.88 with the average value is 0.21 dSm<sup>-1</sup>. The EC value is maximum (0.10-0.88, mean 0.23) and minimum (0.10-0.41, mean 0.17) in Sirmor and Hanumana tehsil, respectively. The calcium carbonate (CaCO<sub>3</sub>) status soil range between 0.50 to 13.50 with the average value is 2.83 g kg<sup>-1</sup>. The CaCO<sub>3</sub> value is maximum (1.00-10.00, mean 3.66 g kg<sup>-1</sup>) and minimum (1.00-3.50, mean 2.09 g kg<sup>-1</sup>) in Rewa and Hanumana tehsil. The organic carbon (OC) status soil range between 2.10 to 11.00 with the average value is 5.03 g kg<sup>-1</sup>. The organic carbon value is maximum (3.40-11.00, mean 6.436 g kg<sup>-1</sup>) and minimum (2.10-7.50, mean 4.46 g kg<sup>-1</sup>) in Hanumana and Teonther tehsil.

### 3.2 Available Sulphur

Data presented in Table 3 indicated that the available S content in soils was found to vary from 2.70 to 42.60 mg kg<sup>-1</sup> with a mean value of 12.09 mg kg<sup>-1</sup> in Rewa tehsil, 3.70 to 27.50 mg kg<sup>-1</sup> with a mean value of 13.84 mg kg<sup>-1</sup> in Gudh tehsil, 1.90 to 27.50 mg kg<sup>-1</sup> with a mean value of 13.72 mg kg<sup>-1</sup> in Sirmor tehsil, 5.20 to 24.60 mg kg<sup>-1</sup> with a mean value of 13.23 mg kg<sup>-1</sup> in Raipur Karchliyan tehsil, 3.00 to 25.00 mg kg<sup>-1</sup> with a mean value of 11.44 mg kg<sup>-1</sup> in Teonther tehsil, 1.90 to 24.60 mg kg<sup>-1</sup> with a mean value of 10.17 mg kg<sup>-1</sup> in Mouganj tehsil, 9.50 to 24.60 mg kg<sup>-1</sup> with a mean value of 10.05 mg kg<sup>-1</sup> in Hanumana tehsil. For the entire Rewa district, available sulphur content in soils varied from 1.90 to 27.50 mg kg<sup>-1</sup> with a mean value of 12.38 mg kg<sup>-1</sup> of soil. Considering 10.0 mg kg<sup>-1</sup> 0.15 % CaCl<sub>2</sub> extractable sulphur as the critical level below which response of crops to the

application of sulphur may be expected 41.86, 44.00, 40.00, 41.18, 60.00, 57.14, & 21.43 percent samples were found deficient in Rewa, Gudh, Sirmor, Raipur Karchliyan, Teonther, Mouganj and Hanumana tehsil, respectively. For the Rewa district as a whole 45.10 per cent samples were tested low in available sulphur. Similar findings were reported by Rathore *et al.* (1995) [6], Singh and Sarkar (1999), Bhatnagar *et al.* (2003) [1] and Singh and Bansal (2007) [9].

### 3.3 Categorization of soils in low, medium and high categories of nutrients of Rewa district.

It was observed from the data presented in Table 4 that in Rewa district 45.10, 39.22 and 15.68 percent samples rated low, medium and high in respect of sulphur content. Soil nutrient index (Table 4) soils of Rewa district were found of Medium fertility status of S. The values worked out from nutrient index for S was 1.71. Against the nutrient index value <1.67 for low, 1.67 to 2.33 for medium and > 2.33 for high status.

### 3.4 Effect of soil properties on the availability of sulphur content in soils.

To study the effect of soil properties on the availability of sulphur in soils the value of correlation coefficient effect were worked out with soil pH, organic carbon and calcium carbonate (CaCO<sub>3</sub>) in soil.

It was noticed in Table 5 that the pH of the soil varied from 5.1 to 8.1 in mixed red and black soils of Rewa district. As evident from the data presented in Table 5 the mean value of sulphur increased from 9.8 to 18.94 mg kg<sup>-1</sup> with the increase in soil pH from 5.5 to 8.1 in Rewa district, though the relationship was found to be statistically non significant ( $r=0.0554$ ).

It is noticed from the data presented in the Table 5 showed that as the organic carbon content range increased from 2.1 to 11.0 g kg<sup>-1</sup> with the increase in organic carbon content the mean value of available sulphur was found to be increased from 11.54 to 13.02 mg kg<sup>-1</sup> in mixed red and black soil of Rewa district. The correlation coefficients was found to be significant at 5 percent level of significance ( $r=0.1502^*$ ). Similar relationship have also been reported by Dhane and Shukla (1995) [3] and Sahoo *et al.* (1998) [7].

It is noticed from the data presented in the Table 5 that the calcium carbonate content range increased from 0.50 to 13.50 g kg<sup>-1</sup> in mixed red and black soils of Rewa district. Sulphur content in soils of Rewa district decreased from 12.53 to 10.25 mg kg<sup>-1</sup> with the increasing calcium carbonate from 0.50 to 13.50. However, the relationship was found to be statistically non significant ( $r=-0.0493$ ).

### 3.5 Nutrient concentration in rice grain (district Rewa).

It can be noted from Table 6 that the sulphur content ranged from 0.021-0.090 % with a mean value 0.055 % in rice grain. Similarly, sulphur content of rice Straw ranged from 0.036-0.160 % with a mean value 0.096 %.

### 3.6 Relationships between the nutrient content in soil Vs rice grain & straw.

Relationship between the available nutrient content in soil and plant grain and straw samples were worked value of correlation coefficient are given in the table 7 which indicated that the nutrient content in soil and plant did not correlate significantly.

**Table 1:** Location of soil samples collected from district Rewa

Tehsils	N.S	Latitude		Longitude	
		From	To	From	To
Rewa	43	24°28'26.6" N	24°48'37.5" N	81°10'50.4" E	81°47'10.9" E
Gudh	25	24°21'59.9" N	24°28'27.3" N	81°13'31.5" E	81°18'35.3" E
Sirmor	45	24°37'17.5" N	24°47'19.5" N	81°09'21.8" E	81°15'42.4" E
Raipur Karchuliyan	17	24°34'32.6" N	24°39'19.6" N	81°26'02.2" E	81°33'08.4" E
Teonther	25	24°39'36.0" N	24°48'18.2" N	81°33'18.7" E	81°46'10.5" E
Mouganj	35	24°40'22.8" N	24°48'40.9" N	81°40'59.9" E	81°55'12.0" E
Hanumana	14	24°41'02.3" N	24°44'03.2" N	81°55'34.7" E	82°02'02.2" E
District Rewa	204	24°21'59.9" N	24°48'40.9" N	81°09'21.8" E	82°02'02.2" E

**Table 2:** Physico-chemical properties in different block of Rewa district

Block	pH		EC (dSm <sup>-1</sup> )		CaCO <sub>3</sub> (g kg <sup>-1</sup> )		OC (g kg <sup>-1</sup> )	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Rewa	6.30-8.10	7.66	0.11-0.79	0.23	1.00-12.00	3.66	3.30-9.60	5.36
Gudh	6.80-8.00	7.59	0.15-0.45	0.20	1.00-7.00	3.24	4.20-8.00	5.71
Sirmor	5.90-8.00	7.46	0.10-0.88	0.23	1.00-13.50	3.4	2.10-10.30	4.57
Raipur Karchuliyan	6.50-8.00	7.66	0.10-0.42	0.18	1.00-7.50	2.92	3.60-7.70	5.00
Teonther	5.50-8.00	7.39	0.10-0.87	0.23	1.00-7.50	2.17	2.10-7.50	4.46
Mouganj	5.60-7.90	7.08	0.10-0.51	0.21	0.50-4.50	1.85	3.10-8.60	4.76
Hanumana	6.20-7.70	6.93	0.10-0.41	0.17	1.00-3.50	2.09	3.40-11.00	6.36
District Rewa	5.50-8.10	7.45	0.10-0.88	0.21	0.50-13.50	2.83	2.10-11.00	5.03

**Table 3:** Distribution of available Sulphur of soil of district Rewa

Block	Available sulphur (mg kg <sup>-1</sup> )		
	Range	Mean	PSD
Rewa	2.70-42.60	12.09	41.86
Gudh	3.70-27.50	13.84	44.00
Sirmor	1.90-27.50	13.72	40.00
Raipur Karchuliyan	5.20-24.60	13.23	41.18
Teonther	3.00-25.00	11.44	60.00
Mouganj	1.90-24.60	10.17	57.14
Hanumana	9.50-24.60	10.05	21.43
District Rewa	1.90-27.50	12.38	45.10

PSD – Denoted percent samples deficient

**Table 4:** Categorization of soils in various categories district Rewa

Nutrients (mg kg <sup>-1</sup> )	Percent samples under classes of nutrients			Nutrient index	N.I Classes
	Low	Medium	High		
S	45.10	39.22	15.68	1.71	Medium

NI – nutrient index

**Table 5:** Effect of pH, Organic carbon and CaCO<sub>3</sub> on the availability of S in soil of Rewa

S. No	pH, O.C. and CaCO <sub>3</sub>	Organic carbon			
		No. of sample	P.S	S (mg kg <sup>-1</sup> )	Mean
<b>Soil pH</b>					
1	5.1-5.5	1	0.49	9.8	9.8
2	5.6-6.0	8	3.93	9.20-16.60	11.13
3	6.1-6.5	15	7.35	8.50-17.40	11.79
4	6.6-7.0	13	6.37	3.40-24.20	12.09
5	7.1-7.5	41	20.08	3.00-25.00	12.55
6	7.6-8.0	123	60.29	1.90-27.50	12.47
7	8.1-8.5	3	1.47	17.00-21.30	18.94
$r = 0.0554, Y = 7.916 + 0.5957X$					
<b>Organic carbon (mg kg<sup>-1</sup>)</b>					
1	2.1-4.5	84	41.17	1.90-27.50	11.54
2	4.6-7.0	98	48.03	2.70-26.70	12.82
3	7.1-9.5	18	8.83	4.50-27.50	14.28
4	9.6-12.0	4	1.95	11.10-15.80	13.02
$r = 0.1502^* Y = 9.299 + 0.6097X$					
<b>CaCO<sub>3</sub> (mg kg<sup>-1</sup>)</b>					

1	0-5	190	93.13	1.90-27.50	12.53
2	5.1-10	12	5.83	2.30-19.30	10.34
3	10.1-15	2	0.83	7.80-12.70	10.25
$r=(-)0.0493, Y=12.815-0.1647x$					

PS –percent sample

**Table 6:** Sulphur concentrations in rice grain and straw (district Rewa)

Tehsil	N.S.	S (%) in Grain		S (%) in Straw	
		Range	Mean	Range	Mean
Rewa	15	0.021-0.078	0.048	0.052-0.145	0.100
Gudh	9	0.031-0.090	0.061	0.047-0.160	0.101
Sirmor	13	0.028-0.090	0.064	0.036-0.160	0.098
Raipur Karchuliyan	3	0.052-0.058	0.055	0.054-0.063	0.059
Teonther	3	0.045-0.074	0.060	0.051-0.154	0.108
Mouganj	6	0.021-0.067	0.046	0.043-0.160	0.088
Hanumana	1	0.031	0.031	0.087	0.087
District Rewa	50	0.021-0.090	0.055	0.036-0.160	0.096

**Table 7:** Relationship between the Sulphur content in soil Vs rice grain & straw

S. No.	Name of district	Plant samples	r value	N.S	S
1	Rewa	Grain	r	50	0.1679
		Straw	r	50	-0.0679

#### 4. Conclusion

It is apparent from study that deficiency of sulphur was found 45.10 % samples. Result indicated that soil pH showed non-significantly positive correlation and soil  $\text{CaCO}_3$  non-significantly negative correlation with available sulphur. Further, organic carbon had a significantly and positive correlation with available sulphur. Hence, soil pH and organic carbon are the main soil characteristic which control sulphur availability in mixed red and black soil of Rewa district, Madhya Pradesh. The studies suggested that higher organic carbon in soil leads to protection of crops from sulphur deficiency.

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