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Determine the Correlation between Different Forms of Sulphur in Surface Soil of Ashoknagar District of MP

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Sulphur is one of the essential elements for plant growth. It is an important constituent of man,y enzymes and amino acids. Photosynthesis and nitrogen fixation are attributed to the type of sulphur linkage present. Sulphur has been found to help the synthesis of amino acids and hence increase the protein content of plants, boosting the oil content. Today, the Sulfur (S) research has extended to various soils, crops cropping systems and different sources of sulphur. Several soil factors influence the availability of sulphur and hence the status of different forms of sulphur in soil varies widely with soil types. Keeping in view, One hundred twenty-five GPS-based surface soil samples (0-15 cm) were collected from five blocks (Mungaoli, Chanderi, Ishagarh, Ashoknagar and Sadora) of Ashoknagar district from April to May 2017. Soils were studied for their physical and chemical characteristics and status of different forms of sulphur and their relationship with different soil properties.The different forms of sulphur, that is water soluble, available, organic and total-S

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were observed in the range of 1.23 – 7.67, 4.36 – 40.25, 89.08 – 194.53 and 167.45 – 422.20 mg kg-1 under different villages of the investigated area with the average value of 4.09, 14.68, 124.21 and 309.17 mg kg-1, respectively. Out of 125 surface samples, 36 samples (28.8%) were found under deficient, 72 (57.6%) under medium and 17 (13.6%) samples were found in sufficient category. The availability of sulphur increased with an increase in organic carbon and clay content in the soil. The correlation study revealed that organic carbon had a greater impact on different forms of sulphur followed by soil texture. It suggested that organic matter was the main contributing factor affecting the sulphur availability in soil. Total S maintained a significant positive association with all the forms of sulphur. Such a relationship suggests that sulphur exists in a state of dynamic equilibrium in these soils.

Keywords: Sulphur; photosynthesis; nitrogen fixation; organic carbon; clay content.

1. INTRODUCTION

Sulphur (S) is the fourth most important nutrient after nitrogen, phosphorus and potassium for Indian agriculture. It is essential for the synthesis of proteins, vitamins and S-containing essential amino acids and is also associated with (N) metabolism. Sulphur improves both yield and quality of crops. It is also a constituent of many enzymes and amino acids and helps in the increase in oil percentage. Heavy removal of sulphur by high-yielding varieties particularly oilseeds crop, intensive cropping with high sulphur-requiring crops and losses of sulphur from soil through leaching and erosion causes S-deficiency in soil. The major sources of S in soils are sulphides, sulphates and organic combinations with C and N contents of soils, though a reflection of parent material from which soils originated, is influenced by climate and management practices. Consequently, different soils maintain a wide range of total -S contents which has been found to extend more than three thousand ppm. Since total S does not relate to plant growth, its plant-available forms are emphasized more often. Mostly the sulphur in the soil can be grouped into four forms viz. total-S, organic-S, non-sulphate-S, and available-S. In these different forms of sulphur organic sulphur dominantly controls the levels of plant-available sulphur. The important factors which influence the content and availability of sulphur in soils are organic matter and the texture of the soil. Sulphate-S represents plant available-S, which is immediate supplier of sulphate ions to the roots of plants. The information regarding different forms of S is very limited. Today, the S research has extended to various soils, crops cropping systems and different sources of sulphur.

2. MATERIALS AND METHODS

The study was carried out during 2016-17 in the Department of Soil Science, College of Agriculture, Gwalior (M.P.).

(a) Location and extent: Ashoknagar is located in the northern part of Madhya Pradesh, between the rivers Sindh and the Betwa. It comes under the northern part of the Malwa plateau, though the main part of its district lies in the Bundelkhand Plateau. The Coordinates of the district are 24°34′ 48″ N and 77°43′ 48″E with an average elevation of 507 metres (1640 ft) above sea level.

(b) Soils: Soils of the investigated area are generally variable in colour, depending on the timing period and sources of the irrigation system. In this region, the main classes of soil are black, brown and bhakti (stony) soil. The volcanic, clay-like soil of the region owes its black colour to the high iron content of the basalt from which it is formed. The soil requires less irrigation because of its high capacity for moisture retention. The other two soil types are lighter and have a higher proportion of sand.

(c) Collection and preparation of soil samples: For the present study, 125 surface (0-15 cm) soil samples (GPS based, detail given in tables) collected from cultivar's fields of five blocks (namely; Mungaoli, Chanderi, Ishagarh, Ashoknagar and Sadora) of Ashoknagar district. The representative soil samples were collected with the help of soil auger. The soil samples were put in the polythene bags properly, labelled and carried to the laboratory. After collection, the samples were brought to the Soil Science Laboratory, College of Agriculture, Gwalior and samples were air dried, crushed and sieved through a 2 mm plastic sieve.

Table 1. Details of soil samples collected from various villages of different blocks of Ashoknagar district

S. No.	Block	Village name	No. of Samples	Total samples
1	Mungaoli	Aathaikheda	05	25
		Bilakhedi	05	
		Mudrakhana	05	
		Chamrai	05	
		Shyampur	05	
2	Chanderi	Barodiya	05	25
		Sangampur	05	
		Tarai	05	
		Mohalichak	05	
		Salona	05	
3	Isagarh	Korwas	05	25
		Kotharkhedi	05	
		Vijaypura	05	
		Pachlana	05	
		Bamawar	05	
4	Ashoknagar	Mau	05	25
		Banyga	05	
		Diyadhari	05	
		Ratikheda	05	
		Ashoknagar	05	
5	Sadora	Kherai	05	25
		Bamuria	05	
		Parwai	05	
		Gugor	05	
		Bagulya	05	
Grand total		**25**	**125**	**125**

3. RESULTS AND DISCUSSION

3.1 Water Soluble – S

Status of water soluble-S (mg kg-1) in the soils under study area was observed in the range of 1.23 to 7.67 with an average value of 4.09 mg kg-1 which constituted only 1.32% content of the total –S. The results are similar to those of Priyadarshi et al*.* [1] who reported that water-soluble sulphur constituted only 2.2 % of total sulphur in old alluvial soils of Nawada district. The average maximum (5.08 mg kg-1) and minimum (2.83 mg kg-1) values of water-soluble S was noted in Barodiya and Mohalichak villages of the Chanderi block, respectively. Water soluble sulphur showed a highly significant and positive correlation with organic carbon and total-N of the soils of the investigated area. A positive relationship between water soluble-S and clay content was also found which indicated that clay content increases the availability of water soluble-S. A significant and positive relationship between these two was also reported by Kher and Singh [2]. Balanagoudar and Satyanarayana [3] also observed a positive and significant relationship between water-soluble S and clay content in Vertisols and Alfisols of northern Karnataka. Das et al*.* [4] reported that all the forms of sulphur significantly and positively correlated with organic C and clay content.

3.2 Organic-S

Organic-S showed a significant and positive correlation with organic carbon, clay and total nitrogen. This may be because organic carbon is the main source of organic-S; therefore a positive significant correlation between the two is expected. These findings conform with Sharma and Jaggi [5]. The positive relationship of organic-S with organic carbon and total-N suggested a simultaneous increase in the status of nitrogen and organic-S in soil with an increase in organic carbon in soils. The results suggest that the organic matter in these soils contains sulphur-containing amino acids which are responsible for contributing to the organic sulphur in soils. A positive correlation of organic-S with organic carbon was also reported by Trivedi et al*.* [6] and Bhatnagar et al*.* [7] The organic sulphur was correlated significantly and

positively with all the forms of sulphur. A similar relationship was also reported by Jat and Yadav [8].

3.3 Total Sulphur

In general, the total S content was found significant and positively correlated with organic carbon, clay and total nitrogen. The significant and positive correlation of total -S with organic carbon and clay and total-N has also been reported by Agarwal and Nayyar [9], Trivedi et al. [10] and Trivedi et al. [6]. Total sulphur appears to be a function of soil organic matter as both are significantly and positively correlated. This is also because in most of the soil S is a constituent of organic matter [11]. Kaur and Jalali [12] noticed that the total- S exhibited a positive and highly significant correlation with organic carbon (r=0.965) and finer fractions of soil viz. clay (r=0.470) and silt (r = 0.682). The sulphate -S (available-S) was correlated positively and significantly with silt content (r = 0.403). Total S maintained a significant positive association with all the forms of sulphur. Such a relationship suggests that sulphur exists in a state of dynamic equilibrium in these soils. The results also suggest that by proper management of organic carbon in soil the possibility of soils becoming deficient may be avoided. The positive relation between organic carbon and organic sulphur and available sulphur further indicates that on mineralizations of organic carbon and organic sulphur, under favourable soil conditions, the level of available S may improve. The positive coefficient of correlation of clay with available and organic –S indicates that sulphate sulphur (So4--) being negative (- ve) in charge is retained by clay particles thus leaching may be cheeked.

Table 2. Status of water-soluble sulphur in the soils of Ashoknagar district

S. No.	Block	Name of Village	Water Soluble-S (mg kg^{-1})	
			Range	**Mean**
1	**Mungaoli** (25)	Aathaikheda	1.52-5.41	3.68
		Bilakhedi	2.93-6.40	3.94
		Mudrakhana	3.63-6.19	4.74
		Chamrai	2.49-6.69	4.39
		Shyampur	2.39-5.02	3.84
		Overall Block	**1.52-6.69**	**4.10**
2	**Chanderi** (25)	Barodiya	3.89-6.53	5.08
		Sangampur	1.23-4.78	3.09
		Tarai	2.78-5.45	4.31
		Mohalichak	1.48-3.56	2.83
		Salona	1.56-4.87	3.26
		Overall Block	**1.23-6.53**	**3.72**
3	**Isagarh** (25)	Korwas	2.45-6.24	4.68
		Kotharkhedi	3.12-7.18	4.93
		Vijaypura	1.62-7.67	4.97
		Pachlana	2.56-7.18	4.52
		Bamnawar	2.81 - 6.41	4.46
		Overall Block	**1.62-7.67**	**4.71**
4	**Ashoknagar** (25)	Mau	3.50-5.17	4.29
		Banyga	3.06-7.26	4.65
		Diyadhari	2.69-5.85	3.89
		Ratikheda	2.25-3.93	3.30
		Ashoknagar	2.93-5.20	389
		Overall Block	**2.25-7.26**	**4.01**
5	**Sadora** (25)	Kherai	2.35-6.33	4.26
		Bamuria	2.34-5.77	4.27
		Parwai	1.34-5.34	3.38
		Gugor	2.56-5.78	3.88
		Bagulya	2.33-5.40	3.63
		Overall Block	**1.34-6.33**	**3.89**
Whole district			**1.23 – 7.67**	**4.09**

Table 3. Status of organic sulphur in the soils of Ashoknagar district

S. No.	Block	Name of Village	Organic -S (mg kg^{-1})	
			Range	**Mean**
1	**Mungaoli** (25)	Aathaikheda	111.04 – 156.42	134.71
		Bilakhedi	89.08 – 126.28	107.85
		Mudrakhana	113.58 – 189.65	153.17
		Chamrai	104.82 -167.12	123.45
		Shyampur	90.87 – 127.31	108.45
		Overall Block	**89.08 – 189.65**	**125.53**
2	**Chanderi** (25)	Barodiya	106.68 – 144.80	125.17
		Sangampur	100.37 – 131.80	114.34
		Tarai	106.79 – 155.54	138.41
		Mohalichak	100.70 – 130.89	117.22
		Salona	100.89 – 152.56	127.85
		Overall Block	**100.37 – 155.54**	**124.60**
3	**Isagarh** (25)	Korwas	112.51 – 194.53	160.89
		Kotharkhedi	105.85 – 116.95	112.94
		Vijaypura	100.16 – 133.90	110.68
		Pachlana	102.52 – 134.71	118.16
		Bamnawar	99.23 – 113.27	106.59
		Overall Block	**99.23 –194.53**	**121.85**
4	**Ashoknagar** (25)	Mau	113.48 – 149.41	131.54
		Banyga	124.44 – 150.54	138.74
		Diyadhari	112.91 – 147.02	130.55
		Ratikheda	113.48 – 134.10	126.29
		Ashoknagar	113.89 – 146.11	134.11
		Overall Block	**112.91 –150.54**	**132.24**
5	**Sadora** (25)	Kherai	92.40 – 145.56	112.22
		Bamuria	108.07 – 145.0	120.79
		Parwai	105.04 – 136.12	114.62
		Gugor	100.77 – 166.74	125.04
		Bagulya	98.43 – 135.29	111.53
		Overall Block	**92.40 – 166.74**	**116.84**
Whole district			**89.08 – 194.53**	**124.21**

Table 4. Status of Total sulphur in the soils of Ashoknagar district

S. No.	Block	Name of Village	Total -S(mg kg-1)	
			Range	**Mean**
1	**Mungaoli** (25)	Aathaikheda	278.02 – 344.57	315.86
		Bilakhedi	167.45 – 305.52	264.01
		Mudrakhana	280.12 - 419.86	366.34
		Chamrai	275.68 – 379.09	308.88
		Shyampur	282.21 – 421.29	366.61
		Overall Block	**167.45 – 421.29**	**324.34**
2	**Chanderi** (25)	Barodiya	235.58 – 397.84	313.39
		Sangampur	240.07 - 311.64	281.41
		Tarai	169.78 – 399.09	337.95
		Mohalichak	235.54 – 322.43	277.30
		Salona	239.07 – 312.48	288.41
		Overall Block	**169.78 – 399.09**	**299.69**

S. No.	Block	Name of Village	Total -S(mg kg-1)	
			Range	**Mean**
3	**Isagarh** (25)	Korwas	277.62 – 422.20	371.17
		Kotharkhedi	283.75 – 389.19	312.40
		Vijaypura	244.37 – 278.30	265.82
		Pachlana	245.00 – 316.73	277.61
		Bamnawar	284.41 – 388.41	312.40
		Overall Block	**244.37 – 422.20**	**307.86**
4	**Ashoknagar** (25)	Mau	286.07 – 398.31	328.29
		Banyga	310.96 – 377.98	333.91
		Diyadhari	278.20 – 394.80	338.76
		Ratikheda	280.05 – 388.79	321.62
		Ashoknagar	287.21 – 400.08	329.13
		Overall Block	**278.20 – 400.08**	**331.14**
5	**Sadora** (25)	Kherai	183.91 – 398.93	285.51
		Bamuria	266.44 – 316.72	284.02
		Parwai	221.26 – 314.53	258.15
		Gugor	240.67 – 397.33	303.01
		Bagulya	266.57 – 315.67	283.42
		Overall Block	**183.91 – 398.93**	**282.22**
Whole district			**167.45 – 422.20**	**309.17**

Table 5. Coefficient of correlation between different forms of sulphur

	Water soluble – S	Available – S	Organic-S	Total –S
W.S. – S	-	0.434**	0.546**	0.543**
Available– S	-	-	0.446**	0.379**
Organic- S	-	-	-	0.728**
Total –S	-	-	-	-

4. CONCLUSION

Global Position System (GPS) based one hundred Twenty-five surface soil (0 -15 cm) samples were collected from five blocks (Mungaoli, Chanderi, Ishagarh, Ashoknagar and Sadora) of Ashoknagar district from April to May 2016 and were analysed status of different forms of sulphur (i. e. total - S, water soluble-S, organic-S and available – S). The results are summarized as follows the different forms of sulphur, i.e. water-soluble, available, organic and total -S were observed in the range of 1.23 – 7.67, 4.36 – 40.25, 89.08 – 194.53 and 167.45 – 422.20 mg kg-1 under different villages of the investigated area with the average value of 4.09, 14.68, 124.21 and 309.17 mg kg-1, respectively. Out of 125 surface samples, 36 samples (28.8%) were found deficient, 72 (57.6%) under medium and 17 (13.6%) samples were found in the sufficient category. Status of water soluble-S (mg kg-1) in the soils under study area was observed in the range of 1.23 to 7.67 with an average value of 4.09 mg kg-1 which constituted only 1.32% content of the total –S. Water soluble sulphur showed a highly significant and positive correlation with organic carbon and total-N of the soils of the investigated area. Available -S observed in the range of 4.36 to 40.25 mg kg-1 under the studied area with the mean value of 14.68 mg kg-1 which is 4.75 percent of the average total –S status of the district found under study. Available sulphur showed a significant and positive correlation with organic carbon and total nitrogen of the soils. Available-S showed a significant and negative correlation with the calcium carbonate content of the soils. Under different forms of sulphur, Available-S was significantly and positively correlated with total- S and organic-S. The status of organic -S was observed in the range of 89.08 – 194.53 mg kg-1 under the investigated area with an average value of 124.21 mg kg-1 which is 40.18 % of the total sulphur status of the district. The average maximum (160.89 mg kg-1) and minimum (106.59 mg kg-1) values of organic - S were observed in Korwas and Bamnawar village of Isagarh block, respectively.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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