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FORMS OF SULPHUR IN SOILS OF ALIGARH DISTRICT, UTTAR PRADESH AND THEIR RELATIONSHIP WITH SOIL PROPERTIES

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ABSTRACT

One hundred fifty one surface soil samples were collected from different parts of Aligarh district of Uttar Pradesh and analysed for various physico chemical properties and forms of sulphur. Relationships of different forms of sulphur with soil properties were investigated. The total S content ranged from 65.0 to 196.0 mg kg^{-1} with a mean of 131 mg kg^{-1} soil. The mean values of organic-S, SO_4-S, water soluble-S and non-sulphate-S were 39.9, 11.9, 20.4 and 73.3 mg kg^{-1}, respectively. Non sulphate sulphur constituted the dominant form (59 %) of total S and sulphate - S constituted only a small fraction (9%) of the total S. All forms of sulphur were significantly and positively correlated with organic carbon. Significant negative correlations of total and non-SO_4-S were recorded with soil pH. Sulphate – S was correlated positively and significantly with EC. All forms of sulphur showed significantly positive correlation among themselves. Based on the available S content, only 39 % of the soils exhibited sulphur deficiency.

Keywords: Sulphur forms, Aligarh district, relationship, soil properties.

INTRODUCTION

Lack of indigenous sources of S, enhanced removal of S from the soil under intensive cropping systems and use of high analysis S-free fertilizers coupled with its leaching from root zone are largely responsible for increasing incidences of S deficiency in the soils. The area speculated as sufficient in sulphur had started showing sulphur deficiency in Agra region. Because of its involvement in vital functions in the plant metabolism sulphur deficiency would lead to adverse effect on growth and yield of many crops. Availability of sulphur is influenced by various soil factors and hence the status of different forms of sulphur in soils varied widely with soil types. Forms of sulphur and their interrelationship with soil properties decide on the sulphur supplying power of soil their influence on its release and dynamics in soil (Das et al 2012). Thus, knowledge of different forms of sulphur is essential in improving its nutrition to crops. In view of this, the present study was undertaken to determine the sulphur status in soils of Aligarh district to find out the relationship of various soil properties with S fractions.

MATERIAL AND METHODS

The Present study covered Atrauli, Gabhana, Iglas, Khair and Kol tehsils of Aligarh district of Uttar Pradesh. One hundred fifty one composite surface soil samples (0-15 cm) were collected from various sites of these tehsils. Processed soil samples (<2mm) were analyzed for different physicochemical properties following standard procedures. Soil samples were also analyzed for different forms of S viz. total S (Chapman and Pratt 1961), water soluble S (Spencer and Freney 1960) and available S in the extract of 0.15% $CaCl_2$ (Williams and Steinbergs 1959). Non sulphate sulphur was computed by subtracting the sum of organic S (Evans and Rost 1945) and available S from the total S. Sulphur in all extracts was determined turbidimetric method (Chesnin and Yien 1951). Simple correlation of different S fractions with some of the relevant physical and chemical properties was worked out by standard statistical methods.

RESULTS AND DISCUSSION

Some of the important chemical properties of soils are presented in Table 1. The soils were alkaline

Table 1: Physico-Chemical properties of soils of Aligarh, Uttar Pradesh

Tehsil	pH	EC (dSm^{-1})	$CaCO_3$ ($g\ kg^{-1}$)	Organic Carbon ($g\ kg^{-1}$)
Atrauli	7.5-8.9	0.06-0.31 (0.15)	5.0-35.0 (15.8)	2.7-6.5 (4.40)
Gabhana	7.6-8.9	0.10-0.91 (0.29)	5.0-40.0 (17.4)	2.0-6.0 (4.25)
Iglas	7.6-8.8	0.07-0.72 (0.24)	5.0-35.0 (16.1)	2.5-6.5 (4.45)
Khair	7.2-9.2	0.07-0.43 (0.21)	5.0-30.0 (15.6)	2.4-6.1 (4.32)
Kol	7.6-9.0	0.06-0.46 (0.23)	5.0-30.0 (15.1)	2.4-6.1 (4.28)

in reaction (pH 7.2-9.2). Organic carbon content in these soils ranged from 2.0 to 6.5 g kg^{-1}. The EC (0.06 to 0.91 dSm^{-1}) showed considerable variation. Most of the soils were noncalcareous (5-40g kg^{-1}).

Total S: The total sulphur content of the soils of Aligarh district varied from 65 to 196 mg kg^{-1} with a mean value of 131 mg kg^{-1}. On an average, the soils of Khair tehsil were found to be relatively rich in total sulphur. On the other hand, the soils of Atrauli tehsil had lower quantities of total sulphur. As shown in Table 4, total sulphur content was positively and significantly correlated with organic carbon (r= 0.38**) but negatively with soil pH (r= -0.40**). The significantly positive correlation of total S with organic carbon was reported by Omsaran *et al.* (2004) and Jat and Yadav (2006). Total S maintained a significant positive association with all forms of sulphur (Table 3). Such relationship suggests that sulphur exists in a state of dynamic equilibrium in these soils.

Table 2: Forms of Sulphur in soils of Aligarh district, Uttar Pradesh

Tehsil	Total (mg kg^{-1})	Sulphate (mg kg^{-1})	Organic (mg kg^{-1})	Water Soluble (mg kg^{-1})	Non-Sulphate (mg kg^{-1})
Atrauli	70.0-192.0 (119.8)	4.5-18.5 (10.8)	20.0-75 (39.5)	15.0-41.0 (22.0)	31.5-112.0 (67.7)
Gabhana	65.0-180.0 (127.8)	5.0-17.0 (11.2)	20.0-70 (36.8)	12.0-36.0 (19.7)	39.5-114.0 (72.3)
Iglas	70.0-190.0 (136.6)	4.0-21.5 (12.6)	24.0-80 (42.5)	11.0-38.0 (21.0)	39.0-121.5 (82.2)
Khair	65.0-196.0 (142.1)	6.0-18.5 (12.8)	20.0-75.0 (43.4)	11.0-36.0 (19.6)	33.5-124.5 (86.6)
Kol	70.0-194.0 (129.0)	7.0-19.5 (12.2)	20.0-70 (37.5)	10.0-36.0 (18.5)	37.5-117.5 (77.4)

Organic S: The mean organic sulphur content of these soils varied from 20 to 80 mg kg^{-1} soil and constituted about 30.5% of the total S. The soils of Khair tehsil contained the highest organic sulphur content while the lowest content was observed in soils of Gabhana tehsil (Table 2). Such variation in organic S content is attributed to variation in organic carbon content. These observations are substantiated by the significant positive correlation of organic S with organic carbon. Sharma and Gangwar (1997) have also reported similar observations. Organic sulphur maintained a significant and positive relationship with all forms of S (Table 3) suggesting a dynamic equilibrium among them (Das *et al.*, 2012).

Non-sulphate sulphur: Non-sulphate sulphur was computed by subtracting the sum of organic S and sulphate S from the total S. It is mostly made up of SO_4 occluded on carbonates (Evans and Rost 1945). Non-sulphate S content in these soils varied from 31.5 to 124.5 mg kg^{-1} soil and it constituted about 59 % total S. The soils of Khair tehsil exhibited the highest mean value of non SO_4 - S as compared to other tehsils (Table 2). It is also evident from the table 2 that non sulphate sulphur was higher than organic sulphur. This might be due to rapid oxidation of organic matter and mineralization of sulphur under arid condition. The results are in accordance with the findings of Jat and Yadav (2006). The EC had non significant positive relationship with non sulphate sulphur. The non-sulphate S exhibited significant positive correlation with organic carbon (r= 3.1) while it was significantly and negatively associated with soil pH. Mahajan *et al.* (2007) also reported significantly and negative relationship between non sulphate sulphur and soil pH.

Table 3: Correlation coefficient among various forms of sulphur (n=151)

Sulphur	Organic sulphur	Sulphate Sulphur	Water Soluble Sulphur	Non-Sulphate Sulphur
Total –S	0.91**	0.73**	0.69**	0.93**
Organic-S		0.76**	0.78**	0.58**
SO_4-S			0.66**	0.48**
Water Soluble S				0.41**

*** Significant at 1% level*

Sulphate sulphur: Sulphate sulphur (0.15% $CaCl_2$ extractable) is used as an index of S availability in many soils, since the variation in this form causes variation in yield and S uptake in crops in many soils. This form of S contributed about 9% total sulphur and ranged from 4.0 mg kg^{-1} to 21.5 mg kg^{-1} with a mean value of 11.5 mg kg^{-1} (Table 2). The sulphate S was significantly and positively correlated with organic carbon (r= 0.58) but negatively with pH (r= -16). The observed significant positive correlation of sulphate S with organic carbon suggests that sulphur supplying power of these soils is largely dependent upon organic carbon. EC correlated positively and significantly with sulphate-S. It indicates that with increase in EC, the concentration of sulphate S increases which in conformity with the results of

Gowrishanker and Shukla (1999). Sulphate S did not exhibit any significant correlation with other soil properties. These results are in accordance with those of Singh *et al.* (1995), Jat and Yadav (2006) and Upadhyay (2012). Sulphate S existed in a state of dynamic equilibrium which was evident from significant positive correlations (Table 3) with almost all other forms of sulphur. This is in close agreement with the findings of Singh *et al.* (1995). Taking 10 mg kg^{-1} as critical limit (Mehta *et al.* 1988), 39% of the soil samples were deficient in sulphur. Responses of sulphur application on crops grown in such area can be expected.

Water soluble sulphur: Water soluble sulphur ranged from 10.0 to 41.0 mg kg^{-1} soil and accounted for 15.4% of total-S in these soils. Lower content of this form of sulphur might be due to concomitant leaching loss of sulphate from the soil. The highest (41.0 mg kg^{-1}) and the lowest (10.0 mg kg^{-1}) values were observed in Atrauli and Kol tehsils, respectively.

Table 4: Correlation coefficient between physico-chemical properties and forms of sulphur (n=151)

Soil Properties	Total S	Organic S	Sulphate -S	Water Soluble S	Non-sulphate-S
pH	-0.40**	0.12	-0.16	-0.18*	-0.24**
EC	0.10	0.08	0.26**	0.06	0.04
Org. Carbon	0.38**	0.58**	0.36**	0.35**	0.31**
$CaCO_3$	0.10	0.08	0.07	0.08	0.06

** Significant at 5% level*
*** Significant at 1% level*

Results are corroborated with the findings of Ram and Dwivedi (2004). Water soluble sulphur had a strong correlation with all the forms of sulphur as reported by Gowrishanker and Shukla (1999) and Jat and Yadav (2006) (Table 3). Water soluble S exhibited a significant negative correlation with pH (r =0.18). It can be explained with the reasoning that when pH increases, sorption of sulphur decreases which in turn augments the water soluble S in soil solution. The water soluble S exhibited positive correlation with organic -C (r=0.35)

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