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FORMS OF SULPHUR IN WHEAT GROWING SOILS OF AGRA DISTRICT OF UTTAR PRADESH

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ABSTRACT

The important forms of sulphur and their relationship with different soil properties were investigated in some wheat growing Entisols of Agra district of Uttar Pradesh. The total S content ranged from 55.0 to 160 mg kg^{-1} with a mean of 98.1 mg kg^{-1} soil. Non - SO_4-S constituted the dominant form (60.1 %) of total S followed by organic –S (32.1%). Water soluble –S (5.5 to 30.0 mg kg^{-1}) and SO_4-S (4.5 to 25.5 mg kg^{-1}) constituted only small fractions of the total S. About 59% of the investigated soils were found to be deficient in plant available S and needed S fertilization for sustainable production of Wheat. All the forms of sulphur had significant and positive relationship with organic carbon as well as total sulphur content of the soils, however negative correlation was observed between forms of S and soil pH. Sulphur content in leaves wheat plants ranged between 0.11 and 0.40 %. Plant sulphur had a significant and positive relationship with soil available sulphur.

Keywords: Forms of sulphur, soil properties, wheat growing soils, Agra

INTRODUCTION

Sulphur (S), the nutrient required for increasing both the quantity and quality of the produce, is gaining importance of late owing to its increased deficiency in soils. Widespread deficiency of sulphur in different soils in several states of India have been attributed to continuous use of high analysis S free fertilizers, inclusion of high yielding varieties in the intensive cropping systems and restricted use of organic manures (Aulakh and Chhibba 1992, Sakal and Singh 1997). To know the exact S supplying capacity of a soil, it is desirable to study the different forms of S rather than the available SO_4- S, as about 90% of total S is present in organic form. 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 (Sammi Reddy *et al*. 2001) So far, inadequate information is available regarding the status of forms of S in soil of Agra district. In view of this, the present study was undertaken to determine the sulphur status in some wheat growing soils of Agra and to find out the relationship of various soil properties with S fractions.

MATERIALS AND METHODS

The present investigation was confined to Entisols of Agra district. Soil samples (0-15 cm) from wheat growing soils were collected for the study of different forms of S. Processed soil samples were analyzed for different physico-chemical properties following standard procedures (Jackson, 1973). The total S was extracted by the method of Butter and Chenery (1959). Organic S was determined as per the method proposed by Williams and Steinbergs (1959). SO_4-S was extracted with 0.15% $CaCl_2$ solution as proposed by Williams and Steinbergs (1959). For determination of water soluble-S, Spencer and Freney (1960) procedure was followed.Non-SO_4-S was calculated by subtracting the sum of organic-S and SO_4-S from total S. Sulphur in all the extracts was determined by the turbidimetric procedure of Chesnin and Yien (1951). The incidence of S deficiency was also confirmed through plant analysis for which leaf samples were collected from the same sites from where soil samples were collected. These samples were washed with water acid solution and distilled water in succession. The oven dried samples were powered by crushing them with hands. Di – acid (HNO_3 and $HClO_4$) digested leaf samples were analyzed for sulphur by turbidimetric method. Simple correlations were worked out relating different S fractions with physico – chemical properties of the soils by standard statistical methods.

RESULTS AND DISCUSSION

Some of the important physico–chemical properties of the soils are presented in Table 1. The soils of Agra district were alkaline in reaction, the variation in pH being from 7.1 to 9.0. The EC values of soils were found to be within safe limits (0.12 to 2.40 dSm^{-1}). Organic carbon content in the soils was low to medium, ranging from 2.6 to 5.6 g kg^{-1} with a mean value of 3.6 g kg^{-1}.The amount of $CaCO_3$ also varied widely (5.0 to 35.0 g kg^{-1}). The total sulphur content in wheat soils ranged from 55.0 to 160.0 mg kg^{-1} with a mean value of 98.0 mg kg^{-1}. The lower values of total S in these soils might be associated with lower amount of organic carbon. Chandel *et al*. (2012) reported similar results in soils of Agra.Total sulphur content was positively and significantly

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correlated with organic carbon and negatively with soil pH.The significant positive correlation of total S with organic carbon has also been reported by Das *et al.* (2012). Total S maintained a significant positive association with all forms of sulphur (Table 2). Such relationship suggests that sulphur exists in a state of dynamic equilibrium in these soils. Similar relationship among various forms of sulphur was earlier reported by Tripathi *et al*. (2000) and Das *et al*. (2012).

Table 1: Physico – chemical properties and forms of sulphur in soils of Agra

Soil Properties	Range	Mean
pH	7.1 – 9.0	
EC (dSm^{-1})	0.1 – 2.4	0.8
Organic Carbon ($g\ kg^{-1}$)	2.6 – 5.6	3.6
CaCO3 ($g\ kg^{-1}$)	5.0 – 35.0	11.8
Forms of Sulphur		
Total Sulphur ($mg\ kg^{-1}$)	55.0 – 160.0	98.1
Non – SO_4 S ($mg\ kg^{-1}$)	24.5 – 102.0	59.0
Organic S ($mg\ kg^{-1}$)	10.0 – 65.0	31.5
Water Soluble S ($mg\ kg^{-1}$)	5.5 – 30.0	12.2
SO_4 – Sulphur ($mg\ kg^{-1}$)	4.5 – 25.5	9.4
Sulphur in plants		
Plant S (%)	0.11 – 0.40	0.28

Non – SO_4 – S is mostly made up of SO_4^{2-} occluded in and adsorbed on carbonates or insoluble S compounds of Fe and Al in soil which remains unextractable after removal of organic C and SO_4-S. The non – SO_4 form of S in these soils ranged from 24.5 to 102.0 mg kg^{-1} and constituted 60.1% of the total sulphur, with a the mean value of 59.0 mg kg^{-1}.Thus, most of the soil sulphur present remains inorganic in nature. The non – SO_4 – S content of the soils of wheat growing areas was significantly related with organic carbon. It did not show any significant relationships with pH, EC and $CaCO_3$ contents of the soils (Table 2), thereby indicating little influence of these soil characters on the amount and distribution of this form of S. The non – SO_4 – S was significantly correlated with SO_4 – S (r = 0.54**) and water soluble S (r = 0.51**) in wheat growing soils of Agra (Table 2). This suggests that a large portion of non – SO_4 – S might have been formed at the expense of SO_4 – S in these soils. Organically bound S ranged from 10.0 to 65.0 mg kg^{-1} in wheat growing soils with a mean value of 31.5 mg kg^{-1} (Table 1).These results are similar to the findings of Kaur *et al.* (2010). Organic S constituted, on an average, 32.1% of the total S. Correlation studies (Table 2) indicated significant positive correlation of organic S with organic carbon. This may be due to the fact that organic carbon is the main source of organic S, therefore positive significant correlation is expected. Borkotoki and Das (2008) have also made similar observation on soils of Assam. Organic S maintained a significant positive correlation with all other forms of S (Table 2) suggesting a dynamic equilibrium among them (Tripathi and Singh 1992). The average content of water soluble S was 12.2 mg kg $^{-1}$ in these soils (Table 1) with a range of 5.5 to 30.0 mg kg $^{-1}$. Water soluble S accounts for only a small fraction (12.6%) of total S. This fraction contains mostly free inorganic and some organically bound SO_4 (Williams and Steinbergs 1959). The low water soluble S in these soils may be attributed to leaching of SO_4 from the surface layer. Almost similar results were reported by Trivedi *et al*. (1998). This S fraction also gives an idea of available S status of the soil. Water soluble S was significantly and positively correlated with organic carbon but non – significant with pH and $CaCO_3$. Since, organic matter plays an important role in influencing S availability in the soil, the same statement also holds good in present investigation with existing positive correlation between water soluble S and organic carbon. A similar relationship between organic carbon and water soluble S has also been reported by Sharma and Jaggi (2001). Water soluble S had a strong correlation with all the forms of S (Table 2). These observations corroborate the findings of Borkotoki and Das (2008) who studied the relationship of forms of sulphur in soil of Assam.

Table 2: Correlation coefficient values (r) of forms of sulphur with some soil properties and among forms of sulphur

Soil properties	Forms of Sulphur				
	Total	Non – SO_4	Organic	Water soluble	Sulphate
pH	- 0.23*	- 0.17	-0.24*	- 0.14	0.27*
EC	0.08	- 0.11	- 0.09	0.07	- 0.17
OC	0.58**	0.47**	0.50**	0.30**	0.56**
$CaCO_3$	- 0.15	- 0.05	- 0.11	- 0.05	- 0.05
Total – S		0.89**	0.79**	0.81*	0.78**
Non SO_4 - S			0.44**	0.51**	0.54**
Organic S				0.88**	0.77**
Water Soluble S					0.87**

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

The SO_4-S (extracted by 0.15%$CaCl_2$ solution) is used as an index of S availability in many soils, since the variation in this form causes variation in yield and uptake of S in crops. The amount of SO_4 – S in wheat soils of Agra district ranged between 4.5 and 25.5 mg kg^{-1} with an average of 12.4 mg kg^{-1}. This variation in SO_4 – S may be attributed to the differences in soil properties, crop management practices and organic matter Chandel *et al.* (2012) reported similar results in Agra Soils. It is well known that plant roots absorb S as SO_4 – S ion from the soil solution. Taking 10 mg kg^{-1} SO_4 as the critical limit, about 59% samples were found to be deficient in SO_4 –S. Chandel *et al*. (2012) also reported similar results.

The SO_4 – S was positively and significantly correlated with organic carbon but negatively with pH. The observed significant positive correlation of available S with organic carbon suggests that S supplying power of these soils is largely dependent upon organic matter. These results are in accordance with those of Kotur and Jalali (2008). Available S existed in a state of dynamic equilibrium which is evident from significant positive correlations (Table 2). This is in close agreement with the findings of Sharma and Jaggi (2001). The concentration of S in leaf samples of wheat plants varied from 0.11 to 0.40 % with a mean value of 0.28%. Leaf S content exhibited a definite relationship (r = 0.73**) with the available S status of the soils. The leaves collected from soils having low available S accordingly had low S concentration. The results, thus, indicate that soil test values corroborate with plant analysis and it is possible to forecast deficiency of S from soil analysis prior to sowing of crop. Similar results were reported by Tripathi *et al*. (2000). The leaf analysis of wheat indicated deficiency to the order of 46% in Agra as per critical limit (0.20%) proposed by Tiwari *et al*. (1995). The extent of S deficiency as revealed by leaf analysis was of smaller order as compared to soil analysis.

From the above results, it is concluded that soil properties (especially pH, organic carbon and free $CaCO_3$) are the major determinants of S in different forms, and S in one form continues to transform into another maintaining a dynamic equilibrium. Further, these S forms contribute in different proportions to the pool of available S.

REFERENCES

Aulakh, M.S., and Chibba, I.M. (1992) Sulphur in soils and response of crops to its application in Punjab. *Fertiliser News* **37:** 33 – 45.

Borkotoki, B. and Das, K.N. (2008) Forms of sulphur and their relationship with soil roperties in Entisols, Inceptisols and Alfisols of Assam. *Journal of the Indian Society of Soil Science* **56**,186 – 191.

Butter, B. and Chenery, F.M. (1959) A rapid method for the determination of total sulphur in soils and plants. *Analyst* **85**, 239 – 246.

Chandel, B.S., Thakur, P.K., Ali, J. and Singh, H. (2012) Soil sulphur status and response of garlic to sulphur in relation to phosphorus. *Annals of Plant and Soil Research* **14:** 156–158.

Chesnin, L. and Yien, C.H. (1951) Turbidimetric determination of available sulphate. *Soil Science Society of America Proceedings* **15:** 149 – 151.

Das, K.N., Basumatari, A. and Borkotoki, B.(2012) Forms of sulphur in some rapeseed – growing soils of Assam. *Journal of the Indian Society of Soil Science* **60:** 13 – 19.

Jackson, M.L. (1973) *Soil chemical Analysis*. Prentice Hall of India Private Limited, New Delhi.

Kaur, S., Arora, S., Jalali, V.K. and Mondal, A.K. (2010) Soil sulphur forms in relation to physical and chemical properties of mid hill soils of north India. *Communications in Soil Science and Plant Analysis* **41:** 277 – 289.

Kotur, S. and Jalali, V.K. (2008) Forms of sulphur and their relationship in soils of different agro climatic zones of Jammu region. *Journal of the Indian Society of Soil Science* **56:** 306 – 312.

Sakal. R. and Singh, A.P. 1997) In proceedings of the National Symposium on Sulphur in Balanced Fertilization (B.C. Biswas, N. Prasad and S.Das, Eds.), FAI, New Delhi, PP. SI– I (1–6).

Sammi Reddy, K., Tripathi, A.K., Singh, M., Subba, Rao, A. and Anand Swarup (2001) Sulphate sorption – desorption characteristics in relation to properties of some acid soils. *Journal of the Indian Society of Soil Science* **49:** 74–79.

Sharma, R.K. and Jaggi, R.C. (2001) Relationships of forms and availability indices of sulphur with properties of soils of Kangra, Himachal Pradesh. *Journal of the Indian Society of Soil Science* **49:** 698 – 702.

Spencer, K. and Freney, J.R. (1960) A comparison of several procedures for estimating the sulphur status of soils. *Australion Journal of Agricultural Research* **11:** 948 – 959.

Tiwari, K.N., Dwivedi, B.S., Tiwari, A., Dagur, B.S. and Sharma, H.L. (1995) Status of S, Zn, Fe, Cu and Mn in soils and plants and delineation of the areas of their deficiencies in central, south western and Bundelkhand zones of Uttar Pradesh. *Fertiliser News* **40:** 19 – 34.

Tripathi, D. and Singh, K. (1992) Vertical distribution of sulphur in representative soil groups of Himachal Pradesh. *Journal of the Indian Society of Soil Science* **40:** 447 – 453.

Tripathi, S.B., Singh, R.S. and Tripathi, S.K. (2000) Distribution of sulphur in Ustrochrepts under cultivation of fodder and natural grass cover. *Journal of the Indian Society of Soil Science* **48:** 608 – 611.

Trivedi, S. K., Bansal, K. N., and Singh, V.B. (1998) Important forms of sulphur in profiles of some soil series of northern Madhya Pradesh. *Journal of the Indian ociety of Soil Science* **46:** 579 – 583.

Williams, C.H., Steinbergs, A. (1959) Soil sulphur fractions as chemical indices of available sulphur in Australian soils. *Australian Journal of Agricultural Research* **11:** 948 – 959.