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Oxidation of elemental sulphur in red non-calcareous (Typic Haplustalf) soil

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Abstract : A laboratory experiment was conducted to examine the oxidation of elemental sulphur (S^o) in a red non - calcareous (*Typic Haplustalf)* soil. Different levels of S^o (60 and 100 mesh size) at a rate equivalent to 1000, 5000 and 10000 mg kg^{-1} were thoroughly mixed with soil and incubated for 120 days at 25°C±2°C. The oxidation was measured by the increase in the concentration of sulphur (SO_4-S) in soil. The highest oxidation of 46.3 per cent was achieved when S^o was added as finer particles (100 mesh) at a rate of 1000 mg S^o kg^{-1} soil. The S^o oxidation also resulted marked reduction in soil pH. *(Key Words : Elemental sulphur, Oxidation, SO_4^{-2} concentration).*

Elemental sulphur (S^o) contains 90-100 per cent sulphur (S), which is slowly oxidised to sulphate (SO_4) through microbial action (Watkinson and Blair, 1993). Besides S oxidising microorganisms, the particle size of S^o (Janzen and Bettany, 1987) soil temperature (Champman, 1989), soil water potential (Watkinson and Blair, 1993), soil texture (Deng and Dick, 1990) and soil pH (Janzen and Bettany, 1987) were found to influence the oxidation of S^o in soil. Information is scarce on the oxidation of S^o in Indian soil, particularly in non-calcareous soils of Tamil Nadu. the present investigation was aimed at measuring the oxidation of different grades of S^o in a red non-calcareous soil.

Materials and Methods

The soil used for the inclubation experiment had sandy clay loam texture, pH of 7.7 and CEC 12.9 cmol (p+) kg^{-1} soil.

A closed incubation experiment was carried out with different levels of S^o at rates equivalent to 0,1000, 5000 and 10000 mg S^o kg^{-1} soil with two different particle sizes (60 and 100 mesh). The S^o was mixed with 100g of soils (<2mm) in plastic cups. These treatments were replicated thrice in a completely randomised block design. After thorough mixing the soil samples were adjusted to a field capacity moisture by adding distilled water and incubated for 120 days at 25°C+2°C under laboratory condition. The soil samples were collected at the end of 0, 15, 30, 45, 60,90 and 120 days and analysed for pH (Jackson, 1973), total S (Chaudhury and Cornfield, 1966) and available S content by calcium chloride 0.15% method (Williams and Steinbergs, 1959).

The amount of S^o oxidised was calculated from the increase in SO_4-S concentration over control soil (Janzen and Bettany, 1987).

Results and Discussion

Acidity producted during S^o oxidation

Oxidation of S^o resulted in significant reduction in soil pH during incubation. In general the amoùnt of SO_4 formed increased the hydrogen concentration in the soil and thus decreased the soil pH. Futher the S oxidising bacteria viz., *Thiobacilli* sp. was identified in the experimental soil, which could be attributed for the higher rate of S^o oxidation. All the treatments except control revealed a significant reduction of pH value from 15 to 120 days incubation. The highest reduction (4.68) was noticed in S^o with mesh size of 100 at 10000 mg kg^{-1} level. Oxidation of S^o resulted in significant reduction of soil pH clearly showed the occurrence of oxidation of S^o. The fineness of S^o particles play a major role in the S^o oxidation and resulted greater reduction in soil pH (Nor and Tabatabai, 1977 and Modaihsh *et al.*, 1989).

Concentration of SO_4-S.

Without the addition of S^o, the SO_4-S varied from 12.5 to 16.3 mg kg^{-1} in soil during 120 days incubation (Table 1). The concentration of SO_4-S ranged from 354.2 to 3750.0 and 466.7 to 4625.0 mg kg^{-1}, for 60 and 100 mesh size, respectively. The 100 mesh size resulted higher concentration of SO_4-S than with 60 mesh size at all days of incubation. The increase in SO_4-S was mainly due to the oxidation of S^o (Nor and Tabatabai, 1977). As only 38.3 mg SO_4-S kg^{-1} was found increased in control soil, almost 98 per cent of the SO_4-S should have originated from the oxidation of S^o (Li and Caldwell, 1966 and Banerjee *et al.*, 1994). The per cent recovery of added S^o which ranged form 84 to 100 per cent initially was found decreased after 120 days. Only 70 to 92 per cent was found recovered as total S after 120 days. This may indicate the

Table 1. Changes in pH and SO_4-S concentration (mg kg^{-1}) due to the oxidation of elemental sulphur at different days of incubation

(Mean of three replications)

Treatments	Days											
	pH						SO_4-S					
	15	30	45	60	90	120	15	30	45	60	90	120
T_1 - Control	7.70	7.65	7.62	7.65	7.62	7.60	12.5	12.5	13.8	15.0	16.3	16.3
T_2 - S° (60 mesh) 1000 mg	7.58	6.49	6.31	5.73	5.46	5.31	354.2	666.7	816.7	1283.3	1325.0	1008.3
T_3 - S° (60 mesh) 5000 mg	7.56	6.90	6.25	5.68	5.29	5.20	525.0	1016.7	1129.2	1404.2	2304.2	2550.0
T_4 - S° (60 mesh) 10000 mg	7.50	6.81	6.16	5.57	5.18	5.05	637.5	1325.0	1766.7	2166.7	3291.7	3750.0
T_5 - S° (100 mesh) 1000 mg	7.42	6.75	6.12	5.41	5.02	4.82	466.7	787.5	1283.3	1375.0	1420.8	1466.7
T_6 - S° (100 mesh) 5000 mg	7.32	6.67	6.03	5.30	4.91	4.78	678.5	1041.7	1129.2	1625.0	2362.5	2304.2
T_7 - S° (100 mesh) 10000 mg	7.28	6.52	5.94	5.19	4.85	4.68	708.3	1466.7	1816.7	2258.3	3916.7	4625.0
SEd	0.17	0.15	0.13	0.12	0.11	34.8	30.5	38.7	39.8	44.2	46.3	
CD (0.05)	0.37	0.33	0.30	0.29	0.26	0.24	75.7	60.5	84.3	86.8	96.2	101.2

considerable amount of S was immobilized into organic S. The decline in the percentage of applied S recovered with time was attributed to mineral fixation of the SO_4 ion or the biological fixation of S by the soil microorganisms (Germida *et al.*, 1994 and He *et al.*, 1996).

Total sulphur

The concentration varied between 0.17 and 0.19 (control), 0.24 and 0.29 (at 1000 mg S kg^{-1}), 0.52 and 0.61 (at 5000 mg S kg^{-1}) and from 1.07 and 1.17 (at 10000 mg kg^{-1}) per cent. The concentration of total S mostly did not change considerably during incubation (Table 2).

Oxidaion of elemental sulphur

The oxidation rate of S° measured through change in SO_4-S in soil showed that irrespective of different level of S° addition and particle sizes, the rate of oxidation increased substantially upto 60 days of incubation. The rate of oxidation at 5000 and 10,000 mg S kg^{-1} showed a small increase at 120 days (Table 3) further confirms the immobilization of SO_4-S as organic S (Chapman, 1997).

Irrespective of mesh sizes, the extent of oxidation was significantly greater at a level of 1000 mg S° kg^{-1} soil. Increase in the levels of S° addition resulted decrease in the rate of oxidation. This might be due to less efficient mixing of S° with soil at higher rates of application (Modaihsh *et al.*, 1989).

At all levels of S° addition, the extent of oxidation was significantly greater for the 100 mesh S° than 60 mesh at all days during incubation. A maximum of about 46.3 per cent was oxidised when S° was added at 1000 mg S° kg^{-1} soil as finer particles (100 mesh). With icnrease in the specific surface area of S° available for reaction with soil, the oxidation rate was higher with 100 mesh sizes (Lee *et al.*, 1988).

The decrease in the rate of S° oxidation at higher levels of elemental sulphur may partly due to the diminishing amount of substrate available as oxidation proceeds (Janzen and Bettany, 1987) and partly due to the inaccessibility of the core of the residual S° particles to the oxidising organis. (Lee *et al.*, 1988). Another possible mechanism is, as S° oxidation proceeds the pH of soil decreases, due to this some S° oxidisers may be inhibited, especially heterotrophs (Wainwright, 1984 and Chapman, 1989).

To conclude, the highest oxidation of S° 46.3 per cent was achieved when S° was added as finer

Table 2. Changes in concentration of Total S due to the oxidation of elemental sulphur at different days of incubation (per cent)

(Mean of three replications)

Treatments	Days					
	15	30	45	60	90	120
T_1	0.18	0.18	0.17	0.17	0.18	0.17
T_2	0.29	0.27	0.27	0.27	0.27	0.24
T_3	0.58	0.57	0.55	0.55	0.53	0.52
T_4	1.17	1.14	1.14	1.11	1.07	1.09
T_5	0.28	0.27	0.27	0.27	0.27	0.25
T_6	0.61	0.58	0.58	0.55	0.54	0.53
T_7	1.17	1.13	1.11	1.11	1.10	1.10
SEd	0.02	0.03	0.03	0.03	0.03	0.02
CD(P=0.05)	0.04	0.06	0.06	0.06	0.06	0.05

Table 3. Oxidation of elemental sulphur during incubation (per cent)

(Mean of three replications)

Treatments	Days					
	15	30	45	60	90	120
T_1	--	--	--	--	--	--
T_2	11.3	21.6	26.5	41.8	43.1	32.7
T_3	3.4	6.6	7.4	9.2	15.1	16.7
T_4	2.1	4.3	5.8	7.1	10.8	12.3
T_5	14.9	25.6	41.9	44.8	46.3	44.8
T_6	4.5	6.8	7.4	10.6	15.5	15.1
T_7	2.3	4.8	6.0	7.4	12.9	15.2

particles (100 mesh) at lower level of addition (1000 mg $S^o kg^{-1}$). Fifty per cent (50%) of added S^o was oxidised at 120 days.

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Yield component analysis in niger (*Guizotia abyssinica* Cass)

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Abstract : In thirty genotypes of niger, a substantial genetic variability was observed for seven characters. Heritability estimates was low for primary branches/plant and high for remaining all characters. High heritability along with high genetic advance was observed for capsules/plant and plant height indicating predominance of additive genetic action. The significant positive correlation of seed yield with days to maturity, seeds/capsule was observed. Genoypic correlations were observed larger in magnitude than their respective phenotypic correlations, indicating that selection for correlated characters could give better yield response to selection. A phenotypic as well as genotypic correlations among days to maturity, plant height, seeds/capsule and 1000 seed weight and their positive association with seed yield was observed indicating that these are the major yield components in niger. Days to maturity, seeds/capsules and 1000 seed weight had large and positive direct effect on seed yield. *(Key Words : Niger, Variability, Interrelationship).*

Cultivated niger (*Guizotia abyssinica* Cass) may have originated from the wild species of *Guizotia scabra*, due to selection by Ethiopian farmers several years ago. Movement of the crop to India may have occurred soon after the crop was domesticated in Ethiopia. Niger is the first ranked oil crop in Ethiopia occupying about 50 to 60 per cent of the total cropped area. However, in India it is very minor oilseed crop cultivated mainly by the poor tribal farmers. The crop is found growing under diverse conditions, where other crops may vertually fail. It can be grown on every type of soils including marginal soil and tolerate waterlogging fairly well. The niger seed contains 40 per cent oil with fatty acid composition of 75 to 80 per cent linoleic acid, 7 to 8 per cent palmitic acid and stearic acid (Getinet and Taklewold, 1995). It is wellknown that dietary fats rich in linoleic acid prevents cardiovascular disorders such as coronary heart disease and high blood pressure. Thus, it is very good and safe oil for human consumption. Now efforts for yield improvement in niger has already been started in India and within a few years, we are expecting very good encouraging results. In view of this the present investigation was undertaken.