suggested that dominant as well as recessive genes controlled the high or low mean performance (Mather and Jinks, 1971). The magnitude of narrow sense heritabilities were low for all the traits studied, suggesting the importance of non-additive gene effect. Bhatade (1981); Duhoon et al., (1983), Amalraj and Gawande (1985) also reported similar findings for boll number, seed cotton yield per plant and bollworm damage.

Both the procedures revealed the prevalence of additive as well as non-additive gene effects for all the traits except egg, green boll damage, boll number and seed cotton yield. But the Jinks - Hayman's approach failed to reveal the existence of additive components for these characters. Since epistasis was also detected for some of the traits in addition to the concentration of genes with additive effects a part of non-allelic interactions may also be fixed to isolate transgressive segregants. Any from of recurrent selection which allows intermating among the selects may be more effective to fix favourable recessive alleles which are hidden in the heterozygous condition.

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TRANFORMATION OF SULPHUR IN SOILS OF NORTH KARNATAKA AS INFLUENCED BY SOURCES AND LEVELS OF SULPHUR

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ABSTRACT

A Laboratory incubation experiment was conducted in Vertisol and an Inceptisol of North Karnataka to know the effect of different sources and levels of sulphur and time of incubation on transformation of available S in soils. Among the different sources of sulphur, ammonium sulphate recorded the highest release of S due to its more soluble nature compared to other sources. The available S content was more in inceptisol. There was a rapid release of S during the first fifteen days of incubation followed by a slower linear release.

KEY WORDS: S transformation, Vertisol, Inceptisol, Incubation, Sources and levels of S

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Sulphur is present in soils in both inorganic and organic forms but the proportion of inorganic to organic form varies widely depending on the nature of soil and its depth and the management system to which the soil is subjected. Sulphur compounds undergo many transformations as a result of activities of plants, animals and microorganisms and to lesser extent due to non-biological action. Sulphur levels in soils are subjected to considerable fluctuations due to minerelisation of organic matter, leaching of soluble sulphate, uptake by plants and sulphate addition through irrigation water and fertilisers. The fate of applied sulphur as a fertiliser ingredient or amendment needs to be looked throughly to understand the possible availability of sulphur to crops from the native or applied source. Nature of soil, type of fertiliser, levels of fertiliser and time of fertiliser application are some of the factors which govern the sulphur availability in soils (Germida and Janson, 1993.)

There is little information available regarding the effect of different sources and levels of sulphur on the transformation of available S in soils of North Karnataka. The objective of this study was to know the pattern of release of sulphur from different sources of sulphur fertilisers under different levels in sulphur dificient vertisol and inceptisol of North Karnataka, kept under incubation for 60 days.

MATERIALS AND METHODS

An incubation study was conducted in surface soils (0-30 cm depth) from ARS, Dharwad (Vertisol) and farmer'S field, Madarkandi (Inceptisol). The details of the soils collected for incubation study and their physico-chemical properties are furnished in Table 1: Physicochemical properties were analysed by adopting standard procedures (Jackson. 1967). Five hundered g of soil was taken from each soil group in plastic containers and required amounts of S through different sources of S were added to soils. The treatments consisted of five sources of S viz. ammonium sulphate, single super phosphate, gypsum, elemental sulphur and pyrite, each at four levels (0,15,30,45 kg s ha-1). Pyrite in powdered form as applied after after passing through a 100 mesh sieve. All the treatments were replicated thrice and the experiment was laid out in three factorial Randamised Complete Block Design. The soils were incubated at 1/3 bar moisture level at room

Table 1. Properties of the soils selected for incubation study

Properties	Vertisol	Inceptisol
Location	Agricultural Research Station, Hebballi,	Farmer's field, Madarkandi,
Dharwad district	Jamakhandi Tq., Bijapur district	
pH	7.50	8.20
EC (dS m-1)	0.10	0.15
Organic Carbon (%)	0.39	0.80
$CaCO_3$ (%)	4.10	2.03
CEC (c mol (p+) kg-1)	63.74	16.00
Particle Size Analysis (%)		
Coarse sand	6.82	24.06
Fine sand	6.00	26.42
Silt	29.20	9.49
Clay	57.98	40 03
Available S (ppm)	6.39	8.12
Organic S (ppm)	105.05	272.60
Total S (ppm)	1160.00	1165.00

temperature for 60 days. Water was added periodically to maintain the moisture content of the soils at field capacity. The soil samples were analysed for $CaCl_2$-extractable sulphur at 15,30,45 and 60 days after incubation.

Available S was estimated by extractiing the soil with 0.15 per cent $CaCl_2$ solution as described by Williams and Steinbergs (1959). Organic S in soils was estimated by using $Na_2H_2PO_4$+ acetic acid as extractant as described by Bardsley and Lancaster (1965). Total S in the soil was estimated by Na_2CO_3-$NaNo_3$ fusion method as outlined by Bardsley and Lancaster (1965). Sulphur in the filtered extract was estimated by turbidimetric method.

RESULTS AND DISCUSSION

The data on available S as influenced by sources and levels of S and time of incubation are presented in Tables 2 to 4.

Effect of sources and levels of S on Available S content in soils

The available S content increased with increasing levels of S added in both the soils (Table 2). At 45 kg ha^{-1} level, maximum availability of 46.37 ppm and 51.21 ppm was noticed in vertisol and inceptisol, respectively. Higher available S content in soils (45 kg ha^{-1}) at higher level may be due to more release of S from the S fertilisers at this level.

Among the different S sources applied, maximum S availability was obtained with ammonium sulphate treatment wherein its content was 40.84 ppm and 47.94 ppm in vertisol and inceptisol, respectively. This may be due to higher solubility of ammonium sulphate (77.24% by weight in water at 20 C) than other sources. Mukhopadhyay and Mukhopadhyay (1985) observed similar results in soils of West Bengal. S release from elemental S and pyrite was found inferior when compared to other sources in both the soil types. This could be due to the inadequate

Table 2. Effect of Sources and levels of S on S availability (ppm) in soils under incubation

Sources of S	Levels of S (kg ha-1)									
	Vertisol (ARS, Dharwad)					Inceptisol (Farmer's field, Madarkandi)				
	0 kg S/ha	15 kg S/ha	30 kg S/ha	45 kg S/ha	Mean	0 kg S/ha	15 kg S/ha	30 kg S/ha	45 kg S/ha	Mean
Ammonium sulphate	25.01	39.36	46.25	52.75	40.84	31.98	45.28	54.60	59.89	47.94
Single super phosphate	23.26	34.71	39.49	49.19	36.66	34.11	38.76	45.19	52.76	42.71
Elemental sulphur	23.53	28.73	34.51	40.59	31.84	31.55	36.55	39.78	46.09	38.49
Gypsum	22.75	33.96	40.32	40.32	36.34	31.74	39.19	44.74	51.72	41.85
Pyrite	23.98	30.60	35.19	40.99	32.69	31.74	35.27	39.76	45.57	38.08
Mean	23.71	33.47	39.15	46.37	35.68	32.22	39.01	44.82	51.21	41.81

	SEm	CD (0.05)	CD (0.01)	SEm	CD (0.05)	CD (0.01)
Sources of S (SS)	0.029	0.087	0.113	0.010	0.033	0.042
Levels of S (SL)	0.026	0.078	0.102	0.009	0.030	0.038
SS x SL	0.059	0.169	0.221	0.020	0.060	0.077

Table 3. Effect of Sources of S and days of incubation on S availability (ppm) in soils under incubation

Sources of S	Days of incubation									
	Vertisol (ARS, Dharwad)					Inceptisol (Farmer's field, Madarkandi)				
	15 days	30 days	45 days	60 days	Mean	15 days	30 days	45 days	60 days	Mean
Ammonium sulphate	33.95	36.98	45.56	46.91	40.84	43.70	42.54	51.62	53.89	47.94
Single super phosphate	30.68	31.85	41.78	42.38	36.66	37.41	36.63	48.63	48.15	42.71
Elemental sulphur	23.03	27.16	37.48	39.68	31.84	33.85	33.96	43.43	42.73	38.79
Gypsum	30.67	30.82	40.28	43.57	36.34	37.55	34.54	47.57	47.72	41.85
Pyrite	23.16	28.13	38.69	40.79	32.69	32.35	33.55	42.77	43.66	38.08
Mean	28.30	30.98	40.76	42.66	35.68	36.97	36.24	46.81	47.23	41.81

	SEm	CD (0.05)	CD (0.01)	SEm	CD (0.05)	CD (0.01)
Sources of S (SS)	0.029	0.087	0.113	0.010	0.033	0.042
Days of incubation (DI)	0.026	0.078	0.102	0.009	0.030	0.038
SS x DI	0.059	0.169	0.221	0.020	0.060	0.078

population of *Thiobacillus thiooxidans* in soils to transform reduced S to sulphate form of S.

The availability of S during incubation was more in Inceptisol (farmer's field, Madarkandi)

Table 4. Effect of levels of S and days of incubation on S availability (ppm) in soils under incubation

Levels of S (kg S ha-1)	Days of incubation									
	Vertisol (ARS. Dharwad)					Inceptisol (Farmer's field. Madarkandi)				
	15 days	30 days	45 days	60 days	Mean	15 days	30 days	45 days	60 days	Mean
0	17.24	19.12	29.09	29.38	23.71	27.25	27.30	36.97	37.38	32.22
15	25.23	29.11	38.50	41.05	33.47	33.41	33.21	44.38	45.04	39.01
30	31.48	34.85	43.71	46.57	39.15	40.66	38.84	49.24	50.52	44.82
45	39.25	40.86	51.74	53.63	46.37	46.58	45.62	56.63	55.99	51.21
Mean	28.30	30.98	40.76	42.66	35.68	36.97	36.24	46.81	47.23	41.81

	SEm	CD (0.05)	CD (0.01)	SEm	CD (0.05)	CD (0.01)
Levels of S (SL)	0.026	0.078	0.102	0.009	0.030	0.038
Days of incubation (DI)	0.026	0.078	0.102	0.009	0.030	0.038
SL x DI	0.052	0.151	0.198	0.018	0.055	0.070

when compared to vertisol (ARS, Dharwad) which may be due to the high amount of organic carbon and slightly higher initial available S in the former (Table 1). Bettany *et. al* (1974) also reported similar results.

Effect of sources and days of incubation on available S content in soils

As the days of incubation propressed from 0 to 60, there was an increase in the amount of available S (table 3). In vertisol, the sulphate S content was increased from 6.39 at 0 dat to 42.66 ppm at 60 days after incubation, whereas in inceptisol, it increased from 8.12 to 47.13 ppm after 60 days of incubation period. The release of S from various sources was rapid during the initial 15 days after which the release was gradual. The decrease in microbial activity as the microbial population ages might be the reason for slow release rate of S after 2 weeks of incubation. Haque and Walmsley (1972) also observed an initial rapid release of sulphur upto 2 weeks of incubation followed by a slow release rate in various soil groups of West Indies.

Because the opposing reactions of immobilization and mineralization occur simultaneously, differing patterns of inorganic sulphate release would be expected, depending upon the availability of energy materials for microorganisms.

The results also revealed that the pattern of release of S from various sources of S differed depending upon the type of fertilisers. During the entire period of incubation the release rate of S was higher in ammonium sulphate whereas it was least in elemental S and pyrite treatments. Pyrite and elemental S needed oxidation time to supply sulphate S in the available form and that resulted in low availability of S from these sources. Ammonium sulphate being the most soluble fertiliser among all the sources used, released the highest amount of S throughout the period of incubation.

Effect of levels of S and days of incubation on sulphiur availability in soils

Data on available S status as incluenced by S levels and days of incubation revealed that with increasing days of incubation, available S also increased correspondingly at all levels (Table4). Minimum increase in S content was observed at 0 kg S ha^{-1} level, whereas the maximum valuc was obtained with 45 kg ha^{-1} level, whereas the maximum value was obtained with 45 kg ha^{-1} level at 60 days of incubation irrespective of different S sources.

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