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Releasing Pattern of Sulphur and Native Phosphorous in Major Soil Series in Madurai District

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A laboratory experiment was carried out at the Agricultural college and Research Institute, Madurai during the year 2005 to evaluate in the releasing pattern of sulphur and native phosphorous from six major soil series of Madurai district, Tamil Nadu. The result revealed that increasing levels of sulphur increased the available sulphur and phosphorous in all the soils. The sulphur availability was increased upto 4 weeks of incubation and thereafter a declining trend was noticed. Whereas the phosphorous availability increased progressively with the increase in period of incubation upto fifth week beyond which the rate of increase narrowed down. Among the six soil series, the maximum available sulphur (27.7 mg kg^{-1}) and phosphorous (25.0 mg kg^{-1}) were observed in anaiyur series followed by kalathur series for available sulphur (21.1 mg kg^{-1}). Madukkar series recorded highest available phosphorous (19.9 mg kg^{-1}).

Key words: Soil series, sulphur, phosphorous, incubation, availability.

Sulphur has been recognized as the fourth major plant nutrient after N, P and K. Crops in general require as much sulphur as they need phosphorous. It is supplied to the soil from weathering of rocks and minerals, mineralised from the organic matter or from added fertilizer. A part of the released sulphate remain in solution and a part gets adsorbed or fixed on the colloidal complexes and its availability in the labile pool gets reduced (Parfitt, 1982;Bhogal *et al.,* 1996). The lability of sulphur in soil depends upon soil properties. Among these, pH, presence of complexing anions (Lande *et al.,* 1977), clay content, sesquioxides (Johnson and Todd, 1983; Fuller *et al.,* 1985) $CaCO_3$ content and native extractable sulphate are most important. Both sulphur and phosphorous are found in soil solution in anionic forms. Both positive and negative interactions have been reported between these two ions. Several workers have reported that at higher concentration of sulphur, sulphate gets adsorbed on the colloidal complexes and the phosphorous will be released to the labile pool. (Pasricha *et al.,* 1987; Aulakh *et al.,*1990). However these interactions depend upon the soil properties. Although the releasing pattern of sulphur have been studied under different agro climatic conditions, the information on the releasing pattern of applied sulphur and its effect on the availability of native phosphorous is lacking. Therefore to develop database for further activities the present investigation was taken up with the objectives of studying the release pattern of applied sulphur at different time intervals and to evaluate the effect of applied sulphur on the availability of native phosphorus.

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Materials and Methods

A laboratory experiment was carried out at the Agricultural College and Research Institute, Madurai during the year 2005 on six major soil series of Madurai district. The soil samples were drawn from a depth of 30 cm. Fifty grams of air dried, sieved soil samples were properly leveled and placed in plastic containers. Some basic physico-chemical characteristics of the experimental soils are given in Table 1.

The study was laid out in a completely randomized design. The treatment included six soil types and six levels of sulphur (0, 10, 20, 30, 40 and 50 mg kg^{-1}). Different amount of sulphur was added through K_2SO_4 salt solution as per treatment. After imposing the treatments, the soils were incubated at room temperature (37°C) and moisture content kept near field capacity and the water was added periodically. At the end of every week, the samples were drawn and the available sulphur in the soil solution was determined turbidimetrically (Chesnin and Yien, 1951). The available P was estimated by Olsen's method (Olsen *et al.,* 1954).

Results and Discussion

Effect of applied sulphur on available sulphur

Different soil types and various sulphur level had a significant effect on available sulphur (Table 2). Regarding the sulphur level, highly significant

increase in available sulphur with the increase in applied sulphur level was observed and the mean available sulphur ranged from 6.0 to 24.6 mg kg^{-1}. The rate of release of applied sulphur was more at higher concentration as compared to the lower levels. Since at lower concentration, the rate of adsorption of sulphate over the soil colloidal complex would be higher to satisfy the positive charges existing in the soil colloids (Sammi Reddy *et al.,* 2001). Among the soil types, the mean available sulphur content ranged for 7.6 to 27.7 mg kg^{-1}. The mean available sulphur was maximum (27.7 mg kg^{-1}) in Anaiyur series followed by Kalathur series (21.1 mg kg^{-1}). The rate of release of sulphur was found to be lower in Irugur series (7.6 mg kg^{-1}) as this soil is rich in sesquioxides which could have adsorbed the sulphate. This is also confirmed by findings of Joshi (1984). The interaction effect of soil types and sulphur levels also had a significant influence on the rate of release of applied sulphur. The highest available sulphur content of 39.2 mg kg^{-1} was noticed in Anaiyur series to which 50 mg kg^{-1} of sulphur was applied.

Table 1. Physico-chemical properties of the experimental soils

Properties	Madukkur	Anaiyur	Vyalogam	Palaviduthi	Kalathur	Irugur
Particle size distribution (%)						
Coarse sand	20.90	28.70	14.30	23.4	22.4	23.80
Fine sand	54.50	33.50	61.80	48.0	20.0	42.60
Silt	4.90	10.70	3.50	6.82	30.4	18.60
Clay	18.90	25.30	19.20	21.40	26.8	15.48
Textural class	sl	scl	sl	sl	l	sl
E.C (dsm^{-1})	0.21	0.24	0.34	0.76	0.82	0.52
pH	7.20	7.80	7.40	7.40	6.80	6.90
CEC (cmol(p+)kg^{-1})	6.40	8.30	6.90	7.80	18.4	10.8
Organic carbon(%)	0.42	0.78	0.33	0.60	0.94	0.48
$CaCO_3$(%)	0.12	0.70	0.30	0.36	Nil	Nil
Total Fe_2O_3(%)	6.30	2.60	8.20	5.40	1.82	10.80
Total Al_2O_3(%)	5.70	3.80	8.80	6.80	4.64	7.40
Available S(mgkg^{-1})	14.60	19.40	11.80	12.80	15.20	7.60
Available P(mg kg^{-1})	16.40	17.20	10.80	8.20	15.40	6.40
Total S(mg kg^{-1})	484.5	345.8	439.5	384.0	484.8	524.6
Total P (%)	0.13	0.18	0.04	0.13	0.22	0.17

Effect of sulphur levels and incubation period on available sulphur.

A perusal of data in Table 3 showed an increase in available sulphur upto 4th week of incubation (19.5 mg kg^{-1}) there after it was found to decline with an advancement of incubation period. The available sulphur also differed significantly at different levels of applied sulphur and it ranged from 8.9 to 24.6 mg kg^{-1}. The interaction effect of applied sulphur and incubation period is statistically significant. Observations on the combined effect of sulphur levels and incubation period, the maximum amount of available sulphur (28.4 mg kg^{-1}) was registered when 50 mg kg^{-1} of sulphur was applied and incubated for 4 weeks. Irrespective of the incubation period, the lower amount of available sulphur was noticed in control.

Table 2. Influence of sulphur levels on the available sulphur content under different soils (mg kg^{-1})

Soil series	Sulphur levels (mg kg^{-1})						
	0	10	20	30	40	50	Mean
Madukkur	9.3	13.1	15.9	20.4	26.2	29.5	19.1
Anaiyur	15.1	20.0	24.9	31.6	35.5	39.2	27.7
Vyalogam	7.1	8.8	11.0	12.9	15.2	16.9	12.0
Palaviduthi	6.7	8.2	9.3	13.4	16.3	18.2	12.0
Kalathur	11.3	14.5	20.6	22.5	26.9	31.0	21.1
Irugur	3.8	5.1	5.9	8.1	9.9	12.7	7.6
Mean	6.0	11.6	14.6	18.2	21.7	24.6	

CD (p = 0.05) Sulphur levels - 2.1, Soil series - 3.1, Interaction - 2.7

Generally the sulphur requirement depends upon the sulphur adsorption capacity of soil influenced by different soil properties. Higher the adsorption capacity of the soil, lower is the increase in the amount of available sulphur with the increase in dose (Arora and Takkar, 1988; Clarson and Ramaswami, 1990).

Effect of incubation period on available sulphur

The data depicted in Table 4 revealed that a significant differences in available sulphur for the incubation period. Increase in available sulphur was observed upto 4th week of incubation (14.4 to 19.6 mg kg^{-1}) and there after a declining trend was noticed. This might be due to the formation of Fe-A_1-SO_4 complex which is relatively insoluble (Lande *et al.,* 1977; Gowrisankar and Shukla, 1999).

Considering the soil series, irrespective of the incubation period, the available sulphur status was found to be higher in Anaiyur series and the highest mean value of 27.8 mg kg^{-1} was noticed followed by Kalathur and Madukkur series. This might be due to the low amount of sesquioxide and high status of organic carbon in Anaiyur series. Due to the low amount of sesquioxide, the adsorption capacity of soil would have been lower which could have favored for the higher available sulphur status in Anaiyur series. While in Irugur series, the available sulphur status was reported to be lower (7.6 mg kg^{-1}). As the soil is rich in sesquioxide and to satisfy the surface positive charges more amount of sulphate would have been adsorbed.

Table 3. Effect of sulphur and length of incubation period on available sulphur content(mg kg^{-1})

Period of incubation (weeks)	Sulphur levels (mg kg^{-1})						
	0	10	20	30	40	50	Mean
1	8.2	10.2	16.4	16.0	18.2	20.8	15.0
2	9.2	11.2	14.0	17.8	21.2	24.1	16.3
3	9.9	12.7	15.7	20.2	23.7	27.5	18.3
4	10.4	14.0	17.6	21.6	25.2	28.4	19.5
5	9.4	12.6	15.7	19.2	22.6	25.9	17.6
6	7.9	10.6	13.4	16.5	21.0	23.4	15.5
7	7.2	10.0	12.8	15.7	19.9	22.3	14.7
Mean	8.9	11.6	15.1	18.1	21.7	24.6	

CD (p=0.05) Soil types - 2.5, Incubation - 1.3, Interaction -1.9

Effect of applied sulphur on the availability of native phosphorus

It is quiet evident from the Table 5 that different soil series and various concentration of added sulphur on available phosphorus status is significant. while considering the soil series, the available phosphorus status ranged from 9.5 to 25.0 mg kg^{-1} and the maximum available phosphorus status (25.0 mg kg^{-1}) was noticed in Anaiyur series followed by Madukkur series (19.9 mg kg^{-1}). It is ascribed that higher initial available P and organic carbon found in Anaiyur series could have aided in the desorption of phosphorus from the labile pool. Regarding the sulphur levels, the available phosphorus status varied from 13.6. to 19.9 mg kg^{-1}. As the concentration of sulphur increases, the availability of phosphorus also increases. This might be due to the adsorption of sulphate which would have desorbed the phosphate through anion exchange mechanisms (Palaskar *et al.,*1981; Pandey *et al.,* 2000).

Table 4. Effect of incubation period on available S in different soil series (mg kg^{-1})

Incubation period (weeks)	Soil series						
	Madukkur	Anaiyur	Vyalogam	Palaviduthi	Kalathur	Irugur	Mean
1	16.6	22.5	10.7	11.2	18.6	6.7	14.4
2	19.2	24.5	13.5	12.4	20.4	7.5	16.3
3	18.8	29.9	15.0	13.6	22.3	8.5	18.0
4	22.6	32.2	14.2	14.7	24.0	9.8	19.6
5	20.9	29.6	11.6	13.0	22.3	8.0	17.6
6	17.3	28.0	10.0	10.3	20.6	6.7	15.5
7	16.4	27.5	9.1	9.2	19.7	5.9	14.6
Mean	18.8	27.8	12.0	12.1	21.1	7.6	

CD (p=0.05) Soil series 1.6, Incubation 0.8, Interaction 1.4

Table 5. Effect of sulphur level on the available phosphorous content (mg kg^{-1}) in different soil series

Soil series	Sulphur levels (mg kg^{-1})						
	0	10	20	30	40	50	Mean
Madukkur	17.7	18.4	19.6	20.8	21.1	21.8	19.9
Anaiyur	21.1	23.0	24.3	26.0	27.3	28.0	25.0
Vyalogam	11.0	11.7	12.9	13.7	14.3	14.7	13.1
Palaviduthi	11.7	14.8	16.6	17.8	18.7	19.4	16.5
Kalathur	14.2	16.2	18.7	20.2	21.6	22.3	18.9
Irugur	6.0	7.1	8.7	9.9	11.9	13.1	9.5
Mean	13.6	15.2	16.8	18.1	19.2	19.9	

CD (p=0.05) Soil types 1.3, Sulphulevel 2.4, Interaction 1.8

Effect of sulphur levels and incubation period on available phosphorus

An increase in the levels of applied sulphur increased the available phosphorus in solution. The mean values extended from 13.6 to 19.9 mg kg^{-1} (Table 6). As the period of incubation proceeded from 1st to 5th week, an appreciable increase in available phosphorus was observed (14.8 to 18.2 mg kg^{-1}) beyond which the difference in availability was found to be minimum. (18.2 to 19.9 mg kg^{-1}). Observation on the combined influence of sulphur levels and incubation period, the maximum amount of available phosphorus (23.3 mg kg^{-1}) was registered with the treatment involving 50 mg kg^{-1} sulphur incubated upto 7 weeks. Even in the control, the availability of phosphorus increased progressively due to the effect of incubation. Due to the continuous availability of moisture at field capacity level the phosphorus bound by the colloidal complexes would have been released to the labile pool and made it available (Vig *et al.,* 1997).

Table 6. Effect of sulphur levels and length of incubation period on available P status (mg kg^{-1})

Period of incubation (weeks)	Sulphur levels (mg kg^{-1})						
	0	10	20	30	40	50	Mean
1	11.7	13.2	14.7	15.6	16.6	17.1	14.8
2	12.3	13.8	15.2	16.1	17.1	17.8	15.4
3	12.9	14.3	15.6	16.8	16.9	18.0	15.8
4	13.6	15.1	16.3	17.8	18.7	19.4	16.8
5	14.5	16.0	178.8	19.1	20.4	21.3	18.2
6	14.9	16.7	18.6	20.0	21.2	22.1	18.9
7	15.4	17.3	19.3	21.1	22.3	23.3	19.9
Mean	13.6	15.2	16.8	18.1	19.0	19.9	

CD (p=0.05), Sulphur levels - 1.3, Incubation - 0.8, Interaction - 0.7

Table 7. Effect of incubation period on available P status (mg kg^{-1})

Incubation period (weeks)	Soil series						
	Madukkur	Anaiyur	Vyalogam	Palaviduthi	Kalathur	Irugur	Mean
1	18.1	22.1	11.6	13.3	16.3	7.6	14.5
2	18.4	22.8	11.8	14.5	16.9	8.0	15.4
3	19.1	23.6	12.2	15.0	17.5	8.4	16.1
4	19.8	24.6	13.3	15.9	18.5	8.6	16.8
5	21.0	26.4	13.8	17.9	19.8	10.3	18.2
6	21.4	27.2	14.3	18.7	20.8	11.0	18.9
7	21.5	28.1	14.7	20.3	22.3	11.9	19.8
Mean	19.9	25.0	13.1	16.5	18.9	9.4	

CD (p=0.05), Soil series 1.6, Incubation 0.9, Interaction 0.7

Effect of incubation period on available phosphorus status in different soil series

A significant difference in available P was observed in the soil types due to the period of incubation (Table 7). The maximum available P (25.0 mg kg^{-1}) was recorded in Anaiyur series followed by Madukkur series (19.9 mg kg^{-1}). Irrespective of the incubation period, the rate of release of P was found to be minimum in Irugur series and the mean value is 9.4 mg kg^{-1}. This may be attributed to relatively

higher amount of sesquioxides found in this series which would have fixed the phosphorus with higher bonding strength and reduced its release to the labile pool. Similar results were also reported by Mongia and Bandyopadhyay (1996).

Conclusion

Application of sulphur have released the adsorbed phosphorus from the colloidal complexes. At lower concentration of sulphur, the sulphate ion would have been absorbed on the hydrous oxides of iron and aluminium. As the concentration of sulphur increased, the rate of release of sulphur to the labile pool has also been increased. While considering the release pattern of this nutrient, there was a constant release of sulphur upto 4th week, beyond which the availability declined. Due to the presence of sesquioxides, the sulphate anion would have snugly fit into the colloidal complexes with greater bonding strength. Hence to increase the availability of sulphur in the labile pool, application of organic manures are very much essential. Among the six soil series studied, the rate of release of sulphur and phosphours were low in Irugur series.

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