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Impact of green manuring on the availability of sulphur and zinc in the rice soils

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Abstract : A greenhouse experiment was conducted at Tamil Nadu Agricultural University, Coimbatore on two soils, deficient in S and Zn *viz.* Typic Ustochrept and Typic Haplustalf using rice as test crop to study the effect of green manure on soil Zn and S availability. Two sources of Zn ($ZnSO_4$ and EDTA-Zn @ 5 kg Zn ha^{-1}) and S (gypsum @ 50 kg S ha^{-1}) along with green manure *viz. Sesbania aculeata* @ 10 t ha^{-1} were applied. The GM application in sandy loam soil manifested higher availability of DTPA-Zn, more particularly with EDTA-Zn than in clay loam soil. Incorporation of GM with EDTA-Zn + NPK enhanced the availability of Zn (2.91, 3.60 and 2.80 mg kg^{-1}) at active tillering (AT), panicle initiation (PI) and harvest stages, respectively followed by GM aplication along with NPK + $ZnSO_4$ + gypsum. The highest sulphur availability was obtained with NPK + GM + $ZnSO_4$ + gypsum at AT (21.38 mg kg^{-1}) and PI (20.13 mg kg^{-1}) and with the treatment, NPK + GM + gypsum at harvest (26.38 mg kg^{-1}) stages. *(Key words : Sesbania green manuring, Zinc and Sulphur fertilizers, Zn and S availability, Rice soils).*

The deficiency of secondary and micronutrients have become common particularly in rice soils and causes reduction in crop yield. Occurence of zinc and sulphur deficiency is known to be associated with many factors like their status in soil, their interaction with other plant nutrients, both synergistically and antagonistically in rice soil system and adverse conditions of soil and

Table 1. DTPA-Zn (mg kg^{-1}) in rice soils at various physiological stages

(Mean of two replications)

Tr. No	Treatments	Active tillering		Mean	Panicle initiation		Mean	Harvest		Mean
		S_1	S_2		S_1	S_2		S_1	S_2	
T1	Absolute Control	1.03	0.74	0.89	1.11	0.68	0.90	0.97	0.64	0.81
T2	NPK	1.28	1.02	1.15	1.97	1.04	1.51	1.26	0.97	1.12
T3	GM	1.54	0.11	1.33	2.73	1.23	1.98	1.50	1.09	1.30
T4	NPK + GM	1.14	1.15	1.15	2.90	1.20	2.06	1.08	1.11	1.09
T5	NPK + $ZnSO_4$	1.29	1.53	1.41	2.59	1.51	2.05	1.26	1.47	1.36
T6	NPK+EDTA-Zn	3.50	1.55	2.53	2.84	1.63	2.24	2.31	1.51	1.91
T7	NPK+Gypsum	1.09	0.94	1.02	1.89	1.01	1.45	1.03	0.91	0.97
T8	NPK + $ZnSO_4$ + GM	1.46	2.33	1.89	2.57	2.57	2.57	1.40	2.27	1.84
T9	NPK+EDTA-Zn+GM	2.58	3.24	2.91	3.02	4.18	3.60	2.51	3.17	2.84
T10	NPK+Gypsum + GM	1.13	0.90	1.02	1.69	1.31	1.50	1.07	0.86	0.96
T11	NPK+$ZnSO_4$+ Gypsum+GM	2.83	1.46	2.14	3.61	3.26	3.44	2.78	1.42	2.10
	Mean	1.17	1.45		2.45	1.78		1.56	1.40	
		SE_d	CD (0.05)		SE_d	CD (0.05)		SE_d	CD (0.05)	
	Soil (S)	0.06	0.13		0.04	0.09		0.03	0.05	
	Treatment (T)	0.15	0.30		0.10	0.22		0.06	0.13	
	S x T	0.21	0.43		0.15	0.30		0.09	0.18	

Table 2. 0.15% $CaCl_2$-5 (mg kg^{-1}) in rice soils at various physiological stages

(Mean of two replications)

Tr. No	Treatments	Active tillering		Mean	Panicle initiation		Mean	Harvest		Mean
		S_1	S_2		S_1	S_2		S_1	S_2	
T1	Absolute Control	7.13	7.63	7.38	11.13	7.75	9.44	17.25	10.88	14.06
T2	NPK	8.63	8.75	8.69	13.75	8.88	11.31	20.88	13.88	17.38
T3	GM	12.50	8.88	10.69	17.25	7.88	12.57	26.00	11.88	18.94
T4	NPK + GM	11.40	16.38	13.89	13.88	12.63	13.25	26.38	25.13	25.75
T5	NPK + $ZnSO_4$	11.25	8.63	9.94	12.63	12.63	12.63	21.00	20.13	20.56
T6	NPK+EDTA-Zn	11.25	13.63	12.44	13.75	16.38	15.06	21.13	25.25	23.19
T7	NPK+Gypsum	16.38	14.88	15.63	12.63	17.63	15.13	21.25	20.13	20.69
T8	NPK + $ZnSO_4$ + GM	13.88	11.25	12.56	18.75	17.50	18.13	23.38	22.75	23.06
T9	NPK+EDTA-Zn+GM	13.75	16.38	15.06	17.63	17.50	17.56	18.88	22.13	20.50
T10	NPK+Gypsum + GM	17.38	17.75	17.56	18.75	17.88	18.31	26.38	26.38	26.38
T11	NPK+$ZnSO_4$+ Gypsum+GM	21.38	21.38	21.38	17.63	22.63	20.13	22.75	20.25	21.50
	Mean	13.17	13.22		15.25	14.48		22.30	19.89	
		SE_d	CD (0.05)		SE_d	CD (0.05)		SE_d	CD (0.05)	
	Soil (S)	0.05	NS		0.08	0.16		0.10	0.21	
	Treatment (T)	0.12	0.24		0.18	0.38		0.24	0.50	
	S x T	0.16	0.34		0.26	0.53		0.34	0.71	

environment. Hence, it has become imperative to apply the required quantity of S and Zn along with NPK in the fertilizer schedule for sustaining high and profitable crop production. The green manures not only supplement the crop nutrition but also improve the soil fertility and soil physical condition. Green manures, being succulent and fast degrading under submerged condition, might act as effective electron acceptor and this property may influence the chemical reduction of all metallic cations thereby affecting their utilisation by rice. Hence, a greenhouse experiment was conducted to study the influence of GM, S and Zn application on the availability of nutrients under lowland rice soils.

Materials and Methods

A green house experiment was conducted in two Zn and S deficient soils *viz.*, Typic Ustochrept (S_1) and Typic Haplustalf (S_2) using rice (ADT 36) as test crop. Bulk soil samples deficient in Zn and S were collected from Coimbatore and Periyar districts of Tamil Nadu possessing the following characteristics. Typic Ustochrept (S_1) : Black calcareous clayloam, pH 8.01: organic carbon 0.56%; alkaline $KMnO_4$-N 152 mg kg^{-1}; Bray P-1 P 15.5 mg kg^{-1}; NH_4OAc-K 196 mg kg^{-1}; DTPA-Zn 0.70 mg kg^{-1}; and 0.15% $CaCl_2$ – S 7.50 mg kg^{-1}. Typic Haplustalf (S_2): Red non-calcareous sandy loam in texture: pH 7.05;organic carbon 0.45%: alkaline $KMnO_4$-N 90 mg kg^{-1}; Bray P-1 P 6.5 mg kg^{-1}; NH_4OAc-K 98 mg kg^{-1}; DTPA-Zn 0.38 mg kg^{-1}: and 0.15% CaCl2 – S 25 mg kg^{-1}. The Zn and S contents of the sources used: $ZnSO_4$. $7H_2O$ – 22%Zn&13% S, EDTA-Zn-12% Zn, $CaSO_4$. $2H_2O$ – 13% S & 22% Ca, Green Manure (fresh) 0.00056% Zn & 0.112% S.

The experiment comprised of 11 treatments and two soils replicated twice in a factorially randomised block design. The following treatment structure was imposed.

T1	Absolute Control
T2	NPK
T3	GM
T4	NPK + GM
T5	NPK + $ZnSO_4$
T6	NPK + EDTA-Zn
T7	NPK + Gypsum
T8	NPK + $ZnSO_4$ + GM
T9	NPK + EDTA-Zn + GM
T10	NPK + Gypsum + GM
T11	NPK + $ZnSO_4$ + Gypsum + GM

A week prior to rice planting, 60 days old dhaincha (*Sesbania aculeata*) was incorporated at 10 t ha^{-1} (40 g pot^{-1}) in all the plots receiving GM treatment. Twenty seven days old rice seedlings were planted in earthern pots lined with polythene sheets containing 8 kg of deficient soils. Totally 66 pots were maintained for each soil group for easy stage sampling. The recommended doses of NPK (100 : 50 : 50 kg ha^{-1}) were added uniformly to all the treatments except the absolute control and the GM check. The test nutrients *viz.*, Zn @ 2.5 mg kg^{-1} as $ZnSO_4$. $7H_2O$ and EDTA-Zn and Sulphur @ 25 mg kg^{-1} were added to the soils and mixed well. The soil samples drawn at all the three stages. The crop was grown to maturity and harvested were analysed for DTPA-Zn using atomic absorption spectrophotometer (Lindsay and Norvell, 1978) and 0.15% $CaCl_2$ – S contents using colorimeter (Williams and Steinberg, 1959).

Results and Discussion

Zinc

The clayloam soil uniformly maintained the highest available Zn content at all the stages of crop growth as compared to sandy loam soil which may be due to higher Zn status of soil. In the present study, higher availability of Zn in sandy loam soil was noticed with the addition of GM. The Zn availability increased upto PI stage and then decreased which could be ascribed to higher Zn uptake by the crop.

The substantial increase in the Zn availability was observed due to the application of EDTA – Zn with GM+NPK (2.91, 3.60 and 2.84 mg kg^{-1} at AT, PI and harvest stages, respectively) followed by the combined application of GM+NK+$ZnSO_4$+gypsum (2.14,3.44 and 2.10 mg kg^{-1} at AT, PI and harvest stages, respectively) (Table 1). This may be due to the stable chelated form of added Zn and the mineralised Zn from the GM to the available pool. This corroborated with the findings of Katyal and Sharma (1991). Similarly, the higher availability of Zn noticed with the application of $ZnSO_4$ along with GM could be related to the formation of organometallic complexes with Zn and its reflection on Zn availability which otherwise made unavailable under submergence due to the preponderance of Fe_2^+ and Mn_2^+ and their antagonistic effect on Zn availability.

The possible reasons for the increased availability of Zn in both the soils are the relatively lesser fixation of applied Zn in soil and moreover, the soils taken for this investigation were deficient in Zn. In clay loam soil, increased Zn content of 3.50 mg kg^{-1} was noticed at AT stage with NPK and EDTA-Zn application. Which could be due to the higher availability of Zn from stable chelated form with poor crop utilisation. Whereas, at PI and harvest stages, the GM incorporation with NPK, $ZnSO_4$ and gypsum recorded significantly higher Zn availability of 3.61 and 3.02 mg kg^{-1}, respectively under submergence. The clay loam, being a calcareous soil, the gypsum addition improved the soil physical conditions. Besides, the GM combinations provided degraded organic metabolites to chelate the added Zn and sustain its availability upto harvest. The inclusion of GM might have created a favourable environment to nullify the ill effects of $CaCO_3$ present in the calcareous clay loam soil which otherwise would have entangled with the Zn and rendered the same into unavailable form through adsorption, chemical fixation or precipitation (Swarup, 1991). With respect to sandy loam soil, GM incorporation with NPK + EDTA – Zn registered the highest Zn availability of 3.24, 4.18 and 3.17 mg kg^{-1} at AT, PI and harvest stages, respectively. Similar observations with EDTA-Zn in light textured soils were reported by Bansal and Nayyar, (1989).

Sulphur

The 0.15% $CaCl_2$ extractable S status was found to be progressively increased with the advancement of crop growth in both the soils. Such a gradual increase in the available S content could be attributed to mineralisation of organic form of S that existed in the soil. The increased availability of S in clay loam soil at PI (15.25 mg kg^{-1}) and harvest stages (22.30 mg kg^{-1}) may be due to some of its soil characteristics like clay minerology, high total S and organic matter status (Aulakh and Chhibba, 1992, Table 2).

The highest S availability was recorded in the treatment *viz.*, NPK + GM + gypsum + $ZnSO_4$ at AT (21.30 mg kg^{-1}) and PI (20.13 mg kg^{-1}) stages. The addition of S through two sources *viz.*, gypsum and $ZnSO_4$ along with the contribution from GM could be the possible reasons for higher S availability. Further, the addition of gypsum might have amended the calcareousness of the rice soils. The application of GM with NPK gypsum also enhanced the available S content of the soil at harvest (26.38 mg kg^{-1}. (Tiwari *et al.* 1992 and Thind and Chahal, 1987).

In general, the study revealed that, the availability of Zn was enhanced by the addition of EDTA – Zn than the $ZnSO_4$ source in sandy loam and the reverse trend was noticed in clay loam soil. The inclusion of GM in both the soils proved its superiority in increasing the availability of Zn and S when compared to treatments excluding GM additions.

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