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Effect of long term fertilizer use on sulphur availability to rice in an Inceptisol

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Abstract : In a long term fertilizer experiment with rice-rice cropping sequence, the changes brought about in the available sulphur status of soil were studied. Available sulphur status decreased from 20 to 9.5 ppm when S-free NPK fertilizers were used for 13 years, whereas it increased to 30.8 and 39.5 ppm, when NPK fertilizers containing 45 and 67.5 kg sulphur were applied per hectare per season, respectively. With the application of S-free NPK fertilizers, there was 21% decrease in grain yield in *kharif* but no decline in yield was noticed in the summer crop because of the addition of around 10 kg S/ha through irrigation water. Over the period a positive response to sulphur in *kharif* rice in most of the years was observed and its magnitude increased with the progress of cropping cycles. This indicated that an application of 44 kg S/ha/cropping cycle would be necessary to maintain the sulphur status of the Inceptisol.

Key words : Rice - Rice sequence, Long term effect of fertilizer, Response to sulphur, Inceptisol.

Introduction

Sulphur is now recognized as the 4th major plant nutrient, along with nitrogen, phosphorus and potassium. The interaction of sulphur with other nutrients improves the quality of crops. Sulphur deficiency has been reported in many crops and 0.15 to 0.20% S are generally considered as deficient in S (Tandom and Messick, 2002). Sulphur deficiency in rice and response to fertilizer sulphur has been reported (Blair *et al*., 1979 b and Ghosh, 1980). A lot of sulphur is also added to soil through irrigation water. Sahoo and Panda (1985) reported that about 10 kgS/ha was added to rice through irrigation water during *rabi* season at Bhubaneswar. Available sulphur refers to soluble plus sulphate fraction of total S in soil. The available sulphate sulphur content in rice soils from Ganjam district of Orissa ranged from 2.70 to 3.30 ppm.

Sulphur uptake by rice depend upon the variety of rice and its yield (Wang, 1976). To produce 4 to 9 t ha^{-1} of rice grain, rice plants removed 8 to 17 kg of S ha^{-1}. Sulphur removal increased with higher dose of sulphur. Hoque and Khan (1980) reported the highest yield of rice (cv. BR-1) with full dose of NPK and Sulphur. Likewise, Paulraj and Balasundaram (1987) reported that, urea at 10 kg N ha^{-1} + Gypsum at 0.5 t ha^{-1} overwhelmingly increased the yield of rice. It was suggested that higher rice yield could be obtained if S had been

Table 1. Details of treatments of the long term fertilizer experiment (Bhubaneswar)

Tr. No.	Treatment	$N - P_2O_5 - K_2O$ kg/ha/crop as fertilizer	Sources of NPK	SO_4^{2-} - S applied to each crop (kg/ha)
1.	50% NPK	50-30-30	CAN/Urea, SSP, MOP	22.5
2.	100% NPK (Weedicide)	100-60-60	-do-	45.0
3.	150% NPK	150-90-90	-do-	67.5
4.	100% NPK	100-60-60	-do-	45.0
5.	100% NPK + $ZnSO_4$ @ 25 kg/ha	100-60-60	-do-	47.8
6.	100% NP	100-60-0	CAN/Urea, SSP	45.0
7.	100% N	100-0-0	CAN/Urea	-
8.	100% NPK + FYM 10 t/ha/year	100-60-60	CAN/Urea, SSP, MOP	45.0
9.	100% NPK (-S)	100-60-60	Urea, UAP, MOP	-
10.	Soil test based NPK, dose	Variable	CAN/Urea, SSP, MOP	Variable
11.	Control	0-0-0	-	-

CAN : Calcium Ammonium Nitrate
SSP : Single Super phosphate
MOP : Muriate of Potash
UAP : Urea Ammonium Phosphate

applied at transplanting for early maturing cultivars and not later than 15 days after transplanting for medium maturity cultivars. In 14 years of cropping in the laterite soils at Bhubaneswar Orissa, responses to S in *kharif* rice was 98% and in *rabi* rice was 6% (Panda and Sahoo, 1989). Continuous application of S @ 45 kg ha^{-1} to rice crop in laterite soil of Bhubaneswar under LTF experiment increased crop yield by 18.7%. But there is very little research done on the sulphur fertilizer need of rice under intensive cropping system and the effect of continuous use of S-free fertilizers. The present study was undertaken to evaluate the long term effects of NPK fertilizes on the available sulphur status of a sandy loam soil and the response to fertilizer sulphur in rice-rice cropping system.

Materials and Methods

The long term fertilizer experiment had been laid out since 1972 on a medium land situated on a rolling topography inside the Central Research Station of QUAT, Bhubaneswar. The soil was sandy loam in the surface 0-20 cm grading to clay loam and clayey in the lower horizons, moderately acidic (pH 5.6), initially low in organic mater (0.27% O.C), high in Olsen's P (31 kg ha^{-1}) and very low in respect of NH_4OAc - extractable K (25 kg ha^{-1}). The soil contained 20 ppm $CaCl_2$ extractable S. The soil has been classified as *Aeric Haplaquept.*

The field remained ill drained during most part of the rainy season because of the closeness of the water table and the rice crop was affected with iron toxicity

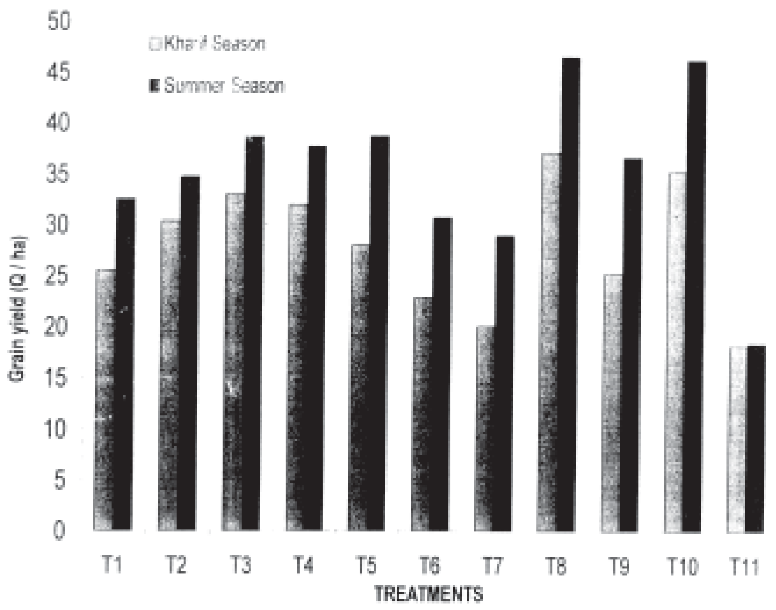

Fig. 1.Effect of treatments on grain yield (q/ha) of rice

at scattered patches. The experiment was laid out with 11 treatments and 3 replications in randomized block design, details of which had been presented in table 1.

The *kharif* and summer rice crops were grown using rice cultivars *Pratap* and OR-26-2014-4, respectively. Standard cultural practices were adopted. During *kharif* the crop was raised mostly as a rain fed crop and only two irrigations amounting to about 10 cm water were given towards the end of the season. Sulphur content of the water ranged from 0.50 to 0.52 ppm. During summer season about 75 cm water was used from tank which contained 0.92 to 1.5 ppm sulphur.

Rice plant samples were collected from individual sub plots at panicle initiation stage in both the season and oven dry (70^oC) plant materials were analyzed for their sulphur content. For this, 1 gm ground plant sample was taken in 100 ml. Erlenmeyer flask with seed solution of K_2SO_4 containing 1 mg S and was digested in HNO_3 + $HClO_4$ (Blancher *et al.*, 1965) The digestate was made to 50 ml and S in 2.5 ml of extract was estimated by modified turbidometric method of Massoumi and Cornifield (1963) described by Hoeft *et al*. (1973). Surface soil samples from individual sub plot treatments were collected following the harvest of the rice crop. Available S in air dry samples was extracted using two extractants *viz*., 0.15% $CaCl_2$ (William and Steinbergs, 1959) and $Na_2H_2PO_4$ solution (500 ppm P) in acetic acid medium (Cooper, 1968). Sulphur in suitable aliquot of both the extracts was estimated by modified turbidiometric method referred above. Sulphur content of the irrigation water samples collected on different dates was also determined turbiodimetrically.

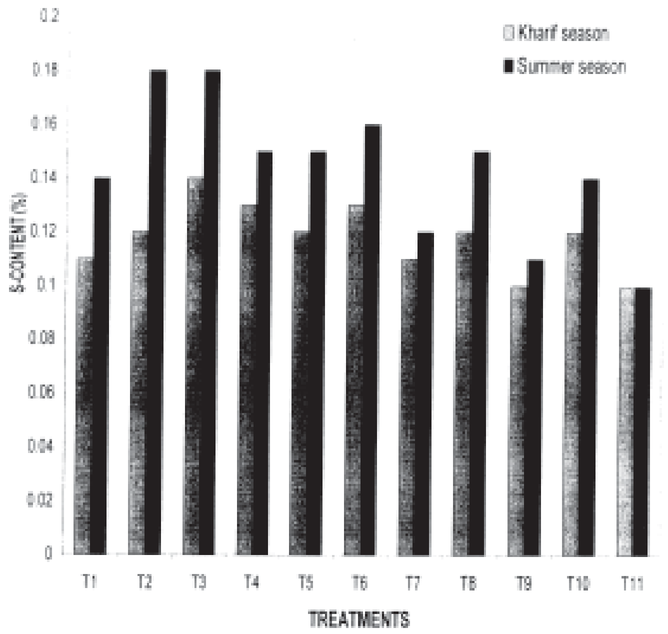

Fig. 2. Effect of treatments on sulphur content (%) in rice plant

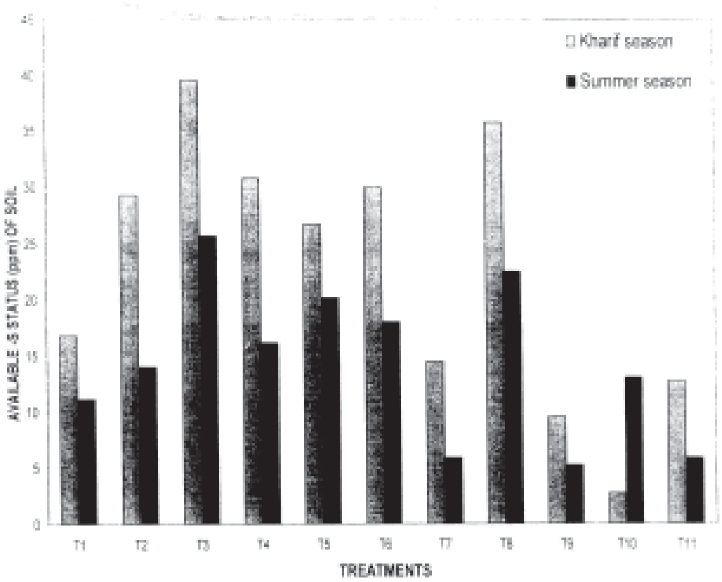

Fig. 3. Effect of treatments on available – S status (ppm) of soil

At harvest, grain and straw yields were recorded and the data were subjected to statistical analysis to evaluate the crop response. Crop responses to S over the period were also evaluated making use of the yield data.

Results and Discussion

Both $CaCl_2$ and $Na_2H_2O_4$ solutions extracted almost comparable amounts of sulphur from the respective treatments. Probably there were negligible amounts of adsorbed SO_4^{2-} to be extracted by the phosphate extractant. Continuous use of phosphate fertilizer has resulted residual P accumulation in the soil (Annonymous, 1984). Adsorption of residual P, might have led to SO_4^{2-} desorption (Bromfield, 1972). Therefore the estimation mostly included SO_4^{2-} -S and the amounts extracted by 0.15% $CaCl_2$ from various treatments have been recorded in table 2.

Available S estimated after the harvest of *kharif* rice was lowest (9.5 ppm) in the treatment receiving S-free NPK fertilizer (Tr. 9). On the other hand, the treatment receiving 67.5 kg S/ha every season through SSP (Tr. 3) contained the highest amount of 39.5 ppm available sulphur followed by 35.8 ppm in the treatment which received 45 kg S/ha/season through SSP besides about 22 kg S/ha through, FYM (Tr. 8). Regular application of S-free fertilizer for 1 year had resulted in around 50% reduction in the available S status of the soil whereas application of sulphur containing NPK fertilizer at 100 and 150% level had raised the status by 50 and 100%, respectively as compared to the initial status in 1972. Results suggested that a portion of the $CaSO_4$ in H_2O applied regularly through SSP had accumulated in the soil inspite of the probability of heavy leaching loss.

The relationship between the change in $CaCl_2$ - extractable S status and the rate of S applied through NPK fertilizer presented in Fig. 1, predicts that an application of 44 kg S / ha cropping cycle would be necessary to prevent soil depletion under the situation.

Amounts of available S estimated after the harvest of summer rice from various treatments were somewhat lower as compared to the amounts extracted after harvest of *kharif* rice. The soil samples in summer season were collected the next day following a heavy summer shower. Displacement of SO_4^{2-} S from the surface to lower horizons can not be overruled under such situation. However, the results showed a similar sequence in available S status in the various treatments as it was observed after *kharif* season.

Sulphur content of the rice plants at panicle initiation stage in various treatments have been recorded in table 2. Rice plants in the treatment which received S free NPK fertilizer (Tr. 9) contained 0.10 and 0.11% in *kharif* and summer seasons, respectively. Compared to this, the plants in the treatment receiving sulphur containing fertilizer (Tr. 4) contained 0.13 and 0.15% S. The relationship between the available S status of soil and S content in rice plants in various treatments was found to be highly significant for both the seasons ($Y = 0.091 + 0.00114X$, $r = 0.896^{**}$ for *kharif* and $Y = 0.101 + 0.003X$, $r = 0.806^{**}$ for summer season). Variations in available S status of soil could account for 81% of the variations in S content of rice plants in *kharif* season but only 65% in summer season. This showed that the plants were depended more on soil available S in *kharif* than in summer season. Probably the 75 cm of irrigation water which contained around 10 kg S/ha would have supplemented a major portion of the sulphur requirement of the crop in the summer season. In the *kharif* season the crop received only two irrigations amounting to 10 cm of water. This would have hardly supplied 0.5 kg S/ ha. Yoshida and Choudhury (1972) had observed that irrigation water with 2.7 ppm S would meet the requirement of the rice crop assuming 50% S recovery. This was further evidenced by the fact that rice plants in respective treatments contained invariably higher % of S in summer season than in *kharif* season. The other reason which might be assigned for the relatively low S contents in the plants in *kharif* season was the relative low availability of S under ill drained intensively reduced condition which existed in *kharif* as compared to the alternate flooded and drained conditions maintained during summer season.

Grain yields obtained from various treatments in *kharif* and summer season had been recorded in table 2. Upon comparing the mean yields of Tr. 9 which received S free NPK fertilizer with those of Tr. 4 which received sulphur containing NPK fertilizer, it was observed that there was a significant response of 6.83 q/ha in *kharif* but there was hardly any response in summer season.

According to Yoshida and Choudhury (1979) the critical S content of rice straw decreased from 0.16% at tillering to 0.07% at flowering for maximum yield. Based on this decreasing trend, the critical S content at panicle initiation might be taken as 0.11%. Rice plants in Tr. 9 were supposed to be deficient in sulphur in *kharif* season as they contained 0.10% S. The deficiency resulted in 21% reduction in yield. On the contrary the rice plants in the said treatment in summer season might be considered to be marginally adequate as they contained 0.11% S for which there was no yield reduction. This differential response might be explained on the basis of the difference in S input applied through irrigation water as had been discussed in the previous section.

Response to S over the period had been represented in Fig. 2. It was observed that in most of the years there was a positive response to S in *kharif* season and the probability of significant response has increased with progress of crop year. Significant response of 5.0 to 9.34 q/ha had been obtained in four out of six *kharif* seasons. The pooled average response over 13 *kharif* seasons worked out to be 4.7 q/ha which is 15% of the pooled average yield obtained in the treatment that received S containing NPK fertilizers. This showed that inadequate S availability resulting from intensive cropping with regular application of S free fertilizer was limiting the crop yield in *kharif* seasons. On the contrary, negligible or negative responses were obtained in most of the summer seasons. Although the available S status of the soil had reached the limiting status of less than 10 ppm due to regular application of S free fertilizers, crop yields were not affected because of the S input through irrigation water and more favourable conditions of sulphur availability in the summer seasons.

It may be concluded that continuous use of S free fertilizer in rice - rice cropping system will lead to sulphur depletion of light textured soil and bring significant reduction in rice yields. It is recommended to apply 44 kg S/ha / cropping cycle through fertilizers to prevent soil depletion.

References

Ananymous (1984). Annual Report of the All India Co-ordinated Project on Long Term Fertilizer Experiment (ICAR). 1982 - 83 PP. 21-28.

Blair, G.J., Momuat, E.O. and Mamaril, C.P. (1979b). *Agron. J.*, **71:** 477-480.

Blancher, R.W., George, R. and Caldwell, A.C. (1965). *Soil Sci. Soc. Am. Proc.*, **29:** 71-72.

Bromfield, A.R. (1972). *J. Agric. Sci.*, **78:** 465-470.

Copper, M. (1968) - Int. Cong. Soil Sci. Trans. 9th (Adelaide, Aust) II. 263-271.

Ghosh, A.B. (1980). *Fert. News.*, **25:** 36-39.

Hoeft, R.G., Walsh, L.M. and Keeney, D.R. (1973). *Soil Sci. Soc. Am. Proc.*, **37:** 401-404.

Hoque, M.Z. and Khan, A.H. (1980). Role of balance fertilization in increasing farmers rice yield and profit. IRRI, News Letter, April. pp. 18.

Massoumi, A. and Cornifield, A.H. (1963). *Analyst.*, **88:** 321-322.

Panda, N. and Sahoo, D. (1989). Long term effect of manure and fertilizers on rice based cropping system in sub-humid laterite soils. *Fert. News*, **34(4):** 39-44.

Paulraj, C. and Balasundaram, C.S. (1987). Effect of S source and fertilizer on rice yield. IRRI, News Letter, June, pp. 52-53.

Sahoo, D. and Panda, N. (1985). Long term effect of intensive cropping and fertilizer use on sulphur availability to rice in an inceptisoil. Proc. TRAUFACT Seminar on Sulphur, Coimbatore 74-84.

Tandon, H.L.S. and Messick, D.L. (2002). Practical Sulphur Guide, TSI, Washinton, D.C., USA.

Wang, C.H. (1976). Sulphur fertilization of rice. Food and Fertilizer Technology Centre, ASPAC. The fertility of paddy soils and fertilizer application for rice. Pp. 149-169.

William, C.H. and Steinbergs. A. (1959). Aust. *J. Agric. Res.*, **10:** 342.

Yoshida, S. and Chaudhury, M.R. (1972). IRRI Saturday Seminar, 1 March 18.

Yoshida, S. and Chaudhury, M.R. (1979). *Soil Sci. Pl. Nutr.*, **25:** 121-134.