Madras Agric. J. 91 (4-6) : 190-194 April-June 2004
https://doi.org/10.29321/MAJ.10.A00088

Response of rice-peanut cropping sequence to sulphur application grow in alluvial soil

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Abstract: A field experiment was conducted to study S response of rice-peanut cropping system with graded doses of S *i.e.* 0, 15, 30 and 45 kg ha^{-1} applied in the form of SSP to rice crop. The peanut was grown as residual crop. The results of the experiment laid on a sulphur deficient (7 ppm 0.15% $CaCl_2$ extractable S) alluvial soil in Niali block of Cuttack district showed that application of S at 30 kg ha^{-1} produced the highest yield of 34.3 q ha^{-1} of rice grain and 21.8 q ha^{-1} of peanut pod. Rice yield was 9 per cent higher and the peanut yield was 31 per cent higher than the yield recorded in control (no sulphur) treatment. Total biomass production from rice-peanut cropping sequence varied between 148.2 and 173.6 q ha^{-1}. There was 17 per cent increase in biomass production due to application of 30 kg S ha^{-1}. Both the crops removed 184.4 to 233.4 kg N, 20.9 to 28.6 kg P, 171 to 213 kg K, 95.8 to 127.2 kg Ca and 16.7 to 22.4 kg of S ha^{-1} from soil. Highest amount of all the test nutrients were removed when both the crops received S at 30 kg ha^{-1}. At this rate of S application the recovery of N, P and K by the crops were 61, 29 and 54 per cent, respectively. The apparent S recovery (19%), shelling (57.3%) oil content (49.7%) oil yield (567 kg ha^{-1}) agronomic efficiency (50.0) and value cost ratio (43.0) were the highest at this rate of S application. This suggest that 30 kg S ha^{-1} in the form of single super phosphate to be the best for rice-peanut cropping system.

Key words : S deficient soil, Graded dose of S, Single super phosphate, Apparent nutrient recovery, Agronomic efficiency and Value cost ratio.

Introduction

Sulphur deficiency in various locations of Orissa (Misra, 1995) and response to sulphur application on different crops grown under deficient soils of Orissa have been reported (Sahoo and Panda, 1985, Misra *et al.* 1990 and Sahu *et al.* 1991). Based on the survey work of available soil sulphur status and S concentration in plant comprising of 1054 soil samples and equal number of plant samples consisting of rice, sugarcane, groundnut, mustard and sesamum collected from five districts of Orissa, Misra and Pattanayak (1999) have reported that on an average 31 per cent of soil samples were found to be sulphur deficient. In general 50.5 per cent of sugarcane soil, 36 per cent of rice, 3.9 per cent of groundnut, 11.1 per cent of sesamum and 3.5 per cent of mustard soil studied were deficient. Based on critical concentration of S in plants, about 50.7 per cent peanut was found to be deficient. Although Cuttack is one of the important agricultu districts of Orissa, no systematic work on has been done in this district. Since rice-pean is one of the important cropping systems follow in alluvial soils, the present work was undertak to study the response of this cropping syst to graded doses of S in a S-deficient so

Materials and Methods

A field experiment in RBD design w four sulphur treatment and five replication w conducted during *kharif* 2000 in S-deficie soil of Kasarda village of Niali block in Cutta district. The soil of the experimental site w sandy clay loam with pH of 6.1 and orga carbon, available N, available P were medi in status (Table 1). However available sulph (0.15% $CaCl_2$ extractable S was 14 kg h and available potassium was low. The fi crop grown was direct seeded medium durati rice (Cv. Khandagiri) which received S at

...e 5. Uptake of Ca and S (kg ha^{-1}) through rice-peanut cropping sequence as influenced by graded ...loses of sulphur

...es of ...g ha^{-1})	Calcium (kg ha^{-1})			Sulphur (kg ha^{-1})		
	Rice	Peanut	Total	Rice	Peanut	Total
	26.4	69.4	95.8	3.9	12.8	16.7
	26.7	88.8	115.5	5.1	13.8	18.9
	25.2	102.0	127.2	5.3	17.1	22.4
	24.1	98.9	123.0	5.7	15.8	21.5
(P=0.05)	NS	9.6	-	0.12	1.45	-

...le 6. Recovery of N,P,K and apparent recovery of S as influenced by graded doses of S in rice-peanut cropping sequence

...es of ...ur ...ha^{-1})	Recovery (%)			
	N	P	K	ASR (%)
	37	19	22	15
	61	29	54	19
	30	8	46	11

...le 7. Oil content and oil yield of peanut as influenced by application of graded doses of S

...atments	Oil content (%)	Oil yield (kg ha^{-1})
...K S0	45.4	399
...K S15	48.7	492 (23)
...K S30	49.7	567 (42)
...K S45	48.4	549 (38)
...(P=0.05)	2.2	-

...ble 8. Effect of sulphur application on agronomic efficiency and economics (value cost ratio) of rice-peanut cropping system

...se of S ...ha^{-1})	Direct effect (Rice)		Residual effect (P.nut)		Cumulative effect	
	AE	VCR	AE	VCR	AE	VCR
	13.3	11.5	15.3	30.9	49.3	42.4
	9.3	8.0	17.3	35.0	50.0	43.0
	5.1	4.4	4.2	8.5	15.2	13.1

...s also treated with DAP to make up the ...$_5$ requirement. Required amount of N in ...m of urea was applied after compensating ... N supplied through DAP. The source of ...was muriate of potash. The fertilizers were ...lied in split doses in furrows. The crop ... harvested at maturity. For N estimation ...t samples were digested by kjeldahl digestion method followed by distillation. For other nutrients the samples were digested with di-acid (HNO_3: $HClO_4$: 3:2) and phosphorus was estimated spectrophotometrically, K flame photometrically, S turbidimetrically and Ca by complexiometric titration method. The oil in peanut kernel was estimated by cold percolation method as suggested by Kartha and Sethi (1957).

Table 1. Initial soil properties of experimental site

Soil type	-	Alluvial	Available N	-	242 kg ha^{-1}
Soil texture	-	Sandy clay loam	Available K	-	125 kg ha^{-1}
Soil pH	-	6.10	Olsen's P	-	21.5 kg ha^{-1}
Organic carbon	-	5.1 g kg^{-1}	Available S	-	14 kg ha^{-1}

Table 2. Yield of rice and peanut as influenced by graded doses of sulphur

Doses of sulphur (kg ha^{-1})	Yield (q ha^{-1})				
	Rice		Peanut		Total
	Grain	Straw	Pod	Haulm	
0	31.5	39.3	16.6	60.8	148.2
15	33.5 (6.3)	41.4	18.9 (13.9)	66.0	159.7 (
30	34.3 (8.9)	42.7	21.8 (31.3)	74.8	173.4 (
45	33.8 (7.3)	41.6	18.5 (11.5)	70.7	164.6 (
CD (P=0.05)	1.96	1.50	2.28	7.4	

Data in the parenthesis indicate per cent increase over control.

Table 3. Residual effect of different doses of sulphur on nodule number, nodule weight, n concentration and nodular N content of peanut crop at 30th day of growth

Doses of sulphur (kg ha^{-1})	Nodules plant^{-1}	Weight of nodules (mg plant^{-1})	Nitrogen (%)	Nodular N (mg plant^{-1})
0	16.2	133.9	1.31	1.75
15	19.6	173.6	1.31	2.27
30	20.0	181.7	1.40	2.54
45	18.6	168.2	1.40	2.35
CD (P=0.05)	2.4	20.8	-	0.28

Table 4. Nutrient (N,P&K) uptake (kg ha^{-1}) through rice-peanut cropping sequence as influenced graded doses of sulphur

Doses of S (kg ha^{-1})	N (kg ha^{-1})			P (kg ha^{-1})			K (kg ha^{-1})		
	Rice	Peanut	Total	Rice	Peanut	Total	Rice	Peanut	To
0	67.3	117.1	184.4	8.1	12.8	20.9	107	64	1
15	73.6	141.1	214.7	9.7	16.2	25.9	110	78	1
30	78.0	155.4	233.4	10.4	18.2	28.6	121	92	2
45	74.0	135.0	209.0	9.4	13.7	23.1	116	91	2
CD (P=0.05)	2.0	109	-	0.3	1.4	-	3.6	8.2	

rates of 0,15,30 and 45 kg ha^{-1} in the form of single super phosphate. No S was applied to groundnut crop (cv AK-12-24) which was grown on residual S after harvest of rice. The dose of N-P_2O_5-K_2O applied to rice was 60-60-60 kg ha^{-1}. The dose of P for the crop was fixed based on the highest dos S as 45 kg of S *i.e.* in the form of which added 60 kg P_2O_5. The treatment w received less than 60 kg P_2O_5 ha^{-1} as

able 9. Soil properties after the harvest of rice-peanut cropping

oses of (kg ha^{-1})	pH		EC dSm^{-1}		O.C. g kg^{-1}		Available Nutrients (kg ha^{-1}) N		P		K		S	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
)	5.8	5.6	0.08	0.14	5.5	5.4	231	237	32	27	117	152	12.0	11.0
5	5.9	5.6	0.08	0.16	5.4	5.8	226	231	31	25	125	144	12.9	11.9
0	5.9	5.5	0.07	0.14	5.5	5.9	222	234	29	23	112	145	14.5	12.2
5	5.8	5.6	0.06	0.18	5.5	5.4	199	247	25	22	96	143	15.7	12.2
nitial		6.1		0.14		5.1		242		21.5		125		14

A = After rice crop, B = After Rice-Peanut cropping sequence

The parameters like apparent sulphur ecovery (ASR) agronomic efficiency (AE) and alue cost ratio (VCR) were calculated to derive a conclusion for the cropping system.

$$\text{ASR (\%)} = \frac{\text{S-uptake due to treatment - S uptake in control}}{\text{Amount of S applied}} \times 100$$

$$\text{AE (kg yield/kg S)} = \frac{\text{Yield with S - Yield without S}}{\text{Amount of S added}}$$

$$\text{VCR} = \frac{\text{Yield gain (grain/pod) in kg ha}^{-1} \text{ x Price of 1 kg produce}}{5.70 \text{ x Sulphur added kg ha}^{-1}}$$

Yield gain = Yield with sulphur - Yield without sulphur

Price used in computation of VCR : Rice - Rs.4.90 kg^{-1}, Peanut = Rs.11.50 kg^{-1} and Sulphur Rs.5.70 kg^{-1}.

The cumulative values were calculated on the basis of rice equivalent yield.

Results and Discussion

Grain yield of rice varied between 31.5 and 34.3 q ha^{-1} (Table 2). Sulphur application resulted in significantly higher grain yield at 15 kg S ha^{-1} but beyond 30 kg S the yield declined. Highest yield of 34.3 q ha^{-1} was recorded with 30 kg S which was 9 per cent more over control. Similar trend was also reflected in straw yield. The pod yield of peanut varied from the lowest yield of 16.6 q ha^{-1} in control to the highest yield of 21.8 q ha^{-1} in 30 kg S ha^{-1} treatment which was 31 per cent more over control (Table 2). At 45 kg ha^{-1} S dose the yield declined to 18.5 q ha^{-1}. The result corroborates with the findings of Ali (1991) who reported that the PxS interaction to be rate dependent. It was absent at 20-40 kg P_2O_5 ha^{-1} with 20 kg S ha^{-1}, strongly synergistic at 40-60 kg P_2O_5 with 20-40 kg S and antagonistic at 60 kg P_2O_5 with 40 kg S ha^{-1}. Due to unusual rain just before harvest, the haulm yield increased about 3 times that of the pod in each treatment. The total biomass production from the rice - peanut cropping sequence (Table 2) varied between 148.2 and 173.4 q ha^{-1}. Highest biomass yield was obtained from the treatment receiving 30 kg S ha^{-1} (17 per cent more over no S application) and lowest due to no S application. The economic biomass production increased significantly with increase in dose of S upto 30 kg ha^{-1}.

The nodular properties of peanut crop at 30th day of growth (Table 3) grown on residual S fertility showed that the nodule no. nodule weight, nodule N of the crop increased with increase in dose of S upto 30 kg S ha^{-1}, but the increase was significant only upto 15 kg S ha^{-1}. Similar response of nitrogen, fixing parameters to low dose S application (17 kg ha^{-1}) was reported by Walker and Adams (1958) in clover crop. The concentration of N and P was higher in rice grain than straw and that of K, S and Ca was more in straw than in grain. The peanut kernel contained more N and P than haulm but the K, S and Ca were more in haulm than kernel. Uptake

of these nutrients by both the crops though ranged from 184.4 kg to 233.4 kg ha^{-1} of N, 20.9 kg to 28.6 kg ha^{-1} of P, 171 kg to 213 kg ha^{-1} of K (Table 4), 95.8 kg to 127.2 kg ha^{-1} of Ca and 16.7 kg to 22.4 kg ha^{-1} of S (Table 5). The residual crop peanut removed more of N, P, Ca and S than the main crop rice. Sulphur application influenced the nutrient uptake significantly upto 30 kg ha^{-1} and beyond this did not influence the yield as well as nutrient uptake except S. Increased rate of S application influenced the recovery of nutrients and apparent recovery of S (Table 6). Recovery of N, P and K varied between 30 and 61 per cent, 8 and 29 per cent and 22 and 54 per cent respectively. Apparent S recovery varied between 11 and 19 per cent, and at 30 kg ha^{-1}, the recoveries of nutrients were higher.

The concentration of oil in peanut kernel (Table 7) due to differential S fertilization varied between 45.4 and 49.7 per cent. Sulphur application upto 30 kg ha^{-1} increased the oil content and yield of kernel significantly, beyond this dose oil content decreased. The oil yield at 30 kg S was 567 kg which was 42 per cent higher over no S application.

The agronomic efficiency (AE-kg yield / kg S) under direct effect was the highest (13.3) at S application rate of 15 kg ha^{-1}, which shifted to S application rate of 30 kg ha^{-1} under residual (17.3) and cumulative (50.0) effect i.e. peanut and rice-peanut cropping system respectively (Table 8). Similarly the highest VCR was under direct effect (11.5) which increased to 35 and 43.0 under residual and cumulative effect with S application rate of 30 kg ha^{-1} respectively. Both AE and VCR were lowest with S application rate of 45 kg ha^{-1} under any crop.

Initially the soil was moderately acidic (pH 6.1). In all the treatments the soil had turned more acidic after harvest of rice crop and still to higher acid level after peanut crop (Table 9). Though the soluble salt concentration decreased after harvest of rice, it increased after peanut which was mostly due to capillary rise during summer season. The organic carbon status had increased compared to initial status mostly due to fall of leaves.

The status of available nutrients in so (Table 9) showed that after harvest of ric crop the mineralizable N level in soil decrease as compared to the initial status, but increase significantly after harvest of peanut crop, whic was mostly due to nitrogen fixation by pean crop. The Olsen's P in soil was maintaine at higher level compared to initial status aft the harvest of both the crops due to less us efficiency. However, available S status in so declined after the harvest of both the crop The available K in soil after harvest of ric decreased but increased after peanut due t capillary rise.

Based on the yield, nutrient uptake, the recovery, agronomic efficiency and value co ratio it can be concluded from the prese experiment that 30 kg S ha^{-1} to be the mo effective dose of S to obtain reasonably hig yields from rice-peanut cropping sequence

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(Received : July 2003; Revised : December 2003