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Sulphur nutrition of crops with and without organic manures under intensive cropping

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ABSTRACT

A field experiment was conducted during pre-rainy season, rainy season (*kharif*) and winter season (*rabi*) of 1989–90 and 1990–91 to evaluate the productivity and fertility building under intensive cropping of rice (*Oryza sativa* L.)–potato (*Solanum tuberosum* L.)–sesame (*Sesamum indicum* L.). The productivity of rice and potato was maximum where these crops were fertilized with 75% (N, P and K @ 45, 10 and 19 kg/ha for rice; 75, 33 and 62 kg/ha for potato) of the recommended doses of N, P (through single superphosphate) and K (60, 13 and 25 kg/ha for rice; 100, 44 and 83 kg/ha for potato) in conjunction with farmyard manure @ 10 tonnes/ha. Sesame grown on residual fertility recorded maximum seed yield (1.4 tonnes/ha) in the treatment receiving 75% of the recommended fertilizer applied to both rice and potato along with incorporation of crop residues of each crop in the sequence. Exclusion of single superphosphate having 12% S either from potato or from rice reduced the productivity of all the 3 crops. Nutrient uptake was maximum where both rice and potato were fertilized with 100% of the recommended doses of N, P (as single superphosphate) and K. Total N, and the available P, K and S status of the soil improved when both rice and potato were fertilized with 75% of the recommended fertilizer along with farmyard manure @ 10 tonnes/ha or incorporation of crop residues. Negative balance of S was recorded under the treatments receiving no single superphosphate, farmyard manure or crop residues. Application of farmyard manure @ 10 tonnes/ha to both rice and potato in conjunction with 75% (N, P and K @ 45, 10 and 19 kg/ha in rice; 75, 33 and 62 kg/ha in potato) of the recommended fertilizer was more remunerative than that of 100%.

Sulphur as an element essential for plant growth ranks in importance with N and P in the formation of plant protein. Mandal and Chatterjee (1991) reported that S fertilization significantly increased the grain yield of rice (*Oryza sativa* L.). Jayaram *et al.* (1990) reported the positive effect of farmyard manure applied to crops at 300% cropping intensity or incorporation of crop residues after harvest of each crop in the sequence. In the Gangetic plains of West Bengal, the mean intensity of cropping is about 200%. As the rainfall is high, and the upland soils are relatively light in texture, a good amount of nutrients is lost from the soil (Entisol) through leaching and crop removal. Since information is meagre on the productivity of crops and fertility building of soil when N, P, K and S fertilizers are added in conjunction with farmyard manure and crop residues in rice–potato (*Solanum tuberosum* L.)–sesame (*Sesamum indicum* L.) sequence, an experiment was conducted on these aspects.

MATERIALS AND METHODS

The field experiment was conducted during pre-rainy season, rainy season (*kharif*) and winter season (*rabi*) of 1989–90 and 1990–91 in Entisol at Kalyani. The soil had *p*H 6.9, total N 0.067% and the available P 15.4 kg/ha, K 229 kg/ha and S 8.7 ppm. The

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experiment was laid out in randomized complete block design with 3 replications, each having 8 treatments. There were: T_1, 100% N, P (as single superphosphate) and K to rice (60, 13 and 25 kg/ha) and potato (100, 44 and 83 kg/ha); T_2, 100% N, P (as diammonium phosphate) and K to rice and potato; T_3, 75% N, P (as single superphosphate) and K to rice (45, 10 and 19 kg/ha) and potato (75, 33 and 62 kg/ha); T_4, 75% N, P (as diammonium phosphate) and K to rice and potato; T_5, T_3 + farmyard manure @ 10 tonnes/ha to rice and potato; T_6, T_4 + farmyard manure @ 10 tonnes/ha to rice and potato; T_7, T_3 + crop residues; and T_8, T_4 + crop residues. Sesame was grown on residual fertility after potato with only 25 kg N/ha (urea basal dose). The crop varieties were 'MW 10' rice (100 days), 'Kufri Badshah' potato (110 days) and 'B 67' sesame (90 days). After harvest of each crop, crop residues were chopped in the field and incorporated into the soil as per treatment. On an average, the crop residues of rice, potato and sesame contributed N, P, K and S @ 109, 28, 175 and 19 kg/ha/annum respectively in the rice–potato–sesame sequence. Potassium (as muriate of potash) and phosphorus (as single superphosphate or diammonium phosphate) were applied basal to both rice and potato as per treatment. Nitrogen in the form of urea was applied to rice in 3 splits (half basal, one-fourth at tillering and one-fourth at panicle initiation) and to potato in 2 splits (half basal and half at first earthing up). Before final land preparation, farmyard manure was applied @ 10 tonnes/ha (contributing N, P, K and S @ 44, 8, 35 and 2 kg/ha respectively) as per treatment. Rice was transplanted in the first week of July, potato tubers were planted in the first week of November and sesame was sown in the first week of March. Irrigation for all crops in the sequence was given as and when needed. Sulphur was estimated by terbidimetric method of Chesnin and Yien (1951).

RESULTS AND DISCUSSION

Dry-matter production

The maximum total dry-matter production of rice was obtained at harvest in rice–potato–sesame sequence under T_5 treatment (Table 1) and it was significantly superior to T_1 and T_2. Single superphosphate containing 12% S might be responsible for increasing the dry-matter production. The result confirms the finding of Puri (1984). Treatment T_1 recorded the highest dry-matter production of potato at harvest. Total dry-matter production of sesame at harvest in the sequence was maximum under T_7.

Yield components

Yield components of rice (effective tillers/m^2, filled grains (%) and 1 000-grain weight) in the plots under T_5 were as good as those under T_1 (Table 1). Application of diammonium phosphate slightly decreased the yield components of rice. In sesame, capsules/plant, seeds/capsule and 1 000-seed weight recorded under T_5 were as good as those recorded in the plots under T_1. Under T_7 capsules/plant were significantly more than those under T_1 and T_2. Seeds/capsule and 1 000-grain weight did not vary so widely.

Yield

Maximum grain yield of rice was recorded (Table 1) in T_5. Productivity of rice decreased sharply where the crop was not nourished with single superphosphate or farmyard manure. Single superphosphate showed better influence on growth and productivity than diammonium phosphate, perhaps owing to the presence of 12% S in single superphosphate. Tandon (1984) reported superiority of single superphosphate to other phosphatic fertilizers, due to high S content in it. Combination of farmyard manure (containing 1.5 kg S/tonne)

Table 1 Productivity of dry matter, grain and tuber, yield components of rice and sesame under rice–potato–sesame sequence (pooled data of 2 years)

Treatment	Total dry matter (g/m^2) at harvest			Yield (tonnes/ha)			Rice			Sesame		
	Rice	Potato	Sesame	Rice	Potato	Sesame	Effective tillers/ m^2	Filled grains (%)	1 000-grain weight (g)	Capsules/ plant	Seeds/ capsule	1 000- seed weight (g)
T_1	635.7	855.2	684.2	3.3	26.6	1.3	295.0	80.6	24.3	21.3	67.2	2.8
T_2	558.2	716.3	629.2	2.8	25.0	1.1	271.7	80.5	24.0	20.9	63.2	2.8
T_3	519.7	699.2	546.0	2.5	22.5	1.0	246.7	79.6	22.8	20.2	61.1	2.7
T_4	487.0	679.1	497.3	2.4	21.0	1.0	236.7	78.0	22.6	16.5	61.1	2.7
T_5	669.0	712.9	658.3	3.4	24.9	1.1	305.0	80.7	24.7	21.3	64.5	2.8
T_6	539.3	679.0	598.5	2.7	23.0	1.0	261.7	80.1	23.3	20.7	64.1	2.8
T_7	587.2	746.0	735.2	3.0	23.0	1.4	288.3	80.3	23.7	27.6	69.1	2.9
T_8	492.2	654.0	723.0	2.5	22.5	1.3	238.3	79.6	22.8	23.6	68.0	2.8
CD (P = 0.05)	7.1	42.8	11.9	0.1	2.7	0.05	17.8	1.0	0.4	4.3	NS	0.1

Details of treatments are given under Materials and Methods

with single superphosphate having 12% S increased the grain yield of rice more than their individual application. Therefore, the beneficial effect of farmyard manure and single superphosphate on the yield of rice may be due to their S content. The result confirms the finding of Nambiar and Ghosh (1984). Highest tuber yield of potato was obtained in T_1. Treatment T_5 also increased the tuber yield, which was statistically at par with the highest tuber yield. It clearly indicates that S-bearing fertilizer single superphosphate (12% S) or farmyard manure (1.5 kg S/tonne) might have a marked effect on tuber yield of potato. Rammurthy (1979) also reported increased tuber yield of potato with S. Maximum seed yield of sesame was obtained from the plots under T_5. Such high seed yield of sesame grown on residual fertility after potato in sequence might be attributed to incomplete utilization of fertilizers applied to the previous crop (potato). Tandon (1984) reported increase in seed yield of sesame due to S application.

Nutrient content

Maximum nitrogen, phosphorus, potassium and sulphur content in rice (1.032, 0.286, 1.522 and 0.219), potato (1.348, 0.298, 2.914 and 0.198) and sesame (1.754, 0.403, 1.751 and 0.289) were recorded in T_1 under rice–potato–sesame sequence (Table 2). The content of N, P and S was more in sesame and of K more in potato. The result confirms the finding of Jayaram *et al.* (1990).

Nutrient uptake

Maximum uptake of nutrients (N, P, K and S) in the sequence (301, 71, 46 and 50 kg/ha/annum respectively) was recorded in the T_1, closely followed by T_5 (259, 62, 404 and 41 kg/ha/annum respectively).

Soil-nutrient status

Total nitrogen status of the soil after 2 years improved slightly in 4 of the 8 treatments (Table 3). Positive nitrogen balance was maximum (+ 0.012%) in T_5. Phosphorus status of the soil was higher under the treatments receiving single superphosphate or farmyard manure. The result confirms the finding of Sanyal *et al.* (1990). Potassium balance (+ 49 kg/ha) as well as available sulphur status of the soil (+ 16.8 kg/ha) was maximum in T_7. Negative balance of S in the soil was observed in the plots receiving no

Table 2 N, P, K and S content in rice, potato and sesame under rice–potato–sesame sequence (mean data of 2 years)

Treatment	Nutrient content (%) in whole plants											
	Rice				Potato				Sesame			
	N	P	K	S	N	P	K	S	N	P	K	S
T_1	1.032	0.286	1.522	0.219	1.348	0.298	2.914	0.198	1.754	0.403	1.751	0.289
T_2	0.972	0.274	1.499	0.172	1.306	0.288	2.737	0.157	1.495	0.299	1.595	0.200
T_3	0.962	0.255	1.496	0.194	1.165	0.273	2.830	0.182	1.482	0.356	1.496	0.202
T_4	0.920	0.240	1.298	0.165	1.022	0.265	2.604	0.158	1.472	0.291	1.480	0.195
T_5	0.926	0.258	1.300	0.205	1.215	0.277	2.851	0.183	1.679	0.377	1.633	0.203
T_6	0.934	0.239	1.306	0.171	0.987	0.259	2.600	0.155	1.594	0.390	1.645	0.237
T_7	0.896	0.228	1.253	0.200	1.060	0.253	2.312	0.169	1.704	0.397	1.715	0.240
T_8	0.864	0.217	1.111	0.172	0.955	0.242	2.106	0.158	1.698	0.381	1.521	0.238

Details of treatments are given under Materials and Methods

Table 3 Change in nutrient status of the soil under rice–potato–sesame sequence after harvest of 6 crops in 2 years

Treatment	Total N (%)	Available nutrient (kg/ha) P	K	S
T_1	0.006	13.5	26	14.8
T_2	0.002	5.9	—2	—3.4
T_3	—0.002	10.0	6	11.6
T_4	—0.006	4.1	—8	—4.4
T_5	0.012	12.0	48	13.8
T_6	—0.004	3.4	12	3.9
T_7	0.007	11.0	49	16.8
T_8	—0.003	8.5	28	2.8

Initial value: total N 0.067%; and available P, K and S 15.4, 229.0 and 17.4 kg/ha respectively

Details of treatments are given under Materials and Methods

single superphosphate, farmyard manure or crop residues.

Net production value

Net production value was maximum (2.16) in the sequence under T_5. At lower dose (75% of the recommendation) of fertilizer in conjunction with organic manures, there was greater economic advantage than at higher (100% of the recommended dose). Perhaps farmyard manure increased the efficiency of chemical fertilizers in addition to supply of many other essential nutrient elements. Sulphur present in single superphosphate might have also increased the efficiency of nutrient utilization, besides acting as the source of adequate amount of sulphate-S for optimum plant growth.

It was concluded that growing crops at high intensity through substitution of diammonium phosphate with single superphosphate containing 12% S maximized the yield and minimized the depletion of sulphate in the soil. Application of farmyard manure or incorporation of crop residues into the soil minimized the decrease in yield by improving the fertilizer-use efficiency of the crops and maintaining positive nutrient balance in the soil.

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