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Potassium and sulphur nutrition of crops with or without organic manure under jute (*Corchorus olitorius*)–rice (*Oryza sativa*)–rapeseed (*Brassica campestris*) sequence

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ABSTRACT

A field experiment was conducted during pre-rainy season, rainy season (*kharif*) and winter season (*rabi*) of 1994–95 and 1995–96 to evaluate the productivity of crops and fertility building of soil under jute (*Corchorus olitorius* L)–rice (*Oryza sativa* L.)–rapeseed *[Brassica campestris* L. ssp. oleifera (Metzger) Sinsk. var. brown *sarson*] cropping sequence. The maximum fibre yield of jute and grain yield of rice were obtained when both jute and rice crops in sequence received both organic and inorganic sources of nutrients (N, P and K @ 40, 20 and 30 kg/ha for jute; and 60, 30 and 30 kg/ha for rice and FYM @ 10 tonnes/ha for both the crops). However, the maximum yield of rapeseed was recorded when the crop was fertilized with elemental S along with N, P, K (N, P, K and S @ 80, 40, 40 and 20 kg/ha). The maximum uptake of nutrients (N,P, K and S) by jute and rice crops was recorded under the treatment comprising FYM along with N, P and K. However, in rapeseed, higher uptake of N, P, K and S was observed when the crop received balanced nutrition of N, P, K and S (either through elemental sulphur or calcium sulphate). The maximum improvement of N, P and K status of soil after the harvest of 6th crop in sequence was observed when organic manure was incorporated along with chemical fertilizers of N, P and K; whereas in case of sulphur the maximum improvement was noticed when all the crops in sequence were fertilized with elemental sulphur along with N, P and K.

Key words : Jute–rice–rapeseed sequence, K, S, Organic manure

West Bengal is endowed with rich physical resources for crop production and in its Gangetic plains, the mean intensity of cropping is about 200%. The rainfall is high and soils are light in texture (Entisol), resulting in a good amount of leaching loss and removal of nutrients by the crops. 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 jute–rice–rapeseed sequence, an experiment was conducted on these aspects.

MATERIALS AND METHODS

The field experiment was carried out during pre-rainy season, rainy season

(*kharif*) and winter season (*rabi*) of 1994–95 and 1995–96 at Kalyani in Entisol soil of neutral reaction, having pH 7.6, total N 0.06%, available P and K 16.80 and 191 kg/ha respectively and available S 8.4 ppm. The experiment was laid out in randomized block design with 4 replications having 10 treatments. These were: T_1, N; T_2, NP; T_3, NPK_1 (low K); T_4, NPK_2 (high K); T_5, NPK_1S (elemental S); T_6, NPK_2S (elemental S); T_7, NPK_1 + farmyard manure @ 10 tonnes/ha; T_8, NPK_1 + crop residues of the previous crop (2,545 kg rapeseed stover) 1,755 kg jute leaves and 3,796 kg rice straw/ha in sequences); T_9, NPK_1 (K_2SO_4); and T_{10}, NPK_1S ($CaSO_4$). Urea and diammonium phosphate were used as the sources of N and P, whereas muriate of potash (KCl) was used as the source of K in all the treatments except T_9 where sulphate of potash (K_2SO_4) was used for this purpose. Dose of N,P, K and S (kg/ha) for jute, rice and rapeseed were 40, 20, 30/60 and 20; 60, 30, 30/60 and 20; and 80, 40, 40/60 and 20 respectively. Nitrogen was applied in splits as per recommended schedule and full doses of P, K and S were applied as basal. Farmyard manure (well-decomposed) and crop residues (well chopped) incorporated into the soil at the time of final land preparation. The mean N, P, K and S content (on dry-weight basis) of farmyard manure was 0.82, 0.60, 1.21 and 0.16% respectively. On an average, the crop residues of rapeseed stover, jute leaves and rice straw contributed N, P, K and S @ 55, 18, 110 and 11 kg/ha/annum respectively in the jute–rice–rapeseed sequence. Mean turn around period (gap) between harvesting of a crop and planting of succeeding crop for decomposition of crop residue were 25 days (rapeseed–jute), 10 days (jute–rice) and 15 days (rice–rapeseed). Jute was sown in the first week of April, rice was transplanted in the first week of August and rapeseed was sown in the second week of November. Jute cv. 'JRO 7835', rice cv. 'IET 4094' and rapeseed cv. 'B 9' were used in both the years.

Irrigation for all the crops in the sequence was given as and when needed as per recommended schedule. Total nitrogen, available phosphorus, available potassium and available sulphur were estimated by modified macro-Kjeldahl's method, Olsen's method, flame photometric method (Jackson, 1967) and turbidimetric method (Chesmin and Yien, 1951) respectively.

RESULTS AND DISCUSSION

Dry-matter production

The maximum dry-matter production of jute and rice was obtained at harvest in jute–rice–rapeseed sequence under treatment T_7 (Table 1) and it was followed by treatment T_9). With the application of sulphur (T_5, T_6 and T_{10}) dry-matter accumulation improved at harvest in the sequence was maximum under T_5 and it was on a par with the dry-matter production under the treatments T_6, T_7 and T_{10} (Table 1). Sulphate of potash (T_9) showed better result than nutrient of potash (T_3 and T_4). Addition of both lower (T_3) and higher (T_4) doses of potassium increased the dry-matter accumulation at harvest significantly in rapeseed crop in sequence over the application of N and P only (T_2).

Yield components

Yield components of rice (effective tillers/m^2, filled grains (%) and 1,000-grain weight) in the plots under T_7 were the maximum and as good as those under T_8 (Table 2). Addition of both lower (T_3) and higher (T_4) doses of potassium over application of N and P only (T_2) increased the yield components and addition of S (T_5, T_6, and T_{10}) was better than T_3 and T_4 in rice. In rapeseed, the number of siliqua/plant was the maximum under the treatment T_5 and it was closely followed by those recorded under treatments T_6, T_{10} and T_7. Application potassium sulphate (T_9) was superior to muriate of potash (T_3). Seeds/siliqua was the maximum under the treatment T_5; but the test weight of seed of rapeseed crop in sequence was not affected significantly due to fertilizer management (Table 1).

Yield

The pooled analysis of crop yields in jute–rice–rapeseed sequence (Table 1) exhibited that the maximum fibre yield of jute and grain yield of rice were obtained when both jute and rice crops in sequence received both organic and inorganic sources of nutrients (T_7) and extent of yield increase of jute and rice crops under T_7 was 18.9% and 16.5% respectively over T_3 (non-organic manured plots). The yield differences between treatments T_7 and T_8 were not wide enough. This is an agreement with the findings of Nambiar and Ghosh (1984) and Abrol and Katyal (1990). The maximum yield of rapeseed was recorded under T_5 (NPK_1S) and the extent of increase was 29.3% over the plots treated only with NPK (T_3). This result confirms the findings of Ganga Saran and Giri (1990). Addition of S through either

Table 1. Productivity of dry matter, fibre, grain and seed yield of crops under jute–rice–rapeseed sequence (pooled data of 2 years)

Treatment	Total dry matter (g/m^2)			Yield at harvest (q/ha)		
	Jute	Rice	Rapeseed	Jute	Rice	Rapeseed
T_1	1,652.32	492.8	242.7	18.4	21.6	5.2
T_2	2,122.80	550.1	303.1	20.8	28.2	6.9
T_3	2,739.92	581.4	363.5	28.2	33.0	8.9
T_4	2,689.16	589.7	381.7	29.1	34.0	9.4
T_5	2,910.30	595.2	429.3	30.6	36.5	11.6
T_6	2,920.32	594.8	417.4	31.9	36.5	11.6
T_7	3,293.75	682.3	408.2	33.5	38.5	10.8
T_8	3,059.82	672.9	388.6	32.3	37.0	9.7
T_9	2,992.42	592.8	383.9	32.1	36.2	9.3
T_{10}	2,889.92	586.4	421.6	29.8	36.0	10.7
CD (P = 0.05)	3,00.132	22.42	21.71	1.54	3.67	1.99

T_1, N; T_2, NP; T_3, NPK_1 (low K); T_4, NPK_2 (high K); T_5, NPK_1S (elemental S); T_6, NPK_2S (elemental S); T_7, NPK_1 + FYM @ 10 tonnes/ha; T_8, NPK_1 + crop residues of the previous crop; T_9, NPK_1 (K_2SO_4); T_{10}, NPK_1 ($CaSO_4$)

Doses of N, P, K, S (kg/ha) for jute, rice and rapeseed were 40, 20, 30/60 and 20; 60, 30, 30/60 and 20; and 80, 40, 40/60 and 20 kg/ha respectively

Table 2. Yield components of crops under jute–rice–rapeseed sequence (pooled data of 2 years)

Treatment	Yield components					
	Effective tillers/m²	Filled grains (%)	1,000-grain weight (g)	Siliquae/ plant	Seeds/ siliqua	1,000-seed weight (g)
T_1	241.0	76.6	19.6	45.5	16.7	3.4
T_2	271.2	79.2	19.9	64.3	17.8	3.5
T_3	295.4	86.0	20.9	82.6	19.0	3.6
T_4	297.2	86.3	20.9	84.9	19.7	3.6
T_5	311.1	87.6	21.2	104.7	23.0	3.7
T_6	313.4	87.5	21.4	100.6	22.1	3.7
T_7	324.8	89.9	21.6	98.9	22.6	3.8
T_8	321.7	88.2	21.4	93.5	22.4	3.7
T_9	310.5	88.5	21.1	83.9	20.2	3.6
T_{10}	300.6	87.6	20.7	99.9	22.6	3.6
CD (P = 0.05)	3.52	4.9	0.73	9.99	1.01	NS

T_1, N; T_2, NP; T_3, NPK_1 (low K); T_4, NPK_2 (high K); T_5, NPK_1S (elemental S); T_6, NPK_2S (elemental S); T_7, NPK_1 + FYM @ 10 tonnes/ha; T_8, NPK_1 + crop residues of the previous crop; T_9, NPK_1 (K_2SO_4); T_{10}, NPK_1 ($CaSO_4$);

Doses of N, P, K, S (kg/ha) for jute, rice and rapeseed were 40, 20, 30/60 and 20; 60, 30, 30/60 and 20; and 80, 40, 40/60 and 20 kg/ha respectively

elemental form or calcium sulphate along with N, P and K improved the fibre yield of jute and grain yield of rice appreciably. Addition of K over N and P only significantly improved the yield of all the crops in jute–rice–rapeseed sequence and the extent of increase was 35.0%, 16.9% and 29.06% in the respective crops. Besides, addition of K through potassium sulphate gave better performance in increasing the yield of all the crops in sequence compared to the application of K through muriate of potash.

Nutrient uptake

The maximum uptake of nutrients (N, P, K and S) by jute and rice crop, recorded under treatment T_7 (NPK_1 + FYM), was very much similar to the uptake by those crops under the treatment T_8 (NPK_1 + crop residues) (Table 3). This may be due to the fact that with the application of FYM in presence of inorganic fertilizers the nutrients become readily available to the plants. This is in agreement with the findings of Zoysa *et al.* (1990). In case of rapeseed, higher uptake of N, P, K and S (through elemental sulphur or calcium sulphate) and this uptake was very much close to that of nutrients by the crops under T_7 and T_8. This confirms the findings of Salhan *et al.* (1994). The uptake of nutrients was more where all crops in sequence received potassium sulphate as compared to potassium chloride. Deletion of K and S in the fertilization of crops in sequence drastically reduced the uptake of N, P, K and S.

Soil-nutrient status

The nutrient (N,P,K and S) status of soil

Table 3. Mean N,P, K and S uptake by jute, rice and rapeseed crop in sequence

Treatment	Uptake of nutrients (kg/ha/annum)											
	Jute				Rice				Rapeseed			
	N	P	K	S	N	P	K	S	N	P	K	S
T_1	39.8	27.8	60.7	4.9	51.5	14.7	63.1	8.0	20.8	8.8	25.9	12.9
T_2	55.6	37.4	96.9	8.6	58.2	18.3	75.8	9.2	26.7	11.6	33.3	16.5
T_3	93.3	51.6	140.0	13.7	65.2	20.4	84.0	10.3	31.7	13.7	39.3	19.4
T_4	96.2	52.6	157.1	13.9	66.9	20.9	85.7	10.5	33.1	14.5	41.6	20.5
T_5	102.4	56.3	167.2	18.7	68.7	21.2	87.9	12.8	39.0	17.2	48.8	24.3
T_6	104.7	57.6	171.5	19.5	68.9	21.7	90.9	13.0	37.9	16.7	47.2	23.7
T_7	120.9	65.3	204.6	19.9	79.1	26.5	114.3	13.3	35.6	15.8	44.9	22.0
T_8	113.8	63.1	188.4	16.6	77.9	25.5	106.4	12.6	34.0	15.0	42.9	20.9
T_9	105.2	56.3	169.1	18.8	68.3	20.4	86.5	12.3	32.3	14.2	40.3	20.2
T_{10}	102.1	55.4	167.3	19.0	68.0	20.5	87.3	11.8	38.3	16.9	47.9	24.0

T_1, N; T_2, NP; T_3, NPK_1 (low K); T_4, NPK_2 (high K); T_5, NPK_1S (elemental S); T_6, NPK_2S (elemental S); T_7, NPK_1 + FYM @ 10 tonnes/ha; T_8, NPK_1 + crop residues of the previous crop; T_9, NPK_1 (K_2SO_4); T_{10}, NPK_{10} ($CaSO_4$); Doses of N, P, K, S (kg/ha) for jute, rice and rapeseed were 40, 20, 30/60 and 20; 60, 30, 30/60 and 20; and 80, 40, 40/60 and 20 respectively.

Table 4. Change in nutrient status of the soil under jute–rice–rapeseed sequence after harvest of 6 crops in 2 years

Treatment	Nutrient (kg/ha)			
	Total N	Available P	Available K	Available S
T_1	–340	–3.3	–40	–3.0
T_2	–220	+3.8	–35	–2.7
T_3	+20	+13.4	+14	0
T_4	+20	+14.0	+14	+0.1
T_5	+20	+14.4	+19	+10.7
T_6	+20	+14.0	+21	+10.4
T_7	+100	+18.9	+30	+9.8
T_8	+100	+18.3	+30	+8.9
T_9	+40	+17.0	+23	+9.0
T_{10}	+20	+14.8	+19	+8.6

Initial value 1,380 kg/ha total N; 16.8, 191.0 and 16.8 kg/ha available P, K and S respectively

T_1, N; T_2, NP; T_3, NPK_1 (low K); T_4, NPK_2 (high K); T_5, NPK_1S (elemental S); T_6, NPK_2S (elemental S); T_7, NPK_1 + FYM @ 10 tonnes/ha; T_8, NPK_1 + crop residues of the previous crop; T_9, NPK_1 (K_2SO_4); T_{10}, NPK_1 ($CaSO_4$)

Doses of N, P, K, S (kg/ha) for jute, rice and rapeseed were 40, 20, 30/60 and 20; 60, 30, 30/60 and 20; and 80, 40, 40/60 and 20 respectively

after harvest of 6th crop in sequence was improved where balanced nutrition of N, P and K was given to all the crops in sequence. But the magnitude of improvement of N, P and K status was the maximum under the treatment T_7 (NPK_1 + FYM) and it was very much similar to the improvement under treatment T_8 (NPK_1 + crop residues). In case of S maximum improvement was noticed under the treatment T_5 (Table 4). Further, improvement of N, P, K and S status of soil was observed when S was added along with N, P, and K, supporting the findings of Panda and Sahoo (1989).

Net production value

The maximum net production value was obtained when all the crops in sequence were fertilized with N, P and K along with farmyard manure (T_7). This was followed by the treatment T_8. The net production values were also high where crops were fertilized with K. The addition of S through elemental form or calcium sulphate over N, P and K improved the productivity of all the crops in sequence, but the net production values were reduced in case of elemental S (due to its high cost) though the net production value was high in case of calcium sulphate.

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