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Rational use of phosphorus on seed yield, nutrient composition and uptake in rice (*Oryza sativa*) – rapeseed (*Brassica campestris* subsp. *oleifera* var. toria) – greengram (*Phaseolus radiatus*) crop sequence

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ABSTRACT

A field investigation was carried out during 1991–92 and 1992–93 to find out the dose of phosphorus sufficient to meet the nutritional requirement of rice (*Oryza sativa* L.) – rapeseed [*Brassica campestris* L. ssp. *oleifera* (Metzger) Sinsk. var. toria] – greengram (*Phaseolus radiatus* L.) cropping sequence. The concentration of N and K reduced by the application of 26.2 kg P/ha to rice and rapeseed in the 3 crops. The P concentration increased in rice and greengram but not in rapeseed. The uptake of N, P and K was more in rice and rapeseed fertilized with 26.2 kg/ha P. The residual effect of 13.1 or 26.2 kg P ha applied to rice also influenced the uptake of these nutrients in rapeseed. Greengram in summer removed more N, P and K due to the cumulative influence of 26.2 kg/P ha through rice and rapeseed. Phosphorus @ 26.2 kg/ha (*rabi*) to rice significantly increased the yield. Its residual effect was also significant in increasing the production of rapeseed grown as second crop in winter (*rabi*) season. The cumulative effect of residual P through the previous crop of rice and its direct application both at 26.2 kg/ha P maximized the grain yield of rapeseed. The third crop of greengram in summer gave maximum yield by the residual effect of phosphorus applied to rice and rapeseed in *kharif* and *rabi* respectively.

Key words: Cropping sequence, Rice, Rapeseed, Greengram, Nutrient uptake, Yield

Rice-based cropping systems are most common in Andhra Pradesh. Cultivation of rapeseed as the second crop in winter (*rabi*) season and greengram as the third crop in summer season after rainy (*kharif*) - season rice is gaining popularity in the state. There is however, apprehension that continued mining of nutrients from the soil due to intensive cropping may render it less potential. Therefore, the lost nutrients are to be replenished through suitable carriers. Inclusion of legumes in the cropping system is one of the widely adopted practices to partly overcome the problem of nitrogen. This is due to the soil N-

Table 1. Nutrient composition (%) of rice, rapeseed and greengram during 1991–92 and 1992–93 as influenced by phosphorus application in rice–rapeseed–greengram crop sequence

Phosphorus (kg/ha)	Rice			Rapeseed			Greengram		
	N	P	K	N	P	K	N	P	K
Rainy season									
0	2.29	0.36	2.60	6.10	1.01	6.92	7.43	0.50	7.77
13.1	2.31	0.40	2.44	5.89	0.98	6.52	7.31	0.51	7.56
26.2	2.25	0.43	2.32	5.79	0.98	6.26	7.02	0.54	7.36
CD (P = 0.05)	0.04	0.05	0.14	0.13	NS	0.20	0.16	0.03	0.23
Winter season									
0	2.28	0.40	2.44	6.81	1.11	7.66	7.97	0.54	8.38
13.1	2.28	0.40	2.45	5.86	0.99	6.50	6.94	0.50	7.33
26.2	2.28	0.41	2.44	5.33	0.90	5.79	6.97	0.52	7.15
CD (P = 0.05)	NS	NS	NS	0.13	NS	0.20	0.16	NS	0.23
Cumulative									
0–0	2.28	0.36	2.59	6.83	1.06	7.74	7.85	0.55	8.16
0–13.1	2.28	0.36	2.61	6.08	1.00	6.94	7.42	0.49	7.80
0–26.2	2.30	0.36	2.61	5.95	1.01	5.56	7.08	0.48	7.42
13.1–0	2.32	0.40	2.42	6.60	1.15	7.68	7.97	0.54	8.40
13.1–13.1	2.32	0.40	2.42	5.77	0.96	6.39	6.94	0.49	7.28
13.1–26.2	2.30	0.40	2.48	5.57	0.96	5.93	7.03	0.49	7.05
26.2–0	2.27	0.44	2.34	6.53	1.10	7.25	8.07	0.55	8.55
26.2–13.1	2.24	0.42	2.32	5.67	0.95	6.10	6.52	0.50	6.94
26.2–26.2	2.25	0.44	2.31	5.02	0.85	5.40	6.63	0.57	6.92
CD (P = 0.05)	NS	0.8	0.18	0.20	NS	0.31	0.24	NS	0.38

Table 2. Nutrient uptake (kg/ha) of rice, rapeseed and greengram as influenced by phosphorus application in rice–rapeseed–greengram crop sequence (mean data of 1991–92 and 1992–93)

Phosphorus (kg/ha)	Rice			Rapeseed			Greengram		
	N	P	K	N	P	K	N	P	K
Kharif									
0	97.92	15.60	111.42	42.72	7.10	48.47	50.02	3.43	52.355
13.1	114.68	20.00	120.92	46.23	7.71	51.15	53.98	3.78	55.83
26.2	120.90	23.46	124.77	49.86	8.49	53.88	55.81	4.33	58.52
CD (P = 0.05)	6.10	2.90	4.12	5.20	0.42	2.10	2.60	0.51	2.70
Rabi									
0	109.77	19.37	117.52	43.77	7.18	49.22	49.39	3.40	51.92
13.1	110.90	19.72	118.98	46.46	7.91	51.52	62.47	3.80	55.37
26.2	112.89	20.40	120.94	48.56	8.19	52.75	57.96	4.35	59.42
CD (P = 0.05)	NS	NS	NS	NS	0.42	2.10	2.60	0.51	2.70
Cumulative									
0–0	97.3	15.63	110.55	40.75	6.35	46.15	46.36	3.25	48.16
0–13.1	97.97	15.51	111.72	43.72	7.18	49.83	50.77	3.40	53.40
0–26.2	98.5	15.70	112.00	46.88	8.01	51.69	52.95	3.65	55.52
13.1–0	113.79	19.73	118.81	42.69	7.43	49.62	50.46	3.45	53.18
13.1–13.1	114.90	20.12	119.65	45.96	7.71	50.90	52.21	3.75	54.82
13.1–26.2	115.37	20.16	124.30	50.73	8.62	54.05	59.28	4.15	59.48
26.2–0	120.25	22.98	124.56	49.0	8.22	52.72	54.45	4.25	57.89
26.2–13.1	120.25	22.98	124.56	49.0	8.22	52.72	54.45	4.25	57.89
26.2–26.2	121.95	23.99	125.44	51.99	8.82	55.90	60.63	6.25	63.25
CD (P = 0.05)	9.30	5.20	7.30	8.10	0.40	6.20	10.20	0.90	5.80

conserving effect of legume–rhizobium symbiosis. But, the problem remains for P which is low to medium in most of the soils of Andhra Pradesh and is abundantly required by oilseeds and legumes. The reserves of potassium are medium to rich in available status and thus do not pose a serious problem. Hence there is a need to understand the relationship between the added inorganic P, its composition and uptake by the crops under intensive cropping systems with the objective of maintaining soil fertility for increasing the crop productivity. Therefore the study was undertaken.

MATERIALS AND METHODS

A field experiment was conducted in the sandy-loam soils of Agricultural College Farm, Rajendranagar, during 1991–92 and 1992–92. The soil was slightly alkaline (pH 8.1), low in available N (253 kg N/ha), medium in available P (18.2 kg/ha) and K (308.4 kg/ha). 'Tellahamsa' rice in rainy season (*kharif*), 'Sangam' rapeseed in winter (*rabi*) and 'LGG 127' greengram in summer were grown during each year. One-month-old seedlings of rice were transplanted in the third week of July and harvested in the third week of October. Rapeseed was sown in the first week of November and harvested in the fourth week of February and greengram was sown in the third week of April and harvested in the third week of June during both the years.

The experiment was conducted in 3^2 factorial randomized block design with 3 replications. There were 9 treatment combinations of 3 levels of P (0, 13.1, 26.2 kg/ha) applied to each of rice and rapeseed. Greengram was grown in for residual P. Nitrogen was applied @ 80, 40 and 20 kg/ha to rice, rapeseed and greengram respectively. Potassium was applied @ 40 kg/ha uniformly to each crop. The plot size was 5.4 m x 3.6 m. Rice was grown with a spacing of 20 cm x 10 cm, and rapeseed and greengram were sown with a spacing of 30 cm x 10 cm.

Composite soil sample was collected from 0–30 cm depth at the beginning of the experiment. Available N (Subbaiah and Asija, 1956), P (Olsen *et al.*, 1954) and K (Muhr *et al.*, 1963) were estimated. The N, P and K contents on dry-weight basis of the crops at harvest were estimated as per standard methods. Uptake of N, P and K was calculated by multiplying the contents with the yield.

RESULTS AND DISCUSSION

The nutrient composition, their uptake and seed yield of crops were greatly influenced by different levels of phosphorus through direct residual and cumulative effects.

Rice fertilized with 26.2 kg P/ha had low concentration of N and K but more P in the

Table 3. Grain yield (kg/ha) of rice, rapeseed and greengram (mean data of 1991–92 and 1992–93) as influenced by phosphorus application in rice–rapeseed–greengram crop sequence

Phosphorus (kg/ha)	Grain yield (kg/ha)		
	Rice	Rapeseed	Greengram
Kharif			
0	4,271	700	673
13.1	4,948	784	738
26.2	5,358	860	795
CD (P = 0.05)	372	39	41
Rabi			
0	4,813	642	619
13.1	4,856	792	755
26.2	4,947	910	831
CD (P = 0.05)	NS	39	41
Cumulative			
0–0	4,257	596	590
0–13.1	4,279	718	684
0–26.2	4,278	787	748
13.1–0	4,895	646	633
13.1–13.1	4,943	796	752
13.1–26.2	5,008	910	843
26.2–0	5,299	684	636
26.2–13.1	5,361	864	834
26.2–26.2	5,416	1,034	914
CD (P = 0.05)	625	95	101

plant tissues than in the control (Table 1). But uptake of the 3 nutrients was minimum in the control plot owing to the low dry-matter production than in P-fertilized crop (Table 2). Enrichment of the soil with P improved the root growth (Fixen and Leikhan, 1989). Thus the uptake of nutrients was more. The synergistic effect of P with N and K also enhanced the nutrient uptake (Dev, 1992). Residual effect of P applied to the preceding *rabi* crop on the nutrient uptake of rice in the second year was not significant.

The concentration of N, P and K in rapeseed reduced with the increase in P level. But, the crop removed 49.86 kg N, 8.49 kg P and 53.88 kg K/ha. This was significantly more than the respective nutrient uptake in the control. The uptake of these nutrients was also influenced by the residual effect of 13.1 or 26.2 kg P/ha applied to the preceding rice crop. The cumulative effect of 26.2 kg P/ha applied to both rice and rapeseed maximized N, P and K uptake which was significantly more than the control.

Greengram significantly removed the maximum quantity of N, P and K due to residual effect of 26.2 kg P/ha applied to rice and rapeseed was markedly evident on the N, P and K uptake.

Application of 26.2 kg P/ha to rice significantly increased the yield (Table 3). It produced additional 1,087 kg grain over the control and 410 kg over the response due to 13.1 kg P/ha. The residual effect of P applied to preceding crops was not significant in the second year. The cumulative effect of 26.2 kg P/ha applied both directly to rice and its residual influence of the preceding year maximized the rice yield to 5,416 kg/ha. It produced 860 kg/ha grain due to direct effect of 26.2 kg/ha compared to the significantly low yield of 700 kg/ha in the control. The residual effect of 26.2 kg/ha P applied to the preceding rice crop was also significantly more. Therefore, the production per hectare of rapeseed was the maximum by the cumulative fertilizer effect. Greengram yield was significantly increased by the residual effect of 26.2 kg/ha P applied to both rice and rapeseed grown as preceding crops.

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