Rational use of phosphorus in a rice-wheat cropping system in Bihar plains

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ABSTRACT

A field experiment was conducted at RAU, Pusa to rationalize use of phosphours in a rice wheat cropping system grown in calearеous silty soil of Bihar plains. Distinct positive response to P was observed by skipping its application in either crops without scarifying yield and economic returns. However, it was more appropriate to skip in wet season for rice alone or by reducing P application dose by 50% for both crops.

Key words: *Rice-wheat cropping system, phosphorus application, nutrient uptake*

Fertilizer scheduling to the whole cropping system, rather than a single crop helps better in its rationalization and economizing the expenses incurred on major nutrients. Rice-wheat cropping system is dominant in Bihar plains and the area is progressively increasing due to the adoption of semi dwarf rice varieties and increased irrigation facilities. However, the productivity of this system can be sustained through proper scheduling application of major three nutrients. Phosphorus is an important nutrient and its availability in Indian soils is low to moderate. There is an urgent need to replenish it in the soils in order to overcome the crop-P starvation. However only 10-20% of the added phosphorus is utilized and the rest gets fixed and becomes available to the succeeding crop (Tandon, 1987). The response ranged from 40 to 100 kg P_2O_5 ha^{-1} for optimum production but was expensive. Considering the moderate status of available P, high rate of its fixation in the soils and high cost, an attempt was made to work out the rational use of phosphorus in a rice-wheat cropping system in the calcareous soil belt of north Bihar plains.

The field experiment was conducted at the Rajendra Agricultural University Farm, Pusa (Bihar) during 1998-99 to 2000-2001. The soil was silty loam, with pH 8.4, organic C 0.57%, available N 267.3 kg ha^{-1}, available P 24.6 kg ha^{-1} and available K 124.6 kg ha^{-1} comprised of P_O-no P application to either crop, P_1 – full P (60 kg P_2O_5 ha^{-1}) applied to rice crop, P_2 – full P applied to wheat crop : P_3 – full P applied to both rice and wheat crops and P_4 – half P applied to both rice and wheat. The experiment was conducted in a randomized block design with six replications. Both the crops were fertilized with a common dose of 120 kg N and 40 kg K_2O ha^{-1} and the fertilizers were applied as per the recommended schedule. P (60 kg P_2O_5 ha^{-1}) was applied as per treatment schedule in both the crops. Thirty-day old seedlings of rice variety 'Rajshree' were transplanted at a spacing of 20cm x 15 cm in the second week of July every year. In the same plots wheat variety UP 262 was sown in lines 20 cm apart, using 125 kg seed ha^{-1}. Rice was harvested in the second week of November and wheat in the middle of April. The data on yield and yield components for three years were pooled. The yields of both the crops were converted into the rice-equivalent yield based on the prevailing market prices and economics of the treatment was calculated. The N, P and K content in grain and straw were estimated by following the standard procedures and nutrient uptake was calculated.

Direct application of P to rice and wheat significantly increased the grain and straw yields of both rice and wheat (Table 1). Addition of P helped increase the values of all yield-attributing characters viz.; panicles m^{-2}, grains $panicle^{-1}$ and 1000-grain weight of rice and wheat which ultimately resulted in significantly higher grain and straw yields of both the crops as compared to no P treatment.

Table 1. Yield, yield components and economics of rice and wheat in a rice-wheat system as influenced by different phosphorus treatments (means of three years)

Phosphorus treatment	Rice					Wheat					Rice equivalent yield ($t\ ha^{-1}$)	Net return ($Rs.ha^{-1}$)	Benefit cost ratio
	Panicles m^{-2}	Grains $panicle^{-1}$	1000-grain weight (g)	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	Panicles m^{-2}	Grains $panicle^{-1}$	1000-grain weight (g)	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)			
P_0	232	73	22.8	3.45	5.10	306	32	29.3	2.48	3.27	6.70	14110	1.95
P_1	249	80	23.2	3.81	5.36	313	33	32.9	2.60	3.34	7.21	17463	2.16
P_2	246	74	23.1	3.60	5.17	321	33	33.1	2.82	3.36	7.29	17982	2.19
P_3	251	81	23.4	3.91	5.53	324	33	33.2	2.85	3.35	7.65	18879	2.21
P_4	247	76	23.1	3.63	5.18	317	33	32.9	2.74	3.48	7.23	17664	2.17
CD (P=0.05)	15	6	0.4	0.26	0.32	12	2	1.5	0.2	0.45	0.37	1246	0.08

P_0 – No P application to either crop; P_1 – P to rice crop; P_2 – Full P applied to wheat crop; P_3 – Full P applied to both rice and wheat crops and P_4 – Half P applied to both rice and wheat crops.

Increased frequencies of P-application to both in rice and wheat crops produced significantly higher grain and straw yields which was closely followed by P_1 and P_4 in case of rice followed by P_2 and P_4 with respect to wheat. This indicated that there was less residual effect of P when applied in wet season crop only or vice-versa. This might be due to higher availability of native P in wet season than in dry season (Tisdale *et al.*, 1995) specially. Therefore, P application in dry season was more essential than in wet season for better utilization of this nutrient (Meelu 1996).

Productivity for rice-wheat sequence revealed that the highest Rice equivalent yields (REY) of 7.67 t ha^{-1} was obtained with the application of P to both rice and wheat crops (P_3). However, the treatment involving application of P only to wheat performed equally good as evident with its statistical parity with P_3. Maximum net return was realized when both the crops were fertilized with P (P_3), that was statistically comparable with P_2 wherein P was applied only to wheat crop or P_4 where the dose was reduced to 50% in both crops. The highest benefit : cost ratio (2.21) was obtained with $P_{3,}$ on par with all other treatments excepting no phosphorus plot recording the minimum (1.95) yield.

The NPK uptake by rice and wheat exhibited significant differences due to different treatments (Table 2). Application of P significantly improved the N, P and K uptake by both the crops under rice-wheat crop sequence and maximum uptake was realized with the application of P to both the crops every year. With regard to total quantum of uptake of nutrients, rice crop recorded higher values than wheat. This might be due to higher yield of rice as well as better soil condition in wet season.

Maximum uptake of P by rice was recorded under P_3 which was significantly superior to P_1 and P_4. Similarly, wheat recorded maximum value of P uptake under P_3 which showed statistical superiority over P_2 and P_4 only. Maximum P use-efficiency and recovery was recorded under P_2 where P was applied to wheat every year.

It was concluded that P can be skipped in either of any crop or may be reduced to 50% its doses under rice-wheat sequence. However, it is better to skip in rice wet season than wheat dry season for economizing the nutrient on the total system basis as well as nutrient uptake point of view.

Table 2. Nutrient uptake (kg ha^{-1}) by rice and wheat (grain + straw) as influenced by different phosphorus doses in a rice-wheat cropping system (means of three years)

Phosphorus Treatment	Rice											
	N				P				K			
	1998-1999	1999-2000	2000-2001	Mean	1998-1999	1999-2000	2000-2001	Mean	1998-1999	1999-2000	2000-2001	Mean
Po	92.2	99.8	97.5	96.5	14.1	17.6	15.2	15.6	97.5	114.2	110.0	107.2
P1	105.1	113.5	112.0	110.2	18.1	22.7	21.0	20.6	111.5	123.0	117.7	117.4
P2	104.3	113.6	110.7	109.5	16.2	21.8	18.8	18.9	110.5	122.8	117.3	116.9
P3	108.9	116.4	115.1	114.1	19.8	24.2	23.4	22.5	113.1	126.2	121.5	120.3
P4	102.7	113.2	110.0	108.6	17.6	22.4	19.4	19.8	109.6	120.1	117.7	115.8
CD (P=0.05)	5.6	5.0	4.9	5.4	1.9	2.3	2.8	2.2	5.1	4.6	3.3	4.3

Phosphorus Treatment	Wheat											
	N				P				K			
	1998-1999	1999-2000	2000-2001	Mean	1998-1999	1999-2000	2000-2001	Mean	1998-1999	1999-2000	2000-2001	Mean
P1	71.9	76.6	75.3	74.6	9.1	11.3	11.2	10.5	43.6	55.5	51.4	50.2
P2	73.3	77.8	75.0	75.4	10.7	13.8	12.9	12.5	45.6	59.2	50.0	51.6
P3	75.8	80.1	79.7	78.5	12.3	15.0	14.1	13.8	45.5	60.4	51.8	52.6
P4	73.1	77.0	74.9	75.0	9.7	11.4	11.3	10.8	45.0	57.7	51.0	51.2
CD (P=0.05)	3.1	3.6	3.5	3.4	2.1	2.9	1.7	1.8	4.3	3.9	3.6	3.1

Phosphorus treatment	NPK uptake by sequence (kg ha^{-1})			Apparent P-recovery (%)	P-use efficiency (kg grain kg^{-1} P)
	N	P	K		
P_0	168.1	24.8	154.7	-	-
P_1	183.5	30.7	167.6	9.8	8.5
P_2	185.4	31.4	167.4	11.0	9.5
P_3	192.2	36.3	172.9	9.6	8.1
P_4	184.5	30.7	168.1	9.8	8.8
CD (P=0.05)					

P_0 – No P application to either crop; P_1 – P to rice crop; P_2 – Full P applied to wheat crop; P_3 – Full P applied to both rice and wheat crops and P_4 – Half P applied to both rice and wheat crops.

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