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Research Paper

Phosphorus management in rice (*Oryza sativa*)–autumn sugarcane (*Saccharum officinarum*) cropping sequence

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ABSTRACT

A field experiment was conducted during 2004-05 and 2005-06 on deep black soil of Navsari, Gujarat to study the direct and residual effect of pressmud biocompost and direct effect of phosphorus in rice (*Oryza sativa* L.) - sugarcane (*Saccharum officinarum* L.) cropping system. Application of pressmud biocompost @ 40 t/ha to rice recorded significantly higher grain yield (5.41 and 5.24 t/ha), total P uptake (9.72 and 9.79 kg/ha) by rice and available P status of soil (15.41 and 9.74 kg/ha) after harvest of rice than control (no phosphorus) during both the years and remained at par with application of pressmud biocompost @ 20 t/ha. Similarly application of pressmud biocompost @ 40 t/ha to preceding rice recorded significantly higher millable cane weight (1.14 and 1.26 kg), millable cane yield (108.6 and 107.8 t/ha), intercrop yield (0.858 and 1.056 t/ha), sugarcane equivalent yield (114.55 and 115.35 t/ha), available P status of soil (14.17 and 9.53 kg/ha) after harvest of sugarcane and net realization from rice-sugarcane cropping system (1,23,800 and 1,49,300 ₹/ha) over other treatments during both the years. Application of recommended dose of P/ha (54.59 kg/ha) to sugarcane raised without intercrop of greengram [*Vigna radiata* (L.) Wilczek] recorded significantly higher millable cane yield (115.4 and 116.8 t/ha) than rest of the treatments. While, sugarcane equivalent yield (119.49 and 123.30 t/ha), available P status of soil (13.86 and 10.51 kg/ha) after harvest of sugarcane as well as net realization (1,32,500 and 1,64,300 ₹/ha) were obtained higher under application of recommended dose of P/ha (54.59 kg/ha) to sugarcane raised with intercrop of greengram.

Key words *:* Cropping system, Intercrop, Phosphorus management, Rice, Sugarcane

Rice–sugarcane cropping system is one of the dominant sequences under vertisol of South Gujarat. Under this cropping system, both crops are nutrient exhaustive and may deplete the soil fertility and productivity. Literature is abundant on response to nitrogen in rice (Kumar and Prasad, 2004; Prasad, 2005) and sugarcane (Yadav, 2000; Singh *et al*., 2006), there are not many reports on response of rice or sugarcane to P. In recent years, P application has been recommended in rice (Prasad, 2007) and sugarcane (Dhillon *et al*., 1993). No information on response of rice and sugarcane to P application is available for sugarcane belt of Gujarat. Recently it was reported that application of 12-15 t/ha seasoned pressmud in sugarcane can save 50 to 75% phosphorus (P) needs of crop (AGRESCO, 2000). However, most of the farmer applied pressmud to rice crop due to inadequate storage facilities. Further, the sugar factories in south Gujarat started production of biocompost from pressmud. The present study was therefore, taken up to study the response of rice and sugarcane to P and to test the profitability of pressmud biocompost as a source of phosphorus in rice-sugarcane cropping system.

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MATERIALS AND METHODS

A field experiment was conducted during 2004-05 and 2005-06 on deep black soil of regional sugarcane research station, Navsari, Gujarat. The soil of the experiment field contained 0.5 % total nitrogen, 10.1 kg/ha Olsen's available phosphorus and 317 kg/ha available (1 M ammonium acetate extractate) potassium, respectively. The experiment on preceding *kharif* rice crop was laid out in randomized block design (RBD) with four treatments, consisting two levels of pressmud biocompost (PB) (20 and 40 t/ha) and one level of inorganic phosphorus in form of single super phosphate @ 13.2 kg P/ha along with control (no phosphorus) replicated four times. The experiment on autumn sugarcane was superimposed on the same site without

changing the randomization of treatments during both the years (a repeat adjacent field was used each year) to assess the residual effect of phosphorus management in preceding *kharif* rice on succeeding autumn sugarcane raised with or without intercrop of greengram 'Co–4' under three phosphorus levels (Control 50% RD of P/ha and RD of P/ha) in split plot design (SPD) with four replications. In sugarcane, there were 24 treatment combinations consisting of four residual treatments of *kharif* rice as main plots and three levels of phosphorus applied to sugarcane raised with or without intercrop of greengram *viz.*, zero kg P/ha without and with intercrop, 50% RD of P/ha without and with intercrop and RD of P/ha without and with intercrop as sub plots. The recommended dose of P for sugarcane is 55 kg/ha. The experiment started during *kharif* season of 2004 and 2005 with sowing of rice 'Jaya'. Rice seedlings (30 days old) were transplanted at 20 cm × 15 cm spacing during first fortnight of July and planting of sugarcane 'CoN-03131' during second fortnight of November in furrows of 100 cm apart. In rice, different levels of PB and phosphorus were applied at time of puddling, while in sugarcane various levels of phosphorus were applied at time of planting. Pressmud biocompost used contained 1.2 and 1.3% N; 2.05 and 2.18% P; 1.10 and 1.20% K; 0.34 and 0.36% S and oven dry weight of 52 and 56% during the year 2004 and 2005, respectively. Nitrogen (100 and 250 kg/ha to rice and sugarcane, respectively) in form of ammonium sulphate in rice and in form of urea in sugarcane and potassium (zero and 125 kg/ha to rice and sugarcane) in form of muriate of potash were applied to both crops as per recommendation. Greengram 'Co-4' as intercrop sown 3 to 4 days after sugarcane planting at 30-40-30 cm spacing in between two rows of sugarcane. All the necessary cultural practices were taken as and when required for *kharif* rice, autumn sugarcane and greengram. The crops were harvested at their maturity *viz.* rice at 90 days after transplanting, greengram at 120 days after sowing (before the earthing-up) and sugarcane at 12 month of planting. The weather during crop period was normal.

RESULTS AND DISCUSSION

Rice

Rice responded significantly to P application pressmud biocompost (PB) as BP (20 or 40 t/ha) and single super phosphate (SSP) were at par in respect of panicles/m^2, filled grains/panicle and grain yield of rice. P uptake by rice and available P in soil after the rice harvest was recorded higher with PB at 40 t/ha compared to SSP (Table 1).

Residual effect of P applied to rice on succeeding sugarcane

Application of phosphorus to preceding rice crop significant increased millable cane yield and sugarcane equivalent of the rice -sugarcane cropping system, total P uptake by sugarcane and available P status of soil after the harvest of sugarcane (Table 2). In general, PB @ 40 t/ha was superior to PB @ 20 t/ha, which in turn superior to SSP. These results show that, while fertilizer P get fixed, P applied as PB becomes available to the succeeding sugarcane crop. Thus, PB is a better source of P for rice – sugarcane cropping system.

Greengram

The highest seed yield of greengram sown as intercrop in sugarcane was recorded under application of 40 t/ha PB. This may be attributed to better utilization of nutrients left in soil applied to rice. Higher seed yield of greengram sown as intercrop in sugarcane was noted under recommended dose of phosphorus (55 kg/ha) applied to sugarcane over other levels of phosphorus.

Direct effect of P fertilization on sugarcane

Sugarcane responded to P fertilization irrespective of greengram intercrop and higher millable cane yield was recorded with the application of recommended dose of P

Table 1. Yield attributes, grain yield (t/ha), biological yield (t/ha), total P uptake (kg/ha) and available P in soil (kg/ha) after harvest of *kharif* rice as influenced by phosphorus management

Treatment	Panicles/m^2		Filled grains/ panicle		Grain yield (t/ha)		Total P uptake (kg/ha)		Available P in soil (kg/ha)	
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
No phosphorus	336.3	300.0	92.15	89.15	4.63	4.57	6.97	6.80	10.84	7.24
PB @ 20 t/ha	385.0	350.0	109.15	114.00	5.21	5.13	9.24	9.20	14.53	9.17
PB @ 40 t/ha	390.0	367.5	115.63	119.20	5.41	5.24	9.72	9.79	15.41	9.74
Single super phosphate @ 13.2 kg P/ha	375.0	335.0	107.63	105.70	5.04	4.96	8.55	8.21	12.77	7.89
SEm±	30.0	13.8	4.77	6.85	0.15	0.14	0.44	0.38	0.50	0.38
CD (P=0.05)	NS	44.15	15.26	NS	0.47	0.45	1.41	1.20	1.60	1.23

PB: Pressmud biocompost

(RDP). These findings support those of Kumar *et al.* (2004) and Patel *et al*. (2004). Sugarcane raised without intercrop of greengram recorded significantly higher millable cane yield as compared to sugarcane raised with intercrop at same level of phosphorus applied to sugarcane during both the years. The low cane yield under intercropping system may be due to less tillering and number of millable canes due to shading effect of intercrop at early stages of crop growth. These results are in accordance with Patel (2000). However, the sugarcane equivalent yield was found significantly higher under application of recommended dose of P/ha with intercrop during both the years except application of recommended dose of P/ha without intercrop during 2004-05. Application of higher level of phosphorus to sugarcane not only increased the millable cane yield but also increased the seed yield of intercrop of greengram, which lead to higher sugarcane equivalent yield under sugarcane-greengram intercropping system. At the same level of phosphorus, sugarcane raised with intercrop of greengram recorded higher sugarcane equivalent yield than sugarcane raised without intercrop of greengram during both the years. It clearly indicated that intercropping of greengram very well compensated the reduction in the sugarcane yield. Higher sugarcane equivalent yield of intercropping system might be due to additional yield from intercrop with good market price. These results are in accordance with the findings of Patel (2003).

Economics

The net realization from rice-sugarcane cropping system increased significantly with application of PB @ 40 t/ha to preceding rice crop over other treatments during both the years but was at par with that of 20 t/ha. It might be due to higher yield of crops under these treatments. The net realization as well as benefit:cost ratio from rice-sugarcane cropping system increased significantly with successive increase in phosphorus levels applied to sugarcane raised with or without intercrop of greengram (Table 3). Application of recommended dose of P/ha to sugarcane raised with and without intercrop of greengram recorded significantly higher net realization than other levels of phosphorus. Prajapati (2008) also reported that raising green manure dhaincha before planting sugarcane with application of pressmud @ 15 t/ha or 10 t/ha + rock phosphate @ 0.5 t/ha, coupled with 50 or 75% RD of P along with setts treatment of PSB to sugarcane seems to be

Table 2. Single cane weight, number of millable cane/ha, millable cane yield (t/ha), seed yield of intercrop (t/ha), sugarcane equivalent yield (t/ha), total P uptake (kg/ha) and available P in soil (kg/ha) after harvest of sugarcane as influenced by different treatments

Treatment	NMC ($x10^3$/ha)		Millable cane yield (t/ha)		Seed yield of Intercrop(t/ha)		Sugarcane equivalent yield (Sugarcane + Paddy) (t/ha)		Total P uptake (kg /ha)		Available P in soil (kg/ha)	
	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06	2004-05	2005-06
Residual effect of P management in preceding kharif rice												
No phosphorus	92.9	80.4	92.7	87.8	0.604	0.981	96.91	94.81	34.1	30.1	10.2	7.4
PB @ 20 t/ha	94.9	85.0	101.5	101.2	0.802	1.022	107.03	108.48	40.3	35.9	13.0	8.5
PB @ 40 t/ha	95.7	86.5	108.6	107.8	0.858	1.056	114.55	115.35	42.6	38.1	14.2	9.5
Single super phosphate @ 13.2 kg P/ha	94.3	83.8	96.6	94.6	0.799	1.012	102.17	101.80	37.1	33.6	11.0	8.1
SEm±	1.7	1.4	2.2	2.0	-	-	2.29	2.09	1.2	0.7	0.4	0.2
CD (P=0.05)	NS	NS	7.1	6.2	-	-	7.31	6.68	3.8	2.3	1.2	0.7
Phosphorus levels with and without intercrop applied to succeeding autumn sugarcane												
Zero kg P/ha, without greengram	91.9	80.1	91.4	86.6	-	-	91.44	86.63	23.8	21.9	10.1	6.5
Zero kg P/ha, with greengram	90.6	77.8	86.0	79.4	0.669	0.944	95.30	92.81	29.1	24.7	11.2	7.3
50% recommended P/ha, without greengram	95.4	85.1	103.5	102.1	-	-	103.48	102.13	36.6	32.2	11.9	7.6
50% recommended P/ha, with greengram	94.6	83.9	95.8	94.4	0.727	1.027	105.93	109.10	39.2	35.2	12.8	9.1
100% recommended P/ha, without greengram	98.1	88.6	115.4	116.8	-	-	115.35	116.75	49.0	44.5	12.6	9.3
100 % recommended P/ha, with greengram	96.0	88.0	107.0	107.9	0.901	1.083	119.49	123.30	53.5	48.0	13.9	10.5
SEm ±	1.6	2.1	2.5	1.7	-	-	2.47	1.68	1.3	1.2	0.4	0.3
CD (P=0.05)	4.5	6.0	7.0	4.8	-	-	6.98	4.75	3.6	3.3	1.1	0.9

NMC : Number of millable cane; Recommended P/ha : 54.6 kg; PB : Pressmud biocompost

Table 3. Net realization (₹/ha) and benefit : cost ratio of *kharif* rice-autumn sugarcane cropping system as influenced by different treatments

Treatment	Cost of cultivation (×10³/ha)		Net realization (×10³/ha)		Benefit : cost ratio	
	2004	2005	2004	2005	2004	2005
Residual effect of P management in preceding kharif rice						
No phosphorus	68.6	74.5	104.6	120.9	1.52	1.62
PB @ 20 t/ha	74.2	80.1	117.9	142.5	1.57	1.78
PB @ 40 t/ha	79.8	85.7	123.8	149.3	1.55	1.74
Single super phosphate @ 13.2 kg P/ha	69.4	75.2	111.9	134.3	1.64	1.79
SEm ±			3.3	4.3	0.05	0.05
CD (P=0.05)			10.4	13.6	NS	NS
Phosphorus levels applied to succeeding autumn sugarcane						
Zero kg P/ha, without greengram	69.9	75.6	98.4	109.0	1.41	1.44
Zero kg P/ha, with greengram	73.7	79.6	100.2	115.4	1.36	1.45
50 % recommended P/ha, without greengram	71.1	76.8	114.5	133.9	1.61	1.74
50 % recommended P/ha, with greengram	74.9	80.9	114.2	141.6	1.53	1.75
100 % recommended P/ha, without greengram	72.4	78.1	130.4	157.3	1.80	2.01
100 % recommended P/ha, with greengram	76.2	82.1	132.5	164.3	1.74	2.00
SEm±	–	–	3.6	2.8	0.05	0.04
CD (P=0.05)	–	–	10.1	8.0	0.14	0.10

NB 1: Selling price of rice grain were 5.93 and 6.5 ₹/kg; rice straw were 1.0 and 1.0 ₹/kg, while sugarcane millable cane were 1,440 and 1,686 /t and green gram seed 20 and 24 ₹/kg during the year 2004 and 2005, respectively.
NB 2: 100% recommended P/ha was 54.6 kg P/ha and PB: Pressmud biocompost

most economical cropping sequence.

Thus, on the basis of net realization and benefit: cost ratio, it could be concluded that in rice-sugarcane cropping system, the rice crop should be fertilized with 20 t/ha pressmud biocompost only and sugarcane crop raised without or with intercrop of greengram 'Co. 4' should be fertilized with recommended dose of P/ha i.e. 55 kg/ha to sugarcane crop only.

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