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Nutrient harvest and soil fertility as influenced by nutrient management in rice (*Oryza sativa*)–forage crop sequences

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ABSTRACT

The field experiment was conducted at Ranchi to study the effect of integrated nutrient management on nutrient removal and soil fertility under rice (*Oryza sativa* L.)–forage crop sequences during 1997-2000. The pooled results indicated that the rice as a succeeding crop to berseem (*Trifolium alexandrinum*) and higher yield when both the crops were grown at 75% recommended level of NPK + 10 tonnes FYM/ha. Application of 75% recommended level of NPK + 10 tonnes FYM/ha in both the seasons also recorded the maximum forage yield in oat (*Avena sativa* L.), followed by the oats forage harvested at 100% recommended level of NPK/ha (40 kg N + 8 kg P + 6 kg K for upland rice, 25 kg N + 24 kg P + 24 kg K for berseem and 100 kg N + 16 kg P + 24 kg K for oat) applied through fertilizers only. Alike oat forage, berseem also gave the maximum forage yield under the same fertility treatment. Rice harvested after berseem removed higher quantity of NPK them rice harvested after oat. Among forage components, berseem gave higher NPK yield than oat, while rice-berseem sequence as a whole removed the maximum quantity of NPK. The balance sheet of nutrients further indicated maximum recovery of these nutrients under cereal-cereal sequence compared to cereal-legume. A definite enhancement in N and P status of soil to its initial level was noticed but the trend was reversed in case of K build-up which indicated some additional application of K in these crops.

Key words : Soil fertility, Yield, Rice-oat, Rice-berseem sequence

Crops differ in their physical and chemical effect on the media in which they are grown and continuous use of fertilizers while growing exhaustive crops impair the soil fertility. Therefore, integration of organic sources of nutrients with fertilizers and inclusion of a legume in general and forage legume in particular in a cropping sequence may take care of soil health and would also give stable yield and help to save chemical fertilizers. Introduction of a forage component can also bridge the gap

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between demand and supply of forages to our dairy industry. Thus the present experiment was planned to assess the beneficial effect of organic matter and forage components on succeeding rice and their ultimate effect on soil productivity and fertility.

MATERIALS AND METHODS

The experiment was conducted at Ranchi, Jharkhand, during the rainy season (*kharif)* and (*rabi)* season, of 1997-2000. The soil was silt loam (sand 38.25%, silt 50.92% and clay 10.83%) and poor in fertility (available N 210 kg/ha, available P 12.2 kg/ha and exchangeable K 141 kg/ha) and acidic (pH 5.9). The total annual rainfall during the crop period of 1997-98, 1998-99 and 1999-2000 were 2,272.4 mm, 1,547.6 mm and 2,027.9 mm respectively.

The treatments consisted of 2 sequences, viz. 'Brown Gora' rice– 'Kent' oat and 'Brown Gora' rice– 'Mescavi' berseem in main plots and 100% N, P and K/ha in *kharif* and *rabi* (F_1), 75% NPK/ha in *kharif* and *rabi* + 10 tonnes FYM/ha in *kharif* only (F_2), 75% NPK/ha in *kharif* and *rabi* + 10 tonnes FYM/ha in *rabi* only (F_3) and 75% NPK/ha in *kharif* and *rabi* + 10 tonnes FYM/ha in *kharif* and *rabi* (F_4) in subplots. Thus 8 treatments combinations were put in split-plot design and replicated thrice. The net plot size was 3.5 m × 2.5 m with 25 cm row-to-row spacing for all 3 crops.

A composite soil sample (top 15 cm depth), before the experiment started and later on, of each subplots after the harvest of individual crops were collected. Organic carbon, available N, P and K of the soil along with N, P and K contents of plant samples were analysed by standard procedures and computed for total nutrients harvest based on concentration and dry-matter yield. The grain and straw yields of food crops, while dry-matter yield of forage crop were recorded. Thus total nutrients added, nutrients removed by crops and balance of the same in soil system were also computed after completion of the 3 years crop sequence.

RESULTS AND DISCUSSION

Rice yield

Grain and straw yields of rice (Table 1) indicated a clear advantage of growing rice after berseem. The beneficial effect of berseem was recorded during all the 3 years as well as in pooled yields over rice harvested after oat. This might be due to fixation of atmospher N by berseem. Prasad and Kerketta (1991) also reported beneficial effect on succeeding rice due to berseem under the same agro-climatic conditions.

The effect of cropping sequence and nutrient-management system as well as their interactions revealed that application of FYM in both the seasons with 25% cut in chemical sources of nutrient gave the highest yield of rice due to creation of better soil environment conditions but the residual effect of FYM on rice yield was not very apparent, might be due to burning of organic matter under high temperature conditions during summer season (Khan *et al.,* 1982).

Oat and berseem yield

Cereal forage crop grown after rice gave higher green forage yield than legume

Table 1. Yields and nutrient harvest as influenced by cropping sequences and fertility management (pooled data of 3 years)

Treatment	Rice yield (q/ha)		Forage yield (q/ha)		Nutrient harvest (kg/ha)		
	Grain	Straw	Green	Dry	N	P	K
Sequence							
Rice-oats (S_1)	16.2	32.3	390.2	78.3	104.7	37.2	170.4
Rice-berseem (S_2)	18.8	37.2	331.6	52.1	160.2	37.5	158.8
CD (P=0.05)	0.69	1.46	4.43	1.46	2.92	NS	5.80
Fertility							
F_1	16.6	33.2	317.8	57.9	118.3	34.3	152.6
F_2	18.2	36.0	332.0	59.6	120.2	34.2	156.5
F_3	15.0	30.3	386.8	64.1	135.3	35.8	160.7
F_4	20.4	39.5	407.0	74.3	156.2	42.6	189.4
CD (P = 0.05)	0.75	1.03	2.06	0.96	2.31	1.32	2.56
Sequence fertility							
S_1F_1	14.8	29.9	360.2	72.9	98.3	34.3	156.2
S_1F_2	17.0	33.7	364.6	73.3	98.3	34.3	156.2
S_1F_3	13.9	28.1	407.3	82.4	109.0	36.6	167.9
S_1F_4	19.1	37.7	428.9	84.6	117.5	40.5	193.8
S_2F_1	18.3	36.6	275.5	42.9	139.3	34.3	149.0
S_2F_2	19.3	38.2	299.2	45.8	142.0	34.2	149.2
S_2F_3	16.2	32.6	366.3	55.8	164.4	35.0	153.6
S_2F_4	21.7	41.4	385.2	64.0	195.1	41.7	183.5
CD (P=0.05)	0.79	1.46	2.92	1.36	2.65	2.22	3.60

F_1, 100% NPK/ha in *kharif* and *rabi*; F_2, 75% NPK/ha 10 tonnes FYM/ha in *kharif* only; F_3, 75% NPK/ha 10 tonnes FYM/ha in *rabi* only; F_4, 75% NPK/ha 10 tonnes FYM/ha in *kharif* and *rabi*

forage (Table 1). The same hold good in dry herbage production too. This might be due to higher dry-matter concentration in oat in relation to berseem. Dubey *et al.* (1997) also reported beneficial effect of integrated nutrient management of cereal grown after rice.

Nutrient harvest

Nitrogen harvest : Rice-berseem sequence removed the maximum quantity of N, being 53.3% higher than cereal-cereal sequence (Table 1). The integration of nutrient also showed a marked influence on N recovery. Addition of FYM in both the seasons with 75% recommended dose of NPK in respective crops removed the highest quantity of N during different years. As a result 156.2 kg N/ha year was harvested which was significantly superior to N recovered by the crops under rest of the fertility treatments. The sequence having grain legume in general and forage legume in particular removed higher quantity of N (Deca and Singh, 1984; Prasad and Kerketta 1991).

Phosphorus harvest : Phosphorus recovery by different crops and cropping

sequences was significant; however these differences were not found in pooled result. Rice as a succeeding crop to berseem removed higher quantity of P. The recovery by oat and berseem varied due to variation in yield (Table 2). Application of 75% NPK through fertilizers + 10 tonnes FYM/ha in both the crops resulted in maximum harvest of P.

The interaction of sequence with fertility treatment further revealed that either rice-oat or rice-berseem sequence at 75% inorganic source of NPK combined with 10 tonnes FYM/ha in both the crops computed

Table 2. Balance sheet of nutrient (kg/ha) after three years of cropping sequences

Treatment	Initial available soil nutrient + added through fertilizer (kg/ha) A	Nutrient harvest (kg/ha) B	Nutrient in balance (expected value (kg/ha) A – B = X	Final available soild nutrients (actual values) (kg/ha) C	Change of nutrients lost or gain (+) (kg/ha) C – X
Nitrogen					
S_1F_1	711.0	295.0	416.0	235.3	– 180.7
S_1F_2	738.0	295.1	442.9	240.6	– 202.3
S_1F_3	888.0	327.1	560.9	291.3	– 509.6
S_1F_4	1038.0	352.6	585.9	260.3	– 425.1
S_2F_1	711.0	418.1	293.0	240.0	– 53.0
S_2F_2	738.0	426.1	311.9	245.0	– 66.9
S_2F_3	888.0	493.2	394.8	252.0	– 142.8
S_2F_4	1038.0	585.3	452.7	262.0	– 190.7
Phosphorus					
S_1F_1	327.5	103.0	224.5	32.0	– 192.5
S_1F_2	409.2	103.0	306.2	23.0	– 283.2
S_1F_3	372.2	109.8	262.4	26.0	– 236.4
S_1F_4	332.2	121.7	210.5	30.0	– 180.5
S_2F_1	327.5	37.2	290.3	31.0	– 259.3
S_2F_2	409.2	102.6	306.6	24.0	– 282.6
S_2F_3	372.2	105.0	267.2	26.0	– 241.6
S_2F_4	332.2	125.1	207.1	27.0	– 180.1
Potash					
S_1F_1	321.6	429.3	– 107.7	125.0	+ 17.3
S_1F_2	426.6	451.7	– 65.1	117.0	+ 51.9
S_1F_3	576.6	503.7	72.9	114.6	+ 41.7
S_1F_4	726.6	581.5	145.1	118.6	– 26.5
S_2F_1	321.6	447.1	– 125.5	127.0	+ 1.5
S_2F_2	426.6	447.7	– 21.1	114.3	+ 93.2
S_2F_3	576.6	460.9	115.7	112.0	– 3.7
S_2F_4	726.6	550.7	175.9	120.0	– 55.9

"Initial soil N, 216 kg/ha; P, 12.2 kg/ha and K, 141.6 kg/ha

for higher quantity of P recovery.

Potassium harvest : The sequence comprising cereal food and forage crops recovered the maximum K (Table 2), which has also accounted for higher gain of potash than the sequence having forage legume component. In the interaction, rice-oat sequence, taken at recommended level of NPK nutrients with 10 tonnes FYM in both crops harvested the maximum quantity of K which was significantly superior to nutrients removed by rest of the treatments. Cereal-cereal sequence removed the maximum quantity of K due to its higher concentration in cereal compared to legume. Higher recovery of K by cereal crops than legumes might be due to higher yield of the crop and higher concentration of the nutrient (Prasad and Kerketta, 1991).

Balance-sheet of nutrients : Balance of N in rice-berseem sequence in presence of organic matter harvested maximum quantity of N which enhanced the available soil N (Table 2). A general build-up in fertility (N) due to berseem to its initial level was very apparent. The change of nutrient, i.e. loss of nutrient under all the interactions was apparent with relatively low value under rice-berseem sequence as compared to corresponding value under rice-oats system. This might be due to use of self-fixed N by berseem.

A general build-up in available soil P to its initial status (Table 2) was analysed under all the sequences with different fertility management. Continuous application of fertilizer P might be the reason for enrichment in available soil P in the soil rhizosphere. A very high P-fixation under all the interactions were noticed. The higher P-fixation rate of acid Alfisols in form of Fe and Al phosphate might be the reasons for higher P-fixation.

An overdraft of K under all the interactions was computed. This was more prevalent in cereal-cereal sequence in particular and cereal-legume sequence in general due to higher extraction of K under all the systems (Table 2). From the balance sheet of K nutrient, it appeared that food-forage system required some additional quantity of K to maintain the soil K status since it has recorded a general deterioration in final soil K status of the soil to its initial level.

REFERENCES

Deka, J. C. and Singh, Y. 1984. Studies on rice-based multiple crop sequences. III. Nutrient uptake studies. *Indian Journal of Agronomy* **29** : 940–494.

Dubey, S. K., Sharma, R. S. and Vishwakarma, S. K. 1997. Integrated nutrient management for sustainable productivity of important cropping systems in Madhya Pradesh *Indian Journal of Agronomy* **42** (1) 13–17.

Khan, L.A., Rawal, D.R. and Bhatia, S.K. 1982. Effect of economising nitrogenous fertilizers through application of organic manures in a bajra-wheat-moong crop sequence. *Indian Journal of Agronomy* **27** (3) : 207–10.

Prasad, N. K. and Kerketta, R. 1991. Nutrient harvest and soil fertility in sequential cropping system. *Indian Journal of Agronomy* **36** : 36-68.

Singh, Harbir, Rana, D. S., Taneja, K. D. and Das, Bhagwan 1984. Effect of varying levels of soil salinity and organic matter application on the yield and quality of berseem forage. *Agricultural Science Digest* (2) : 77-78.