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Effect of integrated nutrient management on baby corn˘rice cropping system: economic yield, system productivity, nutrient-use efficiency and soil nutrient balance

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ABSTRACT

The study was conducted to estimate the nutrient-use efficiency and soil nutrient balance of integrated nutrient management, five combinations of organic and inorganic sources of nutrients. Both partial factor productivity and agronomic-use efficiency of nitrogen, phosphorus and potassium was recorded maximum in F_3 (70% RD of NPK through inorganic fertilizers + 30% N through FYM), F_2 (70% RD of NPK through inorganic fertilizers + 30% N through vermicompost) and F_1 (recommended dose (RD) of NPK (150:26:33) through fertilizers), respectively. Apparently recovery efficiency for N and K was highest in F_1, whereas P in F_3. Physiological-use efficiency (PFP) was highest in F_3, followed by F_1 and F_2 treatment. INM showed actual N gain but apparent N losses. Maximum actual N gain was recorded where nutrients were applied through equal proportion (50:50) of organic and inorganic sources. Similar trend was recorded for actual and apparent P loss/gain as recorded for N. Results showed losses in actual K but gain in apparent K for all the treatments.

Keywords: Baby corn, Cropping system, Nutrient balance, Nutrient-use efficiency, Rice, Soil fertility

Integrated nutrient management (INM), a combined application of organic and inorganic sources of nutrients, maintains storage of plant nutrients in soil and improves nutrients-use efficiency that is essential for sustainable crop production. Organic matter acts as a source and a sink for plant nutrients as well as provides energy substrate for soil microorganisms. Thus, it enhances activities of soil flora and fauna as well as intrinsic soil properties, soil nutrient capital, water-holding capacity and soil structure in turn makes soil less susceptible to leaching and erosion. Therefore, INM practices are essential to maintain/enhance the soil quality and sustainability of an agro-ecosystem (Carter *et al.* 2004). *Rabi* maize often face terminal drought resulted crop failure or very less productivity. It may be overcome by growing the maize for baby corn instead of grain.

Besides farmyard manure (FYM), now-a-days vermicompost is gaining attention of both the researchers and the farmers due to its immense production potential using farm. Vermicomposting is a biotechnological and mesophilic (10–32 °C) process of composting. This process is faster and safe than the conventional composting as the material passes through the earthworm gut resulting earthworm castings is rich in microbial activity and have plant growth regulators. Vermicompost can be utilized in crop production as a component of INM and as a single source of all essential crop nutrients (Bejbaruha *et al.* 2009). All nutrients in vermicompost are in readily available form, thereby, enhancing nutrients uptake by plants (Banik and Sharma 2009). Still the information on this aspect is meager therefore a study thus designed to evaluate the different nutrient management practices on productivity, nutrient-use efficiency and nutrient balance of baby corn–rice cropping system.

MATERIALS AND METHODS

The study was conducted during 2007–08 and 2008–09 at Agricultural Experimental Farm of Indian Statistical Institute, Giridih (latitude 24^0 1/15//N and longitude 86^0 3/0//E and altitude 920 feet), Jharkhand. The soil is sandy loam (sand 57.2%, silt 29.4% and clay 13.4%) having *p*H 6.2, electrical conductivity 0.32 dS/m, cation exchange capacity 9.95 $Cmol^+$/kg, organic carbon 0.59%, available nitrogen 99.05 kg/ha, phosphorus 12.74 kg/ha and potassium 171.90 kg/ha. The mean maximum temperature is generally recorded in the month of June (40–45 °C) and minimum temperature in January (2–5 °C). In eastern plateau rainfall seasonality is influenced by the south-west monsoons. The mean annual

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rainfall is about 1 349 mm of which 82% occurs within the monsoon period (June–September). There are, on an average, about 80 rainy days in a year. Normally the south-west monsoon starts in mid-June and ceases at the end of September. Relative humidity ranges from 78 to 95%. Annual potential evapotranspiration (PET) is 1 293 mm. The mean daily evaporation (Class 'A' pan evaporimeter) reaches to maximum of 12–15 mm/day in June and minimum of 0.5–0.7 mm/day in January. The mean wind velocity varies from 3.5 km/hr during October to 6.4 km/hr during April.

The experiment was laid out in a factorial randomized block design replicated thrice. Six nutrient management practices namely, F_0: Absolute control (no NPK), F_1: Recommended dose (RD) of NPK (150:26:33) through fertilizers, F_2: 70% RD of NPK through inorganic fertilizers + 30% N through vermicompost, F_3: 70% RD of NPK through inorganic fertilizers + 30% N through FYM, F_4: 50% RD of NPK through inorganic fertilizers + 50% N through vermicompost, F_5: 50% RD of NPK through inorganic fertilizers + 50% N through FYM. Required amount of vermicompost ($N:P_2O_5:K_2O$ 1.75:0.75:0.86) and FYM ($N:P_2O_5:K_2O$ 0.51:0.25:0.49) as per treatment was incorporated in the soil at the time of last ploughing. One-third of the N and the entire amount of P and K as per treatment were applied as basal and remaining amount of N was given into two equal splits. After harvest of baby corn (early composite), Aditya rice was raised with residual soil fertility. Plot size was 5 m × 4 m.

Field was ploughed after 2–3 days of pre-sowing irrigation with power-tiller in a crisscross manner followed by planking. Overnight water-soaked seeds of baby corn were sown at a depth of 3–5 cm below soil surface in a spacing of 60 × 10 cm (row × plant). Baby corn was sown on 30 November and 9 December and baby cobs were finally hand-plucked (6–7 times) on 18 February and 27 February in 2007–08 and 2008–09, respectively. After the harvet of baby corn, 20–22 days old rice seedlings were transplanted manually at 20 × 15 cm spacing. Rice sedlings were transplanted on 17 June and 4 June and harveted on 10 September and 31 August of 2008 and 2009 respectively. Weeding was carried out twice for baby corn; first weeding at 25 DAS and second at 45 DAS, whereas once for rice (at 30 days after sowing) to keep the crops weeds free and to ensure proper aeration. Baby corn received two life-saving irrigations; first at grand growth period and second one at tassel initiation while rice did not.

Cleaned cobs and plant samples were oven-dried at 60±5 ^{0}C. The dried samples were ground in a Willy mill, passed through 40-mesh sieve. Plant N, P and K were estimated following the methods as advocated by Jackson (1973). Soil samples were collected from each plot after crops harvest from 0-20 cm depth, air dried and sieved (2 mm mesh). Soil organic carbon was analyzed by the wet oxidation method (Walkley and Black 1934). Soil available nitrogen, phosphorus and potassium were estimated by alkaline potassium permanganate (Subbiah and Asija 1956), sodium bicarbonate (Olsen *et al.* 1954) and ammonium acetate (Hanway and Heidel 1952) method respectively.

The data collected on different parameters were subjected to statistical analysis following the procedure described by Cochran and Cox (1992). Significance of difference between means was tested through 'F' test and the critical difference (CD/LSD) was worked out where variance ratio was found significant for treatment effect. The treatment effects were tested at 5% confidence level for their significance.

The nitrogen (N)-use efficiencies were computed with the formulae given below:

Agronomic-use efficiency (kg grain/kg N applied) = $(Y_t - Y_o)/N_a$

Physiological use efficiency (kg grain/kg N uptake) = $(Y_t - Y_o)/(U_t - U_o)$

Apparent recovery (%) = $[(U_t - U_o)/\times 100]/N_a$

Partial factor productivity (kg grain/kg N applied) = Y_t/N_a

Where: Y_t = Grain yield in the test treatment (kg/ha)

Y_o = Grain yield in the control plot (kg/ha)

U_t = Uptake of N in the test treatment (kg/ha)

U_o = Uptake of N in the control plot (kg/ha)

N_a = N applied to the test treatment (kg/ha)

Phosphorus and potassium-use efficiency was computed in a similar way as that of N-use efficiency.

RESULTS AND DISCUSSION

Economic yield and system productivity

Baby corn yielded maximum cobs with the supply of 100% nutrient through inorganic sources while rice produced maximum grain yield when the preceding baby corn received nutrients through organic and inorganic (50:50) sources (Table 1). Baby corn (dehusked) equivalent yield (BCEY) was computed based on MSP/selling price of the crops. Total system productivity (BCEY) was significantly influenced by the INM practices (Table 1). Thirty per cent of N substituted with organic sources and the rest 70% RD of NPK applied through inorganic sources, followed by 100% RD of NPK applied through inorganic sources registered maximum BCEY. The sources of organic manures did not have any significant impact on system productivity.

System productivity depends upon management practices that cannot accomplish the present demand of the crop but also carry forward sufficient amount of nutrients capital for the follow-up crop. This could be the cause for obtaining maximum total productivity of the system, BCEY, where 30% RD of N was substituted through organic manures. Baby corn produced maximum cob yield under this treatment, only next to 100% inorganic, followed by higher grain yield of follow-up rice. Mahavishnan *et al.* (2005) and Gaur *et al.* (1984) also reported that when FYM was applied at less than 30% N, about 60–70% P and 75% K become available to the

Table 1 Effect integrated nutrient management on dehusked cob yield of baby corn, grain yield of rice and baby corn equivalent yield (BCEY) of the system

Treatment	Deusked cob yield (Mg/ha)		Grain yield (Mg/ha)		BCEY (Mg/ha)	
	2007–08	2008–09	2007–08	2008–09	2007–08	2008–09
F_0	0.51	0.52	1.99	2.03	0.68	0.70
F_1	0.83	0.84	2.36	2.42	1.04	1.06
F_2	0.79	0.82	2.86	2.97	1.06	1.09
F_3	0.77	0.79	2.87	3.01	1.07	1.11
F_4	0.74	0.78	3.05	3.11	0.97	1.01
F_5	0.73	0.76	3.06	3.18	0.98	1.02
SEm±	0.015	0.017	0.04	0.04	0.10	0.09
LSD (P= 0.05)	0.030	0.034	0.08	0.09	0.21	0.19

Selling/MSP of baby corn ₹ 80 and 82/kg and rice ₹ 7 and 8.5/kg in 2008 and 2009 respectively

Treatment details are given in material and methods

immediate follow-up crop. Thus, higher rice grain yield might be due to higher residual soil fertility built-up by organic manure. The results are in conformity with the findings of Banik and Sharma (2009) and Bejbaruha *et al.* (2009).

Nutrient-use efficiency

Partial factor productivity; The PFP of the system remarkably varied with the treatments. The PFP of N was highest in the fertilizer treatment F_3, whereas PFP of P and K were highest in the treatment F_2 (Fig 1a). However, PFP of all three nutrients (NPK) were recorded least in the treatment F_5. Treatments where N was substituted through vermicompost had higher values of PFP of all the three nutrients as compared to the treatments where N was substituted through FYM.

Apparent recovery efficiency: Thirty per cent RD of N substituted through organic sources had higher values of ARE of N, while 100% RD of NPK applied through inorganic sources showed higher values of ARE of P and K (Fig 1b). On the contrary, INM treatments registered lower values of ARE of the nutrients, being lowest in treatment F_5. Overall, in the respect of ARE, N substituted through FYM was inferior to vermicompost.

Agronomic-use efficiency: The AUE of NPK remarkably varied with nutrient management practices. Overall, its values for N and P were higher in INM treatments where 30% N was substituted with organic manure and the rest 70% RD of NPK through inorganic sources (Fig 1c). Values of AUE for K were highest in treatment F_1 and F_2 in 2007 and 2008

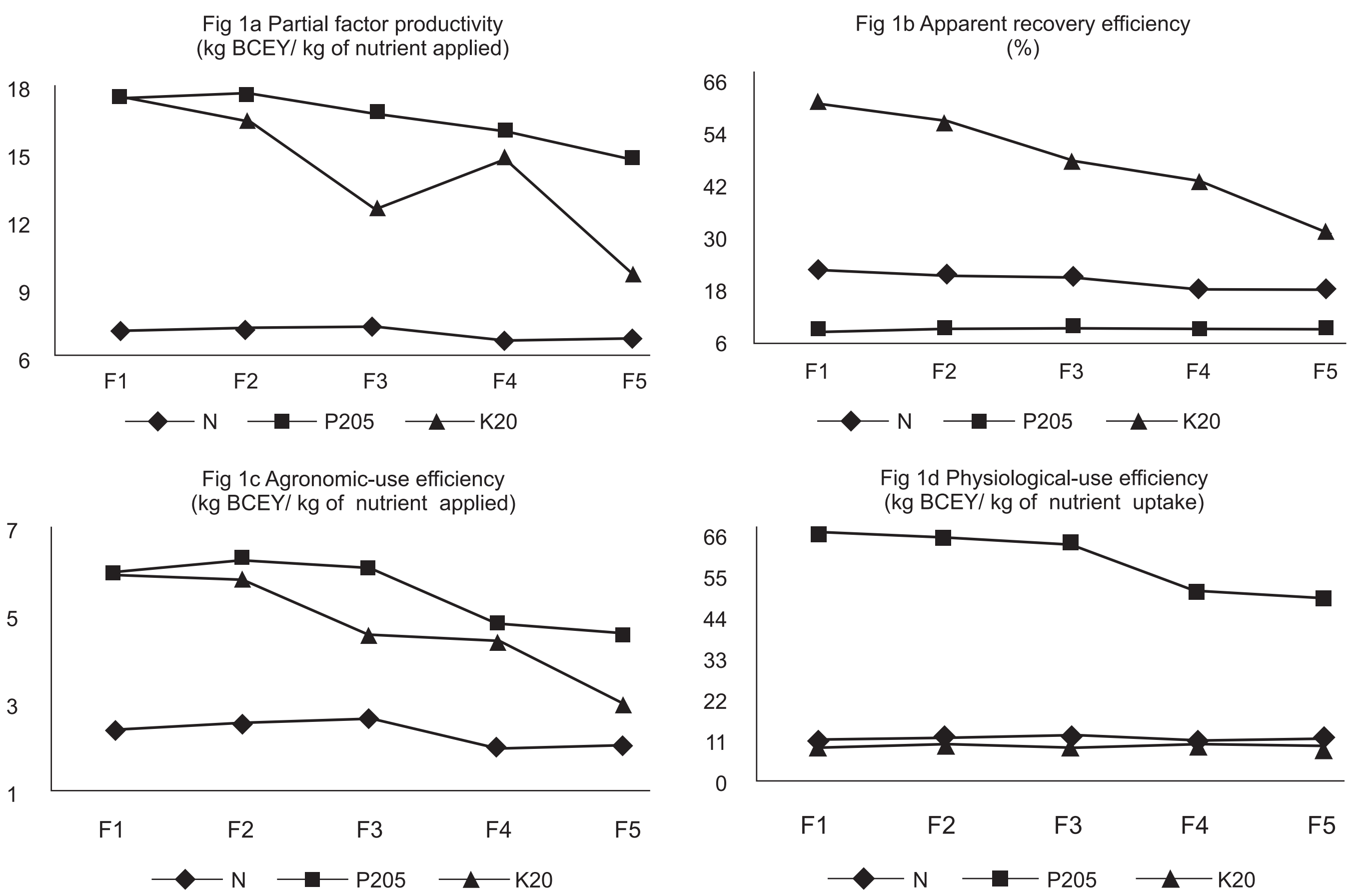

Fig. 1 Nutrients-use efficiency as influence by the integrated nutrient management

respectively. Fifty per cent RD of N exchanged with organic sources showed least values of AUE of NPK. N substituted through FYM was superior superiority in terms of AUE of N, but inferior in terms of PK to vermicompost treatment.

Physiological-use efficiency: This parameter also varied with the treatments. The PUE of NP was highest where 30% RD of N substituted through organic sources; while K was maximum where 50% RD of N substituted through organic sources and the rest 50% RD of NPK was applied through inorganic sources (Fig 1d). N substituted through vermicompost was superior to FYM in respect of PUE.

Soil nutrients balance: Soil nutrient balance, calculated for the system, was remarkably influenced by the baby corn cultivars and integrated nutrient management practices (Table 2). Results showed apparent and actual N loses among all three baby corn cultivars in both the years, being lowest in the cultivar V_2. Apparent and actual P loses was minimum in the cultivar V_1. All three cultivars showed actual K losses, but there was gain in apparent K. Integrated nutrient management treatments showed actual N gain but apparent N losses which were recorded maximum in control treatment followed by NPK supplied through 100% inorganic sources treatment. Maximum actual N gain was recorded where nutrients were applied through equal proportion (50:50) of organic and inorganic sources. Losses of apparent N were recorded in all the treatments except absolute control; however, losses were minimum where nutrients applied through organic and inorganic sources equally (50:50). Similar trend was recorded for actual and apparent P loss/gain as recorded for N. Results showed losses in actual K but gain in apparent K for all the treatments.

Table 2 Soil nutrient balance as influenced by the integrated nutrient management

Treatment	A	B	C	D	(A+B)-C= X	(D-A) =Y	(D-X) = Z
Nitrogen							
F_0	99.1	0	102.4	80.7	-3.4	-18.3	84.1
F_1	99.1	150	140.3	90.1	108.7	-9.0	-18.6
F_2	99.1	150	142.6	99.2	106.5	0.2	-7.3
F_3	99.1	150	141.9	102.8	107.2	3.8	-4.4
F_4	99.1	150	137.9	108.0	111.2	8.9	-3.2
F_5	99.1	150	136.3	112.3	112.8	13.2	-0.5
Phosphorus							
F_0	12.7	0	14.4	8.2	-1.6	-4.6	9.8
F_1	12.7	26	20.7	10.5	18.3	-2.3	-7.9
F_2	12.7	27	22.1	11.0	17.4	-1.8	-6.5
F_3	12.7	28	22.6	11.4	18.6	-1.5	-7.3
F_4	12.7	27	22.4	12.8	17.5	0.1	-4.7
F_5	12.7	30	22.8	13.4	19.7	0.6	-6.4
Potassium							
F_0	171.9	0	140.6	137.4	31.4	-34.5	106.1
F_1	171.9	33	171.7	142.6	33.3	-29.4	109.3
F_2	171.9	36	177.6	146.8	30.1	-25.1	116.7
F_3	171.9	48	182.4	148.9	37.4	-23.1	111.5
F_4	171.9	37	171.5	154.6	37.3	-17.4	117.3
F_5	171.9	57	175.8	155.4	53.4	-16.6	102.0

A, Initial available soil fertility (kg/ha); B, nutrients added (kg/ha); C, nutrients uptake by the system (kg/ha); D, final available nutrients after harvest of rice (kg/ha); X, expected nutrients balance (kg/ha); Y, actual gain/loss (kg/ha); Z, apparent gain/loss (kg/ha)

Treatment details are given in material and methods

In general, efficiency is defined as the amount of production per unit of resource used, i e amount of dry matter produced per unit of nutrient applied or absorbed. Under the field conditions, the economic part of the plant is the best criteria to calculate the nutrient-use efficiency, and agronomic efficiency is the most appropriate to express the nutrient-use efficiency. Physiological and apparent recovery efficiency can be combined to obtain agronomic efficiency. The PFP of N was highest where 30% RD of N supplied through organic sources and rest 70% RD of NPK applied through inorganic sources might be due to synchronized nutrients supply for a longer period. While PFP of P and K were recorded maximum where 30% RD of N supplied through vermicompost and rest 70% RD of NPK applied through inorganic sources because of higher productivity coupled with higher price of baby corn. Since higher amount of P and K supplement as well as lower production potential of baby corn in INM (50:50, organic and inorganic) may have sown least PFP of all three nutrients (NPK). FYM-treated plots received higher amount of nutrients and consequently recorded lower PFP of all three nutrients. Same arguments are also true regarding ARE, quantity of nutrient absorbed per unit of nutrient applied. The AUE, economic production obtained per unit of nutrients applied, of N and P were higher where 30% N was substituted with organic manure and rest 70% RD of NPK through inorganic sources mainly due to synchronized nutrients supply for a longer period. Since AUE influenced by both crop productivity and nutrients applied as well, 50% RD of N exchanged with organic sources had shown least values of AUE of NPK as it had lowest BCEY apart from supply of higher nutrients. N substituted through FYM supplied higher P and K; therefore, it showed inferiority in AUE of P and K. The PUE, production obtained per unit of nutrients absorbed, of NP were highest where 30% RD of N substituted through organic sources as explained for AUE.

Nutrient use efficiency (PFP, ARE, AUE and PUE) was higher due to substitution of 30% N through organic manures, either FYM or vermicompost, and rest 70% RD of NPK applied through inorganic sources. Whereas 50% N substituted through organic manures and 50% RD of NPK supplied through inorganic sources parked maximum nutrient in the soil. It may be concluded that 30% RD of N can be substituted with organic manures through sources, FYM or vermicompost, without compromising the system productivity and soil fertility.

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