

## Effect of integrated nitrogen management techniques on productivity, nitrogen uptake, N-use efficiency, economics and energetics of rice (*Oryza sativa*)–Indian mustard (*Brassica juncea*) sequence

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Received: November 2005

### ABSTRACT

A field study was conducted during 2000–01 and 2001–02 at the Indira Gandhi Agricultural University, Raipur, to evaluate the productivity, N uptake, N-use efficiency, economics and energetics of rice (*Oryza sativa* L.)–Indian mustard [*Brassica juncea* (L.) Czern. & Coss.] cropping system under different nitrogen management techniques. The total productivity of the cropping system in terms of rice-yield equivalent was the highest under 100% recommended dose of nitrogen (RDN) blended with FYM applied in rainy (*kharif*) (113.28 q/ha) and winter (*rabi*) seasons (102.12 q/ha). The N uptake and N-use efficiency for rice and Indian mustard crops were also higher under 100% RDN blended with FYM. Highest net returns and benefit : cost ratio were also observed under 100% RDN blended with FYM applied in rainy and also in winter season. This treatment could bring in 31.9 and 3.8% higher net returns over 100% RDN when applied in rainy season and winter season respectively. The 100% RDN blended with FYM applied in rainy or winter season showed the higher energy output values and application of this treatment in rainy season also recorded the highest energy-use efficiency and output:input ratio. However, in winter energy-use efficiency and output : input ratio under this treatment were low.

**Key words:** Blending, *Azospirillum*, Productivity, Net return, Benefit : cost ratio, Energy-use efficiency

In high rainfall regions of eastern India, rice is commonly grown during the rainy season. After rice, Indian mustard is traditionally grown as an economically viable cropping system for higher crop productivity. Sustenance of the productivity of rice-based cropping systems necessitates the integrated use of organic, bio-organic and inorganic sources of nutrients (Sharma *et al.*, 2001). Integrated nitrogen nutrition to rice–Indian mustard crop sequence can be met through either addition of organic manures and nitrogenous fertilizers separately to soil or addition of nitrogenous fertilizer blended with organic manures.

Though studies have been made on integrated nitrogen nutrition to rice–Indian mustard crop sequence through the former approach, information on the effect of organic and bio-organic blended N fertilizer is lacking. Since urea is the principal nitrogenous fertilizer in rice-growing Asian countries, a study was undertaken to know the comparative effectiveness of organic and bio-organic blended urea on crop productivity, nitrogen uptake, nitrogen-use efficiency, energetics and economics of rice–Indian mustard cropping system.

### MATERIALS AND METHODS

A field experiment was conducted during the rainy (*kharif*) and *rabi* seasons of 2000-1 and 2001-02 at the Instructional farm of the Indira Gandhi Agricultural University, Raipur. The soil was sandy loam, neutral (pH 7.5), low in organic carbon (0.42%) and available N (190.0 kg/ha), medium in available P (13.2 kg/ha) and high in available K (315.5 kg/ha). Ten treatments (Table 1) were applied to rice 'Mahamaya' (125–130 days duration). These treatments were tested during *kharif* seasons in randomized block design with 3 replications. In the succeeding winter (*rabi*) seasons, the residual effect of *kharif* treatments (main plot treatments) and direct effect of 5 N management treatments (Table 1) as subplot treatments were studied on 'Pusa Bold' Indian mustard in split-plot design with 3 replications.

In rice, the recommended dose of N was 100 kg/ha as urea and uniform application of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O @ 60 kg and 40 kg/ha as single superphosphate (SSP) and muriate of potash (MOP), respectively. All P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O were applied basally. Nitrogen was applied in 3 equal splits —

A part of Ph.D. Thesis of the first author submitted in 2002 to the Indira Gandhi Agricultural University, Raipur, Chhattisgarh  
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at transplanting, tillering and panicle-initiation stages. In 100% recommended dose of N (RDN) + 5 tonnes FYM and 80% RDN + 3 tonnes FYM, well-decomposed FYM, as per the doses was incorporated 1 day before transplanting, but in 100% RDN blended with FYM and 80% RDN blended with FYM for each split application, required quantity of N was blended with FYM @ 1 tonne/ha, followed by incubation for 48 hr prior to application. In 60% RDN blended with FYM + *Azospirillum*, blending of urea with FYM was made in similar way, but prior to blending *Azospirillum* @ 2 kg/ha was mixed with FYM only during basal application. In 100% RDN as urea:FYM:soil, these were blended for each split application by thoroughly mixing urea with equal weight of dried powdered soil and 3 times FYM followed by incubation for 48 hr prior to application. In 80% RDN blended with poultry manure urea was blended with 0.5 tonne/ha of poultry manure for each split application. In 60% RDN blended with poultry manure + *Azospirillum*, urea was blended with poultry manure as in 60% RDN blended with FYM + *Azospirillum*. In Indian mustard, blending of 50 and 100% RDN as urea was done with 1.5 tonnes FYM/ha (fresh weight) during each split, applied basally and 30 days after sowing (DAS). The blending technique followed was similar to rainy season treatments. The recommended dose of N for Indian mustard was 80 kg/ha and applied as per the treatments. Common dose of P and K was applied basally @ 40 kg P<sub>2</sub>O<sub>5</sub> and 40 kg K<sub>2</sub>O/ha through SSP and MOP respectively. The FYM contained 11.2% C, 0.61% N, 0.19%P, 0.53% K, 18.2% moisture; and poultry manure contained 26.5% C, 1.6% N, 0.66% P, 1.0% K, 14.6% moisture. The total amount of N received through various treatments is given in Tables 1 and 2.

The yield of mustard was converted into rice-equivalent yield on the basis of minimum support price and the system yield was computed adding both the yields. The plant samples were analysed for N content following the standard procedure and total N uptake was estimated by multiplying the content with the oven-dry weight of biological yield. The effect of treatments on agronomic efficiency was computed as suggested by Stalin *et al.* (1999).

Economics was calculated on basis of prevailing market price of inputs and minimum support price of the produce. Energy input and output was calculated using the energy equivalents as suggested by Mittal *et al.* (1985). The energy-use efficiency was calculated as per the following formula:

Energy-use efficiency  $[q/(MJ \times 10^3)] = [\text{Total produce in terms of rice-equivalent yield } (q)/\text{Energy input } (MJ \times 10^3)]$

## RESULTS AND DISCUSSION

### Productivity

Rice grain yield under 100% RDN blended with FYM

and 100% RDN + 5 tonnes FYM remained at par to each other on the basis of pooled analysis and were significantly superior to all other treatments (Table 1). The performance of 100% RDN was on a par with 80% RDN blended with FYM but was significantly superior to 80% RDN + 3 tonnes FYM, 80% RDN blended with poultry manure and 60% RDN blended with either FYM or poultry manure along with *Azospirillum*. The increase in grain yield owing to 100% RDN blended with FYM, 100% RDN + 5 tonnes FYM and 100% RDN as urea:FYM:soil over 100% RDN was 13.4, 14.2 and 8.2% respectively. Seed yield of Indian mustard was significantly higher in plots receiving 100% RDN blended with FYM during rainy (*khari*) season and remained statistically superior to all other treatments. As per pooled data, the seed yield under this treatment was 11.1 and 34.6% higher over the residual effect of 100% RDN + 5 tonnes FYM and 100% RDN respectively. However, the effect of 80% RDN blended with FYM and 100% RDN + 5 tonnes FYM were comparable, but significantly superior to 80% RDN + 3 tonnes FYM and 100% RDN. Direct application of integrated nitrogen treatments to Indian mustard resulted in the highest seed yield under 100% RDN blended with FYM, which remained significantly higher to all other treatments. Based on pooled data, the yield under this treatment was 8.1% more than that of 100% RDN. However, direct application of 50% RDN blended with FYM resulted significantly lower seed yield than 100% RDN. Superior performance of blending of inorganic N with FYM might be owing to reduced loss of N and its increased availability to crop by fixation of NH<sub>4</sub><sup>+</sup> ion with humus present in FYM (Bellakki *et al.*, 1998). Jain and Sharma (2000) also observed favourable effect of integrated N use over inorganic N in mustard.

Integration of 100% RDN blended with FYM applied in both rice and Indian mustard recorded the highest total productivity of rice-Indian mustard cropping system compared with rest of the treatments applied in respective crops. The second best combination in respect of this parameter was 100% RDN + 5 tonnes FYM applied in rainy season and 100% RDN applied during winter. This was followed by 80% RDN blended with FYM applied during rainy season and 50% RDN blended with FYM applied during the winter season. The least total productivity was noted under no-nitrogen treatment. Superior performance under 100% RDN blended with FYM applied in both rice and Indian mustard could be attributed to slowed down of urea hydrolysis by addition of N-enriched manure, thereby maintained a higher level of available N in soil for a longer period than the fertilizer alone (Prasad and Singhania, 1989). Similar results were obtained in rice-Indian mustard cropping system from combined application of FYM with urea at an equivalent N basis (Singh *et*

**Table 1.** Effect of integrated nitrogen management techniques on productivity and N uptake by rice–mustard cropping sequence (mean data of 2 years)

Treatment	Total amount of N applied	Productivity (q/ha)			N uptake (kg/ha)	
		Rice	Indian mustard	Rice equivalent	Rice	Indian mustard
<i>Rainy season (Rice)</i>						
No N		37.73	8.83	62.44	55.9	32.07
100% RDN	100.0	55.61	13.33	92.93	93.0	49.89
100% RDN + 5 tonnes FYM	125.0	63.53	16.15	104.93	115.0	69.36
80% RDN + 3 tonnes FYM	115.0	51.59	14.34	91.74	80.2	57.51
100% RDN blended with FYM	115.0	63.05	17.94	113.28	110.5	76.53
80% RDN blended with FYM	95.0	55.51	15.61	99.23	85.0	63.24
60% RDN blended with FYM + <i>Azospirillum</i>	90.0	51.42	13.16	88.25	76.8	51.37
100% RDN as urea:FYM:soil	101.5	60.17	13.70	98.54	103.8	51.59
80% RDN blended with poultry manure	100.5	50.96	13.91	89.91	78.3	55.31
60% RDN blended with poultry manure + <i>Azospirillum</i>	105.5	51.47	12.83	87.38	76.5	49.38
CD (P=0.05)		3.17	1.00	2.81	6.3	3.61
<i>Winter season (Indian mustard)</i>						
No N			9.10	79.21		34.45
50% RDN	40.0		13.38	91.17		55.08
50% RDN (blended with FYM)	65.0		14.15	93.33		54.83
100% RDN	80.0		15.99	98.49		65.15
100% RDN blended with FYM	105.0		17.28	102.12		71.61
CD (P=0.05)			0.48		1.59	

RDN, Recommended dose of nitrogen

**Table 2.** Effect of integrated nitrogen management techniques on agronomic efficiency, economics and energetics of rice–Indian mustard cropping sequence (mean data of 2 years)

Treatment	Total amount of N applied	Agronomic efficiency		Net returns ('000 Rs/ha)	Benefit: cost ratio	Energy output (MJ × 10 <sup>3</sup> /ha)	Energy-use efficiency (q rice grain/MJ × 10 <sup>3</sup> /ha)	Energy output: input ratio
		Rice	Indian mustard					
<i>Rainy season (Rice)</i>								
No N			4.64	15.30	0.87	182.2	5.32	15.60
100% RDN	100.0	1.89	7.07	30.21	1.60	268.4	5.48	15.89
100% RDN + 5 tonnes FYM	125.0	20.66	8.59	37.33	1.88	311.9	5.67	16.90
80% RDN + 3 tonnes FYM	115.0	14.62	7.61	28.97	1.50	265.6	5.50	15.97
100% RDN blended with FYM	115.0	20.06	9.53	39.85	2.05	318.4	6.33	17.83
80% RDN blended with FYM	95.0	18.75	8.29	32.69	1.70	26.7	5.95	16.63
60% RDN blended with FYM + <i>Azospirillum</i>	90.0	15.24	6.99	27.26	1.43	250.2	5.67	16.11
100% RDN as urea:FYM:soil	101.5	22.12	7.26	32.76	1.72	277.9	5.74	16.23
80% RDN blended with poultry manure	100.5	13.41	7.39	28.23	1.48	256.5	5.15	14.75
60% RDN blended with poultry manure + <i>Azospirillum</i>	105.5	14.47	6.82	27.06	1.44	247.4	5.35	15.19
CD (P=0.05)				1.41	0.07	4.7	0.15	0.26
<i>Winter season (Indian mustard)</i>								
No N				23.92	1.31	238.4	5.95	17.92
50% RDN	40.0		10.68	29.42	1.57	260.5	5.78	16.53
50% RDN (blended with FYM)	65.0		9.19	29.91	1.54	264.8	5.59	15.86
100% RDN	80.0		8.61	32.67	1.70	278.1	5.41	15.29
100% RDN blended with FYM	105.0		8.62	33.90	1.71	285.8	5.34	14.94
CD (P=0.05)				0.68	0.04	2.4	0.08	0.14

*al.*, 2001).

### **Nitrogen uptake**

Significantly higher total N uptake in rice was observed under 100% RDN + 5 tonnes FYM compared to other treatments. But comparable N uptake was also recorded from 100% RDN blended with FYM. In Indian mustard, the N uptake due to residual effect of 100% RDN blended with FYM was the highest and significantly superior to all the treatments applied in rainy season. Significantly higher N uptake was noted under direct application of 100% RDN blended with FYM to Indian mustard in winter. Higher uptake under these treatments could be owing to higher biological yield under these treatments.

### **Nitrogen-use efficiency**

The agronomic efficiency of N was highest with 100% RDN as urea:FYM:soil (Table 2). In Indian mustard, the residual effect of 100% RDN blended with FYM applied to preceding rice recorded the highest agronomic efficiency, whereas the residual effect of no-nitrogen had the least efficiency. All other treatments including 100% RDN imposed on rice were placed between no-nitrogen and 100% RDN blended with FYM. However, in case of directly applied treatments, 50% RDN was the most efficient, Least efficiency was noted with 100% RDN. Prolonged N availability could be the reason for higher agronomic efficiency (Lakpale *et al.*, 1999).

### **Economics**

Application of 100% RDN blended with FYM to rainy-season rice registered the highest net returns and benefit : cost ratio in rice-Indian mustard cropping system. Similarly, in winter also, application of same treatment combination performed the best. This might be owing to higher productivity of component crops and relatively low production cost per unit of yield under these treatments. Puste *et al.* (1999) reported highest monetary advantage from 75% NPK + 10 tonnes FYM /ha compared to 75% NPK + 10 tonnes cowdung/ha or 100% recommended dose of NPK. However, in the present study, 100% RDN application to Indian mustard also gave similar net returns during the second year and similar benefit : cost ratio during the first year and in pooled data.

### **Energetics**

Energy output, use efficiency and output:input ratio, computed for the rice-Indian mustard cropping system,

was significantly different with respect to integrated N nutrition in rainy and winter seasons. Application of 100% RDN blended with FYM in rainy season and the same treatment combination applied in winter, registered the highest energy output of the cropping system. But energy-use efficiency for production of quintal rice grain equivalence was highest under application of 100% RDN blended with FYM in rainy season and no-nitrogen treatment in winter. However, in *rabi* no-nitrogen and 50% RDN were statistically at par with each other during the second year. Further, maximum energy output:input ratio was computed under 100% RDN blended with FYM applied to rainy-season rice and the same parameter was highest under no-nitrogen treatment imposed to Indian mustard, remaining statistically superior to all other treatments imposed in respective seasons. In winter, more energy consumption under 100% RDN blended with FYM might have brought down the energy-use efficiency and output : input ratio.

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