



Effect of integrated nutrient management on the growth, productivity and quality of crops in rice (*Oryza sativa*) – cabbage (*Brassica oleracea*) greengram (*Vigna radiata*) cropping system

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ABSTRACT

Field experiment was conducted between 2002-2004 at Mohanpur, West Bengal to study the effect of integrated nutrient management (INM) on the growth, productivity and quality of crops in rice (*Oryza sativa* L.) – cabbage (*Brassica oleracea* var. capitata) – greengram (*Vigna radiata* L.R. Wilczek) cropping sequence under irrigated ecosystem on an entisol. The experiment was laid out in RBD replicated thrice with 8 nutrient management treatments of different organic sources of nutrients in combination with inorganic sources. The highest productivity and quality of the crops in sequence and rice equivalent yield (32.4 tonne/ha) was observed with application of 75% recommended dose of fertilizer (RDF) along with 25% N through Neematex. Application of FYM or Biomax were also as good as the highest yield producing treatment. The highest net returns (Rs 1,43,463/ha) and net B:C ratio (2.92) were obtained when crops in sequence were fertilized with 75% RDF along with 25% N through FYM. Combined application of organic and inorganic sources of nutrients improved the nutrient uptake by the crops in sequence as compared to chemical fertilizer alone.

Key words: Cropping system, Nutrient uptake, Soil fertility, Yield

Introduction of high value crops like vegetables, pulses etc. in rice-based cropping system under assured irrigation condition helps in enhancing the income of farmers. To obtain the better yield farmers have to use more and more fertilizers year after year due to decline in soil fertility. More over excessive use of nitrogenous fertilizers alone have not only polluted the groundwater and environment through nitrate poisoning but also lowered its use efficiency by the crops (Abrol and Katyal, 1990). Use of organic manure, green manuring, crop residues along with inorganic fertilizers not only reduces the demand of inorganic fertilizers but also increases the efficiency of applied nutrients due to their favourable effect on physical, chemical and biological properties of soil (Prasad *et al.*, 1992). The productivity of all the crops in rice-potato-soybean sequence was increased when organic manures were applied along with inorganic fertilizers (Sarkar and Mondal, 2005). Generation of information regarding the influence of different sources of organic manure/matter in conjunction with inorganic fertilizers on the productivity, soil fertility and quality of crops under rice-based cropping system is important to the farmers. In view of this, an inves-

tigation was planned to study the effect of integrated nutrient management on the growth, productivity and quality of crops in rice-cabbage-greengram cropping system.

MATERIALS AND METHODS

A field experiment was carried out at Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal (22°5' N latitude, 89° N longitude with an altitude of 9.75 m above mean sea level) in sub-humid to sub-tropical climatic condition from June, 2002 to October, 2004. The average annual rainfall is around 1,450 mm. Usually the monsoon breaks in this area by the second week of June and continuous till end of September to mid of October. During winter rainfall is very scanty. The experimental soil was entisol having clay loam texture with 36.6% sand, 37.3% silt, 26.1% clay, 0.61 % organic carbon, 0.062% total N, 16.25 kg/ha available P and 190.0 kg/ha available K. The experiment was laid out in RBD with 8 treatments replicated thrice. The treatments (to all the crops in sequence) T₁ : 100% recommended dose of NPK through fertilizer (RDF) sources, T₂ : 75% RDF + 25% N through Biomax, T₃ : 75% RDF + 25% N through Biomax, T₄ : 75% RDF + 25% N through enmite T₅ : 75% RDF + 25% N through Neematu, T₆ : 75% RDF + 25% N through FYM. T₇ : 75% RDF + incorporation of crop residues after harvesting of

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each crop in sequence, T₈: 75% RDF + *in situ* green manuring with *dhaincha* (*Sesbania aculeata*) before transplanting of rice. 'IET 4786', 'Green Express' and 'B 105' varieties of rice, cabbage and greengram respectively were grown with RDF of 60:13.21:25, 120:26.43:50 and 20:17.62:16.66 kg N : P : K/ha through urea, single superphosphate and muriate of potash, respectively. Biomax (pelleted organic manure) contained 5% N, 0.88% P, 0.83% K, 1.23% Cr and 5.34% Pb. Biomas (with beneficial microbial content) contained 2% N, 0.67% P, 0.83% K, 4.55% Pb, 13.6% Cr. Enmite (Karanja cake + other oil cake) contained 3% N, 0.44% P, 1.04% K, 0.28% Cd, 1.55% Cr. Neematex contained 2.5% N, 0.44% P, 0.83% K, 4.8% Cr. Farmyard manure (FYM) contained 0.5% N, 0.084% P and 0.41% K. The content of N, P and K (mean of 2 years) were 0.64%, 0.08%, 1.09% in rice residue 1.32%, 0.02%, 0.13% in cabbage residue, 1.41%, 0.11%, 0.89% in greengram residue, 2.5%, 0.22% and 1.0% in *dhaincha* respectively.

Dhaincha was sown on last week of April and incorporated at 47 DAS during both the years (45.3 and 46.6 tonne/ha) as per treatment. Rice was transplanted on first week of July and harvested on first week of October during both the years. Cabbage was planted on second week of October and harvested on third week of December. Greengram was sown on second week of February and harvested on third week of April. In *kharif* rice half of the dose of N and K and full dose of P were applied as basal. The remaining N and K were applied in 2 equal splits, at maximum tillering stage and at panicle initiation stage. In cabbage half dose of N, full dose of P and K were applied as basal in rows and thoroughly mixed in the soil. Remaining N was applied at first earthing up according to treatment.

Before final land preparation organic manure were applied according to the treatment. Fresh rice straw (4.7 and

5.3 tonne/ha in 2002 and 2003) of the preceding crop as well as crop residue after harvest of cabbage (2.1 and 2.3 tonne/ha) and greengram (2.8 and 2.9 tonne/ha) were chopped into pieces and incorporated into the soil as per treatment.

After harvesting of second crop, all nutrients were applied as basal at the sowing of greengram. After harvesting of each crop, soil samples were taken at 0-15 cm depth diagonally across the plots and analysed following standard procedures. Quality of rice (hulling %, milling %, and amylase content) was done as per standard methods. Ascorbic acid content in cabbage was recorded by the method described by Rangana (1979). Rice equivalent yield (REY) were obtained by converting yield of other 2 crops into rice unit (price of rice, cabbage and greengram are Rs 6.00, Rs 3.00 and Rs 18.00/kg respectively).

RESULTS AND DISCUSSION

Yield attributes and yield of rice

Significantly the highest grain yield of rice (4.59 tonne/ha) was recorded in the treatment that received 75% RDF + 25% N through Neematex (Table 1). However, it was at par with the yields obtained in plot fertilized with 75% RDF + 25% N either through FYM or Biomax. The highest decline (12.31%) in yield over best treatment (T₅) was observed in sole inorganic plots. Significantly highest number of panicles/m² (452.25), total number of spikelets/panicle (128.7), filled grain/panicle of rice (74.55%) and 1,000 grain weight (20.77 g) were obtained in the treatment that recorded highest grain yield. Integrated application of organic and inorganic sources of nutrient improving the yield of rice was also reported by Mondal *et al.* (2004).

Growth and productivity of cabbage

Growth and productivity of cabbage were also influenced by integrated nutrient management. Significantly

Table 1. Effect of nutrient management on yield attributes and yield of rice in rice-cabbage-greengram cropping sequence

Treatment	Number of panicles/m ²		Total number of spikelets/panicle		% filled grain/panicle of rice		1,000 grain weight (g)		Grain yield (tonne/ha)	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
T ₁ (RDF)	409.2	380.9	109.1	100.6	70.6	69.8	19.3	19.2	4.20	3.85
T ₂ (75% RDF + 25% N through Biomax)	434.9	447.2	116.9	126.9	72.4	73.4	19.9	20.3	4.40	4.53
T ₃ (75% RDF + 25% N through Biomas)	418.1	431.1	111.7	112.3	69.4	70.9	19.4	19.5	4.30	4.38
T ₄ (75% RDF + 25% N through Enmite)	427.6	441.9	113.4	115.7	71.3	73.0	19.5	20.0	4.38	4.48
T ₅ (75% RDF + 25% N through Neematex)	443.8	460.7	125.7	131.7	73.6	75.5	20.4	21.1	4.51	4.67
T ₆ (75% RDF + 25% N through FYM)	435.4	452.6	120.4	129.5	72.9	74.8	20.3	20.5	4.41	4.54
T ₇ (75% RDF + crop residues)	387.8	420.5	95.6	103.2	70.1	71.6	19.4	19.6	3.84	4.29
T ₈ (75% RDF + <i>dhaincha</i> GM in rice)	394.2	430.8	101.2	116.7	71.4	73.2	19.6	20.0	4.05	4.34
SEm ±	4.6	6.1	3.8	3.9	0.5	0.7	0.17	0.28	0.04	0.06
CD (P=0.05)	12.6	16.9	10.5	10.8	1.4	2.2	0.47	0.82	0.11	0.18

RDF: Recommended dose of fertilizers; GM: Green manuring

highest head yield of cabbage (48.17 tonne/ha) were obtained in the treatment of Neematex (25% N) along with 75% RDF. Head yield of cabbage obtained from the treatment that received FYM or biomass along with 75% RDF was at par with treatment producing highest yield (Table 2). Other growth characters like plant spread at harvest, number of non-wrapped leaves/plant at harvest, head height at harvest, vertical and horizontal head diameter in both the years were highest in the highest yield producing treatment (T₅).

Yield component and yield of greengram

Significantly the highest seed yield of greengram (1.24 tonne/ha pooled) was recorded from application of 75% RDF in combination with 25% N through Neematex (T₅), closely followed by that was obtained under 75% RDF in conjunction with either Biomax or FYM (1.21 and 1.19 tonne/ha), respectively (Table 3). Highest number of pods/m², number of seeds/pod and 1,000 seed weight was recorded under the highest yield producing treatment (T₅).

Quality of crops

The maximum improvement in quality of rice grain (amylose content 25.27%, hulling 77.67%, milling 66.67%) was recorded in the treatment that received 75% RDF + 25% N through Neematex (Table 4). Addition of either FYM or Biomax or Enmite or green manuring *in situ* in conjunction with 75% RDF was as good as the treatment that yielded the best rice grain quality. Exclusion of organic sources of nutrient from the treatments deteriorated the quality of rice grain.

Maximum ascorbic acid content (100 mg/100 g) of cabbage was recorded when crop was fertilized with 75% RDF along with 25% N through FYM which was at par with the ascorbic acid content in the treatment that recorded 75% RDF in conjunction with 25% N through either Neematex or Enmite or Biomax. The higher content of ascorbic acid was also obtained with application of crop residues or *in situ* green manuring of *dhaincha* to rice along with 75% RDF. Minimum ascorbic acid content (73.3 mg/100 g fresh weight) was recorded when the crop was not supplied with any organics.

Maximum improvement of protein content of greengram (9.77%) was recorded with application of 75% RDF along with 25% N through Neematex over the treatment receiving chemical fertilizer only. Higher protein content of greengram was also recorded with addition of organic sources of nutrient along with 75% RDF to all the crops in sequence (Table 4). Integration of organic sources of nutrients along with inorganic sources increased the nitrogen and potassium content of the plants which ultimately influenced the quality of seeds.

Table 2. Growth, yield attributes and head yield of cabbage in rice-cabbage-greengram sequence as influenced by integrated nutrient management

Nutrient management	Plant spread at harvest (cm)		No. of non-wrapped leaves/plant at harvest		Head height (cm) at harvest		Head diameter (cm)		Head yield (tonne/ha)			
							Vertical		Horizontal			
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04		
T ₁ (RDF)	32.5	30.1	12.2	12.0	19.1	18.5	13.4	13.2	15.5	15.0	40.84	39.35
T ₂ (75% RDF + 25% N through Biomax)	38.5	40.6	13.9	14.4	22.0	24.2	15.5	15.9	16.6	16.9	45.45	49.54
T ₃ (75% RDF + 25% N through Biomax)	33.6	37.2	12.9	13.7	19.2	22.0	14.3	14.7	15.6	16.3	43.07	48.77
T ₄ (75% RDF + 25% N through Enmite)	34.8	36.1	13.2	13.9	19.8	22.4	15.0	15.6	16.0	16.9	44.29	48.91
T ₅ (75% RDF + 25% N through Neematex)	39.1	42.4	14.2	14.8	22.9	25.4	15.9	16.4	17.1	17.4	46.18	50.15
T ₆ (75% RDF + 25% N through FYM)	37.8	39.9	13.6	14.3	21.5	23.9	15.1	15.8	16.4	16.7	45.93	49.92
T ₇ (75% RDF + crop residues)	32.4	35.1	12.0	12.7	19.1	21.4	14.2	14.7	15.2	15.7	41.53	46.28
T ₈ (75% RDF + <i>dhaincha</i> GM in rice)	33.0	37.5	13.1	13.9	19.3	22.1	14.3	15.0	15.7	16.5	43.31	46.97
SEm ±	0.5	0.9	0.2	0.2	0.2	0.6	0.19	0.24	0.26	0.25	0.26	0.33
CD (P=0.05)	1.5	2.7	0.8	0.7	0.6	1.8	0.58	0.75	0.81	0.76	0.84	0.96

RDF: Recommended dose of fertilizers; GM: Green manuring

Rice equivalent yield (REY)

The pooled data of the system revealed that the highest REY (32.4 tonne/ha) was obtained with the application of 75% RDF along with 25% N through Neematex, closely followed by that recorded in the treatment of 75% RDF in combination with either FYM or Biomax or Enmite, respectively (Table 4). The REY was reduced whenever organic nutrient was not added to the system.

Economics

The highest net returns (Rs 1,43,463/ha) and net benefit: cost ratio (2.92) were obtained when crops in sequence were fertilized with 75% RDF along with 25% N through FYM which was followed by the treatments that received 75% RDF + *in situ* green manuring with *dhaincha* in rice (T₈) or 25% N through Biomax (T₂) respectively (Table 4).

Nutrient uptake

Significantly the highest nitrogen, phosphorus and potassium uptake by rice, cabbage and greengram in sequence was observed in the treatment that received 75% RDF in conjunction with 25% N through Neematex, closely followed by that obtained under the treatment received 75% RDF along with 25% N through FYM (Table 5). Higher nutrients (N, P and K) uptake by the crops in sequence were also recorded when the crops treated with 75% RDF in addition with 25% N through organic sources of nutrients. This might be due to increased efficiency of fertilizers in presence of FYM or other organic sources of nutrients resulting in increased uptake of nutrients.

Thus it is concluded that application of 75% recommended dose of N, P and K fertilizers to all the crops in sequence along with 25% N through Neematex/Biomax/FYM produced highest productivity (REY) and quality of

Table 3. Effect of nutrient management on yield attributes and seed yield of greengram in rice-cabbage-greengram cropping sequence

Treatment	Number of pods/m ²		Number of seeds/pod		1,000 seed weight (g)		Seed yield (tonne/ha)	
	2002	2003	2002	2003	2002	2003	2002	2003
T ₁ (RDF)	874	726	9.8	9.6	32.6	31.9	0.91	0.90
T ₂ (75% RDF + 25% N through Biomax)	1,056	1,142	11.8	12.1	34.1	34.6	1.18	1.22
T ₃ (75% RDF + 25% N through Biomax)	912	1,014	10.2	10.4	32.3	32.8	0.94	0.99
T ₄ (75% RDF + 25% N through Enmite)	1,002	1,107	11.6	11.9	33.4	33.6	1.08	1.13
T ₅ (75% RDF + 25% N through Neematex)	1,074	1,194	12.1	13.0	34.2	35.1	1.20	1.27
T ₆ (75% RDF + 25% N through FYM)	1,040	1,128	11.9	12.2	33.9	34.4	1.16	1.20
T ₇ (75% RDF + crop residues)	894	986	10.6	10.4	32.1	33.2	0.95	0.97
T ₈ (75% RDF + <i>dhaincha</i> GM in rice)	987	1,056	11.0	11.2	33.2	33.8	1.01	1.05
SEm ±	13	25	0.2	0.3	0.19	0.30	0.03	0.04
CD (P=0.05)	39	76	0.7	1.1	0.60	0.91	0.10	0.12

RDF: Recommended dose of fertilizers; GM: Green manuring

Table 4. Effect of integrated nutrient management on the quality of crops, rice equivalent yield (REY) and economics (Rs/ha) in rice-cabbage-greengram cropping sequence (Pooled data of 2 years)

Treatment	Rice			Cabbage	Greengram	REY (tonne/ha)	Total cost of cultivation of system	Net returns	Net B:C ratio
	Amylose content (%)	Hulling %	Milling %	Ascorbic acid content (mg/100 g)	Protein content (%)				
T ₁ (RDF)	22.9	70.3	61.2	73.3	23.1	26.80	46,939	1,15,589	2.46
T ₂ (75% RDF + 25% N through Biomax)	24.7	76.8	65.7	96.4	25.2	31.83	51,580	1,39,925	2.71
T ₃ (75% RDF + 25% N through Biomax)	24.2	74.4	63.8	89.5	23.7	30.21	58,080	1,23,471	2.13
T ₄ (75% RDF + 25% N through Enmite)	24.2	76.3	65.2	95.9	24.5	31.07	55,780	1,30,865	2.35
T ₅ (75% RDF + 25% N through Neematex)	25.2	77.6	66.6	96.9	25.6	32.40	65,580	1,29,495	1.97
T ₆ (75% RDF + 25% N through FYM)	24.9	77.3	66.0	100.0	24.8	32.33	49,080	1,43,463	2.92
T ₇ (75% RDF + crop residues)	24.1	74.2	64.3	84.4	23.8	28.90	46,580	1,25,980	2.70
T ₈ (75% RDF + <i>dhaincha</i> GM in rice)	24.6	76.2	65.5	87.1	24.1	29.87	46,380	1,33,065	2.87
SEm ±	0.2	0.6	0.5	3.0	0.4	0.68			
CD (P=0.05)	0.7	1.7	1.4	8.1	1.2	1.97			

RDF: Recommended dose of fertilizers; GM: Green manuring

Table 5. Effect of nutrient management on the mean uptake (kg/ha) of nutrients (N, P and K) by the crops in rice-cabbage-greengram sequence

Treatment	Rice			Cabbage			Greengram		
	N	P	K	N	P	K	N	P	K
T ₁ (RDF)	62.88	17.96	95.34	163.21	41.47	145.74	92.19	10.53	71.43
T ₂ (75% RDF + 25% N through Biomax)	83.08	24.06	135.24	190.56	52.24	173.61	160.66	23.38	117.62
T ₃ (75% RDF + 25% N through Biomas)	76.43	26.41	131.71	185.57	50.51	167.85	126.53	21.28	97.59
T ₄ (75% RDF + 25% N through Enmite)	80.37	23.14	134.06	187.72	51.26	170.34	150.28	21.29	113.33
T ₅ (75% RDF + 25% N through Neematex)	89.11	26.48	142.46	192.70	52.98	178.12	173.69	25.66	125.80
T ₆ (75% RDF + 25% N through FYM)	84.29	25.67	139.43	191.93	52.72	175.19	163.52	24.40	118.10
T ₇ (75% RDF + crop residues)	70.64	25.67	115.68	178.09	47.92	159.22	120.21	15.75	92.66
T ₈ (75% RDF + <i>dhaincha</i> GM in rice)	74.75	21.15	122.33	183.11	49.66	165.01	137.19	18.48	105.57
SEm ±	2.10	0.62	5.43	1.55	0.79	3.34	5.36	0.93	3.98
CD (P=0.05)	5.84	1.72	15.07	4.31	2.19	9.26	14.88	2.57	11.05

crops in the sequence. However, Net B:C ratio was high-est when the crops in sequence received 75% RDF along with 25% N through FYM.

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