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Effect of integrated nutrient management on the productivity, quality improvement and soil fertility in rice-onion-cowpea sequence

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ABSTRACT

A field experiment was conducted at Mohanpur, West Bengal to study the integrated nutrient management on productivity, quality improvement of crops and fertility build up of soil under rice-onion-cowpea cropping sequence. Application of 75% recommended dose (RD) of N, P and K along with 25% RD of N through Neematex (neem seed powder + oilcake) produced highest yield of different crops. The highest benefit: cost ratio was recorded with 75% RD of N, P and K + 25% RD of N through FYM. Application of 25% RD of N through organic sources viz. FYM or Neematex or Biomax or in-situ green manuring with Sesbania to rice in conjunction, with 75% RD of N, P and K to all the crops in sequence improved the system productivity, production efficiency, quality of crops, nutrient up take and nutrient status of soil in rice-onion-cowpea cropping sequence.

Key words: *cropping sequence, integrated nutrient, uptake, quality, soil fertility*

Rice is the main staple food crop in West Bengal and there is a need to identify promising profitable crops and cropping system having higher and stable yields ensuring household food, nutritional and economic security. Introduction of vegetable crops play an important role for enhancing the production of nutritious food and simultaneously improves the income of farm family. Integrated nutrient management ensures an immediate improvement in the efficiency plant nutrition supply system and build up of production. Past experiences on integrated nutrient management for rice-potato-sesame, rice-potato-groundnut, rice-potato-greengram recorded positive results with respect to crop yield and fertility build up of soil (Jayaram *et al.*, 1990 and Sanyal *et al.*, 1993). The present investigation has been planned to study the effect of integrated nutrient management on productivity, quality improvement of crops and fertility build up of soil under rice-onion-cowpea cropping sequence.

MATERIALS AND METHODS

A field experiment was conducted at Mohanpur, West Bengal during the cropping seasons of 2004 to 2006 in clay loam soil (Entisol) with 0.61% organic carbon, 0.062% total N, 16.25 kg ha^{-1} available P_2O_5 and 190 kg ha^{-1} available K_2O. The experiment was laid out in RBD with 8 nutritional treatments replicated thrice. The treatments includes 100% recommended dose of N, P and K through fertilizers (RDF), 75% RDF + 25% of N through Biomax (pelleted organic manure containing 5% N, 0.88% P and 0.83% K), 75% RDF + 25% of N through Biomas (with beneficial microbial containing 2% N, 0.67% P and 0.83% K), 75% RDF + 25 of N through Enmite (karanja cake + other oil cake containing 3% N, 0.44% P and 1.04% K), 75% RDF + 25 of N through Neematex (neem seed powder containing 2.5% N, 0.44% P and 0.83% K), 75% RDF + 25% of N through FYM (containing 0.5% 0.84% P and 0.41% K), 75% RDF + incorporation of crop residue after harvest of each crop in sequence and 75% RDF + *in-situ* green manuring with *Sesbania* (containing 2.5% N, 0.22% P and 1.0% K) applied before transplanting of rice. IET-4786, Sukhsagar and Pusa dofosali varieties of rice, onion and cowpea, receptively, were grown with recommended dose of fertilizers 60:30:30, 100:60:80 and 25:75:60 kg N, P

and ha^{-1} through urea, single super phosphate and muriate of potash respectively. *Sesbania* was sown on the 3rd week of May and incorporated at 45 DAS as per treatment. Rice was transplanted on 1st week of July and harvested on first week of October. Onion was transplanted on 4th week of November and harvested on 2nd week of February. Cowpea was sown on 1st week of March and harvested on 2nd week of May.

In rice, half of the dose of N and K with full dose of P were applied as basal. The remaining half of N and K were applied at maximum tillering stage. In onion, half of N and full dose of P & K were applied basal in rows and thoroughly mixed with the soil. Remaining portion of N was applied after first weeding. While, in cowpea, full does of N, P and K were applied as basal. Organic sources of manure were applied according to the treatment during the land preparation. Crop residues were chopped into pieces and incorporated to the soil as per treatment. Soil sample were taken at 0-15 cm depth diagonally across the plots and analyzed by standard procedures (Jackson, 1967). Qualities of the crops were analyzed by standard methods. Rice equivalent yield were obtained by converting yield of onion and cowpea into rice unit (price of rice, onion and cowpea are Rs. 6.00, Rs. 7.00 and Rs. 8.00 per kg, respectively).

RESULTS AND DISCUSSION

The highest dry matter accumulation (1052.5 g m^2) was obtained in the plot treated with 75% RD of N, P and K along with 25% of N through Neematax (Table 1), closely followed by the treatment received 75% of N, P and K + 25% of N through FYM. Application of 75% of NPK + 25 % of N through either Biomax or Biomas or Enmite or *in-situ* green manuring with *Sesbania* to rice resulted higher dry matter accumulation than the sole application of inorganic nutrients. Significantly highest number of panicles (451.5 m^2), total number of filled spikelets $panicles^{-1}$ (128) & 1000-grain weight (20.6 g) of rice were recorded when the crops received 75% RD of N, P and K + 25% of N through Neematex (Table 1), which was closely followed by the treatments with 75% RD of N, P and K + 25% of N through FYM. Application of reduced dose of N, P and K (75% of NPK) along with 25% of N through Enmite or Biomax or Biomas or *in-situ* green manuring with *sesbania* to rice improved the yield components over the treatment receiving inorganic fertilizers only. The highest grain yield of rice (4.55 t ha^{-1}) was recorded when the crops in sequence was treated with 75% RD of N, P and K along with 25% of N through Neematex (Table 1). Combined application of inorganic fertilizers (75% RD of N, P and K) and organic sources of nutrients (25% of N) either through Enmite or Biomas or Biomax or *in-situ* green manuring with *sesbania* to rice in sequence resulted higher grain yield of rice over sole application of chemical fertilizers. The yield increase in rice based cropping system due to integrated nutrient management was also observed by Acharya *et al*. (2008) and Pal *et al*. (2010).

Significantly highest plant height (40.17cm), number of leaves $plant^{-1}$ (13.9) and bulb diameter (Horizontal 5.81cm and Vertical 5.63 cm) were recorded in the treatment received 75% RD of N, P and K in conjunction with 25% of N through Neematex (Table 2), closely followed by the treatment registered with 75% of N, P and K + 25% of N through FYM. Integration of reduced dose of N, P and K (75% NPK) along with 25% of N through either Biomax or Enmite or Biomas or *in-situ* green manuring with *sesbania* to rice improved the growth of the onion. The highest bulb yield was obtained when the crops treated with 75% RD of N, P and K + 25% of N through Neematex, which was at par with the yield recorded with the plot received 75% RD of N, P and K + 25% of N through FYM. Similar results were also reported by Mondal *et al*. (2004). The higher yield of onion bulb was obtained when the corps in sequence were treated with 25% of N through Biomax or Enmite or Biomas or *in-situ* green manuring with *Sesbania* to rice along with 75% RD of N, P and K to all the corps in sequence over the application of fertilizers only.

The highest pod dry weight (77.25 g m^2), length pod^{-1} (50.90 cm) and pod number $plant^{-1}$ (34.5) were recorded in the treatment receiving 75% RD of N, P and K + 25% of N through Neematex (Table 3) which was at per with the treatment receiving 75% RD of N, P and K + 25% of N through FYM. The higher growth attributes were obtained in the treatment received 75% RD of N, P and K + 25% of N through Biomax or Biomas or Enmite or *in-situ* green manuring with *Sesbania* to rice. Significantly highest green pod yield of cowpea (7.54 t ha^{-1}) was obtained when the

Table 1. Effect of nutrient management on dry matter accumulation, yield attributes, yield and amylose content of rice under rice-onion-cowpea sequence (pooled data of 2 years)

Nutrient management Treatment	Dry matter accumulation at harvest (g m^{-2})	No. of panicles m^2	No. of filled spikelets $panicle^{-1}$	1000 grain weight (g)	Grain Yield (t ha^{-1})	Amylose content (%)
100% RD of NPK through inorganic	859.0	394.5	104.5	19.25	3.90	23.7
75% RD of NPK + 25% N through Biomax	1005.5	440.5	121.0	19.90	4.35	24.8
75% RD of NPK + 25% N through Biomas	968.5	424.5	111.5	19.35	4.30	24.2
75% RD of NPK + 25% N through Enmite	993.0	434.0	114.0	19.70	4.40	24.2
75% RD of NPK + 25% N through Neematex	1052.5	451.5	128.0	20.60	4.55	25.3
75% RD of NPK + 25% N through FYM	1008.5	443.5	124.5	20.30	4.45	25.0
75% RD of NPK + incorporation of crop residues of each crop in sequence	889.5	403.5	99.0	19.30	4.00	24.1
75% RD of NPK + *in-situ* incorporation with *sesbania* to rice	925.5	412.0	108.5	19.75	4.25	24.6
CD (P<0.05)	52.5	14.0	10.5	0.63	0.140	0.70

Table 2. Effect of nutrient management on plant height (cm), bulb diameter (cm), number of leaves $plant^{-1}$, and bulb yield (t ha^{-1}) and quality of onion in rice-onion-cowpea sequence (pooled data of 2 years)

Nutrient management Treatment	Plant height (cm)	No. of leaves $plant^{-1}$	Bulb diameter (cm)		Bulb yield (t ha^{-1})	Ascorbic Acid content (mg per 100g)	TSS (^{0}Brix)	Reducing Sugar (%)
			Horizontal	Vertical				
100% RD of NPK through inorganic	35.30	10.58	4.31	4.53	19.95	7.50	9.25	12.55
75% RD of NPK + 25% N through Biomax	37.91	12.87	5.52	5.49	24.06	9.20	11.05	11.25
75% RD of NPK + 25% N through Biomas	37.02	12.26	5.06	4.96	22.91	8.80	10.32	11.52
75% RD of NPK + 25% N through Enmite	37.84	12.69	5.49	5.30	23.25	8.90	10.66	11.41
75% RD of NPK + 25% N through Neematex	40.17	13.90	5.81	5.63	25.12	9.60	11.59	11.09
75% RD of NPK + 25% N through FYM	39.26	13.36	5.62	5.56	24.47	9.40	11.28	10.99
75% RD of NPK + incorporation of crop residues of each crop in sequence	34.86	11.76	4.62	4.84	21.21	8.60	8.95	11.79
75% RD of NPK + *in-situ* incorporation with *sesbania* to rice	36.56	12.42	5.15	5.12	22.17	8.90	10.05	11.61
CD (P<0.05)	1.252	0.89	0.48	0.601	1.01	0.71	0.90	0.50

crops in sequence treated with 75% RD of N, P and K along with 25% of N through Neematex. Higher green pod yield of cowpea was also recorded in the plot treated with 75% RD of N, P and K + 25% of N through Enmite of Biomas or *in-situ* green manuring with *sesbania* to rice as compared with the yield obtained in the treatment received fertilizers only.

The highest system productivity (43.95 t REY ha^{-1} $year^{-1}$) and production efficiency (137.36 kg REY ha^{-1} day^{-1}) were obtained when the crops in sequence received 75% RD of N, P and K + 25% of N through Neematex which was at par with the treatment registered with 75% RD of N, P and K + 25% of N through FYM (Table 4). Higher system productivity and production efficiency of rice-onion-cowpea cropping system were obtained when the crops in sequence were treated with organic and inorganic sources of nutrients over the treatment received only inorganic sources of nutrients. The highest net returns (Rs. 201042 ha^{-1}) and benefit: cost ratio (4.42) were obtained when crops in sequence were treated with 75% RD of N, P and K + 25% N through FYM, which was closely followed by the treatment received 75% RD of N, P and K + *in-situ* green manuring with *sesbania* to

Table 3. Effect of nutrient management on pod dry weight (g), length pod^{-1} (cm), pod plant^{-1}, pod yield (t ha^{-1}), ascorbic acid and protein content of cowpea and system productivity and production efficiency under onion in rice- onion-cowpea sequence (pooled data of 2 years)

Nutrient management Treatments	Dry wt. of pod (g) (20 pod)	Length pod^{-1} (cm)	Pod plant^{-1}	Pod yield (t ha^{-1})	Ascorbic Acid content (mg per 100g)	Protein content (%)	System productivity (t REY ha^{-1} year^{-1})	Production efficiency (kg REY ha^{-1} day^{-1})
100% RD of NPK through inorganic	57.90	38.85	25.51	6.06	10.04	3.42	35.52	111.01
75% RD of NPK + 25% N through Biomax	73.58	48.30	32.60	7.36	12.67	4.07	42.39	132.47
75% RD of NPK + 25% N through Biomas	69.32	46.95	30.63	6.93	12.22	3.72	40.40	126.25
75% RD of NPK + 25% N through Enmite	69.55	47.50	30.84	7.13	12.38	4.03	41.11	128.48
75% RD of NPK + 25% N through Neematex	77.25	50.90	34.55	7.54	13.07	4.39	43.95	137.36
75% RD of NPK + 25% N through FYM	75.11	48.70	33.07	7.46	12.81	4.15	43.06	134.56
75% RD of NPK + incorporation of crop residues of each crop in sequence	64.70	43.40	29.76	6.60	11.82	3.72	37.79	118.10
75% RD of NPK + *in-situ* incorporation with *sesbania* to rice	67.26	44.30	29.90	7.09	11.95	3.92	39.68	124.00
CD (P<0.05)	6.25	3.15	3.35	0.44	0.71	0.41	8.42	24.51

Table 4. Effect of nutrient management on nutrient uptake, soil nutrient status and economics analysis under onion in rice- onion-cowpea sequence (pooled data of 2 years)

Nutrient management Treatments	Uptake of nutrients (kg ha^{-1} year^{-1}) by sequence			Extent of increase (+) or decrease (-) of soil nutrient status after 2 year cropping cycle			Net profit (Rs ha^{-1})	Benefit: cost ratio
Treatments	Nitrogen	Phosphorus	Potassium	Total Nitrogen	Available Phosphorus	Available Potassium		
T_1-100% RD of NPK through inorganic	214.96	44.19	249.42	-123.2	3.44	6.3	155420	3.73
T_2-75% RD of NPK + 25% N through Biomax	305.60	69.67	355.34	296.8	11.84	29.5	193852	4.19
T_3-75% RD of NPK + 25% N through Biomas	270.31	68.98	338.03	190.4	17.23	32.3	175455	3.63
T_4-75% RD of NPK + 25% N through Enmite	287.97	65.25	344.68	235.2	11.35	31.6	182496	3.83
T_5-75% RD of NPK + 25% N through Neematex	325.79	76.11	372.74	380.8	11.87	29.4	190431	3.58
T_6-75% RD of NPK + 25% N through FYM	309.94	73.44	367.44	358.4	12.89	34.0	201042	4.42
T_7-75% RD of NPK + incorporation of crop residues of each crop in sequence	249.43	54.07	298.89	89.6	8.14	27.5	170392	4.03
T_8-75% RD of NPK + *in-situ* incorporation with *sesbania* to rice	270.78	58.92	321.72	201.6	10.73	32.1	181718	4.24
CD (P<0.05)	35.11	9.42	24.94	-	-	-	-	-

Total cost of cultivation: T_1: 56849, T_2: 60800, T_3: 66750, T_4: 64310, T_5: 73750, T_6: 57562, T_7: 56250 and T_8: 56050 Rs ha^{-1} respectively

rice and 25% N through Biomax to all the crops in sequence.

The highest amylose content of rice (25.3%) was recorded in the treatment of 75% RD of N, P and K + 25% of N through Neematex. The higher amylose content was also recorded with the addition of organic sources of nutrients through either FYM or Biomax or

Enmite or *in-situ* green manuring with *sesbania* over chemical fertilizers alone.

Significatly highest ascorbic acid content (9.60 mg/ 100g), total soluble solid content (11.59 ^{0}Brix) of onion were obtained when the crop treated with 75% RD of N, P and K + 25% of N through Neematex which was at par with the treatment receiving 75% RD of N, P and K + 25% of N through FYM. Application of 75% RD of N, P and K + 25% of N through either Biomax or Enmite or Biomas or *in-situ* green manuring with *sesbania* to rice resulted higher ascorbic acid and total soluble solid content of onion over the treatment of inorganic sources of nutrients alone. Highest ascorbic acid (13.07 mg/100g) and protein content (4.39%) of cowpea were recorded when the cowpea was treated with 75% RD of N, P and K + 25% of N through Neematex which was at par with the treatment receiving 75% RD of N, P and K + 25% of N through FYM. Higher ascorbic acid and protein content of cowpea were obtained when the crop was treated with 75% RD of N, P and K + 25% of N through Biomax or Enmite or *in-situ* green manuring with *sesbania* to rice in sequence. The better quality of crop in rice based cropping system due to integrated nutrient management was also reported by Mondal *et al*. (2004).

Significantly highest N, P and K uptake by different crops in sequence was recorded in the treatment of 75% RD of N, P and K along with 25% of N through Neematex (Table-4). Higher nutrients uptake by the crops in sequence were also obtained when the crops was treated with 75% RD of N, P and K + 25% of N through organic sources of nutrients as compared with the addition of inorganic sources of nutrients alone. With addition of organic sources of nutrients the availability of nutrients in the soil might be increased and ultimately the uptake of nutrients by the crops was more. This was corroborated with the findings of Sarkar and Mondal (2005). The maximum soil nutrients status (N, P and K) after harvest of 6th crop in sequence was recorded when the crops in sequence received 75% RD of N, P and K + 25% of N through Neematex (Table-4), that was followed by the treatment registered with 75% RD of N, P and K + 25% of N through FYM. Integration of organic and inorganic sources of nutrients to the crops in sequence improved the soil nutrients status after harvest of 6th crop. The nutrients status of soil was negative or minimum in the plots treated with inorganic sources of nutrients. These results were in accordance with the finding of Brahamachari and Mondal (2000). Application of 25% RD of N through organic sources viz. FYM or Neematex or Biomax or in-situ green manuring with Sesbania to rice in conjunction, with 75% RD of N, P and K to all the crops in sequence improved the system productivity, production efficiency, quality of crops, nutrient up take and nutrient status of soil in rice-onion-cowpea cropping sequence.

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