Indian Journal of Agronomy **53**(2): 107–111 (June 2008)

Effect of organics and inorganics on productivity and uptake of nutrients in rice (*Oryza sativa*)-*toria* (*Brassica campestris*) cropping system

G.C. MUNDA, MOKIDUL ISLAM[1] AND B.B. PANDA[1]*

ICAR Research Complex for NEH Region, Umiam, Meghalaya 793 103

Received: January 2008

ABSTRACT

A field experiment was conducted during 2003-04 and 2004-05 at Umiam, Meghalaya to identify a suitable economically viable and feasible nutrient management practice for rice (*Oryza sativa* L.) - *toria* (*Brassica campestris* L.) cropping system. Application of farmyard manure (FYM) 2.5 t/ha + *Eupatorium* 2.5 t/ha, being on a par with *Eupatorium* 5 t/ha, improved significantly the grain, straw and NPK uptake by rice, registering 11.5, 13.4 and 9.7% increase in grain yield over FYM 5 t/ha, *Alnus* 5 t/ha and FYM 2.5 t/ha + *Alnus* 2.5 t/ha respectively. Manuring of rice with FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha also significantly improved the mean rice-equivalent yield (REY) of the system (10.6-11.7%) compared with *Alnus* 5 t/ha and FYM 2.5 t/ha + *Alnus* 2.5 t/ha respectively, giving the highest net returns (Rs 12.62 x 10^3/ha) and benefit : cost ratio (1.93). However, significantly higher mean grain yield of rice (3.52 t/ha), system productivity (4.64 t REY/ha) and highest monetary returns were achieved with 100% recommended dose of fertilizer (RDF) to rice + 50% RDF to *toria* among the inorganic fertilizer treatments. The rice - *toria* cropping system also removed the maximum N (99.7 kg/ha), P (19.9 kg/ha) and K (100.9 kg /ha) when applied with 100% RDF to rice + 50% RDF to *toria* along with 5 t organic manure to rice. Thus the application of FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha with 100% RDF to rice + 50% RDF to *toria* was found beneficial in terms of REY and economics of rice-*toria* cropping system in mid-hills dry terraces.

Key words: Economics, Inorganics, Nutrient uptake, Organics, Rice, *Toria*

Rice (*Oryza sativa* L.) - *toria* (*Brassica campestris* L. var. *toria* Duth & Full.) is the most prevalent cropping system in mid-hills (800-1,300 in above mean sea-level) of Meghalaya. The productivity of the system is very low due to the use of local long-duration tall varieties, and the absence or meagre use and availability of chemical fertilizers in time to the small and marginal farmers of the state. The conjunctive application of organics with inorganic sources of nutrients reduces the dependence on chemical inputs (Ramteke *et al.*, 1998), and it not only acts as a source of nutrients but also provides micronutrients as well as modifies the soil physical behaviour and increases the efficiency of applied nutrients (Pandey *et al.*, 2007). Utilization of indigenous sources of organics, viz. farmyard manure (FYM), obnoxious weeds and green-leaf manures may serve as alternatives or supplements to chemical fertilizers, and help in increasing the productivity of the rice-based cropping system in hill zones of the country (Manjappa and Kelaginamani, 2005). The optimization of nutrient supply to the crop depends on manures or fertilizers applied to the individual preceding crop and their carry-over effect on the succeeding crop, which is generally ignored and the recommended dose of manures or fertilizers are applied again to the next crop. Besides, the application of inorganic fertilizer to dry season crop is not vary encouraging due to inherent problem of moisture shortage under rainfed uplands in north-eastern hill region of the country. However, as the application of inorganic fertilizers alone could not sustain the soil fertility and productivity under cropping sequences, the only way to realize the potential yield of crops on sustained basis is through the use of various sources of nutrients in integrated manner (Kumar *et al.*, 2001), to make the system productivity profitable (Raju and Reddy, 2000). Keeping this in view, the present investigation was undertaken to study the effect of *Eupatorium* and *Alnus* green-leaf manures and FYM along with inorganic fertilizers on the productivity and nutrient uptake of rice-*toria* cropping system under mid-hill dry terraces of Meghalaya.

MATERIALS AND METHODS

A field experiment was conducted during 2003-04 and

***Corresponding author** (Email: bbpicar@gmail.com)

Present address: [1]ICAR Research Complex for NEH Region, Manipur Centre, Imphal, Manipur 795 004

2004-05 at Research Farm of ICAR Research Complex for NEH Region, Umiam in Meghalaya, having 15 treatment combinations and one absolute control including five 5 organic sources, viz. FYM 5 t/ha, *Eupatorium* 5 t/ha, *Alnus* 5 t/ha, FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha and FYM 2.5 t/ha + *Alnus* 2.5 t/ha; and three inorganic fertilizer levels, viz. 50% recommended dose of fertilizer (RDF) to rice + 75% RDF to *toria*, 100% RDF to rice + 50% RDF to *toria*, and 150% RDF to rice + 25% RDF to *toria*. The experiment was laid out in factorial randomized block design with three replications. The soil was alfisol, acidic in nature (pH 5.2), high in organic C (0.83%), medium in available N (450 kg/ha), low in available P (6.2 kg/ha) and high in available K (303.8 kg/ha). The Siam weed (*Eupatorium odoratum* L.) and alder (*Alnus nepalensis* D. Don.) were analysed for nutrient content and found to have 2.27 and 2.41% N, 0.80 and 0.90% P, and 1.22 and 1.20% K respectively, on dry-weight basis. However, the nutrient content of FYM was 0.39% N, 0.14% P and 0.37% K on dry-weight basis. The recommended inorganic fertilizer doses of 60 kg N + 26.2 kg P + 33.3 kg K/ha for rice and 50 kg N +13.1 kg P + 16.7 kg K/ha for *toria* were supplied through urea, single superphosphate and muriate of potash. Crops were grown with the recommended packages of practices using rice cultivar 'Bhalum 1' and *toria* cultivar 'M 27', sown respectively on 5 June 2003 and 9 June 2004, and 16 October 2003 and 23 October 2004 at the same location. Organic sources of nutrients, viz. FYM, and fresh chopped *Eupatorium* and *Alnus,* were applied 2 weeks before sowing rice. Half the N and full doses of P and K were applied basal, and the rest of the N was applied in two equal splits, each at maximum tillering and panicle initiation stage of rice. The fertilizers were applied to *toria* at the time of sowing as per the treatment.

The yields of both the crops were recorded after harvesting each year and the data were pooled. Both the crops were harvested manually. System productivity in terms of rice-equivalent yield (REY) was calculated by multiplying the economic yield of *toria* with price per t of *toria,* and divided by price per t rice in the local market. The benefit : cost ratio of the system was also calculated as the gross income divided by the total cost of cultivation of rice-*toria* cropping system. The total N content of plants was analysed by micro-Kjeldhal's method, P by vanado-molybdo phosphoric acid yellow-colour method and K was estimated by flame photometer method.

RESULTS AND DISCUSSION

Crop productivity

Grain and straw yields of rice increased significantly with the application of nutrients through organic or inorganic sources. The average grain and straw yield obtained with treatment combinations was 68.9 and 40.9% higher in 2003-04, and 89.1 and 57.8% higher in 2004-05 respectively than the control (Table 1). A significant variation was also observed among the organic sources of nutrient supply to rice. Rice sown under mid-hill dry terraces with FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha recorded the highest grain yield (3.52 and 3.74 t/ha respectively in first and second years) among all the organic sources of nutrients tried, which was though significantly higher than other treatments, was on par with that of fresh chopped *Eupatorium* (5 t/ha). The mean grain yield of rice obtained with combined application of FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha was 11.50, 13.4 and 9.7% more than of FYM 5 t/ha, *Alnus* 5 t/ha and FYM 2.5 t/ha + *Alnus* 2.5 t/ha respectively. Further, significantly higher grain yield with *Eupatorium* 5 t/ha alone proved its superiority over other organic sources of nutrient supply, viz. FYM 5 t/ha and *Alnus* 5 t/ha applied alone in both the years. The probable reason for higher grain yield with FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha or *Eupatorium* 5 t/ha might be the faster release and consequently higher availability of nutrients to rice with the application of *Eupatorium* compared with other organic manures (Manjappa and Kelaginamani, 2005). Similarly, the straw yield of rice was significantly higher with these treatments. Application of different doses of N, P and K fertilizer significantly influenced the grain yield of rice. It increased significantly up to 100% RDF and thereafter decreased with 150% RDF in both the years. These results are in conformity with the findings of Singh and Subbaiah (2007). However, the straw yield of rice increased progressively up to 150% RDF, perhaps because the plants could not transform the nutrients to grains due to vigorous vegetative growth on addition of excessive fertilizer nutrients, resulting in lower grain yield at higher level of inorganic fertilizers (Krishna and Ram, 2006).

The residual effect of organic or inorganic treatment combinations significantly increased the seed and stover yields of *toria.* The treatment combinations increased the mean seed and stover yields of *toria* by 163.2 and 110.0% respectively over the control. This might be due to the carry-over effect of organic or inorganic fertilizers applied to rice and the direct effect of inorganic fertilizers applied to *toria*, which in turn increased the availability of nutrients to plants, resulting in higher uptake and productivity (Table 2). The supply of nutrients through organic sources to the rainy-season (*kharif*) rice under rainfed upland condition had significant residual effect on *toria* seed yield. The residual effect of FYM 5 t/ha applied to rice recorded the highest mean seed yield (0.66 t/ha) of *toria*, which was significantly higher than the residual effect of all other

organic sources of nutrients applied. The residual effect of FYM 5 t/ha applied to rice increased the mean seed yield of *toria* by 200 and 180 kg/ha over *Eupatorium* 5 t/ha and *Alnus* 5 t/ha alone, respectively, and by 170 and 250 kg/ha over FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha and FYM 2.5 t/ha + *Alnus* 2.5 t/ha respectively. The possible reason might be the lower utilization of nutrients by the rice crop, as evident from the uptake of nutrients (Table 2), and consequently higher residual effect of FYM compared with *Eupatorium* alone or its combination with FYM on *toria*. However, no significant difference was observed in respect of stover yield of *toria* due to residual effect of different sources of organic manure treatments. Moreover, inorganic treatments applied to *toria* did not show any significant effect on seed and stover yields, indicating that higher residual effect at higher levels of inorganic fertilizers applied to rice compensated the variations created due to the direct effect of inorganic fertilizers applied to *toria*.

The nutrient treatment combinations positively influenced the total productivity of rice-*toria* cropping system. On an average, the yield of the system in terms of REY increased by 1.97 t/ha with fertilization over the control. The rice-equivalent yield of rice-*toria* cropping system varied significantly with different organic nutrient treatments applied to rice (Table 1). FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha recorded the highest mean rice-equivalent yield of 4.68 t/ha, which was on a par with that of FYM 5 t/ha and *Eupatorium* 5 t/ha alone but significantly higher (10.6-11.7%) than of *Alnus* 5 t/ha alone and FYM 2.5 t/ha + *Alnus* 2.5 t/ha under rice - *toria* cropping system. On the contrary, significant difference was recorded among the inorganic fertilizer treatments for rice-equivalent yield of the system. The highest system productivity in terms of rice-equivalent yield (4.49 an 4.78 t/ha in the first and second years respectively) was recorded with 100% RDF to rice + 50% RDF to *toria*, which was on a par with that of 150% RDF to rice + 25% RDF to *toria* but significantly higher than of 50% RDF to rice + 75% RDF to *toria*.

Nutrient uptake

Fertilization of rice with the application of nutrients through organic or inorganic sources significantly increased the N, P and K uptake by the crop (Table 2). The mean uptake of N, P and K in rice increased by 59.0, 65.8 and 75.2% respectively with fertilization over the control. Minhas and Sood (1994) also reported that the organics after decomposition release both macro- and micronutrients to soil solution, which becomes available to the plant, resulting in higher uptake. The uptake of N, P and K by rice was significantly different among the organic sources of nutrients tried. The maximum uptake of N and P (67.4 and 15.1 kg/ha respectively) was recorded with FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha, whereas the highest K uptake (69.8 kg/ha) was recorded with *Eupatorium* 5 t/ha, which

Table 1. Effect of organics and inorganics on productivity of rice-*toria* cropping system

Treatment	Rice productivity (t/ha)				*Toria* productivity (t/ha)				System productivity (t/ha)	
	Grain		Straw		Seed		Stover		REY	
	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05
Organics										
FYM 5 t/ha	3.17	3.35	7.58	8.02	0.61	0.71	1.59	1.79	4.48	4.86
Eupatorium 5 t/ha	3.49	3.66	8.20	8.73	0.42	0.49	1.37	1.54	4.40	4.72
Alnus 5 t/ha	3.14	3.25	7.49	7.96	0.44	0.52	1.29	1.45	4.09	4.36
FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha	3.52	3.74	8.24	8.71	0.46	0.52	1.31	1.43	4.52	4.85
FYM 2.5 t/ha + *Alnus* 2.5 t/ha	3.23	3.39	7.59	8.09	0.39	0.43	1.40	1.57	4.06	4.32
SEm±	0.08	0.09	0.11	0.12	0.03	0.03	0.08	0.09	0.09	0.10
CD (P=0.05)	0.24	0.25	0.31	0.33	0.08	0.09	NS	NS	0.27	0.30
Inorganics										
50% RDF (rice) + 75% RDF (*toria*)	3.10	3.25	6.99	7.44	0.45	0.53	1.47	1.58	4.06	4.38
100% RDF (rice) + 50% RDF (*toria*)	3.45	3.60	8.17	8.66	0.49	0.55	1.39	1.56	4.49	4.78
150% RDF (rice) + 25% RDF (*toria*)	3.38	3.59	8.31	8.81	0.46	0.52	1.32	1.52	4.37	4.71
SEm±	0.06	0.07	0.08	0.09	0.02	0.02	0.06	0.07	0.07	0.08
CD (P=0.05)	0.19	0.20	0.24	0.26	NS	NS	NS	NS	0.21	0.23
Control vs. rest										
Control	1.96	1.84	5.55	5.26	0.20	0.17	0.74	0.66	2.38	2.22
Rest	3.31	3.48	7.82	8.30	0.47	0.53	1.39	1.55	4.31	4.62
SEd±	0.15	0.16	0.20	0.21	0.05	0.05	0.15	0.16	0.17	0.18
CD (P=0.05)	0.30	0.32	0.40	0.42	0.10	0.11	0.30	0.33	0.35	0.37

RDF = recommended dose of fertilizer; REY = rice-equivalent yield

were on a par with each other. The higher K uptake with *Eupatorium* treatment may be attributed to its higher K content compared with that of FYM and *Alnus*. However, the uptake of N and P by rice crop increased progressively with subsequent increase in the fertilizer levels maximum being at 150% recommended dose of fertilizers. This might be due to higher availability of plant nutrients with fertilization, which resulted in increased nutrient content in the plant tissues and greater biomass production at higher fertilizer levels. More nutrient uptake under higher N and P levels of application proved effective by their greater absorption by the rice crop at all stages due to synergistic effect between N and P. This result corroborates the findings of Balasubramaniyan (2004). However, significantly highest K uptake (70.2 kg/ha) was recorded with 100% recommended dose of fertilizers, which was on a par with that of 150% recommended dose.

The N, P and K uptake by *toria* was significantly higher with fertilization over absolute control (Table 2). The organic sources of nutrients applied to rice had significant residual effect on the uptake of nutrients by *toria*. Among the various organic treatments, significantly highest N, P

Table 2. Effect of organics and inorganics on N, P and K uptake by rice, *toria* and total uptake of the system (mean data)

Treatment	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	Rice	*Toria*	System	Rice	*Toria*	System	Rice	*Toria*	System
Organics									
FYM 5t/ha	62.42	41.89	104.31	11.41	8.06	19.47	64.39	38.07	102.46
Eupatorium 5 t/ha	66.63	29.10	95.63	14.78	5.50	20.28	69.83	26.80	96.63
Alnus 5 t/ha	61.73	30.95	92.68	10.77	5.97	16.74	63.38	28.24	91.62
FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha	67.35	31.85	99.20	15.11	6.15	21.26	69.15	28.90	98.05
FYM 2.5 t/ha + *Alnus* 2.5 t/ha	62.37	26.77	89.14	11.18	5.18	16.36	63.41	25.34	88.75
SEm±	1.18	1.63	1.85	0.37	0.31	0.35	1.24	1.49	1.78
CD (P=0.05)	3.42	4.70	5.33	1.07	0.89	1.01	3.57	4.30	5.12
Inorganics									
50% RDF (rice) + 75% RDF (*toria*)	58.10	31.18	89.28	11.16	5.97	17.13	58.17	28.58	86.75
100% RDF (rice) + 50% RDF (*toria*)	66.11	33.61	99.72	13.36	6.49	19.85	70.16	30.75	100.91
150% RDF (rice) + 25% RDF (*toria*)	68.09	31.55	99.64	13.43	6.07	19.5	69.78	29.08	98.86
SEm±	0.92	1.26	1.43	0.29	0.24	0.27	0.96	1.15	1.37
CD (P=0.05)	2.65	NS	4.13	0.83	NS	0.78	2.77	NS	3.97
Control vs. rest									
Control	40.31	9.27	49.58	7.63	2.16	9.79	37.68	11.24	48.92
Rest	64.10	32.11	96.21	12.65	6.17	18.82	66.03	29.47	95.50
SEd±	2.12	2.91	3.30	0.66	0.55	0.63	2.21	2.67	3.17
CD (P=0.05)	4.32	5.94	6.75	1.35	1.12	1.28	4.52	5.44	6.48

Table 3. Effect of organics and inorganics on economics of rice-*toria* cropping system (mean data)

Treatment	Cost of cultivation (x 10^3 Rs/ha)			Net returns (x 10^3 Rs/ha)			Benefit : cost ratio		
	Rice	*Toria*	System	Rice	*Toria*	System	Rice	*Toria*	System
Organics									
FYM 5 t/ha	11.80	2.93	14.73	6.44	4.99	11.43	1.55	2.78	1.78
Eupatorium 5 t/ha	10.80	2.93	13.73	9.23	2.58	11.81	1.86	1.87	1.86
Alnus 5 t/ha	11.05	2.93	13.98	6.84	2.83	9.68	1.63	1.98	1.69
FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha	10.68	2.93	13.60	9.67	2.95	12.62	1.91	2.08	1.93
FYM 2.5 t/ha + *Alnus* 2.5 t/ha	10.80	2.93	13.73	7.75	2.00	9.75	1.73	1.72	1.71
Inorganics									
50% RDF (rice) + 75% RDF (*toria*)	9.83	3.39	13.23	7.96	2.45	10.41	1.82	1.72	1.79
100% RDF (rice) + 50% RDF (*toria*)	11.03	2.93	13.95	8.69	3.32	12.01	1.79	2.13	1.86
150% RDF (rice) + 25% RDF (*toria*)	12.23	2.47	14.69	7.31	3.44	10.75	1.60	2.39	1.73
Control vs. rest									
Control	6.90	2.00	8.90	3.73	0.23	3.97	1.54	1.12	1.45
Rest	11.03	2.93	13.95	7.99	3.07	11.06	1.74	2.08	1.79

Sale price (x 10^3 Rs/t): Rice, 5.60; *toria*, 12.00; FYM, 0.50; *Eupatorium*, 0.30; *Alnus*, 0.35; urea, 5.90; single superphosphate, 5.10; muriate of potash, 8.20

and K uptake was recorded with FYM 5 t/ha, followed by FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha. On the contrary, the N, P and K uptake was lowest with FYM 2.5 t/ha + *Alnus* 2.5 t/ha. However, the N, P and K uptake by *toria* did not differ significantly with inorganic treatments. It could be due to the balancing act of residual effect of higher doses of fertilizer to rice with the direct effect of nutrients applied to *toria* as the fertilizer applied to *toria* was in reverse order of rice.

The average N, P and K uptake by the rice-*toria* cropping system increased by 46.6, 9.0 and 46.6 kg/ha with fertilization compared with the control (Table 2). Significantly higher N, P and K uptake by rice-*toria* cropping sequence was recorded with FYM 5 t/ha, followed by FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha among the organic treatments tried which is mainly attributed to significantly higher level of N, P and K uptake by *toria* with FYM 5 t/ ha in the dry season and rice with FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha in the rainy season. However, application of different levels of inorganic fertilizer to rice and *toria* had significant variations in total N, P and K uptake by the system, and maximum uptake was obtained with 100% RDF to rice + 50% RDF to *toria.*

Economics

Fertilization with organic manures and inorganic fertilizer gave remarkably higher net monetary returns and benefit : cost ratio of rice–*toria* cropping system, registering 178.6 and 23.5% increase respectively over the control (Table 3). Fertilization of rice with FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha fetched the highest net monetary returns (Rs 9.67 x 10^3/ha) and maximum benefit : cost ratio (1.91), followed by *Eupatorium* 5 t/ha (Rs 9.23 x 10^3/ha and 1.86 respectively), but the residual effect of FYM 5 t/ ha gave the maximum net return (Rs 4.99 x 10^3/ha) and benefit : cost ratio (2.78) in *toria*. However, higher net returns (Rs 12.62 x 10^3/ha) and benefit : cost ratio (1.93) of the rice-*toria* cropping system was achieved with FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha, followed by *Eupatorium* 5 t/ ha alone (Rs 11.81 x 10^3/ha and 1.86 respectively), because the magnitude of increase in net returns in rice were more in these treatments compared with the residual effect of FYM 5 t/ha in *toria*. The higher net returns and benefit : cost ratio realized with FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha or *Eupatorium* 5 t/ha alone over FYM 5 t/ha and *Alnus* 5 t/ha and FYM 2.5 t/ha + *Alnus* 2.5 t/ha can be attributed to higher REY of the system and involvement of lower input cost for collecting the locally-available *Eupatorium* plant compared with *Alnus* and higher cost of FYM. Among the inorganic fertilizer treatments, the highest net returns (Rs 8.69 x 10^3/ha) and benefit : cost ratio (1.79) of rice and the system (Rs 12.01 x 10^3/ha and 1.86 respectively) as a whole was obtained with 100% RDF to rice + 50% RDF to *toria*, which can be attributed to higher total productivity compared than that with 50% RDF to rice + 75% RDF to *toria* and lower cost of cultivation in comparison with the 150% RDF to rice + 25% RDF to *toria*. But in *toria*, the highest net returns (Rs 3.44 x 10^3/ ha) and benefit: cost ratio (2.39) were achieved with 150% RDF to rice + 25% RDF to *toria* due to the lower cost of cultivation (Rs 2.47 x 10^3/ha) of *toria*.

Hence the application of FYM 2.5 t/ha + *Eupatorium* 2.5 t/ha with 100% RDF to rice + 50% RDF to *toria* was found beneficial in terms of REY and economics of rice-*toria* cropping system under mid-hills dry terraces of Meghalaya.

REFERENCES

Balasubramaniyan, P. 2004. Yield potential of fine-grain rice (*Oryza sativa*) under integrated nutrient management. *Indian Journal of Agronomy* **49**(3): 157–159.

Krishna, D. and Ram, S. 2006. Long-term impact of organic and inorganic fertilization on grain yield and quality of rice (*Oryza sativa*) in Mollisol of tarai. *International Journal of Agricultural Sciences* **2**(1): 61–63.

Kumar, N., Verma, L.P., Singh, R. and Prasad, K. 2001. Soil properties, nutrient uptake and productivity of rice under integrated nutrient management system. *Annals of Plant and Soil Research* **3**(1): 54–57.

Manjappa, K. and Kelaginamani, S.V. 2005. Long-term effect of integrated nutrient management practices on productivity of rice-cowpea cropping system under rainfed lowland rice situation. In: *Extended Summaries of National Seminar on Rice and Rice-based System for Sustainable Productivity,* pp. 131-132. Manjunath, B.L., Faleiro, J.R., Ramesh, R., Hegde, K.K. and Satarkar, V. (Eds). Association for Coastal Agricultural Research, ICAR Research Complex for Goa, Old Goa, Goa.

Minhas, R.S. and Sood, A. 1994. Effect of inorganic and organics on yield and nutrients uptake by three crops in rotation on in acid alfisol. *Journal of Indian Society of Soil Science* **42**: 257–260.

Pandey, N., Verma, A.K., Anurag and Tripathi, R.S. 2007. Integrated nutrient management in transplanted hybrid rice (*Oryza sativa*). *Indian Journal of Agronomy* **52**(1): 40–42.

Raju, R.A. and Reddy, N.N. 2000. Integrated management of green leaf compost, crop residues and inorganic fertilizers in rice (*Oryza sativa*) - rice system. *Indian Journal of Agronomy* **45**(4): 629–635.

Ramteke, J.R., Mahadhkar, U.V. and Yadav, R.S. 1998. Sustainable crop production through cropping system and organic farming. In: *Extended Summaries of First International Agronomy Congress on Agronomy, Environment and Food Security for 21st Century*, pp. 393-394. Indian Society of Agronomy, Indian Agricultural Research Institute, New Delhi.

Singh, S.P. and Subbaiah, S.V. 2007. Effect of integrated nutrient management on grain yield and economic returns of hybrid rice. *Oryza* **42**(2): 174–176.