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Effect of different vermicomposts under integrated nutrient management on soil fertility and productivity of rice

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ABSTRACT

Studies on effect of different vermicomposts under integrated nutrient management (INM) on soil fertility status, soil humic substances, grain yield and benefit cost ratio in rice were conducted at Anakapalle during wet season 2009 and 2010. Rice was grown with 12 treatments, consisting of INM practices (where 50 % or 75 % recommended dose of fertilizer (RDF) was integrated with vermicomposts prepared from sugarcane trash, weeds, vegetable waste and rice straw) and certified organic manures. The data indicated that, there was no change in the pH and EC of the soil, whereas the values of available macro and micro nutrients (N, P, K, Zn, Fe, Cu and Mn) were higher with INM practices, specially when vermi compost prepared from vegetable waste was applied. A distinct decrease was noticed in all the values, when crop was raised without any external supplement of nutrients. Application of vermicomposts enhanced the humic and fulvic acid content in the soil over initial value. Significantly higher grain yield was recorded in 75% RDF + vegetable market waste vermicompost @ 2.5 t ha^{-1} and it was on par with 50 % Prathista organic manures + 50% chemical fertilizers. The treatment with 100% Prathista organic manures recorded highest (BCR = 2.92).

Key words: *vermicompost, INM, rice, soil fertility and grain yield*

Chemical fertilizers are essential basic needs of the present day intensive agriculture. Continuous use of these chemical fertilizers lead to the deterioration in soil fertility. In India, about 340 million tons of agricultural wastes are generated and the recycling of these wastes has a great potential to be used as organic manure (Statistics at a Glance 2010). The approach to improve the productivity, profitability, soil health and quality of produce through the locally available resources will attract the farmers to use these resources. Contrary to detrimental effects of inorganic fertilizers, organic manures are available indigenously which improve soil health resulting in enhanced crop yield. However, the use of organic manures alone might not meet the plant requirements due to presence of relatively low levels of nutrients. Therefore, in order to make the soil well supplied with all the plant nutrients in the readily available form and to maintain good soil health, it is necessary to use organic manures in conjunction with inorganic fertilizers to obtain optimum yields. Hence, the present investigation was undertaken to study the effect of different vermicomposts obtained from various organic residues integrated with inorganic fertilizers on soil fertility and productivity of rice.

MATERIALS AND METHODS

Vermicomposts obtained from different organic residues viz., cane trash, weeds, vegetable market waste and rice straw were used @ 2.5 t ha^{-1} along with different levels of nitrogen fertilizers were used to evaluate their efficiency under integrated nutrient management in rice. The recommended dose of chemical fertilizers applied in the field was 80kg N, 60kg P_2O_5 and 40kg K_2O ha^{-1}. Along with these treatments, certified organic manures supplied by M/s Prathista Industries Ltd., Hyderabad, India *viz.,* Suryamin (20% N) for N supplement, Biophos (20% P_2O_5) and Biopotash (14% K_2O) for P and K supplements, Biozinc (12% Zn) for zinc supplement were tested together along with other INM treatments.

Recommended doses of phosphorus and potassium were applied uniformly to all the treatments in the form of single super phosphate and muriate of potash as basal. Urea was applied in 3 equal splits *i.e*. basal, tillering and panicle initiation stages of the rice crop and Prathista organic manures were applied at the time of transplanting and foliar sprays at tillering and PI stage of the crop. The study was conducted at Anakapalle, Andhra Pradesh during wet season 2009 and 2010 with rice variety Vasundhara (RGL 2538). There were 12 treatments of integrated nutrient management. The treatments include 50% RDF + 2.5 t ha^{-1} cane trash vermicompost, 50% RDF + 2.5 t ha^{-1} weed vermicompost, 50% RDF + 2.5 t ha^{-1} vegetable market waste vermicompost, 50% RDF + 2.5 t ha^{-1} rice straw vermicompost, 75% RDF + 2.5 t ha^{-1} cane trash vermicompost, 75% RDF + 2.5 t ha^{-1} weed vermicompost, 75% RDF + 2.5 t ha^{-1} veg. market waste vermicompost, 75% RDF + 2.5 t ha^{-1} rice straw vermicompost, 100% RDF and 0 % RDF (Absolute Control, (100% Prathista organic manures) and (50% RDF + 50% Prathista organic manures), Different vermicomposts *viz*., cane trash, weed, vegetable market waste and rice straw vermicompost @ 2.5 t ha^{-1} were used along with different levels of chemical fertilizers i.e 50% RDF (40kg N, 30 kg P_2O_5 and 20 kg K_2O ha^{-1}) and 75% RDF (60 kg N, 45 kg P_2O_5 and 30 kg K_2O ha^{-1}) in rice and later greengram was grown. The different vermicomposts were prepared by using the earthworm species *Eisenia foetida* @ 1kg ton^{-1} of organic residue. The basic raw materials used for vermicomposting were sugarcane trash, weeds (*Cyperus rotundus, Cynodon dactylon, Cleome viscosa, Commelinabengalensis* and *Trianthema portulacastrum)*, vegetable market waste and paddy straw. Vermicomposting was carried out in cement pits with 6 x 2 x 0.6 m. size in a hut.

Initial and post harvest soil samples were dried under shade, pounded, to pass through a 2 mm sieve. The samples were analysed for pH, EC, OC, available N, P, K, micronutrients (Zn, Fe, Cu and Mn) and humic and fulvic acids by adopting standard procedures (Jackson, 1967).The data on Initial soil analysis presented in table 1 revealed that the soil was neutral in soil reaction (pH 7.22) and non saline (0.210 dSm^{-1}). The organic carbon content was 0.51 g kg^{-1} and the available nitrogen content was low (241 kg ha^{-1}), available phosphorus was medium in status (27.45 kg ha^{-1}) and potassium content was high (309 kg ha^{-1}). The data on initial micronutrient status revealed that the available zinc, copper, manganese and iron were 0.74, 1.10, 8.2 and 10.5 ppm, respectively. Benefit cost ratio was calculated as gross returns accrued divide by total cost incurred.

Table 1. Effect of INM on physico chemical properties in post harvest soils of rice during wet season 2009 and 2010

Treatments	*p*H			EC (dS m^{-1})			OC (g kg^{-1})		
	2009	2010	Mean	2009	2010	Mean	2009	2010	Mean
50% RDF + CTC @ 2.5 t ha^{-1}	7.14	6.96	7.05	0.179	0.199	0.189	5.4	5.6	5.5
50% RDF + WC @ 2.5 t ha^{-1}	7.03	6.95	6.99	0.161	0.141	0.151	5.6	5.8	5.7
50% RDF + VMWC @ 2.5 t ha^{-1}	7.04	7.01	7.03	0.161	0.131	0.146	5.7	6.1	5.9
50% RDF + RSC @ 2.5 t ha^{-1}	7.08	6.91	7.00	0.115	0.142	0.128	5.3	5.6	5.5
75% RDF + CTC @ 2.5 t ha^{-1}	7.18	7.11	7.15	0.207	0.134	0.170	5.6	6.0	5.8
75% RDF + WC @ 2.5 t ha^{-1}	7.12	6.90	7.01	0.208	0.156	0.182	5.8	6.0	5.9
75% RDF + VMWC @ 2.5 t ha^{-1}	7.13	7.10	7.12	0.151	0.232	0.191	6.0	6.3	6.2
75% RDF + RSC @ 2.5 t ha^{-1}	7.14	7.06	7.10	0.197	0.164	0.180	5.4	6.1	5.8
100% RDF	7.21	7.23	7.22	0.159	0.210	0.184	5.3	5.4	5.4
Control	7.08	7.11	7.10	0.176	0.143	0.159	4.5	4.1	4.3
100% Prathista organic manures	7.10	7.08	7.09	0.180	0.144	0.162	5.7	6.0	5.9
50% RDF + 50% Prathista organic manures	7.12	7.06	7.09	0.169	0.156	0.162	5.6	6.0	5.8
Mean	7.11	7.04	7.08	0.178	0.165	0.172	5.5	5.8	5.7
CD ($P<0.05$)	NS	NS	NS	NS	NS	NS	0.38	0.42	0.41

RDF - Recommended dose of fertilizer, CTC - Cane trash compost, WC - Weed Compost, VMWC - Vegetable market waste compost, RSC - Rice straw compost

RESULTS AND DISCUSSION

The *p*H and soluble salt content of the soil was not significantly influenced by the addition of vermicomposts in both the years though there was a slight decrease in second year as compared to first year. Post harvest soils were neutral in reaction with normal conductivity. The organic carbon content showed significant difference between the treatments. Organic carbon content varied from 4.5 to 6.0 g kg^{-1} during first year and 4.1 to 6.3 g kg^{-1} during the second year. Organic carbon content of soil with an initial value of 5.1 g kg^{-1} had increased significantly and attained a maximum value of 6.3 g kg^{-1} at the end of second year, in the treatment involving 75% RDF + vegetable market waste vermicompost @ 2.5 tha^{-1}. This could be ascribed to the contribution from annual use of vermicompost consecutively for two years, and it was on par with T6 which received weed vermicompost. Where as in absolute control treatment it was decreased to 4.1 g kg^{-1} in second year from its initial value of 5.1 g kg^{-1}. The treatment 100% RDF to wet season rice and 50 % RDF to rabi greengram was inferior to all the INM treatments, but was superior to absolute control. It may be attributed to higher contribution of biomass to the soil in the form of crop stubbles and residues. The subsequent decomposition of these materials might have resulted in enhanced organic carbon content of the soil.

The level of organic carbon is the indication of soil fertility and its production potential. Organic carbon is one of the most important fertility parameters that determines the quality of soils. The organic carbon content increased with the incorporation of different vermicomoposts as well as with the incorporation of Prathista organic manures as compared to 100 % recommended dose of chemical fertilizer. Addition of vermicomoposts have created environment conducive for formation of humic acid which stimulates the activity of soil microorganisms resulting in an increase in the organic carbon content of the soil. Datta and Singh (2010) noticed an appreciable rise in organic carbon content from its initial value in organic manure added plots under rice-pulse cropping system. This also indicates that if balanced fertilizer is used and integrated with manures, substantial improvement in soil health can be achieved. These results are in conformity with the findings of Virdia and Mehta (2009). Kumarjit Singh *et al*. (2005) observed that the application of vermicompost plus inorganic fertilizers increased the organic carbon content of post harvest soils of rice. Increase in organic carbon content due to use of chemical fertilizers over control can also be attributed to higher contribution of biomass to the soil in the form of stubbles and residues (Bajpai *et al*., 2006). The significant increase in organic carbon content due to

Table 2. Effect of INM on available NPK status in post harvest soils of rice during wet season 2009 and 2010

Treatments	Available N (kg ha^{-1})			Available P_2O_5(kg ha^{-1})			Available K_2O (kg ha^{-1})		
	2009	2010	Mean	2009	2010	Mean	2009	2010	Mean
50% RDF + CT VC @ 2.5 t ha^{-1}	254	258	256	31.1	33.1	32.1	324	336	330
50% RDF + W VC @ 2.5 t ha^{-1}	260	261	261	33.1	36.3	34.7	320	340	330
50% RDF + VMW VC @ 2.5 t ha^{-1}	261	264	263	34.1	38.1	36.1	318	334	326
50% RDF + PS VC @ 2.5 t ha^{-1}	258	260	259	32.1	35.1	33.6	321	340	333
75% RDF + CT VC @ 2.5 t ha^{-1}	254	259	256	31.5	37.1	34.3	326	339	334
75% RDF + W VC @ 2.5 t ha^{-1}	261	267	264	36.1	39.3	37.2	324	350	337
75% RDF + VMW VC @ 2.5 t ha^{-1}	268	274	271	38.7	40.5	39.6	320	344	332
75% RDF + PS VC @ 2.5 t ha^{-1}	256	260	258	35.1	38.2	36.6	328	351	340
100% RDF	249	251	250	31.1	35.0	33.0	314	325	320
Absolute control	202	185	193	22.2	16.5	19.3	265	209	237
100% Prathista organic manures	261	268	264	35.1	39.5	37.3	325	343	334
50% RDF + 50% Prathista organic manures	260	266	263	34.3	37.3	35.8	322	344	333
Mean	254	256	255	32.8	35.5	34.1	317	330	324
CD ($P<0.05$)	14.2	17.8	20.4	2.8	3.1	3.0	28.5	29.2	28.7

RDF - Recommended dose of fertilizer, CTC - Cane trash compost, WC - Weed Compost, VMWC - Vegetable market waste compost, RSC - Rice straw compost

addition of vegetable market waste vermicompost than other form of vermicomposts might be due to more biomass and its subsequent decomposition. Similar results were reported by Barik *et al*.(2008) in post harvest soils of rice under integrated nutrient management.

Available N, P and K were significantly affected due to application of different types of vermicomposts with chemical fertilizer treatments over chemical fertilizers alone. Available nitrogen varied from 202 to 268 kg ha^{-1} during 2009 and 185 to 274 kg ha^{-1} during 2010. Continuous use of different types of vermicomposts consecutively for two years tended to increase the available nitrogen, phosphorus and potassium content of the soil from an initial values of 241, 27.45 and 309 kg ha^{-1} to 274, 40.50 and 340 kg ha^{-1} respectively. Application of vermicomposts with fertilizers proved to be superior to chemical fertilizers alone in respect of build-up of available macro nutrient content. Among different vermicomposts, significantly highest available N and P content was recorded in the treatment involving 75% RDF with vegetable market waste vermicompost @ 2.5t ha^{-1} and it was on par with other INM treatments and integrated use of Prathista organics+chemical fertilizers. Highest available potassium content was recorded in the treatment with 75% RDF+rice straw vermicompost @ 2.5 tha^{-1}. Further it was also observed that the available macro nutrient status in soil increased with the increasing levels of fertilizer application from 50% RDF to 75% RDF. With the same level of fertilizer and vermicompost application, vegetable market waste vermicompost recorded highest available macro nutrient content compared to other sources of vermicomposts. Significantly lower available macro nutrient content was recorded in control treatment. All the three macro nutrients were decreased significantly in 100% RDF treatment as compared to all the INM treatments. There was a depletion of available nitrogen to the extent of 8.5% during second year in unfertilized plot. Kundu and Ladha (1997) noticed that the growing rice increased mineral N availability in the flooded soil by an average of 31%.

Apparently higher available nutrient status under INM treatments may be due to the reason that even after the harvest of rice, certain quantities of vermicompost continue to mineralize releasing nutrients which could add to the available pool. The treatment with 75% RDF+2.5t ha^{-1} veg. market waste vermicompost maintained more available nutrient status than other vermicompost treatments. This was attributed to the high initial nutrient status in vegetable market waste and the differences in time required for mineralization process and release of nutrients. Compared to fertilizer treatments, more depletion of nutrients were observed under control and lower values of available nutrient were

Table 3. Effect of INM on micronutrient status (ppm) in post harvest soils of rice during wet season 2009 and 2010

Treatments	Zn			Fe			Cu			Mn		
	2009	2010	Mean	2009	2010	Mean	2009	2010	Mean	2009	2010	Mean
50% RDF + CT VC @ 2.5 t ha^{-1}	0.81	1.02	0.92	7.6	8.1	7.85	1.06	1.24	1.15	11.6	12.7	12.1
50% RDF + W VC @ 2.5 t ha^{-1}	0.98	1.31	1.15	8.4	8.9	8.65	1.22	1.45	1.33	12.4	13.2	12.8
50% RDF + VMW VC @ 2.5 t ha^{-1}	0.95	1.22	1.09	9.2	9.7	9.45	1.43	1.56	1.49	14.2	15.8	15
50% RDF + PS VC @ 2.5 t ha^{-1}	0.79	0.98	0.89	7.8	8.3	8.05	0.98	1.20	1.09	10.7	12.1	11.4
75% RDF + CT VC @ 2.5 t ha^{-1}	0.83	1.16	1.00	7.9	8.3	8.1	1.22	1.31	1.26	12.8	13.4	13.1
75% RDF + W VC @ 2.5 t ha^{-1}	1.03	1.3	1.17	8.6	9.2	8.9	1.37	1.52	1.45	13.7	14.7	14.2
75% RDF + VMW VC @ 2.5 t ha^{-1}	1.04	1.26	1.15	9.5	10.2	9.85	1.52	1.64	1.58	15.2	16.5	15.8
75% RDF + PS VC @ 2.5 t ha^{-1}	0.82	1.14	0.98	8.1	8.4	8.25	1.14	1.23	1.18	12.2	13.2	12.7
100% RDF	0.7	0.74	0.72	7.5	7.6	7.55	1.01	1.02	1.02	10.2	10.5	10.3
Absolute control	0.64	0.58	0.61	5.9	5.4	5.65	0.85	0.74	0.79	7.4	7.0	7.2
100% Prathista organic manures	1.07	1.34	1.21	7.9	8.2	8.05	1.12	1.24	1.18	11.5	12.5	12.0
50% RDF+50% Prathista organic manures	1.01	1.25	1.13	7.7	8.0	7.85	1.07	1.15	1.11	10.8	11.5	11.15
Mean	0.89	1.11	1.00	8.01	8.35	8.18	1.16	1.27	1.22	11.89	12.7	12.3
CD (P<0.05)	0.074	0.080	0.076	0.68	0.71	0.71	0.11	0.12	0.11	1.1	1.6	1.4

RDF - Recommended dose of fertilizer, CTC - Cane trash compost, WC - Weed Compost, VMWC - Vegetable market waste compost, RSC - Rice straw compost

recorded in the treatment which received 100 % RDF as compared to INM treatments. This may be due to maximum utilization of applied nutrients by both the crops in sequence (Peda Babu *et al.,* 2008, Upendra Rao *et al.*, 2009). In both the years control plot showed reduction in the available nutrient status due to removal of nutrients by the crop. Conjunctive application of organics along with inorganics sets a congenial soil environment with consistent supply of nutrients during the crop period by enhancing the crop growth resulting in higher yield. Production of organic acids during decomposition might have solubilized the unavailable forms of phosphorus. Virdia and Mehta (2009) reported that the application of vermicompost with chemical fertilizers increased the available phosphorus content as compared to chemical fertilizer alone and this might be due to mineralization of added P. Available P status in post harvest soils of paddy markedly improved from the initial status. NPK status in control indicated considerable mining of available nutrients. The results are in agreement with the findings of Datta and Singh (2010). Increase of the available potassium content under integrated nutrient management might be due to reduction of K fixation and release of K from interaction of organic matter with clay besides addition of K to the available pool. These findings are in close agreement with the findings of Barik *et al.*(2008). Among all the sources of comopost, paddy straw and cane trash vermicompost treated soils recorded higher available potassium content than vegetable market waste and weed vermicompost. This could be due to higher total potassium content in cane trash and paddy straw comoposts. Shailaja (2006) reported maximum available potassium content in paddy straw vermicompost treated soils than weed vermicompost treated soils.

Available micronutrient contents observed under INM treatmens were higher over chemical fertilizers alone and the contents were higher in the second year than first year. Considering the critical limits of Zn (0.6 ppm), Cu (1 ppm), Fe (4.5 ppm) and Mn (2 ppm), all the treatments fall under sufficiency range except control. The treatment with 75% RDF + vegetable market waste vermicompost @ 2.5 tha^{-1} recorded significantly higher available micronutrient content except zinc. In both the years, the highest available zinc content was recorded in the treatment 100% Prathista organic manures which was on par with the treatment 75% RDF + VMW C @ 2.5 t ha^{-1}, 75% RDF + W C @ 2.5 t ha^{-1} and 50% RDF + 50% Prathista organic manure, where as lowest available zinc content was recorded in control.

The results are well supported by the findings of Ramesh *et al.* (2006) and Banik and Sharma (2008). The higher availability of micronutrients in soil particularly with use of organic manures may be ascribed to mineralization, reduction in fixation of nutrients by organic matter and complexing properties of vermicompost with micronutrients (Prasad *et al.* 2010). The INM treatments with organic manures either increased or retained the fertility status of micronutrients. Organic manures on decomposition produced a variety of biochemical substances (organic acids, polyphenols, amino acids and poly saccharides) which stimulate the solubility, transport and availability of micronutrients. Effectiveness of organic manures may be ascribed to their ability after degradation to form water soluble complexes with iron and other ions. The most significant influence of organic manures in increasing the solubility and availability of iron in the soil is through solubilization and mass flow in the immediate vicinity of plant (Prasad *et al.* 2010).

Humic and fulvic acid content in soil was significantly influenced by the application of different vermicomposts (Table 4). Humic acid content extracted from different treatments varied from 0.20 to 0.37 per cent during 2009 and 0.18 to 0.43 per cent during 2010. Highest humic acid content was recorded in the treatment which received 75% RDF + VMWC @ 2.5 t ha^{-1}). In both the years vegetable market waste vermicompost performed better than other sources of vermicomposts and it was on par with 75% RDF + W C @ 2.5 tha^{-1}, 50% RDF + VMWC @ 2.5 tha^{-1} and 100% Prathista organic manures. All the INM treatments were superior to recommended dose of chemical fertilizers. Control plots recorded the lowest humic acid content. Fulvic acid content also followed the similar trend like that of humic acid content. Application of organic manures enhanced the fulvic acid content in the soil ranged between 0.12 and 0.24 per cent during 2009 and 0.11 and 0.25 per cent during 2010. All the INM treatments were superior to recommended dose of chemical fertilizers.

The most biologically active component of the soil system is the organic matter. Application of organic amendments to the soil system will significantly

Table 4. Effect of INM on soil humic substances (%) in post harvest soils of rice during wet season 2009 and 2010

Treatments	Humic Acid			Fulvic Acid		
	2009	2010	Mean	2009	2010	Mean
50 % RDF + CT VC @ 2.5 t ha^{-1}	0.31	0.36	0.34	0.16	0.17	0.16
50 % RDF + W VC @ 2.5 t ha^{-1}	0.35	0.39	0.37	0.19	0.21	0.2
50 % RDF + VMW VC @ 2.5 t ha^{-1}	0.36	0.41	0.38	0.20	0.23	0.22
50 % RDF + PS VC @ 2.5 t ha^{-1}	0.32	0.36	0.34	0.17	0.19	0.18
75 % RDF + CT VC @ 2.5 t ha^{-1}	0.32	0.38	0.35	0.18	0.22	0.20
75 % RDF + W VC @ 2.5 t ha^{-1}	0.37	0.41	0.39	0.21	0.24	0.22
75 % RDF + VMW VC @ 2.5 t ha^{-1}	0.37	0.43	0.40	0.24	0.25	0.25
75 % RDF + PS VC @ 2.5 t ha^{-1}	0.34	0.37	0.36	0.17	0.20	0.18
100 % RDF	0.28	0.28	0.28	0.14	0.16	0.15
Absolute control	0.20	0.18	0.19	0.12	0.11	0.12
100 % Prathista organic manures	0.36	0.41	0.38	0.20	0.24	0.22
50% RDF + 50% Prathista organic manures	0.34	0.38	0.36	0.21	0.23	0.22
Mean	0.32	0.36	0.34	0.18	0.20	0.19
CD ($P<0.05$)	0.022	0.024	0.024	NS	NS	-

RDF - Recommended dose of fertilizer, CTC - Cane trash compost, WC - Weed Compost, VMWC - Vegetable market waste compost, RSC - Rice straw compost

increases the humic fractions of soil and these fractions enhances the nutrient availability (Zhang and Dousen, 2002). Application of different vermicompost from different sources significantly enhanced the humic substances in soil. Among the different treatments, the higher humic acid content was recorded in the treatment which received 75% RDF + VMW C @ 2.5 t ha^{-1}. This could be due to fact that the vegetable market waste contains high organic matter and its application to soil on decomposition increases the humic acid content in soil. Similar results were obtained by Garcia *et al.* (2004) and Shailaja (2006). Gathala *et al.* (2007) reported that humic acid and fulvic acid contents got increased with application of organic amendments to the soil. Soil organic matter influences humic fractions by its ability to interact with metals,

It was observed that the grain yield varied from 2.8 to 5.5 t ha^{-1} during 2009 and 2.4 to 6.2 t ha^{-1} during 2010 (Fig.1). Significantly higher grain yield was

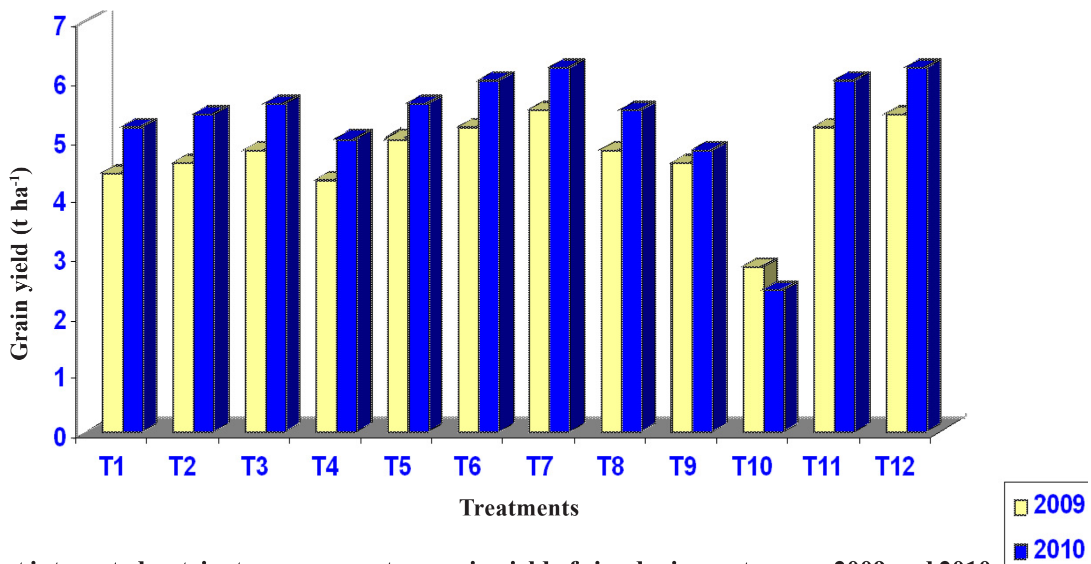

Fig. 1. Effect integrated nutrient management on grain yield of rice during wet season 2009 and 2010

recorded in 75% RDF+ vegetable market waste vermicompost @ 2.5 t ha^{-1} and it was on par with 50% Prathista organic manures + 50% chemical fertilizers, 75% RDF+ weed vermicompost @ 2.5 t ha^{-1} and 100% Prathista organic manures. All the treatments were significantly higher than control which recorded the lowest grain yield of 2.8 and 2.4 t ha^{-1} during 2009 and 2010, respectively. Straw yield also followed the same trend and all the treatments with 75% RDF+ vermicomposts @ 2.5 t ha^{-1} were superior to 100% recommended dose of chemical fertilizers.

The higher grain and straw yield of rice with integrated use of vermicomposts from different sources and chemical fertilizers with 75% and 50% of recommended dose of nitrogen might be attributed to higher availability and uptake of macro and micro nutrients, facilitating uptake by plants resulting in better growth and dry matter production and also occurrence of different beneficial microorganisms, presence of growth promoting substances, hormones, enzymes, antibiotics etc., in vermicompost (Prasad *et al.*, 2010). Among different INM treatments, 75% RDF in combination with different vermicomposts @2.5 t ha^{-1} recorded significantly higher grain and straw yields compared to 50% RDF in combination with different vermicomposts @ 2.5 t ha^{-1}. This could be due to high availability and utilization of nitrogen by the crop from inorganic source (fertilizer) whereas release of nitrogen from organic source may not be complete during the crop growth period. These findings are in conformity with Singh *et al.* (2005).

Increase in growth and yield of rice with application of vermicompost and chemical fertilizers were also reported by Banik and Ranjita Bejbaruah (2004) and Chakravorti and Samantaray (2006). Among different vermicomposts (cane trash, weeds, vegetable market waste and rice straw vermicomposts) used in the study, rice responded favourably to the addition of vegetable market waste vermicompost as a substitute for a part of chemical nitrogen fertilizer compared to application of other vermicomposts. This might be due to the rate of decomposition and C/N ratio of the organic manures, which decide the availability of nutrient (Fateh Singh *et al.*, 2008). Conjunctive application of organics along with inorganics sets a congenial soil environment with consistent supply of nutrients over the crop period by enhancing the crop growth which results in high yields.

Cost of cultivation was slightly reduced in all the INM treatments over 100% RDF. However, the gross returns were more in INM treatments than 100% RDF and control plots (Table 5). The net returns from the unfertilized rice crop was ₹ 10,330/-. The addition of fertilizers increased the net gain. An addition of ₹ 25,755/- was obtained as a net gain by applying the recommended dose of chemical fertilizers. Among different INM treatments, the plot which received 75% RDF + VMW C @ 2.5 t ha^{-1} recorded maximum gross returns of ₹ 58,793/- with a benefit cost ratio of 2.81, However, maximum net returns and BC ratio of ₹ 38,350/- and 2.92 was recorded in 50% RDF + 50% Prathista organic manures. Higher returns from INM

Table 5. Benefit-Cost ratio under Integrated Nutrient Management

Treatments	Cost of cultivation (₹ ha^{-1})	Gross Income (₹ ha^{-1})	Net income (₹ ha^{-1})	BC ratio
50 % RDF + CT C @ 2.5 t ha^{-1}	20,380	48,240	27,860	2.37
50 % RDF + W C @ 2.5 t ha^{-1}	20,380	50,250	29,870	2.47
50 % RDF + VMW C @ 2.5 t ha^{-1}	20,380	52,260	31,880	2.56
50 % RDF + PS C @ 2.5 t ha^{-1}	20,380	46,733	26,353	2.29
75 % RDF + CT C @ 2.5 t ha^{-1}	20,905	53,265	32,360	2.55
75 % RDF + W C @ 2.5 t ha^{-1}	20,905	56,280	35,375	2.69
75 % RDF + VMW C @ 2.5 t ha^{-1}	20,905	58,793	37,888	2.81
75 % RDF + PS C @ 2.5 t ha^{-1}	20,905	51,758	30,853	2.48
100 % RDF	21,480	47,235	25,755	2.20
Control	15,800	26,130	10,330	1.65
100 % Prathista organic manures	20,400	56,280	35,880	2.76
50% RDF + 50% Prathista organic manures	19,940	58,290	38,350	2.92

treatments than 100% chemical fertilizers is due to reduction in cost of cultivation, vermicompost is prepared in the farm itself (assuming production cost is 0.50 paise kg^{-1} only) and the integrated use of Prathista organics and 50% chemical fertilizers enhanced the yield and reduction in cost of cultivation which leads to maximum BC ratio among all the treatments. The treatment with 100% Prathista Organic manures is highest profitable among all the treatments (BCR=2.92) and it was closely followed by the treatment 75% RDF+VMWC @ 2.5 t ha^{-1} (BCR=2.81).

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