Effect of Integrated Nutrient Management (INM) on Humic substances and Micronutrient Status in Submerged Rice Soils

Ch. S. Rama Lakshmi*, P.C. Rao, T. Sreelatha, G. Padmaja, M. Madhavi, P.V. Rao and A. Sireesha

Regional Agricultural Research Station, Anakapalle

Abstract

Field experiments were conducted during *kharif* 2009 and 2010 with rice as the test crop under submerged conditions using different vermicomposts under integrated nutrient management (INM) at Regional Agricultural Research Station, Anakapalle, Andhra Pradesh, India. In the present study, *kharif* rice was grown with 12 treatments, consisting of different treatments. The data indicated that the values of available micro nutrient status, their uptake and humic substances were higher with INM practices, specially when vegetable market waste vermicompost was applied. With continuous chemical farming, there was a slight reduction in the soil micronutrient nutrient status, nutrient uptake and humic substances. Conjunctive application of organics along with inorganics exhibited higher grain and straw yields of rice with high micronutrient uptake and soil humic substances over application of inorganics only.

Key words: INM, micronutrients, humic substances, rice.

Application of organic amendments to the soil system will significantly increase the humic fractions of soil and these fractions enhance the nutrient availability. The humic substances are the most active components of soil organic matter and have multiple effects that can greatly benefit plant growth (Zhang and Dousen, 2002). It is widely recognized that neither use of organic manures nor chemical fertilizers can achieve the sustainability of the yield under the modern intensive farming. The escalating costs of chemical fertilizers on one hand and undesirable effects on soil properties on the other have led to inclusion of organic manures in cultivation of crops. Application of organic manures in combination with inorganic fertilizers improves soil health and maximize sustainable productivity through increased soil humic substances which leads to higher availability of macro and micronutrients to crops. Hence, the present investigation involving vermicomposts obtained from various organic residues integrated with inorganic fertilizers was taken up to study the effect of Integrated nutrient management on micronutrient status, their uptake and humic substances under submerged rice soil.

Corresponding author: sitaramalakshmi20@yahoo.com

Materials and Methods

A field experiment was conducted during *kharif* 2009 and 2010 consecutively for two years with rice as the test crop at Regional Agricultural Research Station, Anakapalle, Visakhapatnam district of Andhra Pradesh. The soil was clay loam in texture with neutral in soil reaction (pH 7.22) with non saline conductivity (0.21 dSm^{-1}). The organic carbon content was 0.51 % and the available zinc, copper, iron and manganese status in initial soils were 0.74, 1.10, 8.20 and 10.50 mg kg^{-1}, respectively. There were 12 treatments of integrated nutrient management imposed to rice crop. The treatments include T_1- 50 % RDF + 2.5 t ha^{-1} cane trash compost, T_2- 50 % RDF + 2.5 tha^{-1} weed compost, T_3- 50 % RDF + 2.5 t ha^{-1} vegetable market waste compost, T_4- 50 % RDF + 2.5 t ha^{-1} rice straw compost, T_5- 75 % RDF + 2.5 t ha^{-1} cane trash compost, T_6- 75 % RDF + 2.5 t ha^{-1} weed compost, T_7- 75 % RDF + 2.5 t ha^{-1} vegetable market waste compost, T_8- 75 % RDF + 2.5 t ha^{-1} rice straw compost, T_9- 100 % RDF, T_{10}- Absolute control, T_{11} -100 % Prathista organic manures and T_{12} -50 % Prathista organic manures + 50 % chemical fertilizers. Certified organic manures supplied by M/s Prathista Industries Ltd., Hyderabad, they produce and market the different organic products i.e., Suryamin for N supplement, Biophos and Biopotash for P&K supplements, Biozinc for Zinc supplement were tested along with different levels of chemical fertilizers. 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 % recommended dose of chemical fertilizers (40 kg N, 30 kg P_2O_5 and 20 kg K_2O ha^{-1}) and 75 % recommended dose of chemical fertilizers (60 kg N, 45 kg P_2O_5 and 30 kg K_2O ha^{-1}) to rice. Chemical composition of different vermicomposts and Prathista organic manures were presented in Table 1.

Available micronutrients (Zn, Fe, Cu and Mn) were extracted from soil by using DTPA reagent as per the procedure of Lindsay and Norvell (1978) and were determined using atomic absorption spectrophotometer. Grain and straw samples at harvesting stage were collected, oven dried, ground and total micronutrients viz., zinc, iron, copper and manganese in these samples were analysed in diacid extract by using an atomic absorption spectrophotometer (Varian AA 240 FS) and expressed as mg kg^{-1} (Piper, 1966). Concentration of nutrients was multiplied by yield for calculation of nutrients uptake. All the parameters were analysed in a randomized block design to list the variance of different treatments at 5 per cent level of significance.

Results and Discussion

Micro nutrient status in submerged rice soil at harvest Irrespective of the treatments, the available micronutrient status (Zn, Fe, Cu and Mn) observed under integrated nutrient treatments were higher over chemical fertilizers alone and the contents were higher in second year than first year (Table 2). Considering the critical limits of Zn (0.65 m g kg^{-1}), Cu (0.2 mg kg^{-1}), Fe (4.5 mg kg^{-1}) and Mn (1 mg kg^{-1}), all the treatments were under sufficiency range except control. The treatment with T_7 : 75 % chemical fertilizers + vegetable market waste vermicompost @ 2.5 t ha^{-1} recorded significantly higher available micronutrient status except zinc. In both the years, the highest available zinc status was recorded with 100 % Prathista organic manures, however which was on par with T_7, where as lowest available zinc status was recorded in absolute control. The data revealed that the available iron and copper content in post harvest soils of rice ranged between 5.9 to 9.5 and 0.85 to 1.52 during 2009 and 5.4 to 10.2 and 0.74 to 1.64 mg kg^{-1} during 2010, respectively.

The results indicated that the available manganese status varied from 7.4 to 15.2 during 2009 and 7.0 to 16.5 mg kg^{-1} during 2010, respectively. More micronutrient build up was observed during second year over first year in all the integrated nutrient treatments. 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 vermicompost may be ascribed to mineralization, reduction in fixation of nutrients by organic matter and complexing properties of humic substances released from vermicomposts with micronutrients (Prasad *et al.* 2010). The INM treatments with organic manures either increased or retained the critical fertility status of micronutrients. Organic manures on decomposition produce a variety of biochemical substances (organic acids, polyphenols, amino acids and poly saccharides) which stimulate the solubility, transport and availability of micronutrients. Effectiveness of vermicomposts may be ascribed to their ability after degradation to form water soluble complexes with iron and other ions. Perhaps, humic substances and organic acids formed after decomposition of crop residue by microflora may help in the translocation of iron which can be transported only with difficulty within the plant. The most significant influence of vermicomposts 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 fractions (%) extracted from submerged rice soil

A close perusal of data presented in Table 3 revealed that humic and fulvic acid contents in soil was significantly influenced by the application of different vermicomposts. 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 % recommended dose of nitrogen fertilizers + vegetable market waste @ 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 % recommended dose of nitrogen fertilizers + weed compost @ 2.5 t ha^{-1}, 50 % chemical fertilizers + vegetable market waste vermicompost @ 2.5 t ha^{-1} and 100 % Prathista organic manures. All the INM treatments were superior to recommended dose of chemical fertilizers, however it was superior to absolute control (T_{10}) which 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. Highest fulvic acid content of 0.24 per cent was recorded in the treatment which received 75 % recommended dose of nitrogen fertilizers + vegetable market waste @ 2.5 t ha^{-1} during 2009 and it was slightly increased to 0.25 % during 2010. Lowest fulvic acid content was recorded in absolute control. All the INM treatments were superior to recommended dose of chemical fertilizers.

Application of different vermicomposts significantly enhanced the humic substances in soil. Among the different treatments, the higher humic acid content was recorded in the treatment which received 75 % chemical fertilizers + vegetable market waste vermicompost @ 2.5 t ha^{-1}. This could be due to the fact that the vegetable market waste contains high organic matter and its application to soil on decomposition increases the humic acid content in the soil. Similar results were obtained by Garcia *et al.* (2004). 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, oxides, hydroxides and clay minerals to form metallo-organic compounds and act as ion exchanger and store house of nutrients. The increase in humic substances due to addition of different vermicomposts may be due to the fact that the organic manures added to the soil, on further decomposition released humic fractions. The increase in humic substances by integrated use of chemical fertilizers and organic sources was reported by Zhang and Dousen (2002).

Influence of INM on micronutrient uptake by rice

The data on zinc and copper uptake by rice grain and straw at harvest stage was presented in Table 4. The data obtained from different treatments indicated that the treatment effects on zinc and copper uptake was significant. Significantly highest zinc and copper uptake was recorded in the treatment which received 75 % chemical fertilizers + vegetable market waste vermicompost @ 2.5 t ha^{-1}. Significantly lowest zinc and copper uptake was recorded in absolute control. All the INM treatments were superior than the treatment with 100 % recommended dose of chemical fertilizers.

Ansari *et al.* (2008) observed that vermicompost application enhanced the activity of beneficial microbes and colonization of mycorrhizal fungi, which play an important role in mobilization of micronutrients, there by leading to better uptake by plants. The increased micronutrient uptake under integrated nutrient management practices was due to the production of organic acids during decomposition of organic matter, which are capable of releasing the nutrients associated with clay minerals and better availability from both organic and inorganic sources. Prasad *et al*. (2010) reported that the incorporation of vermicomposts increased the micronutrient uptake by rice. More over, the beneficial effect of vermicompost and fertilizer NPK on micronutrient uptake might be attributed to their increased humic substances, faster release of nutrients during mineralization, thereby resulting in higher uptake by rice owing to higher grain yield. In addition, vermicompost also contained different growth promoting substances which induced high dry matter yield leading to higher uptake of nutrients (Prakash and Bhadoria, 2003).

Grain yield of rice

Significantly higher grain yields were recorded when 25 % N was substituted through vegetable market waste vermicompost, which was on par with weed vermicompost. The higher grain yields of rice with integrated use of different vermicomposts and chemical fertilizers might be attributed to higher availability of macro and micro nutrients and facilitating uptake by plants resulting in better growth and dry matter production (Barik *et al*., 2008). 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 vermicompost, which decide the availability of nutrients (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.

References

Ansari, N., Ishihara, R., Nakajima, Y., Kimura, M and Asakawa, S. 2008. Cyanobacterial communities of rice straw left on the soil surface of a paddy field. *Biology and Fertility of the Soils* 44: 605-612.

Banik, P and Sharma, R.C. 2008. Effects of integrated nutrient management with mulching on rice based cropping systems in rainfed Eastern Plateau area. *Indian Journal of Agricultural Sciences* 78(3): 240-243.

Barik, A.K., Raj, A and Saha, R.K. 2008. Yield performance, economics and soil fertility through organic sources (vermicompost) of nitrogen as substitute to chemical fertilizers in wet season rice. *Crop Research*. 36 (1,2 &3): 4-7.

Chakravorti, S.P and Samantaray, R.N. 2006. Annual Report. CRRI, Cuttack.

Fateh Singh, Ravindra Kumar and Samir Pal. 2008. Integrated nutrient management in rice-wheat cropping system for sustainable productivity. *Journal of the Indian Society of Soil Science* 56 (2): 205-208.

Garcia Gil, J.C., Plaza, C., Senesi, N., Brunetti, G and Polo, A. 2004. Effect of sewage sludge amendment on humic acids and microbiological properties of a semi and Mediterranean soil. *Biology and Fertility of Soils* 39 (5): 320-328.

Gathala, M.K., Kanthaliya, P.C., Arvind Verma and Chahar, M.S. 2007. Effect of INM on soil properties and humus fractions in the long term fertilizer experiments. *Journal of the Indian Society of Soil Science* 55(3): 360-363.

Lindsay, W.C and Norwell, A. 1978. Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal* 42: 421-428.

Piper, C.S. 1966. Soil and Plant Analysis. Hans Publishers, Bombay.

Prakash, Y.S and Bhadoria, P.B.S. 2003. Relative influence of organic manures in combination with chemical fertilizers in improving rice productivity of lateritic soil. *Journal of Sustainable Agriculture*. 23(1): 77-87.

Prasad, J., Kurmakar, S., Kumar, R and Mishra, B. 2010. Influence of Integrated Nutrient Management on yield and soil properties in maize-wheat cropping system in an Alfisol of Jharkhand. *Journal of the Indian Society of Soil Science*. 58(2): 200-204.

Ramesh, P., Mohan Singh, Panwar, N.R., Singh, A.B and Ramana, S. 2006. Response of pigeon pea varieties to organic manures and their influence on fertility and enzyme activity of soil. *Indian Journal of Agricultural Sciences.* 76 (4): 252-254.

Zhang Jing and Dousen. 2002. Dynamic changes of humic acid and fulvic acid in irrigated soil during corn stalk decomposition. *Journal of Jilin Agricultural University*. 24 (3): 60-64.

Table 1: Nutrient composition of different organic manures used in the study

Treatment	**Total macronutrients (%)**			**Total micronutrients (mg kg^{-1})**			
	N	**P**	**K**	**Zn**	**Fe**	**Mn**	**Cu**
Cane trash vermicompost	1.14	0.46	1.61	61	294	32	28
Weed vermicompost	1.88	1.01	1.31	81	365	67	36
Veg. market waste vermicompost	2.11	1.22	1.45	89	412	98	57
Paddy straw vermicompost	1.12	0.43	1.64	58	284	36	24
Suryamin	20	-	-	-	-	-	-
Biophos	-	20	-	-	-	-	-
Biopotash	-	-	14	-	-	-	-
Biozinc	-	-	-	12 %	-	-	-

Table 2: Effect of INM on micronutrient status (mg kg^{-1}) in post harvest soils of rice

Treatments	**Zn**		**Fe**		**Cu**		**Mn**	
	2009	**2010**	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**
T_1: 50 % RDFN + CT VC @ 2.5 t ha^{-1}	0.81	1.02	7.6	8.1	1.06	1.24	11.6	12.7
T_2: 50 % RDFN + W VC @ 2.5 t ha^{-1}	0.98	1.31	8.4	8.9	1.22	1.45	12.4	13.2
T_3 : 50 % RDFN + VMW VC @ 2.5 t ha^{-1}	0.95	1.22	9.2	9.7	1.43	1.56	14.2	15.8
T_4: 50 % RDFN + PS VC @ 2.5 t ha^{-1}	0.79	0.98	7.8	8.3	0.98	1.20	10.7	12.1
T_5: 75 % RDFN + CT	0.83	1.16	7.9	8.3	1.22	1.31	12.8	13.4

VC @ 2.5 t ha^{-1}								
T_6: 75 % RDFN + W VC @ 2.5 t ha^{-1}	1.03	1.3	8.6	9.2	1.37	1.52	13.7	14.7
T_7 : 75 % RDFN + VMW VC @ 2.5 t ha^{-1}	1.04	1.26	9.5	10.2	1.52	1.64	15.2	16.5
T_8: 75 % RDFN + PS VC @ 2.5 t ha^{-1}	0.82	1.14	8.1	8.4	1.14	1.23	12.2	13.2
T_9: 100 % RDFN	0.7	0.74	7.5	7.6	1.01	1.02	10.2	10.5
T_{10} : Absolute control	0.64	0.58	5.9	5.4	0.85	0.74	7.4	7.0
T_{11}: 100 % Prathista organic manures	1.07	1.34	7.9	8.2	1.12	1.24	11.5	12.5
T_{12}: 50% RDF + 50% Prathista organic manures	1.01	1.25	7.7	8.0	1.07	1.15	10.8	11.5
S.Em±	0.031	0.033	0.25	0.29	0.046	0.051	0.045	0.049
CD (0.05)	**0.074**	**0.080**	**0.68**	**0.71**	**0.11**	**0.12**	**1.1**	**1.6**

Table 3: Effect of INM on soil humic substances (%) in post harvest soils of rice

Treatments	Humic acid (HA)		Fulvic acid (FA)	
	2009	2010	2009	2010
T_1: 50 % RDFN + CT VC @ 2.5 t ha^{-1}	0.31	0.36	0.16	0.17
T_2: 50 % RDFN + W VC @ 2.5 t ha^{-1}	0.35	0.39	0.19	0.21
T_3 : 50 % RDFN + VMW VC @ 2.5 t ha^{-1}	0.36	0.41	0.20	0.23
T_4: 50 % RDFN + PS VC @ 2.5 t ha^{-1}	0.32	0.36	0.17	0.19
T_5: 75 % RDFN + CT VC @ 2.5 t ha^{-1}	0.32	0.38	0.18	0.22
T_6: 75 % RDFN + W VC @ 2.5 t ha^{-1}	0.37	0.41	0.21	0.24
T_7 : 75 % RDFN + VMW VC @ 2.5 t ha^{-1}	0.37	0.43	0.24	0.25

T_8: 75 % RDFN + PS VC @ 2.5 t ha^{-1}	0.34	0.37	0.17	0.20
T_9: 100 % RDFN	0.28	0.28	0.14	0.16
T_{10} : Absolute control	0.20	0.18	0.12	0.11
T_{11}: 100 % Prathista organic manures	0.36	0.41	0.20	0.24
T_{12}: 50% RDF + 50% Prathista organic manures	0.34	0.38	0.21	0.23
S.Em$\underline{+}$	0.012	0.015	-	-
CD (0.05)	**0.022**	**0.024**	**NS**	**NS**

Table 4: Effect of INM on zinc and copper uptake (g ha^{-1}) by rice grain and straw at harvest stage

Treatments	Zinc				Copper			
	Grain		Straw		Grain		Straw	
	2009	2010	2009	2010	2009	2010	2009	2010
T_1	52.80	67.60	45.60	68.20	105.60	130.00	108.30	130.20
T_2	78.20	102.60	59.00	75.60	128.80	156.60	129.80	144.90
T_3	86.40	112.00	66.00	91.00	148.80	190.40	144.00	169.00
T_4	47.30	60.00	52.20	61.00	98.90	120.00	116.00	134.20
T_5	60.00	78.40	63.00	81.60	120.00	145.60	126.00	156.40
T_6	93.60	120.00	78.00	91.00	150.80	186.00	143.00	175.00
T_7	99.00	124.00	80.40	100.80	171.60	210.00	166.40	187.20
T_8	57.60	71.50	67.10	88.40	115.20	137.50	122.00	149.60
T_9	46.00	52.80	48.00	59.40	92.00	100.80	102.00	112.20
T_{10}	19.60	12.00	25.90	12.80	44.76	33.60	44.40	32.00
T_{11}	62.40	84.00	70.40	89.70	176.00	210.80	167.50	193.20
T_{12}	59.40	80.60	72.60	84.00	167.40	204.60	165.00	182.00
S.Em$\underline{+}$	2.21	2.47	-	3.04	4.78	5.05	4.33	5.08
CD (0.05)	**5.45**	**6.32**	**NS**	**6.54**	**10.55**	**11.68**	**10.75**	**11.87**

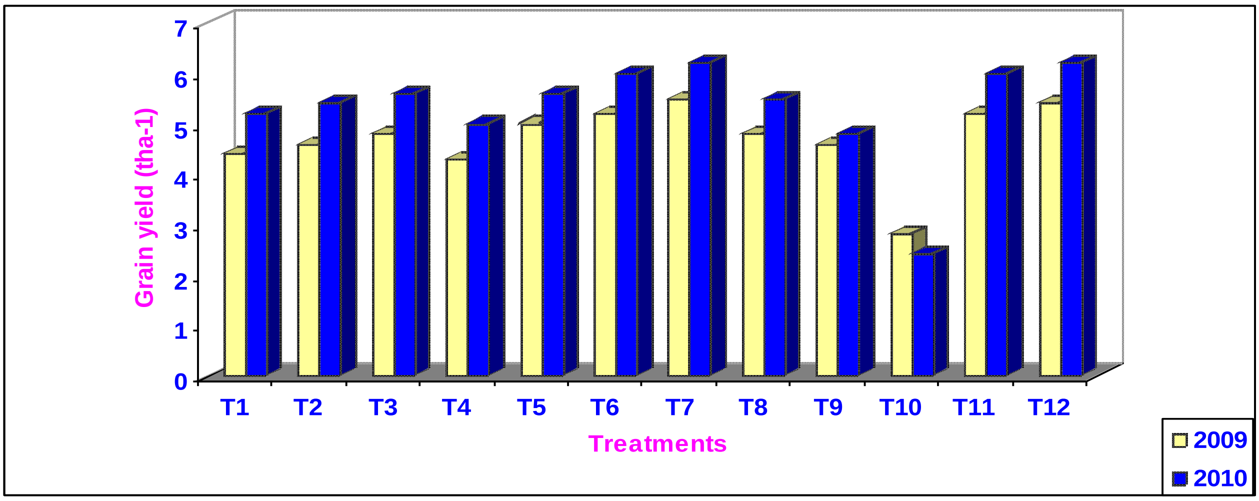

Figure 1: Effect INM on grain yield (t ha^{-1}) of rice