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Effect of organic and inorganic sources of nutrients on secondary and micronutrient content in rice at various growth periods

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ABSTRACT

A field experiment was conducted on fine texture soils to find out the effect of different sources of nutrients on secondary (Ca and Mg) and micro nutrient (Fe, Mn, Cu and Zn) content in rice at various growth periods. The experiment was laid out in a randomized block design in kharif season with four treatments and replicated five times. The treatments consisted of M_1 *(RDF - Control),* M_2 *(10 t FYM* ha^{-1} *+ RDF),* M_3 *(1.5 t vermicompost* ha^{-1} *+ RDF),* M_4 *(Green manuring + RDF). The nutrient content in rice at various growth periods was significantly increased with the application of 100 % NPK in combination with FYM @ 10 t* ha^{-1}*. However, it was on par with that of green manuring together with 100 % NPK during both the years of the study.*

Key words: *Organic sources, inorganic sources and rice crop*

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food grain crops next only to wheat in world and in India. Among several management practices that affect soil quality, fertilizer application is of paramount importance for its role in growth and development of the crop. Due to increased cost of fertilizer and their adverse effect on soil and environment the best alternative sources for plant nutrients needs to be explored to meet partial or full requirement of crop. The integrated use of organic manures and inorganic fertilizers can help to maintain optimum crop yields and high nutrient content in crop which increases bioavailability in humans and may contribute to overcome nutrient deficiency. A significant decrease of 80 % in grain Zn concentration was observed in cereals grown on soils with low plant-available Zn (Cakmak et al., 1997). This decrease in grain Zn also reduces its bioavailability in humans and may contribute to Zn deficiency in susceptible human populations (Hussain et al., 2012). Indeed, Zn deficiency is becoming one of the major public health problem in many countries, especially where people rely on cereal-based food (Welch, 1993). Therefore this experiment was conducted to assess the effect of organic and inorganic fertilizer sources on nutrient content in rice crop.

MATERIALS AND METHODS

In order to investigate the influence of different sources of nutrients on micronutrient content in rice, the present experiment was conducted at Agricultural College Farm, Bapatla, during the years 2011-12 and 2012-13, respectively. Prior to preparatory cultivation of the experimental site, soil samples from 0 to 15 cm depth were collected at random and a composite soil sample during both the years was analyzed for different physico-chemical properties. The results of the soil analytical data indicated that the experimental soil is clay and sandy clay during first and second year, respectively in texture, slightly alkaline in reaction, low in organic carbon (0.52 and 0.50% during first and second year, respectively) and available nitrogen (175.6 and 159.8 kg ha^{-1} during first and second year, respectively), and high in available phosphorus (95.3 and 93.9 kg P_2O_5 ha^{-1} during first and second year, respectively) and potassium (960.0 and 925.6 kg K_2O

ha^{-1} during first and second year, respectively).

The experiment consisted of four treatments *viz*., M_1 (RDF - Control), M_2 (10 t FYM ha^{-1} + RDF), M_3 (1.5 t vermicompost ha^{-1} + RDF), M_4 (Green manuring + RDF). The experiment is laid out in RBD and replicated five times. The recommended fertilizer dose was applied as 160 : 40 : 40 kg N, P_2O_5 and K_2O ha^{-1}. A popular super fine rice cultivar BPT 5204 (Samba Mashuri) was selected for *kharif* season. It is a cross between (GEB-24 x TN-1) and Mashuri. FYM and vermicompost were added 7 days before transplanting of rice on dry weight basis. Dhaincha crop was raised with the seed rate of 60 kg ha^{-1} in individual plots and it was incorporated 7 days before transplanting of rice as green manure at flowering stage. Nitrogen was applied in the form of urea in three splits, first split at the time of transplanting, second split at 30 DAT and third split at 60 DAT. Phosphorus was applied in the form of SSP as basal dose before transplanting. Potassium was applied in the farm of MoP in two splits, first split as basal before transplanting and second split at 60 DAT.

Available nitrogen was estimated by alkaline permanganate method by using macro Kjeldahl distillation unit (Subbiah and Asija, 1956). Available phosphorus was extracted with Olsen's reagent (Olsen et al., 1954), and estimated using spectrophotometer as described by Watanabe and Olsen (1965). Available potassium was extracted with neutral normal ammonium acetate and estimated with the help of flame photometer (Jackson, 1973).

Plant samples of rice were collected from destructive rows at various growth periods and five randomly selected plants at harvest stage. The samples were first dried in shade and then in hot air oven at 65°C. The plant samples were ground in willey mill and stored in labeled brown paper bags for analysis. The grain samples were also processed and stored in similar fashion.

Di-acid extract was prepared as per the method outlined by Jackson (1973). It was carried out using a 9:4 mixture of HNO_3:$HClO_4$. The predigestion of sample was done by using 10ml of HNO_3 g^{-1} sample. This di-acid extract was used to determine Ca, Mg, Fe, Mn, Cu and Zn content in the plant and grain samples. Calcium and magnesium were estimated by EDTA method as described by Hesse (1971) in di-acid extract. Fe, Mn, Cu, Zn were estimated by using AAS (Lindsay and Norvell, 1978) from di-acid extract,

RESULTS AND DISCUSSION

Ca content in rice

Critical observation of the data presented in the table 1 revealed that the highest Ca content in rice straw at all growth stages was observed in the treatment that received FYM @ 10 t ha^{-1} + RDF (M_2) with 1.10 %, 0.60 %, 0.54 % and 0.52 % at 30, 60, 90 DAT and maturity, respectively in 2012 *kharif*. Whereas, during 2011 *kharif* the highest Ca content in rice straw at 60, 90 DAT and maturity was recorded in the treatment M_4. The treatments which received organics to rice were recorded on par Ca content except at 30 DAT in 2012 *kharif* where, the treatment M_2 recorded significantly higher Ca content in rice over all other treatments.

The highest Ca content in rice grain (0.26 and 0.20 % in 2011 and 2012, respectively) was recorded in the treatment M_2 followed by M_4 (0.25 and 0.17 % in 2011 and 2012, respectively) which indicated the Ca supplying capacity of green manuring to the crop was equal to that of FYM.

Table 1. Influence of organics on calcium content (%) at different growth periods of rice.

Treatment	2011-2012					2012-2013				
	30 DAT	60 DAT	90 DAT	Straw	Grain	30 DAT	60 DAT	90 DAT	Straw	Grain
M_1 - RDF (Control)	0.76	0.33	0.27	0.24	0.20	0.84	0.51	0.45	0.42	0.136
M_2 - FYM 10t ha^{-1} + RDF	1.03	0.48	0.33	0.30	0.26	1.10	0.60	0.54	0.52	0.204
M_3 - Vermicompost 1.5 t ha^{-1} + RDF	0.91	0.45	0.31	0.28	0.23	0.90	0.55	0.50	0.47	0.162
M_4 - Green manuring + RDF	0.93	0.50	0.38	0.31	0.25	0.92	0.57	0.50	0.48	0.172
SEm ±	0.035	0.018	0.009	0.010	0.007	0.039	0.015	0.012	0.016	0.007
CD (P: 0.05)	0.11	0.05	0.03	0.03	0.02	0.12	0.048	0.04	0.05	0.02
CV (%)	8.6	8.9	6.6	7.7	6.4	9.3	6.2	5.5	7.4	9.7

Table 2. Influence of organics on magnesium content (%) at different growth periods of rice.

Treatment	2011-2012					2012-2013				
	30 DAT	60 DAT	90 DAT	Straw	Grain	30 DAT	60 DAT	90 DAT	Straw	Grain
M_1 - RDF (Control)	0.232	0.173	0.149	0.127	0.173	0.236	0.188	0.168	0.130	0.168
M_2 - FYM 10 t ha^{-1} + RDF	0.260	0.190	0.167	0.142	0.202	0.274	0.220	0.198	0.162	0.212
M_3 - Vermicompost 1.5 t ha^{-1} + RDF	0.255	0.166	0.164	0.137	0.200	0.259	0.202	0.185	0.150	0.195
M_4 - Green manuring + RDF	0.254	0.179	0.169	0.141	0.203	0.260	0.201	0.193	0.163	0.201
SEm ±	0.005	0.007	0.004	0.003	0.005	0.006	0.007	0.007	0.005	0.007
CD (P: 0.05)	0.016	0.023	0.011	0.009	0.017	0.019	0.023	0.022	0.016	0.022
CV (%)	4.8	9.4	4.9	5.0	6.2	5.3	8.1	8.5	7.6	8.2

Mg content in rice

With the close examination of the data presented in Table 2, it was clear that the higher Mg content at all growth stages of rice was observed in M_2 (FYM) treatment. Irrespective of growth stage of rice and year of the study, the treatments, those received organics along with the RDF (M_2, M_3 and M_4) significantly increased the Mg content over the treatment that received RDF alone (M_1). In the treatment M_3 at 60 DAT the Mg content in rice straw was at par with the treatment M_1 during 2012.

The Mg content in rice grain and straw at maturity ranged from 0.173 to 0.203 % and 0.127 to 0.142 %, respectively during first year of the study. These results were in agreement with Islam et al. (2010) who reported the highest Mg content in grain (0.284 %) and straw (0.215 %) with the treatment NPK + poultry manure application. Rahaman et al. (2007) also reported similar range of Mg content in grain and straw which varied from 0.088 to 0.113% and 0.073 to 1.109 %, respectively.

Fe content in rice

Micronutrient content at 30 DAT, 60 DAT, 90 DAT and maturity was significantly influenced by different organic sources of nutrients during both the years of study. Data presented in the table 3 revealed that irrespective of growth stage of rice and year of the study, Fe content in rice straw was significantly superior in treatments those received FYM, vermicompost and green manuring along with the RDF over the treatment that received RDF alone. The highest Fe content in rice straw (665, 618, 574 ppm at 30, 60 and 90 DAT, respectively) was recorded in the treatment M_4 during first year of the study whereas, it was recorded maximum in the treatment M_2 (682, 660 and 641 ppm at 30, 60 and 90 days after transplanting respectively) during second year of the study (Table 3). The highest Fe content in rice straw at maturity (509 and 615ppm) and grain (170 and 207ppm) was observed in the treatment M_2 followed by M_4 during both the years of study.

Fe content was noticed to be highest at 30 DAT and thereafter there was a decreasing trend with same pattern in the subsequent growth stages (60, 90 DAT and in straw and grain at harvest). These results were in line with the findings of Debiprasad et al. (2010). However, the Fe content due to application of NPK through organic and inorganic sources improved

Table 3. Influence of organics on iron content (ppm) at different growth periods of rice.

Treatment	2011-2012					2012-2013				
	30 DAT	60 DAT	90 DAT	Straw	Grain	30 DAT	60 DAT	90 DAT	Straw	Grain
M_1 - RDF (Control)	496	451	446	423	160	591	534	527	514	172
M_2 - FYM 10 t ha^{-1} + RDF	631	558	547	509	170	682	660	641	615	207
M_3 - Vermicompost 1.5 t ha^{-1} + RDF	662	558	531	483	164	640	638	611	590	202
M_4 - Green manuring + RDF	665	618	574	489	169	670	660	613	602	205
SEm ±	26.7	18.4	19.1	17.7	3.7	15.2	14.6	21.7	12.7	7.2
CD (P: 0.05)	82	57	59	55	11	47	45	67	39	22
CV (%)	9.7	7.5	8.1	8.3	5.0	5.3	5.2	8.1	4.9	8.2

Table 4. Influence of organics on manganese content (ppm) at different growth periods of rice.

Treatment	2011-2012					2012-2013				
	30 DAT	60 DAT	90 DAT	Straw	Grain	30 DAT	60 DAT	90 DAT	Straw	Grain
M_1 - RDF (Control)	196	183	166	155	38	221	217	207	205	36
M_2 - FYM 10 t ha^{-1} + RDF	232	192	197	179	47	275	254	247	236	45
M_3 - Vermicompost 1.5 t ha^{-1} + RDF	207	203	177	167	43	256	257	240	235	40
M_4 - Green manuring + RDF	277	206	201	189	47	270	260	243	221	43
SEm ±	7.9	8.3	6.2	7.0	1.4	8.7	8.7	8.3	6.9	1.4
CD (P: 0.05)	24	26	19	21	4	27	27	26	21	4
CV (%)	7.8	9.5	7.5	9.1	7.2	7.6	7.9	8.0	6.9	7.7

significantly over RDF alone. Organic materials supply chelating agents, which help in maintaining the solubility of micronutrients including Fe and Mn. The presence of organic matter showed a profound influence on the solubility of Fe in waterlogged soils (Das, 2000).

Mn content in rice

Data on Mn content in rice plant recorded at successive growth stages and in straw and grain at maturity are presented in Table 4. Initially, higher Mn content in straw at 30 DAT was observed and decreased with the advancement in age indicating the dilution effect (Debiprasad et al., 2010). The difference in Mn concentration between straw (ranged from 155 to 189 ppm) and grain (ranged from 38 to 47 ppm) might be due to the slow movement of Mn from straw to grain (Duhan and Singh, 2002). Perusal of data revealed significant variations due to various treatments during both the years of study. Irrespective of growth stage of rice during first year of the study, Mn content in rice was significantly increased in treatments M$_2$ and M$_4$ over M$_1$ treatment whereas, during second year M$_3$, also showed the significant superiority over M$_1$.

Application of organics (FYM, vermicompost or green manuring) might have increased the water soluble plus exchangeable and easily reducible fractions of Mn. Das and Mandal (1986) also reported that the application of organic matter enhanced the initial decrease in redox potential and increase in water soluble and exchangeable Mn^{+2} in soil. Several investigators reported increased concentration of Mn in soils particularly under submerged conditions with the application of organic matter (Ponnamperuma, 1972; Das, 2000).

Cu content in rice

Data on Cu content in plant at different stages and in straw and grain at maturity are summarized in Table 5. As the age of rice crop advanced, the Cu content gradually decreased including in straw and grain at maturity. The examination of data revealed significant variations in Cu content due to various treatments. The significantly higher Cu content was recorded with organic amended treatments *viz*., M$_2$, M$_3$ and M$_4$ over M$_1$ during both the years of study except at 30 DAT in 2012 *kharif*. All the organics were on par with each

Table 5. Influence of organics on copper content (ppm) at different growth periods of rice.

Treatment	2011-2012					2012-2013				
	30 DAT	60 DAT	90 DAT	Straw	Grain	30 DAT	60 DAT	90 DAT	Straw	Grain
M_1 - RDF (Control)	13.40	12.58	8.78	6.58	2.00	12.70	6.74	4.62	2.96	2.00
M_2 - FYM 10 t ha^{-1} + RDF	16.78	14.84	11.16	7.94	2.56	14.34	8.30	5.72	3.40	2.32
M_3 - Vermicompost 1.5 t ha^{-1} + RDF	15.60	14.70	10.50	7.90	2.52	14.52	8.26	6.34	3.98	2.26
M_4 - Green manuring + RDF	17.62	15.44	10.94	9.04	2.66	14.20	7.96	5.70	3.42	2.30
SEm ±	0.641	0.485	0.429	0.283	0.055	0.490	0.194	0.126	0.100	0.079
CD (P: 0.05)	1.98	1.49	1.32	0.87	0.17	1.51	0.60	0.39	0.31	0.24
CV (%)	9.0	7.5	9.3	8.0	5.0	7.9	5.6	5.0	6.5	8.1

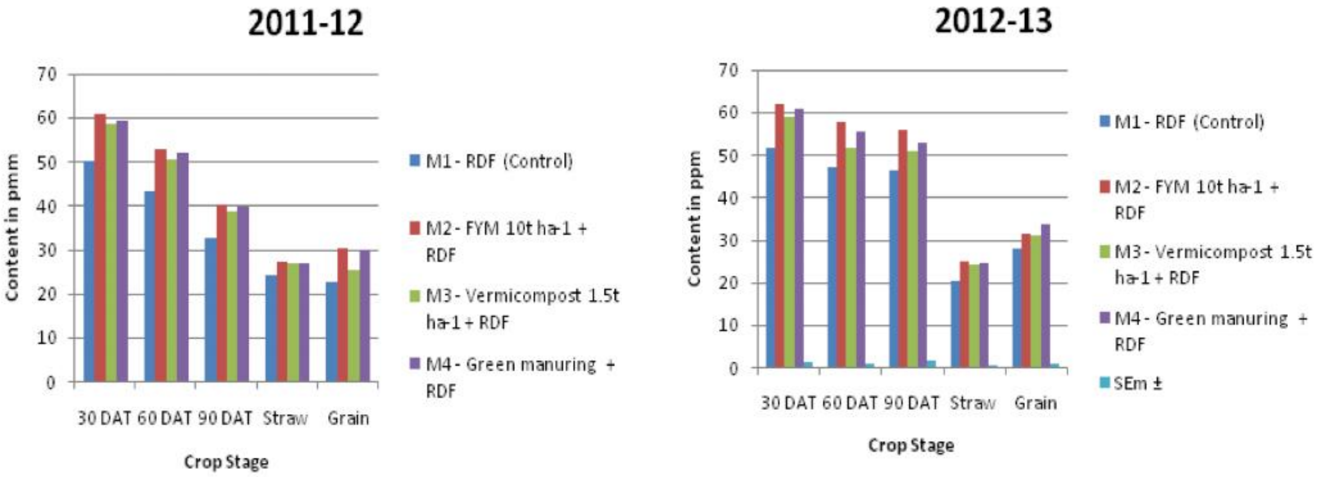

Fig. 1. Influence of organics on zinc content (ppm) at different growth periods of rice.

other regarding Cu content. The increase in Cu content might be due to better root proliferation which helped in the absorption of Cu from native source under favourable reduced conditions (Debiprasad et al., 2010).

Loneragan et al. (1981) showed that Cu had a strong affinity for the N atom of amino groups and it appeared quite likely that soluble N compounds like amino acids act as Cu carriers in xylem and phloem. The copper concentration in rice grain with different organic manures was found in the following increasing order: $M_1 < M_3 < M_2 < M_4$ during 2011 and $M_1 < M_3 < M_4 < M_2$ during 2012. These results were in conformity with the findings of Davari et al. (2012).

Zn content in rice

The data pertaining to Zn content in plant at different stages of growth and in grain at harvest are presented in Table 6 and Fig. 1. Analysis of data showed significant variations as affected by different treatments. The higher Zn content was recorded at 30 DAT but decreased slightly at successive stages of rice. The highest Zn content in rice straw at all growth stages was observed in the treatment that received FYM @ 10 t ha^{-1} in combination with 100 % NPK (60.68, 52.96, 40.07 and 27.09 ppm at 30, 60, 90 and maturity in 2011) followed by green manuring + 100 % NPK (M_4) during both the years of study. All the organic treatments were on par with each other. Similar results were observed by Davari et al. (2012) who reported on par results of FYM and vermicompost and significant increase in Zn concentration of mungbean over the control.

According to Stevenson and Ardakani (1972) on an average 60 % of the soluble Zn in soil occurs in soluble Zn - organic complexes. Soluble Zn - organic complexes are mainly associated with amino, organic and fulvic acids while insoluble Zn - organic complexes are derived from humic acids. Das (2000) reported that the DTPA - extractable Zn was found to be increased in the treatment receiving organic matter (well rotten FYM) 14 and 28 days before puddling or nonpuddling

Table 6. Influence of organics on zinc content (ppm) at different growth periods of rice.

Treatment	2011-2012					2012-2013				
	30 DAT	60 DAT	90 DAT	Straw	Grain	30 DAT	60 DAT	90 DAT	Straw	Grain
M_1 - RDF (Control)	50.24	43.29	32.57	23.95	22.45	51.68	47.31	46.28	20.43	27.99
M_2 - FYM 10 t ha^{-1} + RDF	60.68	52.96	40.07	27.09	30.12	62.15	57.91	55.99	25.08	31.53
M_3 - Vermicompost 1.5 t ha^{-1} + RDF	58.64	50.59	38.63	26.86	25.19	58.98	51.61	50.85	24.52	31.01
M_4 - Green manuring + RDF	59.44	51.86	39.69	26.95	29.92	60.97	55.66	53.04	24.91	33.90
SEm ±	1.995	1.506	1.094	0.922	0.880	1.633	1.245	1.743	0.702	0.955
CD (P: 0.05)	6.15	4.64	3.37	2.84	2.71	5.03	3.84	5.37	2.16	2.94
CV (%)	7.8	6.9	6.5	7.9	7.3	6.2	5.2	7.6	6.6	6.9

the soil. In majority of studies, there were significant positive correlations (De et al., 1994) existed between organic matter and available Zn in soils. This might be the reason of increasing Zn content in the rice straw and grain.

CONCLUSION

The contents of secondary and micro nutrient in rice grain and straw were significantly increased with the combined application of nutrients through organic and inorganic sources over supply of nutrients only through inorganic sources. The higher nutrient content in rice grain and straw was observed in treatment received 100 % NPK in combination with FYM @10 t ha^{-1} over other treatments followed by green manuring along with 100 % NPK.

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