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Effect of Integrated Use of Municipal Compost, Sewage Sludge, Farm Yard Manure with Chemical Fertilizers on soil Enzymatic Activity and Yield of Rice–Groundnut Cropping System

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Abstract: *The objective of this study was to determine integrated effect of municipal compost, sewage sludge, farmyard manure with chemical fertilizers on soil enzymatic activity and yield of rice–groundnut cropping system". Activity of various soil enzymes viz., urease, dehydrogenase, acid and alkaline phosphatases were highest in the treatments that received Sewage sludge @ 20 t ha^{-1} in combination with full dose of recommended fertilizers to rice. The mean values being 6.020 mg of NH_4^+–N released h^{-1} g^{-1} soil, 0.630 mg of TPF released d^{-1} g^{-1} soil, 89.80 and 98.70 mg of PNP released h^{-1} g^{-1} soil, respectively under field conditions. During rabi season, the maximum activities of enzymes viz., urease (5.930 mg of NH4$^+$–N released g^{-1} h^{-1}) dehydrogenase (0.450 mg of TPF produced g^{-1} h^{-1}), acid phosphatase and alkaline phosphatase (86.80 and 93.70 mg of PNP released g^{-1} soil h^{-1}) were observed in soil treated with Sewage sludge @ 20 t ha^{-1} in combination with 100 per cent RDF applied treatment. Rice crop performance was significantly improved by the application of sewage sludge, urban compost, FYM along with different levels of recommended dose of fertilizers as compared to control. grain yield recorded in 100 per cent RDF (120:60:40 N:P_2O_5:K_2O kg ha^{-1}) treatment over control (0 percent RDF) was 70 per cent under field conditions. Groundnut crop grown during rabi after harvest of rice crop responded favorably to the residual effects of various treatments applied to rice crop along with the RDF given to groundnut crop. Kernel yield increased by 31 per cent over control under field conditions in the treatments that received entire dose of RDF and sewagesludge @ 20tha^{-1} to the previous rice crop. The increase in yields of groundnut due to cumulative effects of fertilizers and residual effects of organic manures along with enhanced microbial and enzymatic activity and also atmospheric N fixed by bacteria (Rhizobia) could be contributed to enhance the N availability to groundnut crop.*

Key words: *enzymatic activity, inorganic fertilizers, Organic manures, rice and groundnut yield.*

MATERIALS AND METHODS

A field experiment was conducted at college farm, Rajendranagar. Data partaning to the physico–chemical properties of experimental soil are presented in Table 1. The soil was sandy loam in texture and slightly alkaline in reaction. It was low in available nitrogen, medium in available phosphorus, potassium and organic carbon. The experiment was laid out in a split plot design with the 28 treatments, each being replicated thrice consisting of two levels of each of sewage sludge ,urban compost and FYM @ 10, 20 t ha^{-1} and combination of four levels of fertilizers 0,50,75 and 100 percent RDF (120:60:40 N:P_2O_5:K_2O kg ha^{-1}) during *kharif* . The organic manures *i.e.*, Farmyard manure (FYM), urban compost (UC) and sewage sludge (SS) procured from dairy farm, Rajendranagar, Hyderabad, SELICO private company gandemguda, Rangareddy and Amberpet sweage treatment plant, respectively. All theses manures were analyzed for their chemical composition *viz.*, N, P, K, OC, pH, EC and available micronutrients etc. All these manure were applied as per the treatments. Nitrogen, phosphorus and potassium were applied through urea, SSP and muriate of potash, respectively while the total quantity of phosphorus and potassium were applied as basal and nitrogen was applied in two equal splits *viz.*, half as basal and half at maximum tillering stage for rice crop. Twenty eight days old seedlings of rice were transplanted at the

Table 1
Initial characteristics of experimental soil

Sl. No.	Characteristics of soil	Value
I	*Physical properties*	
	(a) Bulk density (Mg m^{-3})	1.47
	(b) Mechanical composition (%)	
	Sand	64.5
	Silt	22.8
	Clay	12.7
	Textural class	Sandy loam
	(d) Hydraulic conductivity (cm h^{-1})	0.35
	(e) Porosity (%)	38.20
	(f) Water holding capacity (%)	15.69
II.	*Physico–chemical properties*	
	(a) Soil reaction (pH)	7.64
	(b) Electrical conductivity (EC) (d Sm^{-1})	0.24
	(c) Cation exchange capacity (CEC) (c mol $(p)^+$ kg^{-1})	24
	(d) Exchangeable sodium percentage (ESP)	12.85
	Chemical properties	
	(a) Organic carbon (%)	0.51
III.	*Chemical properties*	
	(a) Nitrogen (kg N ha^{-1})	215.7
	(b) Phosphorus (kg P_2O_5 ha^{-1})	28.3
	(c) Potassium (kg K_2O ha^{-1})	252.6
IV.	*Enzymatic activity*	
	(a) Urease (mg of NH_4^+N released g^{-1} soil h^{-1})	2.61
	(b) Acid phosphatase (mg of *p*–nitrophenol released g^{-1} soil h^{-1})	44.37
	(c) Alkaline phosphatase (mg of *p*–nitrophenol released g^{-1} soil h^{-1})	48.52
	(d) Dehydrogenase (mg of TPF produced g^{-1} soil d^{-1})	0.15

rate of two seedlings per hill by adopting a spacing of 20 cm × 15 cm in well puddle and leveled plots. yield of grain was recorded after thoroughly sun drying. Soil samples collected after harvest of rice were anlysed for their enzyme activity by following standard procedures outlined by Tabatabi and Bremner (1972) (21) for urease activity, Tabatabi and Bremner (1969), Eivazi and Tabatabi (1977) (3) for Acid, alkaline phosphatase activity, Casida *et. al.*, (1964) (2) for dehydrogenage activity.

During *rabi* season Ground nut crop Var. TAG-24 was grown to know the residual effect of applied organic sources *i.e.*, FYM, urban compost and sewage sludge each applied at two levels *viz.*, 10 t ha^{-1} and 20 t ha^{-1} to rice crop during *kharif* season. Manures were not applied only different levels of RDF were applied to groundnut crop in all plots according to the treatments (RDF 30 : 40 : 50 N : P_2O_5 : K_2O kg ha^{-1}, respectively). After harvest of the groundnut crop kernel yields were recorded and post harvest soil samples were analysed for their enzyme activity. Data was analyzed statistically to test significances and the treatments are tested at five percent level of significance. The analysis was carried out by the methodology as described Panse and Sukahtme (1976)[16] for split plot technique.

RESULTS AND DISCUSSION

Rice crop performance was significantly improved by the application of sewage sludge, urban compost, FYM along with different levels of recommended dose of fertilizers as compared to control. The grain yield was increased by the application of recommended dose of fertilizers (120:60:40 N:P_2O_5:K_2O kg ha^{-1}) in 100 per cent RDF treatment over control was 70 per cent under field conditions. The increase in the yields of rice was mainly due to the availability of major nutrients (N, P and K) that were essential to the crop during the critical growth stages of life cycle. Sharma *et al.*, (2001)[18] also reported increased grain yield of rice was due to the applied nitrogenous fertilizers

The data on yield (Table 2) showed that the rice crop was benefited by the application of organic manures such as sewage sludge, urban compost and FYM. Application of organic materials were found to influence on the growth of rice crop directly by supplying nutrients (Palaniappan and Balasubramanian, 1991) [15] and by stimulating the microbial activity (Kukreja *et al.*, 1991)[10]. The rice grain yield was highest with sewage sludge (20 t ha^{-1}) treatment when compared to urban compost and FYM (@ 20 t ha^{-1}. The values were 51.13, 44.38 and 47.20 q ha^{-1} at highest level of SS, UC and FYM. The increase in grain yield in SS (20 t ha^{-1}) treatment was 27 per cent as compared to control. The results showed that sewage sludge is a

Table 2
Effect of sewage sludge, urban compost, FYM and inorganic fertilizers on yields rice and groundnut

Treatments	*Grain (q ha^{-1})*					*Kernel (kg ha^{-1})*				
Main	*Fertilizer levels (%RDF)*					*Fertilizer levels (%RDF)*				
Sub	*0*	*50*	*75*	*100*	*Mean*	*0*	*50*	*75*	*100*	*Mean*
Control	27.50	40.00	44.50	48.50	40.13	1190	1303	1399	1451	1336
UC 10 t ha^{-1}	29.00	43.50	47.50	52.30	43.08	1213	1321	1416	1485	1359
UC 20 t ha^{-1}	31.00	44.50	48.50	53.50	44.38	1235	1348	1433	1504	1380
FYM 10 t ha^{-1}	31.50	47.50	49.50	55.50	46.00	1224	1344	1427	1496	1373
FYM 20 t ha^{-1}	33.00	48.30	52.50	55.00	47.20	1248	1372	1444	1537	1400
SS 10 t ha^{-1}	34.50	48.50	53.50	56.00	48.13	1269	1359	1435	1528	1398
SS 20 t ha^{-1}	37.50	52.50	54.50	60.00	51.13	1299	1392	1451	1568	1427
Mean	32.00	46.40	50.07	54.40		1240	1348	1429	1510	

	S.Em(±)	*C.D. (0.05)*	*S.Em(±)*	*C.D. (0.05)*
Main	0.19	0.65	20.33	70.34
Sub	1.36	3.86	23.29	NS
Main at same or different level sub	1.12	NS	52.85	NS

UC: Urban compost,FYM : Farm yard manure SS: sewage Sludge.

better source of nutrients to rice than urban compost. The increase in grain yield with sewage sludge application to rice field might be increased microbial activity and enzymatic activity which plays an important role in mobilization of nutrients facilitating uptake by plants that might be resulted in better growth and yields of crop. Increase in yields of rice grain over control due to the application of urban compost was because of supply of more quantities of major nutrients as well as micronutrients through it. Similar results were also reported by Jeevan Rao and Shantaram (1996)[9].

Of all the combined treatments, higher dose of recommended fertilizer alone recorded 48.5 q ha^{-1} of grain yield, but sewage sludge at a dose of 10 t ha^{-1} along with half of recommended fertilizer performed similar to the entire dose of RDF recording the grin yield of 48.5 q ha^{-1} (Table 2). Sewage sludge at 20 t ha^{-1} in combination with 100 per cent RDF recorded 23 per cent increased yield over full dose of fertilizers applied, this treatment was superior to urban compost and FYM along with 100 per cent RDF which recorded 10 per cent and 13 per cent increased yields respectively when compared to the treatment received 100 per cent RDF alone. However, the per cent increase was maximum with sewage sludge treatments

From the results of study it was very clear that the combined application of organic manures and inorganic fertilizers would augment the efficiency of both the substances when compared with their individual application. Similar results also reported by Jayabaskaran and Sreeramulu (1998)[7], Malik *et al.* (2001)[12], and Jeevan Rao (1992)[8].

Performance of Ground Nut

Residual effects of organic manures increased the yields of groundnut appreciably, among the all treatments sewage sludge at higher level of application gave maximum kernel yield of 1427 kg ha^{-1} as compared to other organic sources there was an increase of 27 kgs over FYM and UC 47 kgs and 91 kgs against control treatments. However different levels of RDF (0, 50, 75 and 100 per cent of RDF) applied treatments were shown higher increase over the residual effects of organic manures, 1510 kgs of kernel yield recorded at 100 % RDF level was more than the highest yield obtained with the residual effects of organic manures (1427 kg ha^{-1} at SS 20 t ha^{-1} treatment). Increase in yield of kernel was due to availability of nutrients that are needed for the growth and development of plant (essential major and micronutrients) through subsequent mineralisation of undecomposed organic manures and enhanced enzymatic activity. Application of organic manures during rainy season to rice crop affects the yield of subsequent crop in sequence due to residual effects (Gill and Meelu1982; (5), Veeraiah, 2003(24). Residual effects of organic manures in combination with fertilizers added to groundnut crop increased the yield of groundnut kernel higher than their individual increments (Table 2). Among all the combined treatments sewage sludge in combination with 100 per cent RDF recorded highest kernel yield of 1568 kg ha^{-1} while control recorded only 1190 kg ha^{-1} in field conditions. The increase in yield might be due to the residual effects of organic manures and cumulative effects of inorganic fertilizers. Sewage sludge applied @ 20 t ha^{-1} along with 50% RDF was shown good residual effect and produced the kernel yield which was equal to that of 100 per cent RDF applied treatments hence there was possibility of saving 50% RDF without effecting the yields by the application of SS @ 20 t ha^{-1} to the previous rice crop in rice-groundnut cropping system. Increase in groundnut yields due to addition of RDF was also observed by Narsa Reddy *et al.* (1987)(14).

The residual effects of different organic treatments may be ascribed to the increased availability of nutrients due to mineralisation of organic materials release of CO_2 increasing fertilizer use efficiency accumulation of organic carbon and improvement of soil physical properties (Thimmenegowda, 1993) (22).

The residual effects due to conjunctive use of nutrients partly through organic manures and partly through inorganic fertilizers to *kharif* rice on subsequent groundnut might be due to the mineralized macro and micronutrients in addition to the microbial activity and physical improvement of the soil slowly and steadily over a period of time which probably coincide with the efficient utilization of these resources at most of the critical state of translocation of photosynthates to the kernel. Several such responses of crops through nutrient utilisatio vis–à–vis improvement in soil physical and biological environment in the rhizosphere due to use of organic and inorganic sources of nutrients partly substituting the fertilizer nutrients were reported by Singh *et al.* (1996), (19) Hegde (1998), (6) Vanaja (2000), (23) Aruna (2003), (1) Veeraiah (2003) (24) and Madhuvani (2004). (11)

Ureage Enzyme Activity

Ureage enzyme is responsible for hydrolysis of urea applied to the soil the minimum Ureage activity was recorded in control treatment (3.197 μg of NH^{+}_{4} N released h^{-1} g^{-1} soil) and 3.00 μg of NH^{+}_{4}N released h^{-1} g^{-1} soil in post harvested rice and groundnut soils, respectively. Among different organic sources sewage sludge @ 20 tha^{-1} recorded highest activity of the Ureage enzyme than urban compost and FYM that is mainly due the more favourable environment for the accumulation of enzyme in soil matrix. Application of fertilizers alone or in combination with organic manures resulted in increase in Ureage activity over control the percent increase in Ureage activity was 88 percent in treatments received sludge @20 tha^{-1} along with full dose of fertilizers to the rice and 97 percent increment was observed in groundnut crop over control (Table 3 and 4). Frankberger *et al.*, (1983), (4)Martens *et al.*, (1992),(13) sreedhar (2003)(20) also found that increased urease activity with organic amendments

Dehydrogenase Activity

The dehydrogenase activity is commonly used as indicator of biological activity in soils as the enzyme is known to oxidize the soil organic matter. Similar to urease the dehydrogenase activity also found to increase with increased fertilizers from 0 to 100 percent RDF and increase in organic manures application from 0 tha^{-1} to 20 tha^{-1} mean highest values were 0.506 μg of TPF released d^{-1} g^{-1} soil at entire dose of RDF applied treatments and 0.546 μg of TPF released d^{-1} g^{-1} soil in sewage sludge 20 tha^{-1}, among the combined treatment 0.630 (μg of TPF released d^{-1} g^{-1} soil) noticed at 100 percent RDF and 20 tha^{-1} sewage sludge applied treatment (Table 3) and the residual effects of organic manures and direct effects of fertilizers also shown the same trend in groundnut crop post harvested soils recording the mean highest values of 0.450 μg of

Table 3
Effect of sewage sludge, urban compost, FYM and inorganic fertilizers on enzyme activities in post harvest soil of rice

Treatments	*Urease (μg of NH^+_4N released h^{-1} g^{-1} soil)*					*Dehydrogenase (μg of TPF released d^{-1} g^{-1} soil)*				
Main	*Fertilizer levels (%RDF)*					*Fertilizer levels (%RDF)*				
Sub	*0*	*50*	*75*	*100*	*Mean*	*0*	*50*	*75*	*100*	*Mean*
Control	3.197	3.540	3.730	3.800	3.567	0.270	0.310	0.390	0.420	0.348
UC 10 t ha^{-1}	3.287	3.860	4.053	4.120	3.830	0.310	0.360	0.440	0.480	0.398
UC 20 t ha^{-1}	3.570	4.170	4.630	4.730	4.275	0.340	0.410	0.460	0.520	0.433
FYM 10 t ha^{-1}	3.340	3.480	3.890	3.980	3.673	0.310	0.340	0.400	0.430	0.370
FYM 20 t ha^{-1}	3.620	3.800	4.210	4.340	3.993	0.330	0.370	0.420	0.470	0.398
SS 10 t ha^{-1}	4.250	5.230	5.690	5.810	5.245	0.410	0.410	0.540	0.590	0.508
SS 20 t ha^{-1}	4.653	5.510	5.930	6.020	5.528	0.453	0.490	0.580	0.630	0.546
Mean	3.702	4.227	4.591	4.686		0.346	0.400	0.461	0.506	
	S.Em(±)		*C.D. (0.05)*			*S.Em(±)*		*C.D. (0.05)*		
Main	0.114		0.393			0.008		0.029		
Sub	0.141		0.400			0.016		0.045		
Main at same or different level sub	0.298		NS			0.024		NS		

Treatments	*Acid phosphatase (μg of PNP released h^{-1} g^{-1} soil)*					*Alkaline phosphatase (μg of PNP released h^{-1} g^{-1} soil)*				
Main	*Fertilizer levels (%RDF)*					*Fertilizer levels (%RDF)*				
Sub	*0*	*50*	*75*	*100*	*Mean*	*0*	*50*	*75*	*100*	*Mean*
Control	53.54	58.50	61.20	65.80	59.76	57.37	66.40	68.20	71.50	65.87
UC 10 t ha^{-1}	59.92	64.30	67.40	72.90	66.13	75.80	77.90	82.50	86.60	80.70
UC 20 t ha^{-1}	63.12	66.80	73.34	78.96	70.56	79.70	81.70	87.40	92.00	85.20
FYM 10 t ha^{-1}	55.30	59.90	62.20	67.41	61.20	73.20	77.60	80.80	84.60	79.05
FYM 20 t ha^{-1}	61.30	67.20	70.32	75.36	68.55	75.70	79.40	82.70	87.30	81.28
SS 10 t ha^{-1}	74.50	79.20	83.50	85.20	80.60	80.50	82.30	90.10	94.40	86.83
SS 20 t ha^{-1}	80.20	82.21	87.20	89.80	84.85	83.60	88.70	96.50	98.70	91.88
Mean	63.98	68.30	72.17	76.49		75.12	79.14	84.03	87.87	
	S.Em(±)		*C.D. (0.05)*			*S.Em(±)*		*C.D. (0.05)*		
Main	0.814		2.818			1.86		6.42		
Sub	2.328		6.614			2.68		7.61		
Main at same or different level sub	2.659		NS			4.97		NS		

TPF released d^{-1} g^{-1} soil and 0.230 µg of TPF released d^{-1} g^{-1} soil at that same treatmental combinations and control (Table 4), respectively. Quasim etal., (2001)(17) jeevanrao and shantaram(1996).(9) Application of organic manures led to substantial increase in dehydrogenase activity over the rest of the treatments. Residual effects of organic and direct effects of fertilizers showed good increase in dehydrogenase activity may be due the availability of substrate under these conditions

Table 4
Direct effects of fertilizers and residual effects of sewage sludge, urban compost and FYM on enzyme activities in post harvest soil of ground nut

Treatments	*Urease (μg of NH^+_4N released h^{-1} g^{-1} soil)*					*Dehydrogenase (μg of TPF released d^{-1} g^{-1} soil)*				
Main	*Fertilizer levels (%RDF)*					*Fertilizer levels (%RDF)*				
Sub	*0*	*50*	*75*	*100*	*Mean*	*0*	*50*	*75*	*100*	*Mean*
Control	3.000	3.320	3.480	3.720	3.380	0.230	0.280	0.310	0.330	0.288
UC 10 t ha^{-1}	3.280	3.550	3.960	4.100	3.723	0.250	0.270	0.300	0.350	0.293
UC 20 t ha^{-1}	3.470	3.750	4.470	4.600	4.073	0.260	0.280	0.320	0.340	0.300
FYM 10 t ha^{-1}	3.220	3.650	3.690	3.780	3.585	0.310	0.330	0.350	0.380	0.343
FYM 20 t ha^{-1}	3.450	3.760	4.020	4.240	3.868	0.360	0.370	0.390	0.410	0.383
SS 10 t ha^{-1}	4.100	4.250	5.480	5.670	4.875	0.330	0.350	0.380	0.400	0.365
SS 20 t ha^{-1}	4.320	4.550	5.730	5.930	5.133	0.380	0.390	0.440	0.450	0.415
Mean	3.549	3.833	4.404	4.577		0.303	0.324	0.356	0.380	

	S.Em(±)	*C.D. (0.05)*	*S.Em(±)*	*C.D. (0.05)*
Main	0.050	0.173	0.003	0.01
Sub	0.036	0.103	0.011	0.03
Main at same or different level sub	0.125	0.385	0.011	NS

Treatments	*Acid phosphatase (μg of PNP released h^{-1} g^{-1} soil)*					*Alkaline phosphatase (μg of PNP released h^{-1} g^{-1} soil)*				
Main	*Fertilizer levels (%RDF)*					*Fertilizer levels (%RDF)*				
Sub	*0*	*50*	*75*	*100*	*Mean*	*0*	*50*	*75*	*100*	*Mean*
Control	50.50	56.20	59.21	63.80	57.43	58.78	63.45	65.27	69.54	64.26
UC 10 t ha^{-1}	57.81	61.37	65.11	70.85	63.79	72.54	74.17	80.50	85.50	78.18
UC 20 t ha^{-1}	61.23	63.80	71.37	76.99	68.35	76.11	79.79	86.00	90.00	82.98
FYM 10 t ha^{-1}	53.54	55.08	60.22	65.00	58.46	70.32	75.46	78.81	82.10	76.67
FYM 20 t ha^{-1}	59.36	64.99	69.31	72.30	66.49	72.26	77.25	80.77	84.60	78.72
SS 10 t ha^{-1}	70.25	77.20	80.75	83.25	77.86	78.25	80.00	87.15	91.30	84.18
SS 20 t ha^{-1}	79.30	80.00	85.15	86.80	82.81	80.16	85.30	93.25	93.70	88.10
Mean	70.25	77.20	80.75	83.25	77.86	78.25	80.00	87.15	91.30	84.18

	S.Em(±)	*C.D. (0.05)*	*S.Em(±)*	*C.D. (0.05)*
Main	0.42	1.46	0.22	0.76
Sub	0.31	0.90	0.34	0.96
Main at same or different level sub	1.06	NS	0.59	NS

Phosphatase Activity

Soil enzymes regulate the transformation of nutrients in soil required for plant growth. Transformation of organic P through enzymatic reactions and immobilization of P in the biomass play an important role in P recycling and likely to be effected by the different amendments .Acid phosphate and alkaline phosphatase activities were significantly increased either with fertilizers or with manures in post harvested soils of rice crop registering

63.98 μg of PNP released h^{-1} g^{-1} soil and 75.12 μg of PNP released h^{-1} g^{-1} soil at 0 percent RDF levels, 76.49 and 87.87 μg of PNP released h^{-1} g^{-1} soil at 100 percent RDF level among organic manurial level mean acid and alkaline phosphatase activities were high in sewage sludge applied treatment 84.85 and 91.88 μg of PNP released h^{-1} g^{-1} soil, respectively in post harvest rice soil samples. However the interaction effect of organic and in organics did not shown any significant increase on acid and alkaline phosphatase activities in post harvested soils of rice crop. Residual effects of organic manures and direct effects of fertilizers on ground nut also shown the same trend as in rice crop.

In summary it can concluded that activities of urease, dehydrogenase acid and alkaline phosphatase enhanced due addition of organic manures and fertilizers, among organic manures sewage sludge recorded highest activity due high organic carbon which might be helped for increased nutrient availability to the crops thereby highest yields of grain and kernel of rice and groundnut were registered in those treatments as compared to urban compost and FYM. Sewage sludge applied @ 20 t ha^{-1} along with 50% RDF was shown good residual effect and produced the kernel yield which was equal to that of 100 per cent RDF applied treatments hence, there was possibility of saving 50 % RDF without effecting the yields by the application of SS @ 20 t ha^{-1} to the previous rice crop in rice – groundnut cropping system.

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