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Influence of nutrient substitution through sugarcane trash composts and inorganic fertilizers for rice-rice cropping system

N. RAVISANKAR, V. VEERABADRAN, B. CHANDRASEKHARAN AND C. SIVAKUMAR
Agricultural College and Research Institute, Killikulam, Vallanad - 628 252, Tamil Nadu.

Abstract : A field experiment was conducted at Agricultural College and Research Institute Killikulam during 1996-97 to study the effect of sugarcane trash compost (ST) and inorganic fertilizers on rice-rice sequence. Before initiation of field experiment, sugarcane trash composts were prepared by using various additives. The experiment was conducted in split-plot design, assigning trash composts along with raw trash and no trash treatment in main plot and four levels of fertilizers (F_0, F_{50}, F_{75} and F_{100}) to subplots with three replications. Residual effect of composts and fertilizers was tested by raising residual rice crop. The data on plant height, dry matter production, number of productive tillers, number of grains panicle^{-1}, grain yield and straw yield were recorded. The results revealed that among the various composts tested, trash composted with urea, SSP and MOP in 1:2:2 ratio @ 25 kg t^{-1} of trash applied @ 10 t ha^{-1} recorded higher number of productive tillers (525 m^{-2}) and grain yield (6337 kg ha^{-1}). The nutrient content of the applied compost was 1.21, 0.73 and 0.82 per cent N, P_2O_5, K_2O respectively with lower C:N ratio of 24.1:1. This compost along with 50 per cent of recommended dose of fertilizer (120:60:60 kg NPK ha^{-1}) recorded higher yield parameters, yield and it was comparable with the same compost + 100 per cent of recommended dose.

Keywords : Sugarcane trash, Composts, Rice, Nutrient substitution.

Introduction

In India, about 40 per cent of the total plant nutrients are consumed only by rice crop. Though the use of fertilizers per unit area of rice was higher, the Fertilizer Use Efficiency (FUE) was far below. The overall consumption trend at national level has been just marginal increase from 70.7 to 74.0 kg during 1995-96. Abrupt increase in prices of fertilizers and reduced/ withdrawal of subsidy on phosphatic and potassic fertilizers are the major reasons for the reduced consumption which has affected the productivity of rice more than that of other crops. Reports on environmental pollution through excessive, improper and imbalanced application of inorganic fertilizers have added new dimensions to their use in rice nutrition. This situation can possibly be remedied through the popularization of Integrated Nutrient Management (INM) involving recycling of crop residues in agriculture.

The estimated crop residue potential of 10 major crops are about 274 million tonnes annually with an utilizable nutrient potential of 2.47 million tonnes and fertilizer equivalence of 1.23 million tonnes (Veeraraghaven *et al.* (1983). At the farm level, INM may be able to maximize the use of residues from the farm. Sugarcane trash is one such residue and commonly available in the wetland cropping systems. Trash constitutes about 10 per cent of the total sugarcane biomass, thereby posing a serious problem of disposal. According to estimates, 22 million tonnes of sugarcane trash is produced every year (Velayutham and Bharadwaj, 1994). Trash contains about 0.35 per cent N, 0.13 per cent P_2O_5, 0.65 per cent K_2O, 0.27 per cent CaO and also appreciable quantity of micronutrients (Rakkiyappan, 1995). But the use of trash for crop nutrition is beset with wider C:N ratio. This causes immobilization of nutrients when incorporated directly without any pre processing. Therefore, proper method of decomposition of trash with microbes or through the addition of inorganic chemicals has to be evolved and its influence on cropping system should be tested. The present investigation was therefore undertaken to assess the possible level of substitution of inorganic fertilizers through the addition of trash composts in rice nutrition.

Materials and Methods

The field experiment was conducted in the wetlands of Agricultural College and Research Institute (Tamil Nadu Agricultural University), Killikulam during 1996-97. The soil of the experimental field was moderately drained, deep and clay loam in texture. The fertility of soil was classified as low in available N and P and medium in available K. Sugarcane trash was composted by using various additives namely

Table 1. Nutrient content and C:N ratio of trash composts

Treatments	Nutrient content			C:N ratio
	N	P_2O_5	K_2O	
Raw trash	0.34	0.13	0.65	118.2:1
Trash composted without additives	0.39	0.42	0.48	82.3:1
Trash + CDS + MRP + Gypsum + Urea	0.67	0.53	0.65	47.5:1
Trash + CDS + Azospirillum + Phosphobacterium	0.58	0.59	0.69	49.8:1
Trash + *Pleurotus* + Urea	0.86	0.62	0.72	31.7:1
Trash + Urea + SSP + MOP	1.21	0.73	0.82	24.1:1

CDS - Cow Dung Slurry; MRP - Musorie Rock Phosphate;
SSP - Single Super Phosphate; MOP - Muriate of Potash
Data not statistically analysed.

Pleurotus, urea, Musorie Rock Phosphate (MRP), gypsum, Single Super Phosphate (SSP), Muriate of Potash (MOP), Azospirillum and Phosphobacterium in different combinations. The nutrient content and C:N ratio of different composts are presented in Table 1. The experiment was conducted in split plot design assigning trash compost to main plots and fertilizer levels to sub plots with three replications. The treatments details are indicated in Table 2. Rice variety ASD 16 was grown in Kar (June - September) season. The recommended seed rate of 60 kg ha^{-1} was used. The field was thoroughly puddled with tractor cage wheel, levelled with leveller and plots were laid with bunds all around as per the experimental design. The raw as well as composted sugarcane trash were applied @ 10 t ha^{-1} and incorporated one week before transplanting as per the treatment. The inorganic fertilizer was also applied as per the treatments. Entire quantity of P_2O_5 was applied as basal dose and K_2O was applied in two splits, one at basal and another at panicle initiation stage. Transplanting was taken up with 24 days old seedlings during both the seasons adopting a spacing of 12.5 x 10 cm. Three seedlings per hill were planted. Gap filling was taken up 10 days after transplanting to maintain optimum plant population. Butachlor, a pre-emergence herbicide was applied @ 1.25 kg a.i. ha^{-1} three days after transplanting followed by hand weeding before second top dressing. The bunds between plots were rectified as and when required so as to avoid seepage of nutrients. Adequate prophylactic measures were taken against major insects and pests. A residual crop of rice was raised in the same plots during November-February (1996-1997) with the same rice variety (ASD 16). After the harvest of first crop, the stubbles were incorporated in the same plots. The plots were prepared by manual digging. No organic and inorganic fertilizers were applied to residual crop. The seedlings of ASD 16 rice variety was transplanted at 12.5 x 10 cm spacing. Biometric observations on plant height, DMP, productive tillers, number of grains panicle^{-1}, grain yield and straw yield were recorded for both the crops. Economics of rice-rice system was also worked out.

Results and Discussion

Influence on growth and yield attributes

Growth of rice measured in terms of plant height and DMP at different stages showed significant improvement due to incorporation of raw cane trash as well as after composting (Table 2). The increase in plant height at harvest due to incorporation of trash composted with NPK as additives was 15-84 per cent over no trash application. The percentage increase decreased with the addition of other type of composts. Sundaram (1996) also reported similar finding. The DMP of rice with no trash was 10636 kg ha^{-1} and it was improved to varying degrees (by 186-4775 kg ha^{-1}) with the addition of trash. The addition of trash composted with NPK as additives produced higher DMP of 15411 kg ha^{-1}, whereas other trash composts were relatively less effective. The increase in DMP might be due to the increased availability of nutrients in this compost (1.21% N, 0.73% P_2O_5 and 0.82% K_2O) which inturn increased the DMP. Increase in fertilizer level also increased the plant height and DMP. Similar finding was reported by Radhakrishna *et al.* (1995).

Table 2. Influence of trash composts and inorganic fertilizers on growth and yield parameters of rice-rice system.

Treatments	Plant height (cm)		DMP (kg ha^{-1})		Productive tillers (m^{-2})		No.of grains panicle^{-1}	
	Main crop	Residual crop	Main crop	Residual crop	Main crop	Residual crop	Main crop	Residual crop
M_1 : No trash	89.50	70.57	10636	5033	399	264	91.44	64.29
M_2 : Raw trash	90.39	74.06	10822	7316	407	290	93.19	70.69
Trash comp. without M_3 : additives Trash +	92.37	72.63	11587	6209	423	279	96.09	68.04
CDS + MRP + M_4 : Gypsum + Urea	95.65	75.38	12755	8343	453	301	104.58	73.23
Trash + CDS + Azospirillum + M_5 : Phosphobacterium	96.42	74.38	12922	7385	462	293	106.27	71.31
M_6 :Trash + Pleurotus + Urea	100.31	76.23	14161	9382	496	308	115.53	74.90
M_7 : Trash + Urea + SSP + MOP	103.68	77.28	15411	10347	525	317	122.81	76.98
SEd	1.04	0.62	71	81	5	2	0.85	0.29
CD (P=0.05)	2.27	1.35	155	117	11	4	1.86	0.63
F_0 : Control (No inorganic fertilizer)	88.65	72.01	10256	5978	412	275	90.36	66.92
F_{50} : 50% of Rec.dose	93.96	74.02	11917	7390	440	290	101.07	70.68
F_{75} : 75% of Rec.dose	97.99	75.31	13904	8431	471	301	110.97	73.13
F_{100} :100% of Rec. dose (120:60:60)	101.28	76.11	14377	9066	485	307	114.07	74.68
SEd	1.13	0.41	60	47	3	1	0.71	0.22
CD (P=0.05)	2.28	0.83	121	95	6	2	1.44	0.44

CDS - Cow Dung Slurry; MRP - Musorie Rock Phosphate;
SSP - Single Super Phosphate; MOP - Muriate of Potash

The addition of composted cane trash significantly improved the various yield attributes of rice. The number of productive tillers and grains panicle^{-1} were improved to a considerable extent with the incorporation of composted cane trash. Composting of trash with NPK as additives resulted in maximum level of yield attributes. The incorporation of raw trash did not produce any significant effect on yield attributes. Among the composts, trash + MRP + gypsum + urea was on par with trash + Azospirillum + Phosphobacterium for all the characters. The increase in number of productive tillerswith the addition of trash composts ranged from 8-126 m^{-2} over no trash incorporation. Similarly, the increase in grains panicle^{-1} due to different trash composted with additives varied from 13.14 - 31.37%. For all yield attributes every increment in fertilizer caused an increase, but the rate of increase was not proportionate to the increment. Steady and adequate supply of nutrients from trash + urea + SSP + MOP resulted in better absorption of nutrients and subsequent utilization in partitioning assimilates from the source to sink leading to the production of yield components as evidenced in the increased number of grains panicle^{-1}. It corroborates the earlier findings of Dev and Bharadwaj (1994).

The improvement in available soil N status with the addition of trash composted with NPK as additives to the first crop (Fig. 1) was reflected in the enhancement of growth and yield of succeeding rice also. Growth parameters such as

Table 3. Influence of trash composts and inorganic fertilizers on grain and straw yield of main crop.

Treat-ments	Grain yield (kg ha^{-1})					Straw yield (kg ha^{-1})				
	F_0	F_{50}	F_{75}	F_{100}	Mean	F_0	F_{50}	F_{75}	F_{100}	Mean
M_1	3816	4456	4678	4873	4456	4266	5013	6495	6920	5674
M_2	3994	4518	4715	4948	4544	4303	5196	6539	7026	5766
M_3	4184	4603	4889	5091	4692	4527	5700	6993	7372	6148
M_4	4328	4793	5568	5688	5094	4761	5902	7997	8202	6716
M_5	4456	4826	5646	5780	5177	4835	6011	8049	8255	6788
M_6	4962	5259	6073	6223	5629	6186	6699	8174	8391	7362
M_7	5112	6228	6284	6337	5991	6952	8283	8358	8486	8020
Mean	4408	4955	5407	5563		5118	6115	7515	7807	

	SEd	CD (P=0.05)	SEd	CD (P=0.05)
M	41	89	49	106
F	36	73	50	101
F at M	95	193	133	268

Table 4. Grain and straw of succeeding rice as influenced by residual effect of trash composts and fertilizer levels.

Treat-ments	Grain yield (kg ha^{-1})					Straw yield (kg ha^{-1})				
	F_0	F_{50}	F_{75}	F_{100}	Mean	F_0	F_{50}	F_{75}	F_{100}	Mean
M_1	1213	1845	2231	2699	1997	1698	2583	3123	3779	2796
M_2	2198	2695	3105	3458	2864	3033	3774	4347	4737	3973
M_3	1822	2330	2716	2987	2464	2551	3262	3802	4182	3449
M_4	2621	3063	3671	3812	3292	3669	4288	5056	5299	4578
M_5	2298	2833	3202	3470	2951	3263	3966	4483	4858	4143
M_6	3002	4014	4263	4386	3984	4584	5860	6053	6148	5661
M_7	3274	4014	4263	4386	3984	4584	5860	6053	6148	5661
Mean	2347	2890	3298	3547		3286	4080	4656	4993	

	SEd	CD (P=0.05)	SEd	CD (P=0.05)
M	31	67	46	100
S	17	35	26	53
S at M	72	146	108	218
M at S	81	165	121	245

plant height and DMP of second crop of rice registered significant improvement. This might be due to the increased available nutrients after first crop leading to higher uptake of nutrients, which intern increased the growth components. But the addition of raw cane trash showed better residual effect than the trash composted without additives. The reason may be due to the late mineralization of nutrients in the raw trash after a prolonged period of decomposition. The productive tiller count, number of grains panicle^{-1} also showed similar results. Trash composted with additives (M_4 to M_7) produced greater residual effect which was evidenced through improvement in plant height, DMP, productive tiller count and number of grains panicle^{-1}. This might be due to the steady supply of nutrients through out the crop period. Sundaram (1996) also reported similar finding.

Grain and straw yield

The grain yield of rice showed a significant increase due to incorporation of raw trash and trash composts (Table 3). Among the five type of composts, the effect of trash composted with NPK as additives was superior. The highest increase in yield of 1535 kg ha^{-1} (34.45%) over no trash was observed with trash + NPK as additives.

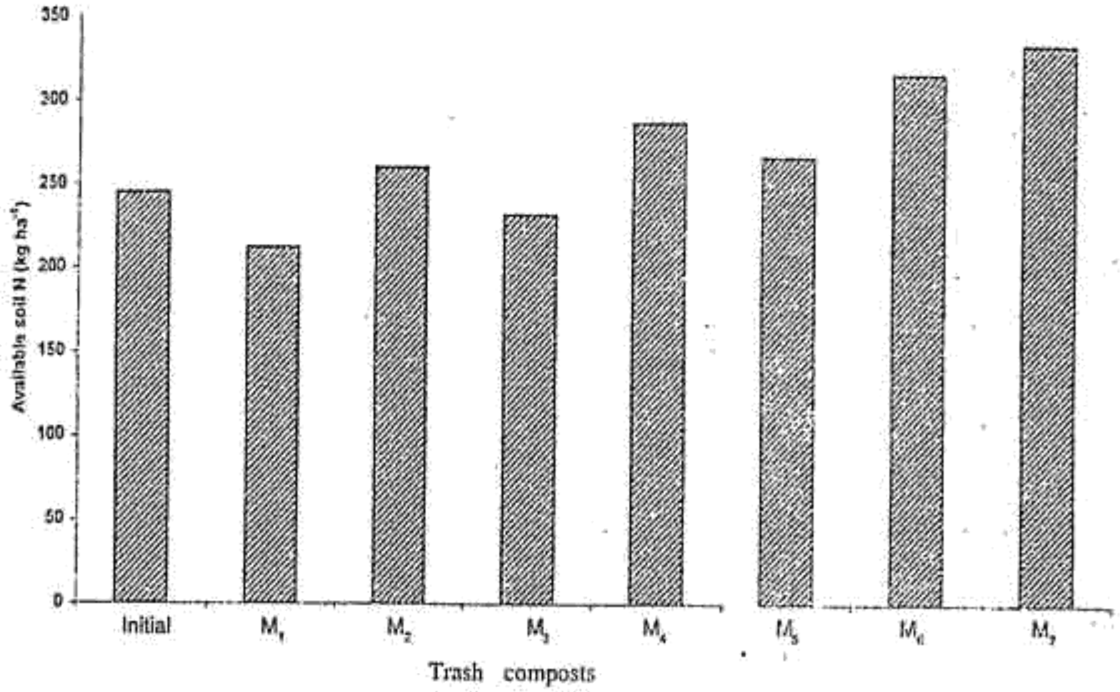

Fig.1 Influence of trash composts on available soil nitrogen after the harvest of first rice

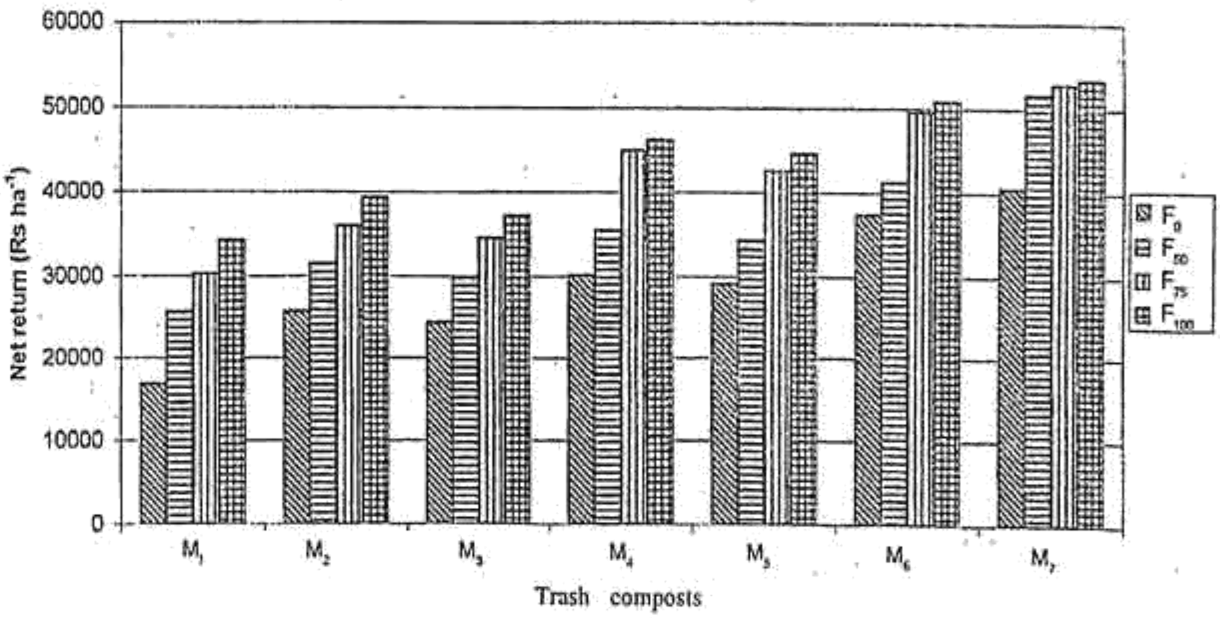

Fig.2. Effect of trash composts and fertilizer levels on net return of rice-rice system

Trash + Pleurotus + urea increased the yield to the tune of 26.32 per cent. Straw yield also exhibited same trend as that of grain yield. The increase in yield due to the additioin of NPK as additives might be due to the addition of nutrients equivalent to 70 kg ha^{-1} and also increased P and K in this compost. It promoted the uptake of nitrogen, which inturn resulted in improvement in growth and yield attributes and finally yield. The increase in grain yield due to above treatment may be due to increased microbial decomposition and less loss of nutrient in earlier stages. This is in agreement with the findings of Radhakrishna *et al.* (1995). Incorporation of raw trash and trash composted without additives was less effective, compared to trash composted with additives. This may be due to the spurt in microbial activity during cellulose and pentosan decomposition and conversion of native N into microbial protein and retardation in nitrifiers activity due to addition of more carbonaceous materials which resulted in depression in nitrate content in the first season (Buckman and Brady, 1967). The yield of the residual crop was very low (1213 kg ha^{-1}) under no trash and no fertilizer application (Table 4). Trash +urea + SSP + MOP, trash + Pleurotus + urea, trash + MRP + gypsum + urea and raw trash showed a significant effect on the yield of residual crop. This was possibly due to the substantial improvement in the soil available nutrient status after the harvest of first crop with the addition of the above composts. Sharma and Mittra (1991) stated that significant yield increase of residual crop in plots receiving composts was due to the increase in availability of nutrients and organic matter content of soil.

Substitution of NPK with trash composts

The addition of various trash composts were intended not only to serve as source of organic matter but also to substitute the inorganic fertilizer to the extent possible. The increase in yield due to incorporation of trash + NPK as additives + 100 per cent fertilizer level was 1464 kg ha^{-1} over 100 per cent inorganic alone (Table 3). It was interesting to note that even at 0 level of inorganic fertilizer, trash + Pleurotus + urea and trash + urea + SSP + MOP were able to produce a yield which can be compared with 100 per cent NPK application without trash. However under raw trash incorporation, 100 per cent inorganic were needed. This might be because of lower nutrient content of raw trash and wider C:N ratio. The interaction effect between trash composts and fertilizer levels on grain and straw

Table 5. Influence of trash composts and inorganic fertilizers on nutrient uptake (kg ha^{-1}) at harvest by rice-rice system.

Treatments	N uptake		P uptake		K uptake	
	Main	Residual	Main	Residual	Main	Residual
M_1	87.4	80.0	11.1	7.5	115.7	91.9
M_2	92.4	87.7	11.2	9.0	117.3	101.2
M_3	95.7	84.4	12.1	8.5	121.6	97.3
M_4	103.6	88.5	13.2	9.7	133.8	104.7
M_5	105.4	87.9	13.9	9.2	131.5	101.7
M_6	113.5	90.9	14.4	10.1	151.9	107.1
M_7	121.5	92.9	15.1	10.8	154.4	110.1
SEd	0.8	0.5	0.3	0.1	1.6	0.3
CD (P=0.05)	1.9	0.9	0.5	0.2	3.5	0.6
F_0	88.6	80.9	11.3	8.1	114.1	95.6
F_{50}	99.8	86.5	12.5	9.0	131.1	101.1
F_{75}	109.7	90.2	13.9	9.7	140.3	104.4
F_{100}	113.0	92.3	14.3	10.1	143.8	106.7
SEd	0.5	0.3	0.2	0.1	0.9	0.2
CD (P=0.05)	1.0	0.6	0.4	0.2	1.9	0.5

yield of rice was significant. Addition of more fertilizers increased the yield correspondingly, but the increment in yield with 100 per cent fertilizer over 50 per cent fertilizer was not proportionate with the addition of trash + urea + SSP +MOP. The grain yield with 50 per cent NPK along with trash + urea + SSP + MOP was 6228 kg ha^{-1} which was comparable with 100 per cent NPK along with trash + urea + SSP + MOP (6337 kg ha^{-1}). This might be due to more amount of nutrients (1.21% N, 0.73% P_2O_5 and 0.82 % K_2O) in this compost which enabled substitution upto 50 per cent. By using this compost @ 10 t ha^{-1}, additional N to the tune of 70 kg ha^{-1} was made available to the crops. Similar saving in fertilizer level to the extent of 50 per cent with enriched composts was also reported by Radhakrishna *et al.* (1995).

Effect of trash composts on nutrient uptake

The NPK uptake with trash + NPK as additives was higher which recorded the uptake of 121.53, 15.09 and 154.34 kg NPK ha^{-1} respectively at harvest in the main crop as against 87.37, 11.09 and 115.66 kg NPK ha^{-1} with no trash application (Table 5). The favourable effect of trash composts on the uptake of N by rice was due to the faster release of N during critical period of crop growth with narrow C:N ratio. Rajput (1995) ascribed that increased uptake of P and K to more availability of these nutrients from the solublising action of organic acids produced during degradation of composts resulting in more release of native and plant remains of P and K under wetland rice culture.

Economics (Net return)

The highest net return was realized from the treatment combination of trash + urea + SSP + MOP + 100 per cent recommended dose of fertilizer (Fig. 2) which was closely followed by trash + urea + SSP + MOP + 50 per cent recommended dose of fertilizer for the cropping systems as a whole. Similar results were also obtained by Setty and Channabasavanna (1990).

Application of 50 per cent recommended dose of 120:60:60 kg NPK ha^{-1} along with cane trash composted with urea, SSP and MOP as additives is recommended for realizing higher yield and net returns in rice-rice cropping system.

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