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Qualitative Assessment of Co-compost Prepared by Paddy straw and Pressmud using Microbial Consortia

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A B S T R A C T

Paddy straw and press mud are agricultural and industrial wastes, which are generated in rice fields and sugar mill respectively. The disposal of these wastes into land or water is great environment hazard. So, co-composting could be considered as a feasible and safe method to recycle and transform them into organic manures which can be used in agricultural soil. So, the present investigation was planned with the objectives to co-compost paddy straw and pressmud using microbial consortia. Co-composting of paddy straw and pressmud in different ratio was carried out in pits by adjusting initial C/N ratio to 50:1. Total organic carbon in different treatments decreased due to losses of C and total N increased due to accumulation of nitrogen upto 90 days. Ammoniacal nitrogen decreased with time during composting in all the treatments. Amount of nitrate-nitrogen increased significantly and varied from 180 mg/kg to 527 mg/kg. The C: N ratio declined from 59.95 and 33.89 to 33.75 and 22.45 in controls (T1 and T2) respectively, after 90 days of composting and treatment T6 had minimum C/N ratio (15.51). Amount of total phosphorous varied from 185 to 1035 mg/kg. Total potassium increased from 0.89 to 1.53 % and 0.72 % to 1.02% in controls.

Introduction

Paddy straw and pressmud are agricultural and industrial wastes which are generated in rice fields and sugar mill, respectively. Paddy straw is a vegetative part of rice plant (*Oryza sativa)*, cut at grain harvest or after. It is a major agricultural waste in rice producing countries. About 95 million tons of paddy straw is produced in the Indo-Gangetic plains which is about 39% of total crop residue generated (Sidhu *et al.,* 2003). In Haryana, about 6 million tons of paddy straw is produced annually and approximately 63% of this is burnt which causes environmental and health problems (Reinhard *et al.,* 2001).The open field burning is a major source of air pollutants such as carbon dioxide, carbon monoxide, un-burnt carbon as well as traces of methane, nitrogen oxide and comparatively less amount of sulphur dioxide (Tipayarom and Oanh, 2007). Paddy straw burning is also known to emit particulate matter and other elements such as dioxins and furans that affect human health (Torigoe *et al.,* 2000; Gadde *et al.,* 2009). Based on a study of the

Department of Science and Technology (DST), burning of rice straw and other agricultural wastes contribute more dioxins and furans to air and land than vehicle emissions.

Pressmud is a residue of the filtration of sugarcane juices which is soft, spongy, amorphous and dark brown material containing sugar, fibre, coagulated colloides including cane wax, albuminoids and inorganic salts (Ramaswamy *et al.,* 1999). The composition of pressmud depends upon quality of cane and process of cane juice clarification. Sugar industry in India is the second largest agro processing industry after textiles. A typical sugar factory generates large quantity of byproducts like bagasse, pressmud and molasses (Patil *et al.,* 2000). India produces on an average 270 million tons of sugarcane per year (Zeyer *et al.*, 2004) and for every 100 tons of sugarcane, 3 tons of pressmud is left behind as a byproduct (Solomon, 2011). This industrial waste is mostly used as soil conditioner, soil fertilizer, for wax production, cement and paint manufacturing and as a foaming agent (Van der Poel *et al.,* 1998). However, due to its bulky nature and wax content, it usually gives less benefit when applied directly into soil (Joshi and Sharma, 2010). Composting is a well-known system for rapid stabilization and humification of organic matter. This process is aerobic and uses various microorganisms such as bacteria, fungi and actinomyces to break down the organic compounds into much simpler substances. During composting, microbes consume oxygen when fed upon organic matter. This generates a large amount of heat, large quantities of carbon dioxide and water vapours are released into the air. The carbon dioxide and water losses can amount to half the weight of the initial organic materials, thus composting reduces both the volume and mass of the raw materials while transforming them into beneficial humus like material (Patil *et al.,* 2000). Composting is a simple, non technical and low-investment process that adds value to organic solid wastes by converting them into organic fertilizer known as compost (Neves *et al.*, 2009).

Materials and Methods

Paddy straw was obtained from Farmer's field of village Mangali, Distt. Hisar (Haryana) India and Pressmud from Sugar mill, Meham (Rohtak) respectively. The cattle dung and microbial consortium of three fungi (*Aspergillus awamorii, Paecilomyces fusisporus* and *Trichoderma viride*) used during the present investigation was obtained from Animal Science Department and Department of Microbiology, CCS Haryana Agricultural University, Hisar respectively.

Composting experiment

Composting of paddy straw and pressmud was carried out in the 1.5×1.5×1.5 ft. size pits using following treatments:

Ten kilograms of compostable material was taken on dry weight basis and mixed with above amendments. The material was put in cemented pits and allowed to decompose. Moisture was adjusted to 60% of water holding capacity (WHC) and initial C: N ratio was maintained to 40-50:1. Two turnings of compostable material were done at 15 and 30 days of intervals. The samples were drawn at 0, 15, 30, 45, 60, 75 and 90 days for analysis of different parameters.

Chemical analysis of compostable samples

Organic carbon

Organic carbon was determined by dry combustion method (Nelson and Sommers, 1982).

Weight of compostable sample = Weight of compostable sample with crucible - Empty crucible

Weight of Ash = Weight of ash with crucible - Empty crucible

$$\% \text{ of Ash} = \frac{\text{Weight of ash} \times 100}{\text{Weight of compostable sample}}$$

$$\% \text{ of organic carbon} = \frac{100 - \% \text{ ash}}{1.724}$$

Total nitrogen

Total nitrogen was estimated by Kjeldahl's method (Bremner, 1982)

Percent N was calculated as follows:

1 ml of 0.02N HCl = 0.28 mg N

$$\% \text{ N} = \frac{0.28 \text{ (S-B)} \times 100}{\text{Weight of compostable sample (mg)}}$$

Where,

S = ml of 0.02N HCl used for compostable sample
B = ml of 0.02N HCl used for blank

Ammoniacal and nitrate nitrogen (Bremner, 1965)

Compostable sample (10 g) was taken in 250 ml conical flask and 100 ml of 2M KCl was added. Flask was kept on a rotary shaker (160 rpm) for 1h. The suspension was filtered through Whatman no.1 filter paper and filtrate was analyzed by steam distillation procedure used for determination of ammoniacal and nitrate nitrogen as follows

1 ml of 0.005N H2SO4 = 70 µg N

$$\mu\text{g N/g sample} = \frac{\text{ml of 0.005N } H_2SO_4 \text{ used} \times 70 \times 100 \times \text{wet weight of compostable sample}}{20 \times 10 \times \text{dry weight of compostable sample}}$$

Total phosphorus

The total phosphorus content in the compostable sample was determined by the method of John (1970).

Calculation

$$\text{mg/kg compostable sample} = \frac{\mu\text{g P/ml corresponding to absorbance} \times 50 \times 100}{\text{ml of aliquot taken for color development} \times \text{weight of the compost}}$$

Total potassium

Total Potassium in the samples was estimated using Flame photometer by direct feeding method (Jankowski *et al.*, 1961).

Calculations

Total K (%) = Concentration of K in ppm corresponding to Flame photometer reading × dilution factor × 100 / weight of soil sample (g) × 10000

Carbon-dioxide evolution in finished compost

Carbondioxide evolution was determined by measuring CO_2 evolved in compost for 4 weeks by method of Pramer and Schmidt (1964) with slight modification.

Calculations

One ml of 1 N HCl used against 1 N NaOH = 22 mg carbon dioxide

mg CO2-C/100 g compostable sample = {(B-R) × 22 × 12 × 10}/ 44

Where,

B= ml of 1 N HCl used in blank
R= ml of 1 N HCl used in flask with compostable sample

Water soluble carbon

Water soluble carbon in compost was determined by wet digestion method (Kalembassa and Jenkinson, 1973).

Calculations

Normality of FAS (Ferrous Ammonium Sulfate) (x) = $0.5 \times 20/y$

% Organic C = $x\ (Vh-Vs) \times 3 \times 100/W \times 1000$

Where,

x = Normality of FAS
y = Volume of FAS used for cold blank (ml)
Vh = Volume of FAS used for hot blank (ml)
Vs = Volume of FAS used for sample (ml)
W = Weight of compostable sample in grams

Results and Discussion

Initial analysis of compostable material

Table 1 shows the initial analysis of paddy straw and pressmud for organic C, total and available N, total P and K, ammonical-N, nitrate-N and C: N ratio

Analysis of compostable material at different stages of composting

Changes in total organic C

Organic carbon decreased significantly in the control (T1 and T2) as well as in all other treatments with time (Table 2). It was 47.96 and 36.27% initially in control and decreased to 35.10 and 25.15% respectively after 90 days of composting. Minimum organic C (19.39%) was recorded in the treatment 6 having paddy straw and pressmud (1:2) + cattle dung (10%) + microbial consortia after 90 days of composting. There was a significant decline in % organic carbon with the inoculation of microbial consortia in all the treatments as compared to the treatments not having microbial consortia.

Total and available N

Table 3 shows the amount of total N in different treatments at different days of composting. The total N content increased significantly from 0.80% and 1.07 to 1.04 and 1.12% during composting in control T1 and T2 respectively. Maximum total N (1.25%) was recorded in T6 having paddy straw and pressmud (1:2) + cattle dung (10%) + microbial consortia after 90 days of composting followed by T5 (1.23%) having paddy straw and pressmud (1:2) + cattle dung (10%).

Changes in ammoniacal nitrogen at different days of composting

The ammoniacal nitrogen decreased significantly with time during composting in all the treatments. After 90 days of composting, minimum amount of ammoniacal – N was recorded in treatment T 6 (5.14 mg/kg) having paddy straw and pressmud (1:2) +cattle dung (10%) + microbial consortia and maximum amount of ammoniacal nitrogen was observed in treatment T11 (5.55 mg/kg) having paddy straw and pressmud (3:1) + cattle dung (10%).

Table 5 shows the changes in nitrate nitrogen at different days of composting. Amount of nitrate nitrogen increased significantly and varied from 180 mg/kg to 527 mg/kg and was maximum in the treatment T6 (527 mg/kg) having paddy straw and pressmud (1:2)

+cattle dung (10%) + microbial consortia and minimum for T 1 (394 mg/kg) having paddy straw alone + cattle dung (10%) after 90 days of composting.

C: N ratio

The C: N ratio declined from 59.95 and 33.89 to 33.75 and 22.45 in control (T1 and T2) respectively, after 90 days of composting. A significant reduction in C: N ratio of the compost was observed in all the treatments. With the addition of microbial consortia, decline in C/N ratio was more as compared to treatments, not having microbial consortia. Treatment T6 having paddy straw and pressmud (1:2) +cattle dung (10%) + microbial consortia had minimum C/N ratio (15.51) than treatments without microbial consortia.

Total P

Table 7 shows the amount of total P in different treatments at different days of composting. Total phosphorous content increased significantly in composting of paddy straw and pressmud in different ratios with or without microbial consortia after 90 days of composting. The amount of total phosphorous varied from185 to 1035 mg/kg. It was 250 and 185 mg/kg in control initially and increased to 659 and 332 mg/kg respectively after 90 days of composting. Maximum amount of total phosphorous was observed in treatments T6 (1035 mg/kg) after 90 days of composting followed by T10 (1020 mg/kg).

Table.1 Showing different treatments

Sr.No.	Treatments
T1	Paddy straw alone + Cattle dung (10%)
T2	Pressmud alone + cattle dung (10%)
T3	Paddy straw and pressmud (1:1) + cattle dung (10%)
T4	Paddy straw and pressmud (1:1) + cattle dung (10%)+ microbial consortia
T5	Paddy straw and pressmud (1:2) + cattle dung (10%)
T6	Paddy straw and pressmud (1:2) + cattle dung (10%) + microbial consortia
T7	Paddy straw and pressmud (2:1) + cattle dung (10%)
T8	Paddy straw and pressmud (2:1) + cattle dung (10%)+ microbial consortia
T9	Paddy straw and pressmud (1:3) + cattle dung (10%)
T10	Paddy straw and pressmud (1:3) + cattle dung (10%)+ microbial consortia
T11	Paddy straw and pressmud (3:1) + cattle dung (10%)
T12	Paddy straw and pressmud (3:1) + cattle dung (10%) + microbial consortia

Table.2 Initial analysis of paddy straw and pressmud

Component	Paddy straw	Pressmud
Organic carbon (%)	49.02	34.50
Total nitrogen (%)	0.58	1.00
C:N ratio	84.56	34.50
Ammonical nitrogen (mg /kg)	8.09	7.60
Nitrate Nitrogen (mg /kg)	160	182
Total phosphorous (mg/kg)	207	106
Total Potassium (%)	0.90	0.71
pH	6.20	6.90

Table.3 Changes in total organic C during different days of composting

Treatments	Total C (%)						
	Days of composting						
	0	15	30	45	60	75	90
T1	47.96	43.65	40.34	37.9	36.67	35.97	35.1
T2	36.27	36.21	36	32.02	29.58	25.4	25.15
T3	41.99	34.09	30.33	28.71	27.72	24.53	24.24
T4	41.36	30.07	28.05	27.44	25.03	21.35	20.99
T5	33.93	32.1	29.99	27.95	24.32	22.34	20.92
T6	33.88	30.61	27.41	23.4	22.87	21.99	19.39
T7	43.47	39.99	37.52	35.49	34.12	32.65	29.12
T8	43.3	38.49	36.68	34.01	33.99	30.99	28.02
T9	33.9	30.72	28.16	26.01	25.16	24.56	23.01
T10	33.01	30.03	27.39	24.76	23.06	22.34	22.13
T11	44.14	39.01	36.01	35.99	33.01	31.75	30.85
T12	42.31	36.01	34.99	32.69	30.91	29.41	29.01
C.D. at 5%	0.53	0.59	0.65	1.2	0.1	0.35	0.85

Table.4 Changes in total N at different days of composting

Treatments	Total N (%)						
	Days of composting						
	0	15	30	45	60	75	90
T1	0.80	0.86	0.98	1.02	1.03	1.03	1.04
T2	1.07	1.09	1.10	1.11	1.11	1.12	1.12
T3	0.83	0.86	0.99	1.01	1.02	1.06	1.10
T4	0.80	0.83	0.97	0.99	1.05	1.10	1.12
T5	0.92	0.86	1.01	1.02	1.04	1.11	1.23
T6	0.99	0.83	1.03	1.05	1.07	1.15	1.25
T7	0.77	0.79	0.81	0.83	0.94	1.02	1.06
T8	0.78	0.81	0.83	0.85	0.97	1.06	1.09
T9	0.80	0.82	1.04	1.07	1.11	1.14	1.16
T10	0.82	0.85	1.09	1.11	1.16	1.18	1.19
T11	0.74	0.78	0.85	0.90	1.03	1.12	1.14
T12	0.76	0.81	0.87	0.92	1.06	1.16	1.16
C.D. at 5%	0.01	0.02	0.01	0.01	0.02	0.03	0.01

Table.5 Changes in ammoniacal nitrogen at different days of composting

Treatment	Ammoniacal nitrogen (mg/kg)						
	Days of composting						
	0	15	30	45	60	75	90
T1	8.19	8.09	8.08	7.86	6.45	5.6	5.07
T2	7.81	7.56	7.21	6.95	6.32	5.11	5.02
T3	8.05	7.88	7.45	7.21	6.39	5.42	5.17
T4	8.09	8.01	7.99	7.45	6.42	5.45	5.15
T5	7.99	7.84	7.39	7.19	6.29	5.32	5.21
T6	8.02	7.97	7.85	7.12	6.32	5.35	5.14
T7	10.24	7.9	7.56	7.25	6.41	5.46	5.24
T8	9.66	8.03	7.95	7.56	6.45	5.49	5.21
T9	8.04	7.9	7.45	7.25	6.32	5.35	5.45
T10	8	7.95	7.82	7.1	6.25	5.2	5.32
T11	10.3	7.92	7.6	7.28	6.45	5.5	5.55
T12	9.54	8	7.82	7.45	6.4	5.39	5.3
C.D. at 5%	0.02	0.04	0.18	0.06	0.02	0.02	0.01

Table.6 Changes in nitrate nitrogen at different days of composting

Treatments	Nitrate nitrogen (mg/Kg)						
	Days of composting						
	0	15	30	45	60	75	90
T1	180	290	320	358	378	388	394
T2	186	300	340	370	395	406	420
T3	182	290	310	365	425	450	475
T4	185	292	325	395	450	498	510
T5	184	289	332	368	420	456	498
T6	190	294	356	398	422	502	527
T7	181	206	320	375	450	460	480
T8	182	210	335	401	475	506	520
T9	189	197	342	378	430	465	500
T10	194	203	370	406	442	504	525
T11	180	260	322	384	451	475	495
T12	182	275	345	410	495	520	522
C.D. at 5%	0.9	1.5	5.6	10.2	1.1	15.4	20.6

Table.7 Changes in C/ N ratio at different days of composting

Treatment	C:N ratio						
	Days of composting						
	0	**15**	**30**	**45**	**60**	**75**	**90**
T1	59.95	50.75	41.16	37.15	35.60	34.92	33.75
T2	33.89	33.22	32.72	28.84	26.64	23.09	22.45
T3	50.59	39.63	30.63	28.42	27.17	23.14	22.03
T4	51.70	36.22	28.91	27.71	23.83	19.40	18.74
T5	36.88	37.32	29.69	27.40	23.38	20.12	17.00
T6	34.22	36.87	26.61	22.28	21.37	19.12	15.51
T7	56.45	50.34	45.94	42.42	35.06	32.00	27.47
T8	54.88	47.51	43.94	40.01	34.98	29.01	25.70
T9	42.37	37.46	27.01	24.23	22.66	21.41	19.78
T10	40.25	35.32	25.12	22.14	19.78	18.93	18.59
T11	59.64	50.01	42.36	39.98	32.04	28.34	27.06
T12	55.67	44.45	40.01	35.50	29.01	25.16	25.00

Table.8 Changes in total phosphorous content at different days of composting

Treatment	Total phosphorous (mg/kg)						
	Days of composting						
	0	**15**	**30**	**45**	**60**	**75**	**90**
T1	250	320	402	480	550	608	659
T2	185	191	298	304	325	330	332
T3	212	310	680	720	860	910	980
T4	216	325	735	798	890	945	1010
T5	198	308	654	735	875	925	990
T6	201	323	765	800	902	980	1035
T7	245	315	695	735	874	935	990
T8	244	335	750	805	908	985	1011
T9	188	320	675	755	895	955	978
T10	191	355	785	825	935	989	1020
T11	225	345	703	760	900	975	918
T12	222	360	790	850	926	962	990
C.D. at 5%	0.8	13.5	20.6	30.7	22.4	12.3	14.7

Table.9 Changes in total potassium content at different days of composting

Treatmem t	Total K (%)						
	Days of composting						
	0	15	30	45	60	75	90
T1	0.89	0.92	1.26	1.42	1.49	1.51	1.53
T2	0.72	0.75	0.89	0.96	0.99	1.00	1.02
T3	0.91	0.94	1.19	1.31	1.42	1.49	1.53
T4	0.94	0.97	1.29	1.45	1.56	1.61	1.68
T5	0.78	0.80	1.16	1.29	1.41	1.46	1.52
T6	0.81	0.85	1.34	1.44	1.53	1.60	1.65
T7	0.93	0.95	1.36	1.49	1.61	1.68	1.75
T8	0.96	0.98	1.46	1.54	1.69	1.72	1.77
T9	0.82	0.83	1.20	1.39	1.48	1.49	1.55
T10	0.84	0.86	1.39	1.51	1.59	1.62	1.69
T11	0.96	0.98	1.38	1.59	1.71	1.72	1.74
T12	0.99	1.00	1.49	1.68	1.73	1.74	1.76
C.D. at 5%	0.01	0.01	0.71	0.03	0.01	0.01	0.01

Table.10 Amount of carbon dioxide evolution (mg CO_2/100g compost) in mature compost

Treatment	Incubation time (weeks)				
	1	2	3	4	Total
T1	148.40	136.02	122.20	98.5	505.1
T2	41.10	38.20	32.50	30.60	142.4
T3	110.30	106.40	96.80	68.50	382.0
T4	108.20	102.70	92.40	65.20	368.5
T5	96.40	80.60	70.90	50.50	298.4
T6	94.50	75.20	55.30	35.20	260.2
T7	118.80	97.40	85.40	70.10	371.7
T8	109.30	90.30	82.30	60.40	342.3
T9	105.90	85.60	68.20	46.90	306.6
T10	102.80	70.10	60.40	40.20	273.5
T11	120.60	100.10	85.40	50.30	356.4
T12	145.20	120.50	95.10	60.20	421.0
C.D. at 5%	1.9	3.1	2.9	2.8	4.2

Total K

Total potassium content increased significantly with the progress of decomposition in all the treatments. Total Kincreased from 0.89 and 0.72 % to 1.53 and 1.02% in controls, which were having paddy straw alone and pressmud alone with cattle dung (10%). Total potassium was highest at the end of 90 days of composting. Among all the treatments, maximum total potassium content was observed in T8 (1.77%) having paddy straw and press mud (2:1) +cattle dung (10%) + microbial consortia.

Carbon dioxide evolution

Table 9 shows the amount of carbon dioxide evolution in the composts over a period of 4 weeks. Maximum amount of carbon dioxide evolution was seen in treatment T1 (505.1mg CO_2/100g compost) having paddy straw alone + cattle dung (10%) followed by treatment T12 (421.0 mg CO_2/100g compost) having paddy straw and pressmud (3:1) + cattle dung (10%). The minimum carbon dioxide evolution was observed in the treatment T 2(142.4 mg CO_2/100g compost) having pressmud alone + cattle dung (10%) followed by treatment T6 (260.2 mg CO_2/100g compost) having paddy straw and pressmud (1:2) +cattle dung (10%) + microbial consortia (Table 10).

In conclusion the co-composting of paddy straw and pressmud in different ratio with or without microbial consortia was carried out in pits. Two turnings were given after 15 and 30 days of intervals. Samples were drawn at 0, 15, 30, 45, 60, 75 and 90 days for analysis of different parameters such as C, N, P, K contents.

Total organic carbon was 47.96 and 36.27% initially in control and decreased to 35.10 and 25.15% respectively after 90 days of composting. Minimum organic C (19.39%) was recorded in the treatment T 6 having paddy straw and pressmud (1:2) + Cattle dung (10%) + microbial consortia after 90 days of composting as compared to controls (T1 and T2) and other treatments.

Total N content increased significantly from 0.80% and 1.07 to 1.04 and 1.12% during composting in control (T1 and T2). Maximum total N (1.25%) was present in treatment T6 having paddy straw and pressmud (1:2) + Cattle dung (10%) + microbial consortia after 90 days of composting followed by treatment T5 (1.23%) having paddy straw and pressmud (1:2) + Cattle dung (10%).

Amount of nitrate-nitrogen increased significantly and varied from 180 mg/kg to 527 mg/kg and was maximum in the treatment T6 (527 mg/kg) having paddy straw and pressmud (1:2) +cattle dung (10%) + microbial consortia and minimum for treatment T1 (394 mg/kg) having paddy straw alone + cattle dung (10%) after 90 days of composting.

A significant reduction in C: N ratio in the compost was observed in all the treatments. The C: N ratio declined from 59.95 and 33.89 to 33.75 and 22.45 in controls (T1 and T2) respectively, after 90 days of composting. With the addition of microbial consortia, decline in C/N ratio was more as compared to other treatments which were not having microbial consortia. Treatment T6 having paddy straw and pressmud (1:2) +cattle dung (10%) + microbial consortia had minimum C/N ratio (15.51).

Total P content increased significantly in composting of paddy straw and pressmud in different ratios with or without microbial consortia. Amount of total P varied from 185 to 1035 mg/kg. Initially it was 250 and 185 mg/kg in control and increased to 659 and 332 mg/kg respectively after 90 days of composting. Maximum amount of total P was observed in treatments T6 (1035 mg/kg) after 90 days of composting followed by T10 (1020 mg/kg).

Total potassium content increased significantly with the progress of decomposition in all the treatments. Total potassium increased from 0.89 and 0.72 % to 1.53 and 1.02% in controls, which were having paddy straw alone and pressmud alone with cattle dung (10%). Total potassium was highest at the end of 90 days of composting. Among all the treatments, maximum total potassium content was observed in T 8 (1.77%) having paddy straw and press mud (2:1) +cattle dung (10%) + microbial consortia.

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