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Effect of Different Seasons and Carbonaceous Materials in Nitrogen Conservation While Composting Dead Birds

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Abstract: Composting experiment was carried out under aerobic condition in a mini composter to study the nitrogen conservation while composting dead birds. Six treatment mixtures were formulated with different combinations viz., dead bird + CLM+ PS (T_1), dead bird + CLM + SS (T_2), CLM+SS (T_3 as control), dead bird + FYM + PS (T_4), dead bird + FYM + SS (T_5) and FYM alone (T_6 as control). Composting was done during summer, monsoon and winter to the study the nitrogen profile and C:N ratio. Heavy loss of N was noticed from CLM mixture during summer than monsoon and winter. But the compost mix with dead birds recorded higher N content (16.19 to 17.92 and 12.75 to 23.67 g Kg^{-1} for CLM and FYM groups, respectively) than control bins (13.80 to 16.52 and 9.97 to 16.97 g Kg^{-1} for CLM and FYM groups, respectively), which indicated that carcass compost increased the fertilizer value of compost. From loading to finishing there was a reduction of 18.05, 19.12 and 22.91 per cent N from various CLM compost mixture viz., T_1, T_2 and T_3, respectively. In case of FYM mixture there was an increase in N content (18.40, 3.92 and 57.22 per cent increase for T_4, T_5 and T_6 respectively). In the finished compost the C:N ratio was high in summer (17.56 to 23.10) followed by winter (13.59 to 18.62) and monsoon (14.44 to 17.09).

Key words: Aerobic composting, dead birds, N conservation, poultry (caged layer) manure, FYM

INTRODUCTION

The nutrient that has received the most attention in composting system is nitrogen (N), because it is the most important nutrient for plant growth [1]. Livestock and poultry farm wastes are rich in N content. The wastes of primary concern in poultry production are i) the litter, associated primarily with broiler production ii) manure, resulting from laying hen and other operations and dead birds. Mortality to an extent of 7 to 11 per cent is unavoidable from poultry farms due to various reasons such as disease and mechanical injury [2]. The poultry carcasses are rich in N in organic form stored as protein in various tissues. The poultry carcasses has total N content of 75 g Kg^{-1} on dry weight basis with a narrow C:N ratio of 6:1[3]. The caged layer manure is also rich in N that ranges between 43.5 and 50 g Kg^{-1}[4-7].

It is a common practice among poultry growers to rear few dairy animals and other livestock to meet the family need and for additional income which also generate substantial quantity of farm yard manure (FYM). The N content of farm yard manure was low (16-19.3 g Kg^{-1}) [8]. Huge amount of valuable N (nearly 50 to 77 per cent) is lost through volatilization due to poor handling and storage. Similarly 90 per cent of the dead birds are unused [2]. Composting is an effective and inexpensive means of stabilizing organic matter. However, composting alters the nature of waste and can affect its usefulness as soil amendment. Composting may affect N transformation such as N mineralization, ammonia (NH_3) volatilization, nitrification and denitrification. N mineralization is important in agronomical point of view because it converts organic N into ammonium (NH_4^+). Nearly 21 to 77 per cent loss of N is due to NH_3 volatilization and denitrification [3, 9]. The objective of the present study is to investigate the changes in N transformation during composting of dead birds with various manure substrate viz., caged layer manure (CLM) and farm yard manure (FYM).

MATERIALS AND METHODS

An aerobic composting experiment was carried out as a mean to dispose and utilize the dead birds from commercial poultry farms. Dead birds were composted with caged layer manure (CLM) and farm yard manure (FYM). The initial C: N ratio was fixed as 20: 1 to facilitate quick composting [10, 11]. To meet the carbon (C) requirement, two carbonaceous materials viz., paddy straw (PS) and sorghum straw (SS) were used.

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Six treatment mixtures were formulated with different combinations viz., dead bird + CLM+ PS (T_1), dead bird + CLM + SS (T_2), CLM+SS (T_3 as control), dead bird + FYM + PS (T_4), dead bird + FYM + SS (T_5) and FYM alone (T_6 as control). Composting was done as per the method suggested by Donald *et al.* [12] and USDA-NRCS [11]. To study the year round feasibility, composting was carried out during summer, monsoon and winter.

Dead birds, manure substrate and carbonaceous materials were sequentially layered in 4' x 4' x 4' size wooden bin with 60 per cent moisture [12]. Composting temperature was monitored continuously. When compost temperature fall below 40°C, the bins were opened (primary stage), aerated and repacked after addition of sufficient moisture for second heating cycle (secondary stage). Compost samples were collected during primary and secondary stages and analysed for total N as per the method suggested by AOAC [13] and total carbon as per the method suggested by Allison [14]; Navarro *et al.* [15] and Lawson and Keeling [16]. The bin temperature was monitored by daily recording using compost thermometer at different locations. The data thus collected were analyzed statistically using two way analysis with replication as suggested by Snedecor and Cochran [31].

RESULTS AND DISCUSSIONS

The main objective of composting is to reduce the N loss by NH_3 volatilization and conserving N by favouring N mineralization. In the primary stage of composting the total N of different treatment bins during all the three seasons ranged between 14.19 and 21.72 gKg^{-1}. Even though differences in N content among different seasons and various treatments were noticed (Table 2) a definite pattern could not be inferred with the results and this indicated that different compost bins were in varying degree of N stabilization.

In the secondary stage, the treatment bins with CLM as manure substrate (T_1 to T_3) showed uniformity (except T_3 in summer) in N content ranged between 14.71 and 17.92 gKg^{-1} (Table 2), whereas, the treatment bins with FYM showed higher N content during winter and monsoon (16.52 to 23.67 g Kg^{-1}) and least during summer (9.97 to 13.77 g Kg^{-1}). The increased ambient temperature prevailed during summer synergized with increased compost pile temperature (Fig. 1 and 2). This might have led to heavy loss of N in the form of NH_3 through gaseous emission.

In this experiment heavy loss of N was noticed from CLM (Fig. 3) mixture during summer. This might be due to high temperature profile (ambient temperature of 35.71 to 35.9°C and bin peak temperature of 68.6 to 70.3°C) and higher pH (Table 1) established in the second heating phase and increased porosity of bulking agent due to turning. From the results (Table 2) it was clearly seen that at the end of composting cycle CLM mixture had lower N (13.80 to 17.92 g Kg^{-1}) than FYM mixture (9.97 to 23.67 g Kg^{-1}). More over during monsoon and winter, the N content, increased substantially in FYM group. The lowered C: N ratio of the CLM than FYM (Table 1) warranted addition of more carbonaceous source (paddy straw and sorghum straw), which favour microbial degradation evidenced by the temperature built up and reduction in total organic carbon loss but failed to conserve N. Highly unstable N content of CLM and high porosity and aeration by addition of C source might be the reason for heavy loss of N in the form of gaseous NH_3 [11].

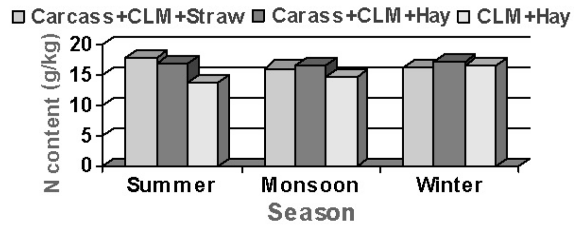

Fig. 1: Total N content of finished compost utilizing CLM substrate

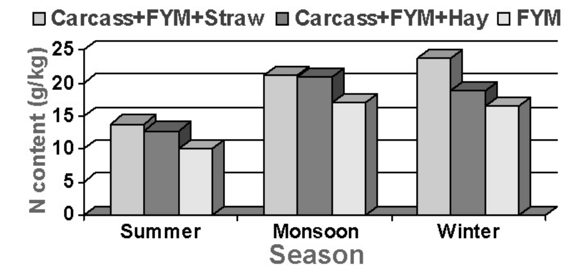

Fig. 2: Total N content of finished compost utilizing FYM substrate

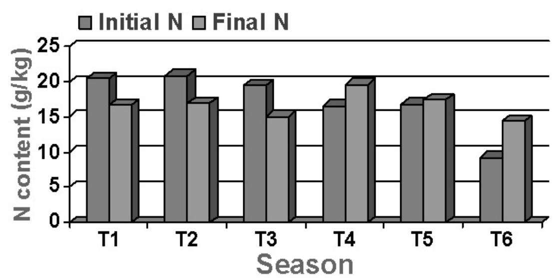

Fig. 3: Total N content at the time of loading and in the finished compost

The reported N value for finished dead bird compost ranged between 25.7 to 40.8 g Kg^{-1} [17-20], which are much higher than the observed value (9.97 to 23.67 g Kg^{-1}). Both cage layer manure and farm

Table 1: Physicochemical properties of ingredients and finished compost

Ingredients and compost	pH	Moisture (%)	Total N (g Kg^{-1})	Total carbon (%)	C:N ratio
Paddy straw	7.28	10.19	1.69	47.21	279:1
Sorghum hay	6.65	10.36	3.55	54.14	152:1
CLM	6.99	27.97	21.45	36.71	17.11:1
FYM	8.09	48.80	9.21	37.18	40.36:1
Poultry Carcass	6.56	62.48	87.44	49.20	5.63:1
Carcass compost with CLM	8.70-8.72	24.42-25.90	17.23-19.04	27.54-27.98	16.76-16.92
Carcass compost with FYM	8.03-8.12	30.68-36.42	15.31-17.00	28.69-28.85	17.50-16.56
CLM compost	8.86	27.644	18.66	27.17	15.01
FYM compost	8.22	43.75	19.07	26.39	14.48

Table 2: Mean ± SE of total Kjeldahl nitrogen (g Kg^{-1}) of compost samples

	End of primary stage				End of secondary stage			
Treatment	Summer	Monsoon	Winter	Pooled	Summer	Monsoon	Winter	Pooled
Dead birds + CLM+ PS	17.74^{Ab}±0.73	16.63^{ABb}±0.84	15.97^{Bd}±0.57	16.78±0.42	17.92^{Aa}±2.91	16.14^{Ab}±1.11	16.19^{Ac}±0.26	16.75±1.02
Dead birds + CLM + SS	19.09^{Aa}±0.76	16.70^{Bb}±0.30	16.61^{Bcd}±0.64	17.47±0.39	16.95^{Aa}±1.15	16.64^{Ab}±1.29	17.17^{Ac}±0.28	16.92±0.57
CLM+SS (T_3 as control)	15.52^{Bc}±0.77	15.56^{Bc}±0.42	17.31^{Ac}±0.39	16.13±0.34	13.80^{Bb}±0.78	14.71^{Ac}±1.07	16.52^{Ac}±0.30	15.10±0.48
Dead birds + FYM + PS	17.66^{Cb}±1.07	21.72^{Aa}±0.48	19.27^{Bb}±0.75	19.55±0.53	13.77^{Cb}±0.55	21.25^{Ba}±0.83	23.67^{Aa}±0.41	19.56±0.79
Dead birds + FYM + SS	17.70^{Bb}±1.01	21.21^{Aa}±0.42	21.35^{Aa}±1.68	20.09±0.71	12.75^{Bb}±0.63	20.84^{Aa}±0.70	18.90^{Ab}±0.49	17.50±0.68
FYM alone (T_6 as control)	14.19^{Cd}±0.65	17.32^{Ab}±0.60	15.98^{Bd}±0.47	15.83±0.39	9.97^{Bc}±0.72	16.97^{Ab}±0.51	16.52^{Ac}±0.78	14.48±0.66

Figures with different small letter column wise and capital letter row wise differ significantly (P< 0.01) except between seasons (P<0.05) in the end of primary stage

Table 3: Mean ± SE of C:N ratio of compost samples

	End of primary stage				End of secondary stage			
Treatment	Summer	Monsoon	Winter	Pooled	Summer	Monsoon	Winter	Pooled
Dead birds + CLM+ PS	18.05^{ABb}±0.76	16.89^{Bab}±0.99	18.92^{Abc}±0.73	17.95±0.49	23.10^{Aa}±4.62	15.94^{Cab}±0.76	18.09^{Ba}±0.32	19.04±1.60
Dead birds + CLM + SS	18.17^{Bb}±0.78	15.81^{Cbc}±0.37	19.22^{Ab}±0.86	17.73±0.46	18.00^{Ac}±1.64	16.25^{Aab}±1.06	17.44^{Aa}±0.39	17.23±0.66
CLM+SS (T_3 as control)	22.05^{Aa}±1.33	16.76^{Cab}±0.56	17.40^{Bd}±0.52	18.74±0.64	21.30^{Aab}±1.09	17.09^{Ba}±1.04	17.60^{Ba}±0.27	18.66±0.59
Dead birds + FYM + PS	14.11^{Bd}±1.11	15.43^{Bc}±0.33	18.06^{Abcd}±0.75	15.87±0.53	17.56^{Ac}±1.13	14.78^{Bbc}±0.67	13.59^{Bb}±0.24	15.31±0.52
Dead birds + FYM + SS	14.27^{Cd}±1.02	15.71^{Bbc}±0.58	17.67^{Acd}±1.59	18.24±0.63	19.28^{Abc}±0.93	14.44^{Cc}±0.67	17.28^{Ba}±0.53	17.00±0.53
FYM alone (T_6 as control)	16.07^{Cc}±1.11	17.41^{Ba}±0.64	21.22^{Aa}±0.92	18.24±0.64	22.05^{Aa}±1.06	16.55^{Bab}±0.79	18.62^{Ba}±0.66	19.07±0.61

Figures with different small letter column wise and capital letter row wise differ significantly (P< 0.01)

yard manure used in this experiment were stored in an open area. The N loss during this storage was the reason for low N content than reported values (Table 1).

The compost mix with dead bird (T_1, T_2, T_4 and T_5) recorded higher N content (16.19 to 17.92 and 12.75 to 23.67 g Kg^{-1} for CLM and FYM groups, respectively) than control bins viz, T_3 and T_6 (13.80 to 16.52 and 9.97 to 16.97 g Kg^{-1} for CLM and FYM groups, respectively), which indicated that carcass increased the fertilizer value of the compost (Fig. 1 and 2). In agronomical point of view, it is helpful to the farmers in efficient disposal of dead birds. This fact was supported by Fonstad *et al.* [21] that addition of hog carcass in the compost mixture increased the level of N by 108 per cent in the finished product.

Mostly added C sources either PS or SS did not reveal any significant effect on N content. Thus, both are equally suitable as carbonaceous material. But, the particle size should be reduced to conserve more N from CLM mixture.

The estimated total N at the time of loading (20.44, 20.92 and 19.47 g Kg^{-1}) was reduced to 16.75, 16.92 and 15.01 g Kg^{-1} which accounted for 18.05, 19.12 and 22.91 per cent N loss in CLM compost mixture viz., T_1, T_2 and T_3, respectively (Fig. 3) and this fact was comparable with the reports (11.19 to 14.54 per cent loss) of Mahimairaja *et al* [4] in poultry manure compost. Still higher reduction was reported (55.2 to 63.2 per cent N loss) by Das *et al* [22] while composting hatchery waste.

In case of FYM mixture, the results were contradictory to CLM mixture. The estimated N at the time of loading (16.52, 16.84 and 9.21 g Kg^{-1}) showed a increasing trend (19.56, 17.50 and 14.48 g Kg^{-1} for T_3, T_4 and T_5, respectively) and this accounted for 18.40, 3.92 and 57.22 per cent increase in the total N content (Fig. 3). Similarly, Vuorinen and Saharinen [23] reported that the total N of cattle and pig manure compost increased during three month composting from 16-20 g Kg^{-1} to 28-30 g Kg^{-1} (50 to 75 per cent increase). They opined that the increase in N was due to C loss and thus N become concentrated after stabilization. Tiquia *et al* [24] observed that the total N content of the spent litter (swine manure+ saw dust) increased slightly during composting from an initial value between 20.10 and 22.50 g Kg^{-1} to 24.80 and 26.0 g Kg^{-1} by the end of composting (day 91). Similar trend of N cycle was observed by Huang *et al.*[25] also.

The results revealed that higher N loss was noticed in CLM group than FYM group. But the dead bird compost clearly established the fact that there is an increase in total N content at the end of composting which accounted for an increase from 11.61 to 12.73 per cent of total N content in CLM group and 20.80 to 35.07 per cent in FYM group than its respective control groups (Table 2). This increase in total N serves as value addition in agronomical point of view and also solves the problem of dead bird disposal. Further the results also thrown light over the heavy loss of N from caged layer manure which required mitigation by way of reducing the particle size of carbonaceous materials used in the compost mixture or by pH adjustment.

Carbon: Nitrogen Ratio: The C:N ratio is the most important criteria in the compost making. Carbon is used both as a source of energy and for growth of microbes. Nitrogen is used for the synthesis of cellular material, amino acids and proteins and is continuously recycled through the cellular material of the microorganisms [11]. An initial C:N ratio of 20:1 to 40:1 is recommended for rapid composting[10] and accordingly the initial C:N ratio was adjusted to 20:1.

In this experiment, a general trend of reduction in C:N ratio was noticed from initial C:N ratio. The treatment mixtures with dead birds (T_1, T_2, T_4 and T_5) had uniform C: N ratio in any particular season than control. The trend was quite uniform in CLM and FYM mixture, indicating that the manure substrate and carbon source are equally good in all the seasons. At the end of second phase of heating cycle, the C:N ratio (Table 3) was high in summer (17.56 to 23.10) followed by winter (13.59 to 18.62) and monsoon (14.44 to 17.09). Heavy loss of N during summer might be the reason for this increase in C:N ratio. This result was contrary to the reports of Cekmecelloglu *et al* [26] who stated that the rate of reduction was high during summer than winter in food waste compost. But, summer compost stabilized faster than winter due to higher decomposition.

Higher rate of reduction in C:N ratio from 23:1 to 9.8:1 was reported by Cummins *et al*[20] in dead bird compost, from 13:1 – 35:1 to 12:1 – 18:1 in slaughter house waste compost[27]. In the present experiment the C:N ratio reduced from 20:1 to 15.9 – 18.7:1 at the end of primary stage of composting and marginally reduced to 15.3:1 to 19.1:1 at the end of secondary stage. In some of the compost mixture viz., T_1, T_3, T_4, T_5 and T_6 the C:N ratio was increased from the level that of primary stage (only during summer) because of heavy loss of N by volatilization. Such increase in C:N ratio was experienced by Das *et al.*[28] while composting hatchery waste (12.4:1 to 23.6:1).

Tiquia and Tam [9] observed an increase in C:N ratio while composting poultry litter from 15:1 to 38:1 and opined that the increase in C:N value during composting could be due to vigorous NH_3 volatilization [1], which normally occurs during composting of animal manure. This supports the concept that heavy loss of N during summer happened in this experiment resulted in increase in C:N ratio.

Vuorinen and Saharinen [23] reported the C:N ratio decreased from 22.6-28.5:1 to 21.8-26.9:1 while composting cattle manure and further reduction was noticed during curing (12.7-13.6). Similar drastic reduction was also noticed by Inbar *et al* [29] in liquid cattle manure from 27.1:1 to 8.1:1 during composting process. Similarly in this study also, heavy reduction in C:N ratio was noticed in FYM particularly T_6 (control) indicating higher decomposition in cattle manure compost.

The C:N ratio below 20 can be considered satisfactory for compost maturity, when the initial C:N ratio is between 25 and 30 [30] and it could not be an absolute indicator for compost maturation [25]. Most of the compost recipes in the present study had a C:N ratio below 20 hence is considered matured.

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