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N Availability in Fresh and Composted Poultry Manure

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Abstract: An incubation study was conducted at Veterinary College & Research Institute, Namakkal, Tamil Nadu to examine the changes in availability of N in soil applied with poultry manure either singly or in combination with Farmyard manure (FYM). Treatments consisted of farmyard manure (FYM), fresh poultry manure (PM), composted poultry manure (CPM) and 50 % PM + 50 % FYM. The experimental soil was sandy loam in texture, slightly alkaline in pH (7.8), free from salinity (0.4 dS m^{-1}) and low in organic carbon content (0.46 %). Soil samples were partially air-dried and sieved through 2 mm and used for the incubation study. The processed soil samples weighing 10 kg were filled in 20 polyethylene containers. The soil samples were then incubated with different organic manures (FYM, PM, CPM and 50 % FYM + 50 % PM) at 30 ± 5°C for 105 days. The treatments were replicated five times in a completely randomized block design (CRBD). The incubation study revealed that fresh poultry manure had higher mineralization rates. The NH_4^+- N content extracted from the soil decreased with varying magnitudes with the highest decrease with fresh poultry manure. Similarly, the NO_3^- - N content increased with varying magnitudes and the higher magnitudes was associated with fresh poultry manure application. Combined application of fresh poultry manure with FYM also gave better results than fresh poultry manure application. Composting yielded a more predictable and reliable source of mineralizable N than fresh manure. Composted poultry manure increased the available soil N progressively to be available to the plants for a longer period of time.

Key words: Poultry manure, composting, N mineralization, N availability, NH_4^+- N, No_3^-- N

INTRODUCTION

Poultry manure is one of the richest sources of N. The N availability from the manure is subjected to various losses through volatilization, denitrification, immobilization, mineralisation and leaching[3]. Mineralization occurs rapidly immediately after the application of poultry manure. Bitzer and Sims[1] reported that 69 per cent of organic N in poultry manure was mineralized in 140 days in a sandy soil but volatilization takes place instantly on incorporation. Wolf *et al*[13] found that 37 per cent of the total - N in surface applied poultry manure was volatilized in 11 days.

Composting, or the controlled biological decomposition of organic waste, has been investigated as a method of stabilising poultry manure prior to land application. This process produces a material with several advantages with respect to handling by reducing volume, mass of dry matter, odours, fly attraction and breeding and weed seed viability. Studies have shown that composting process immobilizes N in the manure and produces humus that can be used as source of organic materials and slow the release of nutrients. The slow release of nutrients from composted poultry manure may lessen leaching of N in runoff from farmlands[4]. Increased soil organic matter and cation exchange capacity from CPM applications may improve nutrient retention in soils. With these ideas in view, an incubation experiment was conducted with the objective of finding out the effect of fresh and composted poultry manure on the N mineralization and release pattern in the soil, in comparison with FYM.

MATERIALS AND METHODS

An incubation study was conducted at Veterinary College and Research Institute, Namakkal, Tamil Nadu to examine the changes in availability of N in soil applied with poultry manure either singly or in combination with FYM. Treatments consisted of FYM, fresh poultry manure (PM), composted poultry manure (CPM) and 50 % FYM + 50 % PM. The experimental soil was sandy loam in texture, slightly alkaline in pH (7.8), free from salinity (0.4 d Sm^{-1}), low in organic carbon content (0.46 %), low in available N (226 Kg ha^{-1}), medium in available P (16.0 Kg ha^{-1}) and low in available K (248 Kg ha^{-1}). Soil samples were partially air-dried and sieved through 2 mm and used for the incubation study.

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Table1: Chemical composition of manures used in the experiment.

Particulars	FYM	Poultry manure (PM)	Composted poultry manure (CPM)
pH	7.6	6.4	7.1
N content (%)	0.55	2.2	1.92
C: N ratio	19 :1	9 :1	16 :1
P content (%)	0.48	1.41	1.35
K content (%)	0.9	1.52	1.55

The processed soil samples weighing 10 kg were filled in 20 polyethylene containers. The soil samples were then incubated with different organic manures (FYM, PM, CPM and 50 % FYM + 50% PM) at 30 ± 5°C for 105 days. The treatments were replicated five times in a completely randomized block design (CRBD).

Composting of poultry manure was initiated using poultry manure and chopped sorghum straw. Poultry manure was mixed with bits of sorghum straw at the rate of 10:1 and packed in dug pits of size 1 m^3 (1 x 1 x1 m) and closed with mud plaster. To maintain optimum moisture, water was sprinkled before it is being packed and left under anaerobic conditions for 75 days as suggested by Sims *et al*[10]. The chemical properties of the manures used in the investigation are presented in Table 1.

FYM was applied @ 6 g kg^{-1} of soil while PM and CPM @ 2.5 g kg^{-1} of soil and thoroughly mixed by hand with the dried soil before incubation. Moisture content of the substrate was maintained below saturation capacity by periodical watering. Soil samples from the containers were drawn at periodical intervals of 0,2,4,6,8,10,12 and 14 days after incubation (DAI) for determining NH_4^+- N and NO_3^-- N and 15, 30, 45, 60, 75, 90 and 105 days after incubation for determination of the available nitrogen. NH_4^+ - N and NO_3^- - N were determined using Bremner apparatus as suggested by Bremner [2] while the available N in soil was determined by the method suggested by Subbiah and Asija[11]. The data collected from the study were statistically analyzed.

Nitrogen Mineralization Rate: The net N mineralized was calculated by subtracting the initial total of mineralized N (NH_4^+ and NO_3^-) in poultry manure and soil mixtures from the final total mineralized N (NH_4^+ and NO_3^-), divided by the original amount of organic N in the poultry manure and soil mixtures. Initial organic N varied among soil manure mixtures. There was 90 mg Kg^{-1} soil in FYM, 101 mg Kg^{-1} soil in in fresh poultry manure, 97 mg Kg^{-1} soil in composted poultry manure and 95 mg Kg^{-1} soil in PM + FYM. The totals of NH_4^+ and NO_3^- were adjusted for the amounts of NH_4^+ and NO_3^-(N mineralized) in the control soils[1]. The resulting N mineralization rates indicate the percentage of organic N mineralized in poultry manure alone after incubation of soil - manure mixtures at 30 º C for 105 days. The N mineralization formula[9] is

$$\%N_{min} = (N_t – S_t) – (N_i – S_i) / N_0 \times 100$$

Where,

N_{min} = N mineralization in poultry manure

N_t = poultry manure and soil mixture total (mg NH_4^+- N + NO_3^- - N Kg^{-1} soil) at final sampling date

N_i = poultry manure and soil mixture total (mg NH_4^+-N + NO_3^- - N Kg^{-1} soil) at initial sampling date

S_t = control soil total (mg NH_4^+-N + NO_3^- - N Kg^{-1} soil) at final sampling date

S_i = control soil total (mg NH_4^+-N + NO_3^- - N Kg^{-1} soil) at initial sampling date

N_o = Initial organic N (mg Kg^{-1} soil in poultry manure and soil mixture) = Soil N added in poultry manure and soil mixture (mg total N Kg^{-1}) - N in poultry manure and soil mixture at initial sampling date (mg NH_4^+-N + NO_3^- - N Kg^{-1} soil).

RESULTS AND DISCUSSIONS

Nitrogen mineralization: Nitrogen mineralization rates of manure varied widely from 19 % to 56 % in 105 days. The N mineralization rate was rapid upto 30 days and thereafter slowed down even though continued upto 105 days. Fresh poultry manure had higher mineralization rates followed by fresh poultry manure applied in conjunction with FYM. The current study agrees with the previous research that fresh poultry manure had higher mieralization rates than composted manure[7]. Fresh manure probably contained recently formed organic N that was less stable than N previously incorporated into the organic fraction which is often found in composted manure[9].

The C: N ratio was lower in fresh poultry manure, which probably contributed to higher mineralization rates with fresh poultry manure (Table 1). In the current study, C: N ratio of 9:1 in fresh poultry manure supported the mineralization rate of 56 %. As the C: N ratio of composted poultry manure was high 16:1; N mineralization rate was generally less than 24 %. (Table 2). Composting yielded a more predictable and reliable source of mineralizable N than fresh manure. These results are in conformity with the findings of Preusch *et al*[9].

Ammonium: The NH_4^+ - N extracted from soil declined with varying magnitudes irrespective of the treatments. The NH_4^+-N extracted from soil treated with fresh poultry manure declined during the first 12 DAI from 30.4 to 2.1mg NH_4^+- N Kg^{-1} soil. These data support the practice of fresh manure application close to time of crop plant uptake of N to reduce losses due to volatilization and $N0_3$+ - N movement in the soil[8]. The NH_4^+ - N in soil treated with CPM declined from 20.6 mg to 1.8 mg NH_4^+ - N Kg^{-1} soil by 14 DAI. Trends of NH_4^+- N extracted over time due to various sources were similar, even though there existed differences in the amount NH_4^+-N extracted.

Table 2: Nitrogen mineralization rates over 105 days from poultry manure mixed with soil

	Average mineralization rate (% of initial organic N) Days after incubation		
Treatments	30	60	105
1. FYM 6 g kg^{-1} soil	11	16	19
2. PM 2.5 g kg^{-1} soil	35	49	56
3. CPM 2.5 g kg^{-1} soil	14	19	21
4. FYM 3 g + PM 1.25 g kg^{-1} soil	24	35	41
SE_d	1.2	1.9	2.4
CD (5%)	2.5	4	5

Table 3: NH_4^+- N status (mg kg^{-1}) in soil applied with manures during incubation

	Days after incubation							
Treatments	0	2	4	6	8	10	12	14
1. FYM 6 g kg^{-1} soil	7.4	6.9	5.8	4.9	3.8	2.6	1.5	1.2
2. PM 2.5 g kg^{-1} soil	30.4	24.2	19.6	16.1	12.4	8.8	4.1	2.1
3. CPM 2.5 g kg^{-1} soil	20.6	14.4	10.8	8.9	6.6	4.1	2.3	1.9
4. FYM 3 g + PM 1.25 g kg^{-1} soil	22.4	16.2	11.4	9.1	6.5	4.7	3.1	2
SE_d	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1
CD (5%)	0.7	0.5	0.5	0.5	0.3	0.3	0.3	0.3

Table 4: $No3^-$- N status (mg kg^{-1}) in soil mixed with organic manures during incubation

	Days after incubation							
Treatments	0	2	4	6	8	10	12	14
1. FYM 6 g kg^{-1} soil	0.51	0.98	1.8	2.63	5.81	8.7	8.92	8.6
2. PM 2.5 g kg^{-1} soil	0.64	2.8	5.62	8.94	12.6	18.7	19.4	19.8
3. CPM 2.5 g kg^{-1} soil	0.58	2.4	4.6	6.2	8.6	11.6	12.8	12.8
4. FYM 3 g + PM 1.25 g kg^{-1} soil	0.6	2.6	5.14	7.46	9.95	14.5	16.4	15.1
SE_d	0	0	0	0.1	0.1	0.1	0.1	0.1
CD (5%)	0	0.1	0.1	0.11	0.13	0.17	0.17	0.17

Table 5: Available N status (mg kg^{-1}) in soil mixed with poultry manure during incubation

	Days after incubation						
Treatments	15	30	45	60	75	90	105
1. FYM 6 g kg^{-1} soil	114.8	116.2	118.1	119	119.8	116	110.8
2. PM 2.5 g kg^{-1} soil	139.8	121.1	119.6	119	120	116	112.1
3. CPM 2.5 g kg^{-1} soil	118.4	120.4	122.3	124	123.8	122	117.6
4. FYM 3 g + PM 1.25 g kg^{-1} soil	128.7	120.7	120.8	121	121.2	118	115.7
SE_d	0.8	0.9	0.8	0.9	0.6	0.8	0.9
CD (5%)	1.8	1.9	1.8	2	1.3	1.8	2.0

FYM - Farm yard manure, PM - Poultry manure, CPM - Composted poultry manure

The NH_4^+- N content of soil treated with fresh poultry manure at 14 DAI was higher. However, this was comparable with soil treated with CPM and soil treated with fresh poultry manure in conjunction with FYM.

Nitrate: In fresh poultry manure, there was a rapid increase in NO_3^- - N during the first 12 days (Table 3) coinciding with a stagnation in $N0_3^-$ - N thereafter. The combination of this rapidly mineralized fraction from applied manure and the inorganic N already present in soil may contribute to significant losses of N from the field early in the growing season when crop uptake is low[1]. The NO_3^- - N extracted from fresh manure treatments was twice higher than NO_3^- - N from composted manure treatments. The higher percentage of organic nitrogen as fulvic and humic acids in compost reduces decomposition and transformation of organic N to NO_3^- - N [12]. Thus, application of composted poultry manure provided plant - available N more slowly over time than fresh manure application.

Available N: The available N of the soil increased progressively up to 75 days after incubation and decreased slowly thereafter irrespective of the manures blended (Table.2). The available N under fresh poultry manure treated soil was markedly higher at 15 days of incubation followed by PM + FYM, CPM and FYM alone. Mineralisation of organic N present in poultry manure ought to have occurred rapidly. Bitzer and Sims (1) reported that major portion of N get mineralized (69%) within 140 days. At 30 days, fresh PM applied soil had the highest available N but was comparable with soil applied with PM + FYM and CPM. From 45 days onwards up to 105 days, soil applied with CPM recorded the highest available N followed by soil applied with fresh PM + FYM. This might be due to volatilization of ammoniacal-N present in poultry manure and immobilization. Wolf *et al*[13] found that 37 per cent of the total - N in surface applied poultry manure was volatilized in 11 days. Volatilization losses significantly reduced the amount of N available for plant uptake. Gale and Gilmour[6] and Chescheir *et al*[5] have suggested immobilization is responsible for reducing inorganic N shortly (1-2 weeks) following application of poultry waste. Undigested feed and the manure bedding materials have been identified as immobilizing agents.

Conclusion: The incubation study revealed that fresh poultry manure had higher mineralization rates. The NH_4^+- N content extracted from the soil decreased with varying magnitudes with the highest decrease with fresh poultry manure. Similarly, the NO_3^- - N content increased with varying magnitudes and the higher magnitudes was associated with fresh poultry manure application. Combined application of fresh poultry manure with FYM also gave better results than fresh poultry manure application. Composting yielded a more predictable and reliable source of mineralizable N than fresh manure.

It can be concluded that poultry manure can be effectively used by composting to increase the available soil N progressively thus, enabling the manure to release the nutrients steadily and make it available to the plants for a longer period of time without much loss.

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