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Carbon Mineralization and Carbon Dioxide Evolution Rate of Cow Dung and Poultry Manure along with Rice Straw and Lime under Covered Condition in the Tropical Environment

U.A. Naher, [1]M.A. Hashem, M.K. Uddin, [3]M. Ahmed and [2]M.A. Saleque
Bangladesh Rice Research Institute, Gazipur, Bangladesh
[1]Soil Science Department, Bangladesh Agricultural University, Mymensingh, Bangladesh
[2]Bangladesh Rice Research Institute, Gazipur, Bangladesh
[3]Bangladesh Agriculture Development Corporation, Bangladesh

Abstract: A study was undertaken to determine the oxidizable organic carbon mineralization rate of cowdung (CD) and poultry manure (PM) alone and with combination of rice straw (RS) and lime under covered condition. The oxidizable organic carbon mineralization rate followed the first order kinetics and was best in logarithmic model of (Co-Ct) vs. t. The carbon mineralization rate was higher in the PM than CD. The application of rice straw reduced mean mineralization rate of both CD and PM and it increased by liming. The cumulative carbon dioxide evolution flux was higher in CD (854 mg kg^{-1}) followed by CD + RS (828 mg kg^{-1}) and CD + lime treatments (780 mg kg^{-1}). The carbon dioxide evolution rate was high up to 20 days in the CD and CD + lime treatments and in the PM it was high up to 30 days. The cumulative carbon dioxide evolution rate was higher in CD treatments than PM treatments. The mineralization rate became steady after 45 days in CD and 60 days in PM treatment so within this period it is mature enough for field application. The addition of lime increased half-life of cowdung and poultry manure. The lowest half- life (19 days) obtained from PM + lime treatment.

Key words: Carbon mineralization, carbon dioxide evolution, cowdung, poultry manure

INTRODUCTION

Organic fertilizer is essential for maintaining soil health. Soil fertility and nutrient availability are closely connected to the soil organic matter content and its mineralization (Zech and Kogel-Kanabner, 1996). The use of chemical fertilizer is adversely affecting the physical, chemical and biological properties of the soil. The losses of soil organic matter can only be replenished in short-term by application of organic matter such as manure (Glaser *et al.,* 2001).

Cowdung, poultry manure and rice straw are the excellent sources of soil organic matter, which are rich in micro and macronutrients. The poultry manure contains about 2% of total nitrogen, 2.91% of Phosphorus and 2.12% of potassium (Saha *et al*., 2004). But these fresh organic matter are not always friendly to environment, human health and also expensive to application. The fresh application of the cowdung and poultry manure to plant may cause crop injury. The recycling of poultry manure needs to be done in a manner that will not only improve soil physical, chemical and biological properties but also minimize environmental risks (Pare *et al*., 2000). The optimum decomposition of these materials is also very important. Carbon dioxide evolution is a good indicator to measure the organic compound decomposition rate and also is a good index to determine the optimum time for organic matter application. The composting process is basically the breakdown of carbon components with the finally release of carbon dioxides, ammonium compounds, sulfur and nitrogen oxides (Golueke, 1975). Several techniques have been developed to measure the decomposition rate of organic matter; however respiration continues to be the most popular methods to measure microbial activity and substrate decomposition in soils (Zibilske, 1994).

There are available literature on the decomposition of organic material and mineralization of carbon in control environment i.e. incubation study with fixed temperature and moisture, but there are not available information about decomposition of such material under natural environment. Hence present study was conducted with the specific aim to determine the carbon mineralization rate under tropical environment, which will helps to define optimum time for application of cowdung and poultry manure in the farmers field.

MATERIALS AND METHODS

The experiment was conducted at green house condition. The materials used for experiment were fresh poultry manure, partially decomposed cowdung, rice

Corresponding Author: Umme Aminun Naher, Scientific Officer, Soil Sciences Division, Bangladesh Rice Research Institute, Gazipur, Bangladesh

straw and lime. The rice straw was chopped about one-inch pieces and mixed as 1:1 (by volume). The samples were kept in to two-kg plastic pots. Twenty-five gm of lime dust was mixed with cowdung and poultry manure in each pot. The pots were kept in covered condition.

Carbon mineralization: The oxidizable organic carbon in the sample was determined volumetrically by wet oxidation method, according to Wakly and Black (1935). A 0.1 gm of wet sample was taken to determine the organic carbon and finally percent organic carbon was calculated on dry weight basis. The sampling was done at each 15 days interval for three months. The oxidizable organic carbon mineralization rate constant k was determined by using the equation $dC/dt = -kC$

Carbon dioxide evolution: The Carbon dioxide measurement was done by using a modified procedure of Isermeyer (1952). The CO_2-C was trapped in 0.05N NaOH and titrated with 0.05 N HCl against a phenolphthalen indicator after precipitation with 0.5 N $BaCl_2$. It was measured at every 3-4 day intervals. The last two measurements were done at 7-day intervals.

Half-life: The 90 days of decomposition period at tropical climate to mineralized one-half of the oxidizable organic carbon, $t_{1/2}$ can be calculated as

$$t_{½} = 0.693/k$$

Statistical analysis: Data were analyzed using a factorial design (three factors in RCB) with 3 replications. The regression analysis was done using the microstate software.

RESULTS AND DISCUSSION

Oxidizable organic carbon mineralization: The mineralization of oxidizable organic carbon of cowdung and poultry manure were best fit in the first order kinetics model. The hypothesis behind that the rate of mineralization was proportional to the amount of potentially mineralizable oxidized organic carbon. Dhull *et al.* (1998) also found that the mineralization pattern of the poultry manure, sewage sludge and farmyard manure were almost identical and followed the first order kinetics. The model was expressed by the equation, $dC/dt = -kC$. Integration of this expression gives, log (Co-Ct) = log Co-k/2.303 (t). The latter equation was employed to arrive at the values of Co giving best fit for the regression of log (Co-Ct) on t. Where log Co = Initial oxidizable organic carbon, log C= oxidizable organic carbon at the time, t (15 days), k = decomposition rate. From observing the curves obtained by plotting (Co-Ct) vs. t, was the apparent giving best fit in logarithmic model by regression analysis, (Fig. 1a and 1b) except the Cowdung + rice straw (r = 0.75) and poultry manure + rice straw (0.69) treatment. The oxidizable organic carbon mineralization rate was higher in the all poultry manure treatments than cowdung treatments (Table 1). The lime incorporation increased mineralization rate in both the cowdung and poultry manure treatments. Waschkies *et al.* (1999) also reported carbon mineralization and microbial biomass in geogenic organic matter increased after liming. The slope (b value) obtained from regression analysis showed highest mineralization took place in t_3 and t_6 (Table 1) treatment. The mineralization rate decreased when rice straw was added with cowdung (t_2) and poultry manure (t_4) treatments. The mineralization rate constant (k) was significantly different ($p<0.05$) at every sampling date during the 90 days of decomposition period. The mineralization rate decreased with passing time, these findings are in agreement with Bernal *et al.* (1998). The lowest mineralization rate constant k= 0.002 was found in cowdung + rice straw treatment at 90 days of decomposition period. After 60 days of decomposition in the poultry manure treatment and after 45 days in cow dung treatments the carbon mineralization rate become steady. So after this period it is mature enough for field application.

Table 1: The regression analysis of variance of oxidizable organic carbon mineralization rate, k =(log C0-Ct) vs. t (15 days interval)

Treatments	Intercept	Slope	SE	R^2	$P<0.05$
Cowdung control (t_1)	0.146	-0.0243	±0.002	0.95	0.0007
Cowdung + rice straw (t_2)	0.091	-0.0221	±0.006	0.75	0.002
Cowdung + lime (t_3)	0.140	-0.0306	±0.004	0.93	0.0016
Poultry manure control (t_4)	0.131	-0.0275	±0.003	0.93	0.0014
Poultry manure + rice straw (t_5)	0.167	-0.0315	±0.010	0.69	0.03
Poultry manure +lime (t_6)	0.172	-0.0367	±0.006	0.89	0.004

Table 2: The half-life of organic carbon for cowdung and poultry manure under different treatment

Treatments	Cowdung	Poultry manure
Control	35	26
Rice straw	39	33
Lime	28	19

Carbon dioxide evolution: The carbon dioxide evolution rate was faster and significantly ($p<0.05$) higher in the cowdung, followed by cowdung + rice straw and cowdung + lime treatment (Fig. 2a). The cumulated carbon dioxide evolution flux was also significantly higher in the cowdung treatments than all poultry manure treatments (Fig. 2b), the fact behind that it may resist to decay than cowdung treatments. In the cowdung treatment (t_1) the carbon dioxide evolution flux was high during the first 20 days after then it decreased and the highest cumulated carbon dioxide flux of 854 mg kg^{-1} was measured after 90 days of decomposition When rice straw was added with cowdung and poultry manure treatment the carbon dioxide evolution rate was delayed and took more time.

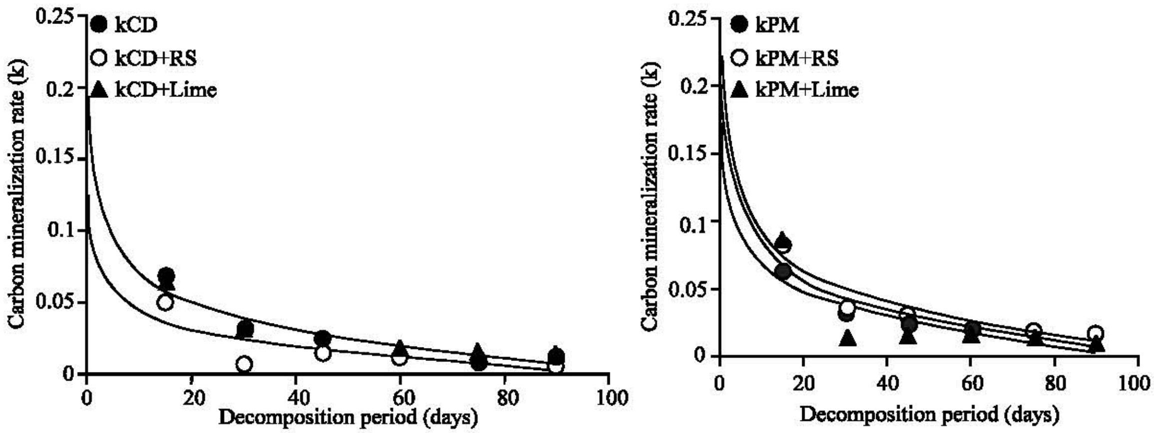

Fig. 1: Carbon mineralization rate of cow drug and poultry manure along with rice straw and lime under covered condition

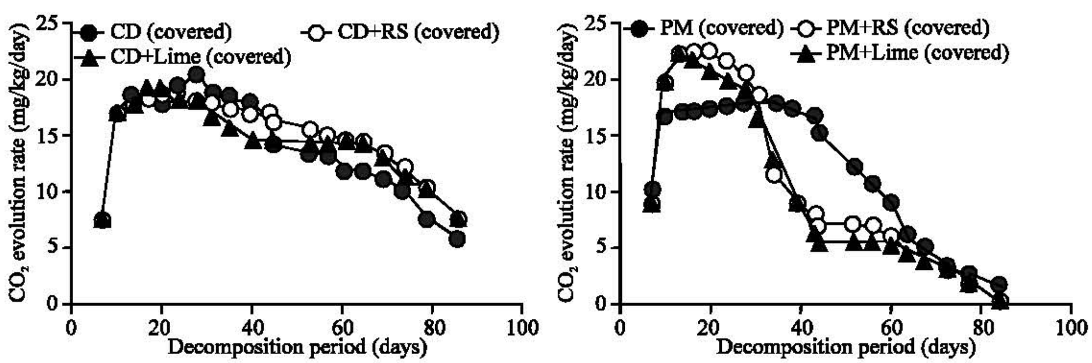

Fig. 2: CO_2 evolution rate of cow dung and poultry manure along with rice straw and lime under covered condition

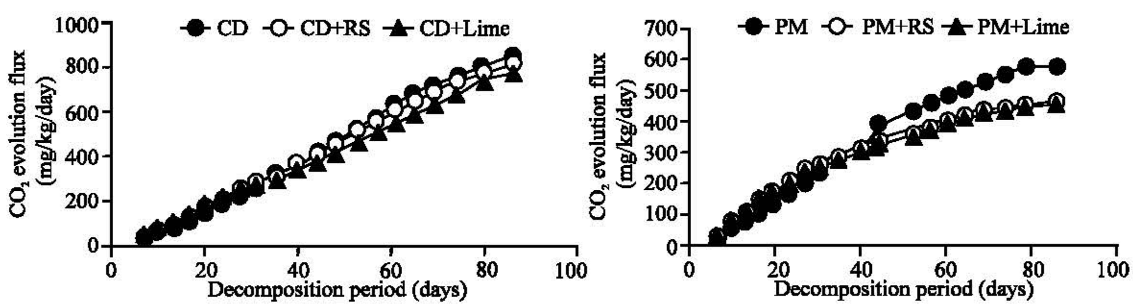

Fig. 3: Cumulative CO_2 evolution rate of cow dung and poultry manure along with rice straw and lime under covered condition

The cumulative carbon dioxide flux 828 mg kg^{-1} was recorded in t_2 treatment. In the cowdung + lime treatment (t_3) and the carbon dioxide evolution rate were higher up to 19 days (Fig. 3). Ajwa and Tabatabai (1994) found the CO_2-C released increased rapidly initially, but the pattern differed among the materials used. More than 50 percent of the total CO_2 produced in 30 days of incubation. These findings are in agreement with the present study. Sarmah and Bordoloi (1995) reported that the rate of carbon dioxide evolution was greatest during the first week of incubation in anaerobic incubation with different types of organic matter. But in the present study it was different. The highest carbon dioxide evolution was found up to 30 days, the fact might be behind that the present study was conducted under natural environment and there was no constant temperature like incubation study.

Depending on carbon mineralization and carbon dioxide evolution rate it may conclude that after 60 days of decomposition the poultry manure be able to be field applicable.

Half-life: The days of decomposition to mineralizable C, $t_{½}$ are given in (Table 2). The estimate of half-life for the treatments derived from mean value of decomposition rate

(k) and was calculating using formulae k= 2.303 (logC-logCo)/t, here t = decomposition time 90 days. The half-life time of cowdung (35 days) and poultry manure + rice straw (26 days) were highest for both the cowdung and poultry manure treatment respectively. The least half-life time obtained from poultry manure + lime (19 days) treatment. The half-life of cowdung and poultry manure decreased when lime was added.

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