



Carbon Dioxide Release as an Index of Mineralization Rates of Organic Substrates

SAMBO PHEAP*

Royal University of Agriculture, Phnom Penh, Cambodia
Email: psambo@rua.edu.kh, ph.sambo@gmail.com

GINA V. PANGGA

Agricultural Systems Cluster, College of Agriculture, University of the Philippines, Los Baños, Laguna, 4013, Philippines

JOCELYN D. LABIOS

Agricultural Systems Cluster, College of Agriculture, University of the Philippines, Los Baños, Laguna, 4013, Philippines

EVALOUR T. ASPURIA

Crop Science Cluster, College of Agriculture, University of the Philippines, Los Baños, Laguna, 4013, Philippines

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Abstract Mineralization of nutrients from organic materials is vital for optimum plant growth and development. Various methods have been used to evaluate the mineralization rate of different organic substrates. Of these, carbon dioxide release is a reliable method to estimate mineralization rate. Four different substrates: dry chicken manure, *Azolla*, coconut coir dust (CCD), and *Gliricidia sepium* leaves and the combination of these substrates with SNAP solution on their rates of mineralization was determined. The results were significantly different in the amounts of CO₂ released from the substrates. CO₂ release from the substrates was stimulated by SNAP. Among all treatments, *G. sepium* with SNAP yielded the highest amount while coconut coir dust gave the lowest. Nitrogen mineralized to about fifty percent (50%) during the first week of all treatments. Using soil organic materials such as *G. sepium* leaves would quickly provide the soil with more mineralized nutrients which are available for plant growth and development.

Keywords mineralization, CO₂ release, organic substrates, *Gliricidia sepium*

INTRODUCTION

Mineralization is an important process which regulates the nutrient cycle (Curtin et al., 1997). It is also a continuous process which is controlled by many factors such as temperature (Curtin et al., 1997; Crohn, 2004; Gaskel and Smith, 2007; Li and Li, 2014), moisture (Curtin et al., 1997; Gaskel and Smith, 2007), pH (Curtin et al., 1997; Ouyang et al., 2008), microorganisms (Frankel and Bazylnski, 2003; Allison et al., 2009) or organisms of higher class such as earthworms (Coúteaux et al., 1995), herbivores (Schrama et al., 2013), soil properties such as clay types (Deenik, 2006), substrate quality and quantity (Howard and Howard, 1993; Eiland et al., 2001; Gaskell and Smith 2007; Li and Li, 2014), and the cultivation practices.

Understanding the processes involved in mineralization, and the factors that affect mineralization rate, would help estimate the right type and amount of mineralized material to guarantee optimum yield

and minimize the adverse effects of the over application of nitrogen (N) sources (Pereira et al., 2006; Hartz et al., 2000; Crohon 2004; Bordilio et al., 2013; Li and Li, 2014).

The contents of carbon dioxide (CO₂) determine the rate of mineralization by measuring the trapped CO₂ in the alkali solution, such as Ca(OH)₂, NaOH or KOH and titrate it against hydrochloric acid (HCl) with addition of barium chloride (BaCl₂) (Peirera et al., 2006; Hartz and Britton, 2003; Makende and Ayeni, 2013).

OBJECTIVE

The objectives of this study were to estimate the mineralization rates of different organic materials using the CO₂ release as an index, and to examine the effects of nutrient additions on the mineralization rates of these materials.

METHODOLOGY

Soil samples (Alipit Clay Soil) were collected from an unfertilized upland area of the U.P. Los Baños Central Experiment Station. The soil was air-dried, cleaned from vegetative material and passed through a 2.0 mm sieve. Fifty (50) grams of this sieved soil was placed inside incubation jars and mixed with 0.125 g of each nutrient source (5 t ha⁻¹). Complete Randomized Design (CRD) with three replications was used in this experiment. The treatments were: Control (CT)-soil alone with no additional nutrients, dry chicken manure (CM), coconut coir dust (CCD), *Gliricidia sepium* (GS), Azolla (AZ), simple nutrient addition program (SNAP) nutrient solution, CM + SNAP, CCD + SNAP, GS +SNAP and AZ + SNAP. The incubation study was conducted from April to May 2014 in the Soil Fertility Laboratory of the Agricultural Science Cluster (ASC), College of Agriculture, U. P. Los Baños, Philippines.

The Simple Nutrient Addition Program (SNAP) nutrient solution was formulated by the Institute of Plant Breeding, College of Agriculture, U.P. Los Baños. The solution was prepared by combining 20 ml of SNAP A and 20 ml of SNAP B, and adding this to one liter of distilled water. Forty (40) ml of the prepared SNAP solution mixture was added to each SNAP-treated jar.

Determination of Carbon Dioxide Release and Mineralized Nitrogen

Mineralization rate was measured by determining the amount of CO₂ released from the different treatments. The incubation jar set-up was prepared prior to the start of the experiment. Prior to application, the substrates were grounded and oven-dried overnight at 40°C. The appropriate amount of residue was added to 50 g soil at a rate of 0.125 g jar⁻¹. Based on the amount of soil, this application rate approximates to 5 t ha⁻¹, the amount of residue applied in many farming systems. For the control treatment, no organic material was added in the same amount of soil. The experiment was conducted for the duration of approximately 8 weeks.

The mixtures of soil and treatment nutrient sources were supplied with moisture at field capacity. A 50 mL beaker containing 30 mL of 0.3 M NaOH was placed in the center of the jar to trap the CO₂ released from each treatment. The trapped CO₂ was then transferred to a 100 mL beaker, and 3 drops of phenolphthalein were added before titration with 0.2 M HCl.

RESULTS AND DISCUSSION

The incubation experiment examined the mineralization rate of different organic materials over a 7-day period. Results showed that there were significant differences between treatments. The highest amount

of CO₂ released on the first day was measured from Azolla and AZ + SNAP with 78.3 and 76.6 mg kg⁻¹ soil, respectively. These treatments were closely followed by *G. sepium* and CM + SNAP with 72.3 and 70.9 mg kg⁻¹ soil respectively. Since the measured CO₂ from these four treatments were ranked closely, differences of the CO₂ released were found to be insignificant.

The measured CO₂ on the second day showed that soft, fresh materials with high source of N continuously exhibited faster rate of mineralization when compared with other organic materials. Treatments with Azolla and *G. sepium* demonstrated the highest amount of CO₂ with 74.2 and 72.7 mg kg⁻¹ soil, respectively. The addition of nutrients hastened the mineralization rates as shown by Azolla + SNAP and GS+ SNAP. Similar effects were observed from Day 3 to Day 7 as those treatments with SNAP recorded high amount of CO₂ release. The *G. sepium* + SNAP Treatment dominated other treatments and their differences were found to be significant. Its performance is clearly presented in Fig. 1. Treatments with Azolla and *G. sepium* alone ranked second and third. It is also interesting to note that coconut coir dust played second on Day 3 to 4. Fontaine et al. (2003) reported that the increase in the amount of CO₂ released in the first week for all treatments may be attributed to the activities of microorganisms attacking the labile and readily decomposable substrates such as sugar, starch, and cellulose. The surge of CO₂ released from the soil in the first day (Fig. 1) might due to rewetting of the soil which allowed the surviving microorganisms to immediately attack SOM and the substrates (Keift et al., 1987). The control, although having a lower total CO₂ release, it had a starting point which was also as high as chicken manure and SNAP solution. The soil had high SOM content (6.3%) could increase mineralization.

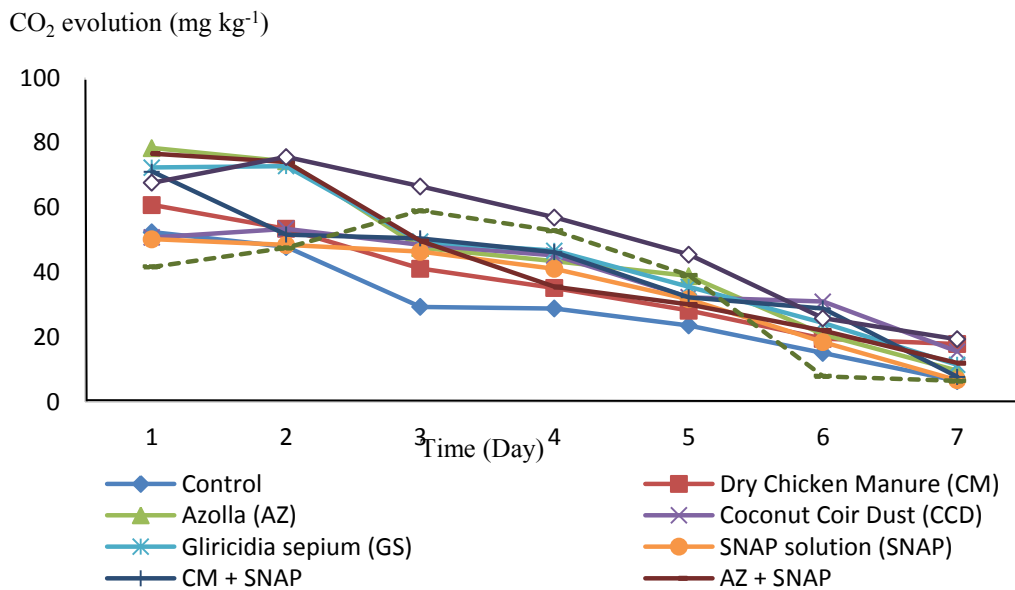


Fig. 1 Daily carbon dioxide (mg kg⁻¹) released from different organic substrates over the period of seven days

Franzluebbers et al. (1994) concluded that N mineralization can be related to the amount of SOM in the soil. Another study of Chuwdhury et al. (2014) on the effect of malic acid addition to CO₂ release found that treatments with or without nutrient addition had very high CO₂ production from 20 to 40 hours after incubation. According to Chen et al. (2014), fresh materials have faster mineralization rates and release more CO₂. *G. sepium* treatment was observed with consistent high amounts of CO₂ released, followed by Azolla and chicken manure.