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Decomposition pattern of two green manures in BAU farm soil

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Abstract

Decomposition pattern of two contrasting green manures viz. water hyacinth (*Eichhornia crassipes*) and mimosa (*Mimosa invisa*) was studied in an incubation experiment at the department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh, during the period from May to July, 2003. The soil was amended with the manures @ 1 g 50 g^{-1} soil. A basal dose of 250 μg N, 200 μg P and 250 μg K g^{-1} soil was also applied to each experimental unit. Microbial respiration as a measure of decomposition was monitored over 50 days at room temperature and different intervals of time. Of the amendments, mimosa decomposed more rapidly (14.3% vs. 3.8% by day 2) than water hyacinth. The highest decomposition rate was observed in mimosa at day 2 and water hyacinth at day 10. The decomposition of mimosa was approximately two times higher than water hyacinth. After 50 days of incubation, a total of 32 and 49% of the added C were respired from water hyacinth and mimosa, respectively. Both the rate and total decomposition of the green manures were also found to be related to their nutrient status (C : N : P : S ratios).

Keywords: Decomposition, Water hyacinth and Mimosa

Introduction

Plant residues are the major source of organic inputs in soil. This plant residue has a primary role in maintaining soil organic matter content, microbial biomass and activity, and the size of the soil nutrient pool (Sanchez *et al.* 1989). Soil microorganisms grow rapidly during the decomposition of plant residues (Brookes *et al.* 1990) and play a major role as a sink (during immobilization) and source (during mineralization) of plant nutrients. Since, the dead cells of microbes are readily mineralized by the living microflora; it also suggested that they also contribute substantially to the pool of mobile plant nutrients in soil (Anderson and Domich, 1980 and Haider *et al.* 1991). In the decomposition of organic matter by microorganisms, most of the carbon is liberated as CO_2. The evolution of this gas can, therefore, be considered as a measure of the rate and extent of the decomposition of organic matter. The total amount of CO_2 liberated depends on the nature of the material, the microbes concerned and the ecological environment of decomposition.

There is a lack of knowledge for utilization of leguminous and nonleguminous wide spread natural weeds like mimosa (*Mimosa invisa*) (Photograph 1) and water hyacinth (*Eichhornia crassipes*) (Photograph 2) as green manures. Such weeds may partially meet the nutrient requirement particularly of nitrogen and may arrest the nutrient losses besides moisture conservation and nutrient release. Unfortunately there is no published report on the decomposition pattern of these green manures. Therefore, an incubation experiment was undertaken to study the decomposition pattern of two important weeds to explore their potentialities as green manure. Such study provides valuable data for both the modeling of organic matter decomposition and management of plant residues in soil.

Photograph 1. Mimosa (*Mimosa invisa)*

Photograph 2. Water hyacinth (*Eichhornia crassipes*)

Materials and Methods

An incubation experiment was carried out in the laboratory of the department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh during the period from May 2003 to July 2003. Green manures viz. water hyacinth and mimosa were collected from Agronomy field laboratory, Bangladesh Agricultural University, Mymensingh. Some properties of the collected green manures have been presented in Table 1.

Table 1. Some selected characteristics of Water hyacinth and Mimosa used for amendment

Green manure	Organic C (%)	Total N (%)	Total P (%)	Total K (%)	Total S (%)	C: N ratio	C: S ratio	C: P ratio
Water hyacinth	50.95	3.21	0.76	0.69	0.079	16	645	67
Mimosa	52.61	4.53	0.83	0.23	0.168	12	373	63

The soil used in this experiment was silty loam with pH 6.5, 1.21% organic matter, 0.12% total N, 12.09 μg g^{-1} soil available P, 0.16 me $100g^{-1}$ soil exchangeable K and 9.12μg g^{-1} soil available S collected from a selected area of Genetics and Plant Breeding research farm, Bangladesh Agricultural University, Mymensingh. Undecomposed plant materials were removed by hand and the soil was sieved (<2 mm). Samples were conditioned aerobically at room temperature and at 40% water holding capacity (WHC) for 7 days. This allowed the soil microbial population to stabilize, minimizing the effects of soil handling and preparation (Chowdhury *et al.* 2000). Immediately after conditioning, the soil was used for amending green manures.

Previously oven dried and finely ground green manures were added to the soil at the rate of 1 g 50 g^{-1} soil and placed in a 100 mL glass jar. The experiment was laid out in a Completely Randomized Design (CRD) with three replications. For each treatment, a nutrient solution was prepared by dissolving appropriate amounts of NH_4NO_3 and KH_2PO_4 in distilled water. 50 g soil (oven dry basis) sample was weighed in a 100 mL glass jar and amended with an aliquot of the nutrient solution (2 mL) having 250 μg N, 200μg P and 250 μg K g^{-1} soil. Two milliliters of distilled water was also added to the control soil to maintain moisture contents equivalent to those of amended soils. Following amendment, glass jars were placed in 1L glass bottles, sealed and incubated at room temperature for 50 days. To trap CO_2 evolved by soil microorganisms during incubation, 20 mL of 1 M NaOH solution was placed inside each jar along with 10 mL distilled water at the bottom of the bottle to maintain internal humidity of the incubation environment. Microbial respiration was monitored from soil samples after 2, 4, 6, 10, 15, 20, 30, 40 and 50 days of incubation. At each sampling, NaOH was renewed. Total CO_2 was then titrated with standard HCl between pH 8.3 to 3.7 using pH meter (WTW pH 5.22). Microbial respiration was expressed as μg CO_2-C evolved g^{-1} soil day^{-1} (Chowdhury, 2000). Following reactions are assumed to be occurred during titration with HCl.

1. $NaOH + CO_2 = Na_2CO_3 + NaHCO_3 + H_2O$, pH-12
2. $Na_2CO_3 + HCl = NaHCO_3 + NaCl$, pH- 12-8.3
3. $NaHCO_3 + HCl = H_2CO_3 + NaCl$, pH- 8.3 - 3.7

Collected data were statistically analyzed by the computer using statistical package programme MSTAT-C developed by Russel (1986). A one way ANOVA was made by F variance test. The pair comparisons were performed by Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

Results and Discussion

Decomposition was measured as CO_2-C evolution from the soil. Since the water hyacinth and mimosa used in this study were not radiolabelled with ^{14}C, it was not possible to partition between CO_2-C evolved directly from green manures and that derived from native soil organic matter. Thus, differences in CO_2-C evolution between the amended and unamended soils was used as an indication of the decomposition of green manures. Decomposition rates varied significantly among the treatments throughout the incubation period. Figure 1 and 2 clearly indicate that mimosa amendments were decomposed rapidly, with some 14.3 % of mimosa-C mineralized to CO_2-C within 2 days of incorporation. Between 2 and 10 days, 12% of the added mimosa-C (645 µg g^{-1} soil) was mineralized. Nevertheless, the mineralization rate decreased markedly (Fig. 1).

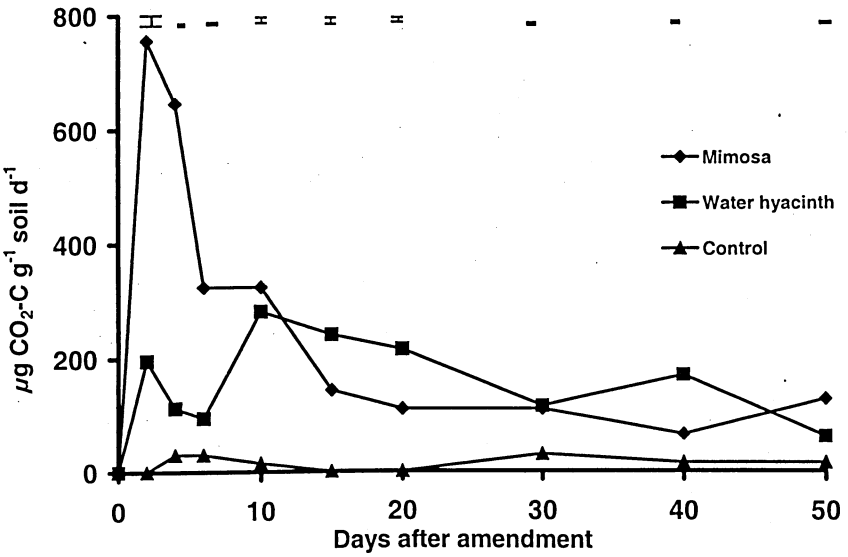

Fig 1. Decomposition of Water hyacinth and Mimosa as CO_2 evolution (μg CO_2-C g^{-1} soil d^{-1}) in amended soil. Bars indicate LSD < 0.05

The decomposition of water hyacinth was considerably slower than that of the mimosa, with the maximum mineralization rate only a quarter (195µg g^{-1} soil) that of mimosa (755µg g^{-1} soil) at day 2 (Fig.1). Unlike the mimosa, however, the water hyacinth followed the expected decomposition pattern, decomposing gradually over 50 days. This mineralization of water hyacinth was, however, biphasic and considerably greater during the early stages (0-10 days) than during the later period (10-50 days). In the first 10 days 16% of hyacinth-C was mineralized to CO_2-C with an additional 14% mineralized during the period 10-50 days.

Decomposition of organic substrate is dependent on the nutrient status of the substrate itself. C: N ratio in the green manure is a determinant of organic matte decomposition (Waksman,

1961). In this experiment, green manure having different nutrient status was amended to the soil (Table 1).Mimosa showed the highest decomposition rate (with C:N ratio 12) while water hyacinth (C:N ratio 16) decomposed very slowly through out the incubation period. These results conformed the findings of Avnimelech (1986) who reported that a fast decomposition leads to a high rate of nutrient release only when the organic substrate is rich in nutrient (low C: N ratio). It was also observed that materials having high C: N and C: P ratios (Table 1), nutrients will first immobilized by growing microbial biomass and then be released from the manure to the soil. Melillo *et al.* (1982) also reported that decomposition rates were found to be related with the initial C: N ratio of the substrate and lower the nitrogen content or a wide C:N ratio of the substrate, the slower the rate of decomposition.

Table 2. Decomposition of Water hyacinth and Mimosa as total CO_2 (μg CO_2-C g^{-1} soil d^{-1}) in amended soil

Treatments	Incubation period (days)								
	2	4	6	10	15	20	30	40	50
Control	0	30	60	75	75	75	105	120	135
Water hyacinth	195	308	403	816	923	1128	1343	1458	1629
Mimosa	755	1400	1723	2045	2188	2298	2408	2473	2601
LSD (0.05)	10	13	13	41	18	33	56	26	31
CV%	22	15	11	19	14	16	16	13	13

After completion of incubation period, a total of 135, 1629 and 2601 μg C g^{-1} soil was respired from control, water hyacinth and mimosa amended soils, respectively (Table 2). It was found that, at the end of incubation, approximately 16 and 25% of the added C were decomposed from water hyacinth and mimosa amended soil, respectively (Fig. 2). Both the green manure showed an exponential response in CO_2-C production (Fig. 2). Wu *et al.* (1993) have shown that during early phase (0-50 days of incubation) of plant residue decomposition, priming effects are small, making it possible to use increase in CO_2-C evolution in amended soils as an indication of the mineralization of the substrate during the early phase of decomposition. Table 2 revealed that mimosa after amendments, decomposed rapidly than water hyacinth. Decomposition was approximately double for mimosa, as compared to water hyacinth in respect of added C to the soil as green manure (Fig. 2).

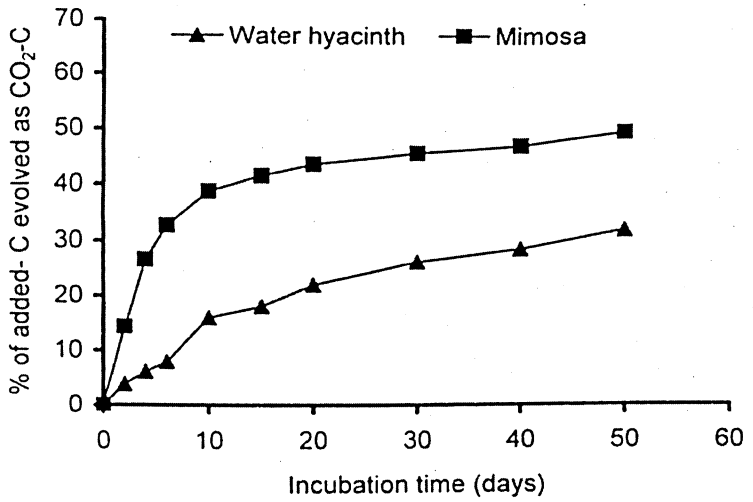

Fig. 2. Decomposition of water hyacinth and mimosa amended to soil.

From the above discussion, it may be concluded that 31.97 and 49.44% C was decomposed after 50 days of incubation of soil amended with water hyacinth and mimosa, respectively. Both green manures showed an exponential response in total CO_2-C production while unamended soil showed linear and lag phase. It was also observed that the decomposition of mimosa was approximately two times higher over water hyacinth. Decomposition of residue also found to be related to its nutrient status (C : N : P : S ratios).

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