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# Effect of organic manures and fertilizer nitrogen on microbial biomass after two different cropping seasons

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**Abstract**: Changes in microbial biomass-C and -N and the contribution of biomass-C and -N to fertility pool of soil was evaluated in submerged and upland conditions after rice and wheat harvest, respectively. Soil samples of ten treatments including control, and incorporation of straw, cowdung, green manures and compost as well as combinations of nitrogen fertilizer with each of these were used. Compost with nitrogen fertilizer produced relatively higher $CO_2$-C and hence biomass-C after both crops compared to control. Contribution of biomass-C to organic-C was the highest in soil treated only with 100 kg N/ha after rice and green manure with urea-N after wheat harvest. The ratio of biomass-C to biomass-N was the highest in soil treated only with nitrogen. Composting with nitrogen and green manure gave comparatively higher ratio of biomass-N to total-N after rice and wheat harvest, comparatively. Compost along with nitrogen fertilizer produced relatively higher yield of rice (4.94t/ha) and wheat (3.65t/ha) as compared to control.
**Key words:** Flush-C, Biomass-C, Flush-N, Biomass-N, Rice, Wheat
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## Introduction

Soil heterotrophic microorganism play an important role in the decomposition of organic materials applied to the soil. These decomposed materials are used as carbon source by the microorganism for the increase of their population. Soil microbes flourish on the ingredients of the soil organic matter. The magnitude of $CO_2$ formation is often taken as an index of organic matter decomposition (Knapp *et al.*, 1983). The bulk of soil microbial biomass is normally inactive because of nutrient limitations. Thus, incorporation of available organic substances into the soil usually results in a tremendous increase in microbial activities and biomass formation (Powlson *et al.,* 1981). Soil microorganisms play a major role not only in decomposing organic matter but also as a sink of plant nutrient in soil (Anderson and Domsch, 1980: Marumoto *et al*., 1982; Haider *et al.,* 1991). Characterization of crop residue decomposition requires knowledge on the dynamic nature of the microbial biomass in relation to other soil organic matter pools (Smith, 1982; Knapp *et al*., 1983).
So far very few studies on microbial biomass of Bangladesh soils have been conducted (Chowdhury and Cornfield, 1978; Haider et al., 1991). However, reports on changes in microbial biomass carbon and nitrogen due to incorporation of organic manures in Bangladesh soils are not available. Therefore, the present study had been undertaken to evaluate (i) the changes of microbial biomass-C and -N in upland and submerged conditions due to incorporation of different organic manures and fertilizer; and (ii) the contribution of microbial biomass-C and -N to carbon and nitrogen pool of red brown terrace soil.

## Materials and Methods

The experiment was conducted in 1991/92 with red brown terrace soil of the Institute Postgraduate Studies in Agriculture (IPSA). Some characteristic of the used soil samples are presented in the Table 1. A long term experiment was initiated in 1988 and ten treatment combinations imposed were comprised of five levels of organic manuring, viz. no manuring/control (M0), incorporation of rice straw @2.5 t/ha (Si), cowdung 25 t/ha (Cd), compost @ 25 t/ha (Cp), green manuring (Gm)@100 Kg/ha and two levels of nitrogen fertilizer as urea, viz. no nitrogen (N0) and nitrogen 100 Kg/ha ($N_2$). However, organic manures were added each year only before rice transplantation and nitrogen fertilizer was applied before each cropping. Soil samples were collected from a depth of 10 cm and were partially dried in the air after removing roots, insects, worms and some discrete pieces of organic matter. There were ground and sieved with 2 mm mesh sieve. A part of the samples were used for analyzing their characteristic presented in the table 1. Remaining samples were adjusted to 50% of maximum water holding capacity and were pre-incubated aerobically at 25˚C in loose polythene bags for 10 days.

**Table 1.** Characteristics of soil samples collected after rice and wheat harvest

| Soil amendments | After rice harvest | | | | | After wheat harvet | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | pH ($H_2O$) | Org. C (%) | Total N (%) | C/N | Total P (%) | pH ($H_2O$) | Org. C (%) | Total N (%) | C/N | Total P (%) |
| NoMo | 5.87 | 0.61 | 0.05 | 12.20 | 0.09 | 5.05 | 0.64 | 0.05 | 12.80 | 0.08 |
| NoSi | 6.13 | 0.64 | 0.05 | 12.80 | 0.11 | 5.23 | 0.67 | 0.05 | 13.40 | 0.12 |
| NoCd | 6.20 | 0.86 | 0.06 | 14.33 | 0.10 | 5.40 | 0.98 | 0.07 | 14.00 | 0.10 |
| NoCp | 6.12 | 1.10 | 0.10 | 11.00 | 0.11 | 5.68 | 1.10 | 0.08 | 13.75 | 0.11 |
| NoGm | 6.33 | 0.68 | 0.05 | 13.60 | 0.08 | 6.35 | 0.63 | 0.05 | 12.60 | 0.08 |
| $N_2$Mo | 5.85 | 0.51 | 0.04 | 12.75 | 0.06 | 5.49 | 0.62 | 0.05 | 12.40 | 0.05 |
| $N_2$Si | 5.52 | 0.70 | 0.05 | 14.00 | 0.07 | 5.70 | 0.80 | 0.05 | 16.00 | 0.06 |
| $N_2$Cd | 5.00 | 0.97 | 0.08 | 12.13 | 0.10 | 4.13 | 0.99 | 0.09 | 11.88 | 0.08 |
| $N_2$Cp | 4.79 | 1.09 | 0.08 | 13.63 | 0.09 | 6.15 | 1.12 | 0.10 | 11.20 | 0.09 |
| $N_2$Gm | 5.00 | 0.62 | 0.06 | 10.33 | 0.08 | 6.05 | 0.60 | 0.08 | 07.50 | 0.09 |

These pre-incubated soils were fumigated with alcohol free $CHCl_3$ for 24h in a desiccators in the dark according to Jenkinson and Powlson (1976). $CHCl_3$ was then removed and the samples were repeatedly evaluated for complete removal of $CHCl_3$. Fumigated samples were incubated with 1g of original soil in incubation bottles fitted with gas exchange plugs. The original soil served as a source of microbial inoculums. Fumigated and control (without fumigation) samples were replicated twice. The stop cock of the bottles were closed and incubated at 25˚C in an incubator.

The evolution of $CO_2$ was trapped in U-Tube coupled in a $CO_2$ measuring apparatus. Amount of $CO_2$ was measured by subtracting the weight of U-Tube after and before $CO_2$ trap. Flush- and biomass-C were calculated according to the method described by Marumoto (1984) and Haider *et al.* (1991). Available nitrogen was determined by Bremner's (1965) distillation method. Biomass-N was calculated as described by Haider *et al.* (1991). This experiment was treated as a laboratory model experiment and therefore no statistical design was used.

## Results and Discussion

**Microbial biomass-C and its contribution to soil organic carbon:** Organic manures as well as nitrogen fertilizer had considerable influence on flush- and biomass-C, and contribution of biomass-C to soil organic-C (BC/OC) after rice and wheat harvest as compared to control is shown in Table 2.

**Table 2.** Mineralization of microbial biomass-C and it's contribution to total organic-C of soil during 10 days period of incubation after fumigation (after rice and wheat harvest)

| Soil Amendments | Flush-C (mg/100g dry soil) | | Biomass-C (Flush-C/0.45) (mg/100g dry soil) | | Biomass-C /Organic-C (%) | |
|---|---|---|---|---|---|---|
| | Rice | Wheat | Rice | Wheat | Rice | Wheat |
| NoMo | 3.94 | 4.01 | 8.75 | 9.10 | 1.43 | 1.42 |
| NoSi | 4.50 | 4.37 | 10.00 | 9.70 | 1.56 | 1.70 |
| NoCd | 6.19 | 6.23 | 13.75 | 13.85 | 1.60 | 1.72 |
| NoCp | 8.66 | 8.84 | 19.25 | 19.65 | 1.75 | 1.79 |
| NoGm | 5.06 | 5.11 | 11.25 | 11.35 | 1.65 | 1.80 |
| $N_2$Mo | 1.95 | 4.93 | 11.00 | 10.95 | 2.17 | 1.77 |
| $N_2$Si | 5.51 | 5.56 | 12.25 | 12.35 | 1.75 | 1.54 |
| $N_2$Cd | 8.21 | 8.26 | 18.25 | 18.35 | 1.88 | 1.85 |
| $N_2$Cp | 9.00 | 9.11 | 20.00 | 20.25 | 1.83 | 1.81 |
| $N_2$Gm | 5.96 | 6.10 | 13.25 | 13.55 | 2.14 | 2.26 |

Manuring increased flush- and biomass-C by 7-120% and BC: OC ratio by 9-27%, which were further improved by added nitrogen. Adding nitrogenous fertilizer in presence of compost incorporation produce continuously the highest flush- and biomass-C among the treatments. Marumoto (1984) also observed that biomass increased with the increase of soil organic carbon content. Generally a negligible increase in flush- and biomass-C was recorded in the samples collected after wheat harvest compared to those collected after rice. This was possibly due to longer decomposition of organic matters added only before rice transplantation.

Contribution of biomass –C to soil organic carbon ranged from 1.43 to 2.17% and from 1.42- 2.26% after rice and wheat harvest, respectively. Biomass-C contributed to a maximum to organic carbon content of soil in green manured plots receiving highest amount of nitrogenous fertilizer ($N_2$Gm). However, an exceptional high value of 2.17% after rice cultivation was encountered in control plots with 100 Kg N/ha. This might have caused due to relatively lower organic carbon content of soil in this treatment.

Carbon dioxide production in samples collected after rice cultivation increased up to 10 days of incubation after chloroform fumigation with higher rates of increased during the first few days. The rate of increase was ceased after third day of incubation. Similar results were also found in soils collected after wheat cultivation. Jenkinson and Powlson (1976) and Haider *et al*. (1991) also reported similar trend. Manures together with nitrogen increased available soil nitrogen up to 5 times over control. The average contribution of biomass-N to available-N ranges from 41% in rice to 46% in wheat (Table 3). Haider *et al.* (1991) found that contribution of biomass-N was only 30% of available-N in eight Bangladesh soils.

**Microbial biomass-N and its contribution in soil total and available nitrogen:** Manuring along with nitrogenous fertilizer increased flush-N and thus biomass-N by more than3 times over control after rice and wheat harvest After rice , contribution of biomass-N to total-N of soil extended from 1.46 to 5.16% (Table 4). Nitrogen in microbial biomass contributed more than 3.5 times to total soil nitrogen as compared with the control. After wheat cultivation a relatively high value of biomass-N (5.88%) contribution towards total N was obtained by green manured plots without urea. Probably this was occurred due to relatively less nitrogen amount obtained from that soil. The above contribution was followed by the compost treatment with urea-N and was 4.62% of total soil nitrogen content.

**Contribution of biomass-N to crop productivity:** Rice yield of 4.94 t/ha was achieved in composted plots with urea-N, which was followed by plots treated with cowdung and green manures along with urea. Relatively highest yield of wheat (3.05 t/ha) was also achieved by the same treatment as in rice, followed by cowdung and straw treatment with N (Table 5).

**Table 3.** Relationship between available-N and biomass-N for 10 days of incubation (after rice and wheat harvest)

| Treatments | Available-N (mg/100 dry soil) | | Biomass-N (mg/100g dry soil) | | Biomass-N/Available-N (%) | |
|---|---|---|---|---|---|---|
| | Rice | Wheat | Rice | Wheat | Rice | Wheat |
| NoMo | 1.68 | 1.88 | 0.73 | 0.83 | 43.45 | 44.15 |
| NoSi | 2.81 | 2.95 | 0.99 | 1.16 | 35.21 | 39.32 |
| NoCd | 4.02 | 5.03 | 1.82 | 2.18 | 45.27 | 43.34 |
| NoCp | 7.38 | 7.85 | 3.30 | 3.63 | 44.72 | 46.24 |
| NoGm | 6.37 | 3.82 | 2.48 | 2.94 | 38.93 | 76.96 |
| $N_2$ Mo | 2.14 | 2.48 | 0.89 | 1.16 | 41.59 | 46.77 |
| $N_2$ Si | 3.35 | 4.22 | 1.39 | 1.75 | 41.49 | 41.47 |
| $N_2$Cd | 5.83 | 6.30 | 2.11 | 2.31 | 36.19 | 36.67 |
| $N_2$Cp | 9.72 | 10.72 | 4.13 | 4.62 | 42.49 | 43.10 |
| $N_2$Gm | 7.04 | 7.44 | 2.81 | 3.20 | 39.91 | 43.01 |

**Table 4.** Mineralization of microbial biomass-N and it's contribution total nitrogen of soil during the 10 day period of incubation after fumigation (after rice and wheat harvest)

| Treatments | Flush-N (0-10 days) mg/100g dry soil | | Biomass-N (Flush- N/0. 68) mg/100g dry soil | | Biomass-N/Total- N of soil (%) | |
|---|---|---|---|---|---|---|
| | Rice | Wheat | Rice | Wheat | Rice | Wheat |
| NoMo | 0.50 | 0.56 | 0.73 | 0.83 | 1.46 | 1.66 |
| NoSi | 0.67 | 0.79 | 0.99 | 1.16 | 1.98 | 2.32 |
| NoCd | 1.24 | 1.48 | 1.82 | 2.18 | 3.03 | 3.11 |
| NoCp | 2.24 | 2.47 | 3.30 | 3.63 | 3.30 | 4.54 |
| NoGm | 1.69 | 2.00 | 2.48 | 2.94 | 4.96 | 5.88 |
| $N_2$ Mo | 0.61 | 0.79 | 0.89 | 1.16 | 2.23 | 2.32 |
| $N_2$ Si | 0.95 | 1.19 | 1.39 | 1.75 | 2.78 | 3.50 |
| $N_2$Cd | 1.43 | 1.59 | 2.11 | 2.31 | 2.64 | 2.57 |
| $N_2$Cp | 2.81 | 3.14 | 4.13 | 4.62 | 5.16 | 4.62 |
| $N_2$Gm | 1.91 | 2.18 | 2.81 | 3.20 | 4.68 | 4.00 |

Table 5. Yield of rice and wheat as affected by various soil amendments

| Soil amendments | Rice | Wheat |
|---|---|---|
| NoM | 2.57 | 0.22 |
| NoSi | 3.67 | 0.36 |
| NoCd | 3.50 | 0.44 |
| NoCp | 3.21 | 0.49 |
| NoGm | 3.64 | 0.30 |
| $N_2$ Mo | 3.64 | 1.54 |
| $N_2$ Si | 4.02 | 2.70 |
| $N_2$Cd | 4.61 | 2.89 |
| $N_2$Cp | 4.94 | 3.05 |
| $N_2$Gm | 4.48 | 2.37 |

Composting along with N-fertilizer (120 KgN/ha.), also, produced comparatively maximum amount of biomass-N (4.13 and 4.62 mg/100 g dry soil) and biomass-C (20 and 20.25 mg/100 g dry soil) after rice and wheat harvest, respectively. Increased biomass-N and –C provided by heterogeneous microbial population contributed towards increased crop yield in that treatment. Rice yield, achieved by compost treatment along with nitrogen fertilizer was about double of the control treatment. On the other hand, this treatment produced about 14 times higher yield of wheat compared to control. This abrupt increase in wheat yield in composted plots with nitrogen fertilizer might have caused due to upland condition of soil, which favoured the growth and activity of aerobic microbial population in soil. In submerged soil microbial biomass could not increase rapidly due to lack of sufficient oxygen. Manuring along with the application of nitrogenous fertilizer contributed to more available microbial carbon and nitrogen than the control. Composting along with nitrogen fertilizer at the rate of 100 kg/ha proved to be the best combination among all treatments that produced comparatively highest yield of rice and wheat.

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