

Original Research Article

<https://doi.org/10.20546/ijcmas.2018.709.047>

## Microbial Biomass - Carbon (SMB-C) and Dehydrogenase Activity (DHA) in Wetland Rice Ecosystem

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### ABSTRACT

A field experiment was conducted in clay loam of Wetlands of TNAU farm, Coimbatore to study the impact of nutrient management technologies on Soil Microbial Biomass-Carbon (SMB-C) and Dehydrogenase Activity (DHA) of soil under lowland rice ecosystem. In the present investigation, integration of inorganics, *Sesbania aculeata* and biofertilizers have intensively triggered the microbial activities, which would have resulted in higher dehydrogenase activity. The better nutrient management leads to better crop productivity which results in incorporation of larger organic matter through root biomass or leaf fall, root exudates, etc. thereby influencing the C dynamics in soil. The nutrient level and moisture play a dominant positive role towards the dehydrogenase activity. The dehydrogenase activity and biomass carbon content tended to increase with the advancement in crop growth. The results from the correlation analysis have revealed that the soil nutrient status has a direct and significant role in enhancing the soil microbial and enzyme activities. Integrated use of inorganic fertilizers, *Sesbania aculeata* and *Azolla* orchestrates soil nutrient availability, biomass production, biochemical activities and favorable soil physical environment that facilitate effective carbon sequestration in lowland rice ecosystem.

#### Keywords

Soil microbial biomass carbon, Dehydrogenase activity, INM

#### Article Info

Accepted:  
04 August 2018  
Available Online:  
10 September 2018

### Introduction

Microbial activity in a soil drives organic matter decomposition and mineralization processes, leading to release of organically bound plant nutrients in forms available to growing plants (Izaurrealde and Cerre, 2002). Soil organisms produce extracellular enzyme and hyphae which hold soil particles and create aggregates. Soil microbial biomass is

the active component in soil organic matter. The change in the microbial biomass carbon reflects the process of microorganism propagation and degradation utilizing soil carbon.

It is the centre of majority of biological activity in soil and therefore, the knowledge of the microbial biomass carbon is highly essential.

Lenhard (1956) introduced the concept of determining the metabolic activity of microorganisms in soil and other habitats by measuring dehydrogenase activity. Soil microbial biomass is more sensitive to agricultural management than other fractions. Therefore, the short-term effect of soil management on soil properties can be determined by looking at the soil microbial biomass (Haynes, 1993). The activity of dehydrogenase is significantly correlated with soil biomass in organic amended soil (Garcia Gill *et al.*, 2000).

It plays a significant role in the biological oxidation of soil organic matter by transferring protons and electrons from substrates to acceptors (Glinski *et al.*, 1986). Soil microbial biomass increased with root growth and rooting density of the crop. Addition of root exudates would be least in soil under fallow rotations and greatest under forage, which is consistent with biomass results. The better nutrient management leads to better crop productivity which results in incorporation of larger organic matter through root biomass or leaf fall, root exudates, etc. thereby influencing the C dynamics in soil (Lynch and Panting, 1980).

Rice occupies a pivotal place in Indian Agriculture, as it is the staple food for more than 70 per cent of our population and a source of livelihood for about 120 to 150 million rural households. In India rice spreads over an area of about 43.9 million hectares that accounts for 26.91 per cent of the world's paddy rice area with total production of 93.88 tonnes. In Tamil Nadu rice cultivation spreads over an area of 2.10 million hectares with a total production of 9.3 million tonnes (Policy note, 2015). The supply of nutrients in the form of organic manures helps in sustaining favorable soil physical properties thereby enhancing the water and nutrient use efficiencies.

Green manuring is the cheapest locally available resource for building up soil fertility and supplementing plant nutrients, especially N. Green manure is an organic resource offer the twin benefits of soil quality and fertility enhancement while meeting a part of nutrient needs of crops (Vinod Kumar *et al.*, 1999). The higher reduction in pH, electrical conductivity and exchangeable sodium percentage of soil was observed by using organic manures along with chemical fertilizers as compared to fertilizers alone (Yadav and Kumar, 2002). Chelating action of organic compounds released during decomposition of organic sources increased the availability of micronutrients by preventing their fixation, oxidation, precipitation and leaching (Yadav and Kumar, 2000). Incorporation of *Sesbania aculeata* residue in soil, fixed more atmospheric N biologically in the soil and also added higher amount of organic matter which is a good indicator of soil fertility and improved status of available nutrients in the soil (Dwivedi *et al.*, 2005).

Roychowdhry *et al.*, (1979) reported that *Azolla*, applied as a dead organic matter, provides only nitrogen to the crop on mineralization and does not help in improving the status of soil aggregation. Singh (1980) revealed that the cumulative release of phosphorus was found to be superior in fresh *Azolla* incorporation than fresh blue green algae. Blue green algae which colonize in the rice fields have been reported to be responsible for the long term fertility of paddy fields. The presence of algal symbiont *Anabaena Azollae* in its leaf cavities helps in N fixation and in turn increases soil organic content in terms of total N after death of the *Azolla* plant (Watanabe *et al.*, 1977). On an average BGA contributes 25-30 kg nitrogen per hectare per season and leads to 10-15 per cent increase in rice productivity (Rao and Burns, 1991).

## Materials and Methods

A field experiment was conducted in clay loam Vertic Ustochrept at Field No. B4 of Wetlands of TNAU farm, Coimbatore (11° 12' N and 77° 03' E) during 2012 with rice (var. CO (R) 50), a medium duration rice variety (130-135 days). The experiment was laid out in Randomized Block Design (RBD) with three replications. The plot size was 20 m<sup>2</sup> (5 m x 4 m). Initial soil characteristics of the experimental site were: pH 8.18; electrical conductivity 0.42 dS m<sup>-1</sup> and cation exchange capacity 19.5 cmol (p<sup>+</sup>) kg<sup>-1</sup>, organic carbon 0.63%, available N (216 kg ha<sup>-1</sup>), available P (20.4 kg ha<sup>-1</sup>) and available K (533 kg ha<sup>-1</sup>) status.

The DTPA extractable available Fe, Zn, Mn and Cu were 12.59, 6.00, 11.39 and 4.00 mg kg<sup>-1</sup> respectively. The treatments consisted of T<sub>1</sub> - Untreated control; T<sub>2</sub> - 75% RDF (112.50:37.50:37.50 kg N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O + 25 kg ZnSO<sub>4</sub> ha<sup>-1</sup>); T<sub>3</sub> - T<sub>2</sub> + *Sesbania aculeata* @ 6.25t ha<sup>-1</sup>; T<sub>4</sub> - T<sub>3</sub> + *Azolla* @ 500 kg ha<sup>-1</sup>; T<sub>5</sub> - T<sub>3</sub> + BGA @ 10 kg ha<sup>-1</sup>; T<sub>6</sub> - 100% RDF (150:50:50 kg N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O + 25 kg ZnSO<sub>4</sub> ha<sup>-1</sup>); T<sub>7</sub> - T<sub>6</sub> + *Sesbania aculeata* @ 6.25t ha<sup>-1</sup>; T<sub>8</sub> - T<sub>6</sub> + *Azolla* @ 500 kg ha<sup>-1</sup>; T<sub>9</sub> - T<sub>6</sub> + BGA @ 10 kg ha<sup>-1</sup>.

The microbial biomass carbon was determined by the incubation and fumigation technique of Jenkinson and Powlson (1976). The dehydrogenase activity was measured by the methodology outlined by Casida *et al.*, (1964).

## Results and Discussion

Correlation between microbial biomass C and dehydrogenase activity was positive and highly significant ( $r = 0.894^{**}$ ). Linear increase in dehydrogenase activity was observed with increase in level of inorganic fertilizers. This observation is in agreement

with the findings of Dhkar and Mishra (1983) that highlighted the dominant positive role of nutrient level towards the enzyme activities. Incorporation of *Sesbania aculeata* would have increased the microbial growth and improved the soil-water-plant relationships. Irrespective of the level of chemical fertilizers, combined application of organic manures and biofertilizers significantly enhanced the biomass carbon.

The dehydrogenase activity was found to be significantly increased by nutrient levels, organic manuring and biofertilizer application. DHA was significantly higher in 100% RDF + *Sesbania aculeata* + *Azolla* treatment (34.85 µg TPF g<sup>-1</sup> soil 24 hr<sup>-1</sup>). At harvest stage, application of 100% RDF + *Sesbania aculeata* + *Azolla* significantly enhanced the dehydrogenase activity (44.23 µg TPF g<sup>-1</sup> soil 24 hr<sup>-1</sup>) (Table 1). The increased dehydrogenase activity might be attributed to the incorporation of *Sesbania aculeata*, owing to increase in microbial activity of the soil. Similar results were reported by Pauscal *et al.*, (1998).

Application of 100% RDF + *Sesbania aculeata* + *Azolla* increased the amount of biomass carbon (435 mg kg<sup>-1</sup>) (Table 2). The maximum effect of inputs on the microbial biomass was realized under 100% RDF + *Sesbania aculeata* + *Azolla*. The lowest biomass carbon content of 162 mg kg<sup>-1</sup> was recorded in control at harvest stage. The highest biomass carbon content of 597 mg kg<sup>-1</sup> was recorded in treatment 100% RDF + *Sesbania aculeata* + *Azolla*. Gayatri Verma and Mathur (2009) indicated the integrated role of FYM and chemical fertilizers in increasing microbial biomass carbon. Application of *Azolla*, besides showing primary effects, is also known to fix C during photosynthesis. Photosynthetic efficiency of *Azolla* over BGA was also reported by Mie Mie Aung *et al.*, (2002).

**Table.1** Effect of nutrient management strategies on dehydrogenase activity at tillering and harvest stages of rice crop

Treatments	Dehydrogenase activity ( $\mu\text{g TPF g}^{-1}$ soil 24 $\text{hr}^{-1}$ )	
	Tillering	Harvest
T <sub>1</sub> . Untreated control	12.75	21.61
T <sub>2</sub> - 75% RDF	14.73	23.57
T <sub>3</sub> - 75% RDF + <i>Sesbania aculeata</i>	17.51	27.06
T <sub>4</sub> -75% RDF + <i>Sesbania aculeata</i> + <i>Azolla</i>	28.46	36.08
T <sub>5</sub> -75% RDF + <i>Sesbania aculeata</i> + BGA	20.64	30.55
T <sub>6</sub> -100% RDF	18.57	28.22
T <sub>7</sub> - 100% RDF + <i>Sesbania aculeata</i>	25.67	34.67
T <sub>8</sub> - 100% RDF + <i>Sesbania aculeata</i> + <i>Azolla</i>	34.85	44.23
T <sub>9</sub> - 100% RDF + <i>Sesbania aculeata</i> + BGA	29.37	38.14
Mean	22.36	31.56
SEd	0.71	1.22
CD (5%)	1.5	2.6

**Table.2** Effect of nutrient management strategies on soil microbial biomass carbon at tillering and harvest stages of rice crop

Treatments	Biomass carbon( $\text{mg kg}^{-1}$ )	
	Tillering	Harvest
T <sub>1</sub> . Untreated control	90	162
T <sub>2</sub> - 75% RDF	135	217
T <sub>3</sub> - 75% RDF + <i>Sesbania aculeata</i>	190	262
T <sub>4</sub> -75% RDF + <i>Sesbania aculeata</i> + <i>Azolla</i>	310	400
T <sub>5</sub> -75% RDF + <i>Sesbania aculeata</i> + BGA	254	326
T <sub>6</sub> -100% RDF	174	318
T <sub>7</sub> - 100% RDF + <i>Sesbania aculeata</i>	260	404
T <sub>8</sub> - 100% RDF + <i>Sesbania aculeata</i> + <i>Azolla</i>	435	597
T <sub>9</sub> - 100% RDF + <i>Sesbania aculeata</i> + BGA	387	513
Mean	248	355
SEd	10.58	9.39
CD (P=0.05)	22.43	19.90

**Correlation coefficients between soil microbial biomass carbon (S-MBC) and dehydrogenase activity (DHA)**

	DHA
SMBC	0.894**

\*\*Correlation significant at  $P = 0.01$ ; \*Correlation significant at  $P = 0.05$

Incorporation of *Sesbania aculeata* in combination with RDF and with RDF + *Azolla* or BGA increased the microbial biomass carbon compared to that of inorganic fertilizers alone. These observations are in accordance with the findings of Haiyan Chu *et al.*, (2007), Khosro Mohammadi (2011) and Neetu Pareek and Yadav (2011).

The soil microbial biomass acts as the transformation agent of the organic matter in the soil. As such, the biomass is both a source and sink of the carbon, nitrogen and phosphorus contained in organic matter. Generally, soil microbial biomass is more dynamic fraction of soil organic C. Dehydrogenase activity is only present in viable cells; it is thought to reflect the total range of oxidative activity of soil microflora and consequently may be considered to be a good indicator of microbial activity. The nutrient level and moisture play a dominant positive role towards the dehydrogenase activity. In the present investigation, integration of inorganics, *Sesbania aculeata* and biofertilizers have intensively triggered the microbial activities, which would have resulted in higher dehydrogenase activity. Buildup of microbial biomass would be mainly due to the microbial biomass contained in the organic residues and the addition of substrate carbon, which stimulates the indigenous soil micro-biota. Moreover, the supply of additional mineralizable and readily hydrolysable C due to the incorporation of *Sesbania aculeata* resulted in higher microbial activity and thereby microbial biomass carbon. The dehydrogenase activity and biomass carbon content tended to increase with the advancement in crop growth. This might be due to the increased root and shoot biomass production at later stages of crop growth. The results from the correlation analysis have revealed that the soil nutrient status has a direct and significant role in enhancing the

soil microbial and enzyme activities. Integrated use of inorganic fertilizers, *Sesbania aculeata* and *Azolla* orchestrates soil nutrient availability, biomass production, biochemical activities and favorable soil physical environment that facilitate effective carbon sequestration in lowland rice ecosystem.

### **Acknowledgements**

This research work was carried out during 'Masters Degree Programme'. The first author is thankful to Indian Council of Agricultural Research (ICAR) for the grant of junior research fellowship during the entire course of research. The authors are thankful to Tamil Nadu Agricultural University for the all facilities and amenities provided during the course of work.

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**How to cite this article:**

Prabha Susan Philip, R.K. Kaleeswari and Kumar, K. 2018. Microbial Biomass - Carbon (SMB-C) and Dehydrogenase Activity (DHA) in Wetland Rice Ecosystem. *Int.J.Curr.Microbiol.App.Sci.* 7(09): 384-389. doi: <https://doi.org/10.20546/ijcmas.2018.709.047>