Diversity of Rice Field Cyanobacteria from Tropical Rice Field of Western Odisha

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Abstract: Diversity of Cyanobacteria from different tropical rice fields of Western Odisha was studied. Eighty soil samples were collected from ten different sites. Sixty species of twenty-one genera were isolated. Aulosira fertilissima and Nostoc carneum showed high frequency of occurrence. Rice field soils of Chiplima and Rengali camp showed 18 different genera with 40 and 38 number of species respectively and Sason has poor Shannon’s Diversity index with 15 species of 13 genera.

Keywords: Cyanobacteria, Diversity, Rice fields, Western Odisha, Species richness

1. Introduction

India is a home of 1.21 billion people, i.e. ~17.4% of total world’s population and is represented as the 2nd most populated country in the world. However, it accounts for only 5.4% of world GDP (Bhagwati, 2013). The economic position of the country is 10th in the world (Bloom, 2011). Sambalpur district lies between 20º43’N 22º11’ N latitude and 82º39’E to 85º13’E longitude occupying an area of 6,667 sq.km and the economy is cultivation based. It comprises 194,000 hectares of cultivable land (Odisha Agriculture Statistics, 2008-09) and out of 100 workers 53 are engaged in agricultural sector (Orissa Review, 2010 Dec.). Rice yield in tropical states like Odisha is affected due to some adverse factor like weed interaction, pest attack etc. and causing severe economic loss. Poor uneducated or less skilled farmers make their livelihood from agriculture and in order to increase rice yield they have used, pesticides (Sahuet et al., 2015) and chemical fertilizer (NPK) in an unbalanced way (RCF, 2013) leading to soil infertility.

Cyanobacteria act as the plough of nature since 3.5 GA (Olson and Blankenship 2004, Bhattacharyya et al., 2014) and now known to be the nature’s gadget that manages the ecological balance of paddy-ecosystem through interactions among biophysical, biochemical and biodiversity milieus. Natural environment such as freshwater, hot springs, lakes, ponds, rivers and soil presents excellent habitats and favourable conditions for the luxuriant growth of this flora. The role of cyanobacteria in enhancing soil fertility by nitrogen fixation has been well documented long ago (Singh, 1961; Venkataraman, 1981). This well known autotrophic nitrogen engineer maintain NPK balance and C:N ratio of rice field through biological nitrogen fixation (Choudhary, 2011), Phosphate utilization and Photosynthesis. Apart from these cyanobacteria contribute to overall soil health by maintaining soil quality preventing erosion and production of bioactive compounds which have growth stimulating effect on plants. But due to modernization of agriculture i.e. with use of chemical fertilizer, pesticides etc (Bhattacharyya et al., 2011,2014) which gradually lead to losses of soil health. Massive industrialization also influencing the cyanobacterial growth (Deep et al., 2013). Above factor may influence diversity and distribution of cyanobacteria in a region. Cyanobacteria are major representative of biodiversity that maintain the homeostasis of rice field as a sustainable system. Here in this study, an attempt has been taken to study the cyanobacterial diversity from different cultivated land of tropical rice fields of Sambalpur and Bargarh districts of Odisha, India.

2. Methods

1) Study Site

The study was conducted from different rice fields of Sambalpur and Bargarh Districts of Western Odisha. Ten different sites were selected from different cultivated lands. These are Sason, Lapanga, Chiplima and Godbhaga from Sambalpur district, Attabira, Lurupali, Rengali camp, Shuktapali and Kalapani from Bargarh district and Kherual from Jharsuguda district.

2) Isolation and Enumeration of Cyanobacteria

Collected soil samples were air dried and homogenized and mixed together thoroughly. 1 g of soil sample of each site was kept in 5 petriplates with 40 ml of sterilized nitrogen free BG-11 medium under 7.5 W/m² light intensity at 25±2°C in a culture room. After 10-12 days of incubation, algal colonies appeared on the plates, number of colony of each species were recorded (CFU), after observation under microscope. After about one week of growth, colonies appearing in agar plates were examined microscopically and data related to trichome shape, filament colour, akinete and heterocyst shape, size, position, number was recorded. Identification of cyanobacteria was done using the keys given by Desikachary (1959) and J Komarek (1998, 2005).

3. Data Analysis

a. Frequency of Occurrence:

\[ FO = \frac{\text{Number of sample containing the species}}{\text{Total no sample examined}} \times 100 \]

b. Relative Frequency:

\[ RF = \frac{\text{Number of sample containing a species}}{\text{Total no of occurrence of all the species}} \times 100 \]
c. Relative Density:  
\[ RD = \frac{Number \ of \ CFU \ of \ a \ species \ in \ all \ samples}{Total \ no \ of \ CFU \ all \ the \ species \ in \ all \ the \ samples} \times 100 \]

d. Relative abundance:  
The relative abundance of a particular cyanobacteria type was calculated by employing the formula:  
\[ RA = \frac{Number \ of \ samples \ containing \ the \ species}{Total \ no \ of \ occurrence \ of \ all \ the \ species} \times 100 \]

e. Diversity index: Cyanobacterial diversity in different sites has been calculated by Shannon’s Diversity index (Shannon Wiener) as per the following formula  
\[ Hs = -\sum_{i=1}^{S} (P_i)(\ln P_i) \]

Where,  
- \( Hs \) - diversity in the sample \( S \) species or kinds  
- \( S \) - the Number of Species in the Sample  
- \( P_i \) - relative abundance of \( i \)th species or Kind measures, \( n_i/N \)  
- \( n_i \) - no of individual of \( i \)th species

4. Results and Discussion

Use of cyanobacteria as biofertiliser in improving soil fertility is well known. To use the full potential of cyanobacterial fertilizer to manage soil fertility synchronized efforts between laboratory and field research is required. Region-based specific cyanobacterial isolates could be more effective as they are pre-acclimatised to the existing environmental conditions. The composite mother culture of efficient nitrogen fixing strains collected from different locations of India and developed by National facility for blue-green algal collection at IARI, New Delhi are being cultured for their application as biofertiliser (Venkataraman, 1981). However, only few of these composite cultures could establish successfully in the fields (Tripathy et al, 1990). Hence a region-specific biodiversity study is important for deriving optimum benefits from indigenous strains. Knowledge on cyanobacterial diversity of a region may help in selecting appropriate cyanobacterial inoculants to be applied as biofertilizer in crop fields as well as help in finding strains with more biotechnological potentials.

80 soil samples were collected from 10 independent sites, isolated cyanobacterial strains were observed under microscope and taxonomically important character such as shape of vegetative cell, heterocyst, akinete position of which FO is 90. Frequency of occurrence of Scytonema simplex is lowest (10) followed by Nostoccladus (20), Anabaena ballygangii, Aphanothece saxicola, Calothrixulisilii, Gloecapsa aeruginosa, Lyngbyabirgei, Nostocphaeicum, Oscillatoriaanguina, Oscillatoriahalba, Oscillatoriaornata, Scytonema simplex, Oscillatoria curviceps, with FO is 30. Relative frequency of A. fertilissima and N. carneum is maximum i.e. 3.24 within the study sites followed by A. variabilis, N. punctiforme, N. lobatus with RF value 2.91. Relative density of N. lobatus (5.33) and Nostoccarneum (3.96) is more than other cyanobacterial strains. Relative abundance is more in case of N.lobatas.e.3.22. This data supports the finding of Nayak et al. (2007). N. lobatus, A. fertilissima, N. carneum, A. variabilis, N. punctiforme, are the dominating species of theropetal rice fields of this region. Many competent Nostocsp (Nilsson et al. 2002), and Anabaena sp. (Adhikary, 2002) was able to colonize rice in root surfaces and intercellular spaces having higher nitrogenase activity compared to their free-living species.

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Name of species</th>
<th>FO</th>
<th>RF</th>
<th>RD</th>
<th>RA</th>
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<tr>
<td>1</td>
<td>Nostoccarneum</td>
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<td>Anabaena variabilis</td>
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<td>2.91</td>
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<td>2.91</td>
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<td>2.91</td>
<td>5.33</td>
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<td>Anabaena oryzae</td>
<td>70</td>
<td>2.27</td>
<td>3.04</td>
<td>2.37</td>
</tr>
</tbody>
</table>

Figure 1: Species richness percentage of ten collection sites

60 species of 21 genera of cyanobacteria was isolated among which Frequency of Occurrence (FO) of Aulosira fertilissima and Nostoccarneumis maximum (Table 1) followed by three species Anabaena variabilis, Nostocfertissima and Nostocpunctiforme of which FO is 90. Frequency of occurrence of Scytonema simplex is lowest (10) followed by Nostoccladus (20), Anabaena ballygangii, Aphanothece saxicola, Calothrixulisilii, Gloecapsa aeruginosa, Lyngbyabirgei, Nostocphaeicum, Oscillatoriaanguina, Oscillatoriahalba, Oscillatoriaornata, Scytonema simplex, Oscillatoria curviceps, with FO is 30. Relative frequency of A. fertilissima and N. carneum is maximum i.e. 3.24 within the study sites followed by A. variabilis, N. punctiforme, N. lobatus with RF value 2.91. Relative density of N. lobatus (5.33) and Nostoccarneum (3.96) is more than other cyanobacterial strains. Relative abundance is more in case of N.lobatas.e.3.22. This data supports the finding of Nayak et al. (2007). N. lobatus, A. fertilissima, N. carneum, A. variabilis, N. punctiforme, are the dominating species of theropetal rice fields of this region. Many competent Nostocsp (Nilsson et al. 2002), and Anabaena sp. (Adhikary, 2002) was able to colonize rice in root surfaces and intercellular spaces having higher nitrogenase activity compared to their free-living species.

Table 1: Relative frequency(RF)/Relative density(RD), Relative abundance(RA), and Frequency of occurrence (FO) of isolated cyanobacteria collected from rice field
Species richness of rice field soil (Figure 2) of Chiplima is highest (13.03%) followed by Rengali camp (12.38%), Lurupali (11.40%) and Kalapani (10.75%) where as Kherual (7.46%) and Sason (5.08%) shows lowest species richness.
References


