

EXPLORATION OF ALGAL DIVERSITY: PHYTOCHEMICAL ANALYSIS AND UTILISATION AS SUSTAINABLE BIO-FERTILIZER FROM PADDY FIELDS OF SIMDEGA, JHARKHAND

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Abstract

The algal and cyanobacterial communities thriving in the paddy-field ecosystems serve as good indicators of the wetland's suitability for the growth of other organisms and can potentially be applied in sustainable agriculture. The main objectives of the present study was to study the diversity of algae present in the paddy fields of Simdega, Jharkhand, to determine their phytochemical and nutrient profile and to determine their potential use as bio-fertilizer in paddy field. The secondary data was obtained from the published research articles, scientific publications, institutional publications, government reports and official government websites. Systematic compilation and descriptive analysis of information related to algal diversity, biochemical constituents, nitrogen fixation, nutrient cycling, soil fertility and cultivation of paddy were carried out and agricultural characteristics of Simdega were discussed. The available evidence suggests that paddy fields can harbour cyanobacteria, green algae, diatoms and other algal groups and their distribution depends on water availability, soil characteristics, nutrients, temperature and agriculture. Proteins, carbohydrates, amino acids, nitrogen, phosphorus, potassium, chlorophyll, carotenoids and phycobiliproteins have been reported in the freshwater algae from regional studies of Jharkhand. Nitrogen-fixing cyanobacteria can supply biologically available nitrogen, algal standing crop can supply organic matter and nutrients, and may also affect soil microbial community activity and plant growth. The results suggest that indigenous algal resources can be used as sustainable alternative for nutrient management in the paddy cultivation system. However, their effectiveness as bio-fertilizers in the field needs to be confirmed through species specific laboratory characterization and controlled field experiments for their efficiency in Simdega.

Keywords: Algal diversity, Paddy fields, Phytochemical composition, Cyanobacteria, Bio-fertilizer, Soil fertility; Simdega

Introduction

Paddy-field ecosystems are dynamic wetland ecosystems which host a variety of microorganisms such as algae and cyanobacteria. Rice fields are flooded periodically, have light and organic substrates, mineral nutrients and changing physicochemical conditions, which make them favorable habitats for photosynthetic microorganisms (Zhang et al., 2026). Paddy soils thus could contain different types of algae, such as green algae, diatoms and cyanobacteria, and cyanobacterial communities are of particular

importance as several species can withstand submerged agricultural conditions and can enrich the soils. Among the important genera reported with paddy fields in tropical and sub-tropical countries are the genera *Anabaena* and *Nostoc* (A. K. Singh et al., 2018), (Selvaraj & Balasubramanian, 2021). Algal communities may be composed of different species and in different proportions depending on soil pH, soil temperature, soil moisture, soil nutrition, light penetration, soil agricultural uses and pesticide exposure. (A. K. Singh et al., 2018)
The algae is an important component of paddy ecosystem as the primary producers and also organic

carbon source to the soil–water system due to photosynthesis. As they grow, they contribute organic matter to be later part of microbial and nutrient cycling. Cyanobacteria have special cells and enzyme systems that allow for biological nitrogen fixation of the atmospheric nitrogen into soil nitrogen, which is especially beneficial. Hence, the cyanobacteria with nitrogen fixing capacity have been used as natural bio-fertilizers for rice culture systems for a long time (Vaishampayan et al., 1998), (Chittora et al., 2020). Cyanobacteria can not only fix nitrogen but also excrete extracellular polysaccharides, amino acids, vitamins and plant-growth-promoting agents which may affect soil structure and plant growth. (Chittora et al., 2020)

Algae are not only a source of nitrogen for agriculture but also provide other benefits. Algal and cyanobacterial biomass can also add carbon and nutrients to agricultural soils and some algae can help to mobilize phosphorus and make nutrients more available. Cyanobacteria are reported to be producers of biologically fixed carbon and nitrogen, phosphorus mobilizing substances, phytohormones and polysaccharides, especially in flooded rice production (Ramakrishnan et al., 2023). The extracellular products they produce can also aid in soil aggregation and affect soil water holding capacity, aeration and other soil physical properties (Chatterjee et al., 2017). Based on these properties, indigenous algal communities could be used as a valuable biological resource in sustainable agriculture.

Another significant role of algae in paddy-field ecosystem is their role in nutrient cycling. While growing, algae can absorb nutrients from the soil and water, and after senescence, the biomass can be broken down and reutilized by the microorganisms in the soil. The nitrogen fixing cyanobacteria also provide biologically fixed nitrogen to the agricultural system. Some more recent research has suggested that application of cyanobacteria can enhance the N-use efficiency and decrease N-losses (e.g. ammonia volatilization and leaching) under specific paddy-field conditions (Song et al., 2022), (Song et al., 2021). Algal biomass can thus play a

role in nutrient retention and nutrient transformation in the flooded rice soils.

Thus, the study on algal diversity in the major Paddy fields of Simdega, Jharkhand is ecologically and agronomically relevant. Records of natural algal taxa can help to determine the baseline data of the biological resource available in the local rice growing ecosystem. Subsequent phytochemical and nutritional characterisation of selected algae may be able to identify algae with compounds or nutrients with potential for agricultural applications. As bio-fertilizer resources they can help in developing local and eco-friendly options/supplements to synthetic fertilizers. The use of microalgae and cyanobacteria for nutrient recyclers, soil improvement, and sustainable agricultural production has begun to be recognized as a potential source for recycling nutrients for future use, however, efficacy of these methods relies on species and environment and specific application strategies. (Sun et al., 2026), (Nawaz et al., 2024)

Study Area and Exploration of Algal Diversity

Simdega district lies in the south west part of Jharkhand and is part of the Netarhat–Ranchi plateau area of the Chotanagpur Plateau. The topography is predominantly hilly, undulating, and has plateaus, valleys, slopes and riverine regions. Rivers and streams that are important drains are the Sankh, South Koel, Deo, Girwa and Palamara. The district area is about 3,760 km² with most of the land area predominantly rural and agricultural. (Administration, 2026d), (Administration, 2026e)

One of the main livelihood activity in Simdega is agriculture with a major crop being rice or paddy grown during kharif season. Rainfed paddy sowing and transplanting is identified as an important farming system as per the official district agricultural profile. Low-lying regions locally known as don are particularly associated with paddy cultivation because water has a tendency to pool in these regions in the wet season, which is favourable for rice production. Relatively high lands have been mostly used for crops like maize, ragi, pulses and vegetables, in contrast (Administration, 2026b), (Administration, 2026d). Soils in the district are red

and lateritic soils as well as sandy-loam soils, and have been reported as acidic to neutral soils. The majority of agriculture is rain-fed and the deep seasonal rainfall results in temporarily flooded agricultural environments favourable to the presence of a variety of algae and cyanobacteria. (Administration, 2026b)

Rice based agriculture is of great significance in the district as about 85,000 ha of the land is cultivated under paddy crops (as per the agricultural information as per the state of the district at present). The extensive paddy crop, seasonal flooding, sunlight availability, together with the variation of soil and water properties offers suitable ecosystem for algal study. **(Administration, 2026d)**

In order to explore the diversity of algae, major paddy fields of Simdega district were selected, which is subjected to different agricultural and environmental conditions. The sampling sites could be located at selected blocks, e.g., Simdega, Kurdeg, Thethaitangar, Kalebira, Jaldega, Bano, Bolba, Kersai, Pakartand and Bansjor which is the administrative and agricultural landscape of the district. **(Administration, 2026b), (Administration, 2026c)**

The topography, availability of water, soil type, cultivation methods and extent of agricultural disturbance should be taken into consideration when selecting fields. If available, both regularly irrigated and predominantly rainfed fields can be considered in order to establish a distribution pattern of algal occurrence. Those fields that contain obvious algal mats, green surface growth, or suspended algal material can be given special attention, and those fields that do not appear to harbor any algae should also be included to prevent the survey from being limited to algae-rich fields. In previous studies on rice-field cyanobacteria, several geographically distant rice fields have been studied, and environmental and physicochemical variations have been taken into account between sampling sites. **(Srivastava et al., 2009)**

Various microhabitat conditions, such as surface water in a flooded paddy, soil-water interface, moist soil surfaces and visible algal mats can be sampled in the selected paddy fields. Samples may be taken

during the growing season of the rice, when moisture and sun are adequate to permit growth of algae. Samples should be taken from each field using sterile containers, spatula or forceps depending on the type of organism (suspended, attached or mat forming). The sample should be marked in all samples with sampling site, date, field/block, sample code and relevant field observations. Samples should then be sent to the lab in appropriate condition for a microscopic examination and additional analyses.

Microscopic observation for initial identification can be done on the basis of morphological characteristics. Significant characteristics are cell shape and size, colony or filament structure and organization, branching pattern, pigmentation, heterocyst and akinete characteristics (cyanobacteria), and other diagnostic features. Some of the same methods have been applied to the investigation of cyanobacteria found in paddy-fields, in which the strains were identified by their microscopic characteristics – cell size, length of filaments, appearance of colonies, and the position and shape of heterocysts and akinetes, etc **(S. S. Singh et al., 2014)**. The presence of the organisms identified can be recorded sitewise, and compared with the standard taxonomic keys, algal flora and relevant taxonomic literature.

The algal diversity and abundance collected can then be placed in major taxonomic groups and by frequency of occurrence. Representative species that are abundant and have desirable agricultural characteristics can be chosen for further phytochemical and nutrient analysis and evaluation of their potential as sustainable bio-fertilizers. This would be in line with the wider goal of identifying algal resources which are of potential agricultural benefit in the local area, and relate to the documentation of biodiversity.

Aim

To explore the algal diversity of paddy fields in Simdega, Jharkhand, characterize their phytochemical and nutrient composition, and assess their potential as sustainable bio-fertilizers for improving soil fertility, nutrient availability, and growth of paddy plants.

Objectives

- To explore and document the diversity of algal species present in paddy fields of Simdega, Jharkhand, with emphasis on their distribution and occurrence across agricultural sites.
- To analyze the phytochemical composition of algal species, including major bioactive compounds and nutrient constituents relevant to their potential agricultural applications.
- To evaluate the potential of algae as sustainable bio-fertilizers by assessing their effects on soil fertility, nutrient availability, and growth-related parameters of paddy plants.

Research Methodology

This study used descriptive and exploratory research with secondary data approach. The data on algal diversity, phytochemical composition, cyanobacterial bio-fertilizers, soil fertility, and cultivation of paddy were gathered from various published scientific works, research papers, books, reports, dissertations, Government sites and other relevant scientific sources. Special focus was laid on the literature on algae, cyanobacteria, freshwater algae, rice-field ecosystems, Jharkhand, and possible applications of these algae and cyanobacteria in agriculture. Further, information on the geographical features, agricultural practices, paddy cultivation, soil condition, irrigation, rainfall and administrative profile of Simdega district was gathered from relevant government websites and government reports namely district and state level agriculture and administrative reports. The information collected was reviewed, organized and discussed systematically based on the three different parts of the study, namely algal diversity in paddy, phytochemical composition and nutritional composition and utilization of algae as sustainable bio-fertilizers. The published results of the different parts of the country were taken from Jharkhand as well as other parts of the country and compared and interpreted in the regional context. Evidence gathered was summarized descriptively to determine

algal characteristics and applications that are of importance to paddy cultivation in Simdega.

Diversity of Algal Species Present in Paddy Fields of Simdega, Jharkhand

Paddy-field ecosystems are dynamic agroecosystems in which periodic inundation, sunlight, water, nutrient availability, and soil–water interactions provide favorable conditions for the growth of diverse algal communities. The study is suitable for Simdega district of Jharkhand as one of the main crops of the district is rice. As per the District Agricultural Profile, the area under paddy cultivation is about 85,000 ha and also the low lying areas called dons are exceptionally apt for paddy cultivation as they can hold water. The district is also characterized by mainly rain fed paddy cultivation, red and sandy-loam soil which can affect the species and seasonality of the algae present in the cultured fields and heavy monsoonal rainfall. (Administration, 2026b), (Administration, 2026d)

Algal flora of paddy fields consists of several taxonomic groups mainly the cyanobacteria, green algae, diatoms and euglenoid forms. Cyanobacteria are especially significant species in flooded rice systems among these species. Genera like *Anabaena*, *Nostoc*, *Aulosira*, *Cylindrospermum*, *Gloeotrichia*, *Rivularia*, *Tolypothrix*, *Oscillatoria*, *Lyngbya*, *Phormidium*, *Hapalosiphon* and *Fischerella* have been reported from Indian rice fields. However, their distribution is not even and can vary with soil properties, water conditions, salinity, pH, temperature, nutrient status and agriculture. (A. K. Singh et al., 2018), (Srivastava et al., 2009)

The presence of green algae is also important in the rice-field environment in Jharkhand. In the Lalgutwa area of Ranchi, Jharkhand 24 chlorophycean taxa were documented including Chlorococcales, Ulotrichales, Cladophorales, Oedogoniales and Zygnematales. The study found that rain and winter seasons were more favorable for algal growth than the summer season and that algal growth was linked to the combinations of favorable temperature, light, nutrients and water (Kumar, 2012). This is significant in the proposed exploration area of Simdega as this district also has high seasonal

rainfall variation and water availability. The high amount of rain in the months of June-September might lead to temporary inundation in paddy field and allow for high algal growth. **(Administration, 2026d)**

The distribution of algae on the agricultural sites in Simdega will therefore be expected to show significant spatial and temporal variation. Lower don landscapes might have longer water retention time than the comparatively higher landscapes of agriculture which might be promoting conditions favourable to aquatic and semi-aquatic algae. The range of soil types, pH, organic matter, nutrient availability, cultivation practice, fertilizer application, pesticide use and length of flooding could further influence the establishment of the algal groups. Previous studies in rice-field cyanobacteria in other parts of India have shown that cyanobacterial community structures are related to environmental variables such as soil salinity. In one study, Aulosira, Nostoc, Anabaena and Hapalosiphon species were identified in various environments of rice field and communities were found to be different depending on the soil environment. **(Srivastava et al., 2009)**

Hence, the algal diversity should be evaluated across the representative major paddy growing site of Simdega not on a particular agricultural site for the present exploration. The district has 10 administrative blocks (Simdega, Pakartand, Kurdeg, Kersai, Bolba, Thethaitangar, Kalebira, Jaldega, Bansjor and Bano) which can be used as a wide geographically defined framework for selecting representative sampling locations **(Administration, 2026a)**. Various field microhabitats (standing water, soil–water interface, moist soil surfaces and visible algal mats) are all considered sampling fields. Further separation of persistent and rice cycle-associated taxa would be achieved by repeated sampling of the seasons.

Microscopic examination and morphological features including cell shape, filament organisation, colony structure, pigmentation, branching and specialised structures like heterocysts and akinetes (cyanobacteria) can be used to identify the collected specimens. The incidence and abundance of single

taxa at each sample station would give a picture of distribution and make it possible to recognize dominant, common and locally restricted taxa. The documentation of such diversity is necessary as not only is it a measure of biological richness, but it can also provide a valuable agricultural resource.

Cyanobacteria, in particular, have been found to play a significant role in rice ecosystems as the organisms are able to fix nitrogen gas and considered as a potential bio-fertilizer organisms **(A. K. Singh et al., 2018)**, **(Yadav et al., 2025)**. Hence, a description of algal flora of Simdega could serve as baseline for the selection of those algal species which are found in the area for further phytochemical, nutritional and bio-fertiliser study. The diversity assessment will therefore be the ecological basis for assessing indigenous algae as potential sustainable agricultural inputs.

Phytochemical Composition of Algal Species and Their Agricultural Relevance in Simdega, Jharkhand

Phytochemical and Biochemical Constituents of Algae

The conditions in Simdega district are suitable to the occurrence of algae and cyanobacteria in agricultural and freshwater habitats. The significance of paddy cultivation is that the district receives considerable monsoonal rain and the low-lying don areas of Simdega offer favourable conditions for paddy cultivation **(Administration, 2026b)**, **(Administration, 2026d)**. A species-specific phytochemical study of algae collected directly from Simdega paddy field was not found in the available literature, however, the biochemical potential of algal taxa found in a similar rice field environment was found to be useful to interpret the biochemical potential of the algal taxa obtained from the Simdega paddy field.

Mehta and Sahu (2018) analyzed the biochemical composition of freshwater algae (Cyanophyceae and Chlorophyceae) of eleven commercially significant species collected from diverse environments in Ranchi, Jharkhand. The investigation revealed a remarkable difference in proteins, carbohydrates,

free amino acids, photosynthetic pigments, phycobiliproteins, nitrogen, phosphorous and potassium across the algae species. *Spirulina platensis* revealed relatively high levels of total protein (58.28%), free amino acids (8.95%), total nitrogen (9.32%) and phosphorus (2.08%) in addition to chlorophyll-a (10.95 mg/g) and β -carotene (1.31 mg/g). *Chlorella vulgaris* observed

comparably high chlorophyll-b (3.30 mg/g), soluble carbs (11.87%) and soluble protein (6.48%). Conversely, *Nostoc commune* contains significant amount of C-phycocyanin (13.08 mg/g) and C-phycoerythrin (6.06 mg/g) which indicates the biochemical variety and possible functional usefulness of freshwater algae found in Jharkhand. (Mehta & Sahu, 2018)

Table 1: Major biochemical constituents reported in freshwater algae from Jharkhand.

Algal taxon	Major constituent reported	Reported value/observation	Potential relevance
<i>Spirulina platensis</i>	Protein	58.28%	Nutrient-rich biomass and biofertilizer potential
<i>Spirulina platensis</i>	Total nitrogen	9.32%	Nitrogen contribution to agricultural systems
<i>Spirulina platensis</i>	Phosphorus	2.08%	Nutrient recycling and soil enrichment
<i>Spirulina platensis</i>	β -carotene	1.31 mg/g	Antioxidant/pigment constituent
<i>Chlorella vulgaris</i>	Soluble carbohydrate	11.87%	Carbon-rich biomass
<i>Nostoc commune</i>	C-phycocyanin	13.08 mg/g	Bioactive photosynthetic pigment
<i>Nostoc commune</i>	C-phycoerythrin	6.06 mg/g	Phycobiliprotein with biotechnological value
<i>Scenedesmus quadricauda</i>	Potassium	0.98%	Potential mineral nutrient source

Source: (Mehta & Sahu, 2018)

Bioactive Compounds and Agricultural Significance

Algae are not only primary nutrients, but also phytochemically important. Cyanobacteria contain photosynthetic pigments (chlorophyll, carotenoids and phycobiliproteins), proteins, carbohydrates, amino acids, exopolysaccharides and antioxidant-associated metabolites. Studies of cyanobacteria in paddy-fields have shown that chlorophyll-a, carotenoids, phycocyanin, allophycocyanin, phycoerythrin, proteins and carbohydrates are present in the cyanobacteria, and their nitrogen-

fixing metabolism endows them with biofertiliser properties. (Tiwari et al., 2020)

This is especially significant for Simdega as the crop is mostly rain-fed and rice being one of the main crops of the district. There is also limited irrigation compared to the land under cultivation in the district, which consider biological nutrient improving methods may be applicable to local agriculture systems (Administration, 2026b). The rice Agroecosystems are well-known to be associated with nitrogen fixing cyanobacteria like *Nostoc*, *Anabaena*, *Aulosira*, *Calothrix*, *Cylindrospermum* and others. (A. K. Singh et al., 2018), (Yadav et al., 2025)

Table 2: Important algal constituents and their potential agricultural applications.

Constituent/group	Representative algal sources	Potential agricultural relevance
Chlorophyll and carotenoids	Spirulina, Chlorella, cyanobacteria	Photosynthetic biomass and antioxidant-related activity
Phycocyanin, phycoerythrin, allophycocyanin	Nostoc, Synechococcus	Bioactive pigments and indicators of cyanobacterial biomass
Proteins and amino acids	Spirulina, Chlorella, cyanobacteria	Nutrient-rich biomass and organic amendments
Nitrogen-fixing systems	Nostoc, Anabaena, Aulosira, Calothrix	Biological nitrogen input in rice fields
Carbohydrates and exopolysaccharides	Paddy-field cyanobacteria	Soil-associated organic matter and stress protection
Carotenoids and antioxidant metabolites	Green algae and cyanobacteria	Potential plant-stress and oxidative-stress applications

The survey of paddy-fields in other parts of Jharkhand also shows a wide diversity of cyanobacteria. During the survey of the district at Ranchi, 68 taxa of 20 genera, such as Nostoc, Anabaena, Calothrix, Aulosira, Cylindrospermum, Oscillatoria and Phormidium, were recorded (Mahto, 2020). Hence, these are useful regional phytochemical and ecological studies to consider algal samples from Simdega and the actual level of concentration of the compounds must be determined in the laboratory of Simdega samples instead of assuming the concentration from Ranchi.

Potential of Algae as Sustainable Bio-fertilizers for Paddy Cultivation in Simdega, Jharkhand

Algal Bio-fertilizers and Improvement of Soil Fertility

The algae, especially cyanobacteria and freshwater microalgae, have potential to be used as bio-fertilizers for agricultural soils that can provide nutrients and biologically active compounds. The

potential is especially important in Simdega district of Jharkhand where agriculture is mainly rainfed and paddy is one of the major farming system. The district administration says only a small percentage of the arable land is irrigated and large tracts of agricultural land rely on seasonal rains. The soils of Simdega are red-lateritic and sandy-loam with strong acidity to neutral condition. Sustainable management practices to sustain soil fertility are required. (Administration, 2026b)

Cyanobacteria (alkaligenes) like Anabaena, Nostoc, Aulosira, Calothrix, Cylindrospermum are capable of fixing atmospheric nitrogen and transforming it to biologically available forms. They can then be applied in paddy fields to supplement nitrogen, and may help to decrease the use of manufactured nitrogen fertilizers. Phosphorus, potassium, sulphur, magnesium, iron and others are also present in the algal biomass that can be released through biomass decomposition. Furthermore, algae extracellular polysaccharides may be involved in soil aggregation and soil microbial activity. (Gonçalves, 2021), (Abinandan et al., 2019)

Table 3: Major mechanisms through which algae may improve soil fertility.

Algal contribution	Expected effect on soil	Relevance to Simdega paddy fields
Biological nitrogen fixation	Increases biologically available nitrogen	Particularly relevant to rainfed rice production
Phosphorus mobilisation	Improves availability of phosphorus	May improve nutrient-use efficiency
Addition of organic biomass	Increases organic matter and carbon inputs	Useful for maintaining soil quality
Release of extracellular polysaccharides	Supports soil aggregation and microbial activity	Potentially beneficial in red-lateritic/sandy-loam soils
Supply of K, Mg, S and Fe	Adds macro- and micronutrients	Supports balanced plant nutrition
Production of growth-promoting metabolites	Stimulates root and shoot development	May improve early crop establishment

Sources: (Renuka et al., 2018), (Abinandan et al., 2019), (Ammar et al., 2022)

Effects on Nutrient Availability and Paddy Growth

The algal bio-fertilizers are not only useful in the supply of nutrients but also useful in other ways in the agriculture. Algal biomass can also affect soil microorganisms, and thus nutrient cycles, improving nutrient availability to crops. Some recent studies have shown that microalgae and cyanobacteria can fix nitrogen, aid in the solubilization of phosphorus and provide micronutrients and that their metabolites such as amino acids, phytohormones and antioxidants can induce germination, root growth and nutrient uptake. (Sun et al., 2026)

In paddy these effects can be measured by growth parameters like plant height, number of tillers, root

length, number of leaves, fresh and dry biomass, chlorophyll content, panicle number and grain yield. Available nitrogen, available phosphorus, available potassium, soil organic carbon and soil pH can all be used to indicate soil fertility. This would help assess the potential of locally available algae species (from Simdega) and not just from other geographical region.

A number of past agricultural trials have shown that the growth and yield of rice can be enhanced and soil nitrogen can be improved by introducing the cyanobacteria. It is reported that they include the fixation of nitrogen in the atmosphere and an increase in nutrient availability and production of plant-growth-promoting substances. (Atnoorkar, 2021), (Gonçalves, 2021)

Table 4: Suggested indicators for evaluating algal bio-fertilizer performance in Simdega.

Assessment area	Parameters that can be measured	Expected response after algal application
Soil fertility	Organic carbon, pH, available N, P and K	Improved nutrient status
Nutrient availability	Available N, P, K and micronutrients	Greater nutrient availability
Vegetative growth	Plant height, leaves plant ⁻¹ , tillers plant ⁻¹	Increased vegetative development
Root development	Root length and root biomass	Improved root growth
Plant biomass	Fresh and dry weight	Greater biomass accumulation
Physiological response	Chlorophyll content	Improved photosynthetic activity

Reproductive growth	Panicles plant ⁻¹ and grains panicle ⁻¹	Improved yield components
Final productivity	Grain and straw yield	Potential increase in paddy productivity

Simdega, in particular, has significant meaning as the administration recognizes the rain supported paddy farming as one of the important farming systems and significant portion of agricultural field is relying on the seasonal and unpredictable rains (**Administration, 2026b**). Algal bio-fertilizers, therefore, might be a locally adaptable biological input that can be used to supply nutrients and to maintain soil biological activity. The effectiveness, however, will probably depend on the species of algae, algal concentration, application rate, soil properties and environmental conditions. Inconsistent field performance and formulation requirements, combined with high scale production costs, are also recent reviews for important limitations. (**Sun et al., 2026**), (**Wao et al., 2026**) Therefore, an experimental assessment of algal/cyanobacterial isolates collected from the area of Simdega and performing the experiments on soil nutrient analysis and measurement of growth of paddy plants would be more appropriate to validate their suitability as bio-fertiliser. Such studies might be able to relate the algal diversity of the district with the practical implication of enhancing the fertility of the soil and sustainable rice cultivation.

Discussion

In the present study, the ecological and agricultural importance of algal communities found in paddy field of Simdega, Jharkhand have been highlighted. The situations at Simdega are favorable for the occurrence of algae because rice is an important crop, significant proportion of the area is rain-fed and low-lying don landscapes hold water during the cropping season. The establishment and distribution of algae can be affected by a combination of seasonal inundation, sunlight, soil characteristics, nutrient availability and agriculture. The likelihood of cyanobacteria, green algae, diatoms and other algae groups is in line with the observations recorded in the Indian rice-fields where the algal community varies

depending upon the environmental and soil conditions.

Several cyanobacterial taxa from rice ecosystems have biological nitrogen fixation ability of which they have special agricultural importance. Certain genera of algae, e.g. *Anabaena*, *Nostoc*, *Aulosira* and *Calothrix*, can biologically fix nitrogen and organic matter in flooded agriculture. Their ecological function is not just as nitrogen fixers as algal biomass can provide carbohydrates, amino acids, pigments, extracellular polysaccharides and other biologically active compounds. The characteristics facilitate the potential use of some of the indigenous algae species as biological inputs, not simply as part of the biodiversity of paddy fields.

The potential is corroborated by the phytochemical evidence obtained from local freshwater algae of Jharkhand region. The study conducted by Mehta & Sahu (2018) highlighted the presence of significant variations in protein, carbohydrates, free amino acids, nitrogen, phosphorus, potassium and photosynthetic pigments of freshwater algae of Jharkhand. For instance, protein and nitrogen contents were significant in *Spirulina platensis* and *Nostoc commune* contained significant phycobiliproteins. These values are to be treated as comparative evidence of the region and not as actual values of Simdega algae. Biochemical analysis of the samples from Simdega is still required for species-specific analysis to determine their actual biochemical composition.

Algal biomass can be utilized as bio-fertilizer which is especially significant in paddy culture as algae can supply nutrients by biomass production, decomposition and in nitrogen fixing species by fixing nitrogen from the atmosphere. They may also affect soil aggregation and the activity of soil microorganisms through their extracellular products. Algal biomass application could thus influence soil organic carbon, soil nitrogen availability, phosphate and potassium levels and growth stimulating

metabolites could impact root growth, tillering, chlorophyll production and plant biomass.

However, algal bio-fertilization is not effective in all species and/or field conditions. It depends on species characteristics, biomass quality, application rate, soil properties, water availability and environmental conditions. Hence, the diversity assessment is a crucial preliminary step and controlled pot and field experiments to measure soil nutrients and paddy growth parameters are needed to determine the effectiveness of bio-fertilizers in Simdega.

Conclusion

The study also highlights the need of exploring the inherent algal diversity in paddy-field ecosystems of Simdega, Jharkhand with favorable habitat for growth of algae and cyanobacteria due to seasonal inundation, rain-fed rice cultivation and diversified soil conditions. The recorded diversity can serve as a biological resource to identify agriculturally useful taxa, in particular nitrogen-fixing cyanobacteria. The freshwater algae resources are available in the region and it is estimated that proteins and carbohydrates could be considerable, with nitrogen, phosphorus, potassium, which are major plant ingredients, and pigments and other bioactive components with possible agricultural applications. Algal biomass can provide nutrients, organic matter and biologically active compounds to paddy soils and can be an aid to sustainable nutrient management. But regional studies alone do not necessarily guarantee effectiveness. It will be necessary to get laboratory characterization and take up controlled pot and field experiments with the isolates from Simdega to find out the suitable species, application rate and measurable effects on soil fertility, nutrient availability and growth of paddy plants.

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