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Prospects of Cyanobacteria for Evergreen Agriculture

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Blue-green algae, technically known as cyanobacteria, are microscopic organisms that are naturally present in lakes and streams. Macro- and micro-algae are currently mainly used for food, in animal feed, in feed for aquaculture and as bio-fertiliser. Biomass from micro-algae is dried and marketed in the human health food market in form of powders or pressed in the form of tablets. Algal biomass could also be used as raw material for co-firing to produce electricity, for liquid fuel production via pyrolysis (bio-oil), or for biohydrogen.

Introduction

Cyanobacteria are distinguishable from other bacteria and algae by their structural and functional peculiarities. They gain importance as environmental ecofriendly inputs in agriculture. Cyanobacteria known as blue-green algae (BGA) evolved 3.5 billion years ago. Stromatolites are earth's oldest fossils and made up of column of calcium carbonate produced by BGA.

Cyanobacteria (Blue-Green Algae) are Gram-negative, Oxygenic, Photosynthetic prokaryotes. They are the oldest and most primitive forms of life. They are single-celled organisms lacking a nuclear membrane having many different forms like filaments, colonies. It comes under domain-bacteria, kingdom-Eubacteria, phylum-Cyanobacteria. "Cyano" means "blue" and "Bacteria"– acknowledge that they are more closely related to prokaryotic bacteria than eukaryotic algae. Habitats are marine sediments, pelagic zone, hot springs, freshwater lakes, soils *etc*. The major genera of cyanobacteria are *Gloeocapsa, Merismopedia, Spirulina, Oscillatoria, Phormidium, Lyngbya, Anabaena, Nostoc, Aphanizomenom, Microcystis, Tolyprhix, Rivularia, etc.*

Characteristics, Evolution and Structure of Cyanobacteria

Cyanobacteria possess various pigments like chlorophyll, phycobiliprotein etc. phycobiliprotein consist of three proteins. Phycoerythrin – red pigment protein also found in red algae. Phycocyanin and allophycocyanin are blue pigment proteins and responsible for green-blue colour of Cyanobacteria. The carbohydrate stored is glycogen. Cyanobacteria are photosynthetic bacteria and produce O_2 during photosynthesis reaction.

Importance of Cyanobacteria in Agriculture:

1. Biofertilizer

Nitrogen-fixing Cyanobacteria *viz.Nostoc, Anabaena, Oscillatoria*, etc. Biological nitrogen fixation (BNF) is the process whereby atmospheric nitrogen (N=N) is reduced to ammonia in the presence of nitrogenase.

Heterocyst: nitrogen-fixing cyanobacteria are filamentaous and produce specialised nitrogen-fixing cells, called heterocysts. Specialized cells containing nitrogenase enzyme able to convert gaseous nitrogen (N_2) to ammonium (NH_4+). Nitrogenase complex is a two-protein complex: nitrogenase Reductase (Fe protein) and nitrogenase (MoFe protein). Both enzymes are highly oxygen-sensitive. The intrinsically anaerobic character of the nitrogenase complex requires special adaptation in cyanobacteria which produce oxygen in a plant-type photosynthesis.

2. Tolerance to abiotic stress

Cyanobacteria have capability to produce metabolites such as phytohormons, proline, proteins, polysaccharides, etc. that relieves abiotic stress which in turn promotes plant growth. They contain an akinete, which can survive under harsh conditions, starvation and dehydration for long periods of freezing time and this is due to its thick wall.

3. Growth hormone production

Growth hormones have vital role in plant growth. Cyanobacteria have capability to produces different types of phytohormones which serve as growth regulators and control the plant growth.

4. Bioremediation

Process of degradation of pesticides and conversion into non-toxic compounds by microorganisms called “bioremediation”. Process of degradation of pesticides and other chemicals conversion into non toxic compounds by microorganisms known as “biodegradation”.

Cyanobacteria reported for degradation of pesticides

Cyanobacterial species	**Pesticide degraded**
Anabaena sp., Microcystis novacekii, Nostoc linckia, N. muscorum, Oscillatoria animalis, Phormidium foveolarum	Methyl parathion
Anabaena fertilissima, Nostoc muscorum	Monocrotophos, malathion, dichlorovos , phosphomidon
Anabaena sp . A. azotica, A. cylindrica, Cyanothece sp., Nodularia sp., Nostoc sp., Oscillatoria sp., Synechococcus sp.	Lindane
Synechocystis sp. Strain PUPCCC 64	Anilofos
Spirulina platensis	Chlorpyrifos

5. Carbon sequestration

It is a geo-engineering technique for the long-term storage of carbon dioxide (or other forms of carbon) for the mitigation of global warming also known as “carbon capture”. In plants and soil “terrestrial sequestration” (“carbon sinks”), underground “geological sequestration” and deep in ocean “ocean sequestration” It is estimated that globally on more than 33 billion tons of carbon emissions per year. Carboxysomes present in Cyanobacteria which contain enzymes involved in carbon fixation thus sequestering carbon for long term.

6. Biofuel

Biofuels are referred to as solid, liquid or gaseous fuels derived from organic matter. Domestic production of renewable fuels including BGA biofuels has the potential to meet the dual goals of improving energy security and decreasing GHG emissions. BGA can increase in biomass several times per day utilizing sunlight, CO_2 and nutrients from Sewage, agriculture waste, etc. and produce 15-30 times more oil/acre than oil derived from plants. Biofuels are made by chemically-reacting lipids and alcohol.

Reasons to choose BGA for biofuel production

- Fast growth
- High photosynthetic efficiency
- Capacity for genetic engineering
- Great capacity to convert CO_2 into carbon rich lipids
- Simple nutrient requirements (mainly water, sunlight, CO_2, nutrient from sewage, agriculture waste, etc.)

Conclusion

Blue green algae (BGA) or Cyanobacteria evolved first on earth which are single celled photosynthetic bacteria which possess plant Growth Promoting traits like Nutrient augmentation (N, P, K, Zn etc.), protection against biotic and abiotic stresses production of phytohormones, amino acids, etc. Cyanobacteria play an important role in maintenance and build-up of soil fertility, consequently increasing plant growth and yield as a natural biofertilizer. Cyanobacteria are the best bioremediators for reducing toxicity of pesticides and heavy metals. Cyanobacteria have a great promise for urban agriculture playing vital role in carbon sequestration and management of GHG mainly CO_2 to produce green energy and protein rich food. Cyanobacterial biofertilizers can be promoted for wetland paddy and other crops. Mitigation of GHG for the management of Global warming by tiny Cyanobacteria converting CO_2 to green biomass to produce Biofuel and food for the next generation. Future study confirming role of Cyanobacteria in plant growth promotion, plant defense and bioremediation with molecular mechanism can be explored.