The Potential Applications of Cyanobacteria (Blue Green Algae) as Biofertilizer: A Review

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INTRODUCTION

Biofertilizer is defined as a substance, contains living microorganisms which colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrient and/or growth stimulus to the target crop, when applied to seed, plant surfaces, or soil (Vessey 2003). Bio-fertilizers containing beneficial bacteria and fungi improve soil chemical and biological characteristics, phosphate solutions and agricultural production. Cyanobacteria play an important role in maintenance and build up of soil fertility consequently increasing rice growth and yield as a natural biofertilizer (Song *et al*, 2005).

The use of biofertilizer in preference to chemical fertilizers, offers economic and ecological benefits by way of soil health and fertility to farmers. Biofertilizers add nutrients through processes of nitrogen fixation, solubilizing phosphorus and stimulating plant growth through the synthesis of growth promoting substances. Biofertilizers can be expected to reduce the use of chemical fertilizers and pesticides (D. Sahu *et al*, 2012). Efficient nitrogen fixing strain like *Nostoclinckia*, *Anabaena variabilis*, *Aulosirfertillissima*, *Calothrix* sp.,

*Tolypothrix*sp. and*Scytonema* sp. were identified from various agroecological regions and utilized for rice production (Prasad and Prasad, 2001). Biofertilizer can also protect plants from soil borne diseases to a certain degree. The need for the use of biofertilizer has arisen, primarily for two reasons. First, because increase in the use of fertilizers leads to increased crop productivity, second, because increased usage of chemical fertilizer leads to damage in soil texture and raises other environmental problems. Therefore, the use of Biofertilizer is both economical and environment friendly.

CYANOBACTERIA USED AS BIOFERTILIZER

Cyanobacteria play an important role in maintenance and build up of soil fertility, consequently increasing rice growth and yield as a natural biofertilizer (Song *et al.*, 2005). The acts of these algae include: (1) Increase in soil pores with having filamentous structure and production of adhesive substances. (2) Excretion of growth-promoting substances such as hormones (auxin, gibberellin), vitamins, amino acids (Roger and Reynaud 1982, Rodriguez *et al.*, 2006). (3) Increase in water holding capacity through their jelly structure (Roger and Reynaud 1982). (4) Increase in soil biomass after their death and decomposition (Saadatnia and Riahi, 2009) (5) Decrease in soil salinity (Saadatnia and Riahi, 2009) (6) Preventing weeds growth (Saadatnia and Riahi, 2009) (7) Increase in soil phosphate by excretion of organic acids (Wilson 2006).

Cyanobacteria or Blue green algae (BGA) are a group of microorganism that can fix the atmospheric nitrogen. BGA can adapt to various soil types and environment which has made it cosmopolitan in distribution. Efficient nitrogen fixing strain like *Nostoc linkia, Anabaena variabilis, Aulosira fertilisima, Calothrix sp., Tolypothrix sp., and Scytonema sp.* were identified from various agro-ecological regions and utilized for rice production (Prasad and Prasad, 2001).

After water, nitrogen is the second limiting factor for plant growth in many fields and deficiency of this element is met by fertilizers (Malik *et al.*, 2001). Cyanobacteria play an important role in maintenance and build-up of soil fertility, consequently increasing rice growth and yield as a natural biofertilizer (Song *et al.*, 2005). Blue green algae (BGA) are photosynthetic nitrogen fixers and are free living. They are found in abundance in India. They too add growth promoting substances including vitamin B12, improve the soil's aeration and water holding capacity and add to biomass when decomposed after life cycle. *Azolla* is an aquatic fern found in small and shallow water bodies and in rice fields. It has symbiotic relation with BGA and can help rice or other crops through dual cropping or green manuring of soil. They manufacture their food by photosynthesis, as they have chloroplasts. Hence, they can live independently. Heterocystous nitrogen-fixing blue-green algae consist of filaments containing two types of cells: the heterocysts, responsible for ammonia synthesis, and vegetative cells, which exhibit normal photosynthesis and reproductive growth. Cyanobacteria are capable of abating various kinds of pollutants and have advantages as potential biodegrading organisms (Subramanian and Uma, 1996).

ALGAL PRODUCTION TECHNOLOGY

The success of any technology usually depends upon its techno-economic feasibility. The algal production technology developed and reported by different Algologists is very simple in operation and easy in adaptability by Indian farmers. The technology has got potential to provide an additional income from the sale of algal biofertilizer. In general, there are four methods of algal production have been reported viz, (a) trough or tank method, (b) pit method, (c) field method and (d) nursery cum algal production method.

The former two methods are essentially for individual farmers and latter two are for bulk production on a commercial scale.

Trough Method

1. Prepare shallow trays (2m x 1m x 23 cm) of galvanised iron sheet or permanent tank. The size of the tank can be increased if more material is to be produced. Spread 4 to 5 kg of river soil and mix well with 100g of superphosphate and 2 g Sodium molubdate.
2. Pour 5 to 15 cm of water in the trays. This will depend upon local conditions i.e. rate of evaporation. Mix the ingredients properly.
3. In order to avoid the nuisance of mosquitoes and insects add 10 to 15 g Furadon granules or malathion, or any other suitable granules.
4. The mixture of soil and water will settle within 8–10 hours. At this time, add 200 to 250 g mother culture of blue green algae to the surface of water. Then don't disturb water.
5. The reaction of the soil should be neutral. If the soil is acidic then add $CaCo_3$ in order to bring the pH of the soil to neutral.
6. If sunlight and temperature are normal then within 10–15 days the growth of the blue green algae will look hard flakes on the surface of the water/soil. Similarly, water level will be reduced due to evaporation.
7. This way water in the tray/pit is allowed to evaporate and the growth of the algae flakes is allowed to dry.
8. If soil is dried the algal growth is separated from soil. These pieces of algal growth are collected and stored in

plastic bags. In this way from one sq.m.tray or/pit about half tonnes kg blue green algal growth is obtained.

9. Again add water to trays and stair the soil well. Then allow the algae to grow in this way. This time it is not necessary to add mother culture of algae or superphosphate. In this manner one can harvest growth of algae 2–3 times. After this effect of superphosphate and soil is reduced.

Pit Method

This method of production of blue green algae does not differ from the one described above i.e. trough method. Instead of troughs or tanks pits are dug in the ground and layered with thick polythene sheet to hold the water or one half cement plastered tanks. Other procedure is the same as in the trough method. This method is easy and less expensive to operate by small farmers.

Field Scale Method

The field scale production of blue green algae is really a scaled up operation of trough method to produce the material on a commercial scale. This type of method of algal production is more common amongst farmers of south India.

1. Demarcate the area in the field for algal production: The suggested area is $40m^2$. No special preparation is necessary although algal production is envisaged immediately after crop harvest, the stubble is to be removed and if the soil is loamy it should be well puddled to facilitate water logging conditions.
2. Prepare a bund with earth so as to store the water.
3. Flood the area with water to a depth of 2.5cm. In trough or pit methods flooding is done only in the beginning, while in field scale method flooding is repeatedly needed to keep the water standing.

4. Then apply superphosphate 12kg/40m^2.
5. To control the insect-pests attach, apply carbofuran (3% granules) or Furadon 250g 40m^2.
6. If the field has received previously algal application for at least two consecutive cropping seasons no fresh algal application is required. Otherwise apply the composite algal culture of 5kg/40m^2.
7. In clayey soils, good growth of algae takes place in about two weeks in clear, sunny weather, while in loamy soils it takes three to four weeks.
8. Once the algae have grown and formed floating mats they are allowed to dry in the sun in the field and the dried algal flake, are then collected in sunny bags for further use.
9. One can continually harvest algal growth from the same area by reflooding the plot and applying super phosphate and pesticides. In such situations an addition of algal innoculum for subsequent production is not necessary.
10. During summer months (April-June), the average yield of algae per harvest ranges from 16–30kg/40m^2.

Nursery Cum Algal Production

Farmers can produce algae alongwith seedlings in their nurseries. If 320m^2 of land are allotted to prepare a nursery, an additional 40m^2 alongside can be prepared for algal production as described above. By the time rice seedlings are ready for transplantation about 15–20 kg of algal material will be available. This much quantity of algal mass will be sufficient to inoculate one and half hectares of area. If every farmer produces the algal material required to inoculate his own land then he will reduce the cost of algal innoculum required to be purchased. So also one can cut the cost of chemical fertilizers to be applied as recommended.

RECOMMENDATION OF BGA FOR FIELD APPLICATION

1. If mineral nitrogen fertilizers are not used, apply blue green algae biofertilizer in order to gain the benefits of 30–40 kg Nitrogen/ha.
2. Broadcast the dry algal material over the standing water in the rice field at a rate of 10–15kg/ha one week after transplanting the seedlings.
3. Addition of excess algal material is not harmful and will accelerate the multiplication and establishment in the field.
4. The sun dried algal material can be stored for a long time in a dry state without any loss in viability.
5. Do not store the algal material in direct contact with chemical fertilizers or other chemicals.
6. Apply algae for atleast three consecutive seasons so that there will be sufficient algal innoculum found in the field.
7. Recommended pest control measures and other management practices don't interfere with the establishment and activity of algae in the field.

CONCLUSION

Biofertilizers have various benefits. Besides accessing nutrients, for current intake as well as residual, different biofertilizers also provide growth-promoting factors to plants and some have been successfully facilitating composting and effective recycling of solid wastes. By controlling soil borne diseases and improving the soil health and soil properties these organisms help not only in saving, but also in effectively utilizing chemical fertilizers and result in higher yield rates. Cyanobacteria play a spectrum of remarkable roles in the field

of biofertilizer, energy production, human food, animal feed, polysaccharides, biochemical, pharmaceutical and changing up of the environment, etc. The cyanobacteria provide inexpensive nitrogen to plants besides increasing crop yield by making the soil fertile and productive. BGA biofertilizer in rice popularly known as 'Algalization' helps in creating an environment friendly agro-ecosystem that ensures economic viability in paddy cultivation while saving energy intensive inputs. Cyanobacterial fertilizer also helps in the stabilization of soil, add organic matter, release growth promoting substances, improve the physico-chemical properties of soil and solubilize the insoluble phosphates. The technology can be easily adopted by farmers for multiplication at their own level.

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