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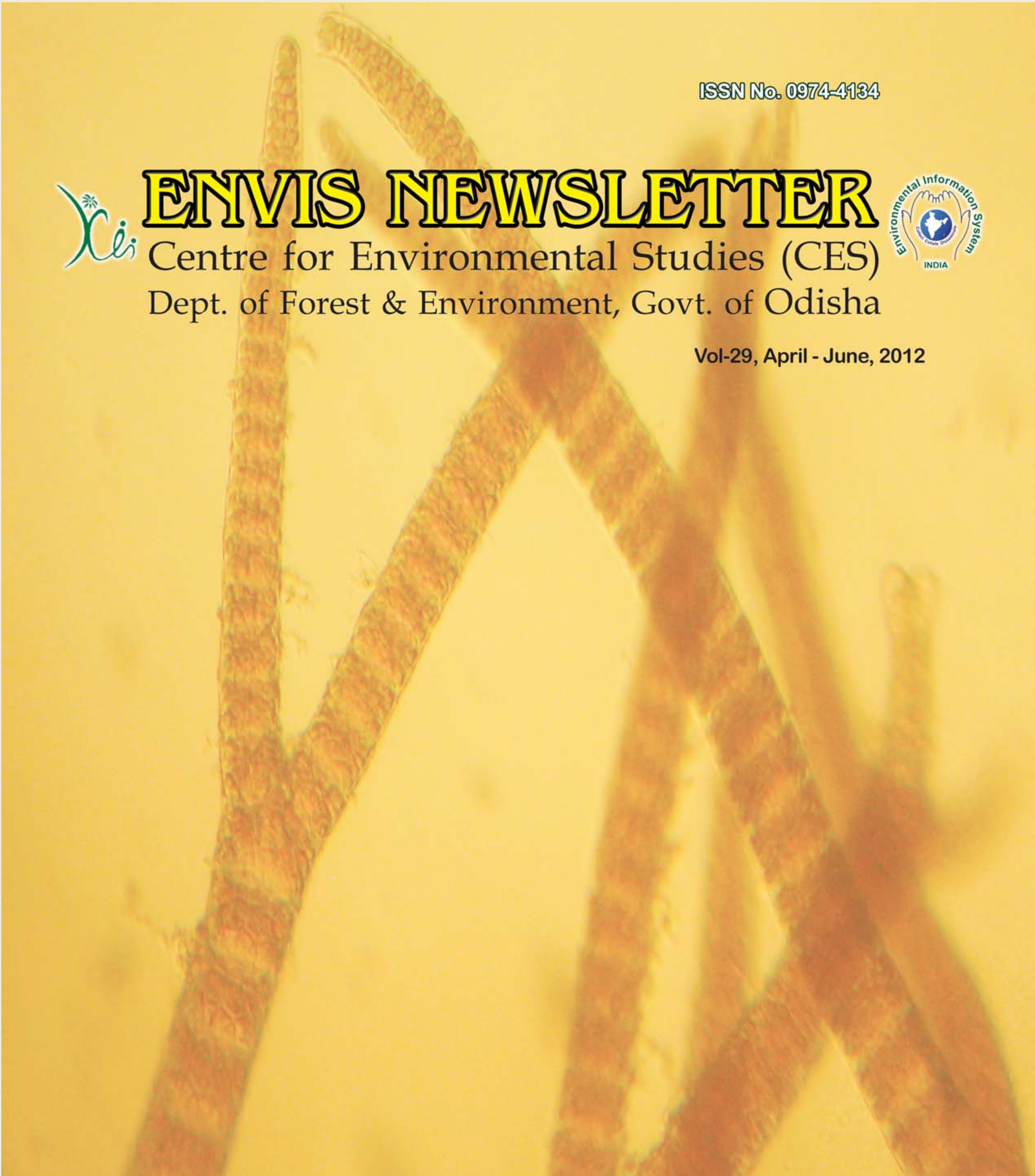

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From the Director's Desk...

Dissemination of information on various issues related to environment of the State is the main objective of establishment of our ENVIS Centre. We have discussed on various issues in our earlier publications. In this issue we have focused on one of the important topic "**Role of Biofertilizers for socio-economic upliftment of farmers community**".

I hope this issue of Newsletter will be useful for various planners, decision makers, scientists, environmentalists, researchers, academicians and other stake holders.

Dr. Sailabala Padhi , M.Phil, Ph.D., D.Sc.
Director, Centre for Environmental Studies

Role of Biofertilizers for socio-economic upliftment of farmers community

Sustainable Agriculture

The close interaction between agriculture and environment, thus calls for promoting sustainable agricultures, which should lead to increased farm productivity while ensuring that risks to the environment are minimized. Odisha is a predominantly agricultural country and more than 80 percent of population depends directly upon agriculture. Our farming community is still outside the purview of modern high energy input agriculture. Developing alternate pathways for sustainable agriculture thus becomes critical for sustainable rural development in the state.

Sustainable agriculture can best be defined as an environmentally safe agro-system that guarantees economic viability on long term basis. Algal farming is a revolutionary step in agriculture. Applying biotechnological methods in several algal farms, various algae have been grown on a very large scale. One of the oldest use of algae in India and abroad is that of algal biofertilizers. It enhanced the crop yield of all the cereals, especially in case of rice crops. Algal fertilizers add both carbon and nitrogen, which help in maintaining the productivity of the soil. Over and above all these algal fertilizers are comparatively much cheaper.

Adequate supply of plant nutrients is necessary for proper growth of crop plants. Nitrogen and phosphorus are the most important among nutrients. Generally they are supplied to crops by applying manures and fertilizers in the soil.

In nature there are certain micro-organisms and minute plants which can absorb gaseous nitrogen directly from the atmosphere and make it available to the plants. Similarly others can convert unavailable forms of phosphorus compounds in the soil into forms available to the plants. They can be identified, multiplied in the laboratories and introduced into root zone of crop plants to supply nitrogen and phosphorus. Materials containing such organisms are called biofertilizers.

Organic agriculture

Organic agriculture is known under various names such as "green culture", "natural farming", "do-nothing farming" etc. The high demand for organic produce by the present-day health conscious society gave further momentum to the organic movement and eventually sporadic attempts have been made by farmers all over the world to detoxify the land dispense with chemically fertilizers, pesticides, fungicides and herbicides and grow crops organically.

Panchagavya - A Vedic Formulation for biofertilizer potential

Basically panchagavya is considered as a living elixir of many microorganism, micronutrients, trace elements, antioxidants, immunity enhancing factors, known and unknown growth promoting factors. Field application of panchagavya have been claimed by farmers in Tamilnadu to have beneficial effects on various commercial crops. Panchagavya is believed to stimulate and promote plant growth and inhibit disease pests. Panchagavya has a potential not only in agriculture but also plays a vital role in animal and human health care.

Components of Biofertilizers

Biofertilizers are basically composed of two components: micro-organisms and carriers

A. Micro-Organisms

A number of micro-organisms fix atmospheric nitrogen or solubilize soil phosphorus. These are isolated and multiplied in laboratories providing suitable nutrient medium. This medium along with the multiplied micro-organisms is later mixed with another component called carrier.

B. Carrier

Carrier is the bulky component of a biofertilizer which preserves the micro-organisms alive till they are applied. Micro-organisms in their original nutrient medium are too concentrated to be applied uniformly. Carriers dilute this concentration and make uniform application possible. Carriers also provide sufficient nutrients to the micro-organisms for their survival. However, as long as they are in the carrier their physiological activities are minimum (dormant stage) and they require very little nutrients to fulfill their energy requirement. Gypsum, peat, muck and very fine textured soil are the common carriers used for preparation of biofertilizers.

Types of Bio-fertilizers

Depending on the nutrients they supply, biofertilizers are grouped into two broad categories: nitrogen supplying biofertilizers and phosphorus supplying biofertilizers.

A. Nitrogen supplying biofertilizers

Before discussing the nitrogen supplying biofertilizers it is important to know the processes of nitrogen fixation in nature.

Among the 17 plant nutrients, nitrogen is the most required nutrient by the plants and it is absorbed by the plants from soil. On the other hand, nitrogen is often deficient in the soil especially in the tropical countries. The atmospheric air has 78% nitrogen and it is estimated that the air volume above one acre land area contains 35,000 tonnes of nitrogen. However, plants cannot use this gaseous form of nitrogen. They can use nitrogen only in solid forms such as nitrates, nitrites and ammonium compounds. Conservations of gaseous form of nitrogen into solid form is called nitrogen fixation which may be natural or artificial.

Nitrogen is fixed through various processes in nature itself. Some amount of atmospheric nitrogen is fixed during lightning. This dissolves in rain water and comes down to the earth. A large amount of nitrogen is also fixed by organisms living in the soil or inside the plant roots like bacteria and algae and by some minute plants like azolla. They directly absorb gaseous nitrogen from atmosphere and convert it into solid structural component of their own body. This component is called protein. When these organisms and plants die, their body is decomposed and protein is degraded into very simple form of nitrogenous compounds which can be utilized by the crop plants

Fixing of nitrogen into chemical fertilizers in factories is known as artificial nitrogen fixation. The common forms of artificially fixed nitrogen are urea, ammonium sulphate, ammonium nitrate, diammonium phosphate and ammonium chloride. Use of these fertilizers is expensive for poor farmers. Hence application of biofertilizers is recommended to them as a substitute to a limited extent

The following are some of the bio-fertilizers used in our country as nitrogen supplying biofertilizers and are named after the micro organisms they contain

1. Rhizobium

Rhizobium refers to a number of strains (varities) of symbiotic bacteria that reside inside the root nodules of pulse or legume crops and fix atmospheric nitrogen. Hence they are used for supplying nitrogen to pulse crops. Biofertilizers containing rhizobium bacteria are called rhizobium biofertilizer culture. For different kinds of pulse crops, different kinds of rhizobium biofertilizers are used and are available in separate packets

Rhizobium in nodules of leguminous plants

a. Methods of Application

One packet of rhizobial culture is enough for treating seeds sown in one acre. The following procedure is adopted for the effective application of rhizobial culture on seeds;

i. dissolve 100-150 gm jaggery in half a litre water;
ii. boil the content till a thick solution is obtained ;
iii. allow the solution to cool to room temperature;
iv. add 100gm gum into the cooled solution and mix well;
v. add one packet of rhizobium culture and mix thoroughly;
vi. mix the required seed for one acre with the prepared culture thoroughly so that each seed is coated with a thin film of bacterial culture; and
vii. spread the treated seed on a non absorbent and clean surface under the shade for drying at room temperature.

The seeds fully dried are ready for sowing. If the seeds are to be shown in alkali soils, they should be treated again with gypsum so that the seed gets a coating of gypsum before it dries up completely.

b. Precautions

Certain precautions are to be taken to ensure greater effectiveness of rhizobial culture;

i. treat the seed within 24 hours prior to sowing. If this is not possible, seed can be treated earlier but not more than a week before sowing;

ii. store the culture packets in cool and dry place and protect them from direct sun light;

iii. use the culture within expiry period (Six months from the date of manufacturing. Otherwise, the population of living bacterial cells will go down below the permissible limit of 108/gm culture);

iv. inoculate the seeds in shade or during night;

v. sow the treated seeds as early as possible;

vi. use the whole content of the packet immediately after it is opened; and

vii. avoid inoculated seeds from coming in direct contact with fertilizers and insecticides.

2. Actinorhizae

Actinorhizae is a symbiotic nitrogen fixer also called Frankia. Like rhizobium in leguminous plants, actinorhizae produce nodules in non-leguminous trees and shrubs. Although scientists have succeeded in preparing the culture of this biofertilizer, it is not available in the market. Experiments have shown that actinorhizae can fix atmospheric nitrogen in the soil up to the extent of 150 kg nitrogen per hectare.

3. Azotobacter

Azotobacter is a non-symbiotic bacterium that fixes nitrogen and is sold in packets under the name azotobacterin or azotobacter inoculum. Crops other than legumes can benefit from azotobacter. Several experiments have shown that application of azotobacter significantly increases the yield (by 2-23%) in wheat, onion , brinjal, cabbage, tomato, oat, barley, maize and potato. The effectiveness of azotobacter is greater if that the soil is rich in organic matter, well aerated and neutral in reaction. Azotobacter culture can be used to enrich the compost manure in aerobic compost making.

a. Methods of application

Azotobacter inoculum is applied to seeds in the same way as described in the case of rhizobium. Seedings are treated by dipping in a slurry of culture in water.

While applying to compost, the packets are torn open and the contents are spread evenly over each layer of composting material.

b. Precautions

To maximize the response from azotobacter, the following points should be kept in mind;

i. incorporate plenty of organic matter in the soil;

ii. acidic soils should be neutralized (by appyling lime) before its application as azotobacter is very sensitive to acidic condition;

iii. adequate moisture should be present in the soil; and

iv. as far as possible use of azotobacter treated seeds should be accompanied by application of phosphatic and potassic fertilizers in the field.

4. Azospirillum

Azospirillum is a non-symbiotic bacteria that can fix nitrogen independently in the soil. This is available in packets similar to rhizobium. This biofertilizer is particularly suited to grass family crops such as maize, jawar, bajar, ragi and sugar cane.

A packet of this bio-fertilizer (200gm) is sufficient for the treatment of seeds required for one acre. A slurry of the biofertilizer in water and gum is sprinkled over the seeds and mixed thoroughly so that each seed is coated with a thin film of slurry. Seeds are dried on a clean and non-absorbent surface under the shade and sown without delay. In the case of transplanted rice, seedlings are dipped for 10 minutes in the slurry of inoculum before transplanting. To treat sugar cane four packets are dissolved in 15-20 litres of water and sugar cane sets are dipped in it for 10 minutes before planting.

5. Azolla

Azolla is a small aquatic fern with a branched stem and bilobed leaves. The roots that emerge from the stem help the plants to float in water. It is generally found on stagnant water. There is a small cavity on the upper most part of the leaf which houses as many as 80,000 blue green algae belonging to *Anabaena azollae* species.These blue green algae have the capacity to fix atmospheric nitrogen and make it available to azolla. In return the blue green algae sets shelter and food from azolla. Hence it is a symbiotic relationship between azolla fern and blue green algae. When the plant dies and decays in the soil, nitrogen becomes available to plants.

Azolla can double its body weight in 3-5 days. In 3-4 weaks, 5-10 tonnes of biomass can be obtained from one hectare providing at least 30 kg nitrogen. Plant body analysis of azolla (dry weight basis) has shown that it contains 4.5% nitrogen (N), 2.6% phosphorus (P) and 0.9 potash (K). Besides NPK, azolla is a good source of secondary nutrients such as calcium, maganesium and sulphur.

Since it contains 16-24% protein, it can also be used in the production of cattle and poultry feed. The use of azolla in rice field at the rate of 200gm per square metre area can increase rice yield by 12-38%. Experiments have shown that application of 10 tonnes of fresh azolla biomass in one hectare, adds as much as 100kg nitrogen.

In rice fields a good growth of azolla can check weed growth as well. More than seven species of azolla have been identified so far. Azolla grows well in soils with less clay and more sand with an optimum pH ranging between 5-7 and temperature range of 20-30 degree C. Azolla can be dried and preserved for later use as manure. It has been estimated that 300 kg dry azolla is equivalent to 5 tonnes of green azolla.

a. Production of azolla culture

Azolla can be multiplied easily even by an ordinary farmer. There are mainly two methods of azolla multiplication: (I) standing water method and (II) nursery method.

i. Standing Water Method

Under this method, a pond or a field with shallow standing water is chosen. The depth of water required for azolla cultivation varies between 5-10 cms. For the rapid growth of azolla, application of super phosphate (4-8 kg P_2O_5/ha) is recommended. Azolla inoculum can be collected from ponds or tanks in which they are found faloating and can be introduced in standing water also. In three weeks time azolla multiplies to form a carpet on the water surface which can be collected and used immediately or dried and preserved for later use. The process is repeated to produce more azolla culture.

ii. Azolla Nurseries

Azolla is raised in small nursery plots of 50-100 square meter size with strong bunds all around so that water can be made to stand upto a height of 5-10 cm. However, in a newly constructed nursery plot retaining water is a problem due to high percolation rate. To control this, pudding (as done in the paddy field) can be adopted. Percolation can also be controlled by compacting the soil. Plastering the bottom and side with a mixture of cowdung and fine clay is yet another effective method of controlling percolation. Permanent azolla nurseries can be constructed with brick and cement. Percolation can be controlled by spreading polythene sheets at the bottom of the nursery beds. Small nursery beds are advantageous campared to large plots as wind causes drifting of azolla towards one side in large plots.

When the plots are prepared and sufficient amount of water is filled inside, super phosphate (4-8kg P_2O_5 per ha) should be applied before introducing the azolla inoculum. Azolla inoculum consists of azolla plants , (full or parts) and spores. Azolla can be multiplied easily through any broken part of the plant. Hence, production and use of spores for azolla multiplication has not been developed. For inoculating nursery beds fresh azolla are spread at the rate of 300-400gm per square metre. It can produce 8-10 tonnes of green biomass in 20days which can be controlled and applied in the field or dried and stored for later use.

b. Methods of application

Azolla can be applied in two ways : green manure form and dual crop form. Azolla is usually applied in rice fields in both ways.

i. Green manured of azolla

In this method, azolla biomass is incorporated into the field prior to rice plantation. It can be either grown in the same field before transplanting rice or grown in nursery beds and then transported and incorporated into the fields by pudding Azolla, when incorporated into the soil, decomposes rapidly within 7-10 days. However, nitrogen availability extends from one week to ten weeks. Experiments have shown that 34% of the total nitrogen is available two weeks after incorporation, 63% after 4 weeks, 76% after 6 weeks and 85% after 8 weeks. Application of azolla in the green form produces better results than dry form.

ii. Dual cropping with rice

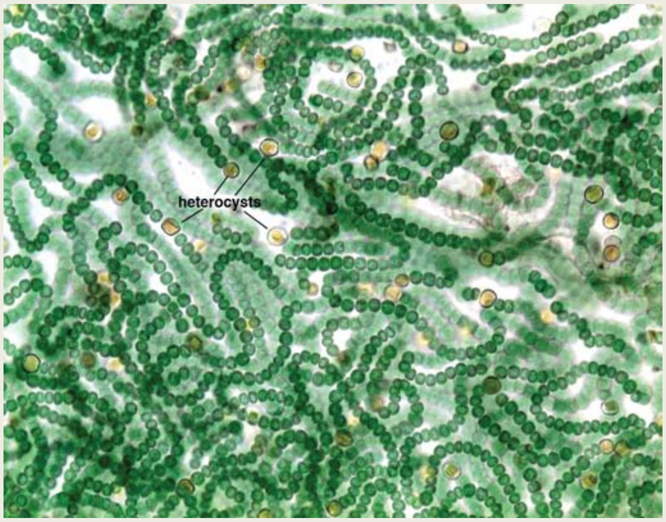
This method involves growing azolla along with rice crop. One week after planting of rice seedling, fresh azolla at the rate of 200-300 gm per square metre should be applied in standing crops. Azolla biomass is formed in three weeks. Water is drained out and azolla is incorporated into the soil using implements.

c. Preservation inoculum

Azolla does not thrive under adverse conditions; extreme cold or heat. But it can be preserved even under such adverse conditions in very slow moving water bodies such as streams, canals, sewage channels, small ponds tanks and unused wells. They are known as inoculum banks. The optimum temperature for azolla ranges between 15-35 degree C.

6. Blue green algae

Algae can be seen growing around the mouths of well as greenish, sliding moss sticking to the bricks and pucca floor. It mostly grows in wet places. Hot and moist weather regions are congenial for algae growth. Blue green algae, besides fixing nitrogen, carry out photosynthesis and secrete certain growth hormones (Vitamin B_{12}, auxins and ascorboic acid) which are beneficial to rice plants. The use of blue green algae is confined only to rice crop.



Various experiments have proved that the use of algae increases the rice yield by 10-15%. It is estimated that in general blue green algae supply about 30-40 kg of nitrogen per hectare to paddy crop. Blue green algae has also shown its effectiveness in improving saline and alkaline soils.

a. Multiplication of algae

One hectare of paddy crop requires 10-15 kg or 50-75 packets (200gms each) of blue algae culture. Therefore, it is advisable to purchase one packet and use it to multiply the culture at home. The following procedure can be adopted for multiplication of blue green algae:

i. dig a pit of 1.83 m length, 0.92 width and 25 cm depth (6"x3"x10") on a leveled but slightly elevated and sunny site protected from animals and children;
ii. the sides are made sloppy towards the pit bed;
iii. the bottom of the pit is levelled well and the sides made straight and smooth;
iv. spread a polythene sheet in the pit stretching the edges 2-3 inches beyond the boundary where it should fixed with stones or soil to keep it in position;
v. about 10 kg of soil free from stones, pebbles and roots (preferably sieved soils) is spread over the polythene sheet. This soil should be neither acidic nor alkaline;
vi. about 200 gms of super phosphate is also spread over the soil;
vii. the pits is gently filled with water up to a height of 10 cm above the soil level;
viii. if available, 2-10 gm sodium ammonium molybdate and 1-2 drops of malathion insecticide is applied to ensure better growth and protection of algae culture;

ix. the contents of the pit is stirred gently using a wooden stick with round and smooth edges to avoid tearing of the polythene sheet ;

x. the soil is allowed to settle down at the bottom of the pit;

xi. saw dust is spread over the water uniformly as it would provide some sort of an anchorage for the germinating algal spores;

xii. sprinkle blue green alga culture uniformly over the water;

xiii. the pit is protected against domestic animals, frogs and children and the water level has to be maintained at the optimum height (10 cm);

xiv. after 4-5 days algal growth is noticed, and it covers the entire water surface in 15-18 days and forms a thick layer.

xv. when algal growth is completed, water is drained out to allow the algal layer to dry;

xvi. the dry algal layer sticking to the pit bed soil is scratched out along with a soil layer avoiding any damage to the polythene sheet;

xvii. repeat all the steps from adding water to harvesting of dry algal culture for second or third harvests;

xviii. the soil in the pit is changed after three harvests; and

xix. repeat the procedure till sufficient quantity of algal culture is produced.

About 1.5 to 2 kg algal culture can be harvested in one harvesting from one pit. After drying in the sun, powder the culture and store in polythene bags in cool and dry place for 2-3 years. Blue green algae should be multiplied in summer as it does not thrive well in cold season.

b. Precautions

The following precautions are taken while preparing the algal culture ;

i. the pit should be protected against animals, children, frogs and other predators;

ii. the polythene sheet should be intact;

iii. avoid shading over the pits;

iv. avoid flooding of the pit at raining; and

v. avoid winter months of multiplication.

c. Application in rice fields

Apply algal culture in the rice field at the rate of 10-15 kg per hectare . It should be applied in standing water just after transplanting and do not allow the culture to flow out of the field. Water level in the field is maintained always around 8-10 cm height. Generally algae grows fully and covers the whole field within 15-20 days time. After draining out the water algae may be incorporated into the soil through various intercultural operations. This practice will enhance repeated multiplication of the algae.

B. Phosphorus solubilizing biofertilizers

Phosphorus is next to nitrogen among the elements required by plants. Sometimes soil is not deficient in phosphorus but its availability to the plants is extremely low. Most of the phosphorus applied to the soil remains insoluble and unavailable to plants. This is called phosphorus fixation in the soil. Plants hardly utilize more than 20%of the total phosphorus applied. But, a number of micro-organisms belonging to bacteria and fungi group can solubilize the fixed phosphorus and make it available to the plant.

Two such groups of organisms have been identified: phosphobacterium group and mycorrhizal fungi group.The biofertilizers containg these organisms are named after them. Phosphobacterin is phosphatic biofertilizer which contains phosphobacterium group of bacteria. Similarly, mycorrhizal biofertilizer contains mycorrhizl fungal group.

1. Phosphobacteria

Like rhizobium, this biofertilizer is also sold in polythene packets. It contains a bacterium namely Bacillus megatherium in large number (108 bacterial cells per gram biofertilizer). This bacterium can convert native unavailable form of phosphorus into available form by solubilizing it. Application of rockphosphate into the field followed by sowing phosphobacterin treated seeds increases the absorption of applied phosphorus by plant roots. Positive results of phosphobacterin inoculation has been shown on many legume and cereal crops. Application of phosphobacterin along with azotobactor in compost pits has been found to improve nutritive value of compost. This biofertilizer is applied through seed treatment like rhizobium.

2. Mycorrhiza

Mycorrhiza is a root fungus that can enhance phosphorus absorption. Technically feasible and economically viable method should be evolved to prepare it artificial culture. A lot of research is still going on to bring it out in biofertilizer form.

Advantages of Biofertilizers

There are a number of advantages in using biofertilizers. The following are the main among them and are briefly explained.

A. Cheap source of nutrients

Bio-fertilizers can be called poor man's technology. Taking in to account the amount of nutrient supplied, bio-fertilizers are many times cheaper than chemical fertilizers. In an experiment conducted in Tamil Nadu, it was found that supplying 25 kg nitrogen by chemical fertilizers costs Rs 180 per hectare whereas blue green algae cost only Rs 54/-. If farmers themselves produce blue green algae culture, the cost could be reduced further. Other experiments showed that spending Rs 30 in blue green algae application @ 10kg blue green algae per ha) resulted in an extra yield of paddy worth Rs. 500-700. One third of the total recommended dose of nitrogen for paddy crop can be reduced if blue green algae or azolla biofertilizer is applied. If the algal technology is introduced into even 50% of the rice growing area in India (20 m.ha), it will supply 800 million kg of nitrogen (at the rate of 40 kg/ha) which in terms of urea would cost Rs 417.6 crores.

B. Supplier of micronutrients

Biofertilizers not only supply nitrogen and phosphorus but also some micronutrients essential for plant growth. Sometimes yield is limited by micronutrients and application of nitrogenous, phosphatic and potassic fertilizer does not improve yield significantly. In this situation the application of bulky biofertilizers like blue green algae and azolla increases yield due to greater supply of micronutrient (nutrients required in minute amounts but essential for plant growth).

C. Supplier of organic matter

Organic matter is the essential component of soil. It serves as an inexhaustible source of nutrients and energy for the plants as well as for useful micro-organisms. Organic matter has great impact on the physical and chemical properties of the soil. Azolla and blue green algae produce on an average 8-10 tonnes of biomass per hectare which adds to the organic matter pool of the soil.

D. Counteracting negative impact of chemical fertilizers

When chemical fertilizers are exclusively and continuously used for a few years, they may create acidity or alkalinity in the soil and deteriorate the quality of the soil. Soil also becomes unresponsive to further use of similar fertilizers. Application of biofertilizers can avoid this problem to a great extent. Besides, large amount of organic matter supplied by the bio-fertilizers impart tolerance power (buffering capacity) to the soil against acidity or alkalinity. It also withholds metallic elements from entering the plant roots, thereby reducing harmful effects of pesticides.

E. Secretion of growth hormones

Plants also need for their growth and development, some natural complex chemical compounds called hormones. Though growing plants do not themselves synthesise hormones in adequate amounts, azotobactor blue green algae and azolla have been found to synthesise growth hormones (e.g. indolacetic acid and vitamin B) which benefit the main crop. Sometimes, biofertilizer application gives significant response even if the soil is already rich in plant nutrients. This occurs due to the supply of growth hormones by biofertilizers to the main crop.

Celebration of World Environment Day on 5th June 2012

On 5th June 2012, the Centre for Environmental Studies organized the World Environment Day function at Rabindra Mandap, Bhubaneswar on theme "Green Economy: Does it include you?". Shri Debi Prasad Mishra, Hon'ble Minister, Forest & Environment, Odisha was the Chief Guest, Shri Raj K. Sharma, IAS, Principal Secretary, Forest & Environment Department, Shri P.N. Padhi, IFS, PCCF, Odisha, Shri Bhanu Pratap Singh, IFS, Director, Environment-cum-Special Secretary and Dr. Sailabala Padhi, Director, Centre for Environmental Studies were present. Hon'ble Forest & Environment Minister of Odisha distributed "Prakruti Mitra" prizes to 231 organisations. An exhibition of the award winning drawings and paintings was organized. Also an exhibition on eco-models was organized. Students from eco-clubs of Angul, Balasore, Bargarh, Bolangir, Bhadrak, Boudh, Dhenkanal, Ganjam, Jagatsinghpur, Jajpur, Kalahandi, Kandhamal, Kendrapara, Khurda, Malkangiri, Mayurbhanj, Nabarangpur, Sambalpur and Sonepur participated in the exhibition. The exhibition was inaugurated by Director, Environment-cum-Special Secretary. Dignitaries from all departments, all officials from Environment Department, State Pollution Control Board, Chilika Development Authority, Regional Plant Resource Centre, students and general public attended this function.

Release of Book on "Climate Change Issues" by (L-R) Sj P.N. Padhi, IFS, PCCF, Odisha, Sj Raj K. Sharma, IAS, Principal Secretary, Forest & Environment Department, Sj Debi Prasad Mishra, Hon'ble Minister, Forest & Environment, Odisha, Sj Bhanu Pratap Singh, IFS, Director, Environment-cum-Special Secretary and Dr. Sailabala Padhi, Director, Centre for Environmental Studies on the occasion of World Environment Day-2012.

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