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Research Article

Ambrosia of Soil: Bio-Fertilizers, its Mechanism and their Role in Forest Trees

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ABSTRACT

In the present context, the best alternative of chemical fertilizer is necessary because of its adverse effects on the soil health. There are several alternatives available to enhance the soil fertility like Vermicompost, FYM (Farm-Yard Manure), Organic Fertilizers, Biofertilizers *viz.*, *Azotobacter*, *Azospirillum*, Phosphate Solubilizing Bacteria, *Rhizobium* and AM (Arbuscular Mycorrhizae) Fungi. They are free living N^{2-} fixer, Phosphate solubilizer diazotroph that has several beneficial effects on the crop growth, yield prevent to the disease. They are helps in synthesis of growth regulating substances like auxins, cytokinin and Gibberellic Acid (GA). In addition, it stimulates rhizospheric microbes, protects the plants from Phyto-pathogens, improves nutrient uptake and ultimately boost up biological nitrogen fixation. The abundance of these bacteria in soil is related to many factors, mostly soil pH and fertility. Bio fertilizers were tested against forest tree species.

Keywords: Biofertilizers; *Azotobacter*; Microflora; Nitrogen fixation; Soil sustainability

INTRODUCTION

Soil microflora (algae, bacteria, fungi, protozoa, and virus) are associated with many fundamental functions of soil such as soil fertility, nutrient cycling, and decomposition of inorganic and organic substances. The microflora of a soil is an intimate part of soil organic matter; in fact, much of the colloidal portion of humus consists of living and dead microbial cells or their disintegrating residues. The cooperation of higher plants with living microorganisms occurs most intensively and strikingly in the root zone. The area immediately surrounding a root, commonly referred to as the "rhizosphere", is the seat of intense biological activity. Most kinds of microorganisms thrive in this region, but usually it is the bacteria that are most responsive. Certain species are affected more than others, which mean that the composition of the microbial population in the rhizosphere may be markedly different from that of similar soil in which no plants are growing. The effect of the mass of microorganisms in contact with, or in extremely close proximity to, the plant roots and root hairs, varies widely. The products produced may be either beneficial or directly toxic. The organisms themselves may have little or no effect or they may be parasitic in or on the roots. At any one time, a condition of biological equilibrium or balance between the various groups of organism's present is likely to prevail. The soil organic matter or humus is primarily a biological one, in which nearly all of the flora and fauna living in or on the soil play a direct or indirect part. The decomposition and synthetic processes helps in soil organic matter formation. Soil organic matter formation is not wholly a degradation process. The microorganisms that are active in the decomposition of plant and animal residues are using a portion of these for the building of their own bodies that soon become a considerable portion of soil organic matter. This synthesized material contains the same elements as were in the source materials but may differ markedly from them in respect to both physical and chemical characteristics and in the proportion of the various elements present. The two fractions are so intermixed and the time involved in humus formation is so great that there seems to be little chance for a quantitative estimation of the two fractions, but the microbial portion is not small even if not recognizable as such.

MATERIALS AND METHODS

Healthy seeds of selected forestry species collected for conducting nursery experiment.

Potting medium

Potting medium used in the present study was a mixture of solar

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sterilized sand: soil: farmyard manure in the ratio 1:2:1. It were analyzed for physicochemical characteristics such as pH, Electrical Conductivity (EC), available Nitrogen (N), available Phosphorus (P), available Potassium (K) and micronutrients such as Copper (Cu), Zinc (Zn), Iron (Fe) and Manganese (Mn) following standard procedures.

Bio-fertilizers

Commercially available bio-fertilizers and Institute of Forest Genetics and Tree Breeding (IFGTB) developed bio-fertilizers such as AM fungi, *Azospirillum*, *Azotobacter*, Phosphobacteria and Potash Mobilizer for nursery application and testing their efficacy. Bio-fertilizers and Bio-control agents: Commercially available bio-fertilizers and Institute of Forest Genetics and Tree Breeding (IFGTB) developed bio-fertilizers such as AM fungi, *Azospirillum*, *Azotobacter*, Phosphobacteria and Potash Mobilizer (Tricho-K) and pathogenic organism (*Fusarium oxysporium*) for nursery application and testing their efficacy.

The following biometric observations were made on seedlings, selected at random from each treatment at 90 and 180 days after inoculation;

Shoot length: The length of the shoot were measured from collar region to tip of the shoot using a scale and expressed in centimetres (cm).

Root length: The seedlings were removed from poly bags without damaging the roots and the root length were measured from the collar region to the tip of the root and expressed in centimetres (cm).

Collar diameter: Collar diameters were measured using digital Vernier Calipers and expressed in millimetres (mm).

Shoot and root dry weights: The seedlings after recording all the above observations were separated into shoot and root. The shoot and root samples were dried at 85°C for 48 hours and the dry weights were recorded when the constant weights obtained and expressed in grams (g) per seedling.

Role and importance of soil micro-flora

Soil microorganisms (bacteria and fungi) are responsible for biomass decomposition, biogenic element circulation, which makes nutrients available to plants, biodegradation of impurities, and maintenance of soil structure [1]. The presence of microorganisms in soil depends on soils chemical composition, moisture, pH, and structure. Human activity has an indispensable influence on the formation of ecosystems. Soil microfauna and microflora have a major role in N cycling. Release of N from plant and animal residue depends on microbial activity. Soil bacteria utilize the more readily available, soluble, or degradable organic fractions. Microbes in the soil are directly tied to nutrient recycling especially carbon, nitrogen, phosphorus and sulphur. Bacteria are a major class of microorganisms that keep soils healthy and productive [2].

Fungi and actinomycetes decompose the resistant cellulose, hemicellulose, and lignin. Dung beetles, earthworms, and other soil fauna increase the decomposition rates of faces and plant litter by mixing them with soil. *Rhizobium* and Vesicular Carbuncular Mycorrhizae (VAM) associate with plant roots to fix Nitrogen (N) and increase nutrient and water scavenging ability, respectively. VAM infection of roots is considered more helpful for tap rooted pasture legume species than for fibrous rooted grasses. At any time, soil-microbial biomass contains much of the actively-cycling N of the soil and represents a relatively available N pool, capable of rapid turnover [3]. The energy flux through the Soil Microbial Biomass (SMB) drives the decomposition of organic residues and soil organic matter [4]. Plant root biomass and soil microbial processes are intimately linked in grassland systems as described by Reeder. If decomposition exceeds Carbon (C) in puts, the soil organic matter will decline. The resulting mineralization of N (and other nutrients) will result in their becoming vulnerable to possible losses into the environment by leaching, denitrification, or other mechanisms [5]. Because its levels are relatively stable for a particular soil/land-use system, even though the SMB pool is very active for nutrient cycling, SMB can serve as a measure (index) of the effects of agricultural management practices on soil quality. In their study, utilized 15 N labelled fertilizer and followed the N in the SMB fraction under no-till in a 4 years (winter wheat-sorghum-fallow-winter wheat) cropping sequence [6]. Their conclusion was that, under no-till, biological processes conserved the N by accumulation of crop residue carbon C and N near the soil surface, recycling of N through the crop-SMB system, and maintenance of N in organic forms.

The presence of *Azotobacter* spp. in soils has beneficial effects on plants, but the abundance of these bacteria is related to many factors, soil physic-chemical (e.g. organic matter, pH, temperature, soil moisture) and microbiological properties [7]. Its abundance varies as per the depth of the soil profile [8]. *Azotobacters* are much more abundant in the rhizosphere of plants than in the surrounding soil and that this abundance depends on the crop species (Figure 1) [9].

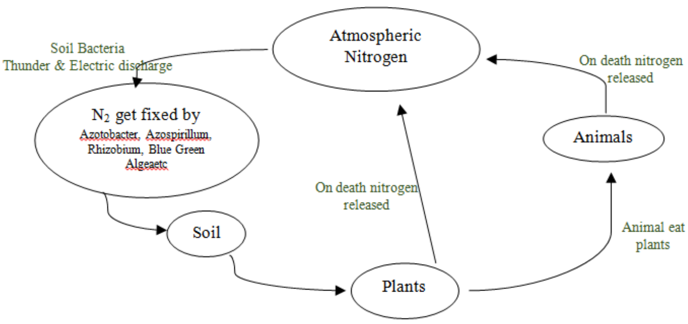

Figure 1: Nitrogen fixation from atmospheric nitrogen.

Nitrogen fixation

Nitrogen is the component of protein and nucleic acids and chlorophyll. Thus, nitrogen supply to the plant will influence the amount of protein, amino acids, protoplasm and chlorophyll formed. Therefore, adequate supply of nitrogen is necessary to achieve high yield potential in crop. The atmosphere comprises of ~78% nitrogen as an inert, in unavailable form. Above every hectare of ground there are ~80000 tons of this unavailable nitrogen. In order to be converted to available form it needs to be fixed through either the industrial process or through Biological Nitrogen Fixation (BNF). Without these nitrogen–fixers, life on this planet may be difficult. Nitrogen (N) deficiency is frequently a major limiting factor for crops production. Nitrogen is an essential plant nutrient, widely applied as N-fertilizer to improve yield of agriculturally important crops [10]. An interesting alternative to avoid or reduce the use of N-fertilizers could be the exploitation of Plant Growth Promoting Bacteria (PGPB) capable of enhancing growth and yield of many plant species, several of agronomic and ecological significance. *Azotobacter* sp. is non-symbiotic heterotrophic bacteria capable of fixing an average 20 kg N/ha/per year. Bacterization helps to improve plant growth and to increase soil nitrogen through nitrogen fixation by utilizing carbon for its metabolism [7,11].

Phosphorus (P) is sequestered by adsorption to the soil surface and precipitation reaction with soil cations, particularly iron, aluminium and calcium. Therefore, a large amount of P fertilizer has been used to increase plant growth, which is likely to cause negative impact in respects to both environment and economy. Insoluble phosphate compounds can be solubilized by organic acids and phosphatase enzymes produced by plants and microorganisms For example, *Pseudomonas fluoresces* have been shown to enhance the solubilization of insoluble P compounds through the release of organic acids and phosphatase enzymes (Figure 2) [12].

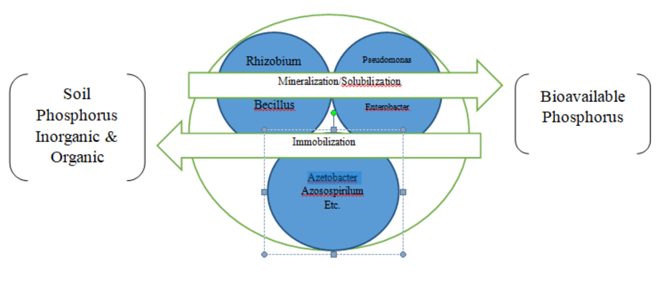

Figure 2: Phosphorus solubilizing bacteria.

Arbuscular Mycorrhizal Fungi (AMF) facilitate host plants to grow vigorously under stressful conditions by mediating a series of complex communication events between the plant and the fungus leading to enhanced photosynthetic rate and other gas exchange-related traits, as well as increased water uptake. Numerous reports describe improved resistance to a variety of stresses including drought, salinity, herbivory, temperature, metals, and diseases due to fungal symbiosis [13-15]. Nearly 90% of plant species including flowering plants, bryophytes, and ferns can develop interdependent connections with AMF [14,16]. AMF form vesicles, arbuscules, and hyphae in roots, and also spores and hyphae in the rhizosphere. Formation of hyphal network by the AMF with plant roots significantly enhances the access of roots to a large soil surface area, causing improvement in plant growth [17]. AMF improve plant nutrition by increasing the availability as well as translocation of various nutrients. AMF improve the quality of soil by influencing its structure and texture, and hence plant health [18,19]. Fungal hyphae can expedite the decomposition process of soil organic matter [20]. Furthermore, mycorrhizal fungi may affect atmospheric CO_2 fixation by host plants, by increasing "sink effect" and movement of photo-assimilates from the aerial parts to the roots.

An experiment carried out in the institutional lab and at divisions nursery at Jabalpur let long about the two sourced bio-fertilizers first one from Institute of Forest Genetics and Tree Breeding (IFGTB) Bio-fertilizer developed by Institute of forest Genetics and Tree Breeding Institute of Forest Genetics and Tree Breeding (IFGTB). Coimbatore and other one is commercially available bio fertilizers strains (*Azotobacter*, *Azospirillum*, Phosphorus solubilizing bacteria, Potash mobilizer and AM Fungi) to increase plant productivity and protect against the diseases in important forest trees *Dalbergia sissoo*, *Gmelina arborea* and *Santalum album*. During the experiment used 11 different treatment of different combination bio fertilizers with pathogen (*Fusarium oxysporium*), one was negative control and one was positive control. Design was CRD, five replications of each treatment and Plant/replication was nine. Recorded biometric observation like Shoot length, Root length, Collar diameter and Plant Height was recorded and graph was plotted respect to collected growth data (Figure 3).

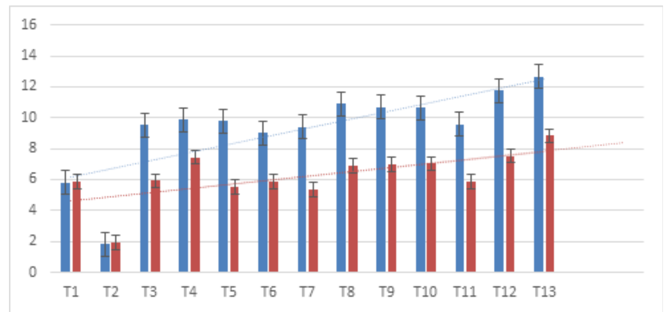

Figure 3: Graph showing comparison of bio-fertilizers. **Note:** (▬): IFGTB; (▬): Commercial; (⋯): Linear (IFGTB); (⋯): Linear (Commercial); T1: Positive control (Blank); T2: Negative control (FO); T3: AM+FO, T4: *Azospirillum*+FO; T5: *Azotobacter*+FO; T6: Poshphobacteria+FO; T7: Potash mobilizer+FO; T8: AM+*Azospirillum*+FO; T9: AM+*Azotobacter*+FO; T10: AM+Phosphobacteria+FO; T11: AM+Potash mobilizer+FO; T12: AM+*Azospirillum*+*Azotobacter*+Potashmobilizer+FO; T13: AM+*Azospirillum*+*Azotobacter*+Potashmobilizer+Potash mobilizer+FO.

RESULTS AND DISCUSSION

The comparison experiment shows that Institute of Forest Genetics and Tree Breeding (IFGTB) developed bio fertilizer are more efficient against pathogens than commercially available bio fertilizers in all the combinations as evident from the graphs. This may be due to presence of requisite number of infective propagule in IFGTB developed Bio fertilizers that commercially available bio fertilizers.

Bacteria are the smallest and hardiest microbe in the soil and can survive under harsh or changing soil conditions. Bacteria are only 20%-30% efficient at recycling carbon, have a high N content (10% to 30% N, 3-10 C:N ratio), a lower C content, and a short life span. There are basically four functional soil bacteria groups including decomposers, mutualists, pathogens and lithotrophs (chemoautotrophs). Decomposer bacteria consume simple sugars and simple carbon compounds, while mutualistic bacteria form partnerships with plants including the nitrogen-fixing bacteria (Rhizobia, *Azotobacter*, *Azospirillum* etc) [21,22].

CONCLUSION

Bacteria can also become pathogens to plants and lithotrophic bacteria convert nitrogen, sulphur, or other nutrients for energy and are important in nitrogen cycling and pollution degradation. Actinomycetes are classified as bacteria but are very similar to fungus and decompose recalcitrant (hard to decompose) organic compounds. Bacteria have the ability to adapt to many different soil microenvironments (wet vs. dry, well oxygenated vs. low oxygen). They also have the ability to alter the soil environment to benefit certain plant communities as soil conditions change.

The majority of agriculture, crop plant and forest plant have been found to be positively affected by the association with rhizospheric microorganisms under phosphorus-deficient conditions. This association could result either in improved uptake of the available phosphates or rendering unavailable phosphorus sources accessible to the plant. Arbuscular Mycorrhizae (AM) belongs to the former category, while the latter category includes numerous bacteria and fungi capable of solubilizing insoluble mineral phosphate. In the present section, an attempt is made to identify such natural phosphate-solubilizing organisms.

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