

REVIEW ARTICLE

**Subject:** Chemical and Bio Engineering

## Status of fertilizer application with a unique focus on biofertilizer in the land of Ethiopia

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### ABSTRACT

This review aims at the explanation of the status of biofertilizer and the available strategies adopted in the application for biofertilizer in the soil for the rejuvenation of the same and increased crop yield in the context of Ethiopia. Ethiopia is the second most populated country in Africa with about 80 million inhabitants. Soil fertility, which is the combination of physical and chemical properties of the soil and soil health, which is the soil fertility plus soil biology should be clearly distinguished. The fundamental opinion of soil fertility management is to “nurture the plant”, and the soil health management is to “foster the soil and not the plant”.

## 1. Introduction

Agriculture is the most significant basis of living practiced by 80% of the Ethiopian population. Subsistence farming, which can lodge increased crop production and soil protection is the backbone of the country's economy. The intense use of rehabilitation and sustainable management system are critical. Research has indicated many promising possibilities for the introduction of biofertilizer into the cropping systems by the adoption of various technologies. The technologies deliver enormous benefits through the thoughtful use of biofertilizer.

Biofertilizers are solely responsible for the increase in the fertility of the soil. By natural processes, they add the nutrients and fix the atmospheric nitrogen. They are responsible for the solubilization of the phosphate. They promote nutrient mobilization and the synthesis of growth promoting substances.[1] They can be grouped in different ways based on their nature and function. Most biofertilizers are produced from microorganisms such as Rhizobium, Azotobacter, Azospirillum, and phosphate solubilising bacteria. Other types include mycorrhizal biofertilizers, potassium mobilizing biofertilizers, and zinc solubilizing biofertilizers. The use of biofertilizers offers economic and ecological benefits by way of soil health improvement and fertility. This standard is in line with the fertilizer policy of Ethiopia, which aims at appropriately tested biofertilizers, providing certified products to farmers, manufacture quality biofertilizers, safe use and promote fair trade.

## 2. Overview of Biofertilizers

Biofertilizers are necessarily living organisms, which are first seed-dressed, then sown, and then applied to the soil.

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They promote the advantages by colonizing the rhizosphere of the plant, which it carries out by increasing the supply of nutrients to the plant. Inoculants are microbial cultures with beneficial microorganisms. They are applied to the seed or the soil. They may be in the form of liquid or solid. Carrier materials are the supports for the inoculants. Their main purpose is to ensure the viability of the inoculants until they are applied to the crops. Nodules are critical during the biofertilizer application. They are characterized by the soft outgrowths significantly on the roots or stems of the leguminous plants. This process confirms the conversion of the atmospheric nitrogen to ammonia by the microorganisms. The microbial action makes the non-available form of the nutrients into available forms, by a process called as the solubilization.[2] The effectiveness of the application of biofertilizers could be measured in terms of plant vegetative performance, dry mass or economic yield. Lot refers to a single consignment of type of material belonging to the same batch of manufacture. Batch refers to the inoculant prepared from a group of flasks/ fermentor. The host is the plant that harbor the useful microorganisms.

To reap the effects of the biofertilizer, they should contain competent, persistent and effective strains, within the applicable minimum microbial population of the single or microbial consortium with no cross strain contamination.[8] They should have properties which include, the exclusion of pathogenic organisms and harmful carrier materials, with enhanced ability to fix atmospheric nitrogen, mineral solubilization, plant growth stimulation and sufficient tolerance to pests. In addition, they should be easily applicable in the fields with longer shelf-life. The carrier materials used the applications should be in the pH between 6.5-7.0, with a high moisture-holding capacity, susceptible to sterilization, free-flowing, devoid of toxic materials, with sufficient quantity of carbon, and free of contamination and also 100% of the carrier material particle should be well below the 150 $\mu$ m.

The biofertilizers should be packed in double packaging, plastic materials. The outer packing made up of the low-density polyethylene should be colored other than the black. The inner packing should be transparent, made up of high-density polyethylene and should be liable to steam sterilization. The package system should be very easy to use and handle. The net weight of inoculants per pack should be for a seed lot that covers a quarter of the hectare. Biofertilizers should be in a cool and dry place at a temperature of 15 °C to 30°C. During the transportation, direct sunlight, and rain should be avoided.[3] Labeling is very important in that, clear indication of product name, brand name, batch number, importer name and address, host, culture, lifespan, manufacture and expiry dates, net weight, applicability for soil types, storage and usage instructions, should be printed on the packaging material with a separate pamphlet holding the critical instructions. The sampling of the biofertilizers is based on the Carrier-based inoculants test, whereby the qualities including the pH, Moisture content, Viable number microorganism and the Plant infection method is given the priority. Symbiotic effectiveness characterization is important to measure the biomass and nitrogen accumulation capacity of the microorganism on the crop.

### **3. Soil and fertilizer**

The soil consists of rock, living things, organic matter, air, and water. Healthy soils

are characterized by hard surfaces, good structure, softness, well-arranged soil particles, excellent nutrient extraction characteristics, exceptional physical, chemical and biological functions. They possess water retaining and draining properties and promote root growth. They possess nitrogen, potassium, phosphorus, zinc, copper, iron, chlorine, manganese, molybdenum in balanced quantities with the desired range of acidity/alkalinity, no difficulty of salinity or sodicity.[4] Healthy soils are fertile and produce good yields of good quality crops. In addition to this, they are responsible for the carbon sequestration, climate regulation, decomposition, cycling of chemicals and nutrients, water purification and flood control. With soil degradation, crop yields fall, soil organic carbon is depleted, soil biodiversity decreases, the capacity to sequester carbon decreases, etc.

The chemical fertilizer could be classified into, single (add only one nutrient), straight (add two or three nutrients), complex fertilizers (add about five nutrients), blended (mechanically combined nutrients). The government has established blending companies in Mekele (Tigray Region), Bechu (Oromia Region), Bahir Dar (Amhara Region). But some disadvantages of chemical fertilizers in Ethiopia are its availability, geographic distribution, streamlined only for few crops, cost, application, combat extraordinary cases, rainfall variability, Lack of awareness, concerned about future productivity, and subsistence orientation. Organic fertilizers are preferred over the chemical fertilizers, as they are available in the local market, low cost, cause no pollution, positive impact on soil microbiology, and manage organic wastes. Some of the organic fertilizers are animal manure, Green manure, compost using the pile and pit method and vermin composting. Organic fertilizer application has barriers, including awareness, competition for resources, scale up, less research, application to soil types and crops, laborious, duration, equipment, and allergic crash on farmers. Biological fertilizers or biofertilizers are special man-made microorganisms and provide functions such as nutrient fixing and nutrient mobilization.[5]

#### **4. The enormity of soil health in the Ethiopian context**

There is an increasing concern in Ethiopia about the farming lands due to the decreased fertility, erosion and disturbed fertilizer strategies. Chemical fertilizer technologies are not affordable and even if they are, their environmental and socio-economic effects are uncertain on a longer tenure. Hence, the country adopts the practice of using the biofertilizers. But this requires the identification of barriers that could prevent farmers from using the Bio-fertilizers, though they promote crop development. Nevertheless, the feat of the bio-fertilizers depends greatly on the quality, correct doses, and time schedule of application. The crop return is proportional to the soil condition after the biofertilizer application.[6] Ethiopia has established 15 soil labs across the country, in order to enable the farmers to accustom to the various soil types and soil condition. Nitisols and vertisols are the two common problematic soil types in the country. Nitisol (red soil) is very acidic with a high aluminum content, pH less than 4 or 5. These soil types convert the nutrients into complex compounds and make them unreachable for the plants. Vertisol (black cotton soil) are the clay soils, very high in nutrients, they make the area waterlogging, and results in the suffocation of roots, making them devoid of oxygen. During the rainy season, they expand, and in the hot season, they crack. Various water management methods, including broad bed furrows (BBFs), and integrated soil fertility

management (ISFM) enables crop cultivation in the country. To improve the soil fertility, nutrients should be added to the soil at the similar rate at which the crops remove them, else this may lead to fertility loss and hence the low yield. The country imports fertilizers including urea (nitrogen source) and DAP(nitrogen and phosphorus source).

## 5. Soil health, a priority

Soil stabilization, soil conditioning, and nutrient addition are some of the ways of improving soil fertility. Research in soil microbiology began in 1986 in Ethiopia. Climate Resilient Green Economy (CRGE) Strategy, 2011, provides an ambitious target in terms of soil health. Conservation agriculture(CA), is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. There are many different practices that are in fact forms of conservation agriculture.[2,7] The Push- Pull Technology (PPT) developed by ICIPE in Kenya in the 1990s to advance the productivity of maize grown by smallholder women farmers was an excellent example for PPT. Conventional tillage practices involve challenges in preparing the soil in time for the critical period like low sowing, unpredictable climatic conditions, and needs towards reiterated plowing, thereby minimizing land degradation. No-tillage and low tillage are the options provided. Traditional land preparation with the maresha plough creates huge V-shaped furrows, leading to the dominance of unplowed area strips. This targets the repeated plowing and cross-plowing. To overcome this, Aybar Broad Bed Maker and Silet Deger, the variations of traditional Maresha are employed.

The first vermin composting in Ethiopia was carried out in Gonder, a project by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in 2007. EIAR started working on vermin composting technology in 2012, using *Eisenia fetida*, a specialized earthworm excellent in compost production. Home-based biogas/bio-slurry operation was enunciated during the Ethiopian Soil Campaign. After the biogas production, from agricultural, municipal, food, plant waste and green waste by anaerobic means, the remaining bioslurry is integrated into the soil either before planting or spraying onto vegetables and fruit crops after the dilution.[5,6] Nutrient Cycling at the Genesis Farms in Debre Zeit is another approach. These farms have large production facilities and ideas about integrating and cooperative farming keeps the soils healthy and fertile. The Fertile Grounds Initiative (FGI) was designed to coordinate nutrient cycling. The criteria identify nutrient stocks, channels of flows and search for methods to connect the sources and users. FGI increases the practice of integrated soil fertility management (ISFM), the application of chemical and organic fertilizers to the soil and thereby improves linkages between the soil fertility and nutrient availability. Biochar, a product of heating biomass in the absence of air, or with limited air, to above 250°C by pyrolysis using a kiln and agricultural waste like the coffee husk, bones, and other farm residues. Composting with biochar enhances nutrient cycling, pathogen suppression and acceleration of decomposition. CASCAPE improves existing soil maps for recommending fertilizer blends for various combinations of soils and climate to the farmers. The foremost finding of CASCAPE is the existence of Nitisols, Vertisols, Leptosols, Luvisols and Cambisols soil types and their corresponding geographic locations. National Soil Testing Center (NSTC) carries

out the soil sample preparation, Spectral analysis, INET chemistry analysis, Biofertilizer production and Soil texture testing. Addis Ababa Environmental Protection Authority (AA EPA) Compost Laboratory, in Addis Ababa, consist of 4 sections dedicated to compost, soil, water, physical, chemical and bacterial analysis. Integrated soil fertility management (ISFM) involves the integration of a series of techniques including increasing the biomass production, quality seed production, crop-specific fertilizer application, liming, and inter-cropping designed to toughen the strength of the complete soil system.[4]

## 6. The biofertilizer campaign

Biofertilizers are applied in the country, since 2000. The Ministry of Agriculture's National Soil Lab and EIAR are the biofertilizer promoting giants in the country. The most widely used and produced biofertilizer is rhizobium-based for nitrogen-fixing. The Ministry of Agriculture funded labs produce biofertilizers in Bahir Dar and Awasa, the Menagasha Bio-Industry (MBI), Pvt. Ltd. is producing biofertilizer in Menagasha, and EIAR produces biofertilizer in Holeta and Debre Zeit. The focus is based on developing and using a specific symbiotic strain of Rhizobium for faba bean, chickpea, lentil, field pea, haricot bean, and soya bean. The application is by inoculating an envelope of the strain into lignite, followed by the addition of blend with warm water and planting the seeds. During the germination of seeds, the bacteria attach to the root and forms nodules and allows nitrogen to be fixed. 125 g packet cover a quarter hectare of legume crops. In the process, it was observed that about 60% of nutrients are used by the growing plants, and nearly 40% remain in the soil providing increased land fertility. During the application of biofertilizers, crop rotation is suggested. In the near future, areas including Mekele, Bahir Dar, Hawassa, Dessie, and Nekemte are identified by the government for the biofertilizer production. The country aims to expand the research on biofertilizers, to identify and isolate, more strains of beneficial microbes.[2,3] Initiation has been taken towards promoting more budget, advocacy and work to promote this technology for the future. The country has identified a tremendous potential in the biofertilizer in increasing the productivity of soils. In Ethiopia, biofertilizers are used to increase nutrient flow to the highland pulse crops. Amare Abebe started the research on biofertilizers as early as 1982 on the Haricot Bean. The Ministry of Agriculture and Natural Resources (MoANR) and the Ethiopian Institute of Agricultural Research (EIAR) are on the continued search for the improvement in the biofertilizers. The institutes aim at meeting the criteria required for the same as they have biofertilizers as the best means of biological nitrogen fixation means for the legume crops in the country. Rhizobium, some genera of bacteria, Bacillus and Pseudomonas and cyanobacteria, Anabina azolea are investigated in the hunt.[8] The most prominent feature is that the application of biofertilizer, has been very effectual in terms of crop output, crop resistance to diseases, pest resistance, transportation, and efficiency. The farmers have identified that the mixed application of biochar, biofertilizer and inorganic fertilizer have increased the soil fertility. Bio-fertilizers are milled peat/lignite beads which carry Rhizobia. They are mixed with a sugar solution in which the seed has been previously soaked. The Rhizobia colonizes the interior of the plant after the process of germination. Bio-fertilizers are responsible for the increase in the rate of root nodule formation in legumes and thus increase the rate of fixation of atmospheric nitrogen, which is then transformed into a more usable form

of nitrogen, N and thereby supports plant growth and productivity.[5,7] After the crop is harvested, the root nodule breaks down and releases the Rhizobia and nitrogen back into the soil, making the entire process a cyclic one for land and soil health restoration.

## 7. Conclusions

The review portrays biofertilizer as ingredients to increase the soil fertility and crop productivity. The most important roles of Biofertilizers are as supplements for chemical fertilizers, minimize the use of chemical fertilizers, to stimulate the production of growth promoting substances, mobilize phosphate, antagonists, suppress the occurrence of soil-borne pathogens, bio-control of diseases, nitrogen-fixing and thereby in the recycling of plant nutrients. In this attempt, the importance of biofertilizer among the farmers of the country are illustrated. Sustainable agriculture is the key as it makes an agriculture ecologically sound, economically viable, socially just, and culturally acceptable across the globe. Adapting and practicing biofertilizer on the fields is a way towards sustainable agriculture.

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## Declaration

The author declares that this contribution is original and is not published elsewhere in part or in whole, elsewhere.

## Conflict of Interest

The author declares no conflict of interest.

## Authorship (contribution or attribution)

Single author.

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