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Review Article

Role of Bio-Fertilizers in Improving Soil Fertility and Crop Production

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Abstract: Bio-fertilizer are an important component of integrated nutrients management. Microorganisms that are used as bio-fertilizer components include; nitrogen fixers (N-fixer), potassium and phosphorus solubilizers, growth promoting rhizobacteria (PGPRs), endo and ecto mycorrhizal fungi, cyanobacteria and other useful microscopic organisms. The use of bio-fertilizers leads to improved nutrients, water uptake, plant growth and plant tolerance to abiotic and biotic factors. This biological fertilizers would play a key role in productivity and sustainability of soil and also in protecting the environment as eco-friendly and cost effective inputs for the small holder farmers. Adding of the nutrients through the natural processes of nitrogen fixation, solubilizing phosphorus, and stimulating plant growth through the synthesis of growth-promoting substances are a good way to sustain our agricultural systems. Soil management strategies today are mainly dependent on inorganic chemical-based fertilizers, which cause a serious threat to human health and the environment. Bio-fertilizer has been identified as an alternative for increasing soil fertility and crop production in sustainable farming. The exploitation of beneficial microbes as bio-fertilizers has become of paramount importance in agricultural sector due to their potential role in food safety and sustainable crop production.
Keywords: Bio fertilizer, Biological Nitrogen fixation, Crop productivity, Soil fertility, Rhizobium.

INTRODUCTION

Bio-fertilizer is a substance which contains living microorganisms which when applied to the soil; a seed or plant surface colonizes the rhizosphere and promotes growth by increasing the supply or availability of nutrients to the host plant and containing living cells of different of micro-organisms which have ability to convert nutritionally important elements from unavailable to available form through biological processes (Vessey JK, 2003). Vishal and Abhishek (2014) showed the distinguish between bio-fertilizer and organic fertilizer said "bio-fertilizers are microbial inoculants consisting of living cells of microorganisms like bacteria, algae, fungi, alone or a combination which may help in increasing crop productivity.

Other researcher also defined it is living microorganisms that colonize the rhizosphere or the interior of the plants and promote growth by increasing the supply or availability of primary nutrients to the target crops, when applied to soils, seeds or plant surfaces" (Mazid *et al.,* 2011). They colonize in rhizosphere accompanying interior of the plant and stimulates growth by increasing the accessibility and uptake of mineral nutrients to the host plant (Malusa *et al*., 2012). It also helps in the growth and development of plants or crops by enhancing the availability and supply of primary nutrients to the plant. Rhizobia are the bacteria that help in the nitrogen fixation and thus help in replenishing soil nutrients and act as bio fertilizers. Now a days, many rhizobium strains are being produced and supplied for faba bean, chickpeas, lentils, field pea, common bean, soybean and mung bean production (Hailemariam and Asfaw, 2015; Assefa, *et al*., 2018).

It is also worth-noting that pulse crops not only avail soil nutrients through nitrogen fixation and nutrient solubilization but also serve to 'break' cycles of different cereal pests as non-host crops (Malhotra *et al*., 2004; Kirkegaard *et al.*, 2008; Keneni *et al.*, 2016). Therefore, the obejective of this review paper is to describe role of biofertilizers in improving of soil fetility and crop production.

Bio-fertilizers and Soil fertility

Gradual increase in chemical fertilizer usage without letting any crop and animal manure residues in farm land leads to the distraction of microorganisms in the soil, poor soil structure, low nutrient and water

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holding capacity of soil and reduce soil fauna–flora distribution. To minimize these environmental and soil damages caused by chemical fertilizers, the contribution of biological nitrogen fixation while increasing crop production plays indisputable role especially in maintaining soil health. Organic farming has emerged as an important priority area globally in view of the growing demand for safe and healthy food and long term sustainability and concerns on environmental pollution associated with indiscriminate use of agrochemicals. As reported by (Getachew, 2018), the extensive use of chemical fertilizers in cropping system for enhancing fertility and agronomic yield induce several issues regarding environmental pollution and soil degradation. Hence, it is very crucial to exploit inexpensive and eco-friendly sources of nitrogen replenishment such as biological nitrogen fixation ((BNF).

Indiscriminate use of synthetic fertilizers has led to the pollution and contamination of the soil, has polluted water basins, destroyed micro-organisms and friendly insects, making the crop more prone to diseases and reduced soil fertility. Youssef MMA and Eissa MFM (2014) stated that the use of chemical fertilizers causes air and ground water pollution as a result of eutrophication of water bodies. Depleting feedstock/fossil fuels (energy crisis) and increasing cost of fertilizers. This is becoming unaffordable by small and marginal farmers, depleting soil fertility due to widening gap between nutrient removal and supplies, growing concern about environmental hazards, increasing threat to sustainable agriculture. Besides above facts, as described by (Subba Roa N. S., 2001) the long term use of bio fertilizers is economical, eco-friendly, more efficient, productive and accessible to marginal and small farmers over chemical fertilizers. Biological nitrogen fixation (BNF) is a process by which N in the atmosphere is reduced into a biologically useful, combined form of N-ammonia by living organisms (Herridge *et al.,* 2008, Giller, 2001).

The greatest proportion of N found on the earth is located in theatmosphere, as nitrogen molecule. Nevertheless, the majority of organisms cannot utilize this free and abundant, but highly stable source of N because they can only use N which is combined with other atoms into plant usable forms, such as ammonium, nitrates and ammonia (Giller, 2001). Ryder *et al.,* (2014) showed that from stand view of environmental sustainability, nitrogen fixation by crop legumes as biofertilizers reduces the need for fertilizer nitrogen (N) and emissions of nitrous oxide to atmosphere.

Bio-fertilizer making

Several steps are followed when producing biofertilizer such as microbe's growth profile, types and optimum conditions of organism and formulation of inoculum. The formulation of inocula, method of application and storage of the products are all critical to the success of the biological product. In general, six steps are involved in making of bio fertilizer. These are choosing of active microorganisms, isolation and selection of target microbes, selection of method of propagation and carrier material, and phenotype testing, and large scale tests (Khosro M and Youssef S, 2012).

Utilization of Rhizobial Biofertilizers

The effectiveness of rhizobial biofertilizers usage is generally governed by four factors. These are microbial quality of rhizobial biofertilizer (rhizobial factor), handling and transport condition (logistic factor), application care (human factor), and soil condition (edaphic factor). The quality of rhizobial and other biofertilizers need to be as to the standard (Ethiopian Biofertilizer Standard, 2016). When some one uses rhizobial biofertilizer, he/she has to apply the right type, the right rate, right crop at the right time. 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 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 (Vessey JK, 2003).

The most important constraint limiting crop yield in developing nations worldwide and especially among resource–poor farmers, is soil infertility. Therefore, maintaining soil quality can reduce the problems of land degradation, decreasing soil fertility, and rapidly declining production levels in large parts of the world that needed the basic principles of good farming- practice (Khosro and Yousef, 2012). Mfilinge *et al*., (2014) said that low crop productivity is a general problem facing most farming systems in Sub- Saharan Africa (SSA). Example, In Ethiopia Nutrient depletion is one of the major causes that contribute to decline in soil productivity, soils under subsistence agriculture have been mined of nutrients for years without replenishment with fertilizer inputs in the country. Hence, the two essential plant nutrients, N and P are the most limiting nutrients nearly in all agricultural soils of Ethiopia (Paulos, 2001; Wassie *et al.,* 2006). Biofertilizer is a biological product that can be used to improve the soil fertility. It is useful in enriching soil with micro-organisms that produces organic nutrients and may also reduce the plant diseases. Bio-fertilizers keep the soil environment rich in all kinds of macro and micro nutrients via nitrogen fixation, phosphate and potassium solubilisation or mineralization, release of plant growth regulating substances, production of antibiotics and biodegradation of organic matter in the soil (Sinha R *et al.,* 2014). In Ethiopia, the tradition of crop rotation where the cycle of continuous production of cereals is broken by producing pulse crops as a means of maintaining soil fertility and diversifying agricultural products is a common practice (Gorfu, 1998; Taa *et al*., 1997). Likewise, the ability of pulse crops to restore soil fertility had been realized and exploited by farmers also in othe parts of the world long before the symbiotic association between bacteria and the host plant was scientifically established (Lim and Burton, 1982; Hirsch, 2009).

Watson *et al*., (2017), studied the role introducing of legumes into agricultural systems often as positively affects the nutrient status, organic matter, soil structure, and disease inoculum levels in the soil increasing subsequent crop yields. Stagnari *et al*., (2017) indicated that legumes are competitive in terms of environmental and socioeconomic benefits, with potential to be introduced in modern agricultural system.

Grain legumes have been used for many years in agricultural system to maintain soil fertility due to the ability of the crops to fix atmospheric nitrogen into the soil. They reduces fertilizer cost and improves productivity in subsequent cereal crops. Legumes role as part of the cropping is very well recognized and most legumes are grown in a mixed cropping system with cereals and other crops under smallholder agricultural system of the country. Inclusion of legumes in agricultural system increases total food production per unit of land and farm diversification, and reduces risks of food shortage (Mashungwa, 2019).

The demand for legumes integration into different agricultural systems is expected to increase as consumers' income increases with a likely shift in preferences from cereal grains to more nutrient-dense foods (Muoni *et al.*, 2019). This requires improved agricultural practices that overcome current crop production constraints which include erratic rainfall patterns, poor soil fertility status, and limited access to adequate inputs. Consequently, intercropping and crop rotation with grain legumes are an important agricultural practice which improves nutrition, soil fertility status, water efficiency by saving water for subsequent crops or by providing soil coverage, minimizing soil evaporation, soil erosion, and reduce diseases and other pests, which makes crop production feasible (Vidigal *et al.*, 2019).

The continuous use of rhizobial biofertilizers in cropping systems help to improve soil fertility status through improving soil nitrogen levels, soil health (by promoting the growth of other beneficial soil microorganisms such as fungi, actinomycetes, bacteria etc, if the roots of the legumes are left in the ground). It also increases soil organic matter as root and leaf drop and systematically worked into the soil. Legumes used as green manures can also provide considerable amounts of nitrogen to the soil that can greatly benefit subsequent crops. Leaf fall during crop legume development in the nodulated roots is also reported to contain up to 40 kg nitrogen ha^{-1} (Srinivasarao *et al.*, 2012). There is fast evidence that using grain legumes in agricultural system increases organic matter and improves soil structure (Vidigal *et al.*, 2019). Some phosphate solubilizing bacteria can accumulate heavy metals and eradicate heavy metal phytotoxicity and promots growth in plants (Katiyar and Goel, 2004).

Soil fertility viz. available P, enzyme activities and PSB population in both maize and wheat crops was significantly improved with combine application of PSB inoculation and rock phosphate fertilization compared to DAP treatment (Kaur and Reddy, 2015). Phosphorus solubiliziing bacterial cultures viz., Agrobacterium radiobacter and Bacillus megatherium and fungus *e.i*. Aspergillus awamori have positive influence on various growth and yield parameters and P uptake (Shankaraiah *et al.*, 2000). Bio-fertilizer acts as a soil conditioner adding organic matter to the soil which helps to bind the soil particles together preventing soil eructing, desertification, and erosion, while increasing the water retention capacity of the soil (Swathi V, 2010). It enriches the soil with beneficial microorganisms while boosting the already existing ones unlike chemical inorganic fertilizers which acidify the soil making it hard for microorganisms to survive (Swathi V, 2010). Therefore, the inoculations with PSB and other useful microbial inoculants soils become mandatory to restore and maintain the effective microbial populations for solubilization of chemically fixed phosphorus and availability of other macro and micro nutrients to harvest good sustainable yield of various crops (Mishra *et al.* 2013).

Bio-fertilizer and crop production

The Pulse crops ability to fix nitrogen is vary from crop to crop accordingly: faba bean > soybean > pea > chickling vetch > chickpea > lentil > lupin> dry bean (Vance, 2002).

Several studies have shown that field pea fulfills more than 80% of its nitrogen requirements through BNF and can subsequently transfers nitrogen to non-fixing plants in the agricultural system (Murat *et al.*, 2008). Rhizobium inoculation positively affects plant height, the number of branches, root and shoot dry weight, the number of nodules, seed and biomass yield, the number of pods, the crude protein concentration, and seed P content (Murat *et al.*, 2009). Biofertilizers, when applied as seed or soil inoculants, multiply and participate in nutrient cycling and leads to crop productivity. Generally, 60% to 90% of the total applied fertilizer is lost and the remaining 10% - 40% is taken up by plants. Hence biofertilizers can be important component of integrated nutrient management systems for to sustaining agricultural productivity and a healthy environment (Adesemoye AO., 2009).

Romdhane *et al*., (2009) studied that the chickpea yield can be enhanced by inoculation with competitive rhizobia. Artificial seed inoculation of chickpea particularly in soils lacking native effective rhizobia is a very useful practice for improving root nodulation and yield of the crop (Muhammad *et al.*, 2010). Inoculation increases soil nitrogen along with the increase in root and shoot nitrogen (Ahmed *et al.*, 2008). On the other hand, the research done by Researchers of Ethiopian institute of Agriculture Research described that rhizobia inoculation improved grain yield of faba bean and chickpea on average by 1200 and 500 kg ha^{-1}, respectively in Arsi and Ada'a areas (AKLDP., 2016). As to the follow-up cereals, 1500 and 800 $kgha^{-1}$ grain yield increments were observed for wheat and barley, respectively in Arsi areas. Grain yields of tef and wheat crops following inoculated chickpea around Ada'a has shown 900 and 400 kg ha^{-1} improvement (Table 1) (AKLDP, 2016).

Effect of Biofertilizer on the yield of barley following faba bean was so significant that more than 35% of average yield increase was realized by farmers who used rhizobia-inoculated faba bean seed (Niguse, 2015). The results generally concur with global and local experiences where cereal crops following pulse crops inoculated with the appropriate strains of rhizobium give better yields (Gan *et al.*, 2015; Assefa *et al.*, 2018).

Table 1: Median grain yield (kg ha^{-1}) response of faba bean and the succeeding cereal crops to biofertilizer application

Destrict/Kebeles	**Non-Biofertilizer**	**Bio-fertilizer**
Bekoji-Negesso	1750	2660
Lemu-Dima	2200	3100
Sagure-Mole	1560	2700
Burkitu-Alkesa	1300	3200
Wheat [b] Sagure-Mole	3310	4800
Barely[b]	3200	4000

Source: Agriculture, Knowledge, learning, Documentation and Policy, 2016.
b= follow up crops to inoculated faba bean

According to Yifru Abera *et al.*, (2008), combined application of Rhizobium (EAL-302) and PSB around Sinana could give superior grain yield. The yield obtained in the area was superior to even 8/20 kg NP ha^{-1} treatment. Biofertilizers show plant growth promoting qualities and increase the yield by various mechanisms like nitrogen fixation, P-solubilization, P-mobilization, K solubilization, micronutrient solubilization, plant growth promotion, preventing the depletion of the soil organic matter (Jeyabal and Kupuswamy, 2001) and maintenance of the natural habitat of the soil. Abiotic and biotic factors are the major constraints that affect the productivity of crops. Many tools of modern science have been widely applied for crop improvement under stress, of which PGPRs' role as bio-protectant has become of paramount importance in this regard (Yang JW, 2009). 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 useable form of nitrogen, N and thereby supports plant growth and productivity (Hailu T *et al.*, 2000). A study made at Bako in 2006 confirmed that inoculation of soybean with rhizobia biofertilizer TAL-379 has showed 53% grain yield increment over the uninoculated control (Solomon Tamiru *et al.*, 2006).

Glazer and Nikado (2007) showed that as biofertilizers have an ability to mobilize nutritionally important elements from non-usable to usable form through biological processes and they have the potential to increase the production of crop by improving yield and quantity. Rhizobial biofertilizers help enhance production and productivity of grain legume crops. It improves grain or biomass yield up to 10% (particularly with 100 kg Di Ammonium Phosphate ha^{-1}) in any cropping system through boosting plant growth promoting enzymes, hormones and auxins and increasing yields leads to higher income that leads to greater margins when favorable markets exist for the farm produces. It also improves protein quality of grain legume crops. Moreover, the residual effect of rhizobial biofertilizers help ultimate yield increment up on control of striga by increasing soil nitrogen and increasing nutrient availability due to higher stover and straw yield. The use of Cp-41 for chickpea inoculation improved grain yield from 1.2 t ha^{-1} to 2.5 t ha^{-1} at Choroko and 1.8 t ha^{-1} to2.5 t ha^{-1} at Taba (Wondewosen Tena *et al.*, 2016). Accordingly, if full benefit from grain legume crop is to be achieved in terms of maximum yield and soil improvement, the seed should be inoculated with its own specific and suitable Rhizobium strain before planting (Ayaz *et al.*, 2010). Producing chickpea using rhizobial isolate CP-17 along with soil and plant tissue test based phosphorus application on Ginchi Vertisol is quite paying in terms of yield and benefit. Hence, these rhizobial isolates were the best candidates for the development of commercial rhizobial inoculants of faba bean in acid prone faba bean growing areas (Getahun mitiku *et al.*, 2017).

Table 2: Rhizobia inoculant grain yield enhancing effect

Region	Destrict	Grain legume	Inoculant yield advantage (%)
Oromia	Girar jarso	Fabbean	10-16
South	Gumer	Fabbean	21-23
	Kacha bira	Fabbean	26.1
		Field pea	13
	Hadero	Fababean	4
Amhara	Basonawerana	Fabbean	26.3

Source: NSTC feed back report (2011), unpublished

Nigussie Alemayehu (2015) studied the inoculation of strain FB-1035 has got yield increment of 1300 kg ha^{-1} on the pre-crop and 18 and 1125 kg ha^{-1} yield for following wheat and barley, respectively, compared to the noninoculated. The research finding of pawe agriculture research center has reported that using of strain SB-MAR-1495 increased grain yield by 25.5% over uninoculated control(Fitsum Merkeb *et al.*, 2016). The experiment that did at Ginchi substation showed that Strain Cp-17 was significantly superior to other strains and the N fertilized treatment in grain yield (HARC., 2016). The experiment of Kaur and Reddy (2015) demonstrated that when applied the inoculation of PSB together with rock phosphate fertilization upgrade the crop growth in terms of shoot height, shoot and root dry biomass, grain yield and total Phosporus uptake in both maize and wheat crops. Phosphorus solubilizing bacteria aid the growth of plants by stimulating the efficiency of biological nitrogen fixation, synthesizing phytohormones and enhancing the availability of some trace elements such as zinc and iron (Wani *et al.*, 2007).

Microorganisms used in Bio-Fertilizer

Rhizobium species are group of bacteria that fix atmospheric nitrogen symbiotically and stimulate the growth of plants. The enzyme system of bacteria supplies constant source of reduced nitrogen to the host plant and the plant in turn provides nutrients and energy for the activities of the bacteria (Singh *et al.*, 2008). Rhizobium inhibited the growth of pathogenic fungi which indicates that Rhizobium may secrete antifungal compounds (Panwar *et al.*, 2014). PGPR and Rhizobia strain can promote seed emergence and seedling attributes which benefits the early seedling establishment and consequently the crop growth and development (Mia, 2012). Rhizobium increases plant growth by various ways such as production of plant growth hormones, vitamins, siderophores, by solubilisation of insoluble phosphates, induction of systemic disease resistance and enhancement in stress resistance (Hussain *et al.*, 2009).

Soil micro-organisms play an important role in regulating the dynamics of organic matter decomposition and the availableness of plant nutrients such as N, P and S. It is well-recognized that microbial inoculants constitute an essential component of integrated nutrient management that leads to sensible agriculture. Additionally, microbial inoculants can be used as an economic input to enhance crop productivity, the dosage of fertilizers can be lowered and more nutrients can be harvested from the soil. Biofertilizer could be used as nutrient source for soil microbiology by maintaining fruit yield and quality and promoting nutritionally supplied plants with lower production costs. If the wrong Rhizobium species is used, inoculation will have no beneficial effect. Soils commonly lack sufficient numbers of the correct Rhizobium bacteria to optimize the nitrogen fixation process (Brockwell *et al.*, 1995).

Table 3: Rhizobium species required for some legume crops

Crop	Rhizobia species
pea, lentil, faba bean, chickling vetch	*Rhizobium leguminosarum var viciae*
Chickpea	*Rhizobium cicero*
dry bean	*Rhizobium phaseoli*
Soybean	*Bradyrhizobium japonicum*
alfalfa, sweet clover	*Rhizobium meliloti*
Clover	*Rhizobium trifolii*
Feenugrek	*Rhizobium spp. Strain RGFU1*

Source: (Brockwell *et al.*, 1995)

Organisms that are commonly used as bio-fertilizers components include nitrogen fixers (N – fixers), potassium solubilizers (K – solubilizer) phosphorus solubilizer (P – solubilizer), phosphorus mobilizers (P – mobilizers), used solely or in combination with of fungi. Most of the bacteria used in bio-fertilizers have close relationship with plant roots and *Rhizobacterium* has symbiotic interaction with legume roots, and *Rhizobacteria* inhabit root surfaces or rhizosphere soil (Khosro M and Yousef S, 2012).

TYPES OF BIO-FERTILIZERS

Bio-fe rtilizers are classified into different types depending on the type or group of microorganisms they contain. The below table shows the classification of bio-fertilizers on the bases of the different types of microorganisms used. The different types of bio-fertilizers include:

Table 4: Different Microorganisms used in Bio-fertilizer Production

Group	**Example**
Nitrogen fixing bio-fertilizers	
Free living	Azotobacter, Bejerinkia, Clostridium, Klebsiella, Anabaena, Nostoc
Symbiotic	Rhizobium, Frankia, Anabaena, Azollae
Associative symbiotic	Azospirillum
Phosphate solubilizing bio-fertilizer	
Bacteria	Bacillus megaterium var, Phosphaticum, Bacillus subtilis, Bacillus circulans
Fungi	Penicillum Spp. Aspergillus awamori
Phosphate mobilizing bio-fertilizers	
Arbuscular Mycorrhiza	Glomus Spp., Gigaspora Spp., Acaulospora Spp. Scutellospora Spp. and Sclerocystis Spp.
Ectomycorrhiza	Laccaria Spp. Pisolithus Spp, Boletus Spp. and Amanita Spp.
Ericoid Mycorrhiza	Pezizella ericae
Orchid Mycorrhiza	Rhizoctonia solani
Bio-fertilizers for micronutrients	
Bacillus Spp	Silicate and zinc solubilizers
Plant growth promoting Rhizobacteria	
Pseudomonas	Pseudomonas fluorescens

Source: Ritika and Uptal (2014)

Nitrogen fixing bio-fertilizers (NFB): Examples include Rhizobium Spp., *Azospirillum Spp. and blue-green algae;* these work by fixing atmospheric nitrogen and converting them to organic (plant usable) forms in the soil and root nodules of legumes, thereby making them available to plants. Nitrogen fixing bio-fertilizers are crop specific bio-fertlilizers (Choudhury MA and Kennedy IR, 2004).

Phosphate solubilizing bio-fertilizer *(*PSB): Examples, include Bacillus Spp., Pseudomoona Spp. and Aspergillus Spp. These work by solubilizing the insoluble forms of phosphate in the soil, so that plants can use them. Phosphorus in the soil occurs mostly as insoluble phosphate which cannot be absorbed by plants (Gupta AK,.2004). However, several soil bacteria and fungi possess the ability to convert these insoluble phosphates to their soluble forms. These organisms accomplish this by secreting organic acids which lower the pH of the soil and cause the dissolution of bound forms of phosphate making them available to plants (Gupta AK,.2004). The phosphorus-solubilizing bacteria (PSB) like Bacillus and Pseudomonas can increase phosphorus availability to plants by mobilizing it from the unavailable forms in the soil (Richardson 2001). These bacteria and certain soil fungi such as Penicillium and Aspergillus bring about dissolution of bound phosphates in soil by secreting organic acids characterized by lower pH in their vicinity.

Phosphate mobilizing bio-fertilizers *(*PMB): Examples are Mycorrhiza. They work by scavenging phosphates from soil layers and mobilizing the insoluble phosphorus in the soil to which they are applied. (Chang and Yang, 2009) stated that phosphorus solubilizing biofertilizer (PSB) sometimes act as phosphate mobilizers. Phosphate mobilizing bio-fertilizers are broad spectrum bio-fertilizers. Soil phosphorus mobilization and immobilization by bacteria.

Plant growth promoting bio-fertilizer (PGPB): Examples of plant growth rhizobacteria are Pseudomonas Spp. etc: these work by producing hormones and anti-metabolites which promotes root growth, decomposition of organic matter which help in mineralization of the soil thereby increasing availability of nutrients and improving crop yield (Khosro M, Yousef S, 2012 and Bhattacharyya PN and Jha DK., 2012).

Potassium solubilizing bio-fertilizer (KSB): Examples include Bacillus Spp. and Aspergillus niger. Potassium in the soil occurs mostly as silicate minerals which are inaccessible to plants. These minerals are made available only when they are slowly weathered or solubilized. Potassium solubilizing microorganisms solubilize silicates by producing organic acids which cause the decomposition of silicates and helps in the removal of metal ions thereby making them available to plants. Potassium solubilizing bio-fertilizers are broad spectrum bio-fertilizers.

Potassium mobilizing bio-fertilizer (KMB): Example of potassium mobilizing bio-fertilizer is Bacillus Species. These work by mobilizing the inaccessible forms of potassium (silicates) in the soil. Some phosphate solubilizing bio-fertilizers such as *Bacillus Spp. and Aspergillus Spp*. has been found to mobilize potassium and also solubilize phosphorus.

Sulfur oxidizing bio-fertilizer (SOB): Example of sulfur oxidizing microorganism is *Thiobacillus Spp*.

These work by oxidizing sulfur to sulfates which are usable by plants.

ADVANTAGE OF BIO-FERTILIZERS OVER CHEMICAL FERTILIZERS

Biofertilizers spontaneously activates the microorganisms found in the soil in an effective and eco-friendly way, thereby gaining more importance for utilization in crop production, restoring the soils fertility and protecting it against drought, soil diseases and thus stimulate plant growth. Biofertilizers lead to soil enrichment and are suitable with long-term sustainability. Further, they pose no danger to the environment and can be substituted with chemical fertilizers. The application of bio-fertilizers can minimize the use of chemical fertilizers, decreasing environmental hazards, enhance soil structure and promote agriculture. Biofertilizers are cheaper and remarkable in affecting the yield of cereal crops.

Bio-fertilizers being important components of organic farming play a key role in maintaining long term soil fertility and sustainability by fixing insoluble P in the soil into forms available to plants, thus increasing their effectiveness and availability. In context of both the cost and environmental impact of chemical fertilizers, excessive reliance on the chemical fertilizers is not a useful strategy in the long run due to the cost, both in domestic resources and foreign exchange; participate in setting up of fertilizer plants and maintaining the production. Biofertilizers are the alternative sources to meet the nutrient requirement of crops. In Biofertilizers, beneficial bacteria are Azotobacter, Azospirillium, Rhizobium, Mycorrhizae which are very essential in crop production. Biofertilizer can also make plant resistant to unfavorable environmental stresses.

LIMITATION OF BIO-FERTILIZER

The most important limitation of bio-fertilizer is their nutrient content when compared to inorganic fertilizers. This might result to deficiency symptoms in plants grown with the bio-fertilizer. However, this problem can be solved by the addition of substances such as bone meal (rich in phosphorus), wood ash (rich in potassium) or other substances of natural origin such as phosphate rock to enrich the fertilizer. Also the use of nutrient rich wastes such as palm wastes (rich in potassium), wood ash (rich in potassium also) in making bio-fertilizer can help to remedy the problem.

Mahimaraja S *et al.,* 2008) stated that the addition of phosphorus to wastes makes the bio-fertilizer more balanced and reduces nitrogen losses. Even though, bio-fertilizer has many positive aspects, its use can sometimes not lead to the expected positive results and this could be because of exposure to high temperature or hostile conditions before usage. Before we use Bio-fertilizer must be stored at room temperature or in cold storage conditions away from heat or direct sunlight and polythene bags used in packaging bio-fertilizer should be of low density grade with a thickness of about 50 –75 microns (Mishra BK and Dadhick SK, 2010). The other limiting factor in using biofertilizer technology is environmental, human resource, unawareness, unavailability of suitable strains, and unavailability of suitable carrier and so on (Ritika B, *et al.,* 2014). Short shelf life, lack of suitable carrier material, susceptibility to high temperature, problem in transportation, and storage are biofertilizers bottlenecks that still need to be solved in order to obtain effective inoculation (Chen J, 2006).

CONCLUSION

This review paper clearly stated the role of biofertilizer in agricultural and the challenge in use of biofertilizer. As its use enhance productivity by biological nitrogen fixation or solubilization of insoluble phosphate or by producing hormones, vitamins and other growth promoters required for plant growth, 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. Adapting and practicing biofertilizer on the fields is a way towards sustainable agriculture.Its bring sustainable agriculture which is ecologically sound, economically viable, socially just, and culturally acceptable across the globe. As a whole bio-fertilizers play great role in maintaining long term soil fertility and sustainability by fixing atmospheric di-nitrogen, mobilizing fixed macro and micro nutrients or convert insoluble P in the soil into forms available to plants, there by increases their efficiency and availability. Over the chemical fertilizer it is preferable regarding of the cost and environmental impact of chemical fertilizers, excessive reliance on the chemical fertilizers is not viable strategy in long run because of the cost, both in domestic resources and foreign exchange, involved in setting up of fertilizer plants and sustaining the production.It is also a viable option for the small holder farmers to increase productivity per unit area and also ingredients to increase the soil fertility and crop productivity. Using of rhizobium inoccula is constrained by low demand, due to lack of awareness and understanding of the product, and limited production capacity.

RECOMMENDATION

It is recommended that a strengthened regulatory system that approves the production of new rhizobia strains and requires clear instructions on their use, including for which crops, in which areas and for which agro-ecologies. Its application must be according to the recommendation by the researchers like chemical fertilizer, when applying /inoculating to the crop. Additional it has to be based on the recommendation rate and population size of native rhizobium within the soil. Improve the awareness creation,training the farmers,because biofertilizer is sensitive when exposed to sun light and if not handle properly it become ineffective.

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