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Review Article

Nexus of biofertilizers with healthy soil, greener production and vigor socio-economy: A close look from Bangladesh perspective

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To save the rapidly increasing world population from food crisis, agriculturists are moving towards intensive cultivation with inorganic fertilizers for more crop yield. But this is the high time to be concerned about the soil; the ultimate medium for large scale plant growth, nutrition of population as well as the better socio-economic condition of the nation. As the solution of ever growing chemical pollution, agriculturists, environmentalists, policy makers, stake holders, other relevant government bodies – all are now standing in the same platform and promoting organic foods. Biofertilizer is one of the most promising options to go for sustainable agriculture. Although there are quiet a large number of advantages, some agri-based countries are still not adopting the technology unanimously, Bangladesh is one of them. The reasons for not accepting biofertilizers en bloc, solutions, potentials of biofertilizer market in Bangladesh and other important ways for educating field level workers about the soil health, secured social life and stronger economic status are recommended in this article.

Key words: Biofertilizers, soil, socio-economy, potentialities, Bangladesh

INTRODUCTION

One of the most promising technologies in the field of sustainable agriculture is the application of biofertilizers. Biofertilizers are living microorganism containing biological products which introduce numerous mechanisms such as increasing the supply of nutrients as well as nutrient uptake capacity of plants along with increasing root biomass or root area to crop growth, when applied to plants, seeds or soils (Vessey, 2003). Because of the long-term harmful effects of chemical fertilizers on soil and other environmental components, biofertilizers are receiving more concentrations and popularities among the soil scientists and agriculturists. Besides, the current alarming concerns of the rapid decrease of rock phosphate reserves and fossil fuel have made biofertilizer a center of attraction for the scientists, particularly in developing countries (St.Clair and Lynch, 2010). Though sustainable crop production has drawn maximum attention of global scientists, commerce and policy makers (Wezel et al., 2014), the intervention of comprehensive biogeochemicals specially intimidated by chemical fertilizers has become a serious setback (Kahiluoto et al., 2014). Therefore biofertilizers have been considered as the source of plant nutrients which is by far the most eco-friendly, renewable and cost-effective for supplementing inorganic chemical fertilizers in soils(Ahmad-et al.,2022) and as the tool for remediating polluted soils (Pandey and Singh, 2019).

A densely populated country having agriculture based economy, like Bangladesh, should promote the manufacturing, distribution and application of biofertilizers without doing any more delay to achieve the goal of sustainable agriculture by getting healthy soils, producing nutritious foods as well as securing the socio-economic condition for the long run.

LITARATURE REVIEW

Types

Principally three types of microorganisms; bacteria, fungi and cyanobacteria are used to prepare bioertilizers. Diverse microbial taxa possess considerable effect on different nutrient fixation in different biofertilizers. Specific taxa of biofertilizers are currently in use, mainly for solubilizing phosphates and for fixing atmospheric nitrogen, round the globe based on the effects of different microbial community to access nutrients from different sources like fertilizers and soil reservoirs (Schütz et al., 2018). Considering their actions on nutrients, biofertilizers are of two types, N fixing biofertilizers and P solubilizing biofertilizers. In the case of fixing N, biofertilizers are selected based on crop cultivar, for instance, *Rhizobium* for leguminous crops; *Azotobacter* or *Azospirillum* for non leguminous crops;

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Acetobacter for sugarcane and Blue-Green Algae (BGA) and Azolla for low land rice cultivation. On the other hand, P solubilizing biofertilizers are not crop-sensitive, rather they concentrate more on bringing P into soil solutions from possible sources. Mentionable P solubilizing microbes are Phosphatika for all crops, *Bacillus*, *Pseudomonas, Aspergillus*, *Rhizobium*, *Azotobacter*, *Azospirillum* and *Acetobacter*. Principally they hydrolyze organic as well as inorganic insoluble phosphates and convert into soluble and plant available phosphorus Additionally, Phosphatika and *Azotobacter* culture are also marked for enriching compost in soils by breaking down compost waste.

Apart from these two major groups (N and P fixing biofertilizers), some other types of biofertilizers, such as potassium mobilizing, zinc solubilizing, and NPK consortia liquid biofertilizers, are also in use but they do not have as large market size as the previously mentioned two. *Bacillus glucanolyticus, B. mucilaginous, B. circulans,* and *B. edaphicus* are most common genera of silicate bacteria to solubilize and mobilize K in the soils.

As a whole, the principal microorganisms in use for producing biofertilizers are *Rhizobium*, *Azotobacter*, *Azospirillum*, *Acetobacter*, BGA, Phosphate solubilizing bacteria, mycorrhiza, *Cyanobacteria,* Plant Growth-Promoting Rhizobacteria (PGPR) and some other microorganisms. Carrier enriched biofertilizers, liquid biofertilizers and some others are common types as far as the technology of biofertilizer is concerned. Biofertilizers are applied on soils (enhance crop yield by 15%-20%) or seed (dominated the market with a share of 73.2% in 2019 for ensuring better nutritional quality in crops) for treatments and the major crop types where biofertilizers are found to be used are grains and cereals (largest volume share of 76.4% in 2019), pulses and oilseeds, fruits and vegetables, plantation crops and a few other types of crops (Grand View Research, 2018; Mordor Intelligence, 2021).

Uses and benefits

Application of biofertilizers has some immense potentialities towards achieving the goals of agricultural sustainability promising over the use of conventional inorganic fertilizers. While associating with plant roots, microorganisms of biofertilizers converts complex organic substances into simple compounds, as a result they can be taken up by the plant roots readily. Thus, microorganisms increase nutrient availabilities in soils by synthesis of plant growth-promoting substances leading to better soil and plant health for long. Biofertilizers are also evidenced to promote better root and shoot growth over control groups (Htwe et al., 2019) directing towards more crop yields, especially in dry pedo-climatic regions (yield response: dry climate +20.0 ± 1.7%, tropical climate +14.9 ± 1.2%, oceanic climate +10.0 ± 3.7%, continental climate +8.5 ± 2.4%) (Schütz et al., 2018). The mechanisms microorganisms apply to add nutrients into the soils are most importantly fixation of atmospheric nitrogen, solubilization and mobilization of phosphorus, production of phytohormones, composting, suppression of diseases and so on. Accordingly they also have the tremendous capacities to access nutrients from fertilizers and soil stocks in conjunction with improving water uptake by plants acting as a biocontrol agent. Indirectly, they improvise plant tissue formation and differentiation together with influencing Fe uptake and translocation by plants (Singh et al., 2021).

Biofertilizers are already in use for treating heavy metal polluted soils, i.e., the soils rich in Cr (Pandey and Singh, 2019) and Cd (Haneef et al., 2014). In accordance with the increase of Cd tolerance in plants, biofertilizers are also evidenced to increase proline and phenolic compounds concentrations (Pandey and Singh, 2019). Thus biofertilizers secure soil cum environmental health by reducing polluting agent. To some extent, biofertilizers reduce the risk of crop failure and therefore reinforce the socio-economic condition of farmers. Application of biofertilizers is noted to increase the crop yield by 20%–35% over the control and to reduce the application of inorganic fertilizers like N, P, and K fertilizers up to 60% (Singh et al., 2021). Considering this point, the contribution of biofertilizers to the local or national economy and the future potential of these fertilizers are contentedly considerable.

Drawbacks

Despite the manifold striking advantages of the use of biofertilizers, their applications have often been found inconsistent. The reasons getting in the way of global use of biofertilizers are noted primarily as the difference in soil and environmental conditions, selectivity of strains, genotype of host etc (Schütz et al., 2018). Other possible reasons could be the slow release of nutrients from biofertilizers, temperature requirement, less effective in supplying plant nutrients at the time of need, lesser nutrient density than chemical fertilizers and necessity of large amount of raw material to produce required quantity of biofertilizers. Together with these, strict aseptic precautions should be taken during production and manufacturing of biofertilizers as contamination of diseases is very common. Light and temperature sensitivity are other difficulties in the way of mass application of biofertilizers. Microbes are actually killed if exposed to sunlight for a long time; moreover, they are viable for six months if stored in room temperatures and for two years if stored in chilling temperatures. Mentioned drawbacks are accumulated from different research works, yet there is a need to spot the key influencing factors hindering biofertilizers to be choosen by farmers.

DISCUSSION

Application pattern in the world

Considering the long term soil health effect and agricultural sustainability in addition to the variety in existing soil-plant systems, biofertilizers are in applications- alone or in combination, in many parts of the world. Taking into account the long term soil, environment and human health effects, the popularity of organic food is blooming in the recent decades. Awareness among the people, increased crop yield and rising income from biofertilizers, improved farming practices, positive reports from scientists about maintaining ecological balance and several actions initiated by Government bodies have make the biofertilizer market more robust. For example, the government of India had made it compulsory to buy biofertilizers along with urea for the farmers in 2020. Similarly, biofertilizer production and use are also backed by government of China and Brazil with some favorable initiatives and incentive actions. European countries are also emphasizing on the use of biofertilizers as a biocontrol of plant diseases. The European Council had declared 20% green house gas emission reduction and 20% energy saving by promoting bio-alternatives such as biofertilizers (Grand View Research, 2018)

(Figures 1-4).

Figure 1. Segmentation of global market of biofertilizers. (**Source:** Grand View Research, 2018).

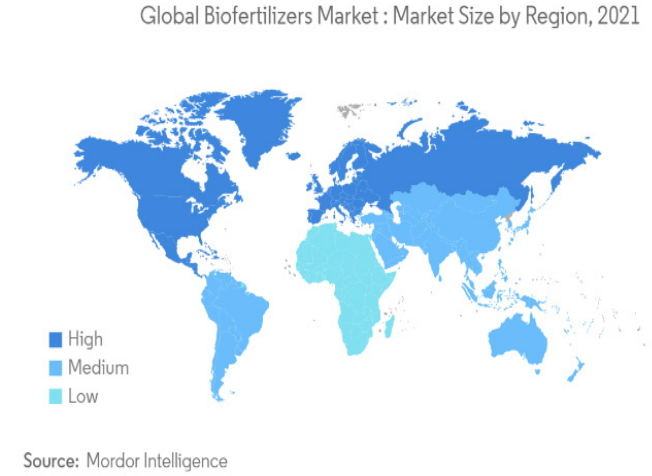

Figure 2. Biofertilizer market size of the world by region. (**Source:** Mordor Intelligence, 2021).
Note: (■)-High; (■)-Medium; (■)-Low.

Figure 3. Largest market of biofertilizers. (**Source:** Grand View Research, 2018)
Note: (■)-Largest market.

Figure 4. Market size of biofertilizers in USA. (Source: Grand View Research, 2018)
Note: (■)-Nitrogen fixation, (■)-Phosphate solubilizing, (■)-Others.

The biggest market of biofertilizers, the North and Latin American countries, are also taking several actions to make biofertilizer market bigger. In terms of revenue, North America dominated the biofertilizer market with a portion of 32.6%, in 2019. The area of total global farming land under biofertilizer use has increased from 69.4 million hectares to 74.9 million hectares between 2017 and 2020 (Mordor Intelligence, 2021). Another report reveals that in 2019, the market value of the global biofertilizers was USD 1.0 billion and is anticipated to reach a Compound Annual Growth Rate (CAGR) of 12.8% from 2020 to 2027. Among all, N fixing biofertilizer alone had a market share of 71.2% in 2019 (Grand View Research, 2018).

Biofertilizers are getting commercialized in each continent more or less. The major countries producing biofertilizers commercially and using on a larger scale are - The U.S., Canada, Mexico from North America; Germany, The U.K., France, Spain, Italy, Russia from Europe; China, Thailand, Malaysia, South Korea, India, Japan, Philipines, Australia from Asia-Pacific region (expected CARG of 13.1% between 2020 to 2027); Brazil, Argentina from Latin America and some other countries from Middle East and Africa. Some other countries of the world are in the process of formulating laws and orders for making biofertilizer dominated agriculture compulsory with some national standards and regulations which includes Nepal, Bangladesh, Pakistan, Kyrgyzstan, and Jordan.

Additionally, according to the promotions of the Common Agricultural Policy it is expected to boost the biofertilizers markets around the world at a phenomenal rate in the near future.

Commercialization

The international companies playing key role in the field of global biofertilizer production and distribution usually focus on product innovation and differentiation strategy. They also work with farmers for field trial, development and customization of their products. CBF China Biofertilizers, Lallemand Inc., Novozymes A/S, Fertilizers USA LLC, AgriLife, Symborg SL, Kiwa Bio-Tech Products Group Corporation, Lallemand Inc., Bayer Crop Science, Rizobacter Argentina SA, Agrinos, Pivot Bio, FMC corporation, Bioworks Inc, Syngenta AG, Sumitomo Chemical Co. Ltd. and BASF SE are some major players in the world market of biofertilizers. India has granted only five biofertilizers, *viz.*, *Rhizobium*, *Azotobacter*, *Azospirillum*, Phosphate-Solubilizing Bacteria (PSB), and Arbuscular Mycorrhiza (AM) for commercialization by Fertilizer Control Order (FCO), 1985 (Singh et el., 2021).

Besides these, biofertilizer market has already been segmented to national and local companies focusing on local markets. They have fortified their positions by developing their products considering local geography and crop cultivation pattern which cut significant sales figures for them.

Biofertilizers in Bangladesh

As an agrarian country, Bangladesh has a huge demand of fertilizers and most of them are imported. Bangladesh imported

about 1.8 million tons of fertilizers (68% of total need) in 2015-16 Fiscal Year (FY) (Howlader, 2017) (Figure 5).

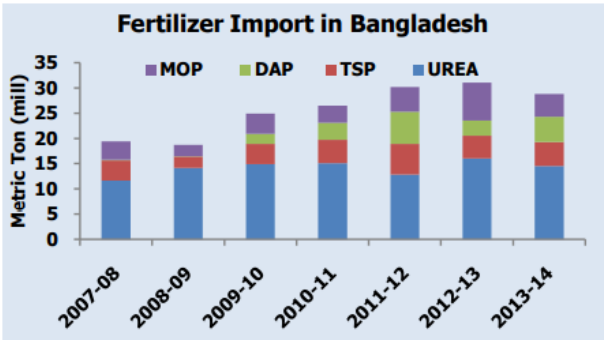

Figure 5. Amount of different chemical fertilizer import in Bangladesh from FY 2007-08 to 2013-14. (Source: Bangladesh Agricultural Research Institute, 2015).
Note: ( )-MOP; ( )-DAP; ( )-TSP; ( )-UREA.

The increasing demand if inorganic fertilizers to support intensive crop production and to meet the demand, harmful chemicals are mounted in soils at an alarming rate. For better understanding, it can be mentioned that the use of urea has increased from 8.6 kg per hectare to 62.5 kg per hectare from 1961 to 2006. The use of biofertilizers can reduce chemical fertilizer and pesticide application upto 80% and thus reduce the subsidy from the fertilizer sector notably (Basak et al., 2015). Lack of knowledge and awareness about biofertilizer use have brought no remarkable result from the 'Organic fertilizer promotion in Bangladesh' program in 2014, rather ended with lack of understanding about soil and plant specific behavior of biofertilizers (Miah, 2015). Years have passed and now biofertilizer use and manufacture have opened a new dimension. Different experiments and field trials are already going on and under processing to make biofertilizers more popular to field workers and to promote its mass production and commercialization. Bangladesh Institute of Nuclear Agriculture (Bina) had produced a nitrogen-fixing biofertilizer and distributed among the farmers for trial. They have come out with a positive result and expected to supplement urea of 20 kg to biofertilizer of 2 kg only per hectare of pulse land (Siddique, 2014). The Government of Bangladesh has already given permissions to mass production and commercialization of that specific strain of microorganism as biofertilizer.

Non-government companies are also getting interested to invest in this thriving sector following the world market. As the chain of discourse a laboratory experiment from Apex industry is mentionable. The team went for comparing yield growth of wheat (BARI Gom 30), rice (BRRI 129) and strawberry (AOG Strawberry) with selected endophytic microbe containing biofertilizers and reported remarkable increase of yield with increased antibiotic features against pathogens than a control treatment. They suggested more field trials with other crops and recommended commercial manufacturing and application for the above mentioned crops (Sabir et al, 2018).

Though some companies are manufacturing biofertilizers commercially, still more scope and improvisations are badly in need. The demand of biofertilizer is increasing rapidly but few companies, sometimes not-up-to-the-mark products and infrequent distributions are challenging the market of biofertilizers time and again.

Matter of fortune that Bangladesh has a great potential to manufacture, commercialize and application of biofertilizers. In fact the scenario is changing gradually. Vegetable growers are the main consumers of biofertilizers and per head consumption of vegetables has been increased from 42 grams to 70 grams between 1994 and 2013. This is a green signal for increasing use and demand for biofertilizers. Nutritionally enriched organic foods grown by using biofertilizers can meet the national demand as well as can be exported also. The socio-economy of the local as well as national scale can be upgraded easily.

Sufficient knowledge, practical training of farmers, strategies, proper distribution, readily availability and incentives for promotion are necessary for manufacturing, commercialization, market creation and use of biofertilizers in Bangladesh (Miah, 2015). The major companies playing vital role in national biofertilizer market should invest more in new products which are soil-plant specific, pedo-climatology supporting and should have the scope to improvise the product with time. Focusing on R & D to introduce new products at lower cost should be another point they should be kept in mind. Greater importance should be given on distributing their product.

CONCLUSION AND RECOMMENDATIONS

To feed the rapidly growing population of the world, we are running after intensified cropping and using more chemical fertilizer which will cause a serious hazard to soil and environment as well as to human health in the long run. It is the high time for being alert. One of the greener solutions towards sustainable agriculture is the use of biofertilizer which should be adopted right at this time everywhere. Government, policy makers, stake holders and scientists should launch some joint ventures to promote biofertilizers vigorously. In agriculture based economies, like Bangladesh, Government bodies should give maximum support to educating field workers about the usefulness, selection and application method of biofertilizers by extension services, which is far better than giving subsidies on chemical fertilizers.

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