Fresh Biofertilizer: A Novel Concept in Improving Soil Fertility

Prakash Vaghasiya[1*], Krishna Patel[2], Anjali Nair[3]

Vise Innovation Solution Enterprise Pvt. Ltd, Vadodra
*Corresponding Author

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Abstract— *Biofertilizers are gaining tremendous importance in agriculture due to the detrimental effect of chemical fertilizers on plants and soil health. It consists of living beneficial microorganisms that enhance plant growth and maintain soil health by using different mechanisms. For improving the soil health along with the growth of plants Efficiency of biofertilizers depends upon different factors such as quality and formulation of inoculant, total number of living microbes, and shelf life. .Therefore it is very important to discuss the shelf life of biofertilizers and another alternative such as use of fresh biofertilizers. Fresh biofertilizers is a concept that emphasises immediate use of biofertilizer after production to ensure maximum microbial count and hence is a revolutionary idea in the field of agriculture. So this study shows the importance of fresh biofertilizer in improving soil health and plant growth.*

Keywords— Microorganisms, Shelf life, Fresh biofertilizer, Soil fertility.

I. INTRODUCTION

Our dependence on chemical fertilizers helped the survival of many industries that are producing life threatening chemicals which are disturbing the ecological balance. The problem of feeding an increasing global population when the agricultural sector is facing many environmental issues can be solved with the help of biofertilizers. (Deepak Bharadwaj *et al* 2014). Because of the increasing potential of biofertilizer in sustainable agriculture, its demand among farmers is increasing. However, many of the biofertilizers that are produced worldwide are often of poor quality, resulting in loss of confidence of farmers (Herrmann, L., & Lesueur, D. 2013).The formulation and shelf life of inoculant used, act as key components for the development of a successful biofertilizer. This review discusses the importance of good quality fertilizers and the factors determining it. (Herrmann, L., & Lesueur, D. 2013).

II. WHY BIOFERTILIZERS ARE CONSIDERED AS AN ASSET FOR FARMERS?

Biofertilizers are considered as a viable alternative for chemical fertilizers that cause various environmental hazards. Microorganisms such as plant growth promoting rhizobacteria and mycorrhizal fungi are mainly used in the formulation of biofertilizers because of their ability to provide plants with the essential nutrients that enhance their growth (D.Mishra *et al* 2013). Compared to chemical fertilizers, biofertilizers are more accessible to small and marginal farmers (Thomas, L., & Singh, I. 2019). The positive agronomical effect of microbial based products has opened a worldwide market for biofertilizers.

Biofertilizers are cultures of living microorganisms packed in a carrier material. Biofertilizers consist of living or latent cells of efficient strains of nitrogen fixing, phosphate solubilizing or cellulolytic microorganisms. (Paula García-Fraile, *et al*. *AIMS Bioengineering*, 2015.). The major phosphate solubilizers which are free living include *bacillus, aspergillus, pseudomonas, enterobacter, and penicillium* but the N-fixing bacteria could be free living (*rhizobium*) or symbiotic (*azospirillum and azotobacter*) (Elmerich and Newton, 2007; Raimi *et al*., 2017). Biofertilizers helps in increasing the number of beneficial microorganisms in the soil and accelerate their microbial processes that helps increases the availability of nutrients that can be easily assimilated by plants. Biofertilizers play very important role in fixing atmospheric nitrogen and releasing growth promoting substances such as gibberellin, indole acetic acid (IAA), cytokinins and siderophores (Suyal *et al*., 2016). Hormones and antimetabolites released by biofertilizers help in promoting root growth. Another function of biofertilizer includes decomposition of nutrients and soil mineralization [2-4]. Biofertilizers consist of different types of microbes with similar or different functional capabilities (Lesueur *et al.*, 2016).

Organic farming mostly depends on the natural microflora of the soil that contains all beneficial bacteria and fungi called Plant Growth Promoting Rhizobacteria (PGPR). Biofertilizers helps in keeping the soil rich in beneficial microorganism by nitrogen fixation, phosphate and potassium mobilization and solubilization, release of plant growth promoting substances, biodegradation of organic matter in the soil and production of antibiotics (Sinha RK *et al* 2014). Application of biofertilizers helps in multiplying the nutrient cycling and promotes crop productivity (Singh JS *et al* 2011). PGPR act as bio protectants that help in crop improvement under stress (Yang JW *et al* 2009). Even under salinity stress conditions the number of nodulation increased with the application of Rhizobium trifolii inoculated with Trifolium alexandrinum (Hussain N *et al* 2002) (Antoun H *et al* 2005). A root endophytic fungi Piriformospora indica helped the host plant in defending against salt stress (Ansari MW *et al* 2003).Apart from acting as growth promoting agents, biofertilizers provide resistance against pathogens by producing metabolites (Backman PA, Sikora RA: Endophytes: an emerging tool for biological control. Biol Control 2008). In banana roots fusarium infestation can be controlled with the help of Bacillus subtilis N11 along with compost application (Zhang N *et al* 2011). B.subtilis is used in cotton to provide resistance against R.solani along with induction of foliar and root growth (Medeiros FHV *et al* 2011).

III. WHAT DETERMINES THE QUALITY OF A BIOFERTILIZER?

Like any other product, the success of biofertilizer depends upon its quality. Biofertilizers of poor quality are not found helpful in increasing crop yield (Lupwayi et al., 2000; Simiyu *et al*., 2013) because the microbial element that is essential for field action will be missing (Herrmann et al., 2015; Raimi *et a*l., 2019). Poor biofertilizers causes financial losses to the farmers when applied in the field because they do not form associations with host plants (Corkidi *et al*., 2004; Faye et al., 2013). Several biofertilizers have been reported to have contaminants instead of microbes that are mentioned in the products label (Herrmann *et al*., 2015; Olsen et al., 1996).It is very important to have an efficient production system with proper quality control (Herridge et al., 2002; Simiyu *et al*., 2013). Presence of recommended strains in active forms determines the quality of a biofertilizer (joginder singh 2001).

The quality parameters used by India and China include Total Viable Cell(TVC), pH, shelf life, particle size, water content and contaminations (Malusa and Vassilev 2014).Other quality parameters used for biofertilizers include type, effectiveness and functional capabilities of microbe present in the biofertilizer (Lupwayi et al., 2000; Vessey, 2003).

IV. TOTAL VIABLE CELL COUNT AND ITS SIGNIFICANCE

Total Viable Cell count is an important parameter used to identify the quality of a biofertilizer. The microorganisms present in the biofertilizer should be living to ensure the initial infectivity or colonisation of the host plant as well as for the exhibition of other functional abilities (Habte and Osorio, 2001). Hence it is very important for the biofertilizers to contain viable cells and spores that are metabolically and physiologically competent for field efficiency (Raimi A *et al*.2020). Dilution plate technique can be used for estimating total viable cell count using a tenfold serial dilution with saline solution as diluents (Motsara and Roy, 2008). A rotary shaker is used for agitation at 150rpm for 25 minutes before further dilution up to 10-9. Then 0.1 mL of dilution 10-5 to 10-9 is spread on different culture media plates in triplicate. After incubating for 2-5 days the colonies are enumerated and the microbial count are expressed as **Colony Forming-Unit [CFU]** (Raimi A *et al*.2020). CFU is an important criteria to determine the quality of a biofertilizer. This is because a biofertilizer must supply a substantial amount of microorganisms in to the field to ensure guaranteed field efficiency. Therefore, Total Viability Count of a good biofertilizer should be within the acceptable quality standard or should match with those declared by the product or label (Raimi A *et al*.2020).

V. FORMULATION OF A BIOFERTILIZER

Formulation of inoculant is a very crucial process in the manufacturing of biofertilizers. A successful formulation should result in involving one or more microorganism in a suitable carrier, protecting them from harsh conditions during storage, maintaining the count of viable cells and ensuring their survival and establishment after inoculating in to the soil (Herrmann, L., & Lesueur, D. 2013).Formulation decides the potential success of inoculants (Fages 1992). The quality of a microbial inoculant depends mainly on the number of viable cells present in it (Sahu, P. K., & Brahmaprakash, G. P. 2016). The relationship between effectiveness of a biofertilizer and number of viable cells are directly proportional. Formulation is a multi step process that results in different strains of microorganisms in a particular carrier with additives that helps in protection of cells during storage and transport (Xavier et al. 2004). The microorganism present in the formulation should be well protected to survive under harsh conditions so that the numbers of living microbes are maintained. A formulation is considered to be excellent if it provides good condition for survival of microorganism in the soil and helps in enhancing their activity in the soil that helps in plant growth (McQuilken et al. 1998). Different types of formulation used include liquid, peat, granules, powder and success of a formulation depend on different factors such as target crop, environmental constraints, cost, and market availability (Arora et al. 2011). With time, total viability count or total number of living cells of microbes present in a biofertilizer reduces along with its quality. This can be changed with the introduction of the concept of 'FRESH BIOFERTILIZERS'. Fresh biofertilizers should be applied in the field immediately after manufacturing, ensuring the maximum number of living microbes in the biofertilizer. Farmers receive their biofertilizers a long time after its production. During this time period microbial count of the biofertilizer reduces affecting its potential. This can be avoided if biofertilizers are produced by farmers by themselves and applied in the field immediately after production. Technologies enabling this are introduced by biofertilizer companies and awareness about such technology should be created among farmers to assure proper utilization of biofertilizers. FRESH BIOFERTILIZER is a novel concept and should reach all farmers.

VI. SHELF LIFE OF A BIOFERTILIZER

Biofertilizers consist of living organisms that benefit the plant resulting in improved growth and productivity. Therefore viability of these organisms during production, formulation, storage, and transport and field application is directly proportional to the plant growth promoting ability of a biofertilizer formulation. Improper storage and long duration between production and field application is one of the major reasons behind the inefficiency of biofertilizers. This limits the use of biofertilizers due to their stability, compatibility and survival under different soil conditions. Hence improved shelf life or immediate use of biofertilizers after production might helps in maintaining the rate of colony forming unit in biofertilizers and helps in further popularization of biofertilizer application (Satinder Kaur *et al* 2012).

Different strategies are applied to ensure maximum viability of formulations used in bio-fertilizers .These strategies include (Satinder Kaur *et al* 2012):

1. Use of thermo-tolerant/ drought-tolerant/ genetically modified strains.(Satinder Kaur *et al* 2012).
2. Optimization of biofertilizer formulation(Satinder Kaur *et al* 2012).
3. Use of liquid biofertilizers(Satinder Kaur *et al* 2012).

Carriers are used in biofertilizers as a vehicle for the convenient application of microorganisms. This also helps in maintaining the viability of cells and also provides a condition that promotes rapid growth of microorganisms upon their release. For better shelf life of biofertilizers, a carrier or a mixture of carrier material such as peat, vermiculite, lignite powder, clay etc. are selected on the basis of viability of micro-organism mixed with them. Another method used for improving the shelf life of bio-fertilizer is pre-sterilization and nutrient enrichment of carrier material .This allows the micro-organism to grow in a non-competitive environment (Yardin MR *et al* 2000). One of the potential strategies for improving shelf life of biofertilizer is liquid biofertilizers. Liquid biofertilizers allow the manufacturer to include sufficient amount of nutrients, cell protectant and inducers that result in formation of cell/spore/cyst that promotes prolonged shelf life of biofertilizers. In case of solid biofertilizers the shelf life is around 6 months but in case of liquid biofertilizers can be around 2 years (Mahdi SS *et al* 2010). Liquid bio-fertilizers provide improved shelf-life due to their thermo-tolerant capabilities (Mahdi SS *et al* 2010). But the cost of production of liquid biofertilizers is higher than solid biofertilizers thus, successful commercialization of less expensive liquid biofertilizers are still a concern.

VII. FACTORS AFFECTING THE QUALITY AND EFFICACY OF AN INOCULANT

The Quality of an inoculant during production depends on a number of factors (Herrmann, L., & Lesueur, D. 2013). During large scale production of an inoculant a number of technical difficulties occur. For example in case of bacteria, the nature of growing media and the condition of incubation like pH , temperature, and time should be controlled and adjusted to ensure optimum growth of specific strain and good physiological condition of cells. Operators should be well trained to assure implementation of right methodologies. Throughout the process, the purity of culture is maintained to ensure production of good quality product (Malusa *et al*. 2012; Okon and Hadar 1987).

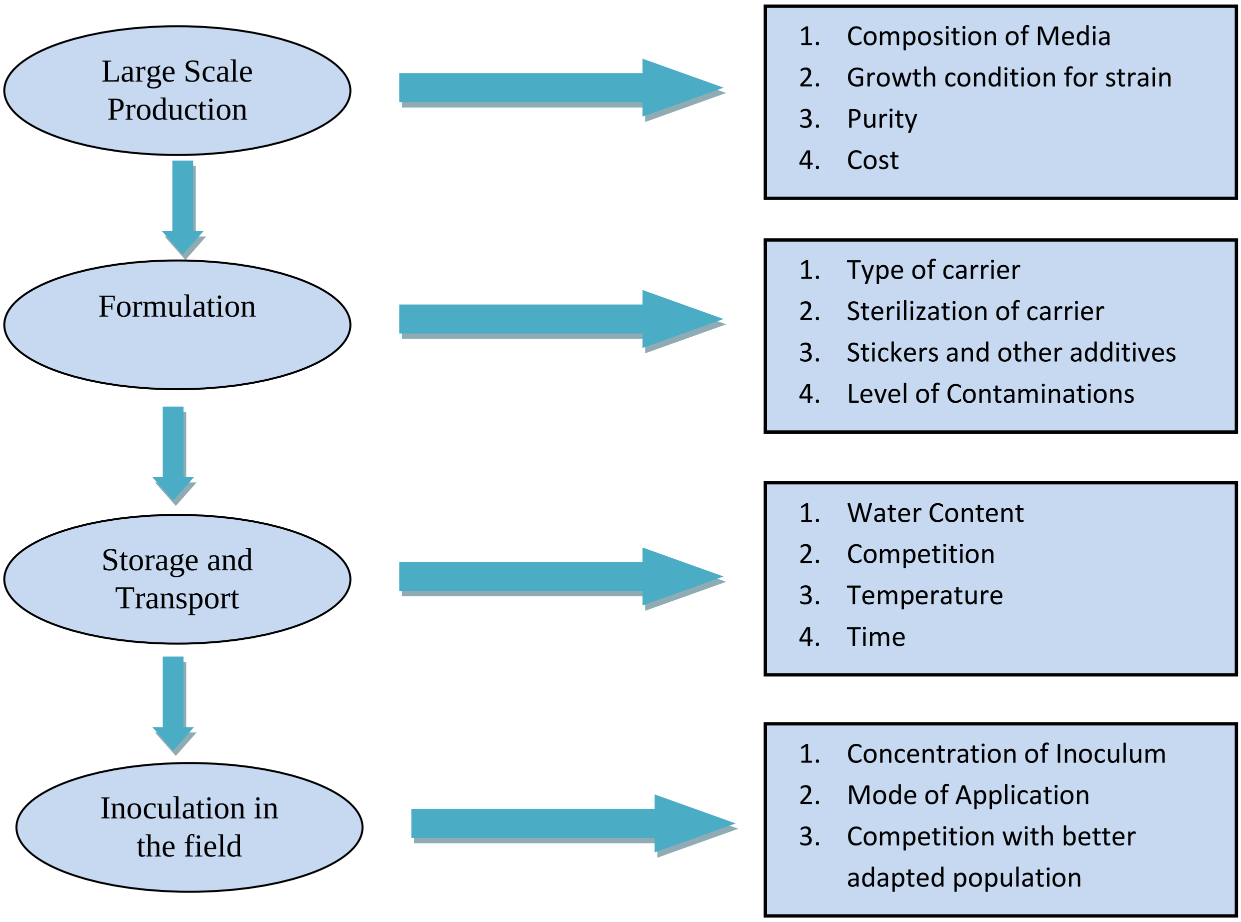

FIGURE 1: Factors affecting quality of inoculants during different stages.

Introduction of new carriers will help to overcome the limitations due to use of peat like its availability, environmental impact and toxicity and it will provide a more sustainable environment for the growth of microorganisms, its viability during storage and on seed and soil after application (Deaker *et al*. 2004; McQuilken et al. 1998).

Many factors affect the viability of cells during transport and storage. In order to maintain viability at storage cool temperature is generally recommended but it is very expensive and lacking in many developing countries (Herridge et al. 2002; Temprano *et al*. 2002).Several studies have reported that the inoculation efficiency reduced due to declining population in inoculation over time. (Biederbeck and Geissler 1993; Catroux *et al*. 2001; Maurice et al. 2001; Revellin *et al*. 2000; Trivedi and Pandey 2007). If the products are not stored under optimal condition then the population of contaminants increases (Hartley *et al*. 2005). Efficiency of a inoculant also depends on the mode of application like seed coating, soil application or on-site seed application (Deaker et al. 2004; Malusa *et al*. 2012).One of the major barrier for successful inoculation is nature and size of native population in the soil. It is challenging for the newly introduced cell to survive in the new potentially harsh condition and along with that, they also have to compete for a protective niche and nutrients with the indigenous, better adapted population (Bünemann et al. 2006; Kloepper *et al*. 1989).

The ability of an introduced strain to maintain a high population level in an unfriendly environment and to live as a member of soil microflora even in the absence of its host legume determines the success of inoculation (Lupwayi *et al*. 2006).

VIII. CONCLUSION

Since biofertilizers are composed of living microorganisms, maintaining the viability of living organisms present in it is an integral step towards production of a good quality biofertilizer. The concept of fresh biofertilizer is a novel approach towards use of biofertilizers. Maintaining cell viability is an important factor affecting biofertilizer quality and that can be achieved with the use of fresh biofertilizers. Hence, this article discuss about the importance of biofertilizers, factors affecting its quality and about the significance of fresh biofertilizer concept.

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