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ROLE OF BIO-FERTILIZERS IN VEGETABLE CROP PRODUCTION: A REVIEW

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ABSTRACT

In the recent years, there has been an increased dependence on chemical fertilizers and pesticides to enhance the production and productivity of agricultural sector to meet the growing global population. This has caused severe impacts on ecosystem. Thus, the search for an environment friendly alternative has ended while realizing the potential of biological inoculants like bio fertilizers and bio control agents. The present review elucidates the important roles and benefits of certain bio fertilizers in the production of agricultural crops. Bio fertilizers have the potential to meet the nutrient requirement of crop plants by increase fixation of mineral nutrients like nitrogen and phosphorus etc. by their respective nitrogen and phosphorus fixing bacteria's viz., Rhizobium, Azotobacter, Azospirillum and Phosphate solubilizing bacteria. Biofertilizers not only ensures the availability of nutrients to the plants but also maintains the soil fertility, ecosystem and improves the productivity of crop.

KEYWORDS: *Bio-fertilizer, Rhizobium, Azotobacter, Azospirillum, PSB*

INTRODUCTION

Vegetables are most important component of a balanced diet and act as a protective food. India occupies a prime position in the world in vegetable production and 2nd largest producer of vegetable next to china.There has been a rapid increase in population since the last few decades which resulted in huge demand crop production. This in turns increased the necessity to produce healthy and quality seedlings. In order to meet the demand for more quality seedlings, there is an excessive use of chemical fertilizers and pesticides, which becomes a matter of concern in the near future. So, the use of biological fertilizers and bio control agents was identified as an alternate system, which may play an important role in achieving timely and sustainable increase in production of vegetable crops without adversely affecting the environment. Vegetables are most important component of a balanced diet and act as a protective food. India's diverse climate ensures availability of all varieties of vegetables. It ranks second vegetables production in the world, after China. As per National Horticulture Database (Second Advance Estimates) published by National Horticulture Board, during 2019-20, India produced 191.77 million metric tonnes of vegetables. The area under cultivation of vegetables was 10.35 million hectares. According to FAO (2019), India is the largest producer of ginger and okra amongst vegetables and ranks second in production of Potatoes, Onions, Cauliflowers, Brinjal, Cabbages, etc. The overall production of vegetables is estimated to be 196.27 MT compared to 188.28 MT in the previous year. The vast production base offers India tremendous opportunities for export. During 2020-21, India exported vegetables worth of Rs. 4,969.73 crores/ 667.61 USD Millions.

The concept of organic farming focuses on exploitation of beneficial microorganisms for providing necessary nutrients, pest-disease resistance to crop plants without adversely affecting the environment. Therefore, the introduction of biological fertilizers goes hand in hand with modern approaches towards agriculture. Bio fertilizers acts as supplementary component to soil and crop management processes *viz.*, crop rotation, organic adjustments, soil fertility renovation, resistance to pest and disease, which can significantly be useful in maintaining the sustainability of various crop productions.

Need of Bio-Fertilizers

Fertilizer prices are increasing day by day so becoming unaffordable by small and marginal farmers, depleting soil fertility due to widening gap between nutrient removal and supplies, growing concern about environmental hazards and increasing threat to sustainable agriculture. Besides above facts, the long term use of biofertilizers is economical, eco-friendly, more efficient, productive and accessible to marginal and small farmers over chemical fertilizers

Bio-fertilizers

Biofertilizers are preparations containing living cells of microbes that increases the availability of nutrients into forms that can be easily assimilated by plants (Asif *et al*., 2018) The replacement of synthetic fertilizers with bio fertilizers has gained popularity as it lowers the cost of crop production along with enhjancing the growth, development and yield of crop by increasing the availability of nitrogen and other mineral nutrients, by producing certain substances like auxin, cytokinins, gibberellins etc. (Amer *et al*., 2002). The use biofertilizers can raise the productivity per unit area in a short time, using smaller amounts of energy and can increase soil structure, decrease environmental hazards. The utilization of nitrogen fixing and phosphorus solubilizing bacteria as bio-fertilization has the potential to make use of available atmospheric nitrogen and fixed phosphorus present in the soil in crop production (Yasin *et al.*, 2012).

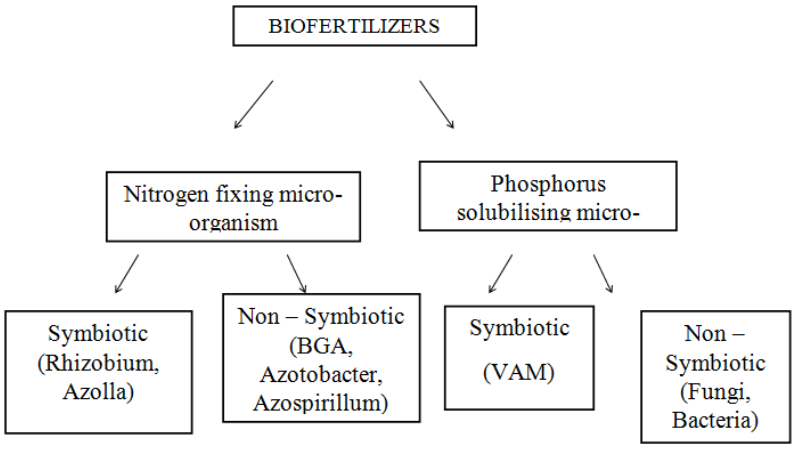

Figure 1: Biofertilizer Types (Jehangir et al., 2017).

Need of Bio-Fertilizers

- Biofertilizers are required to restore the fertility of the soil.
- Prolonged use of chemical fertilizers degrades the soil and affects the crop yield.
- Biofertilizers, on the other hand, enhance the water holding capacity of the soil and add essential nutrients such as nitrogen, vitamins and proteins to the soil.

AZOSPIRILLUM

Azospirillum is a species of bacteria which is utilized as one

Azospirillum, one of the best characterized nitrogen fixing bacteria belongs to family Spirilaceae, heterotrophic and associative in nature. In addition to their nitrogen fixing ability of about 20-40 kg/ha, they also produce growth regulating substances. Presently eight azospirillum species has been. Although there are many species under this genus like, *A.amazonense, A.halopraeferens, A.brasilense,* but, worldwide distribution and benefits of inoculation have been proved mainly with the *A.lipoferum* and *A.brasilense*. The *Azospirillum* form associative symbiosis with many plants particularly with those having the C4-dicarboxyliac path way of photosynthesis (Hatch and Slack pathway), because they grow and fix nitrogen on salts of organic acids such as malic, aspartic acid (Arun, 2007a). *Azospirillum sps.*are capable of promoting the plant growth by different mechanisms, including the biosynthesis and release of amino acids, indo-acetic acid, cytokinins, gibberellins and other polyamines, favoring root growth and, consequently, intensifying water and nutrient uptake by plants. Beyond these, *Azospirillum* has the ability to fix atmospheric nitrogen (N_2) through the biological nitrogen fixation process (BNF) and can therefore directly contribute to make N available to non-leguminous species. The effect of these bacteria could be better explained by the "Multiple Mechanism Theory" formulated by Bashan and Levanony , which describes the *Azospirillum*–plant association (Zeffa *et al.,* 2019).

Benefits of Azospirullum

Azospirullum is known to fix atmospheric nitrogen through the action of nitrogenase complex and benefit host plants by supplying growth hormones and vitamins. *Azospirillum* can promote plant growth by mechanisms of tolerance of abiotic stresses, named as induced systemic tolerance, mediated by antioxidants, osmotic adjustment, production of phytohormones, and defence strategies such as expression of pathogenic- related genes. It is considered as the safest bacteria, which can be used as a biofertilizer at commercial level for several crops.

Azotobacter

Azotobacter is also a potential N_2 fixing bacteria which is present in the soil. It also has the ability to synthesize growth substances to promote growth and development in plants. Three possible mechanisms have been proposed to explain the mode of action of *Azotobacter*: N_2 fixation; delivering combined nitrogen to the plants; the production of phytohormone – like substances that change the plant growth and morphology; thereby increasing nitrogen accumulation in inoculated plants (Sartaj *et al.*,2016). It has been reported that *Azotobacter* has the ability to fix around 20 kg N/ha/year (Kizikaya *et al.,* 2009) and the application of mixed strains of *Azotobacter* could reduce the need of nitrogen fertilizers in plants to 50% (Romero – Perdomo *et al.,* 2017).

Benefits of *Azotobacter*

Azotobacter can promote plant growth and development by nitrogen fixation, production of ploant growth promoting hormones and release of siderophores. *Azotobacter* has the ability to impart resistance against several phytopathogens by several strategies like production of siderophores, antimicrobial substances, toxins etc. *Azotobacter* is also regarded as a potential microbe for bioremediation by removing phytotoxic chemicals released into the soil through industrial effluents, sewage sludge and those chemicals present in pesticide. Being a non-symbiotic bacteria that has the capability to enhance mineral nutrient intake for increasing productivity, it is highly preferred to be utilized as a biofertilizer.

RHIZOBIUM

Rhizobium is a bacterial genus, belong to the family Rhizobiaceae which are usually found in symbiotic association with leguminuous plants. The symbiotic association of *Rhizobium* with plants has been initiated through root hairs as this process of attachment is mediated by the protein lectins that bind the bacteria to the surface of root hair. The infected root cells divide and form nitrogen fiixng nodule for nitrogen fixation (Gomare *et al.*, 2013). It has been estimated that 1g of soil may contain a community of 10^9 microorganisms with *Rhizobia* representing around 0.1% of soil microbes or 10^6 g -1 soil (Thies *et al.*, 1991). *Rhizobium* inoculation improves the nutrient (P, K, Ca and Mg) uptake in different plant parts such as leaves, shoots, roots and thereby ensuring the availability of all micro and macro nutrients to different plant parts. Along with these characteristics, *Rhizobium* also improves the chlorophyll content, facilitates nodulation and nitrogen fixation in crop plants. *Rhizobium* depicted a significant influence on legume vegetable crops, resulting increase in yield from 4-13 %.

Benefits of *Rhizobium*

Rhizobium biofertilizers are recommended for grain legumes to improve the productivity and to augment soil nitrogen status. *Rhizobium* plays an important role in formation and development of root nodules in plants. They are much cheaper than other inorganic fertilizers.

Phosphorus Solubilizing Bacteria (PSB)

Phosphate solubilizing bacteria (PSBs) are a group of beneficial microorganisms capable of hydrolyzing organic and inorganic insoluble phosphorus compounds to soluble P form that can easily be assimilated by plants. Phosphorus is the second most important macronutrient required by the plants, next to nitrogen. Yet, the availability of soluble forms of P for plants in the soils is limited because of its fixation as insoluble phosphates of iron, aluminium, and calcium in the soil. The use of PSM as a biofertilizers has been as subject of study for years. Application of PSB by inoculating in soil converts the insoluble P compounds to plant-available P form, resulting in better plant growth, crop yield, and quality and also results in production of plant growth hormones such as IAA and GA (Girmay *et al.*,2019).

Benefits of using Phosphate Solubilizing Bacteria

- Phosphorus solubilizing bacteria improves 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).
- PSB used in conjuction with low quality rock phosphate may be an alternative to costly phosphate fertilizers (Mahanta *et al.*, 2018).

Vesicular Arbuscular Mycorrhiza (VAM)

The mycorrhizal fungi mobilize phosphates and other micronutrients like zinc, boron and molybdenum from adjacent soil to the root system through hyphal network. Enhanced uptake of phosphorus and increased plant growth due to inoculation of soil with VAM fungi in horticultural crops such chilli, tomato, asparagus, potato, lettuce, Onion and chilli.

Combined Inoculation

The highest number of fruits, fruit weight, length of fruits and thickness of fruits were obtained with the application of combination of organic manures together with *Azotobacter* and PSB in okra crop. Seeds inoculation of tomato plants with a mixture of *Azotobacter chroococcum*, *Azospirillum brasilense* and Bacillus subtilus results an increase in fresh and dry weight of plants over inoculating plants with *Azospirillum brasilense* or *Azotobacter chroococcum* alone. They found that plant dry weight of *Capsicum annum cv. California* Wonder significantly increased by mycorrhizal inoculation together with different diazotrophs. Inoculation of pigweeds (*Amaranthus dubians*) with effective microorganisms can improve their growth and yields

CONCLUSION

As discussed earlier, application of biofertilizer play an important role in improving the availability of nutrients to plants, improving the soil productivity, soil fertility index, maintenance of natural ecosystem and promoting sustainability in the coming years by being alternatives for chemical based agro products. Organic farming contributes a major force on utilizing biological inoculants in soil. In this way, the role and benefits of some of the biofertilizers have been discussed in this review. *Azospirillum, Azotobacter and Rhizobium*, are nitrogen – fixing bacteria's that can induce plant growth and development through several mechanisms. These biofertilizers also possess the ability to synthesize plant growth promoting hormones IAA, Auxins etc. On the other hand, the use of PSM (Phosphate Solubilizing Microbes) has been identified as an efficient way to convert the insoluble P compounds to plant available P forms which results in better plant growth, yield and quality.

The necessity to find immediate solutions on plant pest and disease resistance in an organic environmental friendly manner has led to deeper focus on bio fertilizers apart from imparting plant growth characteristics. The importance of these bio fertilizers needed to be studied with different microbial strains that shows positive influence in the field of agriculture. The commercialization of these biological products must be made over chemical products in a very cost efficient way, so that small and marginal farmers could even easily access them.

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