Biological Forum – An International Journal **15(2): 438-443(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Plant Growth Promoting Rhizobacteria: A Review on Biomass Production and its Scope in Commercialization

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(Received: 20 December 2022; Revised: 07 February 2023; Accepted: 11 February 2023; Published: 14 February 2023)
(Published by Research Trend)

ABSTRACT: The world wide amplifies in human inhabitants and ecological damage has the adverse significance with the intention of world food stuff manufacture. May perhaps shortly turn into inadequate to nourish all populace. It's consequently vital yield output, considerably better in subsequent years. To overcome this condition farming preparation will shift forward a additional defensible, environment responsive perception. A variety of findings include recognized an amplified well being, yield of diverse herb class with the use of phosphate solubilising bacteria beneath together regular and unfavourable circumstances. The herb useful root surface bacteria might decline worldwide faith resting on harmful synthetic pesticides threaten the atmosphere. Power of biofertilizer based on preparations, manufacture, preservation and function of live invisible cells. Improvement of low-cost expertise, economical combination should be used in biofertilizer manufacture. After the Mass cultivation, the creation must composed in fluid or hard form, required long preservation, exploit of preserver /bearer, preservation conditions (hotness, water content) ease of purpose and protection of advantageous possessions on herbs. . Careful determination of these optimal conditions would ensure the low cost efficient bioinoculant that would enhance the growth and yield of various crops. This study aims to review plant beneficial microbial agro inoculants successful formulations and commercialization.

Keywords: Rhizobacteria, PGPR, Biomass production, Protectors, Carriers.

INTRODUCTION

In spite of plant cultivation, regarding one third of the cultivated crops are demolished due to infectious disease, insects. The development of synthetic chemical fertilizers has provided, significantly towards the raise of food manufacture by governing insects and diseases. Though the utilize of these artificial chemicals for the duration of the precedent few years has increased a numeral of environment trouble. In modern period researches have abstracted their concentration in the direction of inspecting the potential of valuable microorganisms, for plant cultivation measures. Biocidal factors are simple to bring, recover plant growth and make active defiance machinery in the host, and amplify biofertilizer manufacture and yield.

Microorganisms that reside in the root surface area are intelligent towards helpful, unbiased, changeable, otherwise harmful possessions in herb development and improvement (Barea, 2015). Root surface bacteria are valuable invisible cells for example N_2 fixing, PO_4 solubilising bacterium (Bharti and Barnawal 2018). These bacteria contain pertinent properties concerning necessary dietary for herbs example N_2, ammonia and PO_4. While root surface live cells are capable to amplify vegetable dietary perception with resources of different extensively deliberate procedure, they include become actually motivating the agricultural manufacture. Many Preparations based on beneficial microbes might prepare through relevance for many herbs all over the planet (Saleem and Khan 2017). Though the contradiction in the results acquires, reliant on a lot of factors such as atmospheric condition, indigenous microorganisms, obtainable nutrient and crop features, makes regulation essential each exacting scheme (Vassilev *et al*., 2015). Research together with physiological and technological studies ought to a main concern so as to create up stable, helpful and dependable inoculants as tools to carry up defendable agriculture (Seema *et al*., 2018).

In this review, attention grabbing of root surface bacteria and their liquid and solid preparations with mass productions were mentioned.

PO_4(PHOSPHATE)-SOLUBILISING BACTERIA

The root surface area could be an essential region for soil microbes and plants. PGPR represent a varied cluster may gift within the in the root surface for soil microorganism. They are currently separated into three purposeful groups: plant growth enhancing bacteria, bio control factors (Berninger *et al*., 2019), and plant pressure regulating bacteria (Cassan *et al*., 2009). These

purposeful PGPR teams will smooth the progress of plant growth beneath the favourable and unfavourable conditions (Singh *et al*., 2016; Bashan *et al*., 2014).

PHOSPHATE-SOLUBILISING BACTERIA AS BIO FERTILIZER

Some PSB are isolated, cultivated and mass production the event of as sorted biofertilizer (Fagorz *et al.*, 2020). Inoculation with PSB like *Pseudomonas aeroginosa, Bacillus megaterium, Azorhizobium, Azoarcus, Herbaspirillum, Phosphaticum*, has been related to a rise in PO_4 (phosphate) dispersible and crop production (Herrmann and Lesueur 2013).

PGPR BIOFERTILIZER DEVELOPMENT

The inoculants appropriately created, developed and functional will promise that the bio fertilizer can offer advantages and speculated to economic. Generally, several privately owned industries provide industrial biofertilizer on the global bazaar, where to hand is a growing order for an extremely prolific and efficient bioinoculant for a broad variety of soils. While, sometimes the bioinoculants obtainable be often low-grade. In budding and urbanized nations, few biofertilizers not having soil microbes otherwise, certain root surface microbes defect through dissimilar organisms (Vassilev *et al*., 2017). This condition creates an irregularity in the functions of bioinoculants, thus disturbing the marketing process. Some bioinoculants be unsuccessful to reveal their exact function once it inoculated in the field, an ending result from trouble related to their cultivation and manufacture procedures (He *et al*., 2015). Inoculants ought to build up as bioinoculant with extended storage capacity.

The desires with shelf life of bioinoculant vary from 1 or 2 months to 1 or 2 years at room temperature. Increasing the beginning quantity of live cells count could be a scheme to create a speedy corrosion of biofertilizer (Joe *et al*., 2014). Anyhow, preservation condition sought to be regulated to maintain long-standing shelf life of cell (Bernabeu *et al*., 2018). Many studies prove the association between amount of bio inoculants application on soil, plant and harvest (Malusá and Vassilev 2014). Bioinoculant excellence principles that vary a little among countries found that the number of microbial cells be obliged to series from 10^5 to 10^8 CFU (colony forming unit/g or CFU/mL. an additional methods to bioinoculums principles account the count of live cells per seed later than the request as advised by the manufacturer. The lowest number of live cells per seed is in the direct of 10^4 for seeds treatment, 10^5 for mid-sized seeds, and 10^6 broad sized for seeds (Bharti and Barnawal 2018). The non uniformity of soils could be a vast obstacle for inoculants, as a result of the microbes inaugurate are incapable to discover an unfilled place. The bio-inoculant must contest in contradiction of an advanced modified native micro biota and live preying by field micro fauna, particularly once they remain introduced in an undefended method. Thus, bioinoculant must deliver an additional fit biological habitat mutual with rheological shield over an extended time, which would avert the rapid reduction of the bacterial inoculation (Berninger *et al*., 2016). Consequently, there solution of biofertilizer composition remains to permit advanced existence of growth promoting bacteria both during preservation and field application. Bioinoculants can be prepared as liquid or solid type by-product, at the end it may be wet or dry form (Shahzad *et al*., 2017).

LIQUID BIOINOCULANT AND BIOMASS PRODUCTION

Liquid bioinoculants are entire cultures or live cells joint with completely diverse mixtures like liquid, lubricant and career materials which power raise bond, constancy, and emulsifier and dispersal competence. The most benefits of fluid bio-inoculants are their calmer process and inferior prices associated to solid preparations (Vyas *et al*., 2018). This can be why liquid preparations establish a important proportion of the bioinoculants bazaar.

Table 1: Liquid bioinoculant of PGPR.

Sr. No.	Carrier	Microorganisms	Visible cells (initial stage)	Self life	Analysed crop
1.	Arabic gum	*Bradyrhizobium* sp.	10^9 colonies /ml	5 months at 37°C.	Ground nut
2.	Carrageen	*Bacillus siamensis*	10^8 colonies /ml	4 months at 37°C	Black pepper
3.	Tender water, polyvinyl compounds	*Pseudomonas* spp.	10^9 colonies /ml	10^8 colonies /ml 5months at 37°C.	Capsicum
4.	Corn starch, humus, urea, sodium bentonite, alginic acid,	*Pseudomonas putida*	10^{12} colonies /ml	4months at 37°C	gossypium
5.	Glycerine compounds	*Pseudomonas fluorescens*	10^8 colonies /ml	4 months at 37°C	Scarlet Banana
6.	Glycerine compounds or disaccharide	*Pseudomonas* spp.	10^9 colonies /ml	5 months at 4 °C	Any herb

Table 1 expressions about current educations on liquid preparations for latent practice as bio-inoculants aimed at various herbs. Incidence in the growth channels of defensive substances otherwise its count once microbial development will extend cell existence throughout preservation (Anith *et al.,* 2016). However, liquid inoculants are often wrapped and kept for extended stages of time; microbes remain focus to non-living

demand, which can be produced by nutrient exhaustion heat stroke, among different reasons, subsequent in a severe decrease in live cells. The chief contest in this esteem is to progress preparations to yield maintenance of the major excellence of liquid inoculants.

Among defensive compounds, innate analogues (e.g., Carrageen, arabic gum, polysaccharide xanthane, agar, hydrocolloid, *etc*.), artificial analogues (e.g., ethyl alcohol and crospovidone), cotton seed oil or sunflower oil, glyserine compounds, and mono- and disaccharides are appropriate for fluid biomass development (Table 1). During many fluid bioinoculant preparations, root surface organisms keep a least amount of live cells mandatory for numerous bio-inoculant (around 10^8 colonies / ml) for seven calendar months preservation at 37°C or cold storage (Valetti *et al.,* 2016). Furthermore, the helpful possessions of growth promoting bacteria on diverse crops were confirmed after various preservation period.

A variety of physical machinery of protecting substance comprises principally supplement stipulation, development of morphological features and osmoprotection of microbial cells. For occurrence, ordinary and artificial analogues give defending favourable conditions for microbes, be capable to bound temperature shift and acquire more water activity (aw), all the above encourage bacterial endurance beneath completely diverse preservation situation. Cotton seed oil or sunflower oil is a secure and cost-effective preservative to be able to catabolised by a little bacteria like pseudomonas sp. therefore, it will be active as an additional supplement to encourage microbial growth during preservation period (Table 1). Former cost-effective compounds (Corn starch, humus, sodium bentonite) be able to act as bacterial supplements (Macik *et al.,* 2020). In addition, their addition in bioinoculants provides a chief reduce the biomass manufacture expenses.

Glycerine compounds is a economical analogue, eminent defensive agent for its capability to guard microbes from inorganic pressure and take part in absorptive pressure and directive of cytoplamic membrane travel. Moreover, glycerol could be a major carbon source supply for soil microbes, contains a more water holding capacity, and can guard cells as of the force of dehydration. Its water holding capacity to encourage speedy kernel casing. On the conflicting offer, the disaccharide such as lactose acts as failure protector due to its water adhesion property, which reduces frost crystal construction when preserving liquid biomass at frozen temperatures. Lactose used to become stable outer coverings and protects the morphology and occupation of proteins (Abbas *et al.,* 2014). Furthermore, the attendance of OH group in lactose substance preserve growth promoting bacterial cells against superoxide radicals made during preservation (Mburu *et al.,* 2021).

Glycerine compounds and lactose were worn as suspicious substance in liquid biomass preparations of *Pseudomonas* sp. (Table 1). The process be since accompanied: bio preparations of *Pseudomonas* sp, formed in economic bioinoculants (Table 1), combination of 15% glycerine compounds or 5% disaccharides (Mejri *et al.,* 2013).

An attractive advance for the development of an enhanced bio inoculants expertise is the allocation of bio film combination bio inoculants. Recently, a liquid biomass was growing as well as growth promoting bacteria disabled by bio film creation on a fungal surrounding substance (Table 1). Microbial inactivation in bio films presents an amount of compensation because it is a technique support encouraged microbial progression that can be conceded through simple and economical procedures, and bacterial cells in bio films demonstrate bigger endurance by means of admiration to independent cells. Furthermore, microbes in bio films frequently reveal advanced plant development encouraging action (Das *et al.,* 2017).

For mass production of growth promoting microbes carried out by batch fermenters. District precise and ecological pressure well-matched bacterial strains isolated as of a variety of agro atmospheric areas are obtain as of genuine sources, full-grown in slants and moved to broth in the rotary shaker to develop mother culture. The cultures are grown-up in huge range in the fermenter for up to five days, harvested in batch culture method and after that assorted with forest soil: carrier in a ratio of 1:3. The shade dried bioinoculant with carrier are mixed and packed in polythene pack, and stored for use as bionoculant for the needed crop.

SOLID BIOINOCULANT AND BIOMASS PRODUCTION

Solid formulations are often supported biotic or non-living carriers and ready as fragment or talc. They are separated on the base of their component range or their uses. In together fragment and talc commodities, the biotic or non-living carrier is one of the on the whole significant components, and consequently comprises a vital constraint in preparation procedure. Tables 2 and 3 illustrate a number of hard damp and waterless preparations passed out along with growth promoting bacteria and diverse microbial group preserver, analogues and bearer. Some research proved those convinced firm wet and waterless preparations of growth promoting bacteria exhibited appropriate constancy throughout amplification and preservation of biofertilizer. Though, mainly the mechanism integrated (Tables 2 and 3), lifespan of preparations be accessible.

In hard drenched preparations, lack of ventilation procedure was functional throughout preparations. As a result, microbial cells be showing to more water contented throughout preservation and field appliance. As revealed in Table 2, solid drenched preparations of growth promoting root surface bacteria were established on binder (Loján *et al.,* 2017), clay, and peat and biomethane mud collective with improved soil, surrounded by other resources. The assortment criteria of binder must comprise price, accessibility, element constancy, pernicious levels and planter expediency through had miration to organization and litheness.

Table 2: Solid bioinoculant of PGPR

Sr. No.	Carrier	Microorganisms	Visible cells (initial stage)	Self life	Analysed crop
1.	Alginate	Methyl bacterium oryzae	10^8 CFU/g of M.	10 months at 37°C	Tomato
2.	Alginate	*Pseudomonas* sp	Around 106 CFU/mL	N/A	Tomato
3.	Alginate, perlite, paraffin	*Pseudomonas* sp	10^7colonies/g	4 months at 4 °C or 37°C	Mouse ear grass
4.	Ammonium molybdate, peat	*Rhizobia* sp	10^8 CFU/g	N/A	fenugreek
5.	Biochar	*Bacillus* sp.	10^7 colonies/ml	8 months at 26°C	gossypium

Mainly solid drenched preparations in Table 2, growth promoting bacteria were inactivated by diverse procedures such as sticking together or biofilm building on concrete supports or sting in binder pellets. As coded over, inactivation method defends microbial cells next to an assortment of unkind ecological circumstances (Rabin *et al.,* 2015). Effectively inactivated *Azospirillum* sp. using bioentapment configuration on a modernrecyclable foam, which was created by predictable substances joint with numerous using expensive manufacturing by-product (example: tapica, amylum, glycerine). In the bacterial sting in binder pellets, the enclosure of vermiculate favoured the automatic constancy of pellets and the microbial continued existence of Pseudomonas sp. in the preparations. On the former offer, nano inactivation of growth promoting bacteria by electro spinning is a substitute rising process of bacterial inactivation. Once with in the field, microbes could be slowly discharged from large-scale- and micro beads or nanofibre grid.

Waterless preparations among the wet content might make bigger microbial endurance for extended time and at upper temperatures than fluid preparations, so falling manufacture and preservation expenses since low temperature preservation is not necessary. Waterless preparations be able to add water to get cell components to wrap kernel, sink radical, otherwise diffuse resting on mud. In contrast, fluid preparations can always be ready to use in field there is no additional steps. Waterless preparations can be formed by aeration, dehydration, cryodesiccation *etc*. (Table 2). Shadow ventilation and aeration are inexpensive procedures (Melin *et al.,* 2006; Kaiser *et al.,* 2019). In contrast, cryodesiccation and scatter drying need exact apparatus and are power consuming events; consequently, they are extra costly compared to other aeration procedures. Cryodesiccation is widely used to protect the microbial feasibility of bioinoculant preparations. By means measured a yielding dryness process in a cell guard combination is primary passed out, creating a medium to integrate cells and defend alongside antagonistic environment (Tamreihao *et al*., 2016).

Table 3: Solid bioinoculant of PGPR: Waterless preparations

Sr. No.	Dry technique	Carrier	Microorganisms	visible cells (initial stage)	Self life	Analysed crop
1.	Aeration	fen	*S. mexicanum*	10^8 CFU/g	7 months at 37°C (10^9 colonies /ml)	Black beans
2.	Aeration	Condensed milk, natrolite, and pectin	*Pseudomonas* sp	$10^{5–8}$ CFU/g	30 days at 37°C. (10^4 colonies/ml)	chilli
3.	Aeration	Talc, carmellose	*Azospirillum*	$10^{9–11}$ CFU/g	N/A	Groundnut
4.	Dehydration	Table sugar, mono sodium glutamate, K_2HPO_4	*Acinetobacter* sp.	10^8 CFU/g	N/A	Maize
5.	Cryodesiccation	Alginate, acacia gum, and powder	*Bacillus* sp	10^6CFU/g	N/A	Maize

Numerous fine particles preparations contain powder as abnormal bearer (Table 3). Powders haverelation chromophore, decrease damp incorporation; in addition, restrict the water content aqueduct, support long-standing preservation. Moreover, waterless preparations of growth promoting bacteria movement arrested by envelopment in binder or natrolite have been effectively prepared. In numerous granular and powder waterless preparations, carrier resources be mutual with paste/suspicious material such as carmellose, acacia gum, malto dextrin, disaccharides and milk-derived compounds. Adding of preserver was a feasible towards amplify microbial lendurance duty throughout preservation. Conversely, preserve effectiveness depends mostly on the bioinoculant class and breed concerned, so each breed needs exact expansion (Verma *et al*., 2019).

A current learn done by our gather revelled that a aeration medium possessed of 10% milk protein and 5% monosodium salt successfully sheltered *Pseudomonas* sp cells during the cryodesiccation procedure, as no defeat in feasibility was noted (Table 3). Cryodesiccation was mainly evaluated to measure up to the microbial constancy of wet preparations with that of waterless preparations (Tables 2 and 3). On the other hand, we do not opponent Cryodesiccation as a extensive aeration technique to manufacture *Pseudomonas* sp bio inoculants while it is an costly procedure. After five months of preservation at Cryodesiccation, the indicate worth of feasible cells

well again from *Pseudomonas* sp dehydrated preparations was advanced than the least amount of live cells established for a lot of bioinoculants (Table 3).

Monosodium salt, a isophthalic, can enlarge cell surrounding volatility become stable head groups, developing membrane protection and rising microbial confrontation to the aeration method. Growth substance and disaccharide from milk waste might shape the surrounding substance immerse the living cells and defensive adjacent to numerous harmful conditions during sub-zero temperature and aeration like arrangement in endocyte iceberg. Condensed milk growth promoting substances permit stability of peptide morphology with reactions among NH groups of microbial cell peptides and the preserver. Lactose also saves microbial cells throughout preservation at freezing (Urbański *et al.*, 2017). In a comparable way to glycerine and maize husk remainders, whey is a milk waste composite that can be second-hand as a supplement and a defensive mediator in preparations and mass cultivations, correspondingly (Zhang *et al*., 2014). Added researches must be carried out to estimate inventive mechanisms (e.g., budding procedures with inactivation/combined-inactivation) designed for improvement with commercial based preparations with enhanced strength and connection with in the commerce field.

CONCLUSIONS

Growth promoting bacteria, as well as phosphate solubilising bacteria, makes use of supportive property on herbs development and outcomes throughout diverse methods. Many growth promoting bacteria include are identified and incorporated to make preparations should use as biofertilizer in farming, while there reasonable selection towards decrease appliance of synthetic substances. The extensive bio inoculants manufacture by unused manufacturing substances or unwanted things like fraction of cultivation preparations might scheme near reduce the expenses among obliging forming technology. Growth promoting bacterial suspensions were prepared as prospective purpose, offer the constructive micro surroundings and to encourage long-standing microbial firmness. Many wet and dry preparations containing Growth promoting bacteria were capable to support the enlargement and yields of various crops. Wet preparations are frequently more simply maked and used more than dry preparations, having more advantage, particularly while considerable quantity is essential. Furthermore, occasion towards wet preparations is economic compared to a few aeration processes. The assortment criterion of the most favourable scheme to build up the last bioinoculant will based on the equilibrium between constancy, efficiency, financial possibility and easiness of apply, in count to the production of an added maintainable and recyclable.

FUTURE SCOPE

The Agro-inoculants discussed in this study are renewable and ecofriendly resources that increases plant productivity, yield and quality of agricultural products.

Acknowledgement. We thank the DST-FIST for the financial support to Cauvery College for women, Ref. no. SR/FST/College-246/2015(c) dated 16.06.216 under "level-0 program for the research instrument facility.
Conflict of Interest. None.

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How to cite this article: V. Aruna, S. Jenny, Jeenathunisa and S. Jeyabharathi (2023). Plant Growth Promoting Rhizobacteria: A Review on Biomass Production and its Scope in Commercialization. *Biological Forum – An International Journal, 15*(2): 438-443.