Sustainable Pulse Production Through the Use of Bio-Fertilizers- A review

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Abstract

An essential component of the Indian cuisine are pulses. Farmers employ a lot of artificial inorganic fertilizers to maximize yields in pulse crops, which can increase yields but degrade soil health. The most common cause of low output was found to be a shortage of fertilizer or water. Because they help with the fixation of nutrients from the atmosphere, bio-fertilizers are advantageous for the production of pulse crops. In an attempt to get the pulse crop closer to organic farming and achieve sustainable growth, numerous initiatives have been undertaken to replace chemical fertilizers with biofertilizers. India has been engaged in ceaseless attempts and battles to switch from chemical fertilizers to biofertilizers since the late 1800s. This demonstrates how several helpful microorganisms are used in agricultural practices. Bio-fertilizers can be used as a seed treatment or directly applied to the soil. Rhizobium strains, cyanobacteria, phosphate-soluble bacteria, vesicular arbuscular mycorrhiza, and other beneficial microorganism fertilizers are examples of bio-fertilizers that can help with nutrient intake, nodule development, and the mineralization process, which converts unavailable nutrients into readily assimilated nutrients. In order to increase growth and production, bio-fertilizers typically have a symbiotic relationship with the host plant.

Keywords: Phosphate solubilizing bacteria, Rhizobium, Vesicular arbuscular mycorrhiza

مطالعه تولید پایداری حبوبات با استفاده از کودهای بیولوژیکی

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خلاصه

یکی از اجزای ضروری غذاهای مردم هند حبوبات هستند. دهاقین از کودهای غیرعضوی مصنوعی زیادی برای به حداکثر رساندن محصول در حبوبات استفاده می‌کنند که می‌تواند حاصل را افزایش دهد، اما سلامت خاک را تخریب می‌کند. شایع‌ترین علت حاصل کم، کمبود کود یا آب است. از آن جای‌که کودهای بیولوژیکی به تثبیت مواد مغذی از اتمسفیر کمک می‌کنند، برای تولید حبوبات مفید هستند. در تلاش برای نزدیک‌تر کردن حبوبات به زراعت اورگانیک و دست‌یابی به رشد پایدار، ابتکارات متعددی برای جای‌گزینی کودهای کیمیاوی با کودهای بیولوژیکی انجام شده است. هند از اواخر دهه ۱۸۰۰ درگیر تلاش‌ها و نبردهای بی وقفه برای تغییر از کودهای کیمیاوی به کودهای بیولوژیکی بوده است. این نشان می‌دهد که چه‌گونه چندین میکروارگانیسم مفید در فعالیت‌های زراعتی استفاده می‌شوند. کودهای بیولوژیکی را می‌توان به‌عنوان تداوی بذر استفاده کرد یا مستقیماً روی خاک اعمال کرد. سویه‌های رایزوبیم، سیانوبکتریا، بکتریای محلول در فاسفیت، مایکورایزای آربوسکولار حفره‌ای و سایر کودهای مایکرو اورگانیسم‌های مفید، نمونه‌هایی از کودهای بیولوژیکی هستند که می‌توانند به دریافت مواد مغذی، توسعه گره‌ها و فرآیند معدنی شدن کمک کنند که به مواد مغذی غیرقابل دسترس تبدیل می‌شود. به منظور افزایش رشد و تولید، کودهای بیولوژیکی معمولاً یک رابطه همزیستی با نبات میزبان دارند.

واژه‌های کلیدی: بکتریای حل کننده فاسفیت، رایزوبیوم، مایکورایزای آربوسکولار حفره‌ای

Introduction

Soil micro-organisms are vital to the production and degradation of biomass, even though their availability ratio is less than 0.5 percent of soil mass (1). Significant interactions occur in nature between plants and microbes as well as between soil and plants (2). These interactions are categorized into three phases, rhizosphere, phyllosphere, and sphemosphere. Microbe interactions are influenced by a variety of microflora and can lead to symbiosis, neutralism, parasitism, photo-corporation, predation, and amensalism. There are roughly 78 different kinds of symbiotic bacteria known to exist that can proliferate and heal nodules in pulse crops. The most common type of nodule fixation in legumes is seen in Rhizobium species) 3). The demand for food has increased as a result of population growth) 4). In order to meet the nation's food needs, current crop management practices include synthetic pesticides and inorganic fertilizers to control diseases and fulfill nutrient requirements. Chemical inorganic fertilizers have the potential to increase yield, but they can also disturb the environment.

India, one of the countries that uses the most inorganic fertilizers to increase production, has reduced soil nutrient usage efficiency, which has become a significant issue in maintaining healthy soil, and as a result, has had a detrimental effect on air, water, and soil fertility. By combining bio-fertilizers and organic sources, we can replace nutrients and resist pests, leading to a more sustainable crop production with higher yields (5, 6).

Legume-based crops, which naturally fix nitrogen, can help minimize the need for agrochemicals in crop management. Additionally, bio-fertilizers, an eco-friendly and less costly way to boost plant growth, can further safeguard the ecosystem against the damaging effects of inorganic fertilizers. Numerous bio-fertilizers are available that contain one or more microorganisms that are vital to the growth and development of the plant (7). Among other things, they support the development of abiotic stress tolerance, soluble phosphorus availability, and nitrogen fixation. Seedlings, seeds, or the field direction are frequently treated with bio-fertilizers (8). Among the bio-fertilizers are rhizobium, azotobacter, azospirillum, phosphate-solubilizing microorganisms, azolla, blue-green algae, and vesicular arbuscular mycorrhiza (9). Because they are made from natural resources and improve soil fertility, biofertilizers present a possible substitute for traditional chemical fertilizers. We hope to investigate how bio-fertilizers might support sustainable agriculture by lowering environmental impact, improving crop yield and quality, and promoting long-term soil productivity by analyzing the literature and research that is already available on the subject. This evaluation also looks for knowledge gaps and identifies areas that need more investigation and advancement in the field of sustainable pulse production. The aim of this study is the sustainable production of legumes using biological fertilizers.

Bio-fertilizers used in pulse production

The production of pulse crops depends on the nodules that are created, primarily by rhizobium strains, which help with nitrogen fixation (10). Plants absorb nitrogen with the help of root nodule formation (11). Only using the appropriate species may help a particular pulse crop since different species of pulse crops have distinct connections with their hosts and bacteria (12). A well-known biofertilizer for absorbing nitrogen and accelerating pulse output is rhizobium (13). Phospho-bacteria, arbuscular mycorrhiza fungi (AMF), plant growth-promoting rhizobacteria (PGPR), and numerous other cooperative microorganisms are examples of additional supporting microbes that have been demonstrated to enhance symbiotic capability, nutrient absorption, and growth in addition to aiding in the development of biotic and abiotic stressors.

Azotobacter, azospirillum, and rhizobium PGPRs are intended for usage in ready-to-use 'live-formulations' which can be applied directly to seeds, roots, or soil to boost agricultural plant development and production (14). Although, PGPRs do not provide any nutrients to crops, their interactions can help to optimize nutrient supplementation. Rhizobium fixes nitrogen, while phosphate solubilizing bacteria (PSB), which include aspergillus, bacillus, and pseudomonas, fix phosphorus. PSBs are involved in the creation of bio-active molecules and organic compounds that aid in the absorption of phosphorus. PSBs are also important in phytate activity, which is the generation of phosphorus through phytate mineralization. Not only PSBs, but also fungi like vesicular arbuscular mycorrhiza (VAM) may aid in the propagation of hyphal development in the root zone to simulate phosphorus absorption.

Symbiotic nitrogen-fixing bacteria

Bacteria that fix nitrogen symbiotically include rhizobium species that help fix nitrogen by living in symbiotic relationships with their hosts. It includes: Rhizobium leguminosarum: This rhizobium species helps legumes, certain beans, and all varieties of pea plants fix nitrogen. Rhizobium japonicum: This species is used to fix nitrogen and is present in soybean crops. Rhizobium phaseoli: This type of rhizobium helps crops of garden and kidney beans fix nitrogen. Rhizobium meliloti: This rhizobium species belongs to the lucerne and alfalfa groups of pulses.

Nitrogen-fixing micro-organisms that are not symbiotic

Azatobacter: These aerobic bacteria help fix nitrogen in the environment. Nitrogen is sensitive to phosphate shortage and works well in neutral soils. Clostridium: Compared to azatobacter, these anaerobic bacteria contribute less to nitrogen fixing. Mycorrhizae: Fungi and the roots of higher plants have a symbiotic interaction. There are two sorts of it:

a) **The vesicular arbuscular mycorrhizae (VAM):** It is a group of endomycorhizae increases phosphorus absorption and confers resistance to drought and some root-infecting fungi. Ectomycorrhizae colonise root surface layers.
b) **Frankia:** It is a symbiotic relationship between actinomycetes and plants. Actinomycetes are intermediates between bacteria and fungus, and they are responsible for the earthy odour generated by the breakdown of chemicals like gaosmin when it rains.

Phosphorus solubilizing bacteria (PSB)

Phosphorus availability and absorption are enhanced by the application of phosphorus-solubilizing microorganisms, such as aspergillus, pseudomonas, bacillus, and mycorrhizal fungus, because the majority of phosphorus sources are fixed in soil and inaccessible to plants.

Different Bio-fertilizers that were used for different pulse crops are as follows:

Chickpea

Even with the use of bio-fertilizers containing acceptable dosages of other nutrients, a significant pulse crop with a high protein content already have the ability to fix nitrogen. This results in the crop growing and producing well. Using biofertilizers such as rhizobium and PSB improved the chickpea yield and growth, resulting in an average of 2.4 t/ha of grain and higher-quality straw for animal feed. Applying biofertilizers as a seed treatment, such as rhizobium and VAM, also yields good results. The application of azotobacter and azospirillum improves nitrogen uptake and raises chickpea yield. The recommended dose of fertilizer, which is 75% RDF, when combined with biofertilizers improves chickpea yield, protein content, and sugar content.

Pea

One important pulse crop grown during the Rabi season, peas are treated with RDF and generated as seeds. Numerous biofertilizers exhibit remarkable outcomes in terms of nutrient uptake, growth, development, and the formation of root nodules, with an average yield of 31 q/ha. These biofertilizers include PSB and rhizobium applied alone or in combination with 1000 percent of the recommended fertilizer dosage applied as a seed treatment. Improved results in terms of seed germination percentage and growth conditions were obtained by applying 50 percent of the recommended amount of inorganic fertilizers to the soil in addition to using bio-fertilizers, such as oscillators and cyanobacteria, as a seed treatment.

Red Gram

After chickpeas, red gram is the second most important pulse crop. Arbuscular mycorrhiza and other biofertilizers yield better results for plant accumulation of nitrogen, phosphate, and chlorophyll. Plant height, branch count, yield-related characteristics such as dry matter and grain yield, as well as financial metrics like net returns, benefit-cost ratio, and gross returns, are all enhanced by PSB and rhizobium seed treatment.

Black gram

Regarding planted area and production, black gram holds significant importance in India. Black gramme is a crop that is perfect for combating malnutrition because of its better grade protein content and easy digestion. In terms of growth and grain yield, 2 kg of Bacillus magaterium + 2 kg of Rhizobium leguminosarum + 1 kg of Bacillus mucilaginous shown satisfactory results. Addition of rhizobium, PSB, and 20 kg of sulfur boosted plant height, dry weight, fresh weight, and black gram production.

Green gram

India's most significant pulse crop, green gram, is mostly grown in rainfed areas with a little amount grown in irrigated areas. In addition to other parameters, such as the usage of rhizobium + PSB + VAM (Vesicular Arbuscular Mycorrhiza) in combination with 60 kg phosphorus/ha, which has improved pods per plant, plant height, and yield, the use of bio-fertilizers in combination with RDF has boosted yield. Rhizobium, PSB, 15 kg N/ha, and 20 kg P_2O_5/ha were added to green gram seeds to boost germination % and increase growth attributes like branch count and nodule count per plant as well as yield attributes like seed count, pod count per plant, and straw yield. Combining bacillus megaterium, bacillus mucilaginous, and rhizobium leguminosarum has improved green gram root, shoot length, fresh and dry weight of plant, number of pods per plant, number of seeds per pod, and seed weight.

Conclusion

Increased crop output and soil fertility from the use of bio-fertilizers are advantageous for the environment and sustainable. In order to increase food production and fulfil the demands of a growing population while protecting natural resources through sustainable production practices, bio-fertilizers are a crucial component. Farmers and consumers have gotten obsessed on inorganic fertilizers in an attempt to boost productivity since they are unaware of and do not employ biofertilizers. To solve this problem, institutional training programs for farmers, staff members, and students must be held. Information on this technology approach for enhancing organic production must also be distributed through publications, bulletins, and other channels. The utilisation of specific and appropriate strains of nutrient-fixing microorganisms facilitates and enhances the sustainability of the manufacturing process. While pulse crops typically fix atmospheric nitrogen through root nodules, the performance of the plants is enhanced by the use of biofertilizers.

References

1- Alburquerque JA, Salazar P, Barrón V, Torrent J, del Campillo MDC, Gallardo A, Villar R. Enhanced wheat yield by biochar addition under different mineral fertilization levels. Agronomy for Sustainable Developmen. 2013; *33*(3), 475-484.
2- Hanna AL, Youssef HH, Amer WM, Monib M, Fayez M, Hegazi NA. Diversity of bacteria nesting the plant cover of north Sinai deserts, Egypt. Journal of Advanced Research, 2013; *4*(1), 13-26.
3- Terpolilli JJ, Hood GA, Poole PS. What determines the efficiency of N2-fixing Rhizobium-legume symbioses? Advances in Microbial Physiology. 2012; *60*, 325-389.
4- Odeyemi OA, Alegbeleye OO, Strateva M, Stratev D. Understanding spoilage microbial community and spoilage mechanisms in foods of animal origin. Comprehensive Reviews in Food Science and Food Safety, 2020; *19*(2), 311-331.
5- Savci S. Investigation of effect of chemical fertilizers on environment. Apcbee Procedia. 2012; *1*, 287-292.
6- Gruhn P, Goletti F, Yudelman M. Integrated nutrient management, soil fertility, and sustainable agriculture: current issues and future challenges. International Food Policy Research Institute. 2000. 14-19.
7- Vessey JK. Plant-growth-promoting rhizobacteria as bio-fertilizers and bio-pesticides. Handbook of microbial bio-fertilizers, 2006; 137.
8- Sahoo RK, Bhardwaj D, Tuteja N. Bio-fertilizers: a sustainable eco-friendly agricultural approach to crop improvement. In Plant Acclimation to Environmental Stress. 2013; (pp. 403-432). Springer, New York, NY.
9- Suhag M. Potential of bio-fertilizers to replace chemical fertilizers. International Journal of Advanced Research in Science, Engineering and technology, 2016; *3*(5), 163-167.
10- Beyene D. Biological Nitrogen Fixation Research on Grain Legumés in Ethiopia—an Overview. Nitrogen Fixation by Legumes in Mediterranean Agriculture*,* 1988; 73-78.
11- Rajendran G, Patel MH, Joshi SJ. Isolation and characterization of nodule-associated Exiguobacterium sp. from the root nodules of fenugreek (*Trigonellafoenum-graecum*) and their possible role in plant growth promotion. International Journal of Microbiology, 2012.
12- Borrell AN, Shi Y, Gan Y, Bainard LD, Germida JJ, Hamel C. Fungal diversity associated with pulses and its influence on the subsequent wheat crop in the Canadian prairies. Plant and Soil. 2017; *414*(1), 13-31.
13- Chauhan J, Paithankar DH, Khichi P, Ramteke V, Srinivas J, Baghel MM. Studies on integrated nutrient management in Cowpea. Research Journal of Agricultural Sciences, 2016; *7*(2), 256-9.
14- Swarnalakshmi K, Yadav VA, Senthilkumar M, Dhar DW. Bio-fertilizers for higher pulse production in India: scope, accessibility and challenges. Indian Journal of Agronomy. 2016; *61*, 173-181.
15- Rizvi A, Ahmed B, Khan MS, Umar S, Lee J. Psychrophilic Bacterial Phosphate-Bio-fertilizers: A Novel Extremophile for Sustainable Crop Production under Cold Environment. Micro-organisms, 2021; *9*(12), 2451.