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Enhancing Chickpea Production: The Role of Bio-fertilizers and Organic Sources

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Abstract:

Chickpea (*Cicer arietinum* L.) are a vital legume crop, valued for their nutritional benefits and contributions to sustainable agriculture. As global demand for chickpeas rises, enhancing their production is crucial. This study explores the significance of biofertilizers and organic sources in improving chickpea yield and soil health. Biofertilizers, which consist of beneficial microorganisms, play a pivotal role in promoting nutrient availability, enhancing soil structure, and stimulating plant growth. The application of organic sources, such as compost and green manure, further enriches the soil with essential nutrients and improves its microbial activity. Research indicates that integrating biofertilizers and organic amendments can significantly increase chickpea productivity compared to conventional chemical fertilizers. This combination not only enhances crop yield but also promotes sustainable farming practices by reducing chemical input and mitigating environmental impacts. The synergistic effects of these organic approaches lead to improved soil fertility, increased resistance to pests and diseases, and greater resilience to climate stressors. By highlighting their benefits, we aim to encourage farmers and agricultural stakeholders to adopt these eco-friendly practices, thereby fostering a more sustainable agricultural system that supports food security and environmental health.

Keywords: sustainable agriculture, conventional chemical fertilizers, soil health, biofertilizers and organic sources

1. Introduction

Chickpea (*Cicer arietinum* L.), a key legume crop, plays a significant role in the diet of millions of people worldwide, particularly in South Asia and parts of the Mediterranean. It is an excellent source of protein, fiber, vitamins, and minerals. Besides its nutritional value, chickpea contributes to soil fertility due to its nitrogen-fixing ability, which reduces the need for chemical fertilizers. However, achieving sustainable chickpea production with minimal environmental impact has become a key focus in recent years.

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According to the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Chickpea seeds contain on average 21.1% protein, 64% total carbohydrates (47% starch, 6% soluble sugar), 5% fat, 6% crude fibre and 3% ash. High mineral content has been reported for phosphorus (340 mg per 100 g), calcium (190 mg per 100 g) and magnesium (140 mg per 100 g), iron (7 mg per 100 g) and zinc (3 mg per 100 g). It also provides 396 kcal energy from 100 grams of seed (FAO, 2019).

However, India is the largest producer and consumer of pulses among the pulses; gram occupies a predominant position and is considered as a "King of pulses". It being grown on 149.66 lakh ha total area, 162.25 lakh tones production and 1252 kg ha -1 productivity (FAOSTAT, 2021). In India the chickpea production has gone up from 38.55 to 112.29 lakh tonnes during 2000-01 to 2017-18, while the area has also gone up from 51.85 to 105.61 lakh ha, simultaneously, the yield has steadily increased from 744 kg ha -1 to 1063 kg ha -1 during the same period. Madhya Pradesh ranks first among all state in both area and production of chickpea. In Madhya Pradesh it was cultivated in an area of about 3.59 million hectares with production 4.59 million tones and productivity of 1082 kg/ha and it is contributing area and production around 34 and 40 per cent share to the total area and production of gram in the country respectively, (Agricultural statistics at a glance, 2021). The use of biofertilizers and organic sources represents a promising strategy to enhance chickpea production while maintaining soil health and reducing reliance on synthetic inputs. This article discusses the importance of biofertilizers and organic sources in chickpea production, focusing on their role in soil fertility, plant growth promotion, and yield enhancement, as well as their contribution to sustainable agriculture.

2. Biofertilizers

Biofertilizers are substances containing living microorganisms, which, when applied to seeds, plant surfaces, or soil, promote plant growth by increasing the supply or availability of essential nutrients. Biofertilizers are eco-friendly alternatives to chemical fertilizers, and they improve soil fertility by fixing atmospheric nitrogen, solubilizing phosphorus, and stimulating plant growth through the synthesis of growth-promoting substances.

According to Bhattacharjee and Dey (2014), "biofertilizer" is defined as a material containing living microorganisms that, when applied to soil, plant surfaces, or seeds, colonize the rhizosphere, or the interior of the plant, and stimulate growth by increasing the host plant's availability or supply of primary nutrients.

Types of biofertilizers used in chickpea production includes:

Rhizobium: This is a nitrogen-fixing bacterium that forms a symbiotic relationship with leguminous plants such as chickpea. Rhizobium colonizes the root nodules of chickpea plants and converts atmospheric nitrogen into a form that the plant can utilize for growth. The bacteria known as rhizobium coexists symbiotically with the leguminous plants' root nodules. Nitrogen fixation cannot be completed on its own. Rhizobium necessitates a plant host because of this. An essential supplier of nitrogen for agricultural soils, even in arid areas, is rhizobium. They produce ammonia by converting dinitrogen. Since ammonia is poisonous by nature, it is quickly absorbed by organic substances.

Phosphate Solubilizing Bacteria (PSB): These bacteria help in solubilizing insoluble phosphate compounds in the soil, making phosphorus available to the plants. Phosphorus is a critical nutrient for root development and energy transfer in plants. Beneficial bacteria called phosphate solubilizing bacteria (PSB) are able to separate inorganic phosphorus from insoluble substances. The capacity of rhizosphere bacteria to solubilize phosphate is regarded as one of the most crucial characteristics related to plant phosphate nutrition.

Arbuscular Mycorrhizal Fungi (AMF): These fungi form symbiotic associations with plant roots, enhancing nutrient and water uptake, particularly phosphorus, and improving plant resilience to stress conditions. A class of soil-borne fungi known as arbuscular mycorrhizal fungi (AMF) develops a mutually beneficial association with plants. Because they are obligate biotrophs, AMF is reliant on a root host. In a mechanism called endomycorrhizae, they produce intraradical structures in plant roots. Some examples of AMF include: *Glomus mosseae, Glomus aggregatum, Glomus etunicatum, Glomus deserticola, G. clarum, G. monosporum, Paraglomus brasilianum,* and *Gigaspora margarita.*

3. Organic Sources: Types and Their Role in Chickpea Production

Organic sources such as farmyard manure (FYM), compost, and vermicompost provide essential nutrients to crops while improving soil structure, water retention capacity, and microbial activity. The use of organic matter in chickpea production plays a

critical role in promoting sustainable agriculture, improving soil fertility, and reducing environmental degradation caused by chemical fertilizers.

Farmyard Manure (FYM): FYM is a traditional source of nutrients, containing nitrogen, phosphorus, and potassium, along with trace elements. Its slow-release nature ensures a steady supply of nutrients throughout the growing season, leading to improved plant growth and yield. Additionally, FYM enhances soil structure by increasing organic matter content, promoting better root development, and water retention. Farmyard manure, or FYM, is a naturally occurring fertilizer composed of a variety of animal waste materials, such as dung, urine, litter, and leftover roughage and feed. FYM is nutrient-rich and can enhance fertility and soil structure: After roughly six months, FYM is prepared for use as fertilizer. Applying it to fields three to four weeks prior to crop sowing is recommended. A natural fertilizer known as "farmyard manure" (FYM) is created by combining various animal waste products such as dung, urine, litter, and leftover roughage and feed.

Compost: Compost is a decomposed organic material rich in essential nutrients. It improves soil fertility by enhancing the microbial activity necessary for nutrient cycling. Compost application in chickpea fields improves soil health, increases nutrient availability, and boosts the crop's resistance to diseases. Compost is a blend of materials that is applied to soil to enhance its physical, chemical, and biological qualities as well as to feed plants. Typically, manure, organic material recycling, and the breakdown of plant and food waste are used in its preparation.

Vermicompost: Vermicompost, produced through the decomposition of organic material by earthworms, is a nutrient-rich organic fertilizer. It contains plant growth-promoting hormones, enzymes, and beneficial microorganisms that enhance nutrient availability and improve soil structure. Vermicompost application in chickpea

cultivation results in better seed germination, plant growth, and yield. Vermicompost, also known as vermi-compost, is a mixture of decomposing vegetable or food waste, bedding materials, and vermicast that is produced by a decomposition process involving several species of worms, most commonly red wigglers, white worms, and other earthworms.

4. Importance of Biofertilizers and Organic Sources in Chickpea Production

The integration of biofertilizers and organic sources into chickpea production offers several agronomic, environmental, and economic benefits. These advantages contribute to higher productivity and sustainable farming practices, making biofertilizers and organic inputs crucial for enhancing chickpea production.

4.1 Improved Nutrient Availability

Biofertilizers like *Rhizobium* and phosphate solubilizing bacteria (PSB) improve nutrient availability by fixing atmospheric nitrogen and solubilizing bound phosphorus, which are essential nutrients for plant growth. Chickpea, being a legume, benefits significantly from nitrogen-fixing biofertilizers, which reduce the need for external nitrogen inputs. This leads to better root development, vigorous plant growth, and enhanced yield. Organic sources such as FYM and compost provide a steady supply of nutrients, including micronutrients, that are often deficient in chemical fertilizers. Organic inputs also promote the mineralization of nutrients, making them more available for plant uptake throughout the growing season.

4.2 Enhanced Soil Health and Fertility

Continuous use of chemical fertilizers can degrade soil health by reducing its organic matter content, increasing soil acidity, and disturbing the balance of soil microorganisms. In contrast, biofertilizers and organic sources contribute to the restoration and enhancement of soil fertility. Organic matter from FYM, compost, and vermicompost improves soil structure, increases its water-holding capacity, and enhances microbial activity, all of which are crucial for healthy soil ecosystems. The microorganisms introduced by biofertilizers help in the decomposition of organic matter and the cycling of nutrients, leading to improved soil fertility. Furthermore, biofertilizers play a significant role in maintaining the biological balance of the soil,

promoting beneficial microbial communities, and suppressing soil-borne pathogens.

4.3 Sustainable Agriculture and Environmental Benefits

The use of biofertilizers and organic inputs is a critical component of sustainable agriculture, as it reduces the dependency on synthetic chemical fertilizers and pesticides. Chemical fertilizers are associated with several environmental issues, including water pollution, greenhouse gas emissions, and soil degradation. By replacing or reducing the use of synthetic inputs, biofertilizers and organic sources help mitigate these environmental impacts. Moreover, biofertilizers and organic amendments contribute to the sequestration of carbon in the soil, helping to reduce the carbon footprint of agricultural activities. Organic sources, by increasing soil organic matter content, also play a role in enhancing soil carbon storage, which is vital for climate change mitigation.

4.4 Improved Crop Yield and Quality

Several studies have demonstrated that the combined use of biofertilizers and organic inputs significantly improves chickpea yield and quality. The application of Rhizobium, along with FYM or vermicompost, has been shown to increase seed yield, plant biomass, and nitrogen content in chickpea. The increased nutrient availability from biofertilizers and organic inputs leads to healthier plants, better pod formation, and higher seed quality. Organic sources also improve the physical and biological properties of the soil, creating a more favorable environment for root growth and nutrient absorption. The improved soil health, coupled with the nutrient supply from biofertilizers, enhances the overall productivity of chickpea crops.

5. Challenges and Future Prospects

Despite the proven benefits of biofertilizers and organic sources, several challenges limit their widespread adoption in chickpea production. These challenges include:

Lack of awareness: Many farmers are unaware of the benefits and proper use of biofertilizers and organic inputs, limiting their adoption.

Availability and quality: The availability of high-quality biofertilizers and organic inputs is often limited, particularly in rural areas. Ensuring consistent quality and efficacy of these products is crucial for their success in the field.

Cost and economic returns: Although biofertilizers and organic inputs can reduce the need for chemical fertilizers, their initial cost may be higher, and the economic returns may not be immediately evident. This can deter farmers from switching to these sustainable practices. Looking ahead, research and

development in the formulation and application of biofertilizers and organic inputs will be essential to improve their efficiency and accessibility. Governments and agricultural extension services can play a key role in promoting awareness and providing support to farmers for adopting these practices. Additionally, integrating biofertilizers and organic sources with other sustainable practices, such as crop rotation and integrated pest management, will be crucial for the long-term sustainability of chickpea production.

6. Conclusion

The use of biofertilizers and organic sources in chickpea production offers numerous benefits, including improved nutrient availability, enhanced soil health, reduced environmental impact, and increased crop yield and quality. By reducing the reliance on chemical fertilizers, these sustainable inputs contribute to the long-term sustainability of chickpea farming and ensure food security in regions where chickpea is a staple crop. While challenges remain in their adoption, the potential of biofertilizers and organic sources to revolutionize chickpea production is immense, and future efforts should focus on overcoming these obstacles to ensure widespread implementation.

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