Review Article

Role of Biofertilizers in Chickpea- A review

Abstract

Compared to when both *rhizobium* and the bacteria that solubilize phosphate are inoculated separately, the interaction effect between the two inoculations gradually increases the growth parameters and yield production. *Rhizobium* and phosphate solubilizing bacteria (PSB) had shown advantage in enhancing chickpea productivity, cost effective, ecofriendly and renewable sources of plant nutrients. Biofertilizers have the ability to improve the growth and nodulation of chickpea enables it to withstand the periods of drought. Utilising *Rhizobium's* symbiotic properties to increase the nitrogen supply to agricultural plants.

Key Words: Chickpea, Rhizobium, phosphate solubilizing bacteria, nodulation, yield.

Introduction

Chickpea (*Cicer arietinum* L.) is a valued crop and provides nutritious food for increasing world population and will become important with climate change. Gram is one of the most important *Rabi* season pulse crops grown in India and as whole in Asia for economic importance and maintaining soil fertility. Chickpea is an important pulse crop of western Rajasthan and is commonly known as Gram or Bengal gram belongs to *Fabaceae* family. Chickpea is the third most important pulse crop in the world after French bean (*Phaseolus vulgaris* L.) and Field pea (*Pisum sativum* L.). India has first position in area and production in the world. Chickpea is extensively grown in rainfed areas and nutrient deficiency is widespread in these areas **(Venkatesh *et al.*, 2013)**. Dried seeds of gram have a high nutritional value. It's dried seed contain about 7% moisture, 22.19% protein, 64.90% carbohydrate, 2.10% fat, 3.20% mineral ash, 45 mg/100 g Ca, 2.8 mg/100 g Fe and high calorific value (370 Kcal/100 g) **(Shad *et al.*, 2009)**.

Comment [D1]: Citation....????

Comment [D2]: Source???

Comment [D3]: Update citataion it is too old

Comment [D4]: Same as D3

India is the largest acreage holder and producer of chickpea in the world. In our country, total pulses covered about 28.23-million-hectare area, with 25.72 MT production and 892 kg/ha productivity in 2020-2021. During 2020-21, chickpea a had a lion's share of 49.3% in the total pulses production. In India chickpea area 9.85 million hectare, with 11.99 MT production and 1217 kg/ha productivity in 2020-2021. In India Madhya Pradesh leading state in area and production of chickpea. **(Anonymous, 2020-221)**.

Chickpeas may be a major protein source of essential nutrients like zinc, magnesium, niacin, vitamin C and carotene and amino acids (**Rashid, *et al*., 2013**). Chickpeas are a good source of carbs for those with diabetes or insulin sensitivity since they are strong in fibre. Their leaves have oxalic and malic acids that are helpful for blood cleansing as well as gastric problems.

Biofertilizers may colonizes the rhizosphere and promotes growth by increasing the availability and supply of nutrients to crop. Microorganisms that fix nitrogen and phosphate play a significant part in providing more nitrogen and phosphorus to plants, enabling the fertilizer's utilisation in a sustainable manner **(Tambekar, *et al*., 2009).** *Rhizobium* is one of the nitrogen fixing bacteria which fix atmospheric nitrogen by the symbiotic association with leguminous plants. However, PSB also increase the yield of chickpea by 10- 30%. Due to the nitrogenase enzyme that is found in the bacterium and is introduced by infection, which causes nodule development, both *Rhizobium* and PSB inoculation considerably enhanced the nodules.

Comment [D5]: Too old citation ....??

Functions and Types of Biofertilizers

Biofertilizers are substances made of live microorganisms that can move nutrients from inedible sources through biological processes. Estimates made on global basis indicate that *Rhizobia*, *Cyanobacteria* and *Azospirillus* can fix nitrogen in the range of 25 to 300, 15 to 25 and 10 to 30 kg/ha annually.

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There are mainly two kinds of biofertilizers: nitrogen fixing biofertilizer (NBF) and phosphatic biofertilizers (PBF) :-

Nitrogen Fixing Biofertilizer

These biofertilizers add N to the soil by reducing atmospheric nitrogen.

Rhizobium: *Rhizobium* is an aerobic and heterotrophic bacteria. *Together with certain non-leguminous plants, such as Parasponia, and leguminous crops, Rhizobium can fix atmospheric nitrogen. Rhizobium* species invade the roots of their hosts and produce nodules on the surface of the roots. The host plant provides the bacteria with water and carbohydrates, while the bacteria provide the host plant with nitrogen. Result of All India Coordinated Pulse Improvement Projects (AICRPIP) over years have shown increase in pulse crop yields by 10-15% due to *rhizobium* inoculation. (Ali, 1985).

Comment [D7]: Replace it by newer one

Table 1 Quantity of nitrogen fixed by different leguminous crops

Crop	Nitrogen Fixed (kg/ha)
Groundnut	27-206
Alfalfa	100-300
Pigeon pea	68-200
Soybean	49-450
cowpea	9-125
Pea	40-50
Green gram	50-55

Comment [D8]: From where it can be retracted?/ Can you provide sources???

Table 2 *Rhizobium* species suitable for different crops

Rhizobium species	**Crops**
Rhizobium leguminosarum	Pea**,** Lathyrus, Lentil, Vicia
Rhizobium meliloti	Melilotus, Lucerne, Fenugreek
Rhizobium lupini	Lupinus
Rhizobium phaseoli	Kidney bean
Rhizobium japonicum	Soybean, Cowpea, Sunhemp, Groundnut
Rhizobium tripoli	Berseem
Bradyrhizobium Spp.	Soybean, Groundnut, Cowpea
Rhizobium freddi	Arahar, Moong

Azotobacter**:** *Azotobacter* is a free living (non-symbiotic) heterotrophic nitrogen fixing bacteria encountered in neutral to alkaline soils not only provides the nitrogen, but produce a variety of growth promoting substances. Acidic and arable soils are rich in *Azotobacter chroococcum*, whereas alkaline soils are rich in *Azotobacter beijerinckii*. *Azotobacter chroococcum* may fix 20 to 30 kg of nitrogen per hectare. It may be applied through soil application, seed inoculation, or seedling dipping. It is also effective for cereals, millets, cotton and sugarcane. These bacteria secrete IAA, Kinetin, gibberellins and vita. B.

Comment [D9]: Source??

Azosporollum: *Azosporollum* is non crop specific and is mainly used for cereal crops. *Azosporollum brasilense and Azosporollum lipoferum* are popular in India. *Azosporollum* are utilised in vegetable crops including brinjal as well as maize, barley, oats, sorghum, and forages. cabbage, okra, tomatoes, and peppers.

Blue-Green Algae (BGA): Several species of blue-green algae can fix atmospheric nitrogen. The most important species are *Anabaena* and *Nostoc*. BGA can be mass-multiplied in the main field while it is still green and integrated into the soil before planting, or it can be cultured in small pits and utilised as an inoculum in rice fields at a rate of 12 to 15 kg/ha. The BGA *Anabaena* inhibits cavities in the leaves of floating fern *Azolla* and fix N in lowland rice.

Comment [D10]: Source?

Azolla: Azolla is a free-living floating water fern. *Azolla pinnata* is the most common species occurring in India. A thick mat of Azolla supplies 30 to 40 kg N/ha. Azolla grows normally at temperatures between 20 and 300C. During the monsoon season, when it rains frequently and is cloudy, azolla grows well. The pH range for Azolla's ideal soil is 5.5 to 7.0. Azolla is applied to the main field as a green manure crop and a dual crop. As a dual crop, 1000 to 5000 kg/ha of Azolla is applied to the soil one week after transplanting. Applying 25 to 50 kg/ha of superphosphate and consistently maintaining 5 to 10 cm of standing water in the rice field will improve Azolla's development.

Comment [D11]: Where is citataion??

Mycorrhiza and Phosphorus Solubilising Bacteria

Biofertilizers promotes the growth parameters through increasing the nutrients availability and supply to crop. Phosphorus Solubilising Bacteria belonging to the genera *Pseudomonas* and *Bacillus* and fungi to the *Penicillium* and *Aspergillus*. The common phosphate solubilising bacteria and fungus are *Pseudomonas striata*, *Bacillus polymixa*, *Aspergillus awamori* and *Penicillium digitatum*. Fertilisers and the availability of phosphorus Mycorrhiza, PSB, and fungi can all help to boost the efficiency of phosphorus use. Inoculation of seed or seedling with microphos biofertilizer can provide around 30 kg P_2O_5. Mycorrhiza are mutualistic symbiotic relationships or affiliations between plant roots and soil fungus. The VAM contributes to phosphorus nutrition by enhancing both its availability and mobility.

Comment [D12]: ?????

Effect on Growth Parameters

Results also indicated that ~~In~~ comparison to phosphate fertiliser and Rhizobium, the application of solubilizing bacterial inoculates (PSB) offered the highest value of growth metrics and yield [Thenua, *et al.*, 2011; Raj *et al*., 2014; Hmissi *et al*., 2015].

Rhizobium and PSB inoculated plant's improved photosynthetic efficiency may be the cause of the increased growth. PSB vaccinations, which are known to release growth hormones, are likely to prefer taller plants. Applications of phosphorus boosted plant height and branch count. (Dahiya *et al.*, 1993). Significant increase in plant height with *Rhizobium* and PSB might be due to increase in uptake of N and P by the plants, which might be due to more N-fixation and P-solubilization through micro-organisms (Singh *et al.*, 2018). The number and dry weight of root nodules are an effective measure for assessing the level of infection for starting nodule development (Bhattacharjya *et al*, 2009). Inoculation of seed with *Rhizobium* and PSB produce significantly higher number of nodules in comparison to other inoculants (Akansha *et al*., 2018). Seed inoculation with *Rhizobium* + PSB also produced significantly higher dry matter of chickpea (Abisha and Singh 2023). Compared to the uninoculated control, infected chickpea produced 27.6% more nodules per plant and their dry weight was determined to be 22.2% higher (Singh *et al.*, 2014). The role of Rhizobium inoculation in biological nitrogen fixation and the ability of phosphate-solubilizing bacteria to solubilize insoluble or fixed forms of phosphorus in the rhizosphere and make them available to growing plants through the production of organic acids may both contribute to the increase in nodulation in plants (Singh et al., 2011)

Comment [D13]: Put latest citation

Effect on Yield parameters

Application of Phosphorus, *Rhizobium* and PSB recorded higher value of growth as well as yield contributing characters similar result was given by (Jarande *et al*., 2006). Compared to *Rhizobium* or PSB inoculation alone, the combined effect of *Rhizobium* + PSB seed inoculation demonstrated significantly higher yield features. The beneficial effect of *Rhizobium* and PSB inoculation was also reported by (Singh *et al*., 2011). The majority of the growth and yield-contributing features increased as a result of the use of bio-fertilizers, which ultimately resulted in a significant rise in grain and stover yields. The consequences of the current investigation are additionally in concurrence with the investigation of (Singh A. *et al.* 2011; Patel *et al*., 2020; Kumar, *et al*., 2020). The highest number of pods and grains per plant was obtained in crop stand inoculated with *Rhizobium* as compared to uninoculated plots (Namvar *et al*., 2013). Zaman *et al.* (2011) reported the number of pods per plant, pod dry weight per plant, seeds per pod, seed dry weight per and 50 seeds weight were always higher in those soils which were treated with *Rhizobium* than control. This could be owing to phosphorus's favourable influence on root growth, which created more root surface for bacterial invasion and improved nodulation (Tripathi *et al.,* 2013). The evaluations done by

Abdiev *et al*., (2019) in an experiment showed *Rhizobium* and *Azotobacter* co-inoculation resulted in a yield increase of more than 22% in saline soil. Seed inoculation significantly increases the grain yield as much as 7.9% (Ogola, 2015; Bejandi *et al*., 2012). Grain yield and nodules per plant were higher in inoculated seed rather than un inoculated. This study supports with (Uzma *et al*.2022; Kumawat *et al*.2022).

Effect on quality

The increase in N fertility under 100% fertilized plot which ultimately results in low protein content in seeds (Singh *et al*. 2015). The application of biofertilizers increases the protein content in seeds because they improve nutrient uptake and plant utilisation, which leads to higher protein content in seeds ~~Singh and Prasad (2008).~~(Singh and Prasad, 2008)

Increase in the seed yield increased the protein yield (Khaitov *et al*. 2016). Protein yield is calculated as the product of protein content and seed yield/ha. The yield of protein increased as seed yield increased (Tolanu, 2008).

Conclusion

The purpose of this research is to highlight the significance of the *rhizobium* genus of beneficial soil-borne bacteria. It is clear from the discussion above that *Rhizobium* inoculations have a favourable impact on yield components, growth characteristics and quality of seeds.

Comment [D14]: Where is chickpea??
I cannot see you have mentioned any impact of biofertilizers on growth and yield of chick pea and how it plays role to keep environment sound???????

References

Abdiev, A., Khaitov, B., Toderich, C. and Parc, K.W. (2019). Growth, nutrient uptake and yield parameters of chickpea (*Cicer arietinum* L.) enhanced by *Rhizobium* and *Azotobacter* inoculations in saline soil. *Journal of Plant Nutrition*, 43: 1-12.

Abiha, P. and Singh, S. (2023). Effects of Biofertilizer and Phosphorus on Growth, Yield Components and Yield of Chickpea (*Cicer arietinum* L.) *International Journal of Plant and Soil Science* **34**(20): 326-331

Akansha, Singh, A. K., Sachan, Vipin Kumar, R. K., Pathak, Shubham Srivastav (2018). Effects of Phosphorus with Biofertilizers on Yield and Nutrient Content of Chickpea (*Cicer arietinum* L.) under Central Uttar Pradesh Condition. *International Journal of Current Microbiology and Applied Sciences*. **10**(02):2228-2234.

Anonymous, (2020). Agricultural Statistics at a Glance, Directorate of Economics and Statistics, Ministry of commerce, Government of India.

Bezandi, T. K., Sharifii, R. S., Sedghi, M. and Namvar, A. (2012). Effects of plant density, *Rhizobium* inoculation and microelements on nodulation, chlorophyll content and yield of chickpea (*Cicer arietinum* L.). *Annals of Biological Research*, **3**(2): 951-958

Bhattacharjya, S., Parul and Chandra, R. (2009). Interaction of *Mesorhizobium ciceri* and *rhizospheric* bacteria on nodulation, growth and yield of chickpea. *Journal of Food Legumes*. 22: 137-139.

Dahiya, S., Mehar, S. and Singh, M. (1993). Relative growth performances of chickpea genotypes to irrigation and fertilizers application. *Haryana J. Agron*. **9**(2):172-175.

Hmissi, I., N. Abdi, A. Bargaz, M. Bouraoui, Y. Mabrouk, M. Saidi and B. Sifi (2015). Inoculation Phosphate solubilizing Mezorhizobium strains improves the Performance of chickpea (*Cicer aritenium* L.) under Phosphorus deficiency. *Journal of Plant Nutrition*, 38: 1656-1671.

Jarande, N. N., Mankar, P. S., Khawale, V. S., Kanse, A. A., Mendhe, J. T. (2006). Response of chickpea (*Cicer arietinum*.L) to different levels of phosphorus through inorganic and organic sources *J. Soils Crops*, 16:240-243.

Khaitov, B., Kurbonov, A., Abdiev, A. and Adilov, M. (2016). Effect of chickpea in association with *Rhizobium* to productivity and soil fertility. *Eurasian Journal of Soil Science* **5**(2): 105–12.

Kumar, D., Arvadiya, L. K., Kumawat, A. K., Desai, K. L. and Patel, T. U. (2014). Yield, protein content, nutrient content and uptake of chickpea (*Cicer arietinum* L.) as influenced by graded levels of fertilizers and bio-fertilizers. *Res J Chem Environ Sci*. **2**(6):60-24.

Kumawat, K. C., Singh, I., Nagpal, S., Sharma, P., Gupta, R. K. and Sirari, A. (2022). Co-inoculation of indigenous *Pseudomonas oryzihabitans* and *Bradyrhizobium* sp. modulates the growth, symbiotic efficacy, nutrient acquisition and grain yield of soybean. Pedosphere, **32**(3), 438-451

Namvar, A., Sharifi, R. S., Khandan, T. and Moghadam, M. J. (2013). Seed inoculation and inorganic nitrogen fertilization effects on some physiological and agronomical traits of chickpea (*Cicer arietinum* L.) in irrigated condition. *Journal of Central European Agriculture*, 14: 28-40

Ogola, J. B. O. (2015). Growth and yield response of chickpea to *Rhizobium* inoculation: Productivity in relation to interception of radiation. *Legume Res*. 38: 837-843.

Patel, H. A., Thanki, J. D. (2020). Effect of integrated nutrient management on growth, yield, soil nutrient status and economics of chickpea (*Cicer arietinum* L.) under south Gujarat conditions. *Journal Pharmacogn Phytochem*. **9**(6):623-6.

Raj, P. K., S. B. Singh, K. N. Namdeo, Y. Singh, S. S. Parihar and M. K. Ahirwar (2014). Effect of dual bio- inoculants on growth, yield, economics and uptake of nutrients in chickpea genotypes. *Annals of Plant and Soil Research*, **16**(3): 246-249.

Rashid, A., M. Ishaque, K. Hameed, M. Shabbir and M. Ahmad, (2013). Growth and yield response of three chickpea cultivars to varying NPK levels. *Asian Journal of Agriculture and Biology*, 1: 95-99

Shad, M. A., Pervez, H., Zafar, Z. I., Zia-Ul-Haq, M. and Nawaz, H. (2009). Evaluation of biochemical composition and physicochemical parameters of oil from seeds of desi chickpea varieties cultivated in arid zone of Pakistan. *Pakistan Journal of Botany*, **41**(2), 655-662.

Singh, A., Singh, D., Kumar, R., Pal, S., Sachan, R., Yadav, A. (2021). Study the effect of organic, inorganic and biofertilizers on nutrients content and uptake of chickpea (*Cicer arietinum* L.). *The Pharm Innovation Journal,* **10**(10):418-23.

Singh, G, Sekhon, H. S. and Sharma, P. (2011). Effect of irrigation and biofertilizer on water use, nodulation, growth and yield of chickpea. (*Cicer arietinum* L.). *Archives Agron. and Soil Sci* **57**(7):715-726.

Singh, G., Sekhon, H. S. and Sharma, P. (2011). Effect of irrigation and biofertilizer on water use, nodulation, growth and yield of chickpea (*Cicer arietinum* L.). *Agron. Soil Sci*. **57**(7):715-726.

Singh, R., Babu, S., Avasthe, R. K., Yadav, G. S. and Rajkhowa, D. J. (2015). Influence of tillage and organic nutrient management practices on productivity, profitability and energetic of vegetable pea (*Pisum sativum* L.) in rice – vegetable pea sequence under hilly ecosystems of North East India. *Research on Crops* **16**(4): 683–8.

Singh, R., Pratap, Singh, D., Singh, G. and Singh, A. K. (2018). Effect of phosphorus, Sulphur and biofertilizers on growth attributes and yield of chickpea (*Cicer arietinum* L.) *Journal of Pharmacognosy and Phytochemistry.***7**(2):3871-3875

Singh, Y., Singh, B. and Kumar, D. (2014). Effect of phosphorus levels and biofertilizer on yield attributes, yield and nutrient uptake of chickpea (*Cicer arietinum* L.) under rainfed condition. *Res. crops* 15: 90-95.

Tambekar, D. H., Gulhane, S. R., Somkuwar, D. O., Ingle, K. B., Kanchalwar, S. P. (2009). Potential Rhizobium and phosphate solubilizers as a biofertilizers from saline belt of Akola and Buldhana district, India. *Research Journal of Agriculture and Biological Sciences*. **5**(4):578-582.

Thenua, O. V. S. and Ravindra, K. (2011). Effect of phosphorus, sulphur and phosphate solubilizing bacteria on productivity and nutrient uptake of chickpea. Annals of Agriculture Research New Series, 32: 116-119.

Tolanur, S. I. (2008). Integrated effect of organic manuring and inorganic fertilizer N on yield and uptake of micronutrients by chickpea in vertisol. *Legume Research* **31**(3): 184–7

Tripathi, L. K., Thomas, T. and Kumar, S. (2013). Impact of nitrogen and phosphorus on growth and yield of chickpea (*Cicer arietinum* L.). *An Asian J. Soil Sci* **8**(2):260-263.

Uzma, M., Iqbal, A. and Hasnain, S. (2022). Drought tolerance induction and growth promotion by indole acetic acid producing Pseudomonas aeruginosa in Vigna radiata. *PloS one*, **17**(2), e0262932.

Venkatesh, M. S., Hazra, K. K. and Ghosh, P. K. (2013). Critical tissue zinc concentration: a method to diagnose zinc status in chickpea and lentil. *Indian Journal of Plant Physiology* **18**(2): 191–4.

Zaman, S., Mazid, M. A. and Kabir, G. (2011). Effect of *Rhizobium* inoculation on nodulation, yield and yield traits of chickpea (*Cicer arietinum*) in four different soils of greater rajshahi. *Journal of Life and Earth Science*, 6: 45-50