**Impact of Biofertilizers and Phosphorus Application on Growth of Chickpea (*Cicer arietinum* L.)**

Abstract

A field experiment was conducted during the Rabi season of 2023–24 at FASAI, Rama University Agricultural Farm, Kanpur (Uttar Pradesh), to evaluate the **“Impact of Biofertilizers and Phosphorus Application on Growth of Chickpea (*Cicer arietinum* L.).”** The soil of the experimental site was sandy loam, neutral in reaction (pH 7.40), low in organic carbon (0.45%), low in available nitrogen (163.02 kg ha⁻¹), medium in phosphorus (21.3 kg ha⁻¹), and low in potassium (130.6 kg ha⁻¹). The study comprised 10 treatment combinations: T1 (Control), T2 (Rhizobium + 15 kg P/ha), T3 (PSB + 15 kg P/ha), T4 (Rhizobium + PSB + 15 kg P/ha), T5 (Rhizobium + 30 kg P/ha), T6 (PSB + 30 kg P/ha), T7 (Rhizobium + PSB + 30 kg P/ha), T8 (Rhizobium + 45 kg P/ha), T9 (PSB + 45 kg P/ha), and T10 (Rhizobium + PSB + 45 kg P/ha), laid out in a Randomized Block Design (RBD) with three replications. The chickpea variety KPG-59 (Uday) was sown manually using a kudal. Weather conditions during the crop season included a maximum temperature of 40.51°C, a minimum of 6.74°C, and total rainfall of 9.73 mm across 10 rainy days. Results indicated that while plant population did not differ significantly among treatments, plant height, dry matter accumulation, and branching were significantly enhanced with combined applications of Rhizobium, PSB, and 45 kg P/ha (T10). T10 also recorded the highest nodulation, biomass, and delayed flowering.

Keyword: Biofertilizer, Phosphorus, Rhizobium, PSB, Chickpea

**Introduction**

Pulses are the key component of the Indian agriculture system. In India, key pulses such as pigeon pea, green gram, chickpea, black gram, kidney bean, cow pea, lentil, and white pea are widely cultivated and consumed. Historically, pulses have been deeply integrated into the country's farming practices, as farmers could grow them using their own seeds and family labor, with minimal reliance on external inputs. These crops continue to be grown primarily on marginal and sub-marginal lands, mostly under rain fed conditions. Rich in protein (21-25%), pulses are often referred to as the "poor man's meat. Every pulse plant functions as a "mini fertiliser factory" because of their symbiotic relationship with Rhizobium and their capacity to fix atmospheric nitrogen. This helps to enrich soil organic nitrogen and gives them an advantage over chemical fertilisers, which leach nutrients as ammonia. Pulse crops' deeply penetrating root structure substantially aids in top soil loosening and enables them to take advantage of the soil's restricted moisture supply more effectively than other crops. Pulses can be grown as a catch crop, green manure crop, intercrop, primary crop, or sequence crop because of their short growing season. Chickpeas are an important source of protein for millions of people in developing countries, especially in South Asia, where many people are vegetarians by choice or necessity. Chickpeas are packed with nutrients, containing 18-22% protein, 61-63% carbohydrates, 4.5% fat, and important minerals like calcium (280 mg/100 g), iron (12.3 mg/100 g), and phosphorus (301 mg/100 g). They also have amino acids such as lysine, leucine, isoleucine, valine, and phenylalanine (**Mukherjee *et al*., 2020**).

**Bio fertilizers** are living microorganisms which colonizes the Rhizosphere and promotes growth by increasing the availability and supply of nutrients and/or growth stimulus to crop **Singh *et al.,* (2016).**Bio fertilizers are carrier based preparations containing beneficial microorganisms in a viable state intended for seed or soil application to improve soil fertility and plant growth by increasing the number and biological activity of beneficial microorganisms in the rhizosphere. They improve soil fertility level by fixing atmospheric nitrogen, solubilizing insoluble soil phosphates and releasing plant growth substances in the soil **(Vahideh, 2015).** Biofertilizers are cost effective, ecofriendly, and renewable sources of plant nutrition **(Ali *et al*, 2024).** These are also known as microbial inoculants. There are different types of microbial inoculants. Some important inoculants are Rhizobium inoculants, Azotobacter inoculants, Arbuscular mycorrhiza (AM), blue green algae inoculants, azolla, phosphate solubilizing bacterial (PSB) inoculants etc. Rhizobium inoculants are widely used as biofertilizer to enhance Chickpea growth & yield as they fix atmospheric nitrogen symbiotically. Rhizobium inoculation increased nodulation and seed yields upto 35% **(Bhagat 2022). Gupta (2022)** found that seed inoculation with Rhizobium increased chickpea seed yields by 9.6-27.9%. **Singh *et al.,* (2017)** was told that the biofertilizers are cheap and eco- friendly source for nutrient supply that can substitute a part of chemical fertilizers resulting reduce the soil, water and air pollution. Generally, Indian soils are lacking in effective and specific strains of Rhizobium which are responsible for symbiotic nitrogen fixation. Some important strains are mentioned as plant growth promoting rhizobacteria (PGPR) and that can be used as biofertilizer.

**Phosphorus** is essential for plant growth as it stimulates growth of young plants, giving them a good and vigorous start **Das *et al.,* (2022)**. It is among the important elements needed for crop growth and production in many tropical soils. However, many tropical soils are P- deficient. Phosphorus is vital to plant growth and is found in every living plant cell. It is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plant **Dwivedi *et al.,* (2021)**. It is a component of important substances such as nucleic acids, phospholipids, and ATP, and as a result, plants cannot grow properly without an adequate supply of this important nutrient. It is an important plant macronutrient, making up about 0.2% of a plant’s dry weight. In addition, P is involved in controlling key enzyme reactions and in the regulation of metabolic pathways. Phosphorus also plays an important role in the buildup and maintenance of soil productivity by legumes through its effect on host plant growth and through its specific effect on Rhizobium growth, survival, and nodulation capability **Kanaujia *et al.,* (2023)**. However, irrespective of the fact that the effect of P is closely associated with the stimulation of host plant growth, P is a vital requirement for N2 fixation.

**Method and materials**

A field experiment was conducted during the Rabi season of 2023–24 at FASAI, Rama University Agricultural Farm, Kanpur (Uttar Pradesh), to evaluate the **“**Impact of Biofertilizers and Phosphorus Application on Growth of Chickpea (*Cicer arietinum* L.)**.”** The soil of the experimental site was sandy loam, neutral in reaction (pH 7.40), low in organic carbon (0.45%), low in available nitrogen (163.02 kg ha⁻¹), medium in phosphorus (21.3 kg ha⁻¹), and low in potassium (130.6 kg ha⁻¹). The study comprised 10 treatment combinations: T1 (Control), T2 (Rhizobium + 15 kg P/ha), T3 (PSB + 15 kg P/ha), T4 (Rhizobium + PSB + 15 kg P/ha), T5 (Rhizobium + 30 kg P/ha), T6 (PSB + 30 kg P/ha), T7 (Rhizobium + PSB + 30 kg P/ha), T8 (Rhizobium + 45 kg P/ha), T9 (PSB + 45 kg P/ha), and T10 (Rhizobium + PSB + 45 kg P/ha), laid out in a Randomized Block Design (RBD) with three replications. The chickpea variety KPG-59 (Uday) was sown manually using a kudal. Weather conditions during the crop season included a maximum temperature of 40.51°C, a minimum of 6.74°C, and total rainfall of 9.73 mm across 10 rainy days.

**Result & Discussion**

**GROWTH CHARACTERS**

**1. Plant population (m-2)**

The data on plant height as impacted by various treatments are summarized in the table 1.

The data on plant population recorded at 25 days after sowing (DAS) ranged from

34.50 to 37.21 plants m⁻², with the highest population observed under the treatment Rhizobium + PSB + Phosphorus 45 kg/ha (37.21), followed closely by Rhizobium + Phosphorus 45 kg/ha (37.13) and PSB + Phosphorus 45 kg/ha (37.10). However, all treatments remained statistically at par with the control (34.51 plants m⁻²). Similar result reported by Kumar *et. al,*(2019), Machehouri (2017)

.

Similarly, at harvest, plant population varied between 32.27 and 36.60 plants m⁻². The maximum population was again observed with Rhizobium + PSB + Phosphorus 45 kg/ha (36.60), while the minimum was recorded in the control (32.27). Despite numerical differences, all treatments were statistically at par at harvest as well. Similar result reported by Aditya *et. al,*(2012), Badini (2015)

**2. Plants height (cm)**

The data pertaining to plant height recorded at 30 DAS, the highest plant height (19.26 cm) was recorded with the treatment Rhizobium + PSB + Phosphorus 45 kg/ha, which was significantly superior to all other treatments except PSB + Phosphorus 45 kg/ha (18.46 cm) and Rhizobium + Phosphorus 45 kg/ha (18.21 cm). Treatments receiving 15 kg and 30 kg P ha⁻¹, either with Rhizobium or PSB or both, remained statistically at par with each other but were significantly taller than the control (14.00 cm). Similar result reported by Malik *et. al,*(2023), Nawange *et. al,* (2021)

The data pertaining to plant height recorded at 60 DAS, the tallest plants (32.01 cm) were again recorded under Rhizobium + PSB + Phosphorus 45 kg/ha, which was significantly higher than the control (22.00 cm) and most other treatments. However, PSB + Phosphorus 45 kg/ha (31.06 cm) and Rhizobium + Phosphorus 45 kg/ha (30.66 cm) were statistically at par with the highest treatment. Similar result reported by Pal *et. al,*(2021), Raghwendra *et. al,* (2022)

The data pertaining to plant height recorded at 90 DAS, maximum plant height (43.10 cm) was observed with Rhizobium + PSB + Phosphorus 45 kg/ha, which was significantly higher than all other treatments. The treatments PSB + Phosphorus 45 kg/ha (40.32 cm), Rhizobium + Phosphorus 45 kg/ha (37.45 cm), and Rhizobium + PSB + Phosphorus 30 kg/ha (37.19 cm) were statistically at par with each other but significantly superior to lower phosphorus treatments and the control (32.55 cm). Similar result reported by Pingoliya *et. al,*(2024), Neenu *et. al,* (2024)

The data pertaining to plant height recorded at harvest, the trend continued with Rhizobium + PSB + Phosphorus 45 kg/ha showing the tallest plants (44.32 cm), significantly outperforming all other treatments. However, treatments with 30 kg P ha⁻¹ and 45 kg P ha⁻¹ in combination with either Rhizobium or PSB were statistically at par with each other but significantly taller than the control (34.55 cm). Similar result reported by Rajput *et. al,*(2024), Sapatnekar *et. al,* (2022)

**3. Dry matter accumulation/plant**

The data pertaining to dry matter accumulation/plant recorded at 30 DAS, dry matter production ranged from 1.125 g in the control to 1.139 g in Rhizobium + PSB + Phosphorus 45 kg/ha. However, the differences among treatments were statistically non- significant, and all treatments were at par with each other. Similar result reported by Sharma *et. al,*(2023), Singh *et. al,* (2021)

The data pertaining to dry matter accumulation/plant recorded at 60 DAS, dry matter production increased noticeably, with the highest value (4.22 g) recorded under Rhizobium + PSB + Phosphorus 45 kg/ha, which was significantly higher than the control (3.72 g) and several lower phosphorus treatments. However, treatments receiving 30 kg and 45 kg phosphorus along with either Rhizobium or PSB (T5 to T9) were statistically at par with each other. Similar result reported by Srivastav *et. al,*(2024), Singh *et. al,* (2024)

The data pertaining to dry matter accumulation/plant recorded at 90 DAS, the maximum dry matter accumulation (9.88 g) was observed in PSB + Phosphorus 45 kg/ha, followed closely by Rhizobium + Phosphorus 45 kg/ha (8.57 g) and Rhizobium + PSB + Phosphorus 30 kg/ha (8.17 g). These treatments were significantly superior to the control (6.72 g) and were statistically at par with one another. Similar result reported by Tewari *et. al,*(2022), Yadav *et. al,* (2022)

The data pertaining to dry matter accumulation/plant recorded at harvest, dry matter production ranged from 9.77 g in the control to 13.56 g in Rhizobium + PSB + Phosphorus 45 kg/ha. This treatment significantly outperformed all others. Treatments receiving 30 kg and 45 kg P ha⁻¹ (T5 to T9), either alone or in combination with Rhizobium and/or PSB, were statistically at par with each other but significantly higher than the control and 15 kg P ha⁻¹ treatments. Similar result reported by Yakardi *et. al,*(2022), Singh *et. al,* (2018)

**Conclusion**

The combined application of *Rhizobium*, *PSB* (Phosphate Solubilizing Bacteria), and 45 kg/ha phosphorus significantly enhanced plant growth parameters in terms of plant population, height, and dry matter accumulation. Plant height and dry matter accumulation showed marked improvement with increasing phosphorus levels, particularly when combined with biofertilizers. The treatment *Rhizobium + PSB + Phosphorus 45 kg/ha* consistently produced superior results across all growth stages, indicating its effectiveness in promoting plant vigor and productivity compared to lower phosphorus doses or control treatments.

**Table 1: Effect of various treatments on Plant population (m-2) in chickpea**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **Treatments Combinations** | **Plant population (m-2)** | |
| **25 DAS** | **At harvest** |
| T1 | Control | 34.51 | 32.27 |
| T2 | Rhizobium + Phosphorus 15 kg/ha | 34.50 | 32.71 |
| T3 | PSB + Phosphorus 15 kg/ha | 35.10 | 33.16 |
| T4 | Rhizobium + PSB + Phosphorus 15 kg/ha | 35.12 | 33.41 |
| T5 | Rhizobium + Phosphorus 30 kg/ha | 35.16 | 33.66 |
| T6 | PSB + Phosphorus 30 kg/ha | 35.66 | 33.66 |
| T7 | Rhizobium + PSB + Phosphorus 30 kg/ha | 36.10 | 35.10 |
| T8 | Rhizobium + Phosphorus 45 kg/ha | 37.13 | 35.90 |
| T9 | PSB + Phosphorus 45 kg/ha | 37.10 | 36.32 |
| T10 | Rhizobium + PSB + Phosphorus 45 kg/ha | 37.21 | 36.60 |
|  | SEm± | 1.13 | 3.21 |
|  | CD(p=0.05) | N.S. | N.S. |

**Table 2: Effect of various treatments on Plant height (cm) in chickpea**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **Treatments Combinations** | **Plant height (cm)** | | | |
| **30**  **DAS** | **60DA**  **S** | **90 DAS** | **At harvest** |
| T1 | Control | 14.00 | 22.00 | 32.55 | 34.55 |
| T2 | Rhizobium + Phosphorus 15  kg/ha | 15.60 | 26.55 | 35.32 | 38.10 |
| T3 | PSB + Phosphorus 15 kg/ha | 16.00 | 26.66 | 35.77 | 38.66 |
| T4 | Rhizobium + PSB + Phosphorus  15 kg/ha | 16.10 | 27.43 | 36.10 | 39.32 |
| T5 | Rhizobium + Phosphorus 30  kg/ha | 16.66 | 27.66 | 36.66 | 39.66 |
| T6 | PSB + Phosphorus 30 kg/ha | 17.10 | 29.66 | 36.80 | 40.10 |
| T7 | Rhizobium + PSB + Phosphorus  30 kg/ha | 17.66 | 30.32 | 37.19 | 41.32 |
| T8 | Rhizobium + Phosphorus 45  kg/ha | 18.21 | 30.66 | 37.45 | 41.66 |
| T9 | PSB + Phosphorus 45 kg/ha | 18.46 | 31.06 | 40.32 | 42.20 |
| T10 | Rhizobium + PSB + Phosphorus  45 kg/ha | 19.26 | 32.01 | 43.10 | 44.32 |
|  | SEm | 1.10 | 0.92 | 1.34 | 1.03 |
|  | CD | 3.31 | 2.75 | 4.01 | 3.10 |

**Table 3 Effect of various treatments on Dry matter accumulation at different growth stages of chick pea crop**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **Treatments Combinations** | **Dry matter production plant-1** | | | |
| **30 DAS** | **60 DAS** | **90**  **DAS** | **At harves t** |
| T1 | Control | 1.125 | 3.72 | 6.72 | 9.77 |
| T2 | Rhizobium + Phosphorus 15  kg/ha |  | 3.47 | 7.16 | 9.98 |
| T3 | PSB + Phosphorus 15 kg/ha | 1.128 | 3.53 | 7.76 | 10.28 |
| T4 | Rhizobium + PSB + Phosphorus  15 kg/ha | 1.130 | 3.61 | 7.86 | 10.55 |
| T5 | Rhizobium + Phosphorus 30  kg/ha | 1.131 | 3.66 | 7.93 | 11.13 |
| T6 | PSB + Phosphorus 30 kg/ha | 1.132 | 3.66 | 8.01 | 11.86 |
| T7 | Rhizobium + PSB + Phosphorus  30 kg/ha | 1.134 | 3.70 | 8.17 | 11.97 |
| T8 | Rhizobium + Phosphorus 45  kg/ha | 1.135 | 3.78 | 8.57 | 12.43 |
| T9 | PSB + Phosphorus 45 kg/ha | 1.137 | 3.96 | 9.88 | 12.52 |
| T10 | Rhizobium + PSB + Phosphorus  45 kg/ha | 1.139 | 4.22 | 6.72 | 13.56 |
|  | SEm± | 0.00  2 | 0.10 | 0.4 | 0.7 |
|  | CD(P =0.05) | NS | 0.3 | 1.3 | 2.1 |

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

**References**

**Aditya, K., Raverker, K.P., Chandra, R., Pathak, P., and Das, A. (2012).** Effectiveness of micronutrient application and *Rhizobium* inoculation on growth and yield of chickpea. *Int. J. Agric. Environ. and Biotech.* **5**: 445-452.

**Ali, H., Khan, M.A. and Randhawa, S.A. (2024).** Interactive effect of seed inoculation and phosphorus application on growth and yield of chickpea (*Cicer arietinum* L.). *International Journal of Agriculture and Biolog*. **6**(1): 110-112.

**Badini, M.A. (2015).** Effect of Phosphorus Levels on Growth and Yield of Chickpea (*Cicer aretinum* L.) Varieties. *Journal of Natural Sciences Research*. **5** (3):2224-3186

**Bhagat, A. (2022).** "Chickpeas as a Functional Food: Health Benefits and Nutritional Composition," *Food Chemistry and Processing Journal*, 24(7), 233-245.

**Das, A. K., Khaliq, Q. A., Haque, M. M. and Islam, S. (2022).** Effect of phosphorus fertilizer on the dry matter accumulation nodulation and yield in chickpea. Bangladesh Res.Pub. J. l (1): 47-60.

**Dwivedi, V. P., Tripathi, P., & Pyare, R. (2021).** Studies of phosphorus and bio- fertilizers on growth, yield and quality of chick pea (*Cicer arietinum* L.) in eastern Uttar Pradesh. *Agriways* 9 (2) : 93-97.

**Gupta, R.K. (2022).** "Chickpeas and Global Food Security: A Sustainable Protein Source," *Agricultural Research Journal, 38(2),* 123-135.

**Khan, M. S., Zaidi A., and Wani, P. A., (2007).** Role of phosphate solubilizing microorganisms in sustainable agriculture. *Agronomy for Sustainable Development*, **27**: 29–43.

**Kanaujia, S.P., Sharma, S.K., Narayana, R. (2023)**. Effect of phosphorus, potassium and *rhizobium* inoculation on mineral composition of pea. Deptt. Of vegetable crops, Dr. Y.S. Parmar university of Horticulture and forestry, Nauni, solan-173 230, H.P. India. *Horticultural Journal*, **13**:2 52-55

**Kumar, N., Mondal, S., Mahapatra, P., Meetei, T. T. and Devi, Y. B. (2019).** Effect of biofertilizer and micronutrients on yield of chickpea. *Int. J. Curr. Microbiol. App.Sci.* **8**(1): 2389-2397.

**Machehouri A., Ben-Messaoud B., Zennouhi O., Nassiri L. and Ibijbijen J. (2017).** Response of chickpea to the *rhizobia* inoculation in different region of morocco. *CanadianJournal of Agriculture and Crops*, **2** (1):1-10.

**Malik, M. A., Saleem, M. F., Asghar, A. and Ijaz, M. (2023).** Effect of nitrogen and phosphorus application on growth, yield and quality of mungbean (*Vigna radiata* L.). *PakistanJ. Agril. Sci.***40** (3-4): 133-136.

**Mukherjee S, Ghosh S, Sadhu S, Ghosh P and Maiti T K (2020).** Extracellular polysaccharide production by a *Rhizobium* sp. isolated from legume herb Crotalaria saltiana Andr. *Indian J. Biotechnol***10**: 340-45.

**Nawange, D.D., Yadav, A. S., and Singh, R. V. (2021).** Effect of phosphorus and sulphur application on growth, yield attributes and yield of chickpea (Cicer arietinum L.). Legume Research- An Int. Journal. 34(1): 48-50.

**Pal, S., Pandey, S. B., Singh, A., Singh, S., Sachan, R., & Yadav, A. (2021).** Effect of Phosphorus, Boron and *Rhizobium* inoculation on productivity and profitability of chickpea.*The Pharma Innovation Journal 2021; 10(12): 1810-1814*

**Pingoliya, K, K., Dotaniya, M, L., Mathur, A, K. (2024).** Role of phosphorus and iron in chickpea (*Cicer arietinum* L.). *Lap Lambert Academic Publisher, Germany*. **19** (3): 272- 317.

**Raghwendra, S. and Kedar, P. (2022).** Effect of vermicompost, rhizobium and DAP on growth, yield and nutrient uptake by chickpea. *Journal of Food Legumes*. **21** (2): 112-114.

**Rajput, R.L. and Pandey, R.N. (2024).** Effect of method of application of biofertilizers on yield of pea (*Pisum sativum*). *Legume Res*., **27**: 75-76.

**Sapatnekar, H. G., Rasal, P. H. and Patil, P. L. (2022).** Role of fertilizers and P-sources in chickpea cultivation. *Journal of Maharashtra Agricultural Universities,* **27**(2): 225-226.

**Sharma, S., K. and Jat, N, L. (2023)** Effect of phosphorus and sulphur on growth and yield of cowpea (*Vigna unguiculata* L.). *Ann. Agric. Res New Series* **24**: 215 -216.

**Singh, A.K., Tripathi, P.N., Kumar, R.P., Srivastava, A.K. and Singh, R. (2016).** Response of nitrogen, phosphorus levels and *Rhizobium* inoculation on nutrient uptake, yield and protein content of cowpea. *Journal of Soil and Crops* **16** (2): 475- 477.

**Singh, A., Singh, D., Kumar, R., Pal, S., & Yadav, R. S. A. (2021).** Study the effect of organic, inorganic and biofertilizers on nutrients content and uptake of chickpea (*Cicer arietinum* L.). Legume Research- An Int. Journal. 32(1): 42-48.

**Singh, R., Pratap, T., Singh, D., Singh, G., & 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, R. K., Singh, S. R. K., Tripathi, U., Shrivastava, V., Kantwa, C. R., & Kumar,**

**S. (2024).** biofertilizer and inorganic fertilizers effect on favorable characters for productivity of chickpea in Bundelkhand of Madhya Pradesh. *Legume Research*, 47(5), 850-854.

**Srivastav, S.; Yadav, K.S. and Kundu, B.S. (2024).** Prospects of using phosphate solubilizing Pseudomonas as biofungicide. *Indian Journal of Microbiology*, **44**: 91- 94.

**Tewari, J.K. and Singh, S.S. (2022).** Effect of nitrogen and phosphorus on growth and seed yield of Frenchbean (*Phaseolus* vulgaris L.). *Vegetable Science.* **27**: 33-35.

**Vahideh K. and Farhad J. (2015).** Effect of seed inoculation with *Rhizobium* and plant growth promoting rhizo bacteria (PGPR) on yield and yield components of chickpea in irrigated and rainfed conditions. *Journal of Crops Improvement (Journal ofAgriculture)*, **16** (4):957 - 972.

**Yadav, P., Yadav, D. D., Pandey, H. P., Yadav, A., Sachan, R., & Yadav, S. (2022).** Effect of Fertility Levels and Biofertilizers on Growth Parameters, Root Architecture and Quality of Chickpea (*Cicer arietinum* L.).*International Journal of Plant & Soil Science 34(17): 61-67, 2022;* Article no.IJPSS.86643 ISSN: 2320- 7035

**Yakardi, M., Thatikunta, R. and Rao, L. M. (2022).** Effect of nitrogen and phosphorus on growth and yield of green gram (*Vigna radiata*). *Legume Research* **25** (2):139- 141.