E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(9): 942-945
Received: 12-07-2025
Accepted: 15-08-2025

Abhishek Sharma
Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

SB Agarwal
Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Sanjay Singh Jatav
Department of Forestry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Parikha Prakash Singh
Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Sunil Kumar Upadhaya
Department of Soil Science and Agricultural Chemistry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Vinita Parte
Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Shani Gulaiya
Assistant Professor, SOAG, Galogotia University, Noida, India

Corresponding Author:
Parikha Prakash Singh
Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Enhancing growth indices of chickpea (*Cicer arietinum* L.) through sources of nutrient and bio-inoculants

Abhishek Sharma, SB Agarwal, Sanjay Singh Jatav, Parikha Prakash Singh, Sunil Kumar Upadhaya, Vinita Parte and Shani Gulaiya

DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i9m.3882

Abstract
Chickpea (*Cicer arietinum* L.) is a major pulse crop in central India, yet its productivity is often constrained by nutrient limitations and poor microbial activity in soils. To address this, a two-year field experiment (2023-24 and 2024-25) was conducted at Jabalpur, Madhya Pradesh, using a split-plot design with five nutrient sources and five bio-inoculant treatments. Growth indices such as Leaf Area Index (LAI), Absolute Growth Rate (AGR), and Crop Growth Rate (CGR) were recorded at successive crop stages. Findings revealed that nutrient management with vermicompost @ 2 t ha^{-1} + 40 kg P_2O_5 ha^{-1} consistently produced higher LAI, AGR, and CGR compared to other nutrient sources. Among bio-inoculants, the combined inoculation of Rhizobium + PSB + Trichoderma proved most effective, enhancing canopy expansion, photosynthetic activity, and dry matter accumulation. The integration of organic nutrient sources with microbial consortia demonstrated clear physiological advantages, suggesting that such practices can reduce dependency on synthetic fertilizers while improving chickpea.

Keywords: Vermicompost, bio-inoculants, LAI, CGR, trichoderma

Introduction
Chickpea (*Cicer arietinum* L.) is the second most important pulse crop globally and a vital source of dietary protein in South Asia. India accounts for nearly 70 percent of the world's chickpea area and production, with Madhya Pradesh recognized as one of the leading chickpea-producing states (Upadhyay *et al*., 2024) [15]. The crop is mainly grown under residual soil moisture during the rabi season in central India. Although relatively drought-tolerant compared to other pulses, chickpea productivity is constrained by nutrient deficiencies, biotic stresses, and imbalanced fertilization. Farmers often apply little or no fertilizers, relying on the crop's ability to fix atmospheric nitrogen through symbiosis, which limits its yield potential.

Soil chemical and biological properties are important indicators of soil health and are strongly influenced by management practices (Pant *et al*., 2011) [8]. Vermicompost, a stable organic amendment, is light, odourless, and free of weed seeds (Huerta *et al*., 2010) [4]. It is highly porous, promotes aeration and drainage, enhances water-holding capacity, and supplies essential macro- and micronutrients such as nitrogen, phosphorus, potassium, calcium, magnesium, iron, zinc, copper, and manganese (Huerta *et al*., 2010; Hosseinzadeh *et al*., 2015) [4, 3]. Previous studies have shown that vermicompost improves soil nutrient status, microbial activity, and humic substance production, thereby enhancing soil fertility and plant growth (Lazcano *et al*., 2010; Sharma and Banik, 2014) [7, 13]. Moreover, increased concentrations of CO_2 and humic substances can mitigate the adverse effects of water deficit stress (Hosseinzadeh *et al*., 2012) [2].

Nitrogen is essential for chlorophyll synthesis, amino acid formation, and protein building in plants, directly influencing photosynthesis and nutrient utilization. Similarly, phosphorus plays a crucial role in energy transfer, root development, and reproductive growth, making it indispensable for legumes (Ryan *et al*., 2012) [10]. Bio-inoculants such as *Rhizobium* and phosphate-solubilizing bacteria (PSB) further enhance nutrient availability. *Rhizobium* fixes atmospheric nitrogen through root nodules, while PSB converts insoluble phosphates into plant-available forms, thereby improving nutrient uptake and yield (Sharma *et al*., 2024) [12].

Growth analysis offers a reliable approach to evaluate crop performance under different nutrient and microbial management practices. Indices such as Leaf Area Index (LAI), Absolute Growth Rate (AGR), and Crop Growth Rate (CGR) are critical indicators of canopy development, photosynthetic efficiency, and biomass accumulation. These growth parameters not only represent the physiological status of the crop but also serve as reliable predictors of yield potential. Therefore, assessing the influence of nutrient sources and bio-inoculants on growth indices of chickpea is essential for identifying sustainable strategies to enhance productivity under the conditions of central India.

Materials and Methods

A field investigation was carried out during the rabi seasons of 2023-24 and 2024-25 at the Research Farm, Department of Agronomy, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh. The site is situated at 23°09′ N latitude and 79°58′ E longitude, falling under the Kymore Plateau and Satpura Hills. The experimental field was characterized by clayey soil with a slightly alkaline reaction (pH 7.15), electrical conductivity of 0.36 dS m^{-1}, organic carbon content of 0.59 percent, and available nitrogen, phosphorus, and potassium of 318.54, 13.25, and 340 kg ha^{-1}, respectively. The experiment was laid out in a split-plot design with three replications. The main plot factor consisted of nutrient sources: S_1: RDF (20:60:20 NPK kg ha^{-1}), S_2: Vermicompost @ 2 t ha^{-1}, S_3: Vermicompost @ 2 t ha^{-1} + 40 kg P_2O_5 ha^{-1} through rock phosphate, S_4: Vermicompost @ 1 t ha^{-1}, and S_5: Vermicompost @ 1 t ha^{-1} + 20 kg P_2O_5 ha^{-1} through rock phosphate. The subplot factor comprised bio-inoculants: B_1: Rhizobium, B_2: PSB, B_3: Rhizobium + *Trichoderma*, B_4: PSB + *Trichoderma*, and B_5: *Rhizobium* + PSB + *Trichoderma*. This arrangement resulted in a total of 25 treatment combinations.

Results and Discussion

Leaf Area Index

As shown in Table 1 and fig 1 that among the nutrient sources, the treatment comprising vermicompost @ 2 t ha^{-1} along with 40 kg P_2O_5 ha^{-1} recorded the maximum LAI (0.21, 1.93, and 1.82 at 30, 60, and 90 DAS, respectively). The superiority of this treatment may be attributed to the continuous supply of readily available nutrients, particularly nitrogen and phosphorus, from vermicompost and rock phosphate, which promote leaf expansion and improve photosynthetic surface area (Hosseinzadeh *et al*., 2016) [1]. Combined inoculation of Rhizobium + PSB + Trichoderma consistently recorded Maximum LAI (0.20, 1.89, and 1.79 at 30, 60, and 90 DAS, respectively) compared to individual inoculations. The synergistic action of these inoculants when applied together resulted in better nodulation, efficient nutrient mobilization, and balanced nitrogen and phosphorus nutrition. This in turn enhanced photosynthetic capacity by increasing the number and size of leaves, ultimately reflected in higher LAI values. Similar trends of improved LAI with combined bio-inoculant application in legumes has also been reported by Shome *et al*. (2022) [14]. These results are in close conformity with Seth M and Kumar R (2019) [11].

Absolute growth rate (AGR) and Crop growth rate (CGR)

The results of the present investigation indicated that the application of vermicompost, particularly when combined with phosphorus fertilization, significantly influenced the Absolute Growth Rate (AGR) and Crop Growth Rate (CGR) of chickpea. Data presented in Table 2 and depicted in Fig 1 showed that the treatment comprising vermicompost @ 2 t ha^{-1} + 40 kg P_2O_5 ha^{-1} (S_3) recorded the highest AGR (0.224 and 0.305 g day^{-1}) and CGR (7.46 and 10.18 g m^{-2} day^{-1}) during the 30-60 and 60-90 DAS intervals, respectively, which was closely followed by the recommended dose of fertilizers (RDF). The improvement in AGR and CGR under vermicompost with phosphorus application may be attributed to its ability to supply readily available macro- and micronutrients, plant growth-promoting substances (auxins, gibberellins, cytokinins), and humic compounds. These factors collectively stimulated root proliferation, nutrient uptake, and leaf expansion, thereby enhancing canopy development and dry matter accumulation (Lazcano and Domínguez, 2011) [6]. The synergistic effect of improved nutrient availability and hormonal stimulation ensured better partitioning of assimilates, which facilitated sustained growth during critical vegetative and reproductive phases. While, combined inoculation of Rhizobium + PSB + Trichoderma significantly enhanced the Absolute Growth Rate (AGR) and Crop Growth Rate (CGR) of chickpea compared to individual inoculations. The treatment recorded maximum AGR (0.223 and 0.270 g day^{-1}) and CGR (7.45 and 9.01 g m^{-2} day^{-1}) during the 30-60 and 60-90 DAS intervals, respectively. Both indices showed an increasing trend with crop age up to the 60-90 DAS stage. Improvement in AGR and CGR under combined inoculation may be attributed to the synergistic action of the microbial consortium. Rhizobium contributed to enhanced nitrogen fixation, thereby supplying sufficient nitrogen for chlorophyll formation and protein synthesis. Phosphate-Solubilizing Bacteria (PSB) mobilized insoluble phosphorus into plant-available forms, ensuring adequate energy transfer for metabolic activity. Simultaneously, Trichoderma improved root proliferation and rhizosphere interactions, which collectively increased nutrient uptake efficiency and dry matter accumulation. As a result, chickpea plants maintained a higher rate of biomass production both on a per-plant and per-unit area basis, which was reflected in elevated AGR and CGR values. Similar positive effects of bio-inoculants on physiological growth indices of chickpea have been reported by Kumar *et al*. (2014) [5], Seth and Kumar (2019) [11].

Table 1: Effect of Sources of nutrients and bio-inoculants on leaf area index $plant^{-1}$ at different intervals of crop growth

	Leaf Area Index								
	30 DAS			60 DAS			90 DAS		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
Sources of nutrient									
S1: RDF (20:60:20)	0.14	0.18	0.16	1.75	1.81	1.78	1.60	1.62	1.61
S2: Vermi @ 2 ton ha^{-1}	0.17	0.19	0.18	1.85	1.91	1.88	1.73	1.75	1.74
S3: Vermi @ 2 ton + 40 kg P_2O_5 ha^{-1}	0.19	0.22	0.21	1.89	1.97	1.93	1.79	1.85	1.82
S4: Vermi @ 1 ton ha^{-1}	0.11	0.15	0.13	1.53	1.61	1.57	1.42	1.44	1.43
S5: Vermi @ 1 ton + 20 kg P_2O_5 ha^{-1}	0.13	0.16	0.14	1.57	1.67	1.62	1.43	1.49	1.46
SEm±	0.01	0.01	0.01	0.04	0.04	0.02	0.03	0.04	0.02
CD (0.05)	0.04	0.05	0.02	0.12	0.13	0.06	0.11	0.13	0.06

Bio-inoculants									
B1: *Rhizobium*	0.12	0.15	0.14	1.69	1.75	1.72	1.58	1.57	1.57
B2: *PSB*	0.09	0.13	0.11	1.63	1.70	1.67	1.47	1.51	1.49
B3: *Rhizo* + *Tricho*	0.18	0.20	0.19	1.74	1.83	1.79	1.62	1.68	1.65
B4: PSB + *Tricho*	0.15	0.18	0.16	1.71	1.78	1.74	1.59	1.60	1.60
B5: *Rhizo* + PSB + *Tricho*	0.20	0.23	0.21	1.82	1.91	1.86	1.72	1.78	1.75
SEm±	0.02	0.02	0.01	0.03	0.03	0.01	0.02	0.04	0.02
CD (0.05)	0.05	0.05	0.03	0.07	0.08	0.04	0.07	0.12	0.07

Table 2: Effect of Sources of nutrients and bio-inoculants on AGR and CGR at 30-60 and 60-90 days intervals of crop growth

Treatments	Absolute growth rate (g day^{-1})						Crop growth rate (g m^{-2}day^{-1})					
	30-60 days interval			60-90 days interval			30-60 days interval			60-90 days interval		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
Sources of nutrient												
S1: RDF (20:60:20)	0.200	0.222	0.211	0.256	0.282	0.269	6.65	7.38	7.02	8.55	9.39	8.97
S2: Vermi @ 2 ton ha^{-1}	0.185	0.200	0.193	0.237	0.275	0.256	6.17	6.67	6.42	7.90	9.16	8.53
S3: Vermi @ 2 ton + 40 kg P_2O_5 ha^{-1}	0.208	0.240	0.224	0.275	0.336	0.305	6.93	7.99	7.46	9.16	11.19	10.18
S4: Vermi @ 1 ton ha^{-1}	0.121	0.155	0.138	0.192	0.222	0.207	4.03	5.18	4.60	6.39	7.41	6.90
S5: Vermi @ 1 ton + 20 kg P_2O_5 ha^{-1}	0.125	0.171	0.148	0.208	0.239	0.223	4.17	5.69	4.93	6.92	7.97	7.45
SEm±	0.005	0.003	0.002	0.004	0.009	0.005	0.17	0.11	0.08	0.13	0.29	0.16
CD (0.05)	0.016	0.010	0.008	0.012	0.028	0.016	0.55	0.34	0.26	0.42	0.93	0.52
Bio-inoculants												
B1: *Rhizobium*	0.144	0.185	0.164	0.210	0.255	0.233	4.79	6.16	5.48	7.01	8.50	7.76
B2: *PSB*	0.134	0.161	0.148	0.259	0.235	0.247	4.46	5.38	4.92	8.62	7.85	8.24
B3: *Rhizo* + *Tricho*	0.194	0.205	0.199	0.220	0.295	0.257	6.46	6.83	6.65	7.32	9.83	8.58
B4: PSB + *Tricho*	0.160	0.196	0.178	0.260	0.248	0.254	5.34	6.54	5.94	8.65	8.26	8.46
B5: *Rhizo* + PSB + *Tricho*	0.207	0.240	0.223	0.220	0.321	0.270	6.90	8.00	7.45	7.32	10.70	9.01
SEm±	0.003	0.003	0.002	0.005	0.008	0.005	0.10	0.08	0.07	0.17	0.27	0.15
CD (0.05)	0.008	0.007	0.006	0.014	0.023	0.013	0.28	0.24	0.19	0.48	0.77	0.44

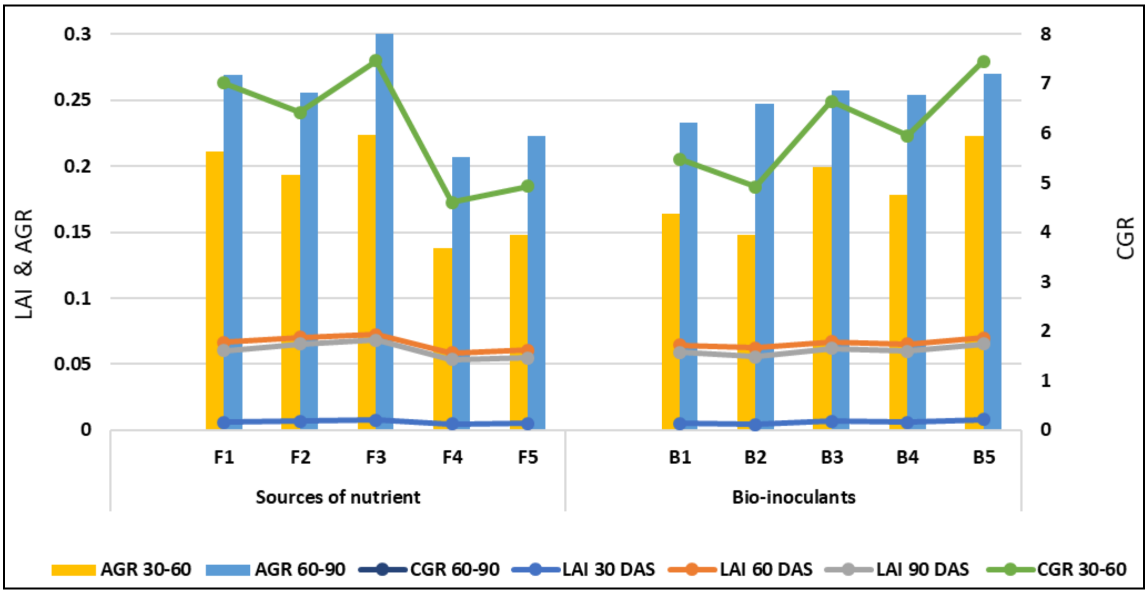

Fig 1: Effect of Vermicompost and Phosphorus on AGR and CGR of Chickpea

Conclusion

The study revealed that the application of vermicompost @ 2 t ha^{-1} + 40 kg P_2O_5 ha^{-1} and the combined inoculation of Rhizobium + PSB + Trichoderma significantly enhanced Leaf Area Index (LAI), Absolute Growth Rate (AGR), and Crop Growth Rate (CGR) in chickpea. Integrated use of organic nutrient sources and bio-inoculants proved superior to individual treatments, highlighting their potential for improving growth efficiency and productivity of chickpea

These findings highlight the potential of integrating vermicompost, phosphorus fertilization, and microbial consortia as a sustainable strategy to improve physiological efficiency and productivity of. Adoption of such integrated nutrient management practices may reduce dependence on chemical fertilizers while maintaining soil health and ensuring long-term crop sustainability.

References

1. Hosseinzadeh SR, Amiri H, Ismaili A. Effect of vermicompost fertilizer on photosynthetic characteristics of chickpea (*Cicer arietinum* L.) under drought stress. Photosynthetica. 2016;54(1):87-92.
2. Hosseinzadeh SR, Salimi A, Ganjeali A, Ahmadpour R. Effects of foliar application of methanol on growth and root characteristics of chickpea (*Cicer arietinum* L.) under drought stress. Eur J Exp Biol. 2012;2(5):1697-1702.

3. Hosseinzadeh SR, Amiri H, Ismaili A. Effect of vermicompost fertilizer on photosynthetic characteristics of chickpea (*Cicer arietinum* L.) under drought stress. Photosynthetica. 2015;54(1):87-92. doi:10.1007/s11099-015-0162-x.
4. Huerta E, Vidal O, Jarquin A, Geissen V, Gomez R. Effect of vermicompost on the growth and production of Amashito pepper, interactions with earthworms and rhizobacteria. Compost Sci Util. 2010;18:282-288.
5. Kumar S, Singh R, Saquib M, Singh D, Kumar A. Effect of different combinations of vermicompost, biofertilizers and chemical fertilizers on growth, productivity and profitability in chickpea. Plant Arch. 2014;14(1):267-270.
6. Lazcano C, Domínguez J. The use of vermicompost in sustainable agriculture: Impact on plant growth and soil fertility. In: Miransari M, editor. Soil Nutrients. USA: Nova Science Publishers; 2011. p. 230-254.
7. Lazcano C, Sampedro L, Zas R, Domínguez J. Assessment of plant growth promotion by vermicompost in different progenies of maritime pine (*Pinus pinaster* Ait.). Compost Sci Util. 2010;18:111-118.
8. Pant A, Radovich TJK, Hue NV, Arancon NQ. Effects of vermicompost tea (aqueous extract) on pak choi yield, quality, and soil biological properties. Compost Sci Util. 2011;19:279-292.
9. Rasool R, Kukal SS, Hira GS. Soil physical fertility and crop performance as affected by long-term application of FYM and inorganic fertilizers in rice-wheat system. Soil Tillage Res. 2007;96:64-72.
10. Ryan J, Ibrikci H, Delgado A, Torrent J, Sommer R, Rashid A. Significance of phosphorus for agriculture and the environment in the West Asia and North Africa region. Adv Agron. 2012;114:91-153.
11. Seth M, Kumar R. Growth indices, nutrient uptake and productivity of wheat + chickpea as influenced by soil moisture regimes and sources of nutrients. J Crop Weed. 2019;15(2):65-71.
12. Sharma A, Vyas MD, Gulaiya S, Singh PP, Kochle P, Sharma BK. Effect of liquid biofertilizer and inorganic nutrients application on growth, physiology and productivity of soybean (*Glycine max* L. Merrill). Plant Arch. 2024;24(Special Issue GABELS):1-6.
13. Sharma RC, Banik P. Vermicompost and fertilizer application: Effect on productivity and profitability of baby corn (*Zea mays* L.) and soil health. Compost Sci Util. 2014;22:83-92.
14. Shome S, Barman A, Solaiman ZM. Rhizobium and phosphate solubilizing bacteria influence the soil nutrient availability, growth, yield, and quality of soybean. Agriculture. 2022;12(8):1136.
15. Upadhyay SK, Kulhare PS, Dixit BK, Tagore GS, Gupta V, Singh S, Sharma A. Impact of FYM and NPK levels on nitrogen, protein content and yield of chickpea in vertisols. Int J Adv Biochem Res. 2024;8(12):113-117.
16. Upadhyay SK, Kulhare PS, Tagore GS, Sharma S, Jatav SS, Raghuwanshi M, Rai V. Impact on growth characteristics and yield of chickpea (*Cicer arietinum* L.) under different FYM and NPK levels in vertisols. Int J Res Agron. 2024;7(12):106-112.