Plant Archives Vol. 25, No. 2, 2025 pp. 1525-1529 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.2.221

CHANGES IN ROOT GROWTH NODULATION BEHAVIOUR, PLANT SURVIVABILITY OF CHICKPEA UNDER ORGANIC SOURCES OF NUTRIENTS AND BIO-AGENTS

Abhishek Sharma[1]*, S.B. Agarwal[1], A.K. Jha[1], R.K. Sahu[2], Sanjay Singh Jatav[3], Parikha Prakash Singh[4] and Vinita Parte[1]

[1]Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.), India
[2]Department of Soil Science and Agricultural Chemistry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (MP), India
[3]Department of Forestry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.), India
[4]Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.), India
*Corresponding Author Email: abhisheksharmatr@gmail.com

(Date of Receiving-19-07-2025; Date of Acceptance-22-09-2025)

ABSTRACT

A field experiment was carried out at Research Farm, Department of Agronomy, JNKVV, Jabalpur, (M.P.) with an objective to assess the changes in plant survivability, root growth and nodulation behaviour due to organics and bio-inoculants. The experiment was laid out in a split-plot design with three replications, where main plots consisted of five nutrient sources including RDF, vermicompost, and vermicompost combined with rock phosphate, and subplots included five bio-inoculant treatments (*Rhizobium*, PSB, *Trichoderma*, and their combinations). Results indicated that vermicompost treatments, particularly when combined with rock phosphate, significantly enhanced nodulation (31.24 and 46.96 nodules plant^{-1} and 67.25 and 115.25 mg plant^{-1} at 30 and 45 DAS) and root biomass (0.35, 0.61 and 0.84 g plant^{-1} at 30, 45 DAS and at harvest) compared to RDF. Among bio-inoculants, the combination of *Rhizobium*, PSB, and *Trichoderma* maintained the highest plant population (53.2 at harvest) and promoted superior root nodules (29.56 and 49.65 at 30 and 45 DAS) and biomass (0.33, 0.57 and 0.87 g plant^{-1} at 30, 45 DAS and at harvest).

Key words: Vermicompost, rock phosphate, nodulation, *Rhizobium*, PSB and *Trichoderma*

Introduction

Pulses hold a unique and indispensable place in Indian agriculture because of their ability to thrive on marginal lands while providing an easily accessible and affordable source of protein. Beyond their dietary role, pulses contribute significantly to human health by lowering the risk of several non-communicable diseases, including colon cancer and cardiovascular disorders (Jukanti *et al.*, 2012). Among pulses, chickpea (*Cicer arietinum L.*), often referred to as the "king of pulses," is highly valued for its nutritional richness, wide adaptability, and enriching soil properties.

Legumes are heavy feeders of phosphorus but require little external nitrogen, as they can meet their nitrogen needs through symbiotic fixation (Kumar *et al.*, 2016). Phosphorus is vital for root development, stem vigor, flower initiation, seed formation, and uniform crop maturity. It also enhances nitrogen fixation, improves grain quality, and increases resistance to diseases (Rehan *et al.*, 2018). Since nitrogen fixation demands substantial energy, legumes generally have higher phosphorus requirements for achieving sustainable yields (Islam *et al.*, 2012).

Biofertilizers further strengthen pulse productivity by promoting plant growth, reducing dependence on chemical fertilizers, hence lowered production costs. They have been shown to improve seed emergence, crop yield, and soil fertility with positive impacts on soil's physical, chemical, and biological attributes (Mondelaers *et al.*, 2009; Nyamadzawo *et al.*, 2014). *Rhizobium* enhances biological nitrogen fixation, phosphate-solubilizing bacteria (PSB) improve phosphorus availability, and *Trichoderma* promotes plant growth through bioactive metabolites.

Vermicompost serves as a rich source of macro- and micronutrients, improves soil structure, and enhances water-holding capacity, thereby acting as an efficient organic soil conditioner (Giusquiani *et al.,* 1995; Diez and Krauss, 1997).

Materials and Methods

A field experiment 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, located at 23°092 N latitude and 79°582 E longitude. The soil of experimental field was clay, with a pH of 7.15 (slightly alkaline), electrical conductivity of 0.36 dS m^{-1}, organic carbon 0.59% and available nitrogen, phosphorus, and potassium of 318.54, 13.25, and 340 kg ha^{-1}, respectively. The test crop was chickpea (*Cicer arietinum L.*), improved wilt-resistant variety JG 14. The experiment was laid out in a split-plot design with three replications. The treatments comprised of five main plots S1: RDF (20:60:20 NPK kg ha^{-1}), S2: Vermicompost @ 2 t ha^{-1}, S3: Vermicompost @ 2 t ha^{-1} + 40 kg P_2O_5 ha^{-1} through Rock Phosphate, S4: Vermicompost @ 1 t ha^{-1}, S5: Vermicompost @ 1 t ha^{-1} + 20 kg P2O4 ha^{-1} through Rock Phosphate and five subplots B1: *Rhizobium*, B2: PSB, B3: *Rhizobium* + *Trichoderma*, B4: PSB + *Trichoderma* and B5: *Rhizobium* + PSB + *Trichoderma* making a total of 25 treatment combinations.

Seeds of chickpea were inoculated with the respective bio-inoculants prior to sowing as per the treatments. For seed treatment, *Rhizobium* and PSB as well as *Trichoderma* were applied @ 5 g kg^{-1} seed, procured from the Microbes Research and Production Centre, Department of Soil Science and Agricultural Chemistry, JNKVV, Jabalpur. Vermicompost used in the experiment was well-decomposed and sieved before application. It contains 1.12% N, 1.02% P_2O_5, 1.19% K_2O, based on dry matter. Vermicompost and rock phosphate were applied to the field and thoroughly incorporated into the soil before sowing. The recommended dose of fertilizers was applied through urea, single super phosphate, and muriate of potash just before sowing. The crop was sown manually by dropping seeds in furrows at spacing of 30 cm within the row, while an approximate distance between plants was 10 cm.

Counting of plants per unit area were taken at 20 days after sowing (20 DAS) and again at harvest. From each subplot, three representative rows (excluding border rows) were selected in which plants were counted from a fixed length of 1 m row) and converted to plants per square metre. Nodules and their dry weight were recorded at 30 and 45 DAS, three plants per subplot were randomly sampled out to assess nodulation. Roots were carefully excavated, washed under running water gently to remove soil and nodules per plant were counted. Detached roots and nodules placed in paper bags, and oven-dried at 65 ± 2 °C until constant weight for assessing biomass. Statistical analysis of data was carried out by "Analysis of Variance" method (Panse and Sukhatme, 1967), the data were analyzed statistically using ANOVA and treatment comparison was made at 5% level of significance.

Results and Discussion

Plant population (m^{-2})

Plant population were recorded at 20 DAS and harvest of crop during both the years of study. Statistical analysis of data (Table 1 and Fig. 1) reveals non-significant variation due to sources of nutrients and bio-inoculants during first, second and pooled analysis at 20 DAS. Further, at harvest of crop, sources of nutrients again failed to bring out any changes in population of plants per m^2. However, bio-inoculants showed markable variation in plants per m^2. The treatment *Rhizobium* + *Trichoderma*, PSB + *Trichoderma* and combined inoculation with *Rhizobium*+ PSB + *Trichoderma* recorded at par plant counts of 51.2, 49.0 and 53.2 m^{-2}, respectively. Whereas, the *Rhizobium* alone recorded 43.3 plants m^{-2} closely followed by 42.1 plants m^{-2} under PSB alone. Hence, *Trichoderma* seems to be an option for protecting the plants of chickpea before harvesting of crop. *Trichoderma* spp. is widely recognized for their ability to enhance plant establishment in legumes. They produce growth-promoting metabolites such as indole-3-acetic acid (IAA), gibberellins, and cytokinins, which accelerate seed germination and improve early seedling vigour. In addition, *Trichoderma* colonizes the rhizosphere and forms a protective barrier around roots, thereby safeguarding seedlings from soil-borne pathogens. Leguminous crops are often vulnerable to germination and establishment losses due to pathogens like *Rhizoctonia solani*, *Fusarium* spp., and *Pythium* spp.; however, *Trichoderma* mitigates these threats by competing for nutrients and space, secreting cell-wall degrading enzymes such as chitinases and glucanases, and producing antifungal metabolites. This multifaceted protection reduces seedling mortality, leading to improved emergence and a higher plant population maintained up to harvest. (Hariharan *et al*., 2022). These results are in accordance with findings of Yadav and Garg (2015).

Nodules count and their dry weight (mg $plant^{-1}$)

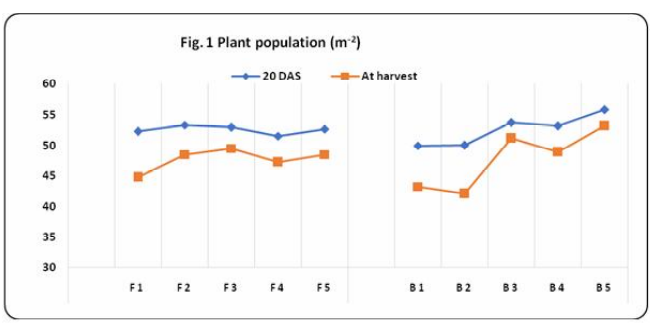
Under the current investigation, all the tested Treatments nutrient sources and bio-inoculants application

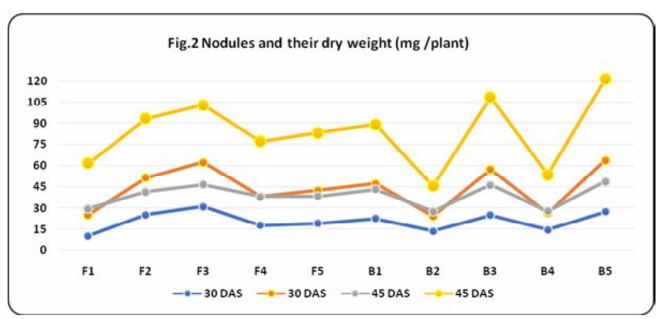
Table 1: Plant population (m^{-2}) affected due to sources of nutrients and bio-inoculants at 20 DAS and harvest of crop.

Treatments	Plant population (m^{-2})					
	20 DAS			At Harvest		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
Sources of nutrients						
S_1: RDF (20:60:20)	51.4	53.2	52.3	44.9	44.6	44.8
S_2: Vermi @ 2 t ha^{-1}	51.8	54.8	53.3	47.3	49.8	48.5
S_3: Vermi @ 2 t + 40 kg P_2O_5 ha^{-1}	50.4	55.6	53.0	48.1	51.0	49.6
S_4: Vermi @ 1 t ha^{-1}	51.0	52.2	51.6	46.8	47.7	47.3
S_5: Vermi @ 1 t + 20 kg P_2O_5 ha^{-1}	51.7	53.7	52.7	47.7	49.4	48.6
SEm±	**3.10**	**4.27**	**2.85**	**5.13**	**5.46**	**3.46**
CD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Bio-inoculants						
B_1: *Rhizobium*	49.4	50.6	50.0	42.9	43.6	43.3
B_2: *PSB*	49.0	51.1	50.1	41.7	42.5	42.1
B_3: *Rhizo + Tricho*	52.3	55.1	53.7	50.4	51.9	51.2
B_4: PSB + *Tricho*	52.3	54.1	53.2	48.6	49.3	49.0
B_5: *Rhizo* + PSB + *Tricho*	53.1	58.6	55.9	51.2	55.2	53.2
SEm±	**1.93**	**3.86**	**2.69**	**4.14**	**4.48**	**3.16**
CD (0.05)	**NS**	**NS**	**NS**	**11.85**	**12.82**	**9.04**

Table 2: Effect of Sources of nutrients and bio-inoculants on nodule counts and their dry weight $plant^{-1}$.

Treatments	Nodules $plant^{-1}$						Nodules dry weight (mg $plant^{-1}$)					
	30 DAS			45 DAS			30 DAS			45 DAS		
	23-24	24-25	Pooled	23-24	24-25	Pooled	23-24	24-25	Pooled	23-24	24-25	Pooled
Sources of nutrient												
S_1: RDF (20:60:20)	18.33	22.52	20.43	36.96	41.84	39.40	46.09	53.05	49.57	99.93	105.65	102.79
S_2: Vermi @ 2 t ha^{-1}	23.01	27.63	25.32	40.22	44.94	42.58	53.82	63.03	58.42	101.53	118.19	109.86
S_3: Vermi @ 2 t + 40 kg P_2O_5 ha^{-1}	27.85	34.63	31.24	41.96	51.96	46.96	63.12	71.38	67.25	108.89	122.22	115.55
S_4: Vermi @ 1 t ha^{-1}	15.04	20.67	17.86	35.57	43.61	39.59	39.88	46.67	43.28	87.24	89.45	88.34
S_5: Vermi @ 1 t + 20 kg P_2O_5 ha^{-1}	17.31	21.45	19.38	35.72	43.52	39.62	44.41	51.74	48.08	93.26	94.70	93.98
SEm±	**1.49**	**2.02**	**0.99**	**1.62**	**2.35**	**1.62**	**3.13**	**4.20**	**1.93**	**4.87**	**7.20**	**3.52**
CD (0.05)	**4.86**	**6.60**	**3.23**	**4.88**	**6.91**	**5.30**	**10.22**	**13.69**	**6.28**	**15.41**	**23.50**	**11.49**
Bio-inoculants												
B_1: *Rhizobium*	22.37	27.27	24.82	42.00	49.60	45.80	46.99	54.96	50.97	91.87	97.66	94.77
B_2: *PSB*	13.19	18.38	15.79	30.98	38.38	34.68	38.35	43.11	40.73	77.78	89.61	83.69
B_3: *Rhizo + Tricho*	25.35	29.23	27.29	43.80	51.68	47.74	55.85	66.00	60.93	110.67	117.61	114.14
B_4: PSB + *Tricho*	13.28	20.23	16.76	26.72	33.84	30.28	44.38	48.49	46.44	87.16	94.16	90.66
B_5: *Rhizo* + PSB + *Tricho*	27.35	31.77	29.56	46.93	52.37	49.65	61.75	73.30	67.53	123.36	131.16	127.26
SEm±	**2.04**	**2.47**	**1.14**	**2.51**	**2.96**	**1.99**	**4.51**	**5.40**	**2.51**	**6.01**	**9.61**	**4.67**
CD (0.05)	**5.83**	**7.06**	**3.25**	**10.02**	**11.89**	**5.69**	**12.90**	**15.42**	**7.18**	**25.77**	**27.47**	**13.34**





in chickpea depicted variable result. Nodule number and their biomass showed a progressive increment from 30 to 45 DAS across all nutrient sources (Table 2 & Fig. 2 & 3). The data revealed that, significantly higher nodule

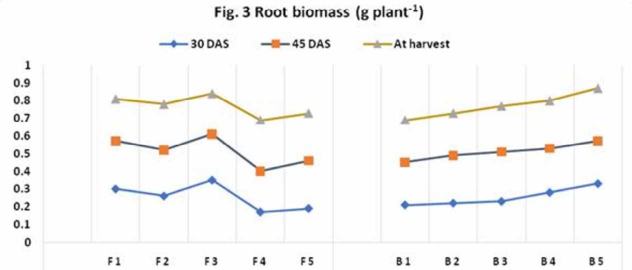
Table 3: Effect of Sources of nutrients and bio-inoculants on root biomass (g) at different intervals of crop growth.

Treatments	Root biomass (g plant^{-1})								
	30 DAS			45DAS			Harvest		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
Sources of nutrients									
S_1: RDF (20:60:20)	0.28	0.32	0.30	0.55	0.58	0.57	0.80	0.82	0.81
S_2: Vermi @ 2 t ha^{-1}	0.25	0.27	0.26	0.49	0.55	0.52	0.77	0.79	0.78
S_3: Vermi @ 2 t + 40 kg P_2O_5 ha^{-1}	0.33	0.37	0.35	0.58	0.63	0.61	0.83	0.86	0.84
S_4: Vermi @ 1 t ha^{-1}	0.18	0.17	0.39	0.41	0.40	0.68	0.70	0.69	
S_5: Vermi @ 1 t + 20 kg P_2O_5 ha^{-1}	0.18	0.21	0.19	0.44	0.47	0.46	0.72	0.75	0.73
SEm±	**0.02**	**0.02**	**0.01**	**0.03**	**0.04**	**0.03**	**0.01**	**0.03**	**0.01**
CD (0.05)	**0.06**	**0.08**	**0.04**	**0.11**	**0.13**	**0.09**	**0.04**	**0.10**	**0.04**
Bio-inoculants									
B_1: *Rhizobium*	0.19	0.22	0.21	0.44	0.46	0.45	0.68	0.71	0.69
B_2: *PSB*	0.21	0.23	0.22	0.47	0.51	0.49	0.72	0.74	0.73
B_3: *Rhizo* + *Tricho*	0.22	0.25	0.23	0.49	0.53	0.51	0.75	0.79	0.77
B_4: PSB + *Tricho*	0.25	0.30	0.28	0.51	0.55	0.53	0.78	0.82	0.80
B_5: *Rhizo* + PSB + *Tricho*	0.31	0.34	0.33	0.55	0.60	0.57	0.86	0.87	0.87
SEm±	**0.03**	**0.03**	**0.01**	**0.02**	**0.03**	**0.02**	**0.02**	**0.04**	**0.02**
CD (0.05)	**0.07**	**0.08**	**0.04**	**0.07**	**0.09**	**0.07**	**0.06**	**0.11**	**0.07**

number plant^{-1} and their dry weight was recorded under the treatments Vermi 2 ton ha^{-1} along with 40 kg P_2O_5 ha^{-1}. This treatment was found at par with Vermi 2 ton ha^{-1} alone at 45 DAS only. While, the lowest number of these characters were noted in RDF plot. This might be because of Vermicompost contains enzymes that stimulate rhizobial activity, leading to increased nodule formation and nitrogen fixation. Synergistic effect of vermicompost and phosphorus support in proliferation of rhizobia and their activities which are conducive for root elongation and nodulation. Lakum *et al.*, (2020), who reported that, application of organic fertlizers enhanced nodulation and nitrogen fixation in legumes. Similar results were also reported by Yadav *et al.*, (2017)

It is clear from the data present in Table 2 and Fig. 2 & 3 that bio-inoculants treatment of *Rhizobium* + PSB + *Trichoderma* recorded the highest nodules plant^{-1} (29.56 and 49.65 plant^{-1} at 30 and 45 DAS) as well as nodule dry weight, (67.53 mg and 127.26 mg plant^{-1} at 30 and 45 DAS) followed by *Rhizobium* + *Trichoderma*. The superiority of co-inoculation is due to complementary role rhizobia and PSB in formation of root nodules and subsequently the fixation of N and solubilization of phosphorus in the soil which was utilized by plants through roots. Joint action of rhizobia and PSB support the root and nodule development. While *Trichoderma* create a favourable rhizospheric environment by suppression of soil pathogens (Tagore *et al.*, (2013). These results are confirmed with the findings of Singh *et al.*, 2018.

Fig. 3 Root biomass (g plant^{-1})



Root biomass (g plant^{-1})

Significantly higher root biomass (Table 3 and Fig. 3) of chickpea at 30, 45 DAS, and harvest of crop was recorded under application of vermicompost either alone or along with 40 kg P_2O_5 ha^{-1} and proved statistically superior over rest of treatments including RDF (20:60:20). Vermicompost has been reported to enhance organic matter content of soil and stimulate root growth as it contains humic substances, hormones like auxin and cytokinin. These findings are closely related with Yadav *et al.*, (2022) and Sharma *et al.*, (2024)

Application of bio-inoculants, *Rhizobium* + PSB + *Trichoderma* (B5) consistently resulted in significantly higher root biomass (0.33, 0.57 and 0.87 g at 30, 45 DAS and harvest). This enhancement may be due to the synergistic effect of the inoculants—*Rhizobium* aiding in biological nitrogen fixation, PSB solubilizing insoluble phosphorus, and *Trichoderma* acting as a plant growth-promoting fungus by releasing phytohormones and enhancing root system development. Similarly, co-inoculation of *Rhizobium* and PSB has been reported to significantly increase root growth and biomass of chickpea. Vermicompost is reported to promote root growth due to the auxin impact of humic substances

(Trevisan *et al*., (2010). Similar results are also reported by Singh and Singh (2014).

Conclusion

The present study demonstrated that nutrient sources significantly influenced root development and nodulation in chickpea. Vermicompost, either alone or in combination with rock phosphate, consistently enhanced nodule number, nodule dry weight, and root biomass compared to chemical fertilizer (RDF). Among bio-inoculants, the combined inoculation of *Rhizobium*, PSB, and *Trichoderma* was most effective in maintaining higher plant population and promoting root growth. These findings suggest that the combined use of organic nutrient sources and bio-inoculants is a promising strategy for improving legume establishment, nodulation, and overall root growth, contributing to sustainable and productive chickpea cultivation.

References

Diez, T. and Krauss M. (1997). Effect of long-term compost application on yield and soil fertility. *Agrobiological Research-Zeitschrift Fur Agrarbiolgie-Agriculture chemie Okologie, Germany*. **50**, 78-84.

Giusquiani, P.L., Pagliai M., Gigliotti G., Businelli D. and Benetti A. (1995). Urban waste compost: effects on physical, chemical and biochemical soil properties. *Journal of Environmental Quality*. **24**, 175-182.

Hariharan, G., Rifnas J.M. and Prasannath K. (2022). Role of Trichoderma spp. in Biocontrol of Plant Diseases. Microbial Biocontrol: Food Security and Post Harvest Management. 39-78.

Islam, M., Mohsan S., Ali S., Khalid R. and Afzal S. (2012). Response of chickpea to various levels of phosphorus and sulphur under rainfed conditions in Pakistan. *Romanian Agric Res*., **29**, 175-183.

Jukanti, A.K., Gaur P.M., Gowda C.L.L. and Chibbar R.N. (2012). Nutritional quality and health benefits of chickpea (*Cicer arietinum* L.). *A Review British J. Nutr*., **108**, S11-S26.

Kumar, S., Tripathi D.K., Bharose R., Kumar M. and Kumar R. (2016). Effect of different fertility level and micronutrients on nodulation and nutrient uptake by chickpea. *An Asian Journal of Soil Sci*., **11(1)**, 62-66.

Lakum, Y.C., Patel H.K., Patel G.G., Patel P.D. and Patel D.K. (2020). Residual Effect of Manure and Fertilizer on Growth, Yield of Chickpea and Soil Nutrient Status under Maize-Chickpea Cropping System. *International Journal of Current Microbiology and Applied Sciences*, **9(4)**, 2940-2945.

Mondelaers, K., Aertsens J. and Huylenbroeck G.V. (2009). A metaanalysis of the differences in environmental impacts between organic and conventional farming. *British Food Journal*. **111**, 1098-1119.

Nyamadzawo, G., Wuta M., Nyamangara J., Smith J.L. and Rees R.M. (2014). Nitrous oxide and methane emissions from cultivated seasonal wetland (dambo) soils with inorganic, organic and integrated nutrient management. *Nutrient Cycling in Agroecosystem*. **100**, 161-175.

Panse, V.G. and Sukhatme P.V. (1967) "Statistical Methods for Agricultural Workers," 2nd Edition, Indian Council of Agricultural Research, New Delhi.

Rehan, W., Jan A., Liaqat W., Jan F.M., Ahmadzai M.D., Ahmad H., Haroon J., Anjum M.M. and Ali N. (2018). Effect of phosphorous, rhizobium inoculation and residue types on chickpea productivity. *Pure Appl. Biol*., **7(4)**, 1203-1213.

Sharma, A., Bochalya R.S., Choudhary K., Devi R., Dhatwalia R.K., Kumar R. and Meenakshi (2024). Effect of different fertility levels and bio-fertilizers on growth, yield and economics of chickpea (*Cicer arietinum* L.) in mid-hills of Himachal Pradesh. *International Journal of Research in Agronomy*, **7(9)**, 170-173.

Singh Raghvendra, Singh V., Singh P. and Yadav R.A. (2018). Effect of phosphorus and PSB on yield attributes, quality and economics of summer greengram (*Vigna radiata* L.). *Journal of Pharmacognosy and Phytochemistry*, **7(2)**, 404-408.

Singh, U. and Singh B. (2014). Effect of basal and foliar application of diammonium phosphate in cognizance with phosphate-solubilizing bacteria on growth, yield and quality of rainfed chickpea (*Cicer arietinum*). *Indian Journal of Agronomy*, **59(3)**, 427-432.

Tagore, G.S., Namdeo S.L., Sharma S.K. and Kumar N. (2013). Effect of Rhizobium and phosphate solubilizing bacterial inoculants on symbiotic traits, nodule leghemoglobin, and yield of chickpea genotypes. *International Journal of Agronomy*.

Trevisan, S., Pizzeghelloi S., Ruperti B., Fransisco O., Sassi A., Palme K., Quaggiotti S. and Nardi S. (2010). Humic substances induce lateral root formation and expression of the early auxin-responsive IAA19 gene and DR5 synthetic element of Arabidopsis. *Plant Biology*. **12**, 604-14.

Yadav, A. and Garg V.K. (2015). Influence of vermi-fortification on chickpea (*Cicer arietinum* L.) growth and photosynthetic pigments. *International Journal Recycle Organic Waste Agriculture*, **4**, 299-305.

Yadav, J.K., Sharma M., Yadav R. and Yadav S.K. (2017). Effect of different organic manures on growth. *Journal of Pharmacognosy and Phytochemistry*, **6(5)**, 1857-1860.

Yadav Pratistha, Yadav D.D., Pandey H.P., Yadav A., Sachan R. and 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.