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Effect of Organic Manures and Micronutrient Application on Growth and Yield of Chickpea (*Cicer arietinum* L.)

Sudarshan Panchal [a++*], Shivam Yadav [a#], Shivendra Singh [a#], Rohitashv Nagar [a#], Gunnjeet Kaur [a#], Khushi Kachhawa [a++], Mohit Malav [a++] and Deepa Khandelwal [a++]

[a] *School of Agricultural Sciences, Career Point University, Kota (Rajasthan)-325003, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

Chickpea (*Cicer arietinum* L.) is an important pulse crop; however, its productivity is frequently constrained by low soil organic matter content and micronutrient deficiencies. In this context, a field experiment was conducted during the rabi season of 2025–26 at the Agricultural Farm of Career Point University, Alaniya, Kota (Rajasthan), to assess the effects of organic manures and foliar-applied micronutrients on the growth and yield performance of chickpea (variety GNG 1581). The experiment was arranged in a factorial randomised block design (FRBD) comprising 12 treatment combinations with three replications. The treatments included three levels of organic manure (control, vermicompost at 2.0 t ha^{-1}, and farmyard manure (FYM) at 5 t ha^{-1}) and four foliar micronutrient applications (control, zinc at 0.5%, boron at 0.2%, and iron at 0.2%). The experimental soil was clay loam in texture, alkaline in reaction (pH 8.35), and characterised by

[++] *M.Sc. Agronomy;* [#] *Assistant Professor;*
**Corresponding author: E-mail: saumypanchal@gmail.com;*

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low organic carbon content. Results indicated that the application of Vermicompost @ 2.0 t ha^{-1} significantly enhanced all growth attributes, recording the highest plant height (45.60 cm), number of branches per plant (9.65), and dry matter accumulation (34.90 g) at harvest. Yield studies further demonstrated the superiority of this treatment, which registered the maximum grain yield (1980 kg ha^{-1}), straw yield (3680 kg ha^{-1}), and harvest index (34.98%) over FYM @ 5 t ha^{-1} and the control. Among the micronutrient treatments, the foliar application of Zinc @ 0.5% consistently outperformed the others. It maximized vegetative growth, leading to the highest plant height (45.45 cm), branches per plant (9.70), and dry matter accumulation (35.20 g). Consequently, the Zinc treatment also produced the highest grain yield (2010 kg ha^{-1}), straw yield (3710 kg ha^{-1}), and harvest index (35.13%), significantly surpassing the Boron, Iron, and control treatments. The strategic integration of Vermicompost @ 2.0 t ha^{-1} and foliar Zinc @ 0.5% emerged as the most effective nutrient management approach for optimizing the overall growth and yield of chickpea.

Keywords: Chickpea; vermicompost; zinc; foliar application; crop yield.

1. Introduction

chickpea (*Cicer arietinum* L.), commonly known as Bengal gram or chana, is one of the most significant pulse crops in India and ranks third globally, contributing approximately 20% of total world production. It plays a vital role in dietary protein supply, particularly within vegetarian diets, serving as an affordable and accessible protein source (Ali et al., 2005; Gaur et al., 2010; Merga & Haji, 2019). With rising income levels in India, the future demand for plant-based protein is expected to increase substantially. Notably, around 43.6% of chickpea growers are smallholder and marginal farmers, for whom the crop contributes nearly 50% of household income. As a predominantly single-season crop, chickpea remains an essential livelihood and nutritional security crop for resource-poor farmers (FAO, 2022; Meena & Prakasha, 2024).

At the global scale, chickpea is cultivated over approximately 10.56 million hectares with a production of about 11.49 million tonnes, of which India accounts for nearly 70% of both area and production (Food and Agriculture Organization of the United Nations, 2023). Within India, major producing states include Madhya Pradesh, Rajasthan, Maharashtra, Gujarat, Uttar Pradesh, Andhra Pradesh, Karnataka, Chhattisgarh, Bihar, and Jharkhand, collectively contributing more than 95% of national production. Chickpea is also recognised as an efficient leguminous crop due to its ability to improve soil fertility through biological nitrogen fixation, thereby enhancing the sustainability of cropping systems (Saxena, 1990; Singh and Diwakar, 1995).

In India, both desi and kabuli types of chickpea are cultivated. While the country continues to be a major importer of desi types, it has emerged as a significant exporter of kabuli chickpea over the past decade. Considerable progress has been achieved in expanding chickpea area and production, particularly in central and southern India, where cultivation has increased by approximately 4 million hectares over the past two decades. This expansion has partly compensated for the decline in chickpea area in northern India, largely attributed to the intensification of irrigated wheat cultivation (AICRP-Chickpea, 2022). Furthermore, improvements in agronomic practices, varietal development, and integrated nutrient management have collectively contributed to enhanced productivity in India (Sodavadiya et al., 2023).

Nutritionally, chickpea is a rich source of protein (18–24%), carbohydrates, minerals, and vitamins, making it a key component of global food and nutritional security strategies (Jukanti et al., 2012; Ibrikci et al., 2003). It is widely consumed across the world, particularly in Afro-Asian regions. Its protein quality is considered superior to that of many other pulses, as it contains most essential amino acids except sulphur-containing ones, which can be complemented through cereal-based diets. Carbohydrates are predominantly present as starch, followed by dietary fibre, oligosaccharides, and simple sugars such as glucose and sucrose. Although lipid content is relatively low, chickpea contains nutritionally important unsaturated fatty acids, including linoleic and oleic acids. In addition, sterols such as β-sitosterol, campesterol, and stigmasterol are present in chickpea oil. The seed also contains essential minerals including calcium, magnesium, phosphorus, and particularly potassium, along with appreciable levels of micronutrients such as zinc and iron, which are critical for human nutrition (Grusak, 2007; Jha & Warkentin, 2020).

Chickpea is also a valuable source of vitamins, including riboflavin, niacin, thiamine, folate, and provitamin A (β-carotene). Like other pulses, it contains anti-nutritional factors that can be reduced through appropriate processing and cooking methods. In addition to its nutritional importance, chickpea is associated with several health benefits, and when consumed as part of a diversified diet with cereals and other pulses, it may contribute to the prevention of non-communicable diseases such as cardiovascular disorders, type 2 diabetes, digestive ailments, and certain cancers (Jukanti et al., 2012; Wood and Grusak, 2007; Yadav et al., 2007). The application of organic manures has been shown to markedly influence soil biological properties by enhancing microbial abundance, diversity, activity, and overall soil health. Organic inputs supply organic matter, nutrients, and energy sources that stimulate beneficial microbial populations, thereby improving nutrient cycling, organic matter turnover, and overall soil ecosystem functioning. Enhanced microbial activity contributes to improved soil structure, nutrient availability, and disease suppression, ultimately increasing soil fertility, resilience, and sustainability under environmental stress conditions. Accordingly, the integration of organic manures into soil management practices is essential for sustaining soil biological quality and agricultural productivity under contemporary environmental challenges (Verma et al., 2024). Earlier studies (Gaur, 1992; Beaton et al., 2005; Bhattacharyya et al., 2008) similarly emphasised that organic manures improve soil physico-chemical and biological properties, thereby enhancing nutrient use efficiency and crop productivity. Moreover, integrated nutrient management systems combining organic and inorganic sources have been widely reported to be particularly effective in pulse-based cropping systems under sustainable agriculture frameworks (Khan et al., 2024; Dhakal et al., 2016).

Despite its high genetic yield potential, chickpea productivity is often constrained by widespread “hidden hunger” of micronutrients in intensively cultivated soils. Deficiencies of zinc (Zn), boron (B), and iron (Fe) are among the most limiting nutritional constraints affecting growth and yield. Zinc plays a crucial role as a cofactor in enzymatic reactions, photosynthesis, and auxin biosynthesis, thereby promoting cell elongation, plant vigour, and seed quality (Kuldeep et al., 2018). Boron is essential for reproductive development, regulating pollen viability, fertilisation, and flower retention, which directly influences pod setting and seed formation. Iron is particularly important in legumes, as it is involved in chlorophyll synthesis and forms a key component of leghemoglobin in root nodules, thereby supporting effective symbiotic nitrogen fixation and overall plant growth (Sodavadiya et al., 2023). Similar findings regarding micronutrient deficiencies and their adverse impacts on legume productivity have been reported by Alloway (2008), Marschner (2012), and Cakmak (2008). Furthermore, zinc application has been shown to enhance enzymatic activity, chlorophyll formation, and seed quality in pulse crops (Hafeez et al., 2013).

Boron plays a major role in reproductive physiology and carbohydrate translocation in legumes (Dell and Huang, 1997), while iron application improves nodulation and nitrogen fixation efficiency (Mengel et al., 2001). Because soil applications of these micronutrients are frequently subjected to chemical fixation and poor availability, foliar nutrition provides a highly efficient alternative. Foliar sprays bypass soil-related constraints, delivering nutrients directly to the active sites of metabolism during critical phenological stages, which significantly improves agronomic use efficiency and crop productivity (Ray *et al*., 2024). Foliar nutrition has been reported as an efficient strategy to correct micronutrient deficiencies and improve productivity in pulse crops under diverse agro-climatic conditions (Fageria *et al*., 2009; Bhowmick, 2018).

2. Materials and Methods

A field experiment entitled “Effect of organic manures and micro nutrient levels on growth, yield and economics of chickpea (*Cicer arietinum* L.)” was conducted at the Agricultural Farm of Career Point University, Alaniya, Kota during the *rabi* season of 2025-26. The farm is located at 25° 11' N latitude and 75° 54' E longitude with an elevation of 273 meters above mean sea level, falling under the Humid South Eastern Plain Zone (Zone V) of Rajasthan. The weather during the crop period recorded an average maximum temperature of 30.60°C, a minimum of 26.4°C, an average relative humidity of 78.95%, and a total rainfall of 34 mm.

The experimental soil was clay-loam in texture with an alkaline pH of 8.35. It was low in organic carbon (0.42%) and available nitrogen (177 kg ha^{-1}), medium in available phosphorus (14.6 kg ha^{-1}), and high in available potassium (321 kg ha^{-1}). The field possessed a stable cropping history, having been under a Soybean-Chickpea rotation in the preceding season, ensuring normal fertility was maintained.

The experiment consisted of 12 treatments laid out in a Factorial Randomized Block Design (FRBD) with 3 replications. The treatments included organic manures (Control, Vermicompost @ 2.0 t ha^{-1}, FYM @ 5 t ha^{-1}) and micronutrient levels (Control, Zinc @ 0.5%, Boron @ 0.2%, Iron @ 0.2%). The chickpea variety GNG

1581 was sown on October 28, 2025, using a seed rate of 80 kg ha^{-1} with a spacing of 30 cm × 15 cm. A recommended basal dose of fertilizers was applied, and foliar applications of micronutrients were carried out as per the treatments. Standard intercultural operations and irrigations were followed, and the crop was harvested upon full maturity on March 3, 2026.

2.1 Growth and Development Studies

Biometric observations were recorded from five randomly selected and tagged plants in each net plot. Plant height was measured from the cotyledonary node to the shoot apex at harvest and averaged. To determine dry matter accumulation per plant, whole plant samples were chopped, sun-dried, and then oven-dried at 65ºC for 72 hours until a constant weight was achieved. The total number of branches and fully matured pods per plant were also counted from these tagged plants. Additionally, the weight of 100 seeds was recorded in grams from the threshed produce of each plot.

2.2 Yield Studies

The crop was harvested from a net plot area of 7.20 m² (3.0 m × 2.4 m). The number of days from sowing to the first picking of pods was recorded. After complete sun drying, the biological yield of the unthreshed produce was weighed. Following threshing and manual winnowing, the clean seed yield was recorded. Both seed and biological yields were converted into kg ha^{-1}. The haulm yield was computed by deducting the seed yield from the total biological yield. The harvest index was calculated as the ratio of economic yield (seed yield) to biological yield, expressed as a percentage.

2.3 Statistical Analysis

The experimental data generated for various parameters were statistically analyzed using the standard "analysis of variance" method as reported by Panse and Sukhatme (1967). The significance of the treatments was tested, and the critical difference (C.D.) at a 5% level of significance was calculated to compare treatment means, following the procedure described by Snedecor and Cochran (1968).

3. Results and Discussion

3.1 Growth Studies

3.1.1 Plant Height (cm)

The data presented in Table 1 and Fig. 1 indicated that different treatments significantly influenced the plant height of chickpea. Plant height increased gradually with the advancement of crop growth stages. A continuous improvement in plant height was observed up to harvest, and the crop attained an average height of 43.31 cm at harvest stage.

Table 1. Effect of different treatment on Plant height (cm) of chickpea

Treatments	30 DAS	60 DAS	90 DAS	At harvest
Organic manures (O)				
O_1 - Control	12.10	27.85	38.50	40.15
O_2 - Vermicompost @ 2.0 t ha^{-1}	12.55	31.40	43.80	45.60
O_3 - FYM @ 5 t ha^{-1}	12.42	30.65	42.10	44.20
SE(m)±	0.22	0.58	0.82	0.88
CD at 5%	NS	1.68	2.38	2.55
Micro nutrient (M)				
M_1 - Control	12.15	28.10	39.20	41.00
M_2 - Zinc @ 0.5 %	12.58	31.50	43.50	45.45
M_3 - Boron @ 0.2 %	12.28	29.45	40.80	42.60
M_4 - Iron @ 0.2 %	12.42	30.80	42.35	44.20
SE(m)±	0.25	0.67	0.95	1.02
CD at 5%	NS	1.95	2.75	2.95

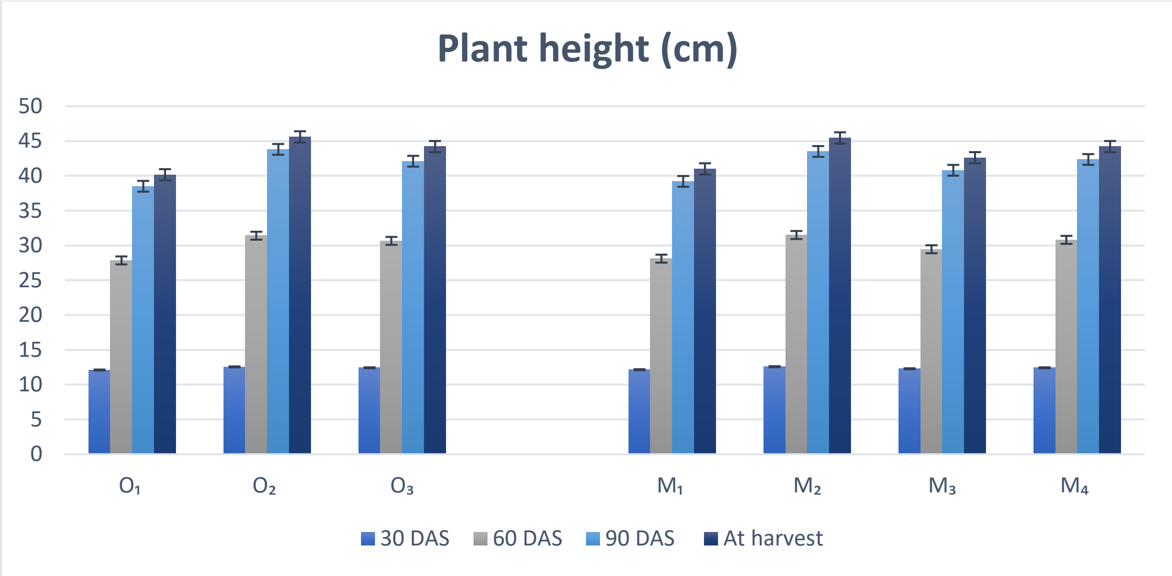

Fig. 1. Graph showing Effect of different treatment on Plant height (cm) of chickpea

Table 2. Effect of different treatment on Number of branches plant^{-1} of chickpea

Treatments	30 DAS	60 DAS	90 DAS	At harvest
Organic manures (O)				
O_1 - Control	3.02	6.10	8.50	8.50
O_2 - Vermicompost @ 2.0 t ha^{-1}	3.08	6.85	9.65	9.65
O_3 - FYM @ 5 t ha^{-1}	3.05	6.55	9.20	9.20
SE(m)±	0.06	0.12	0.15	0.15
CD at 5%	NS	0.35	0.45	0.45
Micro nutrient (M)				
M_1 - Control	3.01	6.15	8.55	8.55
M_2 - Zinc @ 0.5 %	3.10	6.90	9.70	9.70
M_3 - Boron @ 0.2 %	3.04	6.40	8.95	8.95
M_4 - Iron @ 0.2 %	3.06	6.65	9.25	9.25
SE(m)±	0.08	0.14	0.18	0.18
CD at 5%	NS	0.40	0.52	0.52

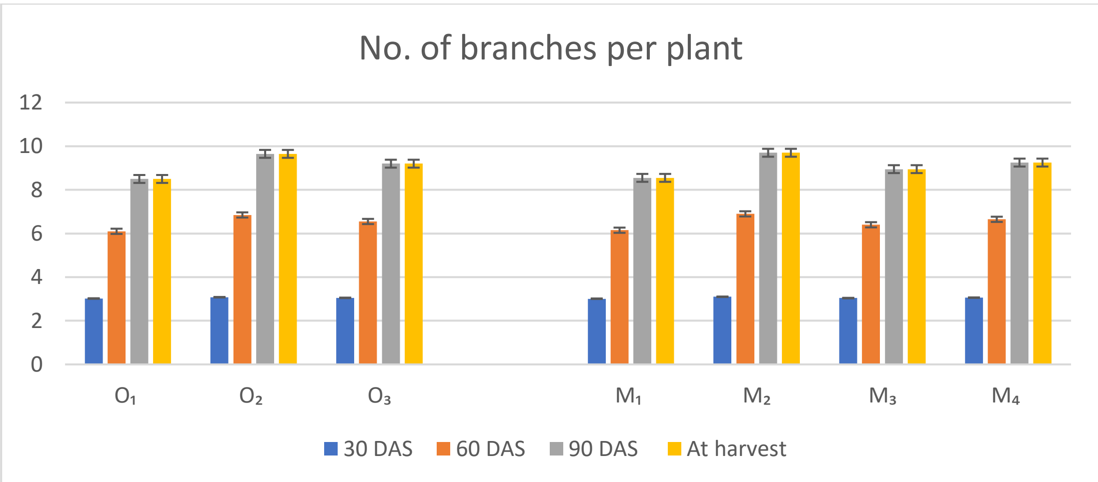

Fig. 2. Graph showing Effect of different treatment on Number of branches plant^{-1} of chickpea

Table 3. Effect of different treatment on Dry matter accumulation plant^{-1} (g) of chickpea

Treatments	30 DAS	60 DAS	90 DAS	At harvest
Organic manures (O)				
O_1 - Control	2.15	16.80	27.40	31.05
O_2 - Vermicompost @ 2.0 t ha^{-1}	2.25	18.90	30.80	34.90
O_3 - FYM @ 5 t ha^{-1}	2.20	17.85	29.50	33.20
SE(m)±	0.08	0.30	0.42	0.52
CD at 5%	NS	0.95	1.35	1.65
Micro nutrient (M)				
M_1 - Control	2.16	16.90	27.60	31.20
M_2 - Zinc @ 0.5 %	2.28	19.10	31.10	35.20
M_3 - Boron @ 0.2 %	2.19	17.50	28.50	32.50
M_4 - Iron @ 0.2 %	2.22	18.20	29.80	33.80
SE(m)±	0.10	0.35	0.50	0.60
CD at 5%	NS	1.05	1.50	1.85

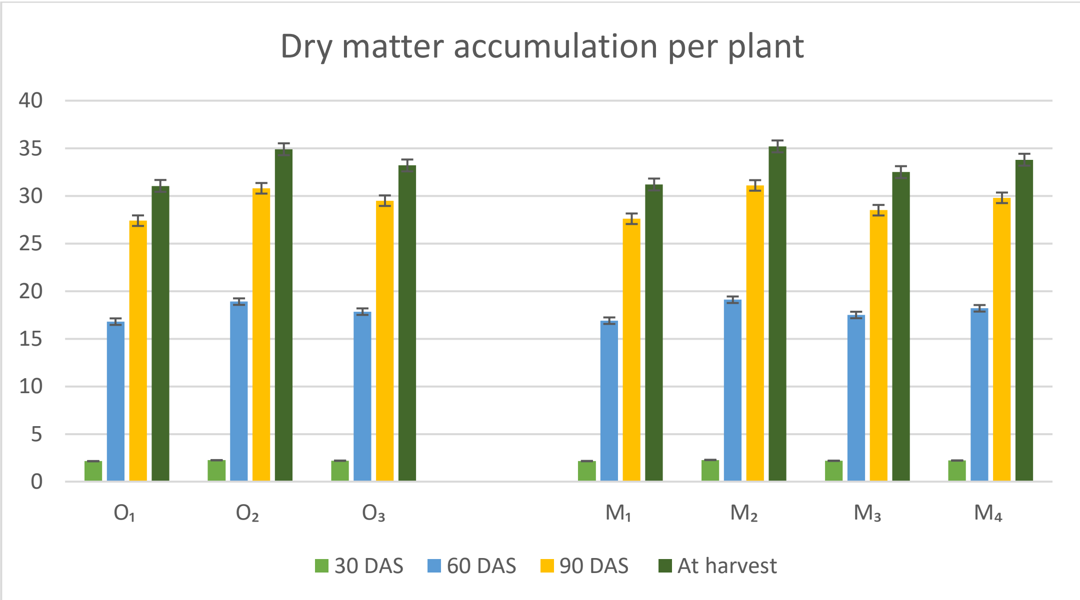

Fig. 3. Graph showing Effect of different treatment on Dry matter accumulation plant-1 (g) of chickpea

Table 4. Effect of different treatment on yield (g) of chickpea

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
Organic manures (O)			
O_1 - Control	1560	3350	31.77
O_2 - Vermicompost @ 2.0 t ha^{-1}	1980	3680	34.98
O_3 - FYM @ 5 t ha^{-1}	1790	3520	33.71
SE(m)±	45	48	-
CD at 5%	155	165	-
Micro nutrient (M)			
M_1 - Control	1580	3370	31.91
M_2 - Zinc @ 0.5 %	2010	3710	35.13
M_3 - Boron @ 0.2 %	1720	3480	33.07
M_4 - Iron @ 0.2 %	1850	3580	34.07
SE(m)±	52	55	-
CD at 5%	175	188	-

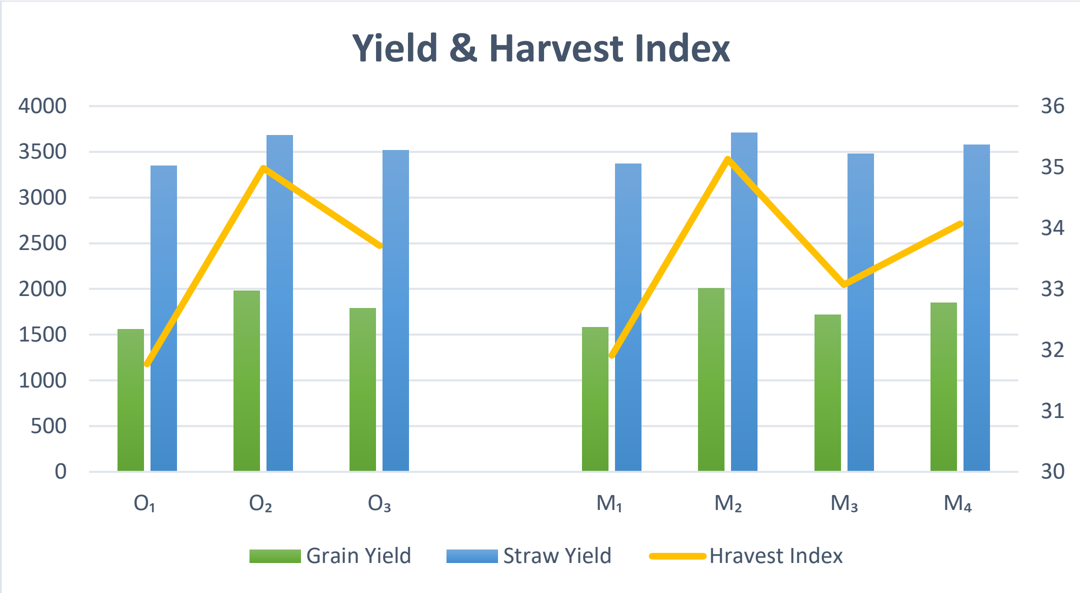

Fig. 4. Graph showing Effect of different treatment on yield (g) of chickpea

It is observed from the data that the application of organic manures with the treatment Vermicompost @ 2.0 t ha^{-1} recorded significantly higher plant height at harvest (45.60 cm) over the control (40.15 cm), but was statistically at par with FYM @ 5 t ha^{-1} (44.20 cm) at 60, 90 DAS, and at harvest. The plant height was positively influenced by vermicompost due to the prolonged and steady release of macro and micro nutrients, which increased the efficiency of nutrients and provided favourable conditions for plant growth. This might be due to the greater availability of nutrients that enhanced crop growth by rapid cell division in the meristematic region and increased activity of the growing tips of the crop. These results are in accordance with those reported by (Jat & Ahlawat, 2006) and (Meena & Suman, 2025).

The results indicated that foliar application of micronutrients significantly improved the plant height of chickpea over the control treatment. Among the treatments, Zinc @ 0.5% recorded the highest plant height (45.45 cm) at harvest, though it remained statistically at par with Iron @ 0.2% and Boron @ 0.2%. The increase in plant height due to zinc application may be attributed to its important role in auxin synthesis, cell elongation, chlorophyll formation, and overall metabolic activities, which ultimately enhanced vegetative growth and plant vigour. Iron and boron also contributed positively towards plant growth by improving physiological and biochemical processes in the crop. The superior performance of micronutrient-treated plants over the control suggests that foliar nutrition effectively enhanced nutrient availability during critical growth stages. Similar findings were also reported by (Valenciano *et al.,* 2010) and (Pathak *et al.,* 2012).

3.1.2 Number of Branches Per Plant

The data presented in Table 2 and Fig. 2 indicated that the number of branches plant^{-1} in chickpea increased significantly with the advancement of crop growth stages up to 90 DAS, thereafter remaining almost unchanged till harvest. The maximum mean number of branches plant^{-1} (9.12) was recorded at harvest stage.

Application of organic manures, specifically Vermicompost @ 2.0 t ha^{-1}, recorded a significantly higher number of branches plant^{-1} at harvest (9.65) over the control (8.50) but was at par with FYM @ 5 t ha^{-1} (9.20) at 60, 90 DAS, and harvest. The application of vermicompost increased the number of branches plant^{-1}, which might be due to better uptake and translocation of nutrients by growing plants, boosting the production of a greater number of branches. The results are in accordance with those reported by (Jat & Ahlawat, 2006) and (Meena & Suman, 2025).

The effect of different micronutrient treatments on the number of branches plant^{-1} was found to be significant at 60 DAS, 90 DAS, and harvest stage. Among the treatments, foliar application of Zinc @ 0.5% recorded a significantly higher number of branches plant^{-1} at harvest (9.70) compared to the control (8.55) and Boron @

0.2% (8.95), while it remained statistically at par with Iron @ 0.2% (9.25). The increase in branching due to zinc application may be attributed to its beneficial role in activating several enzymatic and physiological processes, which enhanced photosynthetic efficiency, nutrient utilization, and overall vegetative growth of the crop. Improved metabolic activities under zinc nutrition might have promoted better growth and development, resulting in higher branching. Similar findings were also reported by (Khorgamy & Farnia, 2009) and (Pathak *et al.,* 2012).

3.1.3 Dry Matter Accumulation Per Plant (g)

The values of dry matter accumulation plant^{-1} data pertaining in Table 3 of chickpea increased with the advancement in age up to harvest. The mean dry matter accumulation at harvest was 33.05 g. The treatment receiving Vermicompost @ 2.0 t ha^{-1} recorded significantly higher dry matter accumulation plant^{-1} at harvest (34.90 g) over the control (31.05 g) at 60, 90 DAS, and harvest, but was statistically at par with FYM @ 5 t ha^{-1} (33.20 g). Higher dry matter accumulation plant^{-1} might be due to increased plant height, more leaves, a greater number of branches, and a better soil-plant atmosphere provided by the sustained nutrient release from vermicompost. Results obtained are similar to the findings of (Jat & Ahlawat, 2006) and (Meena & Suman, 2025).

Dry matter accumulation plant^{-1} was significantly influenced by foliar application of micronutrients. Among the treatments, Zinc @ 0.5% recorded significantly higher dry matter accumulation at harvest (35.20 g plant^{-1}) over the control (31.20 g plant^{-1}) and Boron @ 0.2% (32.50 g plant^{-1}), while remaining statistically at par with Iron @ 0.2% (33.80 g plant^{-1}). The increase in dry matter accumulation under zinc application may be attributed to its catalytic role in several enzymatic and metabolic activities, which promoted better leaf development, enhanced photosynthetic efficiency, and improved nutrient utilization. These favourable physiological effects ultimately resulted in greater biomass production and overall crop growth. Similar findings were also reported by (Khorgamy & Farnia, 2009; Valenciano *et al.,* 2010).

3.2 Yield Studies

3.2.1 Grain Yield (kg ha^{-1})

The data pertaining in Table 4 to mean grain yield ha^{-1} was obtained as 1776 kg ha^{-1}. Treatment Vermicompost @ 2.0 t ha^{-1} (1980 kg ha^{-1}) recorded significantly higher grain yield over FYM @ 5 t ha^{-1} (1790 kg ha^{-1}) and the control (1560 kg ha^{-1}). Vermicompost enhances nutrient utilization efficiency and improves soil microbial activities, leading to higher yields. Similar results are reported by (Jat & Ahlawat, 2006) and (Meena & Suman, 2025).

The foliar application of Zinc @ 0.5 % produced significantly higher grain yield (2010 kg ha^{-1}) over Boron @ 0.2 % (1720 kg ha^{-1}) and the control (1580 kg ha^{-1}), but was at par with Iron @ 0.2 % (1850 kg ha^{-1}). This might be due to a greater number of pods plant^{-1} and improved grain filling facilitated by zinc. Similar results were observed by (Khorgamy & Farnia, 2009; Valenciano *et al.,* 2010).

3.2.2 Straw Yield (kg ha^{-1})

The data pertaining in Table 4 to mean straw yield ha^{-1} was 3516 kg ha^{-1}. Treatment Vermicompost @ 2.0 t ha^{-1} (3680 kg ha^{-1}) recorded significantly higher straw yield over the control (3350 kg ha^{-1}) but was at par with FYM @ 5 t ha^{-1} (3520 kg ha^{-1}). This is attributed to the cumulative effect of improvement in vegetative growth parameters. The results are closely related to the findings of (Jat & Ahlawat, 2006).

Treatment Zinc @ 0.5 % produced significantly higher straw yield (3710 kg ha^{-1}) over Boron @ 0.2 % (3480 kg ha^{-1}) and the control (3370 kg ha^{-1}), but was at par with Iron @ 0.2 % (3580 kg ha^{-1}). The enhanced enzymatic activities and photosynthesis promoted by zinc drove this increase. The obtained results are confirmed by (Pathak *et al.,* 2012).

3.2.3 Harvest Index (%)

The data pertaining in Table 4 to mean harvest index was 33.56%. Treatment Vermicompost @ 2.0 t ha^{-1} (34.98%) recorded a higher harvest index followed by FYM @ 5 t ha^{-1} (33.71%), and the control (31.77%). The balanced supply of nutrients facilitated efficient partitioning of photosynthates from vegetative parts to developing grains. The results are in accordance with the findings of (Meena & Suman, 2025).

The maximum harvest index among micronutrient treatments was recorded under Zinc @ 0.5 % (35.13%), followed by Iron @ 0.2 % (34.07%), Boron @ 0.2 % (33.07%), and the control (31.91%). This increase is tied to the specific role of zinc in carbohydrate metabolism and starch biosynthesis. These findings are supported by the observations of (Pathak *et al.,* 2012) and (Valenciano *et al.,* 2010).

4. Conclusion

Based on the findings in the present investigation that using manures and micronutrients together really helped chickpea plants grow better and produce more. We tested combinations and found that using 2 tons of Vermicompost per hectare along with a 0.5% Zinc spray on the leaves worked best. This combination made the chickpea plants grow stronger produce more and overall do better. Using Vermicompost and Zinc together seems like a way to take care of the soil and make chickpeas grow well. It looks like this method could be a choice for farmers who want to grow chickpeas in a way that is good, for the environment.

Disclaimer (Artificial Intelligence)

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 writing or editing of this manuscript.

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Competing Interests

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Ali, M., & Kumar, S. (2005a). Chickpea (*Cicer arietinum* L.) research in India: Accomplishments and future strategies. *Indian Journal of Agricultural Sciences, 75*(3), 125–133. https://epubs.icar.org.in/index.php/IJAgS/article/view/9329

All India Coordinated Research Project on Chickpea (AICRP-Chickpea). (2022). *Project Coordinator's Report 2021–22*. ICAR-Indian Institute of Pulses Research. https://icar-iipr.org.in/

Alloway, B. J. (2008). *Zinc in soils and crop nutrition* (2nd ed.). International Zinc Association. http://www.topsoils.co.nz/wp-content/uploads/2014/09/Zinc-in-Soils-and-Crop-Nutrition-Brian-J.-Alloway.pdf

Beaton, J. D., Tisdale, S. L., & Nelson, W. L. (2005). Soil fertility and fertilizers: an introduction to nutrient management.

Bhattacharyya, R., Kundu, S., Prakash, V., & Gupta, H. S. (2008). Sustainability under combined application of mineral and organic fertilizers in a rainfed soybean–wheat system of the Indian Himalayas. *European Journal of Agronomy, 28*(1), 33–46. https://www.sciencedirect.com/science/article/pii/S1161030107000500

Bhowmick, M. K. (2018). Seed priming: A low-cost technology for resource-poor farmers in improving pulse productivity. In *Advances in Seed Priming* (pp. 187–208). Springer Singapore. https://doi.org/10.1007/978-981-13-0032-5_11

Cakmak, I. (2008). Enrichment of cereal grains with zinc: Agronomic or genetic biofortification? *Plant and Soil, 302*(1–2), 1–17. https://link.springer.com/article/10.1007/s11104-007-9466-3

Dell, B., & Huang, L. (1997). Physiological response of plants to low boron. *Plant and Soil, 193*(1–2), 103–120. https://link.springer.com/article/10.1023/A:1004264009230

Dhakal, Y., Meena, R. S., & Kumar, S. (2016). Effect of integrated nutrient management on nodulation, yield, quality and available nutrient status in soil after harvest of greengram. *Legume Research, 39*(4), 590–594. https://doi.org/10.18805/lr.v0iOF.9435

Fageria, N. K., Barbosa Filho, M. P., Moreira, A., & Guimaraes, C. M. (2009). Foliar fertilization of crop plants. *Journal of Plant Nutrition, 32*(6), 1044–1064. https://www.tandfonline.com/doi/abs/10.1080/01904160902872826

FAO. (2022). *World food and agriculture - Statistical yearbook 2022*. Food and Agriculture Organization of the United Nations, Rome. https://doi.org/10.4060/cc2211en

Food and Agriculture Organization of the United Nations. (2023). *FAOSTAT statistical database*. https://www.fao.org/faostat/en/

Gaur, A. C. (1992). Bulky organic manures and crop residues. In H. Tandon (Ed.), *Fertilisers, organic manures, recyclable wastes and biofertilisers: Components of integrated plant nutrition*. Fertiliser Development and Consultation Organisation.

Gaur, P. M., Tripathi, S., Gowda, C. L. L., & Ranga Rao, G. V. (2010). *Chickpea seed production manual*. International Crops Research Institute for the Semi-Arid Tropics. https://oar.icrisat.org/10276/

Grusak, M. A. (2009). Nutritional and health-beneficial quality. In W. Erskine, F. J. Muehlbauer, A. Sarker, & B. Sharma (Eds.), *The Lentil: Botany, Production and Uses* (pp. 368–390). CABI. https://doi.org/10.1079/9781845934873.0368

Hafeez, B., Khanif, Y. M., & Saleem, M. (2013). Role of zinc in plant nutrition: A review. *American Journal of Experimental Agriculture, 3*(2), 374–391.

Ibrikci, H., Knewtson, S. J. B., & Grusak, M. A. (2003). Chickpea leaves as a vegetable green for humans: Evaluation of mineral composition. *Journal of the Science of Food and Agriculture, 83*(9), 945–950. https://scijournals.onlinelibrary.wiley.com/doi/abs/10.1002/jsfa.1427

Jat, R. S., & Ahlawat, I. P. S. (2006). Direct and residual effect of vermicompost, biofertilizers and phosphorus on soil nutrient dynamics and productivity of chickpea-fodder maize sequence. Journal of Sustainable Agriculture, 28(1), 41–54. https://doi.org/10.1300/J064v28n01_05

Jha, A. B., & Warkentin, T. D. (2020). Biofortification of pulse crops: Status and future perspectives. *Plants, 9*(1), 73. https://doi.org/10.3390/plants9010073

Jukanti, A. K., Gaur, P. M., Gowda, C. L. L., & Chibbar, R. N. (2012). Nutritional quality and health benefits of chickpea (*Cicer arietinum* L.): A review. *British Journal of Nutrition, 108*(S1), S11–S26. https://doi.org/10.1017/S0007114512000797

Khan, M. T., Aleinikovienė, J., & Butkeviāienė, L.-M. (2024). Innovative Organic Fertilizers and Cover Crops: Perspectives for Sustainable Agriculture in the Era of Climate Change and Organic Agriculture. Agronomy, 14(12), 2871. https://doi.org/10.3390/agronomy14122871

Khorgamy, A., & Farnia, A. (2009). Effect of phosphorus and zinc fertilisation on yield and yield components of chickpea cultivars. African Crop Science Conference Proceedings.

Kuldeep, Kumawat, P. D., Bhadu, V., Sumeriya, H. K., & Kumar, V. (2018). Effect of iron and zinc nutrition on growth attributes and yield of chickpea (*Cicer arietinum* L.). *International Journal of Current Microbiology and Applied Sciences, 7*(8), 2837–2841. https://doi.org/10.20546/ijcmas.2018.708.298

Marschner, P. (2012). *Marschner's mineral nutrition of higher plants* (3rd ed.). Academic Press. https://doi.org/10.1016/C2009-0-63043-9

Meena, H. M., & Prakasha, H. C. (2024). Impact of organic and inorganic amendments on microbiological and chemical properties and their relationship with rice productivity in an alkali soil of Southern India. *Journal of Soil Salinity and Water Quality, 16*(1), 56–68. https://doi.org/10.56093/JSSWQ.v16i1.149729

Meena, H. O., & Suman, B. (2025). Effect of organic and inorganic fertilizers on growth, yield, nutrient uptake and economic returns of chickpea (*Cicer arietinum* L.). *Journal of Experimental Agriculture International, 47*(9), 320–327. https://doi.org/10.56093/JSSWQ.v16i1.149729

Mengel, K., Kirkby, E. A., Kosegarten, H., & Appel, T. (2001). Principles of plant nutrition (5th ed.). Kluwer Academic Publishers. https://doi.org/10.1007/978-94-010-1009-2

Merga, B., & Haji, J. (2019). Economic importance of chickpea: Production, value, and world trade. *Cogent Food & Agriculture, 5*(1), 1615718. https://doi.org/10.1080/23311932.2019.1615718

Panse VG, Shukhatme PV. Statistical Methods for Agricultural Workers (2nd Ed). ICAR, Publications, New Delhi. 1967.

Pathak, G. C., Gupta, B., & Pandey, N. (2012). Improving reproductive efficiency of chickpea by foliar application of zinc. *Brazilian Journal of Plant Physiology, 24*(3), 173–180. https://doi.org/10.1590/S1677-04202012000300004

Ray, S., Maitra, S., Sairam, M., Sravya, M., Priyadarshini, A., Shubhadarshi, S., & Padhi, D. P. (2024). An unravelled potential of foliar application of micro and beneficial nutrients in cereals for ensuring food and nutritional security. *International Journal of Experimental Research and Review, 41*(spl.), 19–42. https://doi.org/10.52756/ijerr.2024.v41spl.003

Saxena, M. C. (1990). Problems and potential of chickpea production in the nineties. In H. A. van Rheenen & M. C. Saxena (Eds.), Chickpea in the Nineties: Proceedings of the Second International Workshop on Chickpea Improvement (pp. 13–27). International Crops Research Institute for the Semi-Arid Tropics. http://oar.icrisat.org/2341/

Singh, F., & Diwakar, B. (1995). Chickpea botany and production practices (Skill Development Series No. 16). International Crops Research Institute for the Semi-Arid Tropics. https://oar.icrisat.org/2425/1/Chickpea-Botany-Production-Practices.pdf

Snedecor G.W. and Cochran W.G. 1967. Statistical Methods. 6th edn. Oxford and IBH Pub. Co .. Calcutta.

Sodavadiya, H. B., Patel, V. J., & Sadhu, A. C. (2023). Effect of integrated nutrient management on the growth and yield of chickpea (*Cicer arietinum* L.) under chickpea–forage sorghum cropping sequence. *Legume Research, 46*(12), 1617–1622. https://doi.org/10.18805/LR-4465

Valenciano, J. B., Boto, J. A., & Marcelo, V. (2010). Response of chickpea (*Cicer arietinum* L.) yield to zinc, boron and molybdenum application under pot conditions. *Spanish Journal of Agricultural Research, 8*(3), 797–807. https://doi.org/10.5424/sjar/2010083-1281

Verma, S., Pradhan, S. S., Singh, A., & Kushuwaha, M. (2024). Effect of organic manure on different soil properties: A review. *International Journal of Plant & Soil Science, 36*(5), 182–187. https://doi.org/10.9734/ijpss/2024/v36i54515

Wood, J. A., & Grusak, M. A. (2007). Nutritional value of chickpea. In S. S. Yadav, R. Redden, W. Chen, & B. Sharma (Eds.), *Chickpea breeding and management* (pp. 101–142). CAB International. https://doi.org/10.1079/9781845932138.005

Yadav, S. S., Redden, R., Chen, W., & Sharma, B. (Eds.). (2007). Chickpea breeding and management. CAB International. https://doi.org/10.1079/9781845932138.000

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