



# Effects of Rock Phosphate, Farmyard Manure, and Vermicompost on Growth, Yield, and Soil Quality in Field Cultivation of Chickpea

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## 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

The study was carried out to find out the effect of Rock phosphate and organic manures on growth, yield and soil quality of chickpea cultivation and suitable doses of FYM, Vermicompost and Rock Phosphate for Chickpea. The Field experiment was conducted at organic research farm Karguan Ji, Institute of Agricultural Sciences, Bundelkhand University Jhansi (UP), India during rabi season of 2023-2024. The experiment was laid out in randomized block design comprises Three levels of rock phosphate (200, 300 and 400 kg/ha) and two levels of FYM and Vermicompost (100% and 50%) with three replications. The application of FYM, Vermicompost and Rock phosphate were obtained significantly higher values in respect to growth, yield attributes and soil quality of chickpea in all the treatments, over control. The highest values were recorded in respect of plant height (36.37cm), number of branches/plants (11.48), number of pods/plants (99.92), number of seeds/pods (2.67), grain yield (15.57 q/ha), stover yield (21.26 q/ha), biological yield (36.84 q/ha), 100 seed weight (17.91gram) and harvest index (43.54%). Soil pH: Ranged from 6.23 (T<sub>1</sub> and T<sub>7</sub>) to 6.70 (T<sub>2</sub> and T<sub>5</sub>). Soil Electrical Conductivity (Ec): Ranged from 0.49 dS/m (T<sub>5</sub>) to 0.65 dS/m (T<sub>6</sub>). Soil Organic Carbon (OC): Ranged from 0.61% (T<sub>0</sub>) to 0.94% (T<sub>7</sub>). Available Nitrogen (N): Ranged from 86.77 kg/ha (T<sub>0</sub>) to 155.57 kg/ha (T<sub>7</sub>). Available Phosphorus (P): Ranged from 11.07 kg/ha (T<sub>0</sub>) to 21.50 kg/ha (T<sub>4</sub>). Available Potassium (K): Ranged from 155.90 kg/ha (T<sub>0</sub>) to 201.93 kg/ha (T<sub>6</sub>). Available Sulphur (S): Ranged from 9.25 Mg/kg (T<sub>0</sub>) to 19.90 Mg/kg (T<sub>4</sub>). The combined application of FYM, vermicompost, and rock phosphate significantly enhanced chickpea growth, yield, and soil nutrient availability, demonstrating the potential for improved and sustainable agricultural practices. These findings align with previous research indicating the beneficial effects of organic amendments on soil and plant health.

**Keywords:** Organic manure; rock phosphate; growth and yield parameters; soil quality and chickpea.

## 1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is third most important pulse crop after beans and pea in the world. Chickpea is a self-pollinated crop, diploid nature and chromosomes number 2n=16. Chickpea (*Cicer arietinum* L.) is first legumes crop in the world. India is the largest producer and consumer of chickpea. Among the pulses, chickpea occupies a predominant position and is considered as a “King of pulse”. The number of chickpea (*Cicer arietinum* L.) important countries has increased from 30 to 150 during 1981 to 2011. Chickpea (*Cicer arietinum* L.) reached a record high global area of 13.1 million ha and production of 11.05 million tons during 2011. In 2022 the area of chickpea (*Cicer arietinum* L.) cultivation observed 9.86 million ha and production 10.44 million tons (E&S, DA & FW 4<sup>th</sup> Advance estimate 2022). The average composition of chickpeas (*Cicer arietinum* L.) is 2.7% ash, 4.5% fat, 63% carbohydrates, 8.0% crude fibre, and 22% protein. In addition to polluting the environment, the indiscriminate and ongoing use of chemical fertilisers had negative effects on the physical, chemical, and biological characteristics of the soil, which in turn affected the sustainability of crop production. Optimising the crop's nutritional requirements at various stages can increase crop productivity in an organic production system. In order to improve

soil fertility and productivity, organic systems rely on the management of organic matter. It is quite difficult to find high-quality organic sources of nutrients for organic farming, hence the production of organic inputs on farms should be encouraged. It can be accomplished by utilising various nutrient sources, each of which has a unique pattern and efficiency of nutrient release.

One of the key elements influencing high productivity is nutrient management, which is necessary to get a high grain yield. In addition to increasing soil fertility, vermicompost enriches soil in the most natural and organic way possible (Chetankumar et al. 2020). Organic fertiliser and soil microorganisms are fully safe and offer the finest macro and micronutrients for crop growth (Asewar et al., 2003). In addition to being a component of many important plant structural components, phosphorus (P) is a necessary nutrient that catalyses the conversion of many important plant biochemical reactions. P has been linked to several growth factors, including: enhanced root development, increased stalk and stem strength, improved flower formation and seed production, more uniform and earlier crop maturity, increased nitrogen N-fixing capacity of legumes, improved crop quality, and increased resistance to plant diseases. P is particularly known for its role in absorbing and transforming solar energy into beneficial plant compounds,

making it crucial for the overall health and vigour of plants (Chesin and Yien, 1950).

## 2. MATERIALS AND METHODS

The field trial was conducted during rabi season 2023-24 at the organic research farm karguana ji, Institute of Agricultural Sciences, Bundelkhand University Jhansi U.P., India. The experiment was carried out using a RBD with three replication and eight treatments with combined levels of FYM, Vermicompost and Rock Phosphate (100%, 50%, & 100%, 50% and 200, 300 & 400 kg/ha) were added and treatments indicated were T<sub>0</sub>-RDF (20:60:40 kg/ha), T<sub>1</sub> (100% FYM), T<sub>2</sub> (100% Vermicompost), T<sub>3</sub> (Rock Phosphate 200 Kg/ha), T<sub>4</sub> (50% FYM + 50% Vermicompost), T<sub>5</sub> (50% FYM + Rock Phosphate 200 kg/ha), T<sub>6</sub> (50% Vermicompost + Rock Phosphate 300 Kg/ha) and T<sub>7</sub> (50% FYM + 50% Vermicompost + Rock Phosphate 400 kg/ha). The experimental field soil was having pH 6.27, EC 0.49dS/m, organic carbon 0.53%, with available N, P and K as 131.2 kg/ha, 17.5 kg/ha and 165.3 kg/ha, respectively. As regards micronutrient, the soil was sufficient in available sulphur 14.3mg/kg. The experiment was conducted using neutral soil. For each plot seeds shown at 5<sup>th</sup> cm depth on 20<sup>th</sup> November 2023. One week after germination, the seedlings were thinned and maintained the spacing. Soil moisture was maintained by irrigation.

At maturity 28<sup>th</sup> March 2024 crop was harvested. Over all plants including seeds were separated and sun dried. At harvest, plant height, number of branches, number of pods/plants, number of seeds/pods, 100 seed weight, grain yield (q/ha), stover yield (q/ha), biological yield (q/ha), harvest index was determined. N, P, K, and S quality also determined. Soil pH and available potassium were determined according to Jackson (1973), EC by Bouwer (1968), OC by walkley and Black's (1934), available nitrogen Kjeldahl (1883), available phosphorous by Olsen et al. (1954) and available sulphur by turbidity method. Harvest index (HI) determined by dividing the total grain yield by biological yield and multiply with 100.

## 3. RESULTS AND DISCUSSION

### 3.1 Growth Attributes

Data shown in Table 1 clearly indicate with the application of FYM, vermicompost and rock phosphate recorded maximum growth

parameters viz. plant height (36.37cm), number of branches/plants (11.48), number of pods/plants (99.92) and number of seeds/pods (2.67) in treatment T<sub>7</sub> (50% FYM + 50% Vermicompost + Rock Phosphate 400 kg/ha). Data received significantly and increasing trends in all treatments compare to control. While minimum growth parameters viz. plant height (30.12cm), number of branches/plants (7.17), number of pods/plants (87.15) and number of seeds/pods (1.00) in treatment T<sub>1</sub> (100% FYM). It may be due to the combine application of FYM, vermicompost and Rock phosphate enhance the photosynthesis process and increase the all-growth parameters and specially enhance the nodule formation in the root. The synergistic effect of every individual organic source incorporated together with vital and congenial conditions occurring at vicinity of farm. Every component of organic sources, possibly contributed to attain the maximum number of seeds per pod by supplying all requisite dose of macro nutrient in chickpea by slow release in soil and increase solubility and availability of nutrients by vermicompost and FYM, more uptake of nutrient combined application of vermicompost with FYM + Rock Phosphate. Our findings similar as Rao et. al., (2020) and sahu et al. (2010) reported that progressive effect of vermicompost increasing the undulation resulted higher fixation of atmospheric nitrogen and ultimately increase the growth parameters.

### 3.2 Yield Attributes

Data shown in Table 2 clearly indicate with the application of FYM, vermicompost and rock phosphate recorded maximum yield viz. grain yield (15.57 q/ha), stover yield (21.26 q/ha), biological yield (36.84 q/ha), 100 seed weight (17.91gram) and harvest index (43.54%) in treatment T<sub>7</sub> (50% FYM + 50% Vermicompost + Rock Phosphate 400 kg/ha) except harvest index. Data received significantly and increasing trends in all treatments except control. While minimum yield viz. grain yield (9.00 q/ha), stover yield (11.99 q/ha), biological yield (20.99 q/ha), 100 seed weight (11.46gram) and harvest index (41.69%) in treatment T<sub>1</sub>(100% FYM) except harvest index. In case of minimum harvest index obtained in treatment T<sub>6</sub> (Vermi compost @ 50% + Rock Phosphate 300 kg ha<sup>-1</sup>). It may be due to the application of FYM, vermicompost and rock phosphate enhance the production, seed formation, shining of seed and grain quality. Organic manures were attributed to the increased availability of phosphorus which also

avored the symbiotic N<sub>2</sub> fixation and higher growth of plants, thereby had positive effect on yield attributes. That nodulating nitrogenase activity, dry matter production, nutrient uptake, protein content and grain yield of chickpea as well as available P content in the soil. Our findings similar as Patel et. Al., (2011) and Das et. Al., (2016), Also reported significantly increase in straw yield with the application of vermicompost only.

### 3.3 Soil Quality

#### 3.3.1 Soil pH

The soil pH ranged from 6.23 to 6.70 across different treatments. The highest pH was observed in T<sub>2</sub> (Vermicompost @100%) and T<sub>5</sub> (FYM @ 50% + Rock Phosphate 200 kg/ha), both recording a pH of 6.70. The control (T<sub>0</sub>) had a pH of 6.40, while the lowest pH was recorded in T<sub>1</sub> (FYM 100%) and T<sub>7</sub> (FYM @ 50 % + Vermicompost @ 50% + Rock Phosphate 400 kg ha<sup>-1</sup>), both at 6.23. The variations in pH indicate that different treatments influence soil acidity, potentially affecting nutrient availability and microbial activity.

**Soil Electrical Conductivity (Ec):** Soil Ec values varied between 0.49 dS/m and 0.65 dS/m. T<sub>6</sub> (Vermicompost @ 50% + Rock Phosphate 300 kg/ha) had the highest Ec value at 0.65 dS/m, suggesting higher ionic concentration in the soil solution. The control (T<sub>0</sub>) had an Ec of 0.53 dS/m. The lowest Ec was observed in T<sub>5</sub>

(FYM @ 50% + Rock Phosphate 200 kg/ha) at 0.49 dS/m. These variations can influence soil salinity and plant nutrient uptake.

**Soil Organic Carbon (OC):** Soil organic carbon content ranged from 0.61% to 0.94%. The highest OC was found in T<sub>7</sub> (FYM @ 50% + Vermicompost @ 50% + Rock Phosphate 400 kg/ha) at 0.94%, indicating enhanced organic matter content. The control (T<sub>0</sub>) had an OC of 0.61%, the lowest among all treatments. Higher OC levels in treatments with organic amendments suggest improved soil structure and fertility.

**Available Nitrogen (N):** Available nitrogen content ranged from 86.77 kg/ha to 155.57 kg/ha. T<sub>7</sub> (FYM @ 50% + Vermicompost @ 50% + Rock Phosphate 400 kg/ha) had the highest nitrogen availability at 155.57 kg/ha, while the control (T<sub>0</sub>) recorded the lowest at 86.77 kg/ha. Increased nitrogen levels in organic treatments highlight the potential of these amendments to enhance nitrogen availability for chickpea growth.

**Available Phosphorus (P):** Available phosphorus content varied from 11.07 kg/ha to 21.50 kg/ha. The highest phosphorus availability was recorded in T<sub>4</sub> (Vermicompost @ 50% + FYM @ 50%) at 21.50 kg/ha. The control (T<sub>0</sub>) had a phosphorus availability of 11.07 kg/ha, the lowest among all treatments. Enhanced phosphorus levels in treated plots suggest improved nutrient availability due to organic and inorganic amendments.

**Table 1. Effect of FYM, vermicompost and rock phosphate on growth parameters of chickpea cultivation**

Treatments	Plant height (cm)	No. of branches/plant	Number of pods/plant	Number of seeds/pod
T <sub>0</sub> (Control)	27.27	4.88	81.93	1.00
T <sub>1</sub> (FYM 100%)	30.12	7.17	87.15	1.00
T <sub>2</sub> (Vermi compost @100%)	31.26	7.47	92.33	1.33
T <sub>3</sub> (Rock Phosphate (200 kg ha <sup>-1</sup> ))	31.51	8.29	94.00	1.33
T <sub>4</sub> (Vermi compost @ 50% + FYM @ 50%)	34.80	8.70	95.72	1.67
T <sub>5</sub> (FYM @ 50% + Rock Phosphate (200 kg ha <sup>-1</sup> ))	34.97	9.96	97.07	1.67
T <sub>6</sub> (Vermi compost @ 50% + Rock Phosphate (300 kg ha <sup>-1</sup> ))	35.22	10.93	98.35	2.00
T <sub>7</sub> (FYM @ 50 %+ Vermi compost @ 50% + Rock Phosphate (400 kg ha <sup>-1</sup> ))	36.37	11.48	99.92	2.67
Sem±	1.11	0.42	0.90	0.26
CD at 5%	3.25	1.23	2.64	0.75

**Table 2. Effect of FYM, vermicompost and rock phosphate on yield parameters of chickpea cultivation**

Treatments	Grain yield (q/ha)	Stover yield (q/ha)	Biological yield (q/ha)	Test weight (gm)	Harvest index (%)
T <sub>0</sub> (Control)	7.76	10.04	17.80	10.65	43.54
T <sub>1</sub> (FYM 100%)	9.00	11.99	20.99	11.46	42.88
T <sub>2</sub> (Vermi compost @100%)	9.90	13.72	23.62	12.96	41.92
T <sub>3</sub> (Rock Phosphate (200 kg ha <sup>-1</sup> ))	10.70	14.24	24.94	14.34	42.89
T <sub>4</sub> (Vermi compost @ 50% + FYM @ 50%)	11.37	15.13	26.51	15.03	42.88
T <sub>5</sub> (FYM @ 50% + Rock Phosphate (200 kg ha <sup>-1</sup> ))	12.32	17.17	29.48	15.83	41.77
T <sub>6</sub> (Vermi compost @ 50% + Rock Phosphate (300 kg ha <sup>-1</sup> ))	13.29	18.59	31.88	16.29	41.69
T <sub>7</sub> (FYM @ 50 %+ Vermi compost @ 50% + Rock Phosphate (400 kg ha <sup>-1</sup> ))	15.57	21.26	36.84	17.91	42.28
SEm±	0.34	0.39	0.65	0.15	0.63
CD at 5%	0.98	1.14	1.92	0.44	1.83

**Table 3. Effect of FYM, vermicompost and rock phosphate on soil quality parameters of chickpea cultivation**

Treatments	Soil pH	Soil Ec	Soil OC (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Available S (Mg/kg)
T <sub>0</sub> (Control)	6.40	0.53	0.61	86.77	11.07	155.90	9.25
T <sub>1</sub> (FYM 100%)	6.23	0.51	0.63	117.99	17.27	176.67	14.92
T <sub>2</sub> (Vermi compost @100%)	6.70	0.50	0.69	125.51	20.73	171.93	16.17
T <sub>3</sub> (Rock Phosphate (200 kg ha <sup>-1</sup> ))	6.57	0.59	0.70	133.01	21.37	181.50	15.93
T <sub>4</sub> (Vermi compost @ 50% + FYM @ 50%)	6.50	0.59	0.77	137.83	21.50	196.30	19.90
T <sub>5</sub> (FYM @ 50% + Rock Phosphate (200 kg ha <sup>-1</sup> ))	6.70	0.49	0.85	144.49	20.47	194.70	19.43
T <sub>6</sub> (Vermi compost @ 50% + Rock Phosphate (300 kg ha <sup>-1</sup> ))	6.47	0.65	0.87	149.16	19.97	201.93	18.23
T <sub>7</sub> (FYM @ 50 %+ Vermi compost @ 50% + Rock Phosphate (400 kg ha <sup>-1</sup> ))	6.23	0.58	0.94	155.57	20.30	188.93	18.83
SEm±	0.21	0.06	0.03	2.22	1.6	8.07	0.95
CD at 5%	0.65	0.18	0.1	6.5	4.67	23.6	2.78

**Available Potassium (K):** Available potassium content ranged from 155.90 kg/ha to 201.93 kg/ha. T<sub>6</sub> (Vermicompost @ 50% + Rock Phosphate 300 kg/ ha) had the highest potassium availability at 201.93 kg/ha, while the control (T<sub>0</sub>) recorded the lowest at 155.90 kg/ha. Increased potassium levels in amended plots indicate better nutrient management and potential for improved chickpea yield.

**Available Sulphur (S):** Available sulphur content ranged from 9.25 Mg/kg to 19.90 Mg/kg. The

highest sulphur availability was recorded in T<sub>4</sub> (Vermicompost @ 50% + FYM @ 50%) at 19.90 Mg/kg. The control (T<sub>0</sub>) had the lowest sulphur availability at 9.25 Mg/kg. Enhanced sulphur levels in organic treatments suggest improved sulphur nutrition for chickpeas.

The results indicate that treatments involving organic amendments (FYM, vermicompost) and rock phosphate significantly improve soil properties and nutrient availability compared to the control. Notably, the combination of FYM,

vermicompost, and rock phosphate (T<sub>7</sub>) showed the highest improvement in soil organic carbon, available nitrogen, and other nutrients, suggesting it as a potential optimal treatment for enhancing chickpea cultivation. The overall positive impact of organic and inorganic amendments highlights their importance in sustainable agricultural practices. Our result partially enclosed with Rao et al., (2020), Das et al., (2016), Noor et al., (2008) and Sahu et al., (2010).

#### 4. SUMMARY

The study evaluates the impact of different combinations of FYM (farmyard manure), vermicompost, and rock phosphate on the growth, yield, and soil quality of chickpea cultivation. The treatments include various proportions of these organic and inorganic amendments, with T<sub>7</sub> (50% FYM + 50% vermicompost + rock phosphate at 400 kg/ha) showing the best results across several parameters.

**1. Growth Attributes:** Plant Height T<sub>7</sub> recorded the highest plant height (36.37 cm), while T<sub>1</sub> (100% FYM) had the lowest (30.12 cm). Number of branches per plant: T<sub>7</sub> had the highest number of branches (11.48), whereas T<sub>1</sub> had the least (7.17). Number of pods per Plant: T<sub>7</sub> recorded the maximum pods (99.92), while T<sub>1</sub> had the minimum (87.15). Number of Seeds per Pod: T<sub>7</sub> had the highest number of seeds (2.67), and T<sub>1</sub> had the lowest (1.00).

**2. Yield Attributes:** Grain Yield: T<sub>7</sub> had the highest grain yield (15.57 q/ha), with T<sub>1</sub> having the lowest (9.00 q/ha). Stover Yield: T<sub>7</sub> recorded the highest stover yield (21.26 q/ha), while T<sub>1</sub> had the lowest (11.99 q/ha). Biological Yield: T<sub>7</sub> had the highest biological yield (36.84 q/ha), with T<sub>1</sub> being the lowest (20.99 q/ha). 100 Seed Weight: T<sub>7</sub> had the highest seed weight (17.91 gm), and T<sub>1</sub> had the lowest (11.46 gm). Harvest Index: The highest harvest index was in T<sub>7</sub> (43.54%), with the minimum in T<sub>6</sub> (41.69%).

**3. Soil Quality:** Soil pH: Ranged from 6.23 (T<sub>1</sub> and T<sub>7</sub>) to 6.70 (T<sub>2</sub> and T<sub>5</sub>). Soil Electrical Conductivity (Ec): Ranged from 0.49 dS/m (T<sub>5</sub>) to 0.65 dS/m (T<sub>6</sub>). Soil Organic Carbon (OC): Ranged from 0.61% (T<sub>0</sub>) to 0.94% (T<sub>7</sub>). Available Nitrogen (N): Ranged from 86.77 kg/ha (T<sub>0</sub>) to 155.57 kg/ha (T<sub>7</sub>). Available Phosphorus (P): Ranged from 11.07 kg/ha (T<sub>0</sub>) to 21.50 kg/ha (T<sub>4</sub>). Available Potassium (K): Ranged from 155.90 kg/ha (T<sub>0</sub>) to 201.93 kg/ha (T<sub>6</sub>). Available

Sulphur (S): Ranged from 9.25 Mg/kg (T<sub>0</sub>) to 19.90 Mg/kg (T<sub>4</sub>).

#### 5. CONCLUSION

The combined application of FYM, vermicompost, and rock phosphate significantly enhances the growth and yield of chickpea plants. Specifically, the treatment combining 50% FYM, 50% vermicompost, and 400 kg/ha rock phosphate (T<sub>7</sub>) demonstrates the highest improvement in both plant growth parameters and yield attributes. Additionally, this treatment also enhances soil quality by increasing the organic carbon content and the availability of essential nutrients such as nitrogen, phosphorus, potassium, and sulphur. These results suggest that the synergistic effects of these organic and inorganic amendments can lead to more sustainable and productive chickpea cultivation practices.

#### 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 no competing interests exist.

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