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Effects of integrated nutrient management on soil health indicators, microbial activity and productivity of chickpea (*Cicer arietinum* L.)

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ABSTRACT

A field experiment was conducted during the Rabi season of 2025–26 at the Research Farm, Mewar University, Gangrar, Chittorgarh (Rajasthan), to evaluate the effect of integrated nutrient management on the growth, yield and post-harvest soil properties of chickpea (*Cicer arietinum* L.) under field conditions. The experiment was laid out in a Split Plot Design (SPD) with three replications, comprising six organic nutrient management treatments [control, FYM @ 5.0 t ha⁻¹, vermicompost @ 2.0 t ha⁻¹, FYM @ 2.5 t ha⁻¹ + vermicompost @ 1.0 t ha⁻¹, FYM @ 3.75 t ha⁻¹ + vermicompost @ 0.50 t ha⁻¹ and FYM @ 1.25 t ha⁻¹ + vermicompost @ 1.50 t ha⁻¹] assigned to the main plots and four fertilizer levels (0, 50, 75 and 100% recommended dose of fertilizers (RDF)) allocated to the sub-plots. The results revealed that integrated application of organic manures and fertilizer levels significantly improved growth, yield attributes, yield and post-harvest soil fertility of chickpea. Among the organic nutrient treatments, application of FYM @ 1.25 t ha⁻¹ + vermicompost @ 1.50 t ha⁻¹ recorded the highest plant height (53.65 cm), branches per plant (13.78), pods per plant (40.33), seeds per pod (1.61), test weight (16.83 g), grain yield (19.20 q ha⁻¹), straw yield (24.33 q ha⁻¹), biological yield (43.53 q ha⁻¹) and harvest index (44.08%). This treatment also improved soil organic carbon (0.424%), available nitrogen (165.09 kg ha⁻¹), phosphorus (23.95 kg ha⁻¹), potassium (304.33 kg ha⁻¹) and microbial populations while reducing soil pH (7.54). Among fertilizer levels, application of 100% RDF recorded the highest plant height (55.53 cm), branches per plant (14.38), pods per plant (42.20), seeds per pod (1.79), test weight (17.99 g), grain yield (20.28 q ha⁻¹), straw yield (25.64 q ha⁻¹), biological yield (45.92 q ha⁻¹) and harvest index (44.10%). It also recorded the highest available nitrogen (166.60 kg ha⁻¹), phosphorus (25.40 kg ha⁻¹), potassium (311.67 kg ha⁻¹), bacterial population (55.51 × 10⁶ CFU g⁻¹ soil), fungal population (44.10 × 10⁴ CFU g⁻¹ soil) and actinomycetes population (37.13 × 10⁵ CFU g⁻¹ soil) after harvest. Post-harvest soil analysis further indicated that integrated nutrient management improved soil organic carbon, available macronutrients and microbial activity while slightly reducing soil pH. The study concluded that the combined application of FYM @ 1.25 t ha⁻¹ + vermicompost @ 1.50 t ha⁻¹ along with 100% RDF is an effective nutrient management strategy for improving growth, productivity and soil fertility of chickpea under the semi-arid conditions of Rajasthan.

Keywords: *Cicer arietinum* L., Integrated nutrient management, Farmyard manure, Vermicompost, Growth, Yield, Soil fertility, Microbial population

Introduction

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops cultivated in India and across the world, serving as a rich source of dietary protein, carbohydrates, vitamins, and minerals (Begum *et al.*, 2023) [1]. India is the largest producer and consumer of chickpea, contributing significantly to global pulse production (Sharma *et al.*, 2020) [2]. In the semi-arid regions of Rajasthan, particularly in Chittorgarh, chickpea occupies an important place in the cropping system due to its adaptability to moisture-deficit conditions and its ability to fix atmospheric nitrogen through symbiosis with *Rhizobium*. Besides improving soil fertility, chickpea contributes significantly to sustainable agriculture and farmers' income. Recent studies have emphasized the importance of improved nutrient management strategies for enhancing chickpea productivity under diverse agro-climatic conditions (Kumar *et al.*, 2025) [3] [4].

Despite its importance, the productivity of chickpea in semi-arid regions remains relatively low due to poor soil fertility, imbalanced nutrient application, declining organic matter, low soil biological activity, and erratic rainfall (Korbu *et al.*, 2020) [5]. Continuous dependence on chemical fertilizers alone has resulted in nutrient imbalance, deterioration of soil health, and reduced microbial activity, thereby affecting the long-term sustainability of crop production systems (Pahalvi *et al.*, 2021) [6]. Therefore, there is a growing need to adopt sustainable nutrient management practices that improve crop productivity while maintaining soil fertility and environmental quality.

Integrated Nutrient Management (INM) has emerged as an effective and sustainable approach for maintaining soil fertility and enhancing crop productivity. It involves the judicious and combined use of inorganic fertilizers, organic manures such as farmyard manure (FYM), compost, and vermicompost, along with biofertilizers including *Rhizobium*, phosphate-solubilizing bacteria (PSB), and *Azotobacter*, to ensure balanced nutrient supply and improve nutrient use efficiency (Panta *et al.*, 2021) [7]. Organic nutrient sources improve soil physical properties, increase soil organic carbon, enhance water-holding capacity, and stimulate beneficial microbial activity, whereas inorganic fertilizers provide readily available nutrients during critical stages of crop growth. The integrated application of these nutrient sources ensures continuous nutrient availability and promotes sustainable crop production.

Soil microorganisms play an important role in nutrient cycling, organic matter decomposition, and the maintenance of soil fertility. Soil enzymatic activities such as dehydrogenase, phosphatase, and urease are considered reliable indicators of soil biological health and are greatly influenced by nutrient management practices (Borase *et al.*, 2020) [8]. The incorporation of organic nutrient sources under INM stimulates microbial growth and enzyme activities, thereby improving nutrient transformation and availability. Similar improvements in microbial population and enzymatic activities under integrated nutrient management have been reported by Verma *et al.* (2024) [9, 10] and Singh *et al.* (2025) [11]. Under semi-arid conditions, the integration of organic and inorganic nutrient sources also improves soil moisture retention, minimizes nutrient losses, and ensures sustained nutrient availability throughout the crop growth period (Selim, 2020) [12].

The combined application of organic manures, inorganic fertilizers, and biofertilizers not only improves nutrient availability but also enhances soil biodiversity and nutrient use efficiency. Organic amendments provide carbon and energy sources for beneficial microorganisms, while biofertilizers enhance biological nitrogen fixation and phosphorus solubilization, thereby reducing dependence on chemical fertilizers (Jakhar *et al.*, 2020) [13]; Verma *et al.*, 2024) [13, 9]. Consequently, integrated nutrient management improves crop growth, nutrient uptake, and soil fertility. Furthermore, several studies have reported higher productivity, profitability, and benefit–cost ratio under integrated nutrient management compared with the sole application of chemical fertilizers (Kumar *et al.*, 2024) [14]; Patel and Thanki, 2020) [14, 15]. Balanced nutrient management also improves quality parameters such as protein content and nutrient composition of chickpea, thereby contributing to nutritional security (Namdeo and Bhatnagar, 2024) [16]; Raghuwanshi *et al.*, 2025) [16, 17]. In addition, INM promotes environmental sustainability by improving soil carbon sequestration, enhancing soil biodiversity, and reducing environmental pollution associated with excessive fertilizer use (Sharma *et al.*, 2022) [18]; Sharma *et al.*, 2025) [19]; Singh *et al.*, 2025) [11] [18, 19, 11].

Although the advantages of integrated nutrient management have been widely reported, location-specific information under the semi-arid conditions of Chittorgarh, Rajasthan, is still limited. Therefore, the present investigation was undertaken to evaluate the effect of integrated nutrient management on soil fertility, growth, yield, nutrient uptake, quality, and economics of chickpea under the semi-arid conditions of Chittorgarh, Rajasthan.

Materials and methods

A field experiment was conducted during the Rabi season of 2025–26 to evaluate the effect of integrated nutrient management on soil health indicators, microbial activity and productivity of chickpea (*Cicer arietinum* L.) at the Research Farm, Mewar University, Gangrar, Chittorgarh, Rajasthan. The experiment was laid out in a Split Plot Design (SPD) with three replications comprising twenty-four treatment combinations. The main plot treatments consisted of six organic nutrient sources [O₀: Control, O₁: FYM @ 5.0 t ha⁻¹, O₂: Vermicompost @ 2.0 t ha⁻¹, O₃: FYM @ 2.5 t ha⁻¹ + Vermicompost @ 1.0 t ha⁻¹, O₄: FYM @ 3.75 t ha⁻¹ + Vermicompost @ 0.5 t ha⁻¹ and O₅: FYM @ 1.25 t ha⁻¹ + Vermicompost @ 1.5 t ha⁻¹], whereas

the sub-plot treatments comprised four fertilizer levels [F₀: Control, F₁: 50% RDF, F₂: 75% RDF and F₃: 100% RDF]. Chickpea variety GNG-1581 was sown at a spacing of 30 cm × 10 cm. The experimental farm is situated in the South-Eastern Plain Agro-climatic Zone of Rajasthan under semi-arid climatic conditions. Before sowing, composite soil samples (0–15 cm depth) were collected and analyzed using standard analytical procedures. The experimental soil was clay loam in texture with a pH of 8.14, electrical conductivity of 0.36 dS m⁻¹, organic carbon content of 0.42%, available nitrogen of 216.45 kg ha⁻¹, available phosphorus of 17.84 kg ha⁻¹ and available potassium of 254.52 kg ha⁻¹, indicating low organic carbon, low available nitrogen and phosphorus, and medium available potassium status.

The crop was grown under the prevailing weather conditions of the Rabi season (2025–26). During the crop growth period, the maximum temperature ranged from 22.5 to 41.3 °C, while the minimum temperature varied from 4.9 to 25.8 °C. The mean relative humidity ranged from 21 to 75%, bright sunshine duration varied between 6.5 and 10.8 h day⁻¹, and a total rainfall of 9.0 mm was received during the cropping season, providing favourable conditions for evaluating the response of chickpea to integrated nutrient management practices. The recommended dose of fertilizers (20 kg N and 40 kg P₂O₅ ha⁻¹) was applied through urea and diammonium phosphate (DAP), respectively, according to the treatment schedule. Organic nutrient sources were incorporated into the soil during final land preparation before sowing. The entire quantity of fertilizers was applied as a basal dose at sowing. Recommended agronomic practices, including irrigation, weed management, plant protection, and harvesting, were followed uniformly in all the treatments. Observations on growth, yield, soil physico-chemical properties, soil microbial activity, and economics were recorded using standard procedures. The experimental data were subjected to analysis of variance (ANOVA) appropriate for the Split Plot Design (SPD), and treatment means were compared using the critical difference (CD) test at the 5% level of significance.

Results and discussion

Growth parameters

Effect of organic sources

Application of different organic nutrient sources significantly influenced plant height and number of branches per plant at all growth stages (Table 1), whereas their effect on days to 50% flowering and days to maturity was non-significant. At 30 DAS, the maximum plant height (18.26 cm) was recorded under vermicompost @ 2.0 t ha⁻¹ (O₂), which was statistically at par with O₅ and O₃. However, at 45 DAS and at harvest, the highest plant height (30.58 and 53.65 cm, respectively) was recorded under O₅ (FYM @ 1.25 t ha⁻¹ + vermicompost @ 1.50 t ha⁻¹), which remained statistically at par with O₂ and O₃. Likewise, the maximum number of branches per plant at all growth stages was also recorded under O₅ and was statistically comparable with O₂ and O₃, whereas the lowest values were observed under the control (O₀). Although differences in days to 50% flowering and days to maturity were statistically non-significant, O₅ recorded the earliest flowering (68.72 days) and maturity (124.36 days), while the control required the maximum number of days.

The superior vegetative growth observed under the combined application of FYM and vermicompost may be attributed to the balanced and sustained supply of nutrients, improvement in soil physical conditions, enhanced soil organic carbon, and greater microbial activity, which collectively improved nutrient uptake and photosynthetic efficiency (Selvaganapathi *et al.*, 2025) [20]. Vermicompost is also known to contain plant growth regulators such as auxins, gibberellins, and cytokinins that stimulate cell division, root proliferation, and vegetative growth, resulting in taller plants and more branches. The relatively earlier flowering and maturity under integrated organic nutrient management may be due to improved physiological activity and efficient translocation of assimilates, which accelerated crop development (Cheng *et al.*, 2026) [21]. Similar findings have been reported by

Zhiipao *et al.* (2023)^[22], Javed *et al.* (2022)^[23], and Ray *et al.* (2020)^[24].

Effect of fertilizer levels

The data presented in Table 1 indicated that fertilizer levels significantly influenced plant height, number of branches per plant, days to 50% flowering, and days to maturity of chickpea. Plant height increased progressively with increasing fertilizer levels throughout the crop growth period. The application of 100% RDF (F₃) recorded the maximum plant height of 19.79, 33.13, and 55.53 cm at 30 DAS, 45 DAS, and at harvest, respectively, which remained statistically at par with 75% RDF (F₂) but was significantly superior to 50% RDF (F₁) and the control (F₀). The lowest plant height at all growth stages was recorded under the control treatment. A similar trend was observed for the number of branches per plant. The highest number of branches (3.05, 7.55, and 14.38) at 30 DAS, 45 DAS, and at harvest, respectively, was recorded under 100% RDF (F₃), which was statistically at par with 75% RDF (F₂) and significantly superior to 50% RDF (F₁) and the control (F₀). The minimum number of branches per plant was observed under the control treatment. Days to 50% flowering and days to maturity were significantly affected by fertilizer levels. The crop supplied with 100% RDF (F₃) attained 50% flowering (67.96 days) and physiological maturity (124.25 days) significantly earlier than the control (73.45 and 129.38 days, respectively). Treatment F₂ (75% RDF) was statistically at par with F₃ for days to 50% flowering, while both F₂ and F₁ were statistically at par with F₀ for days to maturity.

The significant improvement in growth parameters under higher fertilizer levels may be attributed to the balanced and adequate supply of essential nutrients, particularly nitrogen and phosphorus, which enhanced chlorophyll formation, photosynthetic activity, protein synthesis, and cell division. Adequate nutrient availability also promoted vigorous root growth and increased nutrient uptake, resulting in greater vegetative growth, as reflected by increased plant height and branching (Lalkhumliana *et al.*, 2025)^[25]. Furthermore, balanced fertilization accelerated physiological and metabolic activities, leading to earlier flowering and maturity by promoting the timely transition from vegetative to reproductive growth. These findings are in close agreement with those of Baek *et al.* (2026)^[26], Tiwari *et al.* (2026)^[27] and Wang *et al.* (2024)^[28].

Yield parameters

Effect of organic sources

The data presented in Table 2 revealed that different organic nutrient sources significantly influenced all the yield parameters of chickpea, including number of pods per plant, number of seeds per pod, test weight, grain yield, straw yield, biological yield, and harvest index. Among the organic nutrient sources, O₅ (FYM @ 1.25 t ha⁻¹ + Vermicompost @ 1.50 t ha⁻¹) recorded the maximum number of pods per plant (40.33), number of seeds per pod (1.61), test weight (16.83 g), grain yield (1.43 kg plot⁻¹ and 19.20 q ha⁻¹), and harvest index (44.08%), which remained statistically at par with O₂ (Vermicompost @ 2.0 t ha⁻¹) and O₃ (FYM @ 2.5 t ha⁻¹ + Vermicompost @ 1.0 t ha⁻¹). The highest straw yield (24.63 q ha⁻¹) and biological yield (43.57 q ha⁻¹) were recorded under O₂, which was statistically at par with O₅ and O₃. The minimum values for all yield parameters were observed under the control treatment (O₀).

The significant improvement in yield attributes and yield under integrated application of FYM and vermicompost may be attributed to the sustained and balanced supply of nutrients throughout the crop growth period, improved soil physical properties, enhanced microbial activity, and increased nutrient use efficiency. Organic manures also improve soil moisture retention, root growth, and nutrient availability, resulting in greater photosynthetic activity and efficient translocation of assimilates towards reproductive organs (Baharvand *et al.*, 2026)^[29]. Consequently, better pod development, seed formation, seed weight, and overall biomass production were achieved, leading to

higher grain, straw, and biological yields. The improvement in harvest index further indicates efficient partitioning of photosynthates towards economic yield. Similar findings have been reported by Miglani *et al.* (2021)^[30], Peng *et al.* (2026)^[31], Patel *et al.* (2025)^[32], and Shahi *et al.* (2025)^[33].

Effect of fertilizer levels

Fertilizer levels significantly influenced all the yield parameters of chickpea (Table 2). The application of 100% RDF (F₃) recorded the highest number of pods per plant (42.20), number of seeds per pod (1.79), test weight (17.99 g), grain yield (1.51 kg plot⁻¹ and 20.28 q ha⁻¹), straw yield (25.64 q ha⁻¹), biological yield (45.92 q ha⁻¹), and harvest index (44.10%), which remained statistically at par with 75% RDF (F₂) for number of pods per plant and harvest index but was significantly superior to 50% RDF (F₁) and the control (F₀) for the remaining parameters. The lowest values for all yield parameters were recorded under the control treatment.

The marked improvement in yield attributes and yield under higher fertilizer levels may be attributed to the balanced availability of essential nutrients, particularly nitrogen and phosphorus, which promoted vigorous vegetative growth, enhanced chlorophyll synthesis, and increased photosynthetic efficiency. Adequate nutrient supply also improved flowering, pod setting, seed development, and dry matter accumulation, resulting in higher grain and straw yields (Kumar *et al.*, 2022)^[34]. Furthermore, enhanced nutrient uptake and efficient translocation of assimilates from source to sink contributed to increased biological yield and harvest index under 100% RDF. These findings are in conformity with those reported by Yadav *et al.* (2025)^[35], Meena *et al.* (2021)^[36] and Varatharajan *et al.*, (2022)^[37].

Soil properties

Effect of organic sources

The data presented in Table 3 revealed that different organic nutrient sources significantly influenced soil pH, electrical conductivity (EC), organic carbon (OC), available nitrogen (N), available phosphorus (P₂O₅), available potassium (K₂O), and microbial populations of bacteria, fungi, and actinomycetes at harvest of the chickpea crop. Among the organic nutrient sources, O₅ (FYM @ 1.25 t ha⁻¹ + Vermicompost @ 1.50 t ha⁻¹) recorded the lowest soil pH (7.54), whereas the highest soil pH (7.81) was observed under the control (O₀). The highest EC (0.373 dS m⁻¹), organic carbon (0.424%), available nitrogen (165.09 kg ha⁻¹), available phosphorus (23.95 kg ha⁻¹), available potassium (304.33 kg ha⁻¹), bacterial population (50.77 × 10⁶ CFU g⁻¹ soil), fungal population (39.81 × 10⁴ CFU g⁻¹ soil), and actinomycetes population (33.55 × 10⁵ CFU g⁻¹ soil) were also recorded under O₅, which remained statistically at par with O₂ (Vermicompost @ 2.0 t ha⁻¹) and O₃ (FYM @ 2.5 t ha⁻¹ + Vermicompost @ 1.0 t ha⁻¹) for most of the parameters. The lowest values for organic carbon, available nutrients, and microbial populations were recorded under the control treatment (O₀).

The improvement in soil physico-chemical and biological properties under integrated application of FYM and vermicompost may be attributed to the addition of organic matter, which enhanced soil organic carbon, improved nutrient mineralization, and increased nutrient retention in the soil (Dhaliwal *et al.*, 2021)^[38]. Organic amendments also stimulated microbial proliferation by providing a continuous source of carbon and energy, thereby enhancing microbial activity and nutrient cycling. The slight reduction in soil pH under organic treatments could be due to the production of organic acids during decomposition, while the increase in EC remained within the normal range because of the gradual release of soluble nutrients (Dissanayake *et al.*, 2024)^[39]. Enhanced microbial populations further accelerated nutrient transformation and availability, resulting in improved residual soil fertility after harvest (Chauhan *et al.*, 2024)^[40]. These findings are in close agreement with those reported by Walia *et al.* (2024)^[41], Kumar *et al.* (2025)^[3] and Sharma and Chadak (2022)^[18, 42].

Effect of fertilizer levels

Fertilizer levels significantly influenced soil pH, EC, available macronutrients, and microbial populations at harvest of chickpea (Table 3). The application of 100% RDF (F₃) recorded the lowest soil pH (7.42) and the highest EC (0.358 dS m⁻¹), available nitrogen (166.60 kg ha⁻¹), available phosphorus (25.40 kg ha⁻¹), available potassium (311.67 kg ha⁻¹), bacterial population (55.51 × 10⁶ CFU g⁻¹ soil), fungal population (44.10 × 10⁴ CFU g⁻¹ soil), and actinomycetes population (37.13 × 10⁵ CFU g⁻¹ soil), which were significantly superior to the lower fertilizer levels. Organic carbon content varied only marginally (0.395–0.399%), although the differences were statistically significant, with the maximum value recorded under 100% RDF (F₃). The control treatment (F₀) recorded the lowest values for EC, available nutrients, and microbial populations.

The improvement in soil nutrient status under higher fertilizer levels was primarily due to the adequate and balanced application of nitrogen and phosphorus, which increased the residual availability of nutrients in the soil after crop harvest. Enhanced plant growth and root development under optimum fertilization also stimulated root exudation, creating a favourable environment for microbial multiplication. The slight decline in soil pH with increasing fertilizer levels may be attributed to nitrification and the release of hydrogen ions during nitrogen transformation (Awadelkareem *et al.*, 2023)^[43], whereas the increase in EC resulted from the higher concentration of soluble nutrients in the soil solution (Ismayilov *et al.*, 2021)^[44]. The improved bacterial, fungal, and actinomycetes populations under higher fertilizer levels may be associated with greater root biomass and increased substrate availability in the rhizosphere. Similar results have been reported by Ali *et al.* (2025)^[45], Silva *et al.* (2022)^[46] and Aechra *et al.* (2021)^[47].

Conclusion

The present investigation demonstrated that integrated nutrient management (INM) significantly improved the growth, yield, soil health, microbial activity, and profitability of chickpea under the semi-arid conditions of Chittorgarh, Rajasthan. Among the organic nutrient sources, the combined application of FYM @ 1.25 t ha⁻¹ + vermicompost @ 1.50 t ha⁻¹ (O₅) proved to be the most effective, record-

ing superior plant growth, yield attributes, grain yield, available soil nutrients, soil organic carbon, microbial populations, and economic returns. However, several parameters remained statistically at par with vermicompost @ 2.0 t ha⁻¹ (O₂) and FYM @ 2.5 t ha⁻¹ + vermicompost @ 1.0 t ha⁻¹ (O₃), indicating that these treatments were also equally effective.

Among the fertilizer levels, the application of 100% RDF (F₃) consistently produced the highest values for growth parameters, yield attributes, grain yield, soil fertility status, microbial populations, and economic returns, although it was statistically at par with 75% RDF (F₂) for several characters. Integrated application of organic manures with the recommended fertilizer dose improved nutrient availability, enhanced microbial activity, and promoted efficient nutrient utilization, resulting in better crop performance and soil health.

Overall, the study suggests that the integrated use of FYM @ 1.25 t ha⁻¹ + vermicompost @ 1.50 t ha⁻¹ along with 100% recommended dose of fertilizers (20 kg N + 40 kg P₂O₅ ha⁻¹) can be recommended for achieving higher productivity, improving soil fertility and microbial activity, and maximizing profitability of chickpea under the semi-arid conditions of Rajasthan.

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Table 1. Effect of Integrated Nutrient Management on growth parameters of chickpea

Treatments	Plant height (cm)			Number of branches per plant			Days to 50% flowering	Days to maturity
	30 DAS	45 DAS	At harvest	30 DAS	45 DAS	At harvest		
	Effect of organic sources							
O ₀ -Control	13.44	23.10	47.46	2.55	5.78	10.82	71.51	131.99
O ₁ -FYM @ 5.0 t ha ⁻¹	16.74	29.35	51.97	2.73	6.48	13.02	70.53	128.67
O ₂ -Vermicompost @ 2.0 t ha ⁻¹	18.26	30.24	53.09	2.92	6.95	14.03	69.97	126.73
O ₃ -FYM @ 2.5 t/ha + Vermicompost 1.0@ t ha ⁻¹	17.35	30.17	53.34	2.76	6.59	13.20	70.40	127.18
O ₄ -FYM @ 3.75t ha ⁻¹ + Vermicompost 0.50 @ t ha ⁻¹	16.22	28.92	51.71	2.65	6.05	12.72	70.64	126.99
O ₅ -FYM @ 1.25 t ha ⁻¹ + Vermicompost 1.50 @ t ha ⁻¹	17.98	30.58	53.65	2.85	7.15	13.78	68.72	124.36
SEM±	0.46	0.85	1.71	0.10	0.24	0.44	1.70	2.15
CD@5%	1.46	2.56	4.91	0.27	0.70	1.31	NS	NS
CV%	9.62	10.22	7.16	7.44	9.87	11.68	8.33	5.83
Effect of fertilizer level								
F ₀ -Control	12.29	21.95	46.18	2.20	4.80	10.60	73.45	129.38
F ₁ -50 % RDF	15.74	28.16	51.00	2.69	6.33	12.42	71.16	128.10
F ₂ -75 % RDF	18.84	31.68	54.77	3.03	7.32	14.32	68.61	128.88
F ₃ -100 % RDF	19.79	33.13	55.53	3.05	7.55	14.38	67.96	124.25

(continued on next page)

Treatments	Plant height (cm)			Number of branches per plant			Days to 50% flowering	Days to maturity
	30 DAS	45 DAS	At harvest	30 DAS	45 DAS	At harvest		
SEm±	0.47	0.88	1.07	0.06	0.19	0.42	1.64	2.22
CD@5%	1.35	2.52	3.23	0.18	0.56	1.19	4.71	6.37
CV%	4.89	5.29	5.72	6.04	6.46	5.58	4.03	3.01

Table 2. Effect of Integrated Nutrient Management on yield parameters of Chickpea

Treatments	Number of pods per plant	Number of seeds per pod	Test weight (100 seed) (g)	Grain yield (kg plot ⁻¹)	Grain yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)	Biological yield (q ha ⁻¹)	Harvest index (%)
Effect of organic sources								
O ₀ -Control	32.60	1.42	14.60	0.92	12.30	16.80	29.10	42.20
O ₁ -FYM @ 5.0 t ha ⁻¹	38.50	1.53	16.31	1.34	17.96	23.45	41.41	43.22
O ₂ -Vermicompost @ 2.0 t ha ⁻¹	39.76	1.58	16.65	1.41	18.94	24.63	43.57	43.37
O ₃ -FYM @ 2.5 t/ha + Vermicompost 1.0@ t ha ⁻¹	39.80	1.56	16.16	1.37	18.45	24.10	42.54	43.26
O ₄ -FYM @ 3.75t ha ⁻¹ + Vermicompost 0.50 @ t ha ⁻¹	37.50	1.50	15.67	1.33	17.88	22.93	40.80	43.74
O ₅ -FYM @ 1.25 t ha ⁻¹ + Vermicompost 1.50 @ t ha ⁻¹	40.33	1.61	16.83	1.43	19.20	24.33	43.53	44.08
SEm±	1.12	0.08	0.48	0.04	0.59	0.64	0.72	1.24
CD@5%	3.37	0.22	1.45	0.13	1.77	1.94	2.17	3.73
Cv%	10.17	8.52	10.38	11.64	11.64	9.82	6.21	9.91
Effect of fertilizer level								
F ₀ -Control	30.98	1.29	13.85	1.03	13.77	18.40	32.17	42.61
F ₁ -50 % RDF	37.41	1.45	15.73	1.21	16.31	22.05	38.36	42.53
F ₂ -75 % RDF	41.73	1.62	16.58	1.45	19.47	24.72	44.19	44.00
F ₃ -100 % RDF	42.20	1.79	17.99	1.51	20.28	25.64	45.92	44.10
SEm±	1.09	0.04	0.48	0.04	0.56	0.57	0.83	1.07
CD@5%	3.12	0.04	1.37	0.12	1.60	1.62	2.37	3.07
Cv%	4.95	7.93	5.14	5.54	5.54	4.31	3.57	4.29

Table 3. Effect of Integrated Nutrient Management on soil parameters at harvest of Chickpea crop

Treatments	soil pH	EC (dS m ⁻¹)	OC (%)	Available macronutrients (kg ha ⁻¹)			Microbial populations		
				N	P ₂ O ₅	K ₂ O	Bacteria (CFU × 10 ⁶ g ⁻¹ soil)	Fungi (CFU × 10 ⁴ g ⁻¹ soil)	Actinomycetes (CFU × 10 ⁵ g ⁻¹ soil)
				Effect of organic sources			39.38	29.81	28.71
O ₀ -Control	7.81	0.267	0.356	142.88	19.25	264.83			
O ₁ -FYM @ 5.0 t ha ⁻¹	7.65	0.317	0.392	158.20	22.14	289.33	47.39	37.30	31.41
O ₂ -Vermicompost @ 2.0 t ha ⁻¹	7.58	0.364	0.412	162.58	23.34	300.33	50.03	39.12	33.23
O ₃ -FYM @ 2.5 t/ha + Vermicompost 1.0@ t ha ⁻¹	7.61	0.355	0.404	160.21	22.80	294.33	48.80	38.19	32.26
O ₄ -FYM @ 3.75t ha ⁻¹ + Vermicompost 0.50 @ t ha ⁻¹	7.64	0.326	0.392	155.67	21.72	285.33	45.89	35.79	30.53
O ₅ -FYM @ 1.25 t ha ⁻¹ + Vermicompost 1.50 @ t ha ⁻¹	7.54	0.373	0.424	165.09	23.95	304.33	50.77	39.81	33.55
SEm±	0.02	0.0005	0.006	1.11	0.32	3.04	0.66	0.52	0.25

(continued on next page)

Treatments	soil pH	EC (dS m ⁻¹)	OC (%)	Available macronutrients (kg ha ⁻¹)			Microbial populations		
				N	P ₂ O ₅	K ₂ O	Bacteria (CFU × 10 ⁶ g ⁻¹ soil)	Fungi (CFU × 10 ⁴ g ⁻¹ soil)	Actinomycetes (CFU × 10 ⁵ g ⁻¹ soil)
CD@5%	0.07	0.0016	0.017	3.34	0.95	9.15	2.00	1.56	0.75
CV%	1.03	0.55	4.93	2.44	4.92	3.63	4.89	4.88	2.73
Effect of fertilizer level									
F ₀ -Control	7.90	0.305	0.395	144.67	19.11	268.00	37.69	27.01	23.64
F ₁ -50 % RDF	7.71	0.327	0.395	154.54	21.09	282.33	43.39	34.66	29.98
F ₂ -75 % RDF	7.52	0.345	0.398	163.95	23.21	297.00	51.58	40.91	35.71
F ₃ -100 % RDF	7.42	0.358	0.399	166.60	25.40	311.67	55.51	44.10	37.13
SEm±	0.06	0.0005	0.003	0.49	0.18	1.96	0.52	0.43	0.18
CD@5%	0.16	0.0013	0.009	1.41	0.53	5.61	1.48	1.22	0.51
CV%	1.30	0.24	1.32	0.54	1.44	1.17	1.90	2.01	0.98

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