International Journal of Plant & Soil Science

Volume 37, Issue 6, Page 260-270, 2025; Article no.IJPSS.137042
ISSN: 2320-7035

Assessment of Soil Health and Productivity of Chickpea (*Cicer arietinum* L.) as Influenced by FYM, Vermicompost and NPK Treatments under Semi-Arid Climatic Condition

Maina Jaat [a], Rajendra Bairwa [a*], Nabam Anil [a], Manohar Lal Meghwal [a], Bhagwan Suman [a], Champa Lal Regar [a] and Omprakash Regar [a]

[a] *Faculty of Agriculture and Veterinary Sciences, Mewar University, Gangrar, Chittorgarh, Rajasthan, 312901, India.*

Authors' contributions

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

Article Information

DOI: https://doi.org/10.9734/ijpss/2025/v37i65506

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://pr.sdiarticle5.com/review-history/137042

Original Research Article

Received: 03/04/2025
Accepted: 05/06/2025
Published: 09/06/2025

ABSTRACT

The present study was formulated during the Rabi season of 2024-2025 at Research Farm, Mewar University Gangrar, (Chittorgarh) Rajasthan, to study the "Assessment of Soil Health and Productivity of Chickpea (*Cicer arietinum* L.) Influenced by Ten treatments, i.e., T_1; Control, T_2; NPK

**Corresponding author: E-mail: rajendrabairwa@mewaruniversity.co.in;*

Cite as: *Jaat, Maina, Rajendra Bairwa, Nabam Anil, Manohar Lal Meghwal, Bhagwan Suman, Champa Lal Regar, and Omprakash Regar. 2025. "Assessment of Soil Health and Productivity of Chickpea (Cicer Arietinum L.) As Influenced by FYM, Vermicompost and NPK Treatments under Semi-Arid Climatic Condition". International Journal of Plant & Soil Science 37 (6):260-70. https://doi.org/10.9734/ijpss/2025/v37i65506.*

100% (20:40:20), T_3; NPK 50% + FYM 50% T_4; FYM 100% (10 t ha^{-1}), T_5; NPK 50% + VC 50%, T_6; VC 100% (5 t ha-^{1}), T_7; FYM 50% +VC 50%, T_8; NPK 50% + FYM 25% +VC 25%, T_9; NPK 25% +FYM 50 % +VC 25% and T_{10}; NPK 25% + FYM 25% + VC 50% under Semi-Arid Climate**"**. The experimental data was laid out in Randomized Block Design (RBD) with three replications. Experimental data that was recorded at different days of interval that is 30, 60 and 120 days. The treatments T_6 (1.44 Mg m^3) and T_7 (1.47 Mg m^3) having lower bulk densities. The steady increase from T_2 (0.33%) to T_6 (0.40), and then T_7 (0.37), T_{10} (0.37%) and T_9 (0.36%) indicates a progressive enhancement of additional mixture in the soil. The improvement was recorded for nitrogen availability in treatments T_6 to T_{10} (above 240 kg ha^{-1}). The highest P and K were recorded in treatment T_7 (27.64 kg ha^{-1}) and T_7 (365.53 kg ha^{-1}), respectively. The bacterial, fungi and actinomycetes counts were observed highest in T_6 (34.50×10^6 g^{-1} of soil), T_7 (24.86×10^4 g^{-1} of soil) and T_4 (29×10^6 g^{-1} of soil), respectively.

Keywords: Soil health; FYM; vermicompost; bacteria; fungi; actinomycetes.

1. INTRODUCTION

"Leguminous crops are considered as an important component of all types of farming systems in agriculture-based countries of the world and these considered an important food source for human and animal nutrition". "Chickpea (*Cicer arietinum* L.) ranks third among leguminous crops after pea (*Pisum sativum* L.) and beans (*Phaseolus vulgaris* L.) and it is an important legume crop in many countries and considered a functional food source, mostly due to its high protein content (17–31% protein)" (Jukanti *et. al*., 2012). "Nutritionally, chickpea is a good source of proteins and can serve as an alternative to meat. Nitrogen nutrient plays important role in synthesis of chlorophyll, amino acids and other organic compounds of physiological significance in plant system. *Rhizobium* plays an important role in increasing the availability of nitrogen to the plants and helps in boosting the production through nitrogen fixation. (Dakora *et. al*., 1997). Chickpea plays a significant role in improving soil fertility by fixing the atmospheric nitrogen. (Aslam *et al*., 2003). Due to continuous use of unbalanced chemical fertilizers and decreased use of organic manures, most of the soils are getting depleted with nutrient availability and degraded. Inorganic fertilizers alone cannot sustain the soil productivity and their large-scale use as a source of nutrients has less efficiency (Bhatt *et al*., 2019). In this region, the soil is having low organic carbon content, which may be due to the extreme climate conditions and low use of organic manures. In order to boost and maintain crop yield and sustain productivity, use of organics is one of the methods that has become more popular among the scientists and farming community which includes the use of bulky organic manures like farmyard manure (FYM), and vermicompost. Vermicompost is made of worm castings, undigested organic waste, microorganisms with a neutral pH and higher ion exchange capacity and high buffering capacity (Baliah and Muthulakshmi, 2017; Saxena, *et al.,* 2011). It has less soluble salts like nitrates (NO3 -), calcium (Ca+2), magnesium (Mg+2), and humic acid but higher amount of nutrients which makes the macro- and micro-nutrients available for plant uptake (Rekha *et al*., 2018). Application of vermicompost increases total porosity of soil, soil aeration, infiltration and water holding capacity of soil (Aksakal *et al*., 2016; Munnoli and Bhosle, 2011). There is a scope to improve the productivity of pulses by enhancing the soil fertility and its productivity through increasing soil organic carbon, soil moisture storage capacity and adopting integrated nutrient and pest management practices. Integrating organic and inorganic sources of nutrients can reduce environmental pollution along with increased crop production and soil health and also to minimize nutrient losses, and ensure sustainable productivity. This combination will favour soil carbon accretion and correction of secondary and micronutrient deficiency and long-term enhancement of soil quality (Padbhushan *et al*., 2019). This integration proved to be beneficial for maintaining soil nutrient balance, aggregation, moisture retention capacity and fertility (Saha *et al*., 2007; Dunjana *et al.,* 2012). The availability of primary nutrients (N, P, and K) depends mainly on the nutrient composition of the organic sources but the efficiency of organic sources of nutrients is less as compared to mineral fertilizers. In addition to providing those nutrients, organic manures often make the scarce elemental N available, solubilization of phosphates and micronutrients, and helps in the decomposition of crop residues to promote the absorption of nutrients by plants (Lalrintluangi *et* *al*., 2019). Furthermore, organic sources of nutrients promote the activity of beneficial microorganisms and therefore, ultimately improve crop productivity and soil health (Kumar *et al.,* 2024).

2. MATERIALS AND METHODS

The present study was conducted during the Rabi season of 2024-2025 at Research Farm, Mewar University Gangrar, (Chittorgarh) Rajasthan, to study the **"**Assessment of Soil Health and Productivity of Chickpea (*Cicer arietinum* L.) Influenced by Different Treatments of FYM, Vermicompost and NPK nutrient sources under Semi-Arid Climate Condition**".**

The experimental site is located at 25.03037° N latitude and 74.63763° E longitude, at an elevation of 145 m above mean sea level. The study area falls under Agro-Climatic Zone IV-A, the sub-humid Southern Plain Zone of Rajasthan. Agro-climatically, the region remains relatively dry and parched, with an annual rainfall ranging from 350 to 450 mm, primarily occurring between July and September. Climate here is categorized as BSh (Hot Semi-Arid). The summer season extends from March to June, with average temperatures ranging between 23.8 °C and 47.8 °C. During the study period, the maximum recorded rainfall was 4 mm, while the minimum was 0.29 mm. The highest and lowest temperatures recorded were 39 °C and 7 °C, respectively. Relative humidity varied from a maximum of 100% to a minimum of 7%.

The experiment was laid out in Randomized Block Design (RBD) with three replications comprising of Ten treatments (T_1; Control, T_2; NPK 100% (20:40:20), T_3; NPK 50% + FYM 50% T_4; FYM 100% (10 t ha^{-1}), T_5; NPK 50% + VC 50%, T_6; VC 100% (5 t ha^{-1}), T_7; FYM 50% +VC 50%, T_8; NPK 50% + FYM 25% +VC 25%, T_9; NPK 25% +FYM 50 % +VC 25% and T_{10}; NPK 25% + FYM 25% + VC 50%). The texture of the soil is sandy loam soil. The standard methods were described below:

2.1 Initial Properties of the Soil: Physical, Chemical and Biological

Table 1. Physical properties

Parameters	Values	Analysis method	References
Textural class	Sandy loam	Hydrometer method	Bouyoucos, 1962
Bulk density (Mg m^3)	1.77	Core sampling method	Blake, 1965

Table 2. Chemical properties

Parameters	Values	Analysis method	References
Organic carbon (%)	0.2	Wet digestion method	Walkley and Black (1934)
EC (dSm^{-1})	1.7	Soil- water suspension method	Jackson, 1967
Soil pH	7.3	Soil- water suspension method	Jackson, 1967
Available-N (kg ha^{-1})	177.0	Alkaline $KMnO_4$ Distillation method	Subbiah and Asija, 1956
Phosphorus (kg ha^{-1})	13	Olsen method	Olsen *et al*. 1954
Potassium (kg ha^{-1})	319.0	Ammonium acetate extraction method	Hanway and Heidel, 1952
Calcium (kg ha^{-1})	11.0	Ammonium acetate extraction method	Jackson, 1967
Sulphur (kg ha^{-1})	9.5	Turbidimetric method	Chesnin and Yien, 1950
Magnesium (kg ha^{-1})	7.8	Ammonium acetate extraction	Jackson, 1967

2.2 Biological Properties

Bacteria: Thorton's medium was used for the total bacterial count (Thornton, 1922).

Actinomycetes: Ken-knight and munaier's medium was used for the counts of actinomycetes (Ken-Knight and Munaier, 1939).

Fungi: Fungi was counts by Martin's Rose-Bengal medium (Martin, 1950).

3. RESULTS AND DISCUSSION

3.1 Physical Properties of the Soil

Bulk density: From the present study and analysis that shown in Table 3, values of bulk density ranged from treatment T_6 (1.44 Mg m ^{3}) to T_1 (1.67 Mg m^3). The treatments like T_1 and T_2 which values are (1.67 Mg m^3) and (1.65 Mg m^3) are considerably categorized as high bulk densities, suggest as compacted soil with limited porosity. While the treatments T_6 (1.44 Mg m^3) T_7 (1.47 Mg m^3) and T_{10} (1.47 Mg m^3) having lower bulk densities. Due to application of organic source of nutrients which help in soil aggregation improvement. The untreated treatment T_1 recorded the highest bulk density (1.67 Mg m^3), while treatment T_6 exhibited the lowest value (1.44 Mg m^3). Treatments T_5, T_3 and T_8 showed same values. Lower bulk density values also suggest improved soil porosity and increased in clay and slit fractions. Finer particles generally lead to greater total pore space when well-aggregated. Greater porosity enhances water infiltration and storage, promotes gas exchange and provides optimal environmental for root and microbial activities.

Porosity: From the present study and analysis that shown in Table 3, pore space values ranged from treatment T_2 (44.20%) to T_6 (46.0%). The treatments like T_6 (46.0%), and T_4 (45.85%) are considerably categorized as high porosity. Greater porosity generally improves soil health by enhancing structure, drainage, root conditions. and better aeration helps roots and beneficial microbes get more oxygen, which supports healthy plant growth. This is because Soils with higher porosity have more space between particles, allowing water to drain effectively while retaining enough moisture for plant use. These pores also enable the diffusion of oxygen into the soil, which is vital for aerobic respiration in both plant roots and microbes (Lal and Shukla, 2004; Hillel, 2004). Active microbial populations help break down organic matter, fix nitrogen, and make nutrients available to plants-all key aspects of soil fertility and plant productivity. Whereas T_2 (44.20%) and T_1 (44.46%) has lowest porosity. Lowest porosity restricts water and air movement, which can hurt plant health in most cases, but they may be beneficial in very sandy or excessively porous soils by improving water retention. (Brady and Weil, 2016). Similarly, (Lal and Shukla, 2004) emphasize that in coarse-textured soils, moderate compaction (which reduces excessive porosity) can lead to improved seed-soil contact, moisture availability, and even germination rates, particularly under dry conditions. Lowest porosity treatments generally harm soil health by causing compaction, poor drainage, and low biological activity.

The treatment T_6 has high value of porosity and T_2 has lowest value of porosity.

Table 3. Influence of organic and inorganic treatments on soil physical properties

Treatments	Bulk density (Mg m^3)	Porosity (%)
T_1	1.67	44.46
T_2	1.65	44.20
T_3	1.62	45.02
T_4	1.48	45.85
T_5	1.63	45.11
T_6	1.44	46.0
T_7	1.47	45.72
T_8	1.63	45.17
T_9	1.52	45.45
T_{10}	1.47	45.32
S. Em. ± (P=0.05)	0.005	0.10
C.D	0.01	0.30

(T_1; Control, T_2; NPK 100% (20:40:20), T_3, NPK 50% + FYM 50% T_4; FYM 100% (10 t ha^{-1}), T_5; NPK 50% + VC 50%, T_6; VC 100% (5 t ha-^{1}), T_7; FYM 50% +VC 50%, T_8; NPK 50% + FYM 25% +VC 25%, T_9; NPK 25% +FYM 50 % +VC 25%, T_{10}; NPK 25% + FYM 25% + VC 50%)

3.2 Chemical Properties

Organic carbon (%): Organic carbon content showed a clear increasing trend across treatments, as shown in Table 4. In the study, organic values increased progressively from treatment T_1 (0.32%) to treatment T_6 (0.40%), indicating the significant impact of treatments in improving soil organic matter. The lowest organic carbon was recorded in treatment T_1 (0.32%) and highest was observed in treatment T_6 (0.40%). T_1, which had the lowest organic value is an absolute control, leading to lower organic matter accumulation in the soil. The steady increase from T_2 (0.33%) to T_6 (0.40), and then T_7 (0.37), T_{10} (0.37%) and T_9 (0.36%) indicates a progressive enhancement of additional mixture in the soil. Organic carbon contributes indirectly to other soil properties, particularly CEC and nutrient availability that ultimately helps in crop growth, higher yield and soil health enrichment.

Electrical Conductivity (EC): Electrical conductivity was observed lowest in treatment T_1 (1.71 dSm^{-1}) and highest was found in treatment T_2 (1.83 dSm^{-1}). Slight increases in electrical conductivity values corresponded to higher nutrient concentrations but did not show salinity risks. Though after analyzing the soil electrical conductivity, all the values are within the safe range for the most crops (<2.0 dSm^{-1}), the increasing trend suggests an accumulation of salts through external inputs in soil. The treatments T_2 and T_8, had higher nutrient values. Despite that, moderate increases in electrical conductivity also reflects enhanced nutrient concentration. The lowest electrical conductivity in treatment T_1 (7.14) and T_7 (7.22) reflects nutrient poor conditions, while the moderate electrical conductivity in treatment T_5 (1.78) T_3 (1.77) and T_{10} (1.76 dSm^{-1}).

pH: The soil pH in treatment T_2 was recorded at 6.90, while in the remaining treatments (T_1 to T_{10}, excluding T_2), pH values ranged from 7.10 to 7.24, indicating neutral to slightly alkaline conditions. None of the treatments resulted in extreme acidity or alkalinity. Notably, the relatively stable and near-neutral pH across all treatments provides a favorable environment for most crops, as it promotes optimal nutrient availability (Brady & Weil, 2016; Fageria, 2001).

Nitrogen (kg ha^{-1}): Available Nitrogen was recoded lowest in treatment T_1 (176.3 kg ha^{-1}) and highest was seen in treatment T_7 (268.16 kg ha^{-1}). Treatments from T_6 to T_{10} demonstrated significantly higher Nitrogen levels, all exceeding 240 kg ha^{-1}. The increasing trend of available Nitrogen from T_2 to T_{10} shows that there is gradual increase in organic carbon, highlighting the correlation between organic matter content and nitrogen availability. The treatments with high organic carbon i.e., T_6, T_4, T_7 and T_{10} consistently showed higher Nitrogen levels, moreover improved nitrogen availability in treatments T_6, T_4, T_7 and T_{10} (above 240 kg ha^{-1}). The relatively low Nitrogen in treatment T_1 (176.3 kg ha^{-1}) is an absolute control.

Phosphorus (kg ha^{-1}): Phosphorus availability also increased notably with treatment intensity. The lowest value was found in T_1 (13.20 kg ha^{-1}), while the highest was recorded in treatment T_7 (27.64 kg ha^{-1}). Treatments from T_6 to T_{10} had values above 20 kg ha^{-1}, indicating improved Phosphorus availability.

Potassium (kg ha^{-1}): Available Potassium was significantly influenced by treatments. The lowest value was observed in T_1 (321.23 kg ha^{-1}), and the highest in T_7 (365.53kg ha^{-1}). All the treatments from T_6 to T_{10} showed Potassium values above 350 kg ha^{-1}, highlighting the role of treatments in enhancing Potassium release and retention. In the present study, there is significantly increased in values from treatment T_1 to T_{10} as shown in Table 4.

Calcium (kg ha^{-1}): Available Calcium was recoded lowest in treatment T_1 (12.16 kg ha^{-1}) and highest was seen in treatment T_7 (17.96 kg ha^{-1}). Treatments from T_6 to T_{10} demonstrated significantly higher Calcium levels, all exceeding (15 kg ha^{-1}). Improved Calcium availability in treatments T_6 to T_{10} (above 15 kg ha^{-1}). The relatively low Calcium in treatment T_1 (12.16 kg ha^{-1}) is an absolute control.

Magnesium (kg ha^{-1}): Available Magnesium was significantly influenced by treatments. The lowest value was observed in T_1 (7.40 kg ha^{-1}), and the highest in T_7 (15.20 kg ha^{-1}). All the treatments from T_6 to T_{10} showed Magnesium values more than 10 kg ha^{-1}, highlighting the role of treatments in enhancing Magnesium content in the soil. In the present study, there is significantly increased in values from treatment T_1 to T_{10} as shown in Table 4.

Sulphur (kg ha^{-1}): Available Sulphur was significantly influenced by treatments. The lowest value was observed in T_1 (9.83 kg ha^{-1}), and the highest in T_7 (15.93 kg ha^{-1}).

Table 4. Influence of organic and inorganic treatments on soil chemical properties

Treatments	O.C (%)	EC (dSm^{-1})	pH	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})	Available Ca (kg ha^{-1})	Available Mg (kg ha^{-1})	Available S (kg ha^{-1})
T_1	0.32	1.71	7.14	176.33	13.20	321.23	12.16	7.40	9.83
T_2	0.33	**1.83**	6.90	206.16	14.56	325.63	12.60	7.70	10.60
T_3	0.34	1.77	7.10	213.60	16.20	330.63	14.20	9.25	10.86
T_4	0.38	1.73	7.18	220.60	17.57	335.76	14.60	9.69	11.50
T_5	0.35	1.78	7.11	226.33	18.66	350.10	15.16	11.42	11.83
T_6	0.40	1.74	7.24	245.50	21.26	354.00	15.63	11.77	14.00
T_7	0.37	1.72	7.22	268.16	27.64	365.53	17.96	15.20	15.93
T_8	0.35	1.81	7.13	249.50	24.47	357.00	16.43	12.44	14.33
T_9	0.36	1.75	7.16	256.83	24.76	363.00	16.86	13.85	15.33
T_{10}	0.37	1.76	7.20	261.16	26.30	364.00	17.36	14.71	15.60
S. Em. ± (P=0.05)	0.004	0.004	0.003	0.71	0.14	0.92	0.06	0.1654	0.04
C.D	0.01	0.01	0.010	2.13	0.44	2.76	0.18	0.0384	0.12

(T_1; Control, T_2; NPK 100% (20:40:20), T_3, NPK 50% + FYM 50% T_4; FYM 100% (10 t ha^{-1}), T_5; NPK 50% + VC 50%, T_6; VC 100% (5 t ha^{-1}), T_7; FYM 50% +VC 50%, T_8; NPK 50% + FYM 25% +VC 25%, T_9; NPK 25% +FYM 50 % +VC 25%, T_{10}; NPK 25% + FYM 25% + VC 50%)

3.3 Biological Properties of the Soil

Bacteria (*10^{-6} cfu g^{-1} of soil): The Table 5. showed that the total bacterial populations ranged from (27.06 ×10^6 cfu/g) of soil in treatment T_1 to (37.13 ×10^6 cfu/g) of soil in T_6. Treatments T_6 (37.13 ×10^6 cfu/g of soil), T_7 (35.60 ×10^6 cfu/g of soil), and T_4 (34.50×10^6 cfu/g of soil) showed the highest bacterial counts, suggesting a favorable microbial environment. In contrast, T_1 (27.06 ×10^6 cfu/g soil) and T_2 (27.50×10^6 cfu/g soil) had the lowest bacterial Counts. Treatments T_6 and T_7 with the highest bacterial populations, improves soil structure and overall soil fertility.

Actinomycetes (*10^6 cfu g^{-1} of soil): The actinomycetes population was observed lowest in treatment T_1 (19.06 x 10^6 cfu g^{-1} soil) and highest was in treatment T_4 (29 x 10^6 cfu g^{-1} soil). Treatments T_7 (27.50 x 10^6), T_6 (26.16 x 10^6) and T_9 (25.13 x 10^6) also showed relatively high present of actinomycetes populations may due to application of different combination of organic and inorganic nutrient sources that provide energy in those treatments.

As shown in Table 5, the lower values were found in treatment T_1 (19.06 x 10^6 cfu g^{-1} soil), T_2 (20.20 x 10^6 cfu g^{-1} soil) and T_5 (20.50 x 10^6 cfu g^{-1} soil) indicate unfavourable conditions for actinomycetes development. The treatments T_7 (27.50), T_6 (26.16 x 10^6) and T_9 (25.13 x 10^6) also supported strong actinomycetes populations. Actinomycetes prefer slightly alkaline conditions and a stable supply of organic matter (Goodfellow and Williams, 1983). There has been found to be moderate levels in treatment T_4 (24.90) and T_5 (24.26) of actinomycetes.

Fungi (*10^4 cfu g^{-1} of soil): In terms of fungal population, highest was observed in T_4 (25.66 ×10^4 cfu/g soil) and followed by T_7 (24.86 ×10^4 cfu/g soil), T_6 (24.00 ×10^4 cfu/g soil) and T_9 (23.36 ×10^4 cfu/g soil). Indicating that T_4 had the most conducive conditions for fungal growth. Other treatments with moderate fungal counts included T_{10} (21.46 ×10^4 cfu/g soil) and T_8 (21.10 ×10^4 cfu/g soil). At the other side, lowest was observed in T_1 (17.50 ×10^4 cfu/g soil) and T_2 (17.86 ×10^4 cfu/g soil).

The treatments T_6 (24 ×10^4 cfu/g soil) and T_7 (24.86 ×10^4 cfu/g soil) demonstrated high fungal populations as these treatments include T_6-100% vermicompost and T_7-50%vermicompost + 50% FYM. The treatments T_3 (19×10^4 cfu/g soil) and T_5 (18.90×10^4 cfu/g soil) also showed relatively lower fungal values. The positive impact of organic treatments on fungal communities improved the soil aggregation and moderated pH and create ideal conditions for fungal colonization.

Table 5. Influence of organic and inorganic treatments on soil biological properties

Treatments	Total Bacteria (*10^{-6} cfu g^{-1} of soil)	Fungi (*10^{-6} cfu g^{-1} of soil)	Actinomycetes (*cfu g^{-1} of soil)
T_1	27.06	17.50	19.06
T_2	27.50	17.86	20.20
T_3	28.06	19.00	22.20
T_4	34.50	25.66	29.00
T_5	28.50	18.90	20.50
T_6	37.13	24.00	26.16
T_7	35.60	24.86	27.50
T_8	30.00	21.10	24.26
T_9	31.56	23.36	25.13
T_{10}	32.70	21.46	24.90
S. Em. ± (P=0.05)	0.045	0.05	0.01
C.D	0.13	0.17	0.05

(T_1; Control, T_2; NPK 100% (20:40:20), T_3, NPK 50% + FYM 50% T_4; FYM 100% (10 t ha^{-1}), T_5; NPK 50% + VC 50%, T_6; VC 100% (5 t ha^{-1}), T_7; FYM 50% +VC 50%, T_8; NPK 50% + FYM 25% +VC 25%, T_9; NPK 25% +FYM 50 % +VC 25%, T_{10}; NPK 25% + FYM 25% + VC 50%)

3.4 Growth Parameters

Plant height (cm): Data pertaining to influence of organic and inorganic nutrient sources on plant height presented in Table 6. The organic and inorganic nutrient sources showed significant influence on plant height. Plant height was recorded at 30 days and 60 days of intervals. It is evident from the data that height of plant was maximum in T_7 - FYM 50% +VC 50% that is 46 then T_{10}- NPK 25% + FYM 25% + VC 50% (41.3) followed by T_9- NPK 25% +FYM 50 % +VC 25% (41) and T_8- NPK 50% + FYM 25% +VC 25% (40.16) were recorded. And minimum plant height was recorded with T_1 (23.5 cm), followed by T_2 (28 cm), and T_3 (30 cm) were recorded. Further, it was noted that height of plant increases with the advancement of age of plant up to 90 days and subsequently it slightly reduced at harvest of crop over previous stage.

Nodules count per plant: Data pertaining to influence of organic and inorganic nutrient sources on nodules count per plant presented in Table 6. The organic and inorganic sources of nutrient were showed significant influence on nodules count. Data revealed that the maximum nodules count per plant with **T_7**-FYM 50% +VC 50% (21.50) followed by T_{10}-NPK 25% + FYM 25% + VC 50% (20.66), T_9-NPK 25% +FYM 50 % +VC 25% (18.76) and T_8-NPK 50% + FYM 25% +VC 25% (17.33). The minimum number of nodules count per plant recorded with T_1-Control (10.5). Higher number of nodules per plant were observed in treatments which received combination of FYM and vermicompost and this might be due to the fact that *Rhizobium* inoculation increased the root nodulation through better root development and more nutrient availability resulting in significant increase in number of nodules per plant.

Dry matter accumulation per plant (g): Dry matter accumulation per plant (g) were recorded from different treatments after harvesting were presented in Table 6. Maximum dry matter accumulation recorded with **T_7**-FYM 50% +VC 50% (5.16) followed by T_{10}-NPK 25% + FYM 25% + VC 50% (5.03), T_9-NPK 25% +FYM 50 % +VC 25% (4.90), and T_8-NPK 50% + FYM 25% +VC 25% (4.76).

High dry matter accumulation was recorded in treatment which were supplied with organics which include 100%FYM + 100%VC. This might be due to slowly and steadily release of nutrients in soil which matches the crop's nutrient uptake pattern over time to make them available for plant absorption. Also effect on soil chemical processes to make unavailable forms of nutrients into available forms. The high dry matter accumulation obtained with organic manure treated plots might be due to more moisture conservation and additional availability of nutrients. These findings were in conformity with Yadav *et al*. (2004) and Bodamwad and Rajput (2006).

Table 6. Influence of organic and inorganic treatments on plant height(cm), Dry matter accumulation (g), and nodules count plant^{-1}

Treatments	Plant height (cm)		Nodules count per plant at 90 days	Dry matter accumulation per plant (g)
	30 Days	60 Days		
T_1	5.63	23.50	10.50	1.93
T_2	6.03	28.00	11.50	2.13
T_3	6.57	30.00	12.50	2.36
T_4	6.73	33.83	14.83	2.60
T_5	6.60	36.00	16.00	3.30
T_6	6.97	38.33	17.16	3.80
T_7	**8.37**	**46.00**	**21.50**	**5.16**
T_8	7.17	40.16	17.33	4.76
T_9	7.87	41.00	18.76	4.90
T_{10}	7.73	41.3	20.66	5.03
S. Em. ± (P=0.05)	0.57	0.34	0.40	0.04
C.D	O.78	1.03	1.20	0.14
C.V%	14.04	1.66	4.32	2.32

(T_1; Control, T_2; NPK 100% (20:40:20), T_3, NPK 50% + FYM 50% T_4; FYM 100% (10 t ha^{-1}), T_5; NPK 50% + VC 50%, T_6; VC 100% (5 t ha-^{1}), T_7; FYM 50% +VC 50%, T_8; NPK 50% + FYM 25% +VC 25%, T_9; NPK 25% +FYM 50 % +VC 25%, T_{10}; NPK 25% + FYM 25% + VC 50%)

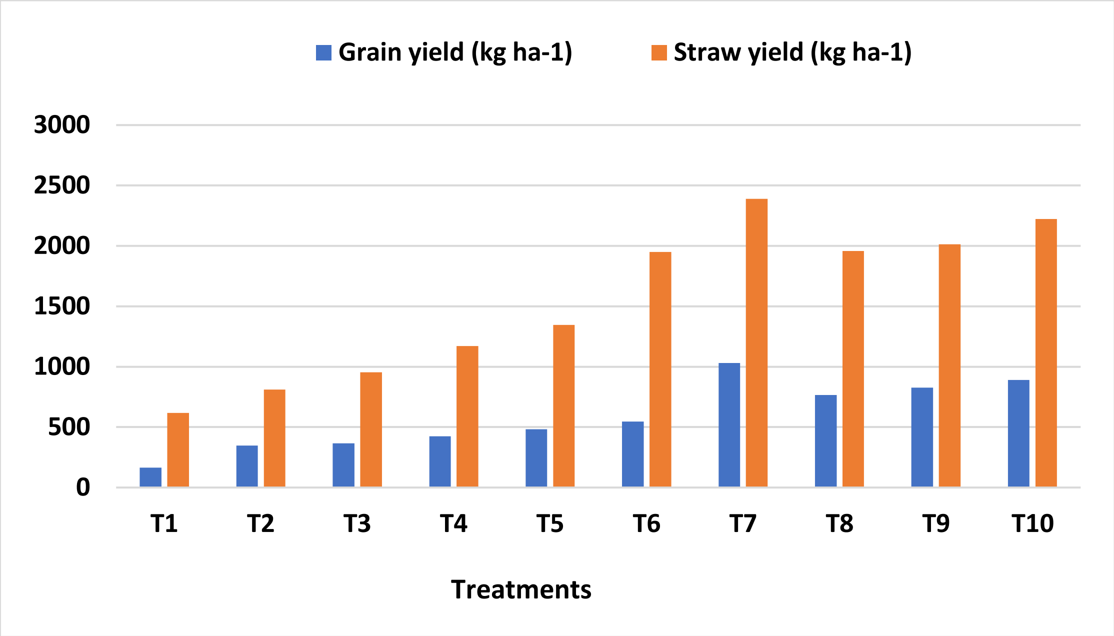

Fig. 1. Influence of organic and inorganic treatments on Grain yield (kg ha^{-1}), Straw yield (kg ha^{-1})

(T_1; Control, T_2; NPK 100% (20:40:20), T_3, NPK 50% + FYM 50% T_4; FYM 100% (10 t ha^{-1}), T_5; NPK 50% + VC 50%, T_6; VC 100% (5 t ha-^{1}), T_7; FYM 50% +VC 50%, T_8; NPK 50% + FYM 25% +VC 25%, T_9; NPK 25% +FYM 50 % +VC 25%, T_{10}; NPK 25% + FYM 25% + VC 50%)

3.5 Yield Parameters

Grain yield (kg ha^{-1}): Data pertaining to influence of organic and inorganic nutrient sources on grain yield presented in Fig. 1. The organic and inorganic sources of nutrient were showed significant influence on grain yield. Data revealed that the maximum grain yield with T_7-FYM 50% +VC 50% (1,030.0 kg ha^{-1}) followed by T_{10}-NPK 25% + FYM 25% + VC 50% (890.0 kg ha^{-1}), T_9-NPK 25% +FYM 50 % +VC 25% (826.66 kg ha^{-1}) and T_8-NPK 50% + FYM 25% +VC 25% (765.00 kg ha^{-1}). The minimum grain yield recorded with T_1-Control (163.33 kg ha^{-1}).

It was observed from the data that highest grain yield was recorded in treatment T_7 (1,030.0 kg ha^{-1}) which received organics compared to inorganics and combination of organics and inorganics. This might be due to the fact that organics application to the chickpea crop enhance soil fertility, leading to improved nutrient availability and higher chickpea productivity.

Straw yield (kg ha^{-1}): Data pertaining to influence of organic and inorganic nutrient sources on straw yield kg ha^{-1} presented in Fig. 1. The organic and inorganic sources of nutrient were showed significant influence on straw yield. Data revealed that the maximum straw yield with T_7-FYM 50% +VC 50% (2390.00 kg ha^{-1}), T_{10}-NPK 25% + FYM 25% + VC 50% (2223.33 kg ha^{-1}) followed by T_9- NPK 25% +FYM 50 % +VC 25% (2013.66 kg ha^{-1}) and T_8- NPK 50% + FYM 25% +VC 25% (1956.66 kg ha^{-1}). The minimum straw yield recorded with T_1-Control (616.66 kg ha^{-1}). This might be due to the fact that organics application to the chickpea crop attributed to improved soil health, enhance nutrient availability, and greater root development, all of which contribute to stronger plant growth and biomass production.

4. CONCLUSION

The combined application of organic nutrient sources has been found to significantly enhance the growth and yield of Chickpea, also positively influences the soil health. Organic inputs demonstrated a notable improvement in soil physical, chemical, and biological properties. Among the various treatments, the application of 50% vermicompost (VC) + 50% Farmyard manure (FYM) showed the most pronounced positive effects on plant growth and yield and overall soil health. Other effective combinations included NPK 50% + FYM 25% + VC 25%, NPK 25% + FYM 50% + VC 25% and NPK 25% +

FYM 25% + VC 50%. These treatments significantly improved soil health and may be contributed to sustainable crop production. Based on the findings of this study, it can be concluded that the integrated use of organic nutrient sources is a viable and sustainable strategy to improve soil health, crop productivity, and quality of Chickpea in the semi-arid regions of India.

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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Aksakal, E. L., Sari, S., & Angin, I. (2016). Effects of vermicompost application on soil aggregation and certain physical properties. *Land Degradation & Development*, 27(4), 983–995.

Aslam, M., Mahmood, I. A., Peoples, M. B., Schwenke, G. D., & Herridge, D. F. (2003). Contribution of chickpea nitrogen fixation to increased wheat production and soil organic fertility in rain-fed cropping. *Biology and fertility of soils*, *38*, 59-64.

Baliah, T. N., & Muthulakshmi, P. (2017). Effect of microbially enriched vermicompost on the growth and biochemical characteristics of Okra (Abelmoschus esculentus (L.) Moench). *Adv. Plants Agric. Res*, *6*(5), 00228.

Bhatt, M. K., Labanya, R., & Joshi, H. C. (2019). Influence of long-term chemical fertilizers and organic manures on soil fertility-A review. *Universal Journal of Agricultural Research*, *7*(5), 177-188.

Blake, G. R. (1965). Bulk density. In C. A. Black (Ed.), *Methods of Soil Analysis: Part I—Physical and Mineralogical Properties* (pp. 374–390). Madison, WI: American Society of Agronomy.

Bodamwad, S.G., Rajput, S.G., Kolgane, S.S., Katkar, P.B. and Mamidwar, S.R., (2006). Influence of organic and inorganic fertilizers on seed quality and seed yield of okra Parbhani Kranti.

Bouyoucos, G. J. (1962). *Hydrometer method improved for making particle size analyses of soils*. Agronomy Journal, 54(5), 464–465.

Brady, N. C., & Weil, R. R. (2016). *The Nature and Properties of Soils* (15th ed.). Pearson Education.

Chesnin L., & Yien, C. H (1950). Turibidimetric determination of available sulphur. *Soil science society of America proceedings*, 14, 149-151

Dakora, F. D., & Keya, S. O. (1997). Contribution of legume nitrogen fixation to sustainable agriculture in sub-Saharan Africa. *Soil Biology and Biochemistry*, 29(5-6), 809–817.

Dunjana, N., Nyamugafata, P., Shumba, A., Nyamangara, J., & Zingore, S. (2012). Effects of cattle manure on selected soil physical properties of smallholder farms on two soils of Murewa, Zimbabwe. *Soil Use and Management*, *28*(2), 221-228.

Fageria, V. D. (2001). Nutrient interactions in crop plants. *Journal of plant nutrition*, *24*(8), 1269-1290.

Goodfellow, M., & Williams, S. T. (1983). Ecology of actinomycetes. *Annual Review of Microbiology*, 37(1), 189–216.

Hanway, J. J. & Heidel, H. (1952). Soil analysis methods as used in lowa state college, Soil Testing Laboratory, *Lawa State College Bulletin*, 57, 1-131

Hillel, D. (2004). *Introduction to Environmental Soil Physics.* Elsevier Academic Press.

Jackson, M. L. (1967). *Soil Chemical Analysis: Advanced Course*. New Delhi: Prentice-Hall of India Pvt. Ltd.

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.

Ken-Knight, G., & Munaier, M. (1939). A medium for the cultivation of actinomycetes. *Soil Science*, 47(6), 467–469.

Kumar, M. G. A., Sivanantha, J., & Shubhiksha, J. B. (2024). The effect of organic and inorganic fertilizers on soil fertility and crop production – A review. *Trends in Agriculture Science*, 3 (Special Issue 01), 109–114.

Lal, R., & Shukla, M. K. (2004). *Principles of soil physics*. CRC Press.

Lalrintluangi, I. F., Kumar, V., Singh, A. K., & Bisarya, D. (2019). Impact of Organic

Farming on soil fertility and crop productivity. *Jetir January*, *6*(1).

Martin, J. P. (1950). Use of acid, rose bengal, and streptomycin in the plate method for estimating soil fungi. *Soil Science*, 69(3), 215–232.

Munnoli, P. M., & Bhosle, S. (2011). Water-holding capacity of earthworms' vermicompost made of sugar industry waste (press mud) in mono- and polyculture vermireactors. *The Environmentalist*, 31(4), 394–400.

Olsen, S. R., Cole, C. V., Watanabe, F. S., & Dean, L. A. (1954). *Estimation of available phosphorus in soils by extraction with sodium bicarbonate* (USDA Circular No. 939). U.S. Government Printing Office.

Padbhushan, R., Sharma, S., & Kumar, U. (2019). Integrated Nutrient Management in Rice–Wheat Cropping System: An Evidence on Sustainability in the Indian Subcontinent through Meta-Analysis. *Agronomy, 9*(2), 71.

Rekha, G. S., Kaleena, P. K., Elumalai, D., Srikumaran, M. P., & Maheswari, V. N. (2018). Effects of vermicompost and plant growth enhancers on the exo-morphological features of *Capsicum annum* (Linn.) Hepper. *International Journal of Recycling of Organic Waste in Agriculture*, 7(1), 83–88.

Saha, D., Pal, D. K., & Mandal, B. (2007). Integration of organic and inorganic fertilizers for sustaining crop productivity and soil fertility in a rainfed rice-based cropping system. *Journal of Agricultural Science*, 145(3), 271–279.

Saxena, M. C., Singh, K. B., & Malhotra, R. S. (2011). *The chickpea: Botany, production and uses*. CAB International.

Subbiah, B.V., and Asija, G.L. (1956). *A rapid procedure for the estimation of available nitrogen in soils.* Current Science, 25**,** 259–260.

Thornton, H. G. (1922). On the Development of a Standardised Agar medium for counting soil Bacteria, with special regard to the regression of spreading colonies. *Annals of Applied Biology*, *9*(3-4), 241-274.

Walkley, A., & Black, I. A. (1934). *An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method*. Soil Science, 37(1), 29–38.

Williams, C. H. & Steinbergs, A. (1959). A estimation of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science, 37, 29-38.*

Yadav, R. L., Dwivedi, B. S., Pandey, P. S., & Shurpali, N. J. (2004). Yield trends and soil fertility changes in a long-term rice-wheat system under integrated nutrient management in western Uttar Pradesh. *Indian Journal of Agricultural Sciences*, 74(9), 477–480.

Peer-review history:
The peer review history for this paper can be accessed here:
https://pr.sdiarticle5.com/review-history/137042