"IMPACT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD ATTRIBUTING CHARACTER AND YIELD OF CHICKPEA"

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ABSTRACT

A field experiment was conducted during the Rabi season of 2023–24 in Mandhana, Kanpur district, Uttar Pradesh, to evaluate the impact of integrated nutrient management on the growth, yield attributes, and yield of chickpea (Cicerarietinum L.). The soil was characterized as loamy sand with a pH of 7.68, electrical conductivity of 0.24 dSm^{-1}, organic carbon content of 0.45%, and available nitrogen, phosphorus, and potassium levels of 218.25, 20.50, and 157.30 kg ha^{-1}, respectively. The study was arranged in a Randomized Block Design (RBD) with 14 treatment combinations replicated three times. The treatments included varying levels of organic and inorganic nutrient sources. This investigation aimed to identify effective nutrient management practices to enhance chickpea productivity. Results demonstrated significant differences among treatments in terms of growth parameters, yield attributes, and overall yield, emphasizing the importance of integrated nutrient management in improving chickpea performance under the tested agro-climatic conditions.

Keywords- Integrated nutrient management, Chickpea, RDF

Introduction

Chickpea (Cicerarietinum L.), a diploid annual leguminous crop with 16 chromosomes, holds significant importance as an ancient, self-pollinated food crop. Cultivated since 7000 BC, chickpea thrives in semi-arid environments and is a staple in regions such as South Asia, the Middle East, the Mediterranean, and North Africa. Globally, it ranks second in cultivated area and third in production among pulses, with India leading both production (45.53%) and cultivation area (36.01%) (DES, Ministry of Agri. & FW, 2017–18). Chickpea (Cicerarietinum L.), a leguminous crop with 16 chromosomes, is a vital source of plant-based protein, playing a key role in addressing protein energy malnutrition (PEM). It also contributes significantly to the Recommended Dietary Allowances (RDA), providing 60 g and 55 g of protein daily for adult males and females, respectively. As one of the earliest domesticated grain legumes, cultivated since 7000 BC, chickpea remains a staple in semi-arid regions across South East Asia, India, the Middle East, and the Mediterranean. Globally, it ranks second in cultivated area and third in production among pulses, making it a crucial food crop. Known as gram in some regions, chickpea is the third most important pulse crop worldwide, cultivated on all continents except Antarctica (Singh et al., 2009).

Major chickpea-producing regions include central and northern India, North Africa, Eastern Africa, and Latin America. The crop spans 29.36 million hectares globally, producing 24.51 million tons with an average productivity of 835 kg/ha. In India, 10.57 million hectares are dedicated to chickpea cultivation, yielding 11.16 million tons at an average productivity of 1056 kg/ha (DES, Ministry of Agri. & FW, 2017–18). Uttar Pradesh alone produces 6.84 lakh tons annually, with an average yield of 909 kg/ha over 6.11 lakh hectares.Additionally, chickpea plays a vital role in international trade, with India importing and exporting 8296.04 tonnes of pulses valued at $135.42 billion globally (Ministry of Commerce, DGCI & S, 2017–18). The crop's adaptability, high protein content, and significant global demand underline its importance as a staple food and a key component of food security.

Chickpea contributes not only to human nutrition but also to soil health through nitrogen fixation, which can save up to 68 kg N/ha for subsequent crops (Ahlawat et al., 1981). However, the long-term reliance on chemical fertilizers and intensive cultivation has led to soil degradation and nutrient imbalances, emphasizing the need for sustainable practices. Integrated nutrient management (INM), which combines organic and inorganic inputs, has emerged as a sustainable approach to enhance yield, maintain soil fertility, and improve the physio-chemical properties of soils. Organic amendments, such as vermicompost and biofertilizers, provide essential nutrients and improve plant growth, while inorganic inputs such as potassium and foliar sprays optimize productivity.

This study explores the impact of INM on yield-attributing characters and overall yield of chickpea, highlighting its role in sustainable agriculture and crop productivity enhancement. By integrating organic and inorganic nutrient sources, INM offers a pathway to address soil health challenges, optimize resource use, and achieve higher yields in chickpea cultivation.

For adult males and females, the Recommended Dietary Allowances (RDA) are 60 g and 55 g daily, respectively. The daily availability of pulses per capita is 52.9 g, and the annual requirement is 19.3 kg. (Source: Ministry of Agriculture & Farmers Welfare, Press Information Bureau, 2017–18). The main source of vegetable protein in the diet of humans is pulses. A diet low in protein can result in protein energy malnutrition (PEM), which can cause anemia in a number of forms. As food legumes, pulses provide a wealth of nutrients for the human diet. They also contribute to atmospheric nitrogen fixation, removing between 72 and 350 kg per hectare annually, and they create soil cover, which maintains soil health (Dept. of Economics and Statistics, 2017).

Chickpeas are not only highly nutritious but also offer various medicinal benefits. They contribute 4.7% (2.7 g) of protein and 2.3% (56 Kcal) of energy daily to the Indian population, with 14 g of chickpeas being a significant source of calcium and iron (10–12%) (Ali and Kumar, 2005). Research has shown that germinated chickpeas effectively reduce cholesterol levels in rats (Gearvani, 1991). Additionally, the plant's leaves, stems, and pods contain malic and oxalic acids, which have medicinal uses for conditions such as aphrodisiac, bronchitis, catarrh, cutamenia, cholera, constipation, diarrhea, digestive disorders, flatulence, sunstroke, and warts. These acids are also known to lower blood cholesterol levels, and the seeds are considered antibilious (Duke, 1981).

Beyond their nutritional and medicinal properties, chickpeas play a vital role in soil health. They enhance the soil's physical, chemical, and biological characteristics by fixing atmospheric nitrogen in their root nodules, with a healthy crop capable of fixing up to 141 kg of nitrogen per hectare (Rupela, 1987). Effective crop management practices, such as proper planting schedules and nutrient management, significantly influence the amount of biological nitrogen fixation in chickpeas (Ali et al., 1998). Moreover, chickpeas help conserve 56–68 kg of nitrogen per hectare, which would otherwise need to be applied to subsequent cereal crops (Ahlawat et al., 1981). In terms of crop diversification, chickpeas have proven advantageous, particularly in the development of short-duration varieties.

The continuous use of high amounts of artificial chemical fertilizers, coupled with the lack of organic inputs and intensive cultivation practices, has led to changes in the soil's physio-chemical condition and widespread nutritional deficiencies, especially concerning essential micronutrients vital for plant growth. To address this, maintaining soil health and enhancing crop yield rely on an appropriate combination of inorganic and organic fertilizers (Weber et al., 2007; Pullicinoa et al., 2009).

India has significant potential for compost production, with an estimated 600 million tons available in rural areas and 16 million tons in urban areas. Despite this, the average annual compost consumption remains around 2 tons per hectare, as a large portion of farmyard manure (FYM) is diverted for non-agricultural purposes such as fuel, leaving less than 50% utilized for crop production. In contrast, microbial biofertilizers offer a cost-effective, renewable, and pollution-free alternative to enhance soil fertility (Mukherjee and Rai, 2000).

Vermicompost, created through the composting process using worms, is rich in nutrients that enhance plant growth and support microbial populations. It contains growth hormones, vitamins, and key elements such as 0.45% sulfur, 0.45% calcium, 0.45% magnesium, 0.45% phosphorus, 0.80% potassium, 0.45% zinc, and 175.2 ppm iron. Organic matter naturally decomposes over time, and studies have shown that increasing the application of vermicompost from 0 to 3 t ha^{-1} significantly improved chickpea grain yields, with 2 t ha^{-1} being identified as the optimal dose (Singh et al., 2012).

Potassium is another critical nutrient for plants, playing a vital role in producing high-quality crops, supporting physiological processes, and protecting against pests and diseases. Optimal growth, higher grain yields, and economic benefits for late-sown chickpeas were achieved by applying 60 kg of potash (K_2O ha^{-1}) at sowing, along with foliar sprays of 2% urea and 0.25% multiplex at the pre-flowering stage (Ganga et al., 2014).

Integrated Nutrient Management (INM) is a cornerstone of sustainable agriculture, emphasizing the efficient use of resources to meet human needs while preserving environmental quality and conserving essential natural resources. With an estimated crop production target of 225 million tons to feed over a billion people, a balanced approach using fertilizers, organic manures, biofertilizers, green manures, and other resources is essential to meet the nutrient requirements of plants (Chandy, 2011).

Material and methods

A field experiment was conducted during the Rabi season of 2023-24 in the loamy sand soil of the rural Mandhana area, located 10 km from Kanpur in Uttar Pradesh, to assess the effect of integrated nutrient management on the growth and yield characteristics of chickpea (Cicerarietinum L.). The soil had a pH of 7.68, an electrical conductivity (EC) of 0.23 dSm^{-1}, organic carbon content of 0.45%, and available nutrient levels of nitrogen (216.12 kg ha^{-1}), phosphorus (19.50 kg ha^{-1}), and potassium (148.30 kg ha^{-1}). The experiment, conducted in the Rabi season of 2023-24, included 14 treatment combinations arranged in a Randomized Block Design (RBD) with three replications. The treatments were as follows:T1: Control, T2: 100% RDF, T3: 75% RDF, T4: 50% RDF, T5: 100% RDF + FYM @ 5 t ha^{-1}, T6: 100% RDF + Vermicompost (VC) @ 3 t ha^{-1}, T7: 100% RDF + Rhizobium culture (RC) + Phosphate Solubilizing Bacteria (PSB), T8: 75% RDF + FYM @ 5 t ha^{-1}, T9: 75% RDF + VC @ 3 t ha^{-1}, T10: 75% RDF + RC + PSB, T11: 50% RDF + FYM @ 5 t ha^{-1}, T12: 50% RDF + VC @ 3 t ha^{-1}, T13: 50% RDF + RC + PSB and T14: FYM @ 5 t ha^{-1} + VC @ 3 t ha^{-1} + RC + PSB

RESULTS AND DISCUSSION

Yield & Yield attributes

Number of pods plant^{-1}

Compared to the control, all treatments significantly increased the number of pods per plant. The highest number of pods per plant, 67.13 and 64.52, was recorded in T7 (100% RDF + Rhizobium + PSB), while the lowest, 28.72, was observed in the control (T1). The integration of biofertilizers, FYM, and vermicompost with 100% RDF (T2) also positively impacted the number of pods per plant compared to 100% RDF alone. Among treatments with 75% RDF, T10 (75% RDF + Rhizobium + PSB) resulted in a higher number of pods per plant than T9 (75% RDF + VC @ 3 t ha^{-1}) and T8 (75% RDF + FYM @ 5 t ha^{-1}). Statistically, the number of pods per plant was similar in treatments T6 (100% RDF + VC @ 3 t ha^{-1}) and T7 (100% RDF + Rhizobium + PSB).

Number of seeds/pods

All treatments significantly influenced the number of seeds per pod compared to the control. The highest number of seeds per pod, 1.72 and 1.65, was recorded in T7 (100% RDF + Rhizobium + PSB), while the lowest number, 1.07, was observed in the control (T1). The integration of FYM and vermicompost with 100% RDF (T2) also positively affected the number of seeds per pod compared to 100% RDF alone. Moreover, T10 (75% RDF + Rhizobium + PSB) produced a higher number of seeds per pod than T9 (75% RDF + VC @ 3 t ha^{-1}) and T8 (75% RDF + FYM @ 5 t ha^{-1}). Statistically, the number of seeds per pod was similar for T6 (100% RDF + VC @ 3 t ha^{-1}) and T7 (100% RDF + Rhizobium + PSB).

Test weight (1000 grains)

The results indicated that the various treatments had no statistically significant effect on grain test weight. However, the highest test weight was observed with T7 (100% RDF + Rhizobium + PSB) and T6 (100% RDF + VC @ 3 t ha^{-1}), both recording 189.73 g, compared to the control (T1), which had the lowest value at 179.89 g. While the integration of FYM and vermicompost with 100% RDF also influenced test weight, the increase was not statistically significant. Among the two, vermicompost integration showed a greater improvement in test weight than FYM. Additionally, the application of T10 (75% RDF + Rhizobium + PSB) resulted in a higher test weight compared to T8 (75% RDF + FYM @ 5 t ha^{-1}) and T9 (75% RDF + VC @ 3 t ha^{-1}). Similar result was also in line with Yadav et al. 2017, Singh et al. 2012.

Biomass yield

T7 (100% RDF + Rhizobium + PSB) achieved the highest biological yield at 55.19 q ha^{-1}, followed by T6 (100% RDF + VC @ 3 t ha^{-1}) at 52.09 q ha^{-1}, while the control (T1) recorded the lowest biological yield at 23.62 q ha^{-1}. The integration of 75% RDF + Rhizobium + PSB (T10) significantly enhanced biological yield compared to 75% RDF with VC @ 3 t ha^{-1} (T9) and 75% RDF with FYM @ 5 t ha^{-1} (T8). Furthermore, the biological yields obtained from 100% RDF + VC @ 3 t ha^{-1} (T6) and 100% RDF + Rhizobium + PSB (T7) were statistically comparable.

Grain yield

The application of 100% RDF + Rhizobium + PSB (T7) resulted in the highest grain yield of 22.63 q ha^{-1}, which was 133.76% higher than the lowest yield of 9.68 q ha^{-1} recorded under the control (T1). Compared to the 100% RDF (T2) treatment, integrating 100% RDF with VC @ 3 t ha^{-1} (T6) led to a 17.35% and 15.50% increase in grain yield. The grain yield under 100% RDF with FYM @ 5 t ha^{-1} (T5) was 8.16% higher than that of 100% RDF (T2).On average, the application of 75% RDF with FYM @ 5 t ha^{-1} (T8), 75% RDF with VC @ 3 t ha^{-1} (T9), and

75% RDF + Rhizobium + PSB (T10) resulted in grain yield improvements of 29.77%, 39.89%, and 43.90%, respectively, compared to 75% RDF (T3). Similarly, when compared to 50% RDF (T4), the addition of FYM @ 5 t ha^{-1} (T11), VC @ 3 t ha^{-1} (T12), and Rhizobium + PSB (T13) to 50% RDF increased grain yield by 18.08%, 26.56%, and 35.34%, respectively. In terms of grain yield, the treatments 100% RDF + Rhizobium + PSB (T7) and 100% RDF + VC @ 3 t ha^{-1} (T6) showed statistically similar results.Similar result was also in line with Yadav et al. 2017, Singh et al. 2012

Stover yield

Management practices incorporating organic, inorganic, and biofertilizers significantly influenced the stover yield of chickpeas. The highest stover yield was observed with treatment T7 (100% RDF + Rhizobium + PSB), yielding 31.56 q ha^{-1}, followed by treatment T6 (100% RDF + VC @ 3 t ha^{-1}), which produced 30.34 q ha^{-1}, while the lowest yield of 13.94 q ha^{-1} was recorded in the control (T1). The stover yield exhibited a similar trend to that of grain yield.When 100% RDF was combined with various organic, inorganic, and biofertilizers, the stover yield consistently surpassed that of 100% RDF alone. The combined application of these nutrient sources had a significant impact on the annual variation in stover yield. Statistically, the stover yields of treatments 100% RDF + VC @ 3 t ha^{-1} (T6) and 100% RDF + Rhizobium + PSB (T7) were found to be comparable.Similar result was also in line with Yadav et al. 2017, Singh et al. 2012

Harvest index

The ratio of grain yield to biological yield is known as the harvest index. Harvest index data are shown in Table 1 and Fig. 1., shows that harvest index was not significantly impacted by any of the treatments.

Conclusion

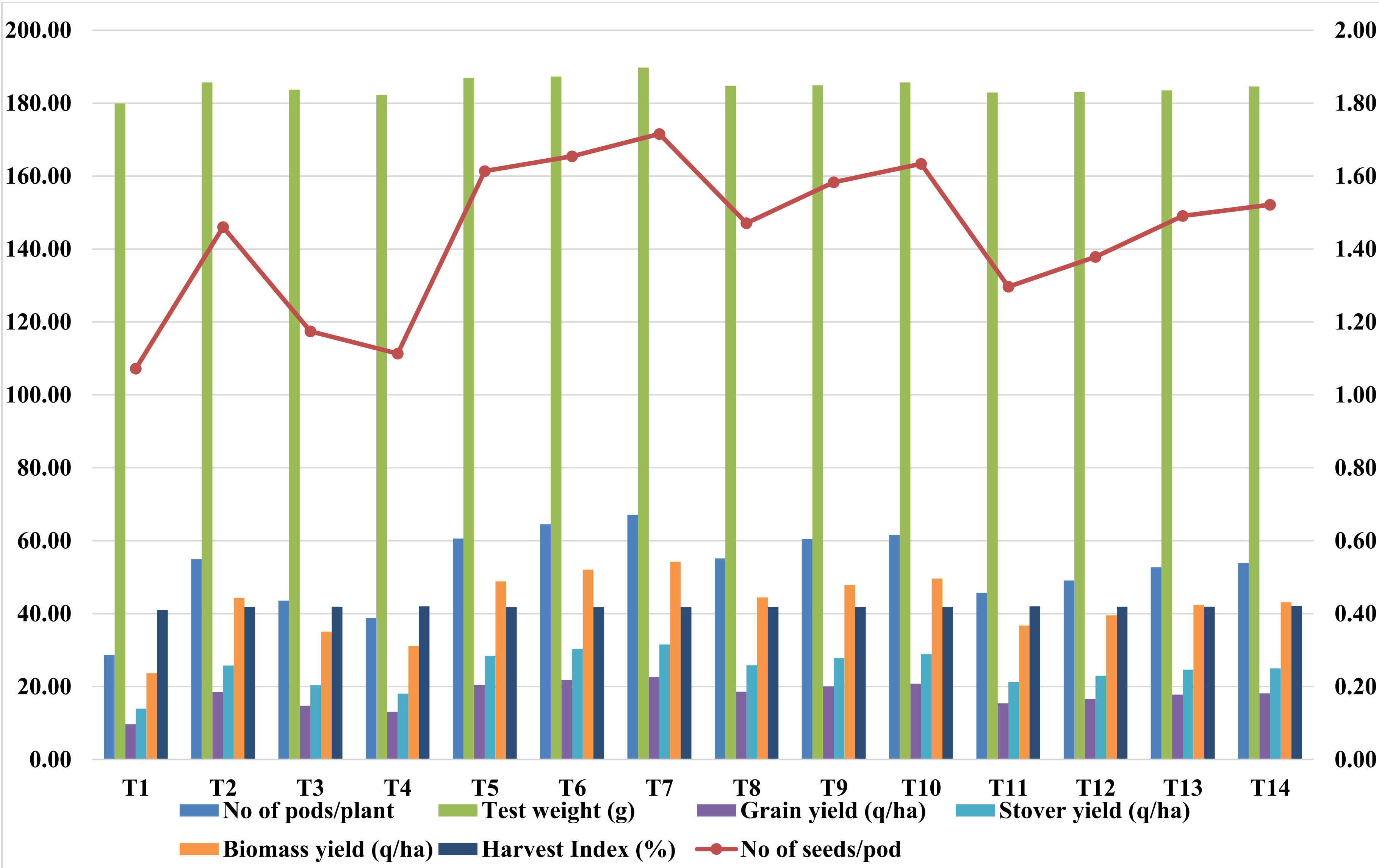
The study demonstrated that the integration of organic, inorganic, and biofertilizers significantly enhanced the growth, yield, and productivity parameters of chickpea. All treatments substantially improved the number of pods per plant, seeds per pod, grain yield, and stover yield compared to the control.Among the treatments, T7 (100% RDF + Rhizobium + PSB) consistently recorded the highest performance across most parameters, including the number of pods per plant (67.13), seeds per pod (1.72), grain yield (22.63 q ha^{-1}), biological yield (55.19 q ha^{-1}), and stover yield (31.56 q ha^{-1}). It demonstrated a significant advantage over the control (T1), with increases of 133.76% in grain yield and substantial improvements in other parameters.Similarly, T6 (100% RDF + VC @ 3 t ha^{-1}) showed comparable results to T7 in terms of test weight (189.73 g), biological yield (52.09 q ha^{-1}), and stover yield (30.34 q ha^{-1}). The integration of vermicompost with RDF proved to be more effective in improving test weight than FYM.The use of 75% RDF + Rhizobium + PSB (T10) also demonstrated a notable increase in yield parameters compared to other 75% RDF treatments. Grain yield improvements of 43.90% were observed compared to 75% RDF alone (T3), highlighting the efficiency of Rhizobium and PSB in nutrient management. Similarly, the addition of biofertilizers and organic amendments to 50% RDF significantly improved yields compared to 50% RDF alone.

Although the harvest index was not significantly impacted by any of the treatments, the study emphasizes the importance of integrating organic, inorganic, and biofertilizers for sustainable chickpea production. Treatments involving 100% RDF + Rhizobium + PSB and 100% RDF + VC @ 3 t ha^{-1} emerged as the most effective strategies for maximizing chickpea yield.

Table 1 Effect of organic, inorganic and bio fertilizers on yield attributes and yield of chickpea.

Treatment	Yield attributing characters			Yield			Harvest Index (%)
	No of pods/plant	No of seeds/pod	Test weight (g)	Grain yield (q/ha)	Stover yield (q/ha)	Biological yield (q/ha)	
T1: Control	28.72	1.07	179.89	9.68	13.94	23.62	40.99
T2: 100% RDF	54.98	1.46	185.72	18.54	25.77	44.30	41.84
T3: 75% RDF	43.62	1.17	183.74	14.71	20.37	35.08	41.92
T4: 50% RDF	38.78	1.11	182.30	13.07	18.04	31.12	42.01
T5: 100% RDF + FYM @ 2.5 t ha^{-1}	60.58	1.61	186.88	20.42	28.44	48.87	41.80
T6: 100% RDF + Vermicompost (VC) @ 3 t ha^{-1}	64.52	1.65	187.26	21.75	30.34	52.09	41.76
T7: 100% RDF + Rhizobium culture (RC) + Phosphate Solubilizing Bacteria (PSB)	67.13	1.72	189.73	22.63	31.56	54.19	41.76
T8: 75% RDF + FYM @ 5 t ha^{-1}	55.14	1.47	184.75	18.59	25.84	44.42	41.84
T9: 75% RDF + VC @ 3 t ha^{-1}	60.43	1.58	184.88	20.03	27.84	47.87	41.84
T10: 75% RDF + RC + PSB	61.55	1.63	185.67	20.75	28.90	49.65	41.79
T11: 50% RDF + FYM @ 5 t ha^{-1}	45.74	1.30	182.92	15.42	21.32	36.74	41.97
T12: 50% RDF + VC @ 3 t ha^{-1}	49.13	1.38	183.13	16.56	22.96	39.52	41.91
T13: 50% RDF + RC + PSB	52.71	1.49	183.48	17.77	24.61	42.38	41.93
T14: FYM @ 5 t ha^{-1} + VC @ 3 t ha^{-1} + RC + PSB	53.86	1.52	184.55	18.16	24.97	43.13	42.10

SEm ±	1.57	0.04	2.89	0.78	0.94	1.57	1.23
CD at 5%	4.58	0.12	NS	2.24	2.75	4.58	NS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T1 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 T13 T14
No of pods/plant
Test weight (g)
Grain yield (q/ha)
Stover yield (q/ha)
Biomass yield (q/ha)
Harvest Index (%)
No of seeds/pod

Fig.1 Effect of organic, inorganic and bio fertilizers on yield attributes and yield of chickpea.

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