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Impact of Integrated Nutrient Management on the Yield of Cowpea (*Vigna unguiculata* L. walp)

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ABSTRACT: The present study "Impact of integrated nutrient management on the yield of cowpea (*Vigna unguiculata* L. walp)" was investigated in a study conducted at Sardar Patel University Instructional Farm during 2021-2022. Various combinations of INM treatments were applied, evaluating their effects on different yield attributes of cowpea. The experiment utilized a Randomized Block design with three replications and eight treatment combinations. Observations were made on parameters including the number of pods per plant, pod length, seed count per pod, test weight, seed yield per plant, seed yield per plot, seed yield per hectare, stover yield per hectare, and harvest index. The results demonstrated a significant positive impact of INM treatments on cowpea yield attributes. Application of 100% Recommended Dose of Fertilizers (RDF) @ 25:50:25 kg NPK/ha (T_2) exhibited superior results compared to control and other INM combinations, showing increased pod formation, longer pod length, higher seed count per pod, better test weight, and enhanced seed yield per plant, plot, and hectare. The balanced nutrient supply from INM treatments, particularly the optimal combination of nitrogen, phosphorus, and potassium, played a crucial role in supporting vegetative growth, improving photosynthesis, and enhancing seed production in cowpea. The findings underscore the significance of a well-balanced INM strategy in optimizing cowpea productivity while potentially promoting soil health through enhanced organic matter incorporation. The key challenge of study is exploring INM effects on cowpea yield highlighted challenges in soil variations, climate impact, and sustainable agricultural practices.

Keywords: Integrated Nutrient Management, Cowpea Yield, Yield Attributes, Vermicompost, Cowpea, FYM.

INTRODUCTION

Cowpea (*Vigna unguiculata* L. walp), belongs to the family Fabaceae, chromosome number 2n = 22 and originated from Central Africa. Cowpea is important *Kharif* pulse crop and grown in India for vegetable pods, grain, for age and for green manure purpose. Cowpea is grown both for its tender pods and also for its dry seeds used as pulse for culinary purpose. Vegetable cowpea is one of the most ancient crops known to man. It is a popular vegetable grown throughout the world. It is a warm season crop, well adopted to many areas of humid tropics and subtropical zones. In India it is grown widely round the year (Ijas Ahmed *et al*., 2021).

Cowpea pods are good source of protein, fibre, minerals, calcium and vitamins particularly Vitamin A and vitamin C. It contains 8 g carbohydrates, 43 g proteins and 0.6 g fat, 2 g fiber per 100 g of edible portion. Tender fruits contain 80 mg calcium, 74 mg phosphorus and 2.5 mg iron per 100 g fresh pod, Amino acid profile particularly high in cowpea which greatly improves the protein quality of pulses (Gopalakrishnan, 2007).

In India during the past 30 years, rigorous agriculture included thorough high yielding varieties has lead to heavy withdrawal of nutrients from the soil. Furthermore, improper use of chemical fertilizers by farmers has deteriorated soil health and decrease soil organic carbon content. FYM is being used as major resource of organic manure in field crops. Inadequate accessibility to some available source of FYM is however, an important limitation in its application as a source of nutrients.

Nitrogen plays an important role in various metabolic process of the plant growth. Nitrogen is a key constituent of protein and chlorophyll (Meena *et al*., 2014). In addition, N and P have a stimulating effect on root activity and rooting pattern of cowpea. Available nitrogenous compound (also through a starter dose) enables seedlings to make a good start even before nitrogen fixation by roots. Plants fed with organic nitrogen during vegetative periods are much larger by the onset of flowering than those dependent on

symbiotic N-fixation. Phosphorus plays an important role in the plant metabolism and is a constituent of various organic substances. It is important role in the plant photosynthesis process, respiration and other physiological process of plant. Potassium has a direct and indirect impact on the plant growth. Using potassium directly causes the reduced transpiration, increasing water absorption or creating internal condition in order to endure the dryness (Nazneen *et al*., 2022).

Bio-fertilizer promotes fertilizer use efficiency. The seed inoculated with Rhizobium increase the number of rhizosphere and enhance microbiologically activities. Seed of pulses when inoculated with phosphate solubilising bacteria (PSB) secret acetic substances which act as a solubiliser to unavailable soil phosphorus (Khandelwal *et al*., 2012).

Vermicompost is a very beneficial organic compost and substitute for other fertilizers for organic farming. Soil biological component is favorably influenced by the addition of vermicompost. Vermicompost increase water retention capacity and make the soil loose and porus. Vermicompost improves the water retention capacity of soil and promote the establishment of microorganisms. It also helps in maintaining the soil pH in acidic soil and thus helps to promote the activity of microbes in soil (Kirubashre *et al*., 2023).

MATERIAL AND METHODS

The experiment was conducted at Sardar Patel University Instructional Farm during 2021-2022 on the crop cowpea (*Vigna unguiculata* L. walp) variety CP-PLUS. The experimental design was Randomized Block with 3 replications and 8 treatment combinations. Each gross plot size was 4.20 m × 3.30 m with a spacing of 60.0 x 15.0 cm^2. The net plot size was 3.0 m × 3.0 m. There were a total of 24 plots with a 1.0 m replication gap. The seed rate used was 20 kg/ha and the RDF was NPK @ 25: 50: 25 kg/ha.

RESULTS AND DISCUSSION

A. Number of Pods Per Plant

An examination of data showed positive effect of different levels of INM treatments application on number of pods per plant of cowpea. The maximum number of pods per plant (16.73) was recorded with the application of treatment, T_2 (100 % RDF @ 25:50:25 kg NPK/ha) which was significantly better than T_1 (control, 6.27), while the crop was sown without fertilization. Treatment of T_2 was found statistically at par with 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6) and 50% RDF + 50% FYM @ 5 t/ha (T_5) with the respective values of 16.13and 15.00, respectively. Among the INM treatment of 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6) was found significantly better than T_5 (50% RDF + 50% FYM @ 5 t/ha) of 15.00 but at par with 25% RDF + 75% Vermicompost @ 3.75 t/ha (T_8) of 13.40 and 25% RDF + 75% FYM @ 7.5 t/ha (T_7) of 12.67. The magnitude of increase due to integrated application of 100 % RDF @ 25:50:25 kg NPK/ha was 3.59, The application of the recommended dose of fertilizer (RDF) at a specific ratio in treatment T_2 may have provided the optimal balance of essential nutrients for cowpea plants, resulting in higher pod production compared to other treatments. The availability of nutrients plays a crucial role in supporting plant growth and development, and the specific composition and quantity of nutrients provided by the different INM treatments could have influenced the overall productivity of the cowpea plants. The similar results have also been reported by Nadeem *et al*. (2017) ; Jayshree and Umesha (2021).

B. Length of Pod (cm)

An examination of data showed positive effect of different levels of INM treatments application on length of pod of cowpea. The highest length of pod (28.60 cm) was recorded with the application of treatment, T_2 (100 % RDF @ 25:50:25 kg NPK/ha) which was significantly better than T_1 (control, 9.28 cm), while the crop was sown without fertilization. Treatment of T_2 was found statistically at par with 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6) and 50% RDF + 50% FYM @ 5 t/ha (T_5) with the respective values of 27.59 cm and 26.24 cm, respectively. Among the INM treatment of 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6) was found significantly better than T_5 (50% RDF + 50% FYM @ 5 t/ha) of 26.24 cm but at par with 25% RDF + 75% Vermicompost @ 3.75 t/ha (T_8) of 26.13 cm and 25% RDF + 75% FYM @ 7.5 t/ha (T_7) of 24.08 cm. The magnitude of increase due to integrated application of 100 % RDF @ 25:50:25 kg NPK/ha was 3.53, 8.25, 8.64, 15.80 and 67.55 per cent over 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6), 50% RDF + 50% FYM @ 5 t/ha (T_5), 25% RDF + 75% Vermicompost @ 3.75 t/ha (T_8), 25% RDF + 75% FYM @ 7.5 t/ha (T_7) and control (T_1), respectively. The reason for the increase in pod length with the application of integrated nutrient management treatments is the balanced supply of essential nutrients. These treatments provide optimal levels of nutrients, such as nitrogen, phosphorus, and potassium, along with organic amendments like vermicompost and farmyard manure, which enhance soil fertility and promote healthy plant growth, resulting in longer cowpea pods. The results obtained in the present study are supported by the works of Paul *et al*. (2021).

C. Number of Seed Per Pod

An examination of data showed positive effect of different levels of INM treatments application on number of seed per pod of cowpea. The maximum number of seed per pod (12.80) was recorded with the application of treatment, T_2 (100 % RDF @ 25:50:25 kg NPK/ha) which was significantly better than T_1 (control, 6.60), while the crop was sown without fertilization. Treatment of T_2 was found statistically at par with 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6) and 50% RDF + 50% FYM @ 5 t/ha (T_5) with the respective values of 12.47 and 12.20, respectively. Among the INM treatment of 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6) was found significantly better than T_5 (50% RDF + 50% FYM @ 5 t/ha) of 12.20 but at par with 25% RDF + 75% Vermicompost @ 3.75 t/ha (T_8) of 11.60 and 25% RDF + 75% FYM

@ 7.5 t/ha (T_7) of 10.53. The magnitude of increase due to integrated application of 100 % RDF @ 25:50:25 kg NPK/ha was 2.58, 4.69, 9.38, 17.73 and 48.44 per cent over 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6), 50% RDF + 50% FYM @ 5 t/ha (T_5), 25% RDF + 75% Vermicompost @ 3.75 t/ha (T_8), 25% RDF + 75% FYM @ 7.5 t/ha (T_7) and control (T_1), respectively. Integrated Nutrient Management (INM) significantly impacts cowpea yield, with the best seed count per pod observed in the T2 treatment (100% RDF at 25:50:25 kg NPK/ha). This method outperformed the control and was equivalent to other combined fertilizer applications, emphasizing the efficacy of a balanced nutrient supply in boosting legume productivity. Also, similar results were reported by Patel *et al*. (2018); Begam *et al*. (2022).

D. Test Weight (g)

An examination of data showed positive effect of different levels of INM treatments application on test weight of cowpea. The highest test weight (63.97 g) was recorded with the application of treatment, T_2 (100 % RDF @ 25:50:25 kg NPK/ha) which was significantly better than T_1 (control, 51.80 g), while the crop was sown without fertilization. Treatment of T_2 was found statistically at par with 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6) and 50% RDF + 50% FYM @ 5 t/ha (T_5) with the respective values of 63.40 g and 63.15 g, respectively. Among the INM treatment of 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6) was found significantly better than T_5 (50% RDF + 50% FYM @ 5 t/ha) of 63.15 g but at par with 25% RDF + 75% Vermicompost @ 3.75 t/ha (T_8) of 62.96 g and 25% RDF + 75% FYM @ 7.5 t/ha (T_7) of 60.47 g. The magnitude of increase due to integrated application of 100 % RDF @ 25:50:25 kg NPK/ha was 0.89, 1.28, 1.58, 5.47 and 19.02 per cent over 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6), 50% RDF + 50% FYM @ 5 t/ha (T_5), 25% RDF + 75% Vermicompost @ 3.75 t/ha (T_8), 25% RDF + 75% FYM @ 7.5 t/ha (T_7) and control (T_1), respectively. Data analysis revealed that the application of Integrated Nutrient Management (INM) treatments significantly improved the test weight of cowpea, with the highest value achieved under the T2 treatment (100% RDF at 25:50:25 kg NPK/ha). This treatment not only outperformed the unfertilized control condition but also showed comparable results to other INM treatments with a mix of reduced chemical fertilizers and organic amendments like vermicompost and farmyard manure (FYM). The results highlight the effectiveness of a well-balanced fertilization strategy in increasing the quality of cowpea grains, with the additional benefit of potentially enhancing soil health through the incorporation of organic matter. The results obtained in the present study are supported by the works of Chatterjee and Bandyopadhyay (2017).

E. Seed Yield Per Plant (g)

An examination of data showed positive effect of different levels of INM treatments application on seed yield per plant of cowpea. The highest seed yield per plant (10.78 g) was recorded with the application of treatment, T_2 (100 % RDF @ 25:50:25 kg NPK/ha) which was significantly better than T_1 (control, 5.26 g), while the crop was sown without fertilization. Treatment of T_2 was found statistically at par with 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6) and 50% RDF + 50% FYM @ 5 t/ha (T_5) with the respective values of 10.69 g and 10.55g, respectively. Among the INM treatment of 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6) was found significantly better than T_5 (50% RDF + 50% FYM @ 5 t/ha) of 10.55 g but at par with 25% RDF + 75% Vermicompost @ 3.75 t/ha (T_8) of 10.11 g and 25% RDF + 75% FYM @ 7.5 t/ha (T_7) of 8.84 g. The magnitude of increase due to integrated application of 100 % RDF @ 25:50:25 kg NPK/ha was 0.83, 2.13, 6.22, 18.00 and 51.21 per cent over 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6), 50% RDF + 50% FYM @ 5 t/ha (T_5), 25% RDF + 75% Vermicompost @ 3.75 t/ha (T_8), 25% RDF + 75% FYM @ 7.5 t/ha (T_7) and control (T_1), respectively. The higher seed yield per plant recorded with 100% RDF (10.78 g) as compared to other treatments may be attributed to better availability of nutrients from the inorganic fertilizers to the crop. Application of recommended doses of nitrogen, phosphorus and potassium helps in proper vegetative growth and development of cowpea plants by enhancing photosynthesis. This leads to increased production of food materials in different plant parts. Eventually more food materials get accumulated in seed pods, resulting in higher individual seed weight and ultimately higher seed yield per plant. The finding of present study is in accordance with those of Birla *et al*. (2018).

F. Seed yield per plot

An examination of data showed positive effect of different levels of INM treatments application on seed yield per plot of cowpea. The highest seed yield per plot (1.57 kg) was recorded with the application of treatment, T_2 (100 % RDF @ 25:50:25 kg NPK/ha) which was significantly better than T_1 (control, 0.64 kg), while the crop was sown without fertilization. Treatment of T_2 was found statistically at par with 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6) and 50% RDF + 50% FYM @ 5 t/ha (T_5) with the respective values of 1.49 kg and 1.38 kg, respectively. Among the INM treatment of 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6) was found significantly better than T_5 (50% RDF + 50% FYM @ 5 t/ha) of 1.38 kg but at par with 25% RDF + 75% Vermicompost @ 3.75 t/ha (T_8) of 1.30 kg and 25% RDF + 75% FYM @ 7.5 t/ha (T_7) of 1.15 kg. The magnitude of increase due to integrated application of 100 % RDF @ 25:50:25 kg NPK/ha was 5.10, 12.10, 17.20, 26.75 and 59.24 per cent over 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6), 50% RDF + 50% FYM @ 5 t/ha (T_5), 25% RDF + 75% Vermicompost @ 3.75 t/ha (T_8), 25% RDF + 75% FYM @ 7.5 t/ha (T_7) and control (T_1), respectively. The higher seed yield per plot recorded with 100% RDF (1.57 kg) could be attributed to better availability and uptake of essential nutrients. Application of recommended doses of nitrogen, phosphorus and potassium would have ensured adequate vegetative growth resulting in higher leaf area duration and more

efficient photosynthesis. This led to greater synthesis and translocation of photosynthates to the developing pods and seeds. Moreover, the inorganic fertilizers might have provided readily available forms of nutrients which were easily absorbed and assimilated by the crop. All these factors might have contributed to an increased number of pods per plant, higher seed set and ultimately a superior seed yield per plot with 100% RDF treatment. The finding of present study is in accordance with those of Sakpal *et al*. (2021).

G. Seed Yield Per Hectare (q/ha)

An examination of data showed positive effect of different levels of INM treatments application on seed yield per hectare of cowpea. The highest seed yield per hectare (17.44 q/ha) was recorded with the application of treatment, T_2 (100 % RDF @ 25:50:25 kg NPK/ha) which was significantly better than T_1 (control, 7.11 q/ha), while the crop was sown without fertilization. Treatment of T_2 was found statistically at par with 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6) and 50% RDF + 50% FYM @ 5 t/ha (T_5) with the respective values of 16.59 q/ha and 15.33 q/ha, respectively. Among the INM treatment of 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6) was found significantly better than T_5 (50% RDF + 50% FYM @ 5 t/ha) of 15.33 q/ha but at par with 25% RDF + 75% Vermicompost @ 3.75 t/ha (T_8) of 14.44 q/ha and 25% RDF + 75% FYM @ 7.5 t/ha (T_7) of 12.74 q/ha. The magnitude of increase due to integrated application of 100 % RDF @ 25:50:25 kg NPK/ha was 4.87, 12.10, 17.20, 26.95 and 59.23 per cent over 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6), 50% RDF + 50% FYM @ 5 t/ha (T_5), 25% RDF + 75% Vermicompost @ 3.75 t/ha (T_8), 25% RDF + 75% FYM @ 7.5 t/ha (T_7) and control (T_1), respectively. The seed yield per plot was highest with 100% RDF due to the balanced supply of major nutrients nitrogen, phosphorus and potassium which promoted optimum vegetative growth and green leaf area duration. This enhanced photosynthesis and production of more photosynthates. More photosynthates were translocated and stored in pods and seeds, resulting in greater number of pods per plant, higher seed set and seed size. Therefore, integrated application of recommended doses of inorganic fertilizers ensured maximum utilization of growth resources for attaining peak seed productivity. The results obtained in the present study are supported by the works of Singh and Kumar (2016).

H. Straw Yield Per Hectare (q/ha)

An examination of data showed positive effect of different levels of INM treatments application on stover yield per hectare of cowpea. The highest stover yield per hectare (25.36 q/ha) was recorded with the application of treatment, T_2 (100 % RDF @ 25:50:25 kg NPK/ha) which was significantly better than T_1 (control, 17.70 q/ha), while the crop was sown without fertilization. Treatment of T_2 was found statistically at par with 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6) and 50% RDF + 50% FYM @ 5 t/ha (T_5) with the respective values of 25.15 q/ha and 23.88 q/ha, respectively. Among the INM treatment of 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6) was found significantly better than T_5 (50% RDF + 50% FYM @ 5 t/ha) of 23.88 q/ha but at par with 25% RDF + 75% Vermicompost @ 3.75 t/ha (T_8) of 23.49 q/ha and 25% RDF + 75% FYM @ 7.5 t/ha (T_7) of 22.51q/ha. The magnitude of increase due to integrated application of 100 % RDF @ 25:50:25 kg NPK/ha was 0.83, 5.84, 7.37, 11.24 and 30.21 per cent over 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6), 50% RDF + 50% FYM @ 5 t/ha (T_5), 25% RDF + 75% Vermicompost @ 3.75 t/ha (T_8), 25% RDF + 75% FYM @ 7.5 t/ha (T_7) and control (T_1), respectively. The maximum stover yield with 100% RDF was due to its optimum supply of nitrogen, phosphorus and potassium. These major nutrients met the crop's requirement for enhanced vegetative growth and biomass production. Higher photosynthesis with increased leaf area led to greater accumulation of photosynthates in different plant parts. The additional availability of nutrients from inorganic fertilizers ensured maximum translocation of carbohydrates to vegetative plant parts, resulting in superior stover yield compared to other treatments. Also, similar results were reported by and Paul *et al*. (2021).

I. Harvest Index (%)

An examination of data showed positive effect of different levels of INM treatments application on harvest index of cowpea. The highest harvest index (40.74 %) was recorded with the application of treatment, T_2 (100 % RDF @ 25:50:25 kg NPK/ha) which was significantly better than T_1 (control, 28.65 %), while the crop was sown without fertilization. Treatment of T_2 was found statistically at par with 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6) and 50% RDF + 50% FYM @ 5 t/ha (T_5) with the respective values of 39.75 % and 39.10%, respectively. Among the INM treatment of 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6) was found significantly better than T_5 (50% RDF + 50% FYM @ 5 t/ha) of 39.10 % but at par with 25% RDF + 75% Vermicompost @ 3.75 t/ha (T_8) of 38.08 % and 25% RDF + 75% FYM @ 7.5 t/ha (T_7) of 36.13 %. The magnitude of increase due to integrated application of 100 % RDF @ 25:50:25 kg NPK/ha was 2.43, 4.03, 6.53, 9.74 and 29.68 per cent over 50% RDF + 50 % Vermicompost @ 2.5 t/ha (T_6), 50% RDF + 50% FYM @ 5 t/ha (T_5), 25% RDF + 75% Vermicompost @ 3.75 t/ha (T_8), 25% RDF + 75% FYM @ 7.5 t/ha (T_7) and control (T_1), respectively. The highest harvest index with 100% RDF may be ascribed to its greater partitioning of photo-assimilates towards economic yield rather than vegetative growth. Optimum nutrient availability from inorganic fertilizers balanced the source and sink strength, favoring higher translocation of photosynthates to seed yield. This resulted in maximum harvest index as the crop could divert maximum amount of biomass towards grain production with balanced fertilization utilizing 100% RDF. The results obtained in the present study are supported by the works of Birla *et al*. (2018).

Table 1: Number of pods per plant, Length of pod (cm), Number of grains per pod, Test weight (g), Grain yield per plant (g) and Grain yield per plot (kg) of cowpea as influenced by different integrated nutrient management treatments.

Tr. No.	Treatment Combinations	Number of pods per plant	Length of pod (cm)	Number of grains per pod	Test weight (g)	Grain yield per plant (g)	Grain yield per plot (kg)
T_1	Control	6.27	9.28	6.60	51.80	5.26	0.64
T_2	100 % RDF @ 25:50:25 kg NPK/ha	16.73	28.60	12.80	63.97	10.78	1.57
T_3	FYM @ 10 t/ha	11.20	21.18	8.20	52.58	8.23	1.04
T_4	Vermicompost @ 5 t/ha	12.47	23.32	9.73	55.84	8.48	1.10
T_5	50% RDF + 50% FYM (5 t/ha)	15.00	26.24	12.20	63.15	10.55	1.38
T_6	50% RDF + 50 % Vermicompost (2.5 t/ha)	16.13	27.59	12.47	63.40	10.69	1.49
T_7	25% RDF + 75% FYM (7.5 t/ha)	12.67	24.08	10.53	60.47	8.84	1.15
T_8	25% RDF + 75% Vermicompost (3.75 t/ha)	13.40	26.13	11.60	62.96	10.11	1.30
S. Em±		**0.68**	**0.29**	**0.29**	**0.44**	**0.26**	**0.03**
C.D.		**1.98**	**0.85**	**0.83**	**1.28**	**0.75**	**0.09**

Table 2: Grain yield per hectare (q/ha), Stover yield per hectare (q/ha) and Harvest index (%) of cowpea as influenced by different integrated nutrient management treatments.

Tr. No.	Treatment Combinations	Grain yield per hectare (q/ha)	Stover yield per hectare (q/ha)	Harvest index (%)
T_1	Control	7.11	17.70	28.65
T_2	100 % RDF @ 25:50:25 kg NPK/ha	17.44	25.36	40.74
T_3	FYM @ 10 t/ha	11.59	19.95	36.77
T_4	Vermicompost @ 5 t/ha	12.22	22.33	35.37
T_5	50% RDF + 50% FYM (5 t/ha)	15.33	23.88	39.10
T_6	50% RDF + 50 % Vermicompost (2.5 t/ha)	16.59	25.15	39.75
T_7	25% RDF + 75% FYM (7.5 t/ha)	12.74	22.51	36.13
T_8	25% RDF + 75% Vermicompost (3.75 t/ha)	14.44	23.49	38.08
S. Em±		**0.36**	**0.37**	**0.77**
C.D.		**1.03**	**1.09**	**2.25**

CONCLUSIONS

The observed increases in various yield attributes can be attributed to the balanced supply of essential nutrients provided by the INM treatments. These treatments ensured optimal levels of nutrients crucial for cowpea plant growth and development, leading to enhanced productivity. Additionally, the incorporation of organic amendments like vermicompost and FYM contributed to improved soil fertility, supporting healthy plant growth and resulting in better yield attributes.

The application of the recommended dose of fertilizer (RDF) at a specific ratio, particularly the treatment involving 100% RDF at 25:50:25 kg NPK/ha (T_2), exhibited superior performance across multiple parameters. This treatment consistently outperformed the control (T_1) and demonstrated comparable results with other INM treatments involving a mix of reduced chemical fertilizers and organic amendments like vermicompost and farmyard manure (FYM).

FUTURE SCOPE

1. Nutrient Ratio Optimization: Investigate optimal nutrient ratios tailored for cowpea growth and yield, examining the specific effects of various nutrient compositions on plant physiology and productivity.

2. Long-term Soil Impact: Explore the enduring effects of integrated nutrient management (INM) on soil health, including microbial diversity, carbon sequestration, and overall soil fertility, to assess sustainability.

3. Economic Viability Analysis: Conduct comprehensive economic evaluations to determine the practicality and profitability of INM practices across diverse agro-climatic regions, facilitating wider adoption.

4. Precision Farming Integration: Explore the integration of precision farming technologies to customize nutrient application, optimizing yield while minimizing environmental impact and resource usage.

5. Agroforestry and Intercropping Studies: Investigate cowpea's potential within agroforestry systems, similar to the fruit tree model, to assess intercropping benefits, diversification, and sustainable farming practices.

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