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Impact of integrated nutrient management on growth and yield potential of chickpea (*Cicer arietinum* L.)

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Abstract
The current study entitled "Impact of Integrated Nutrient Management on Growth and Yield Potential of Chickpea (*Cicer arietinum* L.)" was carried out at Research farm of Sardar Patel University, Balaghat (M. P.) during the Rabi season of 2023–2024. Randomized Block Design with three replications and nine treatments, including integrating inorganic fertilizer with organic (FYM and Vermicompost) and bio-fertilizers (*Rhizobium*) was used to conduct study. At 60 and 90 DAS, the study found that different integrated nutrient treatments caused substantial differences in plant height and number of branches plant^{-1}, while at 30 DAS, these differences were not statistically significant. The integrated nutrient treatment T9 shown superiority in the parameters of root nodules plant^{-1}, leaf area index (LAI), number of pods plant^{-1}, seed yield plant^{-1}, seed yield plot^{-1}, seed yield, and straw yield. The highest net return was generated by treatment T8 (45868.01 Rs/ha), and the best benefit-cost ratio was noted with the application of inorganic nutrients alone.

Keywords: Integrated, FYM, vermicompost, bio-fertilizer, *Rhizobium*, LAI, *etc.*

1. Introduction
Pulses are an essential supplier of nutrition for billions of lives globally. Pulses are an essential source of protein for a significant portion of the global population and also aid in the creation of healthy soils and climate change mitigation by virtue of their nitrogen-fixation capabilities. Amongst the legumes, Chickpea (*Cicer arietinum* L.) is an essential crop cultivate and consumed all over the world. It is an excellent option for protein, fiber, carbs, vitamins along with certain minerals.

India is the world's largest producer of chickpeas, which are cultivated across the world. It is cultivated in an area of 15.1 million ha around the world, with a total production of 15.8 million tons and annual production of 12.52 q/ha (Faostat 2021) [4]. During 2021-22 (fourth estimate), chickpea production of India was 13.75 million tons from an acreage of 10.91 million ha. with a productivity of 12.6 q/ha (DES 2023, MOAF&W, GoI) [1]. Only chickpeas contribute to about half of India's pulse production. In Madhya Pradesh total production of chickpea (2020-21) was 29.31 lakh tons from 19.36 lakh ha area with an annual production 15.14 q/ha (DES 2023, MOAF&W, GoI) [1].

The concept behind integrated nutrient management is Maintaining the fertility of the soil and providing vital plant nutrients at the ideal level for the sustained growth of the targeted crop and crop yield. Vermicompost is a valuable resource of organic matter and nutrients, which may enhance the soil physical characteristics, activity of microbes, moisture retention, availability of nutrients, and soil structures. *Rhizobium* is an essential part of integrated nutrient management (INM) for chickpea production, which provides an inexpensive, cost efficient, environmentally acceptable biofertilizer input. Biofertilizers must be applied conjunction with both organic and inorganic fertilizers in order to boost the productivity of crops.

Regardless of extensive study, there are still gaps, especially when it comes to integrated nutrient management (INM) in certain varieties and specific area. The majority of research has concentrated on general nutrient management techniques without adjusting them to the unique soil and climatic conditions of specific region. There are more regional studies are required to investigate how INM affects chickpea yield in these circumstances.

2. Materials and Methods

The field experiment was carried out during the Rabi season of 2023-24 at the Student Research Farm, Department of Agronomy, School of Agricultural Science, Technology, and Research, SPU Balaghat. The experimental field's soil consisted of medium black clay (Vertisols). The climate in Balaghat is subtropical, defined by hot summers and generally dryness except during the southwest monsoon season. The experiment was conducted using a Randomized Block Design (RBD) featuring three replications and nine treatments. Experiment consist of T_1: Control, T_2: 100% RDF (25:50:30 N: P_2O_5: K_2O kg ha^{-1}), T_3: 75% RDF + FYM@ 2.5 t/ha, T_4: 50% RDF + FYM@ 5 t/ha, T_5: 75% RDF + VC@ 1 t/ha, T_6: 50% RDF + VC@ 2 t/ha, T_7: 50% RDF + RC@ 5g/kg seed, T_8: 50% RDF + FYM@ 5 t/ha + RC@ 5g/kg seed, T_9: 50% RDF + VC@ 2 t/ha + RC@ 5g/kg seed. The chickpea variety JG-322 was sown at a spacing of 30 cm x 15 cm with a seed rate of 70 kilogram per hectare. The necessary quantities of fertilizers, namely FYM, vermicompost, urea, SSP, and MOP, were quantified using a weighing balance at the time of preparation of manures and fertilizers according to treatments. The crop was grown with recommended package of practices and was harvested at maturity. Analysis of variance was used to statistically examine the recorded data and significance was determine as given by Panse and Sukhatme (1967) [12] for Randomized Block Design.

3. Results and Discussion

3.1 Growth parametrs

Table 1: Plant height (cm), Number of branches $plant^{-1}$, Number of root nodules $plant^{-1}$ and Leaf area Index of chickpea as influenced by different treatments

Tr. No	Treatments	PH (cm)	NB/P	NRN/P	LAI
		90 DAS	90 DAS	45 DAS	90 DAS
T_1	Control	42.52	6.00	10.00	1.84
T_2	100% RDF	45.45	6.50	12.50	2.20
T_3	75% RDF + FYM@ 2.5 t/ha	45.01	6.35	12.00	2.11
T_4	50% RDF + FYM@ 5 t/ha	44.44	6.20	12.50	2.06
T_5	75% RDF + VC@ 1 t/ha	45.28	6.30	12.17	2.21
T_6	50% RDF + VC@ 2 t/ha	44.85	6.33	13.17	1.95
T_7	50% RDF + RC@ 5g/kg	44.02	6.20	15.33	1.92
T_8	50% RDF + FYM@ 5 t/ha+ RC@ 5g/kg	46.15	6.65	17.17	2.22
T_9	50% RDF + VC @ 2 t/ha + RC@ 5g/kg	46.58	6.70	18.33	2.30
	S.Em =	0.41	0.06	0.49	0.02
	CD (5%) =	1.21	0.18	1.48	0.05
	CV =	1.56	1.63	6.25	1.41

The observations regarding the growth parameters (table 1) *viz.*, plant height (cm), number of branches $plant^{-1}$, number of root nodules $plant^{-1}$ and LAI were significantly influenced by different integrated nutrient management treatments. The growth characters were observed significantly higher under T9: (50% RDF+VC@ 2t/ha+RC@ 5g/kg) than in the rest of the nutrient management treatments in the study, while it was recorded significantly lowest in absolute control (T1) treatment. This increase in growth parameters with increased fertilizer doses might be due to the availability of sufficient nutrients by mineralization of basic organic and inorganic sources of nutrient at proper growth stages of crop This facilitated the availability of required nutrients for the healthy growth and development of chickpea. The better nutrition to the plant resulted more plant height (cm), number of branches, number of root nodules $plant^{-1}$ and LAI which resulted in better light interception and accumulation of more photosynthesis. The findings were analogous to those obtained by Elamin and Madhavi (2015) [3], Dewangan *et al.*, (2017) [2], Singh *et al.*, (2019) [16], Jakhar *et al.*, (2020) [5], Patel and Thanki (2020) [13], Mohanvel *et al.*, (2021) [9], Ojaswani *et al.*, (2022) [11], Tank *et al.*, (2023) [17] and Meravi *et al.*, (2023) [8].

3.2 Yield attributes and yield

Table 2: Number of pods $plant^{-1}$, Number of seeds $plant^{-1}$, Seed index (g), Seed yield (qt ha^{-1}) and straw yield (qt ha^{-1})

Tr. No	Treatments	Number of pods per plant	Number of seeds per pod	Seed index (g)	Seed yield (q/ha)	Straw yield (q/ha)
T_1	Control	25.56	1.20	14.30	12.88	17.57
T_2	100% RDF	30.35	1.40	16.32	16.45	19.86
T_3	75% RDF + FYM@ 2.5 t/ha	28.40	1.33	15.83	16.21	21.40
T_4	50% RDF + FYM@ 5 t/ha	27.37	1.27	15.30	15.28	21.11
T_5	75% RDF + VC@ 1 t/ha	27.65	1.33	15.85	16.04	21.40
T_6	50% RDF + VC@ 2 t/ha	27.37	1.27	15.37	15.31	21.67
T_7	50% RDF + RC@ 5g/kg	26.22	1.20	15.15	14.57	18.76
T_8	50% RDF + FYM@ 5 t/ha+ RC@ 5g/kg	32.37	1.47	16.48	17.31	22.46
T_9	50% RDF + VC @ 2 t/ha + RC@ 5g/kg	32.80	1.47	16.64	17.61	22.96
	S.Em =	0.46	0.10	0.39	0.63	0.55
	CD (5%) =	1.37	NS	1.17	1.89	1.65
	CV =	2.76	12.78	4.32	6.95	4.59

The important yield contributing characters (Table 2) like the number of pods $plant^{-1}$, seed index (g), seed yield (qt ha^{-1}) and straw yield (qt ha^{-1}) was significantly influenced by different nutrient treatments except the character number of seeds pod^{-1}. The yield contributing characters was significant more under treatment T9: (50% RDF+VC@ 2t/ha+RC@ 5g/kg) than in the rest of the nutrient management treatments in the study, while it was recorded significantly lowest in absolute control (T1)

treatment. The grain and straw yield of chickpea was found to be significantly higher (17.61 and 22.96 qt ha^{-1} respectively) in T9: (50% RDF+VC@ 2t/ha+RC@ 5g/kg). The grain and straw yield are lowest under nutrient management treatment (T1). Adequate supply of NPK played a crucial role in physiological developmental processes in plant life. Important nutrients might have accelerated the growth processes that resulted in enhancement of seed yield and straw yield of the crop. This is due to efficiently utilization of crucial nutrients which was reflected in production of higher seed and straw yield. These results were in agreement with the findings of Elamin and Madhavi (2015) [3], Nemade *et al.*, (2017) [10], Dewangan *et al.*, (2017) [2], Singh *et al.*, (2017) [15], Kumar *et al.*, (2018) [6], Singh *et al.*, (2019) [16], Kumar *et al.*, (2019) [7], Patel and Thanki (2020) [13], Mohanvel *et al.*, (2021) [9], Ojaswani *et al.* (2022) [11].

3.3 Economics

Table 3: Cost of cultivation (Rs/ha), Gross monetary returns (Rs/ha), Net monetary returns (Rs/ha) and Benefit cost ratio (B: C Ratio) as influenced by various treatments

Tr. No.	Treatment combination	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C Ratio
T_1	Control	42300.84	67615.80	25314.96	1.60
T_2	100% RDF	45286.84	90739.75	45452.91	2.00
T_3	75% RDF + FYM@ 2.5 t/ha	50790.34	89690.35	38900.01	1.77
T_4	50% RDF + FYM@ 5 t/ha	49540.84	84685.30	35144.46	1.71
T_5	75% RDF + VC@ 1 t/ha	51540.34	88623.35	37083.01	1.72
T_6	50% RDF + VC@ 2 t/ha	57793.84	84929.35	27135.51	1.47
T_7	50% RDF + RC@ 5g/kg	44102.84	80544.95	36442.11	1.83
T_8	50% RDF + FYM@ 5 t/ha + RC@ 5g/kg	49849.84	95717.85	45868.01	1.92
T_9	50% RDF + VC @ 2 t/ha + RC@ 5g/kg	58102.84	97393.35	39290.51	1.68

The data recorded in Table 3 showed that the among different integrated nutrient management treatments, the application of treatment 50% RDF + FYM@ 5 t/ha + RC@ 5g/kg (T8) recorded significantly maximum gross monetary returns of 80544 Rs ha^{-1} and net monetary returns of 45868 Rs ha^{-1} during *Rabi*, 2023-24 as compared to other integrated nutrient management treatments. The maximum cost of cultivation recorded in treatment 50% RDF + VC @ 2 t/ha + RC@ 5g/kg (T9) than rest of nutrient management treatments and the benefit cost ratio of chickpea fertilized with 100% RDF (T2) was found significantly superior (2.00) as compared to other nutrient management treatments. These confirm with findings Dewangan *et al.*, (2017) [2], Singh *et al.*, (2017) [15], Kumar *et al.*, (2018) [6], Singh *et al.*, (2019) [16], Mohanvel *et al.* (2021) [9] and Raut *et al.*, (2022) [14].

4. Conclusion

Based on the results of the investigation, it could be concluded that among the different integrated nutrient management treatments used in the experiment, application of T9: 50% RDF + VC @ 2 t/ha + RC@ 5g/kg and T8: 50% RDF + FYM@ 5 t/ha + RC@ 5g/kg should be adopted for higher growth, yield, and net monetary returns of chickpea than other nutrient management treatments**.**

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