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Response of Different Organic and Inorganic Inputs on Nutrient Use Efficiency and Their Impact on Yields of Kabuli Chickpea in Partially Reclaimed Sodic Soil

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ABSTRACT

Kabuli chickpea (*Cicer arietinum* L.) is an important leguminous crop grown primarily for its large, light-colored seeds, rich in protein, dietary fiber, and essential minerals. Valued for its nutritional quality and high market demand, especially in international trade, Kabuli chickpea plays a key role in food security and farm income. Integrated Nutrient Management (INM) plays a vital role in enhancing the productivity and sustainability of Kabuli chickpea cultivation, especially under degraded or sodic soil conditions. By combining organic, inorganic, and biological inputs, INM improves nutrient use efficiency, soil health, and crop yield. This holistic approach is crucial for maintaining long-term soil fertility and optimizing chickpea production in challenging agroecosystems. The field experiments were conducted at Agronomy research farm, Acharya Narendra Deva University of Agriculture and Technology, Ayodhya during the year of 2023-24, 2024-25 for integrated nutrient management of Kabuli chickpea crop. The experiment was laid in Randomized Block Design under three replications with 12 treatment combinations. This study seeks to evaluate the impact of different combinations of organic and inorganic nutrient sources on the nutrient use efficiency and yield of Kabuli chickpea cultivated in partially reclaimed sodic soils. The findings are anticipated to contribute to the formulation of sustainable nutrient management strategies for kabuli chickpea cultivation in degraded soil environments. The findings indicated that combining organic, inorganic, and biological nutrient source (T_{11}) improved the nutrient use efficiency and yield of Kabuli chickpea cultivated in partially reclaimed sodic soils.

Keyword Organic manure, Biofertilizer, Nutrient use efficiency, Yield, Kabuli chickpea.

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INTRODUCTION

Kabuli chickpea (*Cicer arietinum* L.), an important pulse crop valued for its high protein content and export potential. Nationally, Uttar Pradesh ranks among the top chickpea-producing states, contributing about 8% to India's total chickpea output with around 3.64 lakh tonnes production and area approximately 3.50

lakh hectare. The state has recorded yields up to 1,371 kg/ha, placing it among the higher-yielding regions in the country (Rani *et. al.* 2023). Integrated Nutrient Management (INM) plays a vital role in advancing sustainable chickpea cultivation. This approach not only boosts crop yields but also improves nutritional quality, contributing significantly to food security and better livelihoods (Subhasmita *et al.* 2023). While chemical amendments can partially reclaim degraded soils, the process is often slow and financially burdensome for many farmers. Therefore, improving nutrient use efficiency (NUE) becomes essential for maintaining productivity under such conditions.

The increase of chemical fertilizers to achieve higher yields has led to negative environmental consequences, including the buildup of heavy metals, nutrient leaching, increased emissions of reactive nitrogen and greenhouse gases, and the degradation of soil organic matter and fertility (Banerjee *et al.* 2021, Meena *et al.* 2020). These signs indicate declining soil health. Over time, INM has emerged as a key strategy to address these issues by enhancing nutrient reserves in the soil, improving nutrient availability and uptake, and reducing dependency on chemical inputs and their harmful impacts. Maintaining a balanced soil nutrient budget across various agroecological zones is essential for tracking NUE by comparing nutrient inputs with outputs. INM techniques improve nutrient retention and availability by refining soil characteristics and implementing efficient fertilizer management. Extensively studied and endorsed, INM is widely accepted as a sustainable practice for enhancing agricultural productivity while minimizing environmental disruption (Selim 2020, Shah and Wu 2019, Lal 2020). This study aims to investigate the effects of various organic and inorganic nutrient combinations on the nutrient use efficiency and yield performance of Kabuli chickpea grown in partially reclaimed sodic soils. The outcomes are expected to inform the development of sustainable nutrient management practices for pulse-based cropping systems in degraded agroecosystems.

MATERIALS AND METHODS

The field experiment was conducted during the *rabi* season (2023-24, 2024-25) at Agronomy research farm located in a sodicity-affected region of ANDUAT, Ayodhya. The soil was moderate sodic and sandy loam with pH of 8.2, electrical conductivity (EC) of 0.334 dSm^{-1}, Soil OC (0.32%), low in soil available nitrogen (137.65 kg/ha) and P (12.5 kg/ha), medium in available K (215 kg/ha). The experiment followed a randomized block design (RBD) with three replications with 12 treatments viz. T_1: Control, T_2: 100% RDF (N: P: K @ 20:40:20 kg ha^{-1}), T_3: 75% RDP + 25% P through FYM, T_4: 75% RDP + 25% P through FYM + Jeevamrit @ 500 L ha^{-1}, T_5: 75% RDP + 25% P through FYM + Jeevamrit @ 500 L ha^{-1} + Biofertilizer (Rhizobium & PSB), T_6: 75% RDP + 25% P through Vermicompost, T_7: 75% RDP + 25% P through Vermicompost + Jeevamrit @ 500 L ha^{-1}, T_8: 75% RDP + 25% P through Vermicompost + Jeevamrit @ 500 L ha^{-1} + Biofertilizer (Rhizobium & PSB), T_9: 50% RDP + 25% P through FYM + 25% P through Vermicompost, T_{10}: 50% RDP + 25% P through FYM + 25% P through Vermicompost + Jeevamrit @ 500 L ha^{-1}, T_{11}: 50% RDP + 25% P through FYM + 25% P through Vermicompost + Jeevamrit @ 500 L ha^{-1} + Biofertilizer (Rhizobium & PSB), T_{12}: 50% P through FYM + 50% P through Vermicompost + Jeevamrit @ 500 L ha^{-1} + Biofertilizer (Rhizobium & PSB). Kabuli chickpea variety 'Pusa-3022' was sown using standard agronomic practices. Soil nutrients like organic manures viz., Vermicompost, Farm yard manure, Jeevamrit and biofertilizers viz., Rhizobium, PSB and chemical fertilizer viz, Urea, SSP and MOP were applied at sowing time. The observations on plant population were recorded at 30 DAS, while yields (Grain, Stover and Biological yield) per hectare were recorded at harvest stage. The Nutrient Use Efficiency of Kabuli chickpea was calculated as follows:

$$\text{Nutrient Use Efficiency (\%)} = \frac{\text{Grain yield of control treat. (kg/ha)} - \text{Grain yield of nutrient applied treat. (kg/ha)}}{\text{Grain yield of control treat.(kg/ha)}} \times 100$$

RESULT AND DISCUSSION

Nutrient use efficiency (%)

Among all treatments, the significantly highest NUE (Table 1, Figure.1) was recorded in T_{11} (50% RDP + 25% P through FYM + 25% P through Vermicompost

Table 1. Response of different treatments on Nutrient Use Efficiency (%) of Kabuli Chickpea crop (Pooled data 2023-24 and 2024-25).

Treatments	Nutrient Use Efficiency (%)		
	2023-24	2024-25	Pooled
T_1: Control	0.00	0.00	0.00
T_2: 100% RDF (N: P: K @ 20:40:20 kg ha^{-1})	30.36	34.87	32.61
T_3: 75% RDP + 25% P through FYM	31.77	36.33	34.05
T_4: 75% RDP + 25% P through FYM + Jeevamrit @ 500 L ha^{-1}	38.35	43.14	40.75
T_5: 75% RDP + 25% P through FYM + Jeevamrit @ 500 L ha^{-1} + Biofertilizer (Rhizobium & PSB)	47.15	52.24	49.70
T_6: 75% RDP + 25% P through Vermicompost	36.10	40.81	38.46
T_7: 75% RDP + 25% P through Vermicompost + Jeevamrit @ 500 L ha^{-1}	40.75	45.62	43.19
T_8: 75% RDP + 25% P through Vermicompost + Jeevamrit @ 500 L ha^{-1} + Biofertilizer (Rhizobium & PSB)	50.98	55.56	53.27
T_9: 50% RDP + 25% P through FYM + 25% P through Vermicompost	45.55	50.59	48.07
T_{10}: 50% RDP + 25% P through FYM + 25% P through Vermicompost + Jeevamrit @ 500 L ha^{-1}	60.82	66.54	63.68
T_{11}: 50% RDP + 25% P through FYM + 25% P through Vermicompost + Jeevamrit @ 500 L ha^{-1} + Biofertilizer (Rhizobium & PSB)	64.61	70.46	67.54
T_{12}: 50% P through FYM + 50% P through Vermicompost + Jeevamrit @ 500 L ha^{-1} + Biofertilizer (Rhizobium & PSB)	59.95	65.48	62.71
SEm±	1.54	1.69	1.14
CD (p=0.05)	4.45	4.91	3.32

+ Jeevamrit @ 500 L ha^{-1} + Biofertilizer), with a pooled NUE 67.54 % of nutrient applied, followed by T_{10} (63.68 %) and T_{12} (62.71 %). The control treatment (T_1), which received no nutrient inputs, recorded zero NUE (%), highlighting the critical role of nutrient supplementation in improving chickpea productivity under sodic soil conditions. These results suggest that the integrated use of inorganic and organic nutrient sources, including biofertilizers and Jeevamrit, significantly enhances nutrient efficiency. The synergistic effect of diverse nutrient sources likely contributed to improved soil microbial activity, enhanced nutrient availability, and better plant nutrient uptake in sodic conditions (Kaur and Singh 2025).

This integrated approach improves nutrient availability, enhances microbial activity, and promotes better root development, ultimately leading to increased crop productivity. These results align with recent studies that underscore the benefits of integrated nutrient management (INM) strategies improving nutrient uptake and nutrient use efficiency and yields

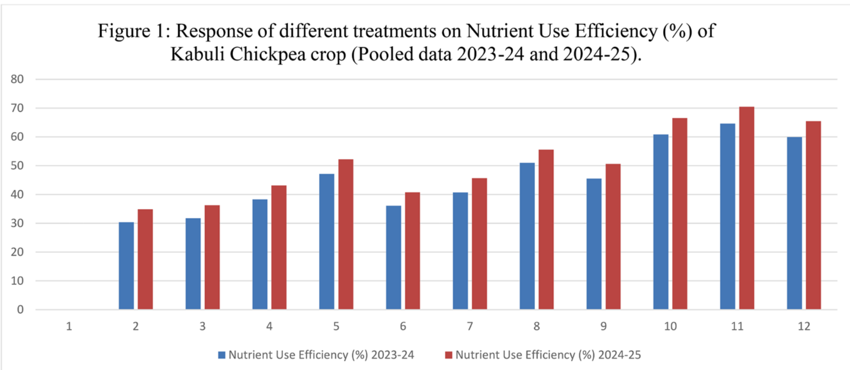

Fig 1. Response of different treatments on Nutrient Use Efficiency (%) of Kabuli Chickpea crop (Pooled data 2023-24 and 2024-25).

Table 2. Impact of different treatments on plant population (Plants/m2) and yield (kg h-1) of Kabuli Chickpea crop (Pooled data 2023-24 and 2024-25).

Treatments	Plant Population (Plants/m^2)	Yield (kg h^{-1})		Harvest Index (%)
	30DAS	Grain	Stover	
$T_{1:}$ Control	22.09	1713.46	2687.51	38.93
$T_{2:}$ 100% RDF (N: P: K @ 20:40:20 kg ha^{-1})	22.13	2288.90	3502.54	39.52
$T_{3:}$ 75% RDP + 25% P through FYM	22.93	2313.68	3573.94	39.30
$T_{4:}$ 75% RDP + 25% P through FYM + Jeevamrit @ 500 L ha^{-1}	23.28	2429.30	3818.38	38.88
$T_{5:}$ 75% RDP + 25% P through FYM + Jeevamrit @ 500 L ha^{-1} + Biofertilizer (Rhizobium & PSB)	24.21	2583.76	4055.21	38.92
$T_{6:}$ 75% RDP + 25% P through Vermicompost	23.19	2389.76	3733.23	39.03
$T_{7:}$ 75% RDP + 25% P through Vermicompost + Jeevamrit @ 500 L ha^{-1}	23.51	2471.43	3930.07	38.60
$T_{8:}$ 75% RDP + 25% P through Vermicompost + Jeevamrit @ 500 L ha^{-1} + Biofertilizer (Rhizobium & PSB)	24.46	2645.50	4366.57	38.19
$T_{9:}$ 50% RDP + 25% P through FYM + 25% P through Vermicompost	23.91	2555.68	4051.44	38.68
$T_{10:}$ 50% RDP + 25% P through FYM + 25% P through Vermicompost + Jeevamrit @ 500 L ha^{-1}	24.84	2825.10	4562.21	38.24
$T_{11:}$ 50% RDP + 25% P through FYM + 25% P through Vermicompost + Jeevamrit @ 500 L ha^{-1} + Biofertilizer (Rhizobium & PSB)	24.96	2891.67	4844.07	37.38
$T_{12:}$ 50% P through FYM + 50% P through Vermicompost + Jeevamrit @ 500 L ha^{-1} + Biofertilizer (Rhizobium & PSB)	24.61	2808.44	4485.68	38.50
SEm±	0.76	58.07	92.69	0.87
CD (p=0.05)	NS	168.48	268.93	NS

(Bhardwaj *et al*. 2023, Namdeo *et al*. 2024).

Plant population

At 30 DAS, plant population ranged from 22.09 plants/m² in the control (T_1) to 24.96 plants/m² in T_{11} (Table 2). Although these differences were not statistically significant, a slight improvement in plant stand was observed with the application of organic inputs, particularly in treatments involving biofertilizers and Jeevamrit. This suggests a possible positive influence of improved soil biological activity on seed germination and early plant establishment (Sinha and Thakur 2025).

Grain yield

Grain and Stover yield varied significantly among treatments, with the highest yield of 2891.67 kg ha-1recorded in T_{11} (50% RDP + 25% P through FYM + 25% P through vermicompost + Jeevamrit + biofertilizer) (Table 2). This was 68.8% higher than the control (T_1) and significantly superior to the recommended dose of fertilizers (T_2), which yielded 2288.90 kg ha^{-1}. The increased yield in T_{11} can be attributed to synergistic effects of organic amendments and biofertilizers that improved nutrient availability, microbial activity, and root nodulation (Thakur *et al.* 2023). Treatments T_8, T_{10}, and T_{12} also performed well, yielding above 2800 kg ha^{-1}, indicating the efficacy of integrating vermicompost and FYM with Jeevamrit and biofertilizers. These results align with earlier findings by Koireng *et al.* 2022 and Mukati *et al*. 2021, who reported improved crop productivity with combined application of organic and biological inputs in degraded soils.

Stover yield

Stover yield followed a similar trend to grain yield, ranging from 2687.51 kg ha^{-1} in control to 4844.07 kg ha^{-1} in T_{11} (Table 2). Treatments with integrated nutrient management, particularly T_{10} and T_{11}, showed significantly higher biomass accumulation, which reflects enhanced overall plant growth. This could be attributed to improved soil physical properties and enhanced microbial activity from organic amendments, leading to better water and nutrient uptake (Pasqualone *et al.* 2021, Ahmad and Khan 2021).

Conclusion of discussion

The integrated application of organic, inorganic, and biological nutrient sources significantly enhances the nutrient use efficiency and yield of Kabuli chickpea in partially reclaimed sodic soils. Treatments combining reduced doses of chemical fertilizers (RDF) with farmyard manure (FYM), vermicompost, Jeevamrit, and biofertilizers (Rhizobium and PSB) consistently outperformed sole chemical or organic applications across all evaluated parameters, including plant population, grain and stover yield, and nutrient use efficiency (NUE). This underscores the synergistic benefits of integrated nutrient management (INM) in improving crop productivity and soil health under sodic conditions

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