International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(5): 217-221
Received: 11-03-2026
Accepted: 15-04-2026

Mohit Malav
M.Sc. Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India

Shivendra Singh
Assistant Professor, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India

Rohitashv Nagar
Assistant Professor, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India

Shivam Yadav
Assistant Professor, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India

Gunnjeet Kaur
Assistant Professor, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India

Sudarshan Panchal
M.Sc. Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India

Deepa Khandelwal
M.Sc. Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India

Kashifa Khan
M.Sc. Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India

Mohd. Zuber
M.Sc. Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India

Corresponding Author:
Mohit Malav
M.Sc. Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India

Integrated nutrient management for enhancing growth and yield of Lentil (*Lens culinaris* Medik.)

Mohit Malav, Shivendra Singh, Rohitashv Nagar, Shivam Yadav, Gunnjeet Kaur, Sudarshan Panchal, Deepa Khandelwal, Kashifa Khan and Mohd. Zuber

DOI: https://www.doi.org/10.33545/2618060X.2026.v9.i5c.5508

Abstract
A field experiment was conducted during the Rabi season of 2025–26 at the Agriculture Research Farm, CPU, Kota (Rajasthan) to evaluate the effect of integrated nutrient management on the growth and yield of lentil (*Lens culinaris* Medik.). The experiment consisted of nine treatments comprising different combinations of recommended dose of fertilizers (RDF), farmyard manure (FYM), vermicompost, *Rhizobium*, and phosphate-solubilizing bacteria (PSB), arranged in a Randomized Block Design with three replications. The results indicated that integrated nutrient management significantly influenced growth parameters such as plant height, number of branches, and dry matter accumulation. The highest values for growth and yield attributes were recorded under the treatment T_7 (50% RDF + Vermicompost @ 2 t ha^{-1} + *Rhizobium* + PSB), which remained statistically at par with T_6 (50% RDF + FYM @ 5 t ha^{-1} + *Rhizobium* + PSB). Maximum grain yield (1025 kg ha^{-1}), straw yield (1615 kg ha^{-1}), and biological yield (2640 kg ha^{-1}) were also recorded under T_7. The enhanced performance under integrated treatments was attributed to improved soil physicochemical properties, enhanced microbial activity, and better nutrient availability and uptake. The study concludes that integration of organic manures, biofertilizers, and reduced chemical fertilizers significantly improves productivity and sustainability of lentil cultivation under the agro-climatic conditions of southeastern Rajasthan.

Keywords: Lentil, integrated nutrient management, vermicompost, rhizobium, yield

1. Introduction
Lentil (*Lens culinaris* Medik.) is a key cool-season pulse in India, providing 22-28% protein and essential micronutrients while supporting cereal-pulse rotations through biological nitrogen fixation and soil fertility enhancement [1]. Globally, Canada is the largest lentil producer, followed by India and Australia, with India ranking high in sown area and consumption due to dietary patterns and policy support for pulses [2]. Syntheses place India's lentil production around 1.5-1.6 million tonnes on approximately 1.4-1.5 million hectares in recent years, reflecting gradual gains from improved varieties and management, though average yields remain below top-exporting countries due to abiotic and nutrient constraints [1, 3].

Global overviews show India contributes roughly a quarter of world lentil area and near one-fifth of production, while Canada's higher per-hectare productivity (often ≥1.3 t ha^{-1}) underpins its leading output and export share [2]. Within India, institutional notes report lentil output fluctuating near 1.3-1.6 million tonnes depending on seasonal rainfall and temperature, with productivity advances linked to timely sowing, phosphorus and zinc nutrition, and short-duration, disease-tolerant cultivars [1].

National compilations attribute the largest state contributions to Uttar Pradesh and Madhya Pradesh, together accounting for roughly two-thirds of national lentil production, followed by West Bengal and Bihar at about one-tenth each, with additional shares from Jharkhand, Rajasthan, Assam, and Uttarakhand [4, 5]. Rajasthan's share is smaller in the all-India lentil landscape (commonly 1-3%), yet the crop has strategic importance in suitable districts under limited irrigation and residual moisture, contributing to diversification and soil health in pulse-based rotations [5].

The southeast region of Rajasthan features light- to medium-textured soils (Inceptisols/Alfisols) and moisture-limited rabi conditions, where erratic winter rainfall, terminal heat, and low inherent fertility constrain lentil productivity, intensifying the need for integrated nutrient management [6]. Regional planning documents highlight imbalances in macronutrients and widespread micronutrient deficiencies, notably zinc and occasional boron, which depress nodulation, biomass accumulation, pod set, and seed size in pulses [4].

Lentil (*Lens culinaris* Medik.) is a cool-season, self-pollinated pulse valued for short cooking time, affordability, and suitability in cereal- pulse rotations due to biological nitrogen fixation that improves soil fertility [7]. It is recognized as a nutrient-dense legume rich in protein, complex carbohydrates, dietary fiber, and folate, contributing significantly to dietary quality in vegetarian populations and food-insecure regions [8]. Beyond macronutrients, lentils contain bioactive compounds such as polyphenols, saponins, and phytosterols associated with antioxidant, antidiabetic, cardioprotective, and anti-inflammatory activities, supporting their positioning as a functional food [9, 10].

Lentil seeds typically provide about 20-30% protein, with favorable amino acid profiles for plant-based diets, alongside prebiotic carbohydrates and minerals including iron and zinc that address micronutrient deficiencies in vulnerable populations [11, 12]. Reviews highlight that lentils are rich in fiber and folates, and their polyphenols and phytosterols are linked to improved glycemic control, lipid metabolism, and reduced risk of chronic diseases when included regularly in diets [8, 9]. Breeding and biofortification programs have released high-iron and high-zinc lentil cultivars across South Asia, enhancing the crop’s role in combating hidden hunger while maintaining agronomic adaptation to local environments [7, 12].

Given lentil’s high protein and mineral density, balanced phosphorus and zinc nutrition is critical for nodulation, root growth, pod set, and seed filling that underpin both yield and grain nutrient quality in semi-arid and sub-humid ecologies like southeast Rajasthan [7, 12]. Integrating organics (e.g., FYM/vermicompost), biofertilizers (Rhizobium, PSB), and calibrated fertilizers enhances nutrient-use efficiency and soil biological activity, improving productivity and sustaining the nutritive quality advantages that make lentil a strategic crop for household nutrition and market demand [7, 8].

FYM, vermicompost, Rhizobium, and PSB work complementarily to raise lentil performance by improving soil health, nutrient availability, and biological N and P supply in moisture-limited rabi systems of southeast Rajasthan, thereby enhancing nodulation, canopy development, pods per plant, seed filling, yield, and profitability [1, 4, 6]. FYM increases soil organic carbon, aggregation, infiltration, and cation-exchange capacity while providing slow-release macro- and micronutrients, which stabilizes establishment and supports higher nutrient-use efficiency when combined with recommended fertilizers in pulses including lentil [4]. Vermicompost supplies readily mineralizable N, P, S, humic substances, and beneficial microbes that stimulate root growth and P uptake; Indian field studies show significant gains in lentil growth, yield, and economics when 5-6.5 t ha^{-1} vermicompost is paired with Rhizobium or PGPR compared with fertilizer-only controls [13, 14]. Lentil-specific Rhizobium (*R. leguminosarum* bv. *viciae*) inoculation increases nodulation, biomass, and seed yield by fixing atmospheric nitrogen, with co-inoculation alongside PSB or PGPR outperforming single inoculations in multi-location field work [15, 16]. PSB mobilize sparingly soluble phosphates common in neutral-alkaline soils, raising plant-available P and improving branches, pods per plant, test weight, and seed yield; factorial trials document that Rhizobium + PSB plus adequate P consistently elevates P uptake and yield over either inoculant alone [17, 18]. Consequently, integrated modules that combine FYM or vermicompost with Rhizobium + PSB and soil-test-based fertilizers (notably P and S, with Zn as needed) are recommended by national pulse programs to close the lentil yield gap, improve benefit:cost ratios, and build soil fertility across pulse-based rotations in the region [1, 6].

Integrated Nutrient Management (INM)- the calibrated combination of organic manures, biofertilizers, and mineral fertilizers- improves soil structure, microbial activity, nutrient availability, and water-holding capacity, thereby enhancing lentil growth, nodulation, and yield under moisture variability typical of southeast Rajasthan [4]. Organics such as FYM and vermicompost increase soil organic carbon and cation exchange capacity, while Rhizobium and phosphorus-solubilizing bacteria (PSB) improve biological nitrogen fixation and phosphorus availability, complementing starter mineral N and band-placed P for early vigor and reproductive success [1].

2. Materials and Methods

The field experiment on the effect of integrated nutrients management on the growth and yield of lentil was conducted at the Agriculture Research Farm, CPU, Kota (Rajasthan) during the Rabi season of 2025-26. The site is located at 25° 11' N latitude and 75° 54' E longitude with an elevation of 273 meters in the Humid South Eastern Plain Zone. The experimental soil was clay-loam in texture with an alkaline pH of 8.35, low organic carbon (0.42%), low available N (177 kg ha^{-1}), medium available P (14.6 kg ha^{-1}), and high available K (321 kg ha^{-1}). Nine treatments, including 100% RDF, various combinations of 75% and 50% RDF with FYM, vermicompost, Rhizobium, and PSB, along with a 100% organic module and a control, were tested in a Randomized Block Design with 3 replications. The lentil variety Kota Masoor-4 was sown on December 15, 2025, using a seed rate of 40 kg ha^{-1} in rows spaced 30 cm apart. Recommended basal doses of fertilizers (20 kg N, 40 kg P2O5, and 20 kg K2O ha^{-1}) were applied along with required organics and biofertilizers. The crop relied on rainfall without supplemental irrigation and was harvested at full maturity on February 14, 2026.

2.1 Growth and Development Studies

Five average plants from each plot were randomly selected and tagged to record plant height from the soil surface base to the tip of the main apical bud at various physiological stages. The same tagged plants were utilized to count the number of branches per plant. Dry matter accumulation per plant was determined by sun-drying and subsequently oven-drying samples at 60±2°C until a constant weight was achieved. Additionally, the plant population per meter row length and the Leaf Area Index (LAI) at 45 days after sowing were also recorded to evaluate crop growth.

2.2 Yield Studies

To study yield attributes, pods picked from five randomly selected plants per plot were threshed and winnowed to determine the average number of pods per plant and seeds per pod. The weight of 100 seeds (seed index) was recorded from representative plot samples using an electronic balance. Biological yield was measured by weighing the completely sun-dried bundles of harvestable biomass for each plot. After manual threshing and cleaning, the final seed yield was recorded and converted into kg ha^{-1}. The straw yield was then computed by subtracting the seed yield from the biological yield.

2.3 Statistical Analysis
The data obtained from the experiment were subjected to analysis of variance (ANOVA) using the SPSS technique to define the statistical significance of the treatment effects. The significance of these effects was judged at a 5% probability level utilizing Fisher's 'F' test. Furthermore, the critical difference (CD) was calculated to examine and compare the significant differences between the various treatments.

3. Results and Discussion
3.1 Crop Growth Parameters
3.1.1 Plant Population (per m row length)
The data on mean plant population revealed non-significant differences across all nutrient management treatments at both 30 DAS and maturity stages. The highest plant population was registered under treatment T_7 (50% RDF + Vermicompost @ 2 t ha^{-1} + Rhizobium + PSB) with 21.25 plants at 30 DAS and 20.65 plants at maturity. The lowest plant population was recorded in the control plot, with 19.15 and 18.45 plants at the respective stages. The lack of statistical significance suggests that initial establishment is primarily governed by seed viability and physical seedbed conditions rather than fertilizer application.

3.1.2 Plant Height (cm)
Plant height grew steadily as the crop progressed toward maturity. At 30 DAS, differences were non-significant, with heights ranging from 9.85 to 13.40 cm. However, at 60 DAS and at harvest, plant height was significantly influenced by integrated nutrient management. The maximum plant height at 60 DAS (35.50 cm) and at harvest (51.20 cm) was recorded under T_7, which remained statistically at par with T_6 (50% RDF + FYM @ 5 t ha^{-1} + Rhizobium + PSB). The control plot produced the shortest plants (33.10 cm at harvest). Vermicompost, also known as FYM, is a storehouse of plant nutrients that may have enhanced the physicochemical and biological qualities of the soil, hence enhancing crop development similar finding found by Singh *et al.* [19, 20].

3.1.3 Number of Branches per Plant
All treatments significantly influenced the number of branches per plant at 30 DAS, 60 DAS, and maturity. At 30 DAS, the maximum number of branches (4.75) was observed in T_7, which was at par with treatments T_1 through T_6. At maturity, T_7 maintained the highest count (5.45), remaining statistically at par with all treated plots except the 100% Organic treatment (T_8). The control recorded the fewest branches (3.30). FYM or vermicompost stores plant nutrients that may have enhanced soil physico-chemical and biological qualities to boost crop development. However, soils fertilised only with chemical fertilisers lack all these advantages needed to accumulate carbohydrates and translocate them to reproductive organs, increase branch number [13, 20].

3.1.4 Dry Weight per Plant (g)
Dry weight increased considerably across all growth phases. The maximum dry weight at 30 DAS (0.30 g), 60 DAS (1.84 g), and maturity (2.25 g) was observed under T_7, which was statistically at par with T_6 at all stages. The control resulted in the lowest dry weight at maturity (0.60 g). The significant enhancement in growth parameters under integrated treatments is attributed to organic sources like FYM or vermicompost acting as a storehouse of plant nutrients. These sources improve the physicochemical and biological properties of the soil, facilitating better accumulation of carbohydrates and their translocation to the plant organs. This results in increased height, branching, and biomass compared to plots receiving only chemical fertilizers. These findings are supported by the work of [19, 21].

3.2 Yield Attributes and Yield
3.2.1 Grain yield (kg ha^{-1})
Grain yield per hectare increased significantly with the application of integrated nutrients compared to the control. The application of T_7 (1025 kg) produced the maximum grain yield, which was statistically at par with T_6 (995 kg). Other treatments, including T_5, T_4, T_3, T_2, T_1, and T_8, also produced significantly higher grain yields over the control (490 kg). The control group had the lowest harvest index (35.38%). Organic sources such as FYM and vermicompost act as a reservoir of plant nutrients, improving the soil's physicochemical and biological properties. Unlike soils fertilised exclusively with chemical fertilisers, integrated treatments create the conditions for higher development of functional leaves as well as increased protein and carbohydrate storage. The synergistic action of organics and biofertilizers guarantees that these nutrients are effectively transported to the reproductive organs, resulting in an increase in pods per plant, seed weight, and total grain production. These findings are congruent with those of [23, 24].

3.2.2 Straw yield (kg ha^{-1})
All treatments were found significantly superior to the control in terms of straw yield. The highest straw yield was observed in T_7 (1615 kg), which was statistically at par with T_6 (1580 kg) and T_5 (1510 kg). The lowest straw yield was recorded in the control plot (895 kg). Organic sources like FYM and vermicompost retain plant nutrients that improve soil physicochemical and biological properties. In contrast to chemically fertilised soils, integrated treatments promote leaf formation and protein and carbohydrate accumulation. The synergy of organics and biofertilizers effectively translocates nutrients to reproductive organs, increasing pods per plant, seed weight, and grain output. These findings are consistent with [22, 23].

3.2.3 Biological yield (kg ha^{-1})
The highest biological yield per hectare was observed in T_7 (2640 kg), which was statistically at par with T_6 (2575 kg). All other integrated modules produced significantly higher biological yields compared to the control (1385 kg). Organic sources such as FYM and vermicompost act as a repository for plant nutrients, which in turn improves the physicochemical and biological characteristics of the soil. Integrated treatments, as opposed to soils that are just fertilised with chemical fertilisers, create the circumstances that are essential for the enhanced generation of leaves that are able to function and for the larger accumulation of proteins and carbohydrates. Because of the synergistic action of organics and biofertilizers, the effective transfer of these nutrients to the reproductive organs is ensured. This results in an increase in the number of pods produced by each plant, the weight of the seeds, and the volume of grain produced overall. These findings are in agreement with the findings of other researchers, such as [21, 24].

3.2.4 Harvest index (%)
The maximum harvest index was observed in T_7 (38.83%),

followed closely by T_6 (38.64%), T_5 (38.62%), and T_4 (38.51%). The lowest harvest index was recorded in the control (35.38%). Organic sources like FYM and vermicompost serve as a storehouse of plant nutrients that improve the soil's physicochemical and biological qualities. Unlike soils fertilized solely with chemical fertilizers, integrated treatments provide the necessary conditions for the increased production of functioning leaves and greater accumulation of proteins and carbohydrates. The synergistic effect of organics and biofertilizers ensures the effective translocation of these nutrients to the reproductive organs, leading to an increase in pods per plant, seed weight, and overall grain yield. These results are consistent with the findings of [19, 21,23,24, 25].

Table 1: Effect of different treatments on Plant population/m row length at 30 DAS and at maturity of lentil

No.	Treatment	Plant population/m row length at 30 DAS	Plant population/m row length at Maturity
1.	T_1- 100% RDF (Recommended Dose of Fertilizers)	20.85	19.80
2.	T_2- 75% RDF + FYM @ 5 t ha⁻¹	20.45	19.65
3.	T_3- 75% RDF + Vermicompost @ 5 t ha⁻¹	20.55	19.85
4.	T_4- 75% RDF + FYM @ 5 t ha⁻¹ + *Rhizobium*	20.70	20.10
5.	T_5- 75% RDF + Vermicompost @ 5 t ha⁻¹ + *Rhizobium*	20.90	20.35
6.	T_6- 50% RDF + FYM @ 5 t ha⁻¹ + *Rhizobium* + PSB	21.15	20.50
7.	T_7- 50% RDF + Vermicompost @ 2 t ha⁻¹ + *Rhizobium* + PSB	21.25	20.65
8.	T_8- 100% Organic (FYM @ 5 t ha⁻¹ + Vermicompost @ 2 t ha⁻¹ + *Rhizobium* + PSB)	20.10	19.30
9.	T_9- Control	19.15	18.45
	SE(m)±	0.55	0.65
	CD at 5%	NS	NS

Table 2: Effect of different treatments on plant height (cm) of lentil

No.	Treatment	Plant height (cm) at 30 DAS	Plant height (cm) at 60 DAS	Plant height (cm) at Maturity
1.	T_1- 100% RDF (Recommended Dose of Fertilizers)	12.15	30.85	44.50
2.	T_2- 75% RDF + FYM @ 5 t ha⁻¹	12.35	31.20	45.10
3.	T_3- 75% RDF + Vermicompost @ 5 t ha⁻¹	12.45	31.60	45.80
4.	T_4- 75% RDF + FYM @ 5 t ha⁻¹ + *Rhizobium*	12.60	32.10	46.50
5.	T_5- 75% RDF + Vermicompost @ 5 t ha⁻¹ + *Rhizobium*	12.80	32.65	47.30
6.	T_6- 50% RDF + FYM @ 5 t ha⁻¹ + *Rhizobium* + PSB	13.15	34.20	49.50
7.	T_7- 50% RDF + Vermicompost @ 2 t ha⁻¹ + *Rhizobium* + PSB	13.40	35.50	51.20
8.	T_8- 100% Organic (FYM @ 5 t ha⁻¹ + Vermicompost @ 2 t ha⁻¹ + *Rhizobium* + PSB)	11.80	29.50	42.10
9.	T_9- Control	9.85	24.15	33.10
	SE(m)±	1.45	0.95	1.55
	CD at 5%	NS	2.85	4.75

Table 3: Effect of different treatments on number of branches/plants of lentil

No.	Treatment	No. of branches/plant at 30 DAS	No. of branches/plant at 60 DAS	No. of branches/plant at Maturity
1.	T_1- 100% RDF (Recommended Dose of Fertilizers)	3.95	4.80	4.85
2.	T_2- 75% RDF + FYM @ 5 t ha⁻¹	4.05	4.75	4.85
3.	T_3- 75% RDF + Vermicompost @ 5 t ha⁻¹	4.15	4.85	4.90
4.	T_4- 75% RDF + FYM @ 5 t ha⁻¹ + *Rhizobium*	4.30	4.95	5.05
5.	T_5- 75% RDF + Vermicompost @ 5 t ha⁻¹ + *Rhizobium*	4.45	5.10	5.15
6.	T_6- 50% RDF + FYM @ 5 t ha⁻¹ + *Rhizobium* + PSB	4.65	5.25	5.30
7.	T_7- 50% RDF + Vermicompost @ 2 t ha⁻¹ + *Rhizobium* + PSB	4.75	5.40	5.45
8.	T_8- 100% Organic (FYM @ 5 t ha⁻¹ + Vermicompost @ 2 t ha⁻¹ + *Rhizobium* + PSB)	3.50	4.35	4.50
9.	T_9- Control	1.85	3.25	3.30
	SE(m)±	0.28	0.24	0.25
	CD at 5%	0.82	0.70	0.72

Table 4: Effect of different treatments on dry weight per plant (g) of lentil

No.	Treatment	Dry weight per plant (g) at 30 DAS	Dry weight per plant (g) at 60 DAS	Dry weight per plant (g) at Maturity
1.	T_1- 100% RDF (Recommended Dose of Fertilizers)	0.22	1.48	1.66
2.	T_2- 75% RDF + FYM @ 5 t ha⁻¹	0.23	1.52	1.72
3.	T_3- 75% RDF + Vermicompost @ 5 t ha⁻¹	0.24	1.55	1.76
4.	T_4- 75% RDF + FYM @ 5 t ha⁻¹ + *Rhizobium*	0.25	1.62	1.84
5.	T_5- 75% RDF + Vermicompost @ 5 t ha⁻¹ + *Rhizobium*	0.26	1.68	1.92
6.	T_6- 50% RDF + FYM @ 5 t ha⁻¹ + *Rhizobium* + PSB	0.28	1.76	2.12
7.	T_7- 50% RDF + Vermicompost @ 2 t ha⁻¹ + *Rhizobium* + PSB	0.30	1.84	2.25
8.	T_8- 100% Organic (FYM @ 5 t ha⁻¹ + Vermicompost @ 2 t ha⁻¹ + *Rhizobium* + PSB)	0.21	1.40	1.54
9.	T_9- Control	0.11	0.58	0.60
	SE(m)±	0.01	0.06	0.09
	CD at 5%	0.03	0.17	0.26

Table 5: Effect of different treatments on yield and harvest index (g) of lentil

No.	Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
1.	T_1- 100% RDF (Recommended Dose of Fertilizers)	860	1410	2270	37.89
2.	T_2- 75% RDF + FYM @ 5 t ha⁻¹	875	1420	2295	38.13
3.	T_3- 75% RDF + Vermicompost @ 5 t ha⁻¹	890	1440	2330	38.20
4.	T_4- 75% RDF + FYM @ 5 t ha⁻¹ + *Rhizobium*	930	1485	2415	38.51
5.	T_5- 75% RDF + Vermicompost @ 5 t ha⁻¹ + *Rhizobium*	950	1510	2460	38.62
6.	T_6- 50% RDF + FYM @ 5 t ha⁻¹ + *Rhizobium* + PSB	995	1580	2575	38.64
7.	T_7- 50% RDF + Vermicompost @ 2 t ha⁻¹ + *Rhizobium* + PSB	1025	1615	2640	38.83
8.	T_8- 100% Organic (FYM @ 5 t ha⁻¹ + Vermicompost @ 2 t ha⁻¹ + *Rhizobium* + PSB)	820	1350	2170	37.79
9.	T_9- Control	490	895	1385	35.38
	SE(m)±	22.50	36.40	52.10	0.55
	CD at 5%	68.50	108.50	155.20	1.65

4. Conclusion

Integrated nutrient management significantly improved the growth and yield of lentil (*Lens culinaris* Medik.) under southeastern Rajasthan conditions. The treatment 50% RDF + Vermicompost @ 2 t ha⁻¹ + *Rhizobium* + PSB (T_7) recorded the highest productivity and remained at par with 50% RDF + FYM @ 5 t ha⁻¹ + *Rhizobium* + PSB (T_6). Hence, combining organic manures and biofertilizers with reduced chemical fertilizers is an effective and sustainable approach for enhancing lentil yield and soil health.

Acknowledgement

The researchers express their gratitude to the Agronomy, School of Agricultural Sciences, Career Point University, Kota (Rajasthan), located in Kota- 325003, for providing their facilities.

Competing Interests

Authors have declared that no competing interests exist.

References

1. ICAR-Indian Institute of Pulses Research (ICAR-IIPR). Lentil: Crop profile and production technologies. ICAR-IIPR, Kanpur. 2024.
2. Khan N, Kousar S, Ahmed M. Lentils: A recent review on global trade and popular consumption patterns. Legume Sci. 2023;5(4):e0252.
3. Drishti IAS. Lentil production in India. Drishti Publications. 2024 Jan 14-18.
4. Department of Agriculture & Farmers Welfare. Final Annual Report 2022–23 with plan-wise and state-wise pulse statistics. Department of Agriculture & Farmers Welfare, Government of India. 2023.
5. Department of Pulses Development (DPD). State-wise national scenario and plan-wise analysis (pulses). Department of Agriculture & Farmers Welfare, Government of India. 2023.
6. Department of Pulses Development (DPD). Annual Report 2023–24. Department of Agriculture & Farmers Welfare, Government of India. 2024.
7. Khorasani MM, Bohlouli S, Khazaei H. Polyphenols, saponins and phytosterols in lentils and their biological activities. Nutrients. 2022;14(19):4106.
8. Kaur R, Kaur J, Singh H. A review of the health benefits of processed lentils (*Lens culinaris* Medik.). Legume Sci. 2024;6(2):e232.
9. Prajapati A, Patel N, Kumar S. Physical and biochemical studies of lentil (*Lens culinaris* Medik.) seeds. Int J Curr Microbiol Appl Sci. 2020;Special Issue 11:1642-1651.
10. Thavarajah D, Thavarajah P, Vandenberg A. Protein biofortification in lentils (*Lens culinaris* Medik.): Breeding advances and nutritional impacts. Front Plant Sci. 2022;13:869733.
11. Jonnadula K, Singh R. Effect of levels of vermicompost and bio-fertilizers on growth and yield of organic lentil (*Lens culinaris* Medik.). Pharma Innov J. 2022;11(2):Part X.
12. Jonnadula K, Singh R, Singh E. Effect of vermicompost and bio-fertilizers on yield and economics of organic lentil (*Lens culinaris* Medik.). Biol Forum Int J. 2022;14(1):1474-1476.
13. FAO. Soils and pulses: Symbiosis for life. FAO, Rome. 2016.
14. Khurana A, Kaur R, Sharma P. Potential for enhancing lentil (*Lens culinaris*) productivity by co-inoculation with PSB, PGPR and Rhizobium. Indian J Agric Sci. 2011;81(10):915-919.
15. Waroda R, Bisen JS. Response of phosphorus levels and bio-inoculants on growth and yield of lentil (*Lens culinaris* Medik.). Int J Res Agron. 2024;7(7S):Part I.
16. Biswas PK, Bhowmick MK, Kundu MC, Mondal S, Ghosh GK. Conjoint application of biofertilizer and phosphorus levels on growth, nodulation, nutrient uptake and productivity of lentil. Crop Res. 2015;50(1-3):31-36.
17. Singh KK, Srinivasarao C, Ali M. Root growth, nodulation, grain yield, and phosphorus use efficiency of lentil as influenced by phosphorus, irrigation, and inoculation. Commun Soil Sci Plant Anal. 2005;36(13/14):1919-1929.
18. Ahmed ZI, Anjum MS, Rauf CA. Effect of Rhizobium inoculation on growth and nodule formation of green gram. Int J Agric Biol. 2006;8(2):235-237.
19. Kumar S, Sahu A. Effect of INM on productivity and fertility status in lentil. Indian J Agric Biochem. 2021;34(1):25-32.
20. Patel M, Tiwari AS, Golhani P. Synchronizing nutrient release with crop demand through integrated nutrient management: Implications for yield sustainability and soil fertility in lentil. Pharma Innov J. 2021;10(12):148-154.
21. Rajput D, Saxena R. Pressmud-organic combination for better lentil returns. Indian J Fertilizers. 2021;17(9):958-963.
22. Sharma P, Kaur R, Dhillon N. Influence of farmyard manure and fertilizers on soil moisture retention, nutrient availability and yield stability of lentil in semi-arid regions. J Soil Water Conserv. 2019;18(4):352-358.
23. Rathi N, Sharma N, Lal M. Integrated nutrient strategies in lentil. Ann Plant Soil Res. 2019;21(4):387-393.