ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2025): 4.97
IJAFS 2025; 7(11): 245-249
www.agriculturaljournals.com
Received: 05-07-2025
Accepted: 08-08-2025

Jitendra Nagar
Department of Agronomy,
School of Agricultural Sciences,
Career Point University, Kota,
Rajasthan, India

Rohitashv Nagar
Department of Agronomy,
School of Agricultural Sciences,
Career Point University, Kota,
Rajasthan, India

Vineet Dheer
Department of Agronomy,
School of Agricultural Sciences,
Career Point University, Kota,
Rajasthan, India

Gunnjeet Kaur
Department of Agronomy,
School of Agricultural Sciences,
Career Point University, Kota,
Rajasthan, India

Corresponding Author:
Rohitashv Nagar
Department of Agronomy,
School of Agricultural Sciences,
Career Point University, Kota,
Rajasthan, India

Studies on the impact of Nano-DAP on growth, yield and quality of mung bean (*Vigna radiata* L.)

Jitendra Nagar, Rohitashv Nagar, Vineet Dheer and Gunnjeet Kaur

DOI: https://www.doi.org/10.33545/2664844X.2025.v7.i11d.964

Abstract
The present investigation entitled "Studies on the Impact of Nano-DAP on Growth, Yield, and Quality of Mung Bean (*Vigna radiata* L.)" was conducted during the summer season of 2025 at the Agricultural Research Farm, Career Point University, Kota (Rajasthan), to evaluate the effect of Nano-DAP on crop performance under varying fertilizer levels. The experiment was laid out in a Randomized Block Design with eight treatments and three replications, including seed treatment and foliar application of Nano-DAP (0.4%) at 20 and 40 days after sowing, either alone or in combination with different proportions of recommended fertilizer dose (RDF). The soil of the experimental field was clay-loam in texture, low in nitrogen and organic carbon, medium in phosphorus, and high in potassium with an alkaline pH. Results revealed that nutrient management practices significantly influenced mung bean growth, yield attributes, and quality parameters. The treatment T_7 (Seed treatment + 75% RDF + Nano-DAP foliar spray) produced the highest plant height, number of branches, dry matter accumulation, and leaf area index, indicating enhanced nutrient uptake and physiological activity. Root length, nodulation, and root biomass were also maximized in T_7, suggesting improved nitrogen fixation due to better rhizobial activity and phosphorus availability. Yield-contributing traits such as pods per plant (17.2), grains per pod (8.8), and 1000-grain weight (35.4 g) were highest in T_7, resulting in the maximum grain yield (11.60 q/ha), straw yield (32.95 q/ha), and biological yield (44.55 q/ha). The same treatment also recorded superior protein content (27.4%) and protein yield (302.22 g/plant). Economically, T_7 achieved the highest net return (₹82,231/ha) and B:C ratio (4.67), followed by T_8 (50% RDF + Nano-DAP). These results demonstrate that integrating Nano-DAP through seed treatment and foliar application with 75% RDF significantly enhances growth, yield, quality, and profitability of mung bean while reducing dependency on conventional fertilizers, making it a sustainable nutrient management strategy for pulse production.

Keywords: Nano-DAP, Mung bean, Growth and yield, Seed treatment, Sustainable nutrient management

Introduction
Pulses are a cornerstone of Indian agriculture, valued for their nutritional, economic, and environmental contributions. As the world's largest producer and consumer of pulses, India relies on these crops to support food and nutritional security, promote sustainable farming, and enhance rural livelihoods (Agarwal *et al*., 2024) [1]. This essay explores the significance of pulses, with a focus on green gram (mung bean), and discusses the role of sustainable nutrient management, particularly vermicompost, in improving productivity and soil health. Pulses are rich in protein, averaging 22–24%, compared to 8–10% in cereals (Gowda *et al*., 2013) [7]. They are a vital source of dietary protein, carbohydrates, and micronutrients such as iron and calcium, especially in vegetarian diets (Gowda *et al*., 2013) [7]. Pulses also provide lysine, an essential amino acid often limited in cereals, making them an excellent complement to cereal-based diets (Gowda *et al*., 2013) [7]. Due to their affordability and nutritional value, pulses are often called the "poor man's meat" (Agarwal *et al*., 2024) [1]. India's pulse production reached 24.49 million tonnes in 2023–24, with major crops including green gram (*Vigna radiata*), chickpea (*Cicer arietinum*), pigeon pea (*Cajanus cajan*), lentil (*Lens culinaris*), black gram (*Vigna mungo*), and kidney bean (*Phaseolus vulgaris*) (Agarwal *et al*., 2024) [1]. However, despite being the largest producer, India faces a widening protein deficit due to population growth and increased demand for protein-rich foods (Lybbert *et al*., 2023) [8].

Pulses play a crucial role in sustainable agriculture due to their ability to fix atmospheric nitrogen through symbiotic relationships with Rhizobium bacteria (Ali & Kumar, 2009) [5]. This process enriches soil fertility, reduces the need for synthetic fertilizers, and benefits subsequent crops in rotation (Ali & Kumar, 2009) [5]. Pulses also improve soil structure, organic matter content, and microbial diversity (Alekhya *et al*., 2024) [3]. Their adaptability to diverse agro-climatic conditions, drought tolerance, and varied maturity periods make pulses suitable for intercropping and crop rotation systems. These characteristics help optimize land use, reduce pest and disease incidence, and enhance overall farm productivity.

Green gram, or mung bean, is a significant pulse crop in India, believed to have originated in the Indian subcontinent (Ali & Kumar, 2009) [5]. It is highly nutritious, containing about 24% protein, 56.6% carbohydrates, and essential minerals such as calcium (124 mg/100g) and iron (7.3 mg/100g) (Ali & Kumar, 2009) [5]. Its calorific value is 334 kcal per 100 grams, making it a valuable dietary component (Ali & Kumar, 2009) [5]. Agronomically, green gram can fix up to 35 kg of atmospheric nitrogen per hectare, improving soil fertility for subsequent crops (Ali & Kumar, 2009) [5]. India cultivated green gram on 3.787 million hectares in 2023–24, producing 2.916 million tonnes, with Rajasthan as the leading producer (Agarwal *et al*., 2024) [1]. However, the average productivity in India (670 kg/ha) remains lower than in countries like the USA and Canada, where yields exceed 1,900 kg/ha (Agarwal *et al*., 2024) [1]. The rising cost of chemical fertilizers and concerns about their environmental impact have highlighted the need for sustainable nutrient management in pulse cultivation. Excessive use of synthetic fertilizers can degrade soil health, reduce microbial activity, and cause environmental pollution (Alekhya *et al*., 2024) [3].

Vermicompost, produced by the breakdown of organic matter by earthworms, supplies balanced nutrients, including nitrogen, phosphorus, potassium, and micronutrients such as zinc and iron (Alekhya *et al*., 2024) [3]. It enhances soil organic matter, improves water retention and aeration, and supports beneficial microbial activity, leading to better root development and plant health (Alekhya *et al*., 2024) [3]. Field studies have shown that applying vermicompost in green gram cultivation improves germination, increases plant vigor, and raises grain yields (Alekhya *et al*., 2024) [3]. For example, integrating vermicompost with recommended fertilizer doses increased green gram yield from 7.5 to 9 quintals per hectare and improved germination rates from 83% to 92% (Alekhya *et al*., 2024) [3]. The use of vermicompost also reduces dependence on chemical fertilizers, lowers input costs, and allows farmers to utilize organic waste efficiently (Alekhya *et al*., 2024) [3]. Recognizing the importance of pulses, the United Nations declared 2016 as the International Year of Pulses to raise awareness and promote production globally (Gowda *et al*., 2013) [7]. In India, government initiatives such as the National Food Security Mission (NFSM) and the Price Support Scheme (PSS) have aimed to boost pulse production and stabilize prices (Agarwal *et al*., 2024) [1]. These programs provide technology dissemination, input subsidies, and assured procurement to incentivize farmers (Lybbert *et al*., 2023) [8]. Despite these efforts, challenges remain. Pulses are often grown on marginal lands with limited irrigation, and there is a lack of high-yielding varieties and access to quality inputs (Gowda *et al*., 2013) [7]. Addressing these issues requires continued policy support, investment in research, and the promotion of sustainable practices such as integrated nutrient management and organic amendments (Alekhya *et al*., 2024) [3].

Materials and Methods

The experiment entitled "Studies on the Impact of Nano-DAP on Growth, Yield and Quality of Mung Bean (*Vigna radiata* L.)" was conducted during the summer season of 2025 at the Agricultural Research Farm, Career Point University, Alaniya, Kota (Rajasthan). This study provides a detailed account of the experimental location, soil characteristics, and prevailing climatic conditions during the crop growth period. The site is situated about 34 km from Kota Railway Station at 25°11' N latitude, 75°54' E longitude, and an elevation of 273 meters above mean sea level, falling within the Humid South Eastern Plain Zone (Zone V) of Rajasthan. The soil of the experimental field was primarily clay loam with saline groundwater and a fairly level topography. Weather data recorded at the Meteorological Observatory of the University indicated that weekly mean maximum temperatures ranged from 22.9 °C to 38.3 °C (average 29.14 °C), and minimum temperatures varied from 3.5 °C to 23.3 °C (average 10.77 °C). Relative humidity fluctuated between 28.8% and 93.0%, with an average of 69.18%, and a total rainfall of 0.3 mm was received during the 50th meteorological week.

To determine the mechanical and chemical composition of the soil at the experimental site, composite soil samples were collected from a depth of 0–15 cm prior to preparatory cultivation. These samples were analyzed using standard procedures to assess various physical and chemical properties. The analysis indicated that the soil of the experimental field was clay-loam in texture**,** low in organic carbon (0.44%)**,** low in available nitrogen (176 kg/ha) medium in available phosphorus (15.6 kg/ha**)**, and high in available potassium (321 kg/ha)**.** The soil was alkaline in reaction with a pH of 8.1 and had an electrical conductivity of 0.26 dS/m indicating non-saline conditions. The cropping history of the experimental field provides an understanding of its production potential and soil fertility status. During the 2021–22 season soybean and wheat were cultivated; in 2022–23, the field was planted with paddy, gram, and urd; while in 2023–24, paddy, wheat, and mung bean were grown successively. The present experiment on mung bean was conducted during the summer season of 2025 at the Agricultural Farm, Career Point University, Kota. The field followed the recommended crop rotations for the region, ensuring balanced nutrient utilization and preventing any adverse impact on soil health and productivity.

The foliar application of Nano-DAP, a 0.4% solution (4 ml Nano-DAP per liter of water) was sprayed at 20 and 40 days after sowing using a knapsack sprayer with a fine nozzle. Spraying was done in the early morning or late evening to ensure uniform coverage and minimize leaf burn. seed treatment**,** 4 ml of Nano-DAP was mixed with 10 ml of vermiwash and blended with 1 kg of mung bean seeds to achieve uniform coating. The treated seeds were shade-dried for 30 minutes before sowing, promoting better germination, early vigor, and improved crop growth.

Experiment details

The treatments (08) comprised of weed management practices involving inorganic, organic sources, herbicides, mulching practices are follows:

S. No.	Treatment	Symbol
1.	Control	T1
2.	100% RDF (NPK) 20:40:40	T2
3.	75% RDF + Nano- DAP (foliar Spray @ 0.4% at 20, 40 DAS)	T3
4.	50% RDF + Nano- DAP (foliar Spray @ 0.4% at 20, 40 DAS)	T4
5.	Nano- DAP (foliar Spray @ 0.4% at 20, 40 DAS)	T5
6.	Seed Treatment of Nano- DAP + Nano- DAP (foliar Spray @ 0.4% at 20, 40 DAS)	T6
7.	Seed Treatment of Nano- DAP + 75% RDF + Nano- DAP (foliar Spray @ 0.4% at 20, 40 DAS)	T7
8.	Seed Treatment of Nano- DAP + 50% RDF + Nano- DAP (foliar Spray @ 0.4% at 20, 40 DAS)	T8

Experimental and layout details

Season	Zaid
Design	RBD (Randomized Block Design)
Total number of treatments	8
Replication	3
Total number of plots: 8 × 3	24
Gross plot size: 4.8m × 3.6m	17.28 m^2
Net plot size: 3.8m × 1.8m	6.84 m^2
Irrigation channels	1.0 m
Replication border	1.5 m
Row to row spacing	30 cm
Plant to plant spacing	08 cm
Seed Rate	12 kg ha^{-1}
Variety	MH 1142
Fertilizers	20 kg N, 40 kg P_2O_5 and 40 kg K_2O ha^{-1}

Results and discussion:

The present investigation entitled "Studies on the Impact of Nano-DAP on Growth, Yield, and Quality of Mung Bean (*Vigna radiata* L.)" was conducted at the Agricultural Research Farm, Career Point University, Kota, during the summer season of 2025 to evaluate the effect of Nano-DAP applied as seed treatment and foliar spray in combination with reduced recommended fertilizer dose (RDF). Growth attributes such as plant height, number of branches, trifoliate leaves, dry matter accumulation, and leaf area index were significantly influenced by nutrient management practices. The combined treatment T_7 (Seed treatment with Nano-DAP + 75% RDF + Nano-DAP foliar spray) consistently produced the highest values across all growth stages. Enhanced vegetative growth in T_7 may be attributed to improved nutrient availability and uptake, particularly nitrogen and phosphorus supplied through Nano-DAP, which promote cell division, elongation, and photosynthetic efficiency (Chhipa & Kaushik, 2023; Prasad *et al*., 2018) [6, 10]. Root parameters including root length, fresh and dry weight, and nodule formation were also highest under T_7, indicating that Nano-DAP enhanced root proliferation and rhizobial activity, leading to better nitrogen fixation (Mukherjee & Rai, 2019) [9]. Phosphorus supplied via Nano-DAP likely improved energy transfer and enzyme function essential for nodulation and root growth (Subramanian *et al*., 2015) [11].

Significant improvements were observed in yield attributes such as number of pods per plant, pod length, grains per pod, and 1000-grain weight, culminating in maximum grain yield (11.60 q/ha), straw yield (32.95 q/ha), and biological yield (44.55 q/ha) under T_7. The enhanced yield was due to improved vegetative growth, higher photosynthetic efficiency, and effective translocation of assimilates (Agarwal *et al*., 2024) [1]. Although the harvest index slightly declined compared to control, the absolute productivity was much higher. In terms of quality, the protein content (27.4%) and protein yield (302.22 g/plant) were highest in T_7, reflecting enhanced nitrogen assimilation under balanced nutrient supply (Alekhya *et al*., 2024). Economically, T_7 recorded the highest gross return (₹104,665/ha), net return (₹82,231/ha), and benefit-cost ratio (4.67), followed by T_8 and T_3. The substantial economic advantage of Nano-DAP-based treatments demonstrates its efficiency in improving yield and profitability with reduced dependence on conventional fertilizers. Overall, the study concludes that integrated use of Nano-DAP (as seed treatment and foliar spray) with 75% RDF significantly enhances growth, yield, quality, and economic returns of mung bean, emphasizing its potential as a sustainable nutrient management strategy for pulse production.

Conclusion

Treatment T_7 (Seed treatment + 75% RDF + Nano-DAP foliar spray) proved most effective, recording the highest grain (11.60 q/ha), straw (32.95 q/ha), and biological yield (44.55 q/ha) with superior yield traits (17.2 pods/plant, 8.8 grains/pod, 35.4 g test weight). It was statistically at par with T_8 (Seed treatment + 50% RDF + Nano - DAP). Economically, T_7 achieved the highest net return (₹81,981/ha) and B: C ratio (4.67)**,** while T_8 offered good profitability (₹70,480/ha, B:C 4.26). The control (T_1) showed the lowest returns (₹24,367/ha, B:C 2.36), highlighting the benefits of Nano-DAP-based nutrient management.

Table 1: Effect different treatment on Plant height (cm) in mung bean during summer mung 2025

Symbol	Treatment	Plant height (cm)		
T_1	Control	25 DAS	50 DAS	At harvest
T_2	100% RDF (NPK) 20:40:40	20.4	33.2	44.6
T_3	75% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	24.1	38.2	49.2
T_4	50% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	27.2	43.9	56.2
T_5	Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	25.7	41.7	53.8
T_6	Seed Treatment of Nano-DAP + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	22.3	36.1	47.3

T_7	Seed Treatment of Nano-DAP + 75% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	24.5	39.8	51.4
T_8	Seed Treatment of Nano-DAP + 50% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	29.7	47.8	60.3
SEm (±)	0.9	28.5	46.2	58.5
C.D. (P=0.05)		2.6	1.5	1.8
		2.6	4.3	5.4

Table 2: Effect different treatment on Number of branches plant-1

Symbol	Treatment	Number of branches plant^{-1}	
T_1	Control	**50 DAS**	**At harvest**
T_2	100% RDF (NPK) 20:40:40	2.1	2.9
T_3	75% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	2.5	3.3
T_4	50% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	3.2	4.1
T_5	Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	3.0	3.9
T_6	Seed Treatment of Nano-DAP + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	2.3	3.2
T_7	Seed Treatment of Nano-DAP + 75% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	2.8	3.7
T_8	Seed Treatment of Nano-DAP + 50% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	3.8	4.8
SEm (±)	0.2	3.5	4.4
C.D. (P=0.05)		0.2	

Table 3: Effect different treatment on Effective Nodules (No. plant-^{1}) and Nodules Dry Weight (mg plant-^{1}) in mung bean during summer mung 2025.

Symbol	Treatment	Effective Nodules (No. plant^{-1})	Nodules Dry Weight (mg plant^{-1})
T_1	Control	31.4	272.0
T_2	100% RDF (NPK) 20:40:40	37.2	318.5
T_3	75% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	42.8	362.4
T_4	50% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	41.5	349.6
T_5	Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	34.6	306.8
T_6	Seed Treatment of Nano-DAP + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	39.8	334.7
T_7	Seed Treatment of Nano-DAP + 75% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	44.8	382.0
T_8	Seed Treatment of Nano-DAP + 50% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	43.7	372.5
SEm (±)		1.3	9.5
C.D. (P=0.05)		3.8	27.6

Table 4: Effect different treatment on yield attribute in mung bean during summer mung 2025.

Symbol	Treatment	No. of Pods plant^{-1}	Pod length (cm)	No. of Grains pod^{-1}	Grain yield (g plant^{-1})	1000 grains weight (g)
T_1	Control	10.0	4.1	4.9	1.60	30.2
T_2	100% RDF (NPK) 20:40:40	12.6	6.3	6.1	2.45	31.8
T_3	75% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	15.4	8.9	7.8	3.78	34.1
T_4	50% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	14.1	8.2	7.4	3.42	33.5
T_5	Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	11.2	5.6	5.8	2.20	31.4
T_6	Seed Treatment of Nano-DAP + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	13.2	7.4	6.7	2.96	32.7
T_7	Seed Treatment of Nano-DAP + 75% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	17.2	10.2	8.8	4.60	35.4
T_8	Seed Treatment of Nano-DAP + 50% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	16.1	9.7	8.2	4.15	34.8
SEm (±)		0.5	0.3	0.2	0.14	0.3
C.D. (P=0.05)		1.4	0.8	0.6	0.42	0.9

Table 5: Effect different treatment on Yield, Straw yield, Biological yield and Harvest index in mung bean during summer mung 2025

Symbol	Treatment	Grain (q ha-^{1})	Straw (q ha-^{1})	Biological q ha-^{1})	Harvest Index (%)
T_1	Control	470	1270	1740	27.01
T_2	100% RDF (NPK) 20:40:40	610	1830	2440	25.00
T_3	75% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	830	2650	3480	23.85
T_4	50% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	750	2380	3130	23.96
T_5	Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	550	1690	2240	24.55
T_6	Seed Treatment of Nano-DAP + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	680	2070	2750	24.73
T_7	Seed Treatment of Nano-DAP + 75% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	1160	3295	4455	26.04

T_8	Seed Treatment of Nano-DAP + 50% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	1020	2940	3960	25.76
SEm (±)		0.42	1.15	1.51	0.24
C.D. (P=0.05)		1.25	3.38	4.47	0.72

Table 6: Effect different treatment on Protein Content (%) and protein Yield (g plant^{-1}) in mung bean during summer mung 2025

Symbol	Treatment	Protein Content (%)	Protein Yield (kg ha^{-1})
T_1	Control	18.3	104.72
T_2	100% RDF (NPK) 20:40:40	20.3	167.62
T_3	75% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	24.5	248.38
T_4	50% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	23.1	221.46
T_5	Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	19.3	136.17
T_6	Seed Treatment of Nano-DAP + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	21.7	194.54
T_7	Seed Treatment of Nano-DAP + 75% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	27.4	302.22
T_8	Seed Treatment of Nano-DAP + 50% RDF + Nano-DAP (foliar Spray @ 0.4% at 20, 40 DAS)	25.9	275.30
SEm (±)		0.5	11.9
C.D. (P=0.05)		1.5	35.3

Table 7: Effect different treatment on Protein Content (%) and protein Yield (g plant^{-1}) in mung bean during summer mung 2025

Symbol	Treatment	Common Cost (₹/ha)	Treatment Cost (₹/ha)	Gross Income (₹/ha)	Total Cost (₹/ha)	Net Income (₹/ha)	B:C Ratio
T_1	Control	17,962	0	42,329	17,962	24,367	2.36
T_2	100% RDF	17,962	3,320	55,156	21,282	33,874	2.59
T_3	75% RDF + Nano-DAP	17,962	4,222	75,241	22,184	53,057	3.39
T_4	50% RDF + Nano-DAP	17,962	3,142	67,971	21,104	46,867	3.22
T_5	Nano-DAP only	17,962	1,482	49,779	19,444	30,335	2.56
T_6	Seed Treatment + Nano-DAP	17,962	1,982	61,522	19,944	41,578	3.08
T_7	Seed Treatment + 75% RDF + Nano-DAP	17,962	4,722	104,665	22,684	81,981	4.61
T_8	Seed Treatment + 50% RDF + Nano-DAP	17,962	3,642	92,084	21,604	70,480	4.26

References

1. Agarwal D, Devra SJ, Siddharajsinh R. Pulses in India: Comprehensive analysis of production, challenges, and strategic vision for 2030. J Exp Agric Int. 2024;46(11):293–304.
2. Agarwal R, Singh P, Meena RS. Status and trends in pulse production in India. Indian J Agric Sci. 2024;94(2):215–23.
3. Alekhya G, Reddy M, Rao V. Impact of organic nutrient management on pulses productivity and soil fertility. J Agron Crop Sci. 2024;210(1):45–56.
4. Alekhya G, Darjee S, Rajareddy G, Reddy KS, Kumar AA, Reddy AJ. Integrating pulses into conservation agriculture for sustainable soil health and productivity in the Indo-Gangetic Plains. J Sci Res Rep. 2024;30(9):560–70.
5. Ali M, Kumar S. Milestones in Food Legumes Research. Kanpur: Indian Institute of Pulses Research; 2009.
6. Chhipa H, Kaushik N. Nanotechnology in nutrient management: Opportunities and challenges. Adv Nano Res Agric. 2023;15(3):112–25.
7. Gowda CLL, Chaturvedi SK, Gaur PM, Kumar CVS, Jukanti AK. Pulses research and development strategies for India. Indian J Agric Sci. 2013;83(12):1239–52.
8. Lybbert TJ, Shenoy A, Bourdier T, Kieran C. Striving to revive pulses in India with extension, input subsidies, and output price supports. Am J Agric Econ. 2023.
9. Mukherjee A, Rai M. Application of nanoparticles in agriculture and their impact on soil microbial activity. Appl Microbiol Biotechnol. 2019;103(2):871–85.
10. Prasad R, Bhattacharyya A, Nguyen QD. Nanotechnology in sustainable agriculture: Recent developments, challenges, and perspectives. Front Microbiol. 2018;9:1014.
11. Subramanian KS, Manikandan A, Thirunavukkarasu M, Rahale CS. Nanofertilizers for balanced crop nutrition. In: Rai M, Ribeiro C, Mattoso L, Duran N, editors. Nanotechnologies in Food and Agriculture. Cham: Springer; 2015. p. 69–80.