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Nikhil Kumar
Department of Agronomy, Sardar
Vallabhbhai Patel University of
Agriculture and Technology,
Meerut, Uttar Pradesh, India

Adesh Singh
Department of Agronomy, Sardar
Vallabhbhai Patel University of
Agriculture and Technology,
Meerut, Uttar Pradesh, India

Mukesh Kumar
Department of Agronomy, Sardar
Vallabhbhai Patel University of
Agriculture and Technology,
Meerut, Uttar Pradesh, India

PK Singh
Department of Agronomy, Sardar
Vallabhbhai Patel University of
Agriculture and Technology,
Meerut, Uttar Pradesh, India

SP Singh
Department of Soil Science, Sardar
Vallabhbhai Patel University of
Agriculture and Technology,
Meerut, Uttar Pradesh, India

Corresponding Author:
Nikhil Kumar
Department of Agronomy, Sardar
Vallabhbhai Patel University of
Agriculture and Technology,
Meerut, Uttar Pradesh, India

Efficient phosphorus management in *Summer mungbean* (*Vigna radiata* L.)

Nikhil Kumar, Adesh Singh, Mukesh Kumar, PK Singh and SP Singh

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Abstract

The present investigation, entitled "Effect of Efficient Sulfur Fertilization on *Summer Mungbean* (*Vigna radiata* L.)", was conducted during the *summer* season of 2025 at the Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh. The experiment was laid out in a Randomized Block Design with ten treatments viz., T₁ Control, T₂-RDP (DAP), T₃-RDP (SSP), T₄-RDP (DAP+SSP, 1:1), T₅-50% RDP + seed treatment with biophos, T₆-50% RDP + Nano DAP @4 ml L⁻¹ at pre-flowering and pod formation stage (IFFCO), T₇-50% RDP + Nano DAP @4 ml L⁻¹ at pre-flowering and pod formation stage (Jai Kisaan Navratna), T₈-50% RDP + DAP @1% at pre-flowering and pod formation stage, T₉-Seed treatment with biophos @20 g kg⁻¹ seed + spray at pre-flowering (IFFCO), and T₁₀-Seed treatment with biophos @20 g kg⁻¹ seed + spray at pre-flowering (Jai Kisaan Navratna).

The results revealed that phosphorus management treatments significantly influenced the growth parameters and yield-attributing characters, viz., number of pods plant⁻¹, number of grains pod⁻¹, grain yield plant⁻¹ and test weight. The crop treated with T₆ had the highest number of pods plant⁻¹ (25.2), number of grains pod⁻¹ (9.8), grain yield plant⁻¹ (4.9 g) and test weight (35.8 g), as against 17.6, 6.0, 2.1 g and 31.0 g, respectively, with the control. The treatment T₆ also recorded the highest grain (1326 kg ha⁻¹), straw (3097 kg ha⁻¹), biological yield (4423 kg ha⁻¹) and harvest index (30.77%), as against 960 kg ha⁻¹, 1887 kg ha⁻¹, 2847 kg ha⁻¹ and 27.78%, respectively, with the control. phosphorus management also improved nodulation, quality attributes, nutrient content and uptake and soil fertility status. The next best options were (50% RDP + Nano DAP @4 ml L⁻¹, Jai Kisaan Navratna, at pre-flowering and pod formation stage) and (RDP through DAP+SSP, 1:1). Thus, it is evident that different sources and methods of phosphorus management significantly affected the population, growth, root development, nodulation, yield attributes, yield, quality, nutrient content and uptake, residual soil fertility and economics of *summer* mungbean.

Keywords: Nanourea, conventional urea, growth, LAI, yield and wheat

1. Introduction

Pulses are nutritionally important food crops owing to their high protein content and wide range of essential nutrients. In general, most pulses contain approximately 21–25 per cent protein, which is considerably higher than that of commonly consumed cereal grains. Pulse proteins are relatively rich in lysine, an essential amino acid that is often limited in cereals; therefore, combining pulses with cereals can improve the overall quality and balance of dietary protein. Incorporating pulses into crop rotations and intercropping systems can further enhance nutrient cycling, soil organic carbon accumulation, soil microbial activity and other important soil properties. Thus, pulse-based cropping systems offer an effective approach for improving soil fertility, resource-use efficiency and the long-term sustainability of agricultural production (Palmero *et al.*, 2022; Kumar *et al.*, 2023) [13, 6].

Mungbean (*Vigna radiata* L.) is a nutritionally important pulse crop and is considered a valuable source of high-quality, easily digestible plant protein. The seeds generally contain about 20–32 per cent protein along with substantial amounts of carbohydrates, dietary fibre, vitamins, minerals and various bioactive compounds. Recent research has demonstrated considerable interest in mungbean protein because of its nutritional quality, digestibility and potential applications in various functional and plant-based food products (Li *et al.*, 2023; Feng *et al.*, 2024) [3]. Mungbean (*Vigna radiata* L.) is an important pulse crop cultivated widely across tropical and subtropical regions, with major production concentrated in South and Southeast Asia. Globally, mungbean is

cultivated on approximately 7.3 million hectares, producing around 5.3 million tonnes annually, with an average productivity of about 721 kg ha⁻¹ (Anonymous, 2025). India is one of the major producers of mungbean and contributes substantially to global production.

Phosphorus (P) is one of the essential macronutrients required for optimum plant growth, development and productivity. It plays a fundamental role in energy transfer, photosynthesis, nucleic acid synthesis, cell division and root development. Phosphorus availability is often constrained in agricultural soils because a considerable proportion of applied P can become unavailable through fixation and precipitation reactions. Phosphorus (P) is one of the essential macronutrients required for optimum growth, development and productivity of crops. However, the recovery of applied phosphorus by crops is generally low because a considerable proportion of fertilizer phosphorus is converted into less available forms through fixation and precipitation reactions. In acidic soils, phosphorus is predominantly associated with iron and aluminium, whereas in alkaline and calcareous soils it may react with calcium and form relatively insoluble compounds. Consequently, improving phosphorus availability and phosphorus-use efficiency is an important component of sustainable nutrient management (Prasad and Shivay, 2021; Lambers, 2022) [14].

2. Materials and Methods

This chapter provides a description of the materials and methodology used in the study Efficient Phosphorus Management in Summer Mungbean (*Vigna radiata* L.). At a latitude of 29.081833 North, longitude of 77.700589 East, and elevation of

237 meters above mean sea level, the field experiment was conducted at the Crop Research Center of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.). Meerut has a subtropical climate and is located in the center of Western Uttar Pradesh. The geography of the trial field was uniform, and the drainage system was effective.

The experimental field's soil had a sandy loam texture, low levels of accessible nitrogen and organic carbon, medium levels of available phosphorus, potassium and sulfur, and a reaction that was almost neutral. Virat (IPM 205-7) was sown on 29 March 2025. The experiment was laid out in a Randomized Block Design (RBD) with 10 treatments with 3 replications. Ten plots of gross plot size (5 m × 3.3 m) and net plot size (4 m × 2.1 m) were included in each replication.

3. Results and Discussion

3.1. Yield attributing characters

3.1.1 Number of pods plant⁻¹

Phosphorus management had a significant effect on the number of pods plant⁻¹. Significantly the highest number of pods plant⁻¹ was obtained with T₆ (25.2), statistically *at par* with T₇ (23.5), but significantly superior to the rest of the treatments. The percentage increase in pods plant⁻¹ under T₂ was 20.5% over the T₉.

3.1.2 Number of grains pod⁻¹

The number of grains pod⁻¹ was significantly influenced by phosphorus management, being highest under T₆ (9.8), followed by T₇ (9.4) and T₄ (9.0), while the minimum number of grains pod⁻¹ was recorded under the control (6.0).

Table 1: Effect of efficient phosphorus management on yield attributes in mungbean

Treatment	Yield attributes			
	No. pods plant ⁻¹	No. grains pod ⁻¹	Grain yield plant ⁻¹ (g)	Test weight (g)
T ₁ - Control (No Phosphorus)	17.6	6.0	2.1	31.0
T ₂ - RDP (DAP)	21.5	8.2	4.3	34.5
T ₃ - RDP (SSP)	22.5	8.6	4.5	35.0
T ₄ - RDP (DAP+SSP,1:1)	23.0	9.0	4.6	35.2
T ₅ - 50% RDP + seed treatment with biophos @20 g kg ⁻¹ seed	20.0	7.5	4.0	33.5
T ₆ - 50% RDP + Nano DAP @4 ml L ⁻¹ at pre-flowering and pod formation stage (IFFCO)	25.2	9.8	4.9	35.8
T ₇ - 50% RDP + Nano DAP @4 ml L ⁻¹ at pre-flowering and pod formation stage (Jai Kisaan Navratna)	23.5	9.4	4.7	35.5
T ₈ - 50% RDP + DAP @1% at pre-flowering and pod formation stage	21.0	8.0	4.2	34.2
T ₉ - Seed treatment with biophos @20 g kg ⁻¹ seed + spray at pre-flowering (IFFCO)	19.5	7.2	3.9	32.8
T ₁₀ - Seed treatment with biophos @20 g kg ⁻¹ seed + spray at pre-flowering (Jai Kisaan Navratna)	18.5	6.8	3.8	32.2
S.Em.±	0.65	0.43	0.20	1.41
C.D. (p=0.05)	1.93	1.27	0.58	4.20

3.1.3 Grain yield plant⁻¹ (g) and test weight (g)

Grain yield plant⁻¹ and test weight varied significantly with phosphorus management. Maximum grain yield plant⁻¹ (4.9 g) and test weight (35.8 g) were recorded with T₆, remaining *at par* with T₇ (4.7 g, 35.5 g) and T₄ (4.6 g, 35.2 g), while significantly superior over the rest of the treatments. The lowest grain yield plant⁻¹ (2.1 g) and test weight (31.0 g) were recorded under the control. Grain yield plant⁻¹ under T₆ increased by 25.6% over the T₉. These findings corroborate the reports of Owla *et al.* (2007) [12], Hamza *et al.* (2016) [4], Venkata Rao *et al.* (2017), Mandiwal *et al.* (2019) [11], Yadav *et al.* (2021) [16], Poudel and Mahato (2025) and Khatik *et al.* (2025) [5] of improved yield attributes and

yield of mungbean and greengram with efficient phosphorus management.

3.2. Yield

3.2.1 Grain yield (kg ha⁻¹)

Grain yield (kg ha⁻¹) varied significantly with phosphorus management (Table 4.12). The maximum grain yield (1326 kg ha⁻¹) was recorded with T₆, which remained *at par* with T₇ (1238 kg ha⁻¹) and T₄ (1205 kg ha⁻¹), while significantly superior to the rest of the treatments. The minimum grain yield was recorded under the control (960 kg ha⁻¹). The increase in grain yield under T₆ was 38.1% over the control.

Table 2: Effect of efficient phosphorus management on yield quality parameters in mungbean

Treatment	Yield kg ha ⁻¹			H.I. (%)
	Grain yield	Straw yield	Biological yield	
T ₁ - Control (No Phosphorus)	960	1887	2847	27.78
T ₂ - RDP (DAP)	1167	2614	3782	30.03
T ₃ - RDP (SSP)	1193	2791	3984	30.40
T ₄ - RDP (DAP+SSP,1:1)	1205	2837	4042	30.49
T ₅ - 50% RDP + seed treatment with biophos @20 g kg ⁻¹ seed	1097	2317	3414	29.07
T ₆ - 50% RDP + Nano DAP @4 ml L ⁻¹ at pre-flowering and pod formation stage (IFFCO)	1326	3097	4423	30.77
T ₇ - 50% RDP + Nano DAP @4 ml L ⁻¹ at pre-flowering and pod formation stage (Jai Kisaan Navratna)	1238	2943	4181	30.50
T ₈ - 50% RDP + DAP @1% at pre-flowering and pod formation stage	1147	2500	3647	29.76
T ₉ - Seed treatment with biophos @20 g kg ⁻¹ seed + spray at pre-flowering (IFFCO)	1037	2091	3129	28.50
T ₁₀ - Seed treatment with biophos @20 g kg ⁻¹ seed + spray at pre-flowering (Jai Kisaan Navratna)	1013	1902	2916	28.25
S.E.m.±	34	91	124	0.60
C.D. (p=0.05)	100	270	369	1.77

3.2.2 Straw yield (kg ha⁻¹)

Straw yield varied between 1887 and 3097 kg ha⁻¹ among the different treatments, being highest under T₆, followed by T₇. The treatments receiving foliar application of phosphorus over and above the sub-optimal basal dose (T₆, T₇ and T₈) remained statistically *at par* with each other. The increase in straw yield under T₂ was 25.01% over the T₉.

3.2.3 Biological yield (kg ha⁻¹)

Biological yield increased significantly with phosphorus management, irrespective of the source, in comparison to the control. The highest biological yield (4423 kg ha⁻¹) was recorded with T₆, followed by T₇ (4181 kg ha⁻¹), while the minimum (2847 kg ha⁻¹) was recorded under the control – an increase of 41.9% under T₄.

3.2.4 Harvest index

Phosphorus treatments varied significant effect on harvest index of mungbean (Table 4.12 and Appendix-XII). Harvest index, among different treatment varied from 27.78 to 30.77%.

The maximum harvest index of 30.77% was recorded in treatment receiving 50% RDP + Nano DAP @4 ml L⁻¹ at pre-flowering and pod formation stage (T₆), which remained *at par* with T₇ (30.50), T₄ (30.49) and T₃ (30.40) minimum under the control (27.78).

4. Phosphorus contents and uptake

4.1 Phosphorus contents (%) in grains and straw

Perusal of data presented in Table 4.14 and their data analysis Appendix-XIV phosphorus content in grain ranged between

0.410 to 0.510% and was significantly highest under 50% RDP + Nano DAP @4 ml L⁻¹ at pre-flowering and pod formation stage (T₆) in grain (0.510%), while the lowest was recorded under the control (0.410%).

Phosphorus content in straw ranged between 0.198 to 0.261%, respectively, and was significantly highest under 50% RDP + Nano DAP @4 ml L⁻¹ at pre-flowering and pod formation stage (T₆) in straw (0.261%), while the lowest was recorded under the control (0.198%).

4.2 Phosphorus uptake in grains, straw and total (kg ha⁻¹)

Significant variation was observed in phosphorus uptake by grains and straw as well as total among different phosphorus management (Appendix-XVII). Phosphorus uptake in grains, straw and ranged from 1.87 to 5.73, 4.16 to 8.59 and 6.0 to 14.3 kg ha⁻¹, respectively under different phosphorus treatments.

Perusal of data presented in Table 4.17 revealed that all the phosphorus management significantly increased the phosphorus uptake over control. Maximum phosphorus uptake was recorded under T₆ (grain 5.73, straw 8.59, total 14.3 kg ha⁻¹), followed by T₇ (total 13.2 kg ha⁻¹), while minimum uptake was recorded under the control (total 6.0 kg ha⁻¹). Under T₇, total phosphorus uptake increased by 23.4% over the T₂. These results are in line with the reports of Mandal *et al.* (2005) ^[10], Appanna *et al.* (2008) ^[11], Kumawat *et al.* (2009) ^[7], Sharma *et al.* (2010) ^[15] and Nandan *et al.* (2013) of phosphorus-nitrogen synergism and enhanced nutrient uptake with efficient phosphorus management in mungbean.

Table 3: Effect of efficient phosphorus management on nutrient content (%) and uptake (kg ha⁻¹) in grains, straw and total in mungbean

Treatment	Phosphorus content (%)		Phosphorus uptake (kg ha ⁻¹)		Total uptake (kg ha ⁻¹)
	Grains	Straw	Grains	Straw	
T ₁ - Control (No Phosphorus)	0.410	0.198	1.87	4.16	6.0
T ₂ - RDP (DAP)	0.470	0.242	3.87	6.83	10.7
T ₃ - RDP (SSP)	0.480	0.248	4.39	7.23	11.6
T ₄ - RDP (DAP+SSP,1:1)	0.490	0.250	4.90	7.41	12.3
T ₅ - 50% RDP + seed treatment with biophos @20 g kg ⁻¹ seed	0.450	0.231	3.11	6.37	9.5
T ₆ - 50% RDP + Nano DAP @4 ml L ⁻¹ at pre-flowering and pod formation stage (IFFCO)	0.510	0.261	5.73	8.59	14.3
T ₇ - 50% RDP + Nano DAP @4 ml L ⁻¹ at pre-flowering and pod formation stage (Jai Kisaan Navratna)	0.500	0.256	5.35	7.88	13.2
T ₈ - 50% RDP + DAP @1% at pre-flowering and pod formation stage	0.460	0.238	3.51	6.7	10.2
T ₉ - Seed treatment with biophos @20 g kg ⁻¹ seed + spray at pre-flowering (IFFCO)	0.440	0.227	3.03	5.92	9.0
T ₁₀ - Seed treatment with biophos @20 g kg ⁻¹ seed + spray at pre-flowering (Jai Kisaan Navratna)	0.430	0.221	2.96	5.57	8.5
S.E.m.±	0.010	0.010	0.14	0.24	0.37
C.D. (p=0.05)	0.030	0.020	0.42	0.70	1.11

5. Conclusion

On perusal of the findings, it is evident that different sources and methods of phosphorus management significantly affected the population, growth, root development, nodulation, yield attributes, yield, quality, nutrient content and uptake, residual soil fertility and economics of *summer* mungbean. It may therefore be concluded that supplementing a reduced (50%) basal dose of recommended phosphorus with foliar spray of Nano DAP @4 ml L⁻¹ (IFFCO) at the pre-flowering and pod formation stages (T₆) led to the highest grain yield (1326 kg ha⁻¹) and fetched the highest net return (Rs 84,476 ha⁻¹), being higher by 366 kg ha⁻¹ and Rs 31,492 ha⁻¹ than the control, respectively, besides improving root development, nodulation, quality attributes, nutrient content and uptake, and residual soil fertility status. The next best options were T₇ (50% RDP + Nano DAP @4 ml L⁻¹, Jai Kisaan Navratna, at pre-flowering and pod formation stage) and T₄ (RDP through DAP+SSP, 1:1). Since the findings are based on a single season of experimentation, there is a need for experimenting for one or more additional seasons to arrive at a consistent and confirmatory conclusion before recommending T₆ for large-scale adoption by farmers.

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