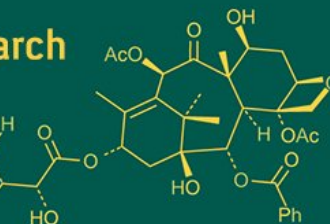
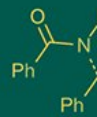


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Effect of nitrogen and phosphorus levels on growth and yield of cowpea (*Vigna unguiculata* L. walp.)

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Abstract

The present investigation was conducted during the *Kharif* season of 2024 at the Horticulture Research Farm, School of Agriculture Science, Technology and Research, Sardar Patel University, Balaghat, Madhya Pradesh, to evaluate the effect of different nitrogen and phosphorus levels on the growth and yield of vegetable cowpea. Nitrogen and phosphorus are the primary macronutrients required for optimum growth and productivity of vegetable cowpea (*Vigna unguiculata* L. Walp.). The experiment was laid out in a factorial randomized block design with three replications comprising four nitrogen levels (0, 20, 40 and 60 kg N ha⁻¹) and four phosphorus levels (0, 20, 40 and 60 kg P₂O₅ ha⁻¹). The results revealed that increasing nitrogen and phosphorus levels significantly improved vegetative growth, nodulation, chlorophyll content, flowering, yield attributes and green pod yield. Among the nitrogen treatments, application of 60 kg N ha⁻¹ (N₃) recorded the maximum plant height (53.78 cm at 60 DAS and 74.40 cm at harvest), number of primary branches (6.06 plant⁻¹), chlorophyll content (2.57 mg g⁻¹), pod length (19.40 cm), pod yield (101.05 g plant⁻¹) and green pod yield (135.90 q ha⁻¹). Likewise, 60 kg P₂O₅ ha⁻¹ (P₃) produced superior growth and yield parameters, recording the highest green pod yield of 133.65 q ha⁻¹. However, 40 kg N ha⁻¹ and 40 kg P₂O₅ ha⁻¹ were statistically at par with the highest fertilizer levels for most observations, indicating that these doses may be economically feasible under similar agro-climatic conditions. The study concluded that balanced nitrogen and phosphorus nutrition plays a crucial role in improving growth, reproductive development and green pod productivity of vegetable cowpea.

Keywords: Cowpea, Nitrogen fertilization, Phosphorus fertilization, Green pod yield and Nutrient management

Introduction

Cowpea (*Vigna unguiculata* L. Walp.) is one of the earliest legumes to have been cultivated as both a grain and a vegetable and is a member of the Fabaceae family. It is thought to have originated in Africa and from there it was transmitted to Asia, Europe and the Americas via ancient trade routes. Because of its great capacity to adapt to a wide range of agro-climatic conditions, the crop is now grown in tropical, subtropical and semi-arid areas all over the world. It is regarded as a climate-resilient crop since it has a high tolerance to drought, high temperatures, low soil fertility and irregular rainfall, which makes it well suited to sustainable agriculture in the light of changing climate conditions. The fact that it can retain its productivity when under moisture stress has increased its value in rainfed farming systems, especially in developing countries where climate variability often hinders agricultural production. Moreover, cowpea has the special ability to form a symbiotic relationship with Rhizobium bacteria, thus allowing biological nitrogen fixation and enhancing soil fertility while at the same time reducing the need for synthetic nitrogen fertilisers. As a result, the crop makes a contribution not only to food and nutritional security but also to environmental sustainability and to the resilience of farming systems. (Kim D-K *et al.*, 2025) [5]. It can be said that cowpea is an all-round crop since every bit of it has economic value. Unripe pods are used as vegetable food, ripe beans are used as pulses, young leaves are used as leafy vegetables in some countries and the residues of the crop provide high-quality fodder for animals. Furthermore, cowpea is often used as green manure and cover crop due to its fast growth, wide canopy formation ability and ability to increase

Soil organic matter. Cowpea helps to control weeds, prevent soil erosion, increase the activity of soil Microbes and provides residual nitrogen for the subsequent crop. Thus, cowpea is commonly used as a component of cropping systems based on cereals and rotations to increase soil fertility and the overall productivity of the system. Its versatility makes it one of the most important legume crops for poor farmers in areas where sustainable agriculture intensification is crucial. (Kim D-K *et al.*, 2025) [5].

From a nutritionist's perspective, cowpea is highly nutritious as a vegetable because it is one of the best sources of proteins and essential minerals in plants. The fresh vegetable pods are rich in protein, carbohydrate, fiber, vitamin C, beta carotene, folic acid, calcium, phosphorus, potassium, and magnesium and iron, whereas the dried seeds have about 23-30% proteins containing reasonable amounts of lysine and other essential amino acids. Cowpea also has substantial levels of phenolics, flavonoids, and antioxidants which are beneficial to humans since they help minimize oxidative stress and prevent the development of different chronic diseases. Due to its high nutritional value and relatively low cost, cowpea has become an important part of balanced diets in many developing nations where it helps address protein-energy malnutrition and micronutrient deficiency issues. The rising demand for nutritious vegetables and plant proteins has increased the significance of cowpea as a global nutritional resource (Shevkani *et al.* 2025) [10]. Vegetable cowpea is among the significant growers of the crop in Asia. Vegetable cowpea is grown in many regions in Asia during kharif, rabi, summer, and spring seasons depending on climatic and irrigation conditions of different regions. Vegetable cowpea is widely cultivated in Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Telangana, Odisha, Uttar Pradesh, Madhya Pradesh, Maharashtra, Gujarat, Bihar, and West Bengal. Of all the mineral nutrients, nitrogen (N) is the most critical yield-limiting macronutrient in agricultural production since it is needed in relatively large amounts during the crop growth stages. Nitrogen is an essential part of amino acids, proteins, nucleic acid (DNA and RNA), chlorophyll, ATP, enzymes, coenzymes, and several other secondary metabolites which play regulatory roles in plants' metabolism and growth (Musa *et al.*, 2026) [8]. Despite cowpea being a leguminous crop that can fix atmospheric nitrogen through the symbiotic relationship with Rhizobium bacteria, the crop needs an adequate amount of available nitrogen in its initial growth period. Nitrogen biological fixation will only become functional once successful root nodulation takes place several weeks after germination (Meknon *et al.*, 2022). Phosphorus (P) is the second most important macronutrient following nitrogen and is absolutely necessary for proper growth, development, and productivity of crop plants. While nitrogen stimulates mainly vegetative growth, phosphorus is involved in energy storage and transport, metabolism and reproduction. This element is a component of adenosine triphosphate (ATP), adenosine diphosphate (ADP), nucleic acids, phospholipids, coenzymes and a wide range of phosphorylated compounds that act as regulators of metabolic reactions inside the cell. As ATP is the universal currency of energy, phosphorus is engaged in all physiological processes in plants, including photosynthesis, respiration, carbohydrate metabolism, protein synthesis, cell division and membrane formation. Therefore, proper phosphorus nutrition is crucial for getting

optimum crop growth, efficient nutrient use, and high productivity in various production systems. (Musa *et al.*, 2026) [8]. Hence, the current study "Effect of Nitrogen and Phosphorus Levels on Growth and Yield of Cowpea (*Vigna unguiculata* L. Walp.)" was conducted to determine the effects of various levels of nitrogen and phosphorus of cowpea.

Materials and Methods

Experimental site

A field experiment was conducted during the Kharif season of 2024 at the Horticulture Research Farm, School of Agriculture Science, Technology and Research, Sardar Patel University, Balaghat, Madhya Pradesh, India. The experimental farm is situated at an altitude of approximately 924.5 m above mean sea level and lies in the Chhattisgarh Plain Agro-climatic Zone of Madhya Pradesh.

Soil characteristics

Before sowing, composite soil samples were collected from the experimental field at a depth of 0–30 cm and analyzed following standard analytical procedures. The soil of the experimental site was sandy loam in texture, well drained, slightly alkaline in reaction (pH 7.81), low in available nitrogen (148.0 kg ha⁻¹), medium in available phosphorus (15.15 kg ha⁻¹) and fairly rich in available potassium (226.3 kg ha⁻¹). The soil contained 0.42% organic carbon with an electrical conductivity of 2.8 dS m⁻¹, indicating normal salinity conditions suitable for vegetable cultivation.

Experimental materials and treatments

The experiment was conducted using the vegetable cowpea variety Pusa Komal, a widely cultivated bush-type variety developed by the Indian Agricultural Research Institute, New Delhi. The variety is characterized by early flowering, light green tender pods and tolerance to bacterial blight. The experiment consisted of four nitrogen levels (0, 20, 40 and 60 kg N ha⁻¹) and four phosphorus levels (0, 20, 40 and 60 kg P₂O₅ ha⁻¹).

Experimental design and crop establishment

The experiment was laid out in a Randomized Block Design (RBD) with three replications, comprising a total of 48 experimental plots. Each plot measured 3.0 × 2.7 m and the crop was planted at a spacing of 20 × 15 cm using a seed rate of 90 kg ha⁻¹.

The field was prepared by one deep ploughing followed by two cross harrowings and levelling to obtain a fine tilth. Healthy seeds of Pusa Komal were treated with Captan @ 2 g kg⁻¹ seed before sowing. Three seeds were dibbled at each hill and thinning was carried out 10 days after sowing to maintain one healthy plant per hill.

Fertilizer application and crop management

Nitrogen was supplied through urea, phosphorus through diammonium phosphate (DAP) and potassium through muriate of potash (MOP). Fertilizers were applied according to the treatment schedule. Farmyard manure was incorporated into the soil during final land preparation. All recommended cultural practices, including irrigation, hand weeding, hoeing and plant protection measures, were adopted uniformly for all treatments to ensure healthy crop growth. The crop was kept weed-free by manual weeding and hoeing at regular intervals. Irrigation was provided

whenever required according to crop stage and prevailing weather conditions. Necessary plant protection measures were undertaken to manage collar rot, aphids and powdery mildew using recommended fungicides and insecticides.

Observations recorded

Observations on growth and yield attributes were recorded from five randomly selected plants in each experimental plot and the average values were used for statistical analysis. Growth observations included plant height (cm), at 60 days after sowing (DAS) and at harvest using a measuring scale. The number of primary branches per plant was counted at harvest. The number of root nodules per plant was recorded at 45 DAS after carefully uprooting the selected plants and the dry weight of nodules was determined. Total chlorophyll content of fresh leaves was estimated at the flowering stage using the dimethyl sulphoxide (DMSO) extraction method and chlorophyll concentration was calculated according to the method of Arnon (1949) [1]. Yield and yield-attributing observations included days to flower initiation, days to pod initiation and days to first picking, which were recorded from the date of sowing until the occurrence of the respective phenological stage. The number of pod pickings was counted throughout the harvesting period. Average pod weight (g) was calculated by weighing representative pods, whereas green pod yield per plant (g) was obtained by recording the cumulative weight of pods harvested from each selected plant. The green pod yield per hectare (q ha⁻¹) was also estimated.

Statistical analysis

The experimental data were subjected to analysis of variance (ANOVA) appropriate for a Randomized Block Design following the procedure described by Fisher and Yates. Treatment effects were tested using the F-test at the 5% level of significance. Whenever treatment differences were significant, the critical difference (CD) at the 5% probability level was calculated for comparison of treatment means. Standard error of mean [SE (m)] and coefficient of variation (CV) were also computed to assess experimental precision.

Results and Discussion

The application of different nitrogen and phosphorus levels significantly influenced the vegetative growth of vegetable cowpea, as evidenced by improvements in plant height, number of primary branches and plant dry weight (Table 1). Increasing nitrogen levels from N₀ (0 kg N ha⁻¹) to N₃ (60 kg N ha⁻¹) resulted in a progressive enhancement of all growth parameters. The highest plant height was recorded under N₃, measuring 53.78 cm at 60 DAS and 74.40 cm at harvest, which remained statistically at par with N₂ (40 kg N ha⁻¹) (50.78 and 70.11 cm, respectively). Similarly, the maximum number of primary branches (6.06 plant⁻¹) and the highest plant dry weight (82.51 g plant⁻¹) were obtained with N₃, whereas the control (N₀) recorded the lowest values of 4.60 branches plant⁻¹ and 47.89 g plant⁻¹, respectively. Likewise, phosphorus fertilization exerted a significant positive effect on vegetative growth. Application of P₃ (60 kg P₂O₅ ha⁻¹) produced the tallest plants (50.40 cm at 60 DAS and 69.29 cm at harvest), the highest number of primary branches (5.95 plant⁻¹) and maximum plant dry weight (81.05 g plant⁻¹). However, these values were statistically comparable with P₂ (40 kg P₂O₅ ha⁻¹) for most

growth traits. The lowest growth parameters were consistently observed under P₀, indicating that inadequate phosphorus supply restricted vegetative development.

The increase in primary branching could be associated with enhanced cytokinin synthesis and greater activation of axillary buds, while the higher dry matter production reflects improved carbon assimilation and efficient conversion of photosynthates into structural tissues. Similar improvements in vegetative growth of cowpea following optimum nitrogen fertilization have been reported by Begam *et al.* (2023) [2], Borges *et al.* (2023) [3] and recent nutrient management studies in grain and vegetable legumes.

Nitrogen and phosphorus levels significantly influenced nodulation and physiological characteristics of vegetable cowpea, including the number of nodules, dry weight of nodules and chlorophyll content of leaves (Table 1). Among the nitrogen treatments, N₃ (60 kg N ha⁻¹) recorded the highest number of nodules (42.75 plant⁻¹), maximum nodule dry weight (285.81 mg plant⁻¹), and highest chlorophyll content (2.57 mg g⁻¹). These values were statistically at par with N₂ (40 kg N ha⁻¹) for most observations, whereas N₀ recorded the lowest values (32.84 nodules plant⁻¹, 257.26 mg plant⁻¹ and 1.92 mg g⁻¹, respectively). Similarly, phosphorus application significantly enhanced nodulation and chlorophyll accumulation. The maximum number of nodules (41.95 plant⁻¹), highest nodule dry weight (283.08 mg plant⁻¹) and greatest chlorophyll content (2.47 mg g⁻¹) were recorded under P₃ (60 kg P₂O₅ ha⁻¹), followed closely by P₂ (40 kg P₂O₅ ha⁻¹). In contrast, the lowest values were observed under P₀, reflecting the adverse effect of phosphorus deficiency on root activity and physiological processes. Nitrogen and phosphorus levels significantly influenced the flowering behaviour and harvesting period of vegetable cowpea (Table 1). Increasing nitrogen application from N₀ (0 kg N ha⁻¹) to N₃ (60 kg N ha⁻¹) progressively reduced the number of days required for first flower initiation, pod initiation and first picking, while increasing the number of pod pickings. The earliest first flower initiation (34.42 days), pod initiation (39.79 days) and first picking (42.95 days) were recorded under N₃, followed by N₂ (40 kg N ha⁻¹). In contrast, the control (N₀) required the maximum number of days for flowering (38.96 days), pod initiation (43.56 days), and first picking (47.35 days). Moreover, the highest number of pod pickings (4.21) was recorded under N₃, whereas the lowest (2.75) was observed in the control. Similarly, phosphorus application significantly accelerated reproductive development. The minimum number of days to first flowering (34.01 days), pod initiation (39.94 days) and first picking (43.58 days) was recorded with P₃ (60 kg P₂O₅ ha⁻¹), which remained statistically comparable with P₂ (40 kg P₂O₅ ha⁻¹) for most traits. Furthermore, the highest number of pod pickings (4.07) was obtained under P₃, while P₀ recorded only 3.09 pickings. The yield attributes of vegetable cowpea, namely pod length, pod diameter, number of pods per plant and average pod weight, were significantly influenced by nitrogen and phosphorus fertilization (Table 2). Among nitrogen treatments, N₃ (60 kg N ha⁻¹) recorded the highest pod length (19.40 cm), pod diameter (4.81 mm), number of pods per plant (18.76) and average pod weight (6.38 g). However, these values were statistically at par with N₂ (40 kg N ha⁻¹) for most traits. The minimum values were consistently observed under N₀, which produced shorter pods (12.48 cm), smaller pod diameter (3.00 mm), fewer

Pods (13.69 plant⁻¹) and lower average pod weight (4.71 g). A similar trend was observed under phosphorus fertilization. Application of P₃ (60 kg P₂O₅ ha⁻¹) resulted in the maximum pod length (18.86 cm), pod diameter (4.69 mm), number of pods per plant (18.35) and average pod weight (6.39 g), followed closely by P₂ (40 kg P₂O₅ ha⁻¹). The lowest values for all yield attributes were recorded in the absence of phosphorus application (P₀). The improvement in pod size and pod weight with increasing nitrogen levels may be attributed to enhanced photosynthetic activity and greater production of carbohydrates, which supplied sufficient assimilates for developing pods. Nitrogen also promotes efficient protein synthesis and enzyme activity, resulting in rapid cell division and expansion during pod development. Consequently, longer and thicker pods with greater fresh weight were produced. The increase in the number of pods per plant further suggests improved flower retention and reduced abscission under balanced nitrogen nutrition. The use of P-fertilizers on cowpea is minimal in Nigeria specifically in the major cowpea producing zones (Magani and Kuchinda, 2009; Saidou *et al.*, 2012) [6, 9] soil organic matter. Cowpea helps to control weeds, prevent soil erosion, increase the activity of soil. Green pod yield per plant and per hectare increased significantly with increasing nitrogen

and phosphorus levels (Table 2). Among the nitrogen treatments, N₃ (60 kg N ha⁻¹) recorded the highest pod yield (101.05 g plant⁻¹ and 135.90 q ha⁻¹), which was statistically at par with N₂ (40 kg N ha⁻¹) (95.87 g plant⁻¹ and 129.11 q ha⁻¹). The lowest yields (60.18 g plant⁻¹ and 78.28 q ha⁻¹) were obtained under the control treatment. Similarly, phosphorus application significantly increased green pod yield, with P₃ (60 kg P₂O₅ ha⁻¹) producing the maximum yield (100.33 g plant⁻¹ and 133.65 q ha⁻¹), followed by P₂ (40 kg P₂O₅ ha⁻¹, 96.88 g plant⁻¹ and 129.40 q ha⁻¹). The control (P₀) recorded the lowest pod yield (59.96 g plant⁻¹ and 83.87 q ha⁻¹). The significant improvement in green pod yield under higher nitrogen levels was primarily the cumulative effect of enhanced vegetative growth, improved chlorophyll content, increased branching, greater nodulation, and superior yield attributes. Efficient nitrogen nutrition strengthened the source-sink relationship, enabling greater translocation of assimilates towards developing pods and ultimately increasing marketable yield. Although the highest yield was obtained with N₃, the statistically comparable performance of N₂ suggests that 40 kg N ha⁻¹ may also be an efficient nitrogen level under similar agro-climatic conditions (Begam *et al.*, 2023; Borges *et al.*, 2023; Musa and Yusuf, 2026) [2, 3, 8].

Table 1: Growth parameters

Treatments	Plant height (cm)		Number of primary branches plant ⁻¹ at harvest	Number of nodules plant ⁻¹	Dry weight of nodules (mg plant ⁻¹)	Dry weight of plant (g plant ⁻¹)	Chlorophyll content (mg g ⁻¹) of leaves at 60 DAS	Days to first flower initiation	Days taken to pod initiation	Days taken to 1 st picking	Number of picking of pods
	60 DAS	At harvest									
Nitrogen levels											
0	34.03	49.05	4.60	32.84	257.26	47.89	1.92	38.96	43.56	47.35	2.75
20 kg ha ⁻¹	43.80	61.53	5.17	38.24	269.14	66.65	2.43	37.37	41.81	45.84	3.64
40 kg ha ⁻¹	50.78	70.11	5.81	40.87	276.73	77.64	2.51	35.53	40.76	44.27	3.99
60 kg ha ⁻¹	53.78	74.4	6.06	42.75	285.81	82.51	2.57	34.42	39.79	42.95	4.21
S.Em.±	1.88	1.73	0.11	0.73	3.53	2.37	0.03	0.66	0.70	0.79	0.09
CD at 5%	3.38	4.99	0.33	2.09	10.16	6.81	0.09	1.89	2.02	2.27	0.26
Phosphorus levels											
0	39.37	56.10	4.74	34.69	259.55	50.97	2.19	39.10	42.87	46.93	3.09
20 kg ha ⁻¹	44.44	62.78	5.23	37.78	269.33	65.10	2.34	38.03	42.03	45.55	3.55
40 kg ha ⁻¹	48.20	66.95	5.71	40.28	276.98	77.57	2.43	35.14	41.08	44.35	3.87
60 kg ha ⁻¹	50.40	69.29	5.95	41.95	283.08	81.05	2.47	34.01	39.94	43.58	4.07
S.Em.±	1.18	1.73	0.11	0.73	3.53	2.37	0.03	0.66	0.70	0.79	0.09
CD at 5%	3.38	4.99	0.33	2.09	10.16	6.81	0.09	1.89	2.02	2.27	0.26

Table 2: Yield attributes

Treatments	Pod length (cm)	Pod diameter (mm)	Number of pods plant ⁻¹	Average pod weight (g)	Pod yield (g plant ⁻¹)	Pod yield (q ha ⁻¹)
Nitrogen levels						
0	12.48	3.00	13.69	4.71	60.18	78.28
20 kg ha ⁻¹	16.11	3.89	16.45	5.70	80.27	108.82
40 kg ha ⁻¹	18.13	4.60	17.80	6.17	95.87	129.11
60 kg ha ⁻¹	19.40	4.81	18.76	6.38	101.05	135.90
S.E.m.±	0.48	0.10	0.37	0.15	2.01	2.45
CD at 5%	1.39	0.30	1.07	0.43	5.78	7.04
Phosphorus levels						
0	13.80	3.30	14.64	4.82	59.96	83.87
20 kg ha ⁻¹	15.89	3.83	16.22	5.59	80.20	105.18
40 kg ha ⁻¹	17.57	4.48	17.50	6.16	96.88	129.40
60 kg ha ⁻¹	18.86	4.69	18.35	6.39	100.33	133.65
S.E.m.±	0.48	0.10	0.37	0.15	2.01	2.45
CD at 5%	1.39	0.30	1.07	0.43	5.78	7.04

Conclusion

The present investigation demonstrated that nitrogen and phosphorus fertilization significantly influenced the growth, flowering behaviour, yield attributes, and green pod yield of vegetable cowpea. Progressive improvement in vegetative growth, nodulation, chlorophyll content, reproductive development and yield was observed with increasing levels of both nutrients. Among the nitrogen treatments, N₃ (60 kg N ha⁻¹) recorded the highest values for most growth and yield parameters, although its performance was statistically comparable with N₂ (40 kg N ha⁻¹) for several observations. Similarly, P₃ (60 kg P₂O₅ ha⁻¹) produced superior performance among phosphorus treatments, while P₂ (40 kg P₂O₅ ha⁻¹) showed statistically similar results for many traits. These findings indicate that adequate nitrogen and phosphorus nutrition plays a crucial role in improving crop growth, accelerating reproductive development and maximizing green pod yield. Considering the comparable performance of 40 and 60 kg ha⁻¹ of both nutrients for several parameters, further economic evaluation may help identify the most cost-effective fertilizer recommendation for vegetable cowpea under similar agro-climatic conditions.

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