



# **Effects of Varying Nitrogen Levels on the Yield and Quality of Cowpea [ *Vigna unguiculata* (L.) Walp.]**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## **ABSTRACT**

Assessing various nitrogen application rates on cowpea yield is critical because of the crop's important contribution to food security and sustainable agricultural practices. Cowpea serves as a key source of protein and essential nutrients, particularly in areas characterized by low rainfall and

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poor soil quality. This study aimed to investigate the impact of varying nitrogen levels on the growth and yield of the cowpea variety Kashi Kanchan. The study conducted at the Horticulture Department's field within the School of Agriculture Research and Technology at Sardar Patel University in Balaghat, Madhya Pradesh, during the Kharif season of 2023, utilized a Randomized Block Design (RBD) featuring eight treatments, each replicated three times. The findings from this research indicated that the treatment T6 (N at 35 kg/ha combined with PK at 75 and 60 kg/ha) significantly enhanced vegetative growth, achieving a plant height of 81.80 cm at 60 days after sowing and an average of 24.40 branches per plant. Additionally, it positively influenced yield characteristics, including a pod length of 32.39 cm, a pod diameter of 1.40 cm, and a maximum of 110.41 pods per plant, with a pod weight of 18.88 grams and a pod yield of 64.33 quintals per hectare. T6 also yielded the highest net returns and a favorable benefit-cost ratio of 1.50. Therefore, applying nitrogen at 35 kg/ha is recommended to enhance cowpea productivity and overall performance in the Balaghat region.

**Keywords:** Cowpea; nitrogen; benefit cost ratio; yield and quality.

## 1. INTRODUCTION

*Vigna unguiculata* (L.) Walp, commonly known as cowpea, is a botanically significant annual herbaceous legume belonging to the genus *Vigna*. Its remarkable tolerance for sandy soils and low rainfall has made it an essential crop in the semiarid regions of Africa and Asia. Cowpea requires minimal inputs due to its ability to fix atmospheric nitrogen through root nodules, making it an invaluable crop for resource-limited farmers and ideal for intercropping with other crops. The entire plant serves as forage for animals, with its use as cattle feed likely contributing to its name. The numerous varieties of cowpea display significant variation in fruit shape, and it stands as one of the many species within the widely cultivated genus *Vigna*. Cowpea is a diploid species, possessing a somatic chromosome number of  $2n=22$ , and is among the most important pulse crops native to West Africa (Vavilov, 1951; Venkatesan et al., 2003). Often referred to as the "poor man's meat" or "vegetable meat" due to its high protein content, cowpea's young leaves, pods, and peas are rich in vitamins and minerals, making them valuable for both human consumption and animal feed. Cowpea demonstrates considerable resilience to both drought and heavy rainfall and can thrive in almost any type of soil, provided it has adequate drainage. Predominantly grown in tropical and subtropical regions for vegetable and grain purposes, and to a lesser extent as fodder, cowpea is a highly versatile pulse crop. Although cowpeas are primarily cultivated for their edible beans, their leaves, green seeds, and pods are also consumed, offering a versatile food source before the dried peas are harvested (Ehlers and Hall, 1997). Like other legumes, cowpeas are typically cooked by boiling to make them edible.

They are versatile in culinary use, featuring in stews, soups, purees, casseroles, and curries, and can also be processed into paste or flour (Goncalves et al., 2016). The cowpea crop is widely cultivated across South and Southeast Asia, in countries such as India, Bangladesh, Pakistan, China, and the Philippines. In India, cowpea cultivation spanned 1.5 million hectares, with a production of 2.25 million metric tonnes in the 2021-22 period. Maharashtra led the country in both area and production of cowpea during that year, followed by Andhra Pradesh and Karnataka. In Madhya Pradesh, cowpea cultivation covered 0.23 thousand hectares, with an estimated production of 8.13 million tonnes for 2021-22 (NHB, 2022). Nitrogen constitutes 1-4% of a plant's dry matter and is instrumental in the translocation of stored photo assimilates as well as the uptake of other essential nutrients, highlighting the need for optimal nitrogen supplementation, particularly given its susceptibility to losses (Ariraman et al., 2020). Increasing nitrogen application levels has been shown to effectively boost crop productivity, serving as a vital strategy to prevent yield penalties (Hammad et al., 2011). Assessing various nitrogen application rates on cowpea yield is critical because of the crop's important contribution to food security and sustainable agricultural practices. Cowpea serves as a key source of protein and essential nutrients, particularly in areas characterized by low rainfall and poor soil quality. Identifying the optimal nitrogen levels is vital, as nitrogen plays a significant role in plant development, photosynthesis, and overall yield. Both excessive and inadequate nitrogen can negatively impact productivity and raise environmental issues like nitrogen leaching. This research seeks to establish the best nitrogen levels for cowpea,

aiming to boost crop yield, improve soil health, and promote sustainable farming methods, ultimately benefiting farmers and enhancing global food security.

## 2. MATERIALS AND METHODS

The current study aimed to investigate the impact of varying nitrogen levels on the growth and pod yield of the cowpea variety 'Kashi Kanchan.' The research was conducted at the experimental fields of the Horticulture Department, School of Agriculture Research and Technology, Sardar Patel University, Balaghat, Madhya Pradesh, during the 2023 Kharif season (monsoon season). Balaghat District is situated in the south-eastern region of the Satpura Range and the upper valley of the Wainganga River, spanning latitudes 21°19' to 22°24' N and longitudes 79°31' to 81°30' E. The treatments were T1 (Control), T2 (N @ 15 kg/ha + PK @ 75 & 60 kg/ha each), T3 (N @ 20 kg/ha + PK @ 75 & 60 kg/ha each), T4 (N @ 25 kg/ha + PK @ 75 & 60 kg/ha each), T5 (RDF 100% [NPK: 30:75:60 Kg/ha]), T6 (N @ 35 kg/ha + PK @ 75 & 60 kg/ha each), T7 (N @ 40 kg/ha + PK @ 75 & 60 kg/ha each) and T8 (N @ 45 kg/ha + PK @ 75 & 60 kg/ha each). The height of five randomly selected plants from each plot was measured in cm with a 100 cm meter scale from ground level to tip of the shoot at 20 DAS, 40 DAS and 60 DAS stage. The average Plant height of each replication was recorded and subjected to statistical analysis. The number of branches per plant (plant) of five randomly selected plants arising from the main shoot was counted and averaged to represent the numbers of primary branches per plant. Number of branches per plant on a basis was counted at 20 DAS, 40 DAS and 60 DAS stage. The days taken from the date of sowing to the date of physiological maturity of the plants in the whole plot, and fruits were harvested for first slot were recorded as days to first pod setting. It was observed on five random plants and averaged for each treatment and each replication and analysed further. Average pod weights were taken from five randomly selected pods from randomly selected plants by using a physical balance, averaged, and subjected to statistical analysis. The yield was calculated by weighing the marketable pods. The readings from five plants/plot were recorded. The average yield/plant was calculated by dividing the total yield of the treatments by the total number of plants in the plot. The statistical analysis was conducted using Fisher and Yates (1967).

## 3. RESULTS AND DISCUSSION

### 3.1 Plant Height

The maximum plant height (14.57, 55.97 and 81.80 cm) at 30, 40 and 60 DAS respectively was observed with treatment T6 (N @ 35 kg/ha + PK @ 75 & 60 kg/ha each) followed by T7 (N @ 40 kg/ha + PK @ 75 & 60 kg/ha each) with 13.13, 52.32 and 75.07 cm at 20, 40 and 60 DAS and at harvest respectively. Minimum height of plant (6.52, 24.14 and 46.89 cm) was observed in T1 (control) at 20, 40 and 60 DAS, respectively. The superior plant height observed in the treatment combination of N @ 35 kg/ha + PK @ 75 & 60 kg/ha each in cowpea, compared to the recommended dose of fertilizer (RDF) 100% [NPK: 30:75:60 kg/ha] and other nitrogen levels, can be attributed to the optimized nitrogen application. The slightly higher nitrogen dose (35 kg/ha) likely provided an immediate and adequate supply of nitrogen, a crucial nutrient for initial seedling vigour and root development, leading to faster germination. Additionally, the balanced phosphorus (P) and potassium (K) levels at 75 and 60 kg/ha, respectively, would have supported root growth and nutrient uptake efficiency, further promoting early seedling establishment and robust vegetative growth. The synergy between these nutrient levels may have created a more favourable soil environment, enhancing the availability and uptake of essential nutrients during the early growth stages. This balanced nutrient availability could have led to more vigorous shoot development, translating into better plant height. In contrast, the RDF treatment, with slightly lower nitrogen, might not have provided the same early growth advantages, and other treatments with varying nitrogen levels could have resulted in either nutrient imbalances or insufficient nitrogen supply, affecting overall plant growth and development. Findings were in accordance with conclusions by Ali et al., (2022); Mahmud et al. (2023).

### 3.2 Number of Branches Per Plant and Number of Nodules Per Plant

The maximum number of branches per plant observed at 20, 40 and 60 DAS (7.49, 18.88 and 24.40 branches respectively) was in treatment T6 (N @ 35 kg/ha + PK @ 75 & 60 kg/ha each) at par with T7 (N @ 40 kg/ha + PK @ 75 & 60 kg/ha each) with 6.56, 17.78 and 23.45 branches observed at 20, 40 and 60 DAS respectively.

Minimum number of branches per plant (4.69, 9.39 and 15.36 branches) in T1 (control) observed at 20, 40 and 60 DAS, respectively. The maximum number of nodules per plant (13.04 nodules) was observed with treatment T6 (N @ 35 kg/ha + PK @ 75 & 60 kg/ha each) followed by T7 (N @ 40 kg/ha + PK @ 75 & 60 kg/ha each) with 10.19 nodules. The minimum number of nodules per plant (5.15 nodules) was observed in T1 (control). The treatment combination of N @ 35 kg/ha + PK @ 75 & 60 kg/ha each in cowpea likely resulted in a higher number of branches and nodules per plant compared to the RDF 100% [NPK: 30:75:60 kg/ha] and other nitrogen treatments due to the optimised nutrient balance. The slightly elevated nitrogen dose (35 kg/ha) provided adequate nitrogen, a key element for promoting vegetative growth and branching. Nitrogen, being a critical component of chlorophyll and amino acids, directly influences cell division and elongation, leading to increased lateral branching. Furthermore, the phosphorus (P) at 75 kg/ha played a crucial role in root development and nodule formation, as it is essential for energy transfer and symbiotic nitrogen fixation in legumes. Potassium (K) at 60 kg/ha would have enhanced the overall physiological processes, including water regulation, enzyme activation, and nutrient transport, further supporting both branching and nodule formation. The combined effect of these nutrients likely created an optimal soil environment, promoting vigorous root and shoot development. This would have resulted in a greater number of nodules, enhancing the plant's nitrogen fixation capacity and subsequently supporting more branches. In contrast, the RDF and other nitrogen treatments might not have provided the same nutrient synergy, leading to less branching and nodule development. Similar findings were reported by Singh et al., (2021); Wadi et al., (2021).

### 3.3 Days to First Flowering and Days to 50% Flowering

The minimum days to first flowering (29.08 days) was observed with treatment T5 (RDF 100% [NPK: 30:75:60 Kg/ha]) followed by T4 (N @ 25 kg/ha + PK @ 75 & 60 kg/ha each) with 29.67 days. Maximum days to first flowering (35.52 days) were observed in T6 (N @ 35 kg/ha + PK @ 75 & 60 kg/ha each). The minimum days to 50% flowering (34.38 days) was observed with treatment T5 (RDF 100% [NPK: 30:75:60

Kg/ha]) followed by T4 (N @ 25 kg/ha + PK @ 75 & 60 kg/ha each) with 35.76 days. Maximum days to 50% flowering (40.42 days) was observed in T6 (N @ 35 kg/ha + PK @ 75 & 60 kg/ha each). The earliness in flowering observed in cowpea under the RDF 100% [NPK: 30:75:60 kg/ha] treatment compared to the N @ 35 kg/ha + PK @ 75 & 60 kg/ha treatment and other nitrogen levels can be attributed to the balanced nutrient supply specifically tailored for optimal growth and development. The RDF treatment provides an ideal ratio of nitrogen (N), phosphorus (P), and potassium (K), ensuring that the plant's nutrient needs are met without excesses or deficiencies, which can delay physiological processes such as flowering. The precise nitrogen level in RDF (30 kg/ha) is sufficient to promote vegetative growth without causing excessive biomass production, which can delay the transition to the reproductive phase. Phosphorus at 75 kg/ha is critical for energy transfer and the development of reproductive organs, facilitating the timely initiation of flowering. Potassium at 60 kg/ha supports overall plant health, including stress tolerance, which can influence the timing of flowering. In contrast, the slightly higher nitrogen in the N @ 35 kg/ha treatment might have promoted more vegetative growth at the expense of reproductive development, delaying flowering. Other treatments with varying nitrogen levels could have created imbalances in nutrient availability, affecting the hormonal signals that trigger flowering, resulting in later flowering compared to the well-balanced RDF treatment. Similar findings were reported by Shahi et al., (2021).

### 3.4 Days to First Pod Setting and Days to First Pod Harvest

The minimum days to first pod setting (34.16 days) was observed with treatment T5 (RDF 100% [NPK: 30:75:60 Kg/ha]) followed by T3 (N @ 20 kg/ha + PK @ 75 & 60 kg/ha each) with 35.27 days. Maximum days to first pod setting (41.89 days) was observed in T8 (N @ 45 kg/ha + PK @ 75 & 60 kg/ha each). The minimum days to first pod picking (60.67 days) was observed with treatment T5 (RDF 100% [NPK: 30:75:60 Kg/ha]) followed by T4 (N @ 25 kg/ha + PK @ 75 & 60 kg/ha each) with 62.19 days. Maximum days to first pod picking (71.08 days) was observed in T8 (N @ 45 kg/ha + PK @ 75 & 60 kg/ha each). Earliness in pod setting and pod harvesting in cowpea under the RDF 100% [NPK: 30:75:60 kg/ha] treatment, compared to the

N @ 35 kg/ha + PK @ 75 & 60 kg/ha treatment and other nitrogen levels, can be attributed to the optimal nutrient balance provided by RDF. The RDF formulation is designed to meet the specific growth requirements of cowpea, ensuring that nutrients are available in the right proportions at the right times. Nitrogen (N) at 30 kg/ha in the RDF treatment is sufficient to support healthy vegetative growth without causing excessive foliage, which can delay the plant's transition to the reproductive stage. Phosphorus (P) at 75 kg/ha is crucial for root development and energy transfer, which promotes early flowering and subsequent pod setting. Potassium (K) at 60 kg/ha plays a significant role in regulating water uptake, enzyme activity, and overall plant vigour, all of which contribute to efficient reproductive development and earlier pod maturation. In contrast, the slightly higher nitrogen in the N @ 35 kg/ha treatment may have encouraged more vegetative growth at the expense of reproductive processes, leading to delayed pod setting and harvesting. Other treatments with varying nitrogen levels might have disrupted the balance needed for synchronized flowering and pod development, delaying these processes compared to the well-balanced RDF treatment. This balance is key to ensuring the timely progression from flowering to pod setting and ultimately to harvesting, contributing to the observed earliness in the RDF-treated plants. Similar findings were reported by Alhasnawi et al., (2020).

### 3.5 Number of Pods Per Plant

The maximum number of pods per plant (110.41 pods) was observed with treatment T6 (N @ 35 kg/ha + PK @ 75 & 60 kg/ha each) followed by T7 (N @ 40 kg/ha + PK @ 75 & 60 kg/ha each) with 105.74 pods. The minimum number of pods per plant (71.56 pods) was observed in T1 (Control). The higher number of pods per plant in cowpea under the treatment combination of N @ 35 kg/ha + PK @ 75 & 60 kg/ha each, compared to RDF 100% [NPK: 30:75:60 kg/ha] and other nitrogen levels, can be attributed to the slight increase in nitrogen coupled with optimal phosphorus (P) and potassium (K) levels. The elevated nitrogen (N @ 35 kg/ha) provides sufficient nutrients to support robust vegetative growth, which in turn establishes a strong foundation for reproductive development. Nitrogen is essential for chlorophyll production and overall plant vigour, which directly contributes to higher pod numbers by supporting

sustained growth throughout the pod formation stage. The higher phosphorus (P @ 75 kg/ha) level plays a crucial role in energy transfer and the development of reproductive structures, enhancing the plant's ability to set and develop a greater number of pods. Potassium (K @ 60 kg/ha) further supports this process by regulating water use, enzyme activity, and carbohydrate metabolism, all of which are essential for the successful development and filling of pods. In contrast, the slightly lower nitrogen level in the RDF treatment may have limited the plant's vegetative and reproductive potential, leading to fewer pods. Other treatments with varying nitrogen levels might have caused nutrient imbalances, hindering the optimal conditions necessary for maximising pod production. This specific combination of nutrients in the N @ 35 kg/ha+ PK @ 75 & 60 kg/ha treatment likely provided a more conducive environment for the plant to produce a higher number of pods. Similar findings were reported by Sharmin and Rahman (2019); Modak et al., (2021).

### 3.6 Pod Length and Diameter

The maximum pod length (32.39 cm) was observed with treatment T6 (N @ 35 kg/ha + PK @ 75 & 60 kg/ha each) followed by T7 (N @ 40 kg/ha + PK @ 75 & 60 kg/ha each) with 31.05 cm. Minimum pod length (20.51 cm) was observed in T1 (Control). The maximum pod diameter (1.40 cm) was observed with treatment T6 (N @ 35 kg/ha + PK @ 75 & 60 kg/ha each) followed by T7 (N @ 40 kg/ha + PK @ 75 & 60 kg/ha each) with 1.30 cm. Minimum pod diameter (1.05 cm) was observed in T1 (Control). The superior pod length and diameter observed in cowpea under the treatment combination of N @ 35 kg/ha + PK @ 75 & 60 kg/ha each, compared to RDF 100% [NPK: 30:75:60 kg/ha] and other nitrogen levels, can be attributed to the precise synchronization of nutrient availability, which fosters optimal pod development. The slightly enhanced nitrogen application (N @ 35 kg/ha) in this treatment supports vigorous vegetative growth and ensures that the plants possess sufficient photosynthetic capacity to sustain the energy-intensive process of pod elongation and expansion. Phosphorus (P @ 75 kg/ha) plays an indispensable role in cellular division and energy transfer, crucial for the development of reproductive tissues. This nutrient facilitates the biosynthesis of nucleic acids and ATP, which are vital for sustaining the growth of pods, leading to increased length and diameter. Meanwhile,

potassium (K @ 60 kg/ha) regulates osmotic balance, enzyme activation, and carbohydrate translocation, all of which contribute to the structural integrity and enlargement of pods. In comparison, the RDF treatment, with slightly lower nitrogen levels, might not provide the same robustness in vegetative growth and nutrient partitioning to the pods, resulting in comparatively smaller pod dimensions. Other nitrogen treatments could create nutrient imbalances that compromise the harmonious development of pod size. The judicious nutrient combination in the N @ 35 kg/ha + PK @ 75 & 60 kg/ha treatment thus creates a more favourable physiological environment, promoting superior pod length and diameter. Similar findings were reported by Modak et al., (2021).

### 3.7 Pod Weight and Yield

The maximum pod weight (18.88 grams) was observed with treatment T6 (N @ 35 kg/ha+ PK @ 75 & 60 kg/ha each) followed by T7 (N @ 40 kg/ha + PK @ 75 & 60 kg/ha each) with 17.25 grams. Minimum pod weight (11.05 grams) was observed in T1 (Control). The maximum pod yield per plant (2.13 kg/plant) was observed with treatment T6 (N @ 35 kg/ha + PK @ 75 & 60 kg/ha each) followed by T7 (N @ 40 kg/ha + PK @ 75 & 60 kg/ha each) with 1.81 kg/plant. Minimum pod yield per plant (0.83 kg/plant) was observed in T1 (Control). The maximum pod yield per hectare (64.33 q/ha) was observed with treatment T6 (N @ 35 kg/ha + PK @ 75 & 60 kg/ha each) followed by T7 (N @ 40 kg/ha + PK @ 75 & 60 kg/ha each) with 62.94 q/ha. Minimum pod yield per hectare (47.73 q/ha) was observed in T1 (Control). The enhanced pod weight and consequent increase in pod yield observed in cowpea under the treatment combination of N @ 35 kg/ha + PK @ 75 & 60 kg/ha each, as opposed to RDF 100% [NPK: 30:75:60 kg/ha] and other nitrogen levels, can be ascribed to the synergistic effects of optimal nutrient allocation. The increment in nitrogen (N @ 35 kg/ha) in this treatment likely fortified vegetative growth, ensuring an adequate supply of photosynthates necessary for pod filling. This nutrient supply supports the synthesis of essential proteins and structural carbohydrates that contribute to the density and weight of the pods. Phosphorus (P @ 75 kg/ha) plays a pivotal role in energy

metabolism and the formation of ATP, which is indispensable for the transfer of nutrients and the development of reproductive structures. This nutrient aids in the accumulation of dry matter within the pods, thereby enhancing their overall weight. Potassium (K @ 60 kg/ha), known for its role in maintaining turgor pressure, enzyme activation, and carbohydrate synthesis, further bolsters pod development by ensuring optimal water relations and nutrient transport, leading to fuller, heavier pods. Conversely, the RDF treatment, with its slightly lower nitrogen provision, may not sufficiently support the same degree of photosynthetic efficiency and nutrient translocation, resulting in comparatively lighter pods. Similarly, other treatments with varying nitrogen levels could disrupt the nutrient equilibrium, thereby impeding the optimal conditions required for maximum pod weight and yield. The tailored nutrient synergy in the N @ 35 kg/ha + PK @ 75 & 60 kg/ha treatment thus fosters an environment conducive to superior pod weight and yield. Similar findings were reported by Modak et al., (2021); Shahi et al., (2021) and Orluchukwu and Amadi, (2022).

### 3.8 Economics Parameters

The maximum cost of cultivation incurred in treatment T8 (N @ 45 kg/ha + PK @ 75 & 60 kg/ha each) with (Rs 1,50,669 ha<sup>-1</sup>) and the minimum (Rs 1,50,130 ha<sup>-1</sup>) was recorded in treatment T1 (Control). Maximum gross returns were recorded in treatment T6 (N @ 35 kg/ha + PK @ 75 & 60 kg/ha each) with (Rs 4,50,711 ha<sup>-1</sup>) followed by T7 (N @ 40 kg/ha + PK @ 75 & 60 kg/ha each) having Rs 2,20,302 ha<sup>-1</sup> and the minimum (Rs 1,67,055 ha<sup>-1</sup>) was recorded in treatment T1 (Control). Maximum net returns were recorded in treatment T6 (N @ 35 kg/ha + PK @ 75 & 60 kg/ha each) with (Rs 74,619 ha<sup>-1</sup>) followed by T7 (N @ 40 kg/ha + PK @ 75 & 60 kg/ha each) having Rs 69,693 ha<sup>-1</sup> and the minimum (Rs 16,925 ha<sup>-1</sup>) was recorded in treatment T1 (Control). Maximum benefit cost ratio was recorded in treatment T6 (N @ 35 kg/ha + PK @ 75 & 60 kg/ha each) with (1.50) followed by T7 (N @ 40 kg/ha + PK @ 75 & 60 kg/ha each) having 1.46 and the minimum (1.11) was recorded in treatment T1 (Control). Similar findings were reported by Raja and Singh (2022).

**Table 1. Effect of different levels of nitrogen on growth parameters of cowpea**

Treatment Symbols	Treatment combination	Plant height (cm)			No of branches per plant			Number of nodules per plant
		At 20 DAS	At 40 DAS	At 60 DAS	At 20 DAS	At 40 DAS	At 60 DAS	
T1	Control	6.52	24.14	46.89	4.69	9.69	15.36	5.15
T2	N @ 15 kg/ha + PK @ 75 & 60 kg/ha each	7.62	29.22	51.98	5.10	11.56	17.22	6.19
T3	N @ 20 kg/ha + PK @ 75 & 60 kg/ha each	9.45	41.84	64.59	5.15	12.82	18.49	5.66
T4	N @ 25 kg/ha + PK @ 75 & 60 kg/ha each	10.17	35.46	58.22	6.23	13.68	19.35	7.23
T5	RDF 100% [NPK: 30:75:60 Kg/ha]	11.81	46.33	69.08	6.20	15.48	21.15	8.93
T6	N @ 35 kg/ha + PK @ 75 & 60 kg/ha each	14.57	55.97	81.80	7.49	18.88	24.40	13.04
T7	N @ 40 kg/ha + PK @ 75 & 60 kg/ha each	13.13	52.32	75.07	6.56	17.78	23.45	10.19
T8	N @ 45 kg/ha + PK @ 75 & 60 kg/ha each	12.60	51.46	74.21	6.42	17.13	22.79	8.65
CD0.05		1.33	3.02	2.22	0.66	0.82	0.89	0.75
SE. m ( $\pm$ )		0.44	1.01	0.74	0.22	0.28	0.30	0.25

**Table 2. Effect of different levels of nitrogen on earliness parameters of cowpea**

Treatment Symbols	Treatment combination	Days to first flowering	Days to 50% flowering	Days to first pod setting	Days to first pod picking	Number of pods per plant
T1	Control	32.57	37.31	35.76	66.43	71.56
T2	N @ 15 kg/ha + PK @ 75 & 60 kg/ha each	34.57	38.09	35.76	63.43	74.55
T3	N @ 20 kg/ha + PK @ 75 & 60 kg/ha each	32.77	37.38	35.27	63.43	85.17
T4	N @ 25 kg/ha + PK @ 75 & 60 kg/ha each	29.67	35.76	35.43	62.19	89.37
T5	RDF 100% [NPK: 30:75:60 Kg/ha]	29.08	34.38	34.16	60.67	96.47
T6	N @ 35 kg/ha + PK @ 75 & 60 kg/ha each	35.52	40.42	40.14	67.43	110.41
T7	N @ 40 kg/ha + PK @ 75 & 60 kg/ha each	33.50	39.90	40.76	68.76	105.74
T8	N @ 45 kg/ha + PK @ 75 & 60 kg/ha each	32.24	40.03	41.89	71.08	103.43
CD0.05		1.79	1.51	1.39	1.24	4.73
SE. m ( $\pm$ )		0.60	0.50	0.46	0.41	1.58

**Table 3. Effect of different levels of nitrogen on yield parameters of cowpea**

Treatment Symbols	Treatment combination	Pod length (cm)	Pod diameter (cm)	Pod weight (grams)	Pod yield per plant (kg/plant)	Pod yield per hectare (q/ha)
T1	Control	20.51	1.05	11.05	0.83	47.73
T2	N @ 15 kg/ha + PK @ 75 & 60 kg/ha each	23.37	1.08	13.37	1.00	51.35
T3	N @ 20 kg/ha + PK @ 75 & 60 kg/ha each	24.53	1.09	13.64	1.16	54.38
T4	N @ 25 kg/ha + PK @ 75 & 60 kg/ha each	26.76	1.15	15.12	1.35	55.55
T5	RDF 100% [NPK: 30:75:60 Kg/ha]	29.88	1.25	16.65	1.61	57.33
T6	N @ 35 kg/ha + PK @ 75 & 60 kg/ha each	32.39	1.40	18.88	2.13	64.33
T7	N @ 40 kg/ha + PK @ 75 & 60 kg/ha each	31.05	1.30	17.25	1.81	62.94
T8	N @ 45 kg/ha + PK @ 75 & 60 kg/ha each	30.54	1.20	16.07	1.65	60.36
CD0.05		1.29	0.18	0.89	0.10	2.59
SE. m ( $\pm$ )		0.43	0.06	0.30	0.03	0.86

**Table 4. Economics as influenced by different treatments applied in Cowpea**

Treatment Symbols	Treatment combination	Cost of cultivation (Rs)	Gross return (Rs)	Net return (Rs)	BC ratio
T1	Control	1,50,130	1,67,055	16,925	1.11
T2	N @ 15 kg/ha + PK @ 75 & 60 kg/ha each	1,50,312	1,79,725	29,414	1.20
T3	N @ 20 kg/ha + PK @ 75 & 60 kg/ha each	1,50,367	1,90,318	39,952	1.27
T4	N @ 25 kg/ha + PK @ 75 & 60 kg/ha each	1,50,427	1,94,425	43,998	1.29
T5	RDF 100% [NPK: 30:75:60 Kg/ha]	1,50,488	2,00,655	50,168	1.33
T6	N @ 35 kg/ha + PK @ 75 & 60 kg/ha each	1,50,548	2,25,167	74,619	1.50
T7	N @ 40 kg/ha + PK @ 75 & 60 kg/ha each	1,50,609	2,20,302	69,693	1.46
T8	N @ 45 kg/ha + PK @ 75 & 60 kg/ha each	1,50,669	2,11,260	60,591	1.40
Selling price of Cowpea: Rs 35/kg					



#### 4. CONCLUSION

The findings from this investigation conclusively demonstrated that the application of T6 (N @ 35 kg/ha + PK @ 75 & 60 kg/ha each) resulted in superior vegetative growth, evidenced by a plant height of 81.80 cm at 60 DAS and 24.40 branches per plant. Yield-related traits also showed notable improvement, with pod length reaching 32.39 cm, pod diameter 1.40 cm, the highest number of pods per plant at 110.41, pod weight of 18.88 grams, and a pod yield of 64.33 q/ha. Additionally, T6 provided the highest net return with (Rs 74,619 ha<sup>-1</sup>) and the most favourable benefit-cost ratio of 1.50. Thus, applying nitrogen at 35 kg/ha is recommended for enhancing cowpea productivity and overall performance under Balaghat (M.P.) conditions.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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