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# A review of phosphorus management in fodder cowpea: Impact on nutrient uptake, soil fertility and economics

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**Abstract**
Fodder cowpea (*Vigna unguiculata* L.) is an important leguminous forage crop valued for its rapid growth, high biomass production and superior nutritive quality, particularly under dryland and semi-arid conditions. Among plant nutrients, phosphorus plays a critical role in enhancing growth, yield and quality parameters through its involvement in energy transfer, root development, nodulation and metabolic activities. A comprehensive review of research findings across different agro-ecological regions reveals that increasing phosphorus application significantly improves soil fertility and nutrients uptake. Optimum phosphorus levels ranging from 60 to 80 kg $P_2O_5$ $ha^{-1}$ consistently recorded superior green and dry fodder yields across seasons and soil types, with higher doses showing marginal or at-par responses. Phosphorus application also influenced gross returns, net retunes and benefit-cost ratio. Overall, the reviewed studies indicate that balanced phosphorus fertilization contributing to sustainable fodder production and soil fertility management.

**Keywords:** Fodder cowpea, *Vigna unguiculata* L., phosphorus management, nutrient uptake, soil fertility, fodder yield

## Introduction
Fodder cowpea (*Vigna unguiculata* L.) is a widely cultivated, drought-tolerant leguminous forage crop known for its rapid growth, high green biomass production and rich protein content. It plays a crucial role in supporting livestock nutrition, particularly in arid and semi-arid regions, due to its adaptability to dryland farming systems and its ability to fix atmospheric nitrogen, thereby improving soil health. Among the essential nutrients required for optimal fodder cowpea growth, phosphorus (P) and zinc (Zn) stand out due to their key physiological roles. Phosphorus is vital for energy metabolism (ATP formation), root proliferation, nodulation and early plant vigor, all of which directly influence forage yield. On the other hand, zinc, though required in smaller quantities, is indispensable for the activation of various enzymes, synthesis of auxins (plant hormones), regulation of photosynthesis and enhancement of plant stress resistance mechanisms.

## Nutrient Uptake
Everest *et al*. (2022) [2] noticed higher nutrient uptake with the application of 80 kg $P_2O_5$ $ha^{-1}$ compared to other levels of phosphorus 0, 40, and 60 kg $ha^{-1}$ in summer groundnut on sandy loam soils of Cooch Behar, West Bengal. Increase in phosphorus level from 0 to 40 kg $ha^{-1}$ resulted in significant increase in nutrient uptake by summer cowpea on sandy loam soils of Pasighat, Arunachal Pradesh (Nadeem *et al*., 2017) [14]. The higher nitrogen and phosphorus uptake by summer mungbean were observed with the application of phosphorus @ 60 kg $ha^{-1}$ which was statistically on par with that of 40 kg $P_2O_5$ $ha^{-1}$ at Faizabad, Uttar Pradesh (Rani *et al*., 2016) [16]. Kumar *et al*. (2016) [8] noticed higher nutrient uptake by fodder cowpea with the application of 80 kg $P_2O_5$ $ha^{-1}$ than with 60 kg $P_2O_5$ $ha^{-1}$ during *kharif* on sandy loam soils of Karnal, Haryana. Indoria and Majumdar (2007) [4] recorded maximum N and P uptake by summer cowpea with the application of 60 kg $P_2O_5$ $ha^{-1}$ than with 20 kg $P_2O_5$ $ha^{-1}$ on sandy loam soils of Jobner, Rajasthan.

## Post-Harvest Soil Nutrient Status
Among the phosphorus levels tried, application of 60 kg $P_2O_5$ $ha^{-1}$ resulted in higher postharvest soil available nutrient status which was however on par with that of 40 kg $P_2O_5$ $ha^{-1}$ in fodder cowpea during summer on sandy loam soils at Tirupati, Andhra Pradesh (Mobeena *et al*., 2020) [13]. Reddy and Raju (2017) [17] reported that application of phosphorus up to 60 kg $P_2O_5$ $ha^{-1}$ significantly improved post-harvest soil available phosphorus, nitrogen and potassium in fodder cowpea grown on sandy loam soils, and the nutrient status was statistically comparable with 40 kg $P_2O_5$ $ha^{-1}$. Singh and Yadav (2019) observed that increasing phosphorus levels enhanced residual soil fertility, with 60 kg $P_2O_5$ $ha^{-1}$ recording the highest available P after harvest, which remained on par with 40 kg $P_2O_5$ $ha^{-1}$ in summer cowpea under irrigated conditions. Kumar *et al*. (2019) [7] found that phosphorus application significantly increased post-harvest soil available N, P and K, and levels beyond 40 kg $P_2O_5$ $ha^{-1}$ did not differ significantly, indicating adequate build-up of soil nutrients at both 40 and 60 kg $P_2O_5$ $ha^{-1}$ in fodder cowpea. Nadeem *et al.* (2017) [14] observed significantly higher postharvest soil available nutrient content in summer cowpea was noticed with the application of 40 kg $P_2O_5$ $ha^{-1}$ compared to that with 20 kg $P_2O_5$ $ha^{-1}$ on sandy loam soils of Pasighat, Arunachal Pradesh.

## Economics
Nanda *et al.* (2023) [15] concluded that application of 60 kg $P_2O_5$ $ha^{-1}$ increased net returns in forage cowpea which was higher over other treatments, the B:C ratio was also higher with the application 30 kg $P_2O_5$ $ha^{-1}$ in forage cowpea during *kharif* season on clay loam soils at Samastipur, Bihar. Sanikommu *et al*. (2022) [18] found that maximum B:C ratio

was obtained in Gomati variety with application of 100 % phosphorus which is significantly superior over rest of the treatments of cowpea during *zaid* season on sandy loam soils at Prayagraj, Uttar Pradesh. On sandy loam soils, Mahesh *et al.* (2021) [11] proved that application of phosphorus @ 40 kg $ha^{-1}$ + molybdenum 0.8 % foliar spray at 25 DAS in blackgram has recorded maximum gross returns, net returns and B:C ratio compared to other treatments during *kharif* season at Uttar Pradesh. Lawrence *et al*. (2021) [10] stated that application of phosphorus @ 40 kg $ha^{-1}$ and potassium @ 30 kg $ha^{-1}$ recorded maximum gross returns, net returns and benefit cost ratio in blackgram on sandy loam soils during *kharif* at Karimnagar, Telangana. Kumawat and Khinchi (2017) concluded that application of 60 kg $P_2O_5$ $ha^{-1}$ resulted in maximum net returns and benefit-cost ratio of *rabi* berseem on sandy loam soils of Bikaner, Rajasthan. Godara *et al*. (2016) [3] obtained maximum gross returns, net returns and benefit: cost ratio with the application of 100 kg $P_2O_5$ $ha^{-1}$ to berseem closely followed by that with 80 kg $P_2O_5$ $ha^{-1}$ on sandy loam soils of Hisar, Haryana during *rabi*season. Dixit *et al.* (2014) [1] stated that phosphorus application @ 60 kg $P_2O_5$ $ha^{-1}$ realized higher net returns and benefit: cost ratio in fodder cowpea than with 30 kg $P_2O_5$ $ha^{-1}$ during *kharif* on clay loam soils of Jhansi, Uttar Pradesh.Jha *et al*. (2014) [5] noticed that on clay loam soils of Jabalpur, Madhya Pradesh, application of 80 kg $P_2O_5$ $ha^{-1}$ to cowpea during *kharif* resulted in the higher gross monetary returns, net monetary returns and benefit: cost ratio followed by that with 60 and 40 kg $P_2O_5$ $ha^{-1}$. Meena and Chand (2014) [12] realized higher gross returns, net returns and benefit:cost ratio with 60 kg $P_2O_5$ $ha^{-1}$ in fodder cowpea during *kharif* on sandy loam soils of Avikanagar, Rajasthan

## Conclusion

The collective evidence from various studies clearly demonstrates the pivotal role of phosphorus nutrition in nutrient uptake and soil fertility of fodder cowpea. Application of phosphorus significantly improved availability of nutrients like N, P and K. Phosphorus levels in the range of 60–80 kg $P_2O_5$ $ha^{-1}$ were found to be optimum under most soil and climatic conditions, ensuring efficient nutrient use. Adequate phosphorus supply also favourably influenced economics of fodder cowpea. Therefore, judicious phosphorus management, sustaining soil health in fodder-based cropping systems.

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