**Nutrient Management on Forage Yield and Quality in Fodder Cowpea**

**ABSTRACT**

A field experiment was conducted during *rabi*, 2024-25 on dryland farm of S.V. Agricultural College, Tirupati, to evaluate the effect of graded levels of phosphorus (0, 20, 40 and 60 kg P₂O₅ ha⁻¹) and zinc (0, 25 and 50 kg ZnSO₄ ha⁻¹) on yield and nutritional quality of fodder cowpea (*Vigna unguiculata* L.). The findings of the present experiment concluded that optimal application of 60 kg P₂O₅ and 25 kg ZnSO₄ ha⁻¹ significantly improves the yield and nutritive value in fodder cowpea, making it more suitable for livestock feeding under dryland conditions.

**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 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.

The current research experiment is planned to know the nutrient management on forage yield and quality in fodder cowpea during *rabi* with the following objectives: 1) To study the response of Phosphorus on growth and yield of fodder cowpea. 2) To find out the effect of Zinc on the productivity and quality of fodder cowpea.

**Material and Methods**

A field experiment was conducted during *rabi*, 2024-25 at dryland farm of S.V. Agricultural College, Tirupati. The experimental soil was sandy loam in texture, neutral in soil reaction (pH 7.0), low in organic carbon (0.4 per cent) and available nitrogen (230 kg ha-1), medium in available phosphorus (22.7 kg ha-1), available potassium (235 kg ha-1) and available zinc (3.0 kg ha-1). The experiment was laid out in randomized block design with factorial concept with four levels of factor-I and three levels of factor-II and replicated thrice.

The treatments comprise of four phosphors levels *viz.,* 0 kg P2O5 ha-1 (P0), 20 kg P2O5 ha-1 (P1), 40 kg P2O5 ha-1 (P2) and 60 kg P2O5 ha-1 (P3) were allotted to Factor-I and three zinc levels *viz.,* 0 kg ZnSO4 ha-1 (Z0), 25 kg ZnSO4 ha-1 (Z1) and 50 kg ZnSO4 ha-1 (Z2) were allotted to Factor-II.

The test variety of cowpea used in the present experiment was MFC-09, released from Mandya Research Station, Karnataka. The recommended basal dose of 25 kg N ha-1, 20 kg K2O ha-1 was applied uniformly as common dose to all the treatments and P2O5 was applied as per the treatments. Fertilizer nitrogen was applied in two equal splits *i.e.,* 50 % as basal and 50 % at 30 DAS. Entire dose of phosphorus and potassium were applied as basal at the time of sowing. Soil application of zinc sulphate at 20 kg ha-1 was done at 10 DAS as per the treatments. The crop was harvested for green fodder purpose by cutting the plants close to the ground at 50 per cent flowering.

**Statistical Analysis**

The data recorded on various growth, yield and quality parameters during the course of investigation were statistically analysed following the analysis of variance procedure suggested by Panse and Sukhatme (1985). Statistical significance was tested by ‘F’ value at 5 per cent level of probability and wherever the ‘F’ value was found significant, critical difference (CD) was worked out at 5 per cent level of probability and the values were furnished. The treatment differences which were non-significant were denoted by “NS”.

**Results and Discussions**

**1. Yield**

Green and dry fodder yield of cowpea was significantly influenced by different levels of phosphorus and zinc, but interaction effect was found to be non-significant (Table 1).

The application of phosphorus significantly influenced the green and dry fodder yield. Higher green (14991 kg ha-1) and dry fodder (6291 kg ha-1) yields were observed with the application of 60 kg P₂O₅ ha⁻¹ (P₃), which was followed by 40 kg P₂O₅ ha⁻¹ (P₂) and it was on par with 20 kg P₂O₅ ha⁻¹ (P₁). Lower green (10728 kg ha-1) and dry (3155 kg ha-1) yields were observed in control (P₀) (Table 1 and Fig 1). The improvement in green and dry fodder yield with increasing levels of phosphorus can be attributed to enhanced nutrient availability and better root development, leading to improved uptake and utilization of nutrients. Phosphorus plays a crucial role in root growth, energy transfer and overall plant vigour, which likely contributed to increased plant height, leaf area, number of leaves plant-1 and number of branches plant-1. These findings were in accordance with the results reported by Kumawat (2017) and Mobeena *et al*. (2020) and Nanda (2023).

Application of 50 kg ZnSO₄ ha⁻¹ (Z2) significantly increased the green (14448 kg ha-1) and dry fodder (5304 kg ha-1) yields of cowpea compared to control (Z0) and green and dry fodder yield recorded at 25 kg ZnSO4 ha-1. Which was statistically on par with 50 kg ha⁻¹ (Z2). Significantly lower green (11143 kg ha-1) and dry fodder (4066 kg ha-1) yields were recorded in control (Z0) (Table 1 and Fig 1). This enhancement in green and dry fodder yield with application of zinc can be attributed to several physiological and biochemical roles of zinc in plant growth and development. Zinc functions as a cofactor for enzymes and proteins involved in essential processes such as cell division, nucleic acid metabolism and protein synthesis (Marschner, 1986). It also plays a critical role in carbohydrate metabolism and is essential for the biosynthesis of tryptophan, a precursor to the plant hormone indole-3-acetic acid (IAA), which regulates plant growth and developmen. Positive responses of cowpea yield to zinc application have also been reported by Pandey *et al*. (2019), Aravind (2020) and Manisha (2021).

**Table 1. Effect of graded levels of phosphorus and zinc on yield (kg ha-1) of fodder cowpea**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Green fodder yield** | **Dry fodder yield** |
| **Phosphorus levels** |  | |
| P0 - 0 kg ha-1 | 10728 | 3155 |
| P1 - 20 kg ha-1 | 13033 | 4707 |
| P2 - 40 kg ha-1 | 13681 | 5179 |
| P3 - 60 kg ha-1 | 14991 | 6291 |
| SEm± | 316 | 151 |
| CD (P=0.05) | 932 | 447 |
| **Zinc levels** |  |  |
| Z0 - 0 kg ha-1 | 11143 | 4066 |
| Z1 - 25 kg ha-1 | 13734 | 5129 |
| Z2 - 50 kg ha-1 | 14448 | 5304 |
| SEm± | 273 | 131 |
| CD (P=0.05) | 807 | 387 |
| **Phosphorus (P) × Zinc levels (P)** |  |  |
| SEm± | 547 | 256 |
| CD (P=0.05) | NS | NS |

**Fig. 1. Yield (kg ha-1) of fodder cowpea as influenced by phosphorus and zinc levels.**

**2. Quality Parameters**

Quality parameters of fodder cowpea were significantly influenced by phosphorus and zinc levels (Table 2 and Fig 2 ), but the interaction between them was found to be non-significant.

**Crude protein content**

Crude protein content of fodder cowpea was significantly higher with application of 60 kg P2O5 ha-1 (P3) (24.1 %) than with other phosphorus doses. The next best phosphorus level was 40 kg P2O5 ha-1 (P2) which was followed by 20 kg P2O5 ha-1 (P1). Lower crude protein content was noticed with control (P0) (18.4 %) (Table 2 and Fig 2). Increase in crude protein content might have resulted from marked increase in nitrogen content due to higher level of phosphorus which might have helped in more protein synthesis, as nitrogen is a constituent of various essential metabolities including protein and aminoacids. These results were in agreement with the findings of Tandon and Patel (2009) and Mobeena (2019).

Application of 50 kg ZnSO4 ha-1 (Z2) recorded significantlyhigher crude protein content (22.9 %), which was statistically at par with 25 kg ZnSO4 (Z1). Lower crude protein was noticed with control (Z0) (19.3 %). The increase in protein content might be due to zinc which helped in the formation and functioning of ribosomes, that are needed for protein production. It also supports nitrogen use in the plant, which is a major part of protein. Zinc deficiency can reduce amino acid formation and protein synthesis. Without enough zinc, plants face oxidative stress, which can damage proteins, chlorophyll and other cell parts (Cakmak *et al.,* 1989). By reducing this stress, zinc helps the plants to build up and maintain more protein. These findings were in agreement with earlier studies by Kumar *et al*. (2017) and Raju *et al*. (2024).

**Crude fibre content**

Significantly lower crude fibre content was recorded with the application of 60 kg P2O5 ha-1 (P3) (19.7 %) followed by that with 40 kg P2O5 ha-1 (P2) and 20 kg P2O5 ha-1 (P1). Higher crude fibre content was recorded with control (P0) ( 28.6 %) (Table 2 and Fig 2) and this might be due to the fact that at higher levels of phosphorus, uptake of nitrogen is increased which is a prime constituent of amino acids that increase the protein content and reduces the crude fibre content. Similar results were obtained by Kumar *et al.* (2012) and Mobeena (2019).

A reduction in crude fibre content was observed with the application of 50 kg ZnSO₄ ha⁻¹ (Z2) (21.9 %) ,which was on par with application of 25 kg ZnSO₄ ha⁻¹ (Z1). Higher fibre content was resulted under control (Z0) (26.2 %), which might be attributed to enhanced nutrient availability and improved vegetative growth, leading to the accumulation of more digestible cellular components such as proteins and soluble carbohydrates. High nutrient supply, particularly of phosphorus or zinc, tends to promote the synthesis of softer tissues over lignified structures, thereby reducing fibre content. Lower fibre content enhances palatability and digestibility, which is beneficial in fodder crops like cowpea. However, excessively low fibre levels might compromise structural integrity and storability of the biomass, suggesting the need for a balanced nutrient management approach (Prasad, 2007 and Fageria *et al*., 2011).

**Table 2. Effect of graded levels of phosphorus and zinc on crude protein, crude fibre, ash and zinc content in fodder cowpea**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Crude protein content (%)** | **Crude fibre content (%)** | **Ash content (%)** | **Zinc content (ppm)** |
| **Phosphorus levels** | | | |  |
| P0 - 0 kg ha-1 | 18.4 | 28.6 | 10.2 | 50 |
| P1 - 20 kg ha-1 | 20.1 | 25.8 | 11.1 | 57 |
| P2 - 40 kg ha-1 | 22.0 | 22.9 | 11.9 | 64 |
| P3 - 60 kg ha-1 | 24.1 | 19.7 | 13.0 | 72 |
| SEm± | 0.51 | 0.89 | 0.24 | 2.2 |
| CD (P=0.05) | 1.6 | 2.6 | 0.7 | 6 |
| **Zinc levels** | | | | |
| Z0 - 0 kg ha-1 | 19.3 | 26.2 | 11.0 | 55 |
| Z1 - 25 kg ha-1 | 21.8 | 24.4 | 11.9 | 62 |
| Z2 - 50 kg ha-1 | 22.9 | 21.9 | 12.1 | 66 |
| SEm± | 0.43 | 0.82 | 0.21 | 1.9 |
| CD (P=0.05) | 1.4 | 2.2 | 0.6 | 5.0 |

**Total Ash Content**

Total ash content of fodder cowpea was higher with application of 60 kg P2O5 ha-1 (P3) (13.0 %) (Table 1 and Fig 2), which was significantly superior to 40 kg P2O5 ha-1 (P1) andfollowed by 20 kg P2O5 ha-1 (P1). Lower total ash content was recorded with control (P0) (10.2 %). Phosphorus application had a positive effect on the ash content of fodder cowpea. The total ash content increased with increasing levels of phosphorus, with the higher values recorded at 60 kg P₂O₅ ha⁻¹. This increase may be attributed to enhanced root growth and nutrient absorption, which facilitates better uptake of minerals such as calcium (Ca), magnesium (Mg), potassium (K) and phosphorus itself, all of which contribute to total ash content. Phosphorus also improves metabolic activities and overall plant vigour, leading to increased mineral deposition in plant tissues. No phosphorus, recorded the lower ash content due to limited root activity and poor nutrient uptake. These results were in line with the findings of Tandon and Patel (2009) and Kundu *et al*. (2015).

**Fig. 2. Quality parameters of fodder cowpea as influenced by phosphorus and zinc levels.**

Among the zinc treatments, application of 50 kg ZnSO₄ ha⁻¹ (Z2) resulted in higher ash content, which was on par with 25 kg ZnSO₄ ha⁻¹ (Z1), whereas lower ash content was observed under control (Z0). The chemical composition, particularly the ash content of cowpea, is influenced by its genetic makeup and heritable traits, as noted by Antwi *et al*. (2007). This increase in ash content may be attributed to improved uptake and accumulation of essential minerals such as potassium (K), copper (Cu), manganese (Mn) and zinc (Zn) itself. According to Prasad *et al*. (2016), zinc interacts positively with potassium and facilitates enhanced absorption of micronutrients like Cu and Mn in plant tissues. In the present study, all zinc-treated plots recorded significantly higher ash content than the untreated control. These findings were in agreement with the results reported by Kumar *et al*. (2017) and Muhammad *et al*. (2024).

**Zinc content**

Zinc content of fodder cowpea was significantly higher with application of 60 kg P2O5 ha-1 (P3) (72 ppm) than with other phosphorus doses(Table 1 and Fig 2a). The next best phosphorus level was 40 kg P2O5  ha-1 (P2) which was followed by 20 kg P2O5 ha-1 (P1). The lower zinc content was noticed with control (P0) (50 ppm). Zinc content was found to be higher with application of 50 kg ZnSO4 ha-1, which might be due to enhanced root proliferation and greater translocation efficiency facilitated by zinc fertilization. This increased uptake and accumulation, particularly in leaves, suggests active metabolic involvement and sink activity. These results were confirmed with Nasri *et al*. (2011) and Girish *et al*. (2012).

**Fig. 2a. Zinc content (ppm) of fodder cowpea as influenced by phosphorus and zinc levels.**

Application of 50 kg ZnSO4 ha-1 (Z2) (66 ppm) recorded significantlyhigher zinc contentand was statistically on par with 25 kg ZnSO4 (Z1). Lower zinc content was noticed with control (Z0) (55 ppm). The lowest zinc content was observed under the control treatment (Z₀), indicating that zinc application effectively enhanced the zinc concentration in plant tissues. This improvement could be attributed to better root proliferation and nutrient uptake facilitated by zinc application. These findings are in accordance with the results of Prasad *et al*. (2016).

**Conclusion**

It can be concluded that application of 60 kg P2O5 ha-1 along with 25 kg ZnSO4 ha-1 resulted in yield and quality of fodder cowpea on nutrient management practice on sandy loam soils of southern Agro-Climatic Zone of Andhra Pradesh.

**Future line of work**

Future research should explore the integration of biofertilizers with phosphorus and zinc to improve nutrient use efficiency and sustainability. Additionally, assessing the varietal response of cowpea to combined nutrient treatments and evaluating their long-term effects on soil health and productivity can provide valuable insights for optimizing fodder crop management practices.

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**References**

Antwi, E. B., Alkoiret, T. I., Sinsin, B and Onifade, O. S. 2007. Effect of phosphorus and zinc fertilization on growth and quality of cowpea (*Vigna unguiculata* L.) as fodder in the Guinea savannah zone of Nigeria. *Journal of Agronomy.* 6(3): 528-533.

Arvind B.P., Sanjeev K.G and Sborna R.C. 2020. Enhancing prodctivity and quality of fodder maize through nitrogen and zinc application levels. *International Journal of Chemistry Studies.* 8(6): 540-545.

Cakmak, I., Marschner, H and Bangerth, F. 1989. Effect of zinc nutritional status on growth, protein metabolism and levels of indole-3 acetic acid and other phytohormones in bean (*Phaseolous vulgaris* L.). *Journal of Experimental Botany*. 40(3): 405-412.

Fageria, N. K., Baligar, V. C and Jones, C. A. 2011. *Growth and mineral nutrition of field crops* (3rd edition). CRC Press.

Girish, C.P., Gupta, B and Pandey, N. 2012. Improving reproductive efficiency of chickpea by foliar application of zinc. *Brazilian Journal of Plant Physiology*. 24 (3): 173-180.

Kumar, A., Yadav, R.K., Singh, R and Yadav, H.K. 2012. Growth, biomass production and quality characters of cowpea as influenced by phosphorus and sulphur fertilization on loamy sands of semi-arid sub tropics. *An Asian Journal of Soil Science*. 7(1): 80-83.

Kumar, R., Singh, M., Meena, B.S., Ram, H., Parihar, C.M., Kumar, S., Yadav, M.R., Meena, R.K., Kumar, U and Meena, V.K. 2017. Zinc management effects on quality and nutrient yield of fodder maize (*Zea mays*). *Indian Journal of Agricultural Sciences*. 87(8): 1013-1017.

Kumawat, S.M and Khinchi, V. 2017. Effect of phosphorus levels on forage yield of promising multicut genotypes of berseem (*Trifolium alexandrium* L.). *Forage Research*. 43(3): 223-226.

Kundu, C.K., Das, H., Roy, D.C., Bandopadhyay, P and Bandyopadhyay, S. 2015. Effect of different levels of phosphorus on yield and quality of fodder ricebean. *Trends in Biosciences*. 8(1): 64-67.

**Manisha. 2021.** Evaluation of fodder cowpea varieties under different zinc management practices. ***M.Sc Thesis*.** ICAR-National Dairy Research Institute, Haryana, India.

manure, phosphorus and sulphur application in central India*. Range Management and Agroforestry*. 35(1): 66-72.

Mobeena, S. 2019. Effect of sowing window and phosphorus levels on growth and yield of summer fodder cowpea. *M.Sc (Ag) Thesis*. Acharya N. G. Ranga Agricultural University, Guntur, India.

Mobeena, S., Nagamani, C., Reddy, G. P and Umamahesh, V. 2020. Effect of sowing window and phosphorus levels on growth and yield of summer fodder cowpea. *Legume Research - An International Journal.* 48(1). 172-175.

Muhammad, A., Muhammad S.A., Muhammad, E.S., Imran, K., Naeem, A., Muhammad, A. H., Muhammad, M., Zhao, B., Hesham, S and Almoallim, M.J.A. 2024. Agronomic bio-fortification of zinc Improves the yield and quality of fodder oat. *Journal of Ecological Engineering.* 25(6): 153-163.

Nanda, G., Nilanjaya and Yadav, K.S.A. 2023. Response of forage cowpea genotypes to graded doses of phosphorus application. *Forage Research*. 48(4): 470-473.

Nasri, M., Khalatbari, M and Farahani, H.A. 2011. Zn-foliar application influence on quality and quantity features in *Phaseolous vulgaris* under different levels of N and K fertilizers. *Advances in Environmental Biology*. 5 (5): 839-846.

Pandey, A. K., Singh, M., Kumar, S., Meena, V. K., Onte, S and Kushwaha, M. 2019. Influence of stage of harvesting and zinc application on yield and zinc uptake in cluster bean [*Cyamopsis tetragonoloba* (L.) TAUB]. *Legume Research-An International Journal*. 42(5): 661-665.

Prasad, R. 2007. *Crop nutrition – Principles and Practices.* 1st edition: 1-272. New Vishal Publications, New Delhi-India.

Prasad, R., Shivay, Y. S and Kumar, D. 2016. Zinc fertilization in agriculture: Current status and future prospects. *Indian Council of Agricultural Research.* 12(1): 16-26*.*

Raju, T., Roopashree, D.H., Bhagyalakshmi. T and Sunil. C.M. 2024. Fortification of fodder maize (*Zea mays* L.) with zinc for enhancing fodder quality, nutrient uptake and economics. *International Journal of Research Agronomy.* 7(7S): 480-483.

Tandon, A and Patel, C.L. 2009. Influence of phosphorus management on growth, yield and quality of lucerne (*Medicago sativa* L.). *Legume* *Research.* 35(1): 5-8.