**Effect of 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 vital leguminous forage crop valued for its high biomass and protein content under dryland conditions. Phosphorus is critical for energy transfer, root development and reproductive growth, while zinc acts as a cofactor for key enzymes and influences auxin synthesis, photosynthesis and stress tolerance. Integrated phosphorus and zinc fertilization can enhance green fodder yield, nutrient uptake and soil fertility, yet optimal rates remain under-studied. This research investigates the effect of nutrient management on forage yield and quality in 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.

**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**

Results of the present study clearly indicated that the combined application of 60 kg P₂O₅ ha⁻¹ and 25 kg ZnSO₄ ha⁻¹ significantly improved the yield and nutritional quality of fodder cowpea. These treatments increased green fodder, dry fodder and enhanced crude protein content, reduced crude fibre levels and improved ash and zinc concentrations in the plant, thereby promoting superior forage quality. Balanced phosphorus and zinc nutrition contributed to better nutrient uptake and assimilation, reflecting in overall improvement in the yield and quality parameters critical for livestock feed value.

**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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