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EFFECT OF PHOSPHORUS MANAGEMENT AND FOLIAR NUTRITION ON NUTRIENT UPTAKE, SOIL NUTRIENT STATUS AND SEED YIELD OF COWPEA

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ABSTRACT

A field experiment was conducted during *rabi*, 2025-26 at S.V. Agricultural College, Tirupati, Andhra Pradesh, India, to study the effect of phosphorus levels and foliar nutrition on nutrient uptake, post-harvest soil available nutrients and seed yield of cowpea. The experiment was laid out in randomized block design with factorial concept with three replications, comprising three phosphorus levels (100% RDP through inorganics (P_1), 75% RDP through inorganics + 25 % RDP through FYM + PSB @ 1.25 l ha^{-1} (P_2) and 50% RDP through inorganics + 50% RDP through FYM + PSB @ 1.25 l ha^{-1} (P_3) and five foliar sprays (water spray (F_1), 2% urea (F_2), 10% cow urine (F_3), 1% KNO_3 (F_4) and 1% seaweed extract (F_5), applied twice at 30 and 45 days after sowing. The application of 75% RDP through inorganics + 25 % RDP through FYM + PSB @ 1.25 l ha^{-1} (P_2) recorded significantly higher seed yield and higher uptake of nitrogen, phosphorus and potassium at harvest, significantly lower post-harvest soil available nitrogen, phosphorus and potassium compared to the other phosphorus levels, reflecting its greater nutrient extraction efficiency. Among foliar sprays, 1% KNO_3 (F_4) produced significantly the highest seed yield and nutrient uptake, while recording the lowest post-harvest soil available nutrient status. Water spray recorded the lowest seed yield and nutrient uptake but the highest residual soil nutrient status. Interaction effects between phosphorus levels and foliar sprays were non-significant for all the parameters studied. The results indicate an inverse relationship between crop nutrient uptake efficiency and post-harvest soil nutrient status and suggest that combining 75% RDP through inorganics + 25 % RDP through FYM + PSB @ 1.25 l ha^{-1} (P_2) along with foliar spray of 1% KNO_3 (F_4) improves nutrient acquisition and seed yield of cowpea, while maintaining reasonable residual soil fertility.

Key words : Cowpea, Phosphorus, Nutrient uptake, Soil fertility, Seed yield.

Introduction

Cowpea [*Vigna unguiculata* (L.)] is an important grain legume of tropical and subtropical regions valued for its adaptability, short duration and nutritional richness. Besides being a major source of dietary protein (Jayathilake *et al*., 2018), it also contributes to soil fertility through symbiotic nitrogen fixation. Despite this inherent advantage, cowpea productivity in India remains low, largely due to inadequate and imbalanced nutrient management particularly of phosphorus which is central to nodulation, root development and reproductive growth in legumes.

Phosphorus use efficiency from inorganic fertilizers alone is often constrained by fixation in soil, necessitating integration with organic manures and biofertilizers. Integrated nutrient management combining inorganic phosphorus with farmyard manure and phosphorus solubilizing bacteria has been shown to enhance nutrient availability, root proliferation and overall nutrient acquisition efficiency in legumes. Foliar nutrition, applied as a supplement to soil based fertilization, further improves nutrient use efficiency by bypassing soil related constraints such as fixation and leaching particularly during critical reproductive stages.

The efficiency of any nutrient management strategy is best evaluated not only in terms of crop yield but also

through its influence on plant nutrient uptake and the residual soil nutrient status left behind after crop harvest, since the latter has direct implications for soil fertility management in subsequent cropping cycles. However, information on the combined influence of integrated phosphorus management and foliar nutrition on nutrient uptake, post-harvest soil fertility and seed yield in cowpea remains limited. The present investigation was therefore undertaken to study the effect of integrated phosphorus management and foliar nutrition on nutrient uptake, post-harvest soil available nutrients and seed yield of cowpea.

Materials and Methods

The field experiment was carried out during *rabi* 2025-26 at S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University, situated at 13° N latitude and 79° E longitude, at an altitude of 182.9 m above mean sea level. The soil of the experimental site was sandy loam in texture, neutral in reaction (pH 6.51), low in organic carbon (0.4%), available nitrogen (207 kg ha^{-1}), medium in available phosphorus (24.3 kg ha^{-1}) and available potassium (213 kg ha^{-1}).

The experiment was laid out in randomized block design with factorial concept with three replications, comprising fifteen treatment combinations of three phosphorus levels: P_1 - 100% RDP through inorganics, P_2 - 75% RDP through inorganics + 25% RDP through FYM + PSB @ 1.25 l ha^{-1} and P_3 - 50% RDP through inorganics + 50% RDP through FYM + PSB @ 1.25 l ha^{-1} (RDP = 50 kg P_2O_5 ha^{-1}) and five foliar sprays: F_1 - control (water spray), F_2 - 2% urea, F_3 - 10% cow urine, F_4 - 1% KNO_3 and F_5 - 1% seaweed extract, applied twice at 30 and 45 DAS. A uniform basal dose of 20 kg N ha^{-1} and 25 kg K_2O ha^{-1} was applied to all plots. The short duration cowpea variety TPTC-29 was sown on 19th November 2025 at a spacing of 45 cm × 15 cm.

Seed yield was recorded from the net plot area at harvest and expressed as kg ha{ ¹ after adjusting to 12% moisture content. For nutrient uptake, oven-dried plant samples were digested in a di-acid mixture (HNO_3 :$HClO_4$, 9:4); nitrogen content was estimated by the micro-Kjeldahl method, phosphorus by the vanadomolybdo-phosphoric yellow colour method using a spectrophotometer and potassium by flame photometry. Nutrient uptake was computed by multiplying nutrient content with the corresponding dry matter yield and expressed as kg ha^{-1}. Post-harvest soil samples (0-15 cm depth) were analysed for available nitrogen by the alkaline potassium permanganate method (Subbiah and Asija, 1956), available phosphorus by Olsen's method using 0.5 M $NaHCO_3$ extractant (Olsen *et al.*, 1954) and available potassium by neutral normal ammonium acetate extraction followed by flame photometry (Jackson, 1973).

Results and Discussion

Seed yield

Seed yield of cowpea was significantly influenced by phosphorus levels and foliar sprays, while their interaction effect was non-significant (Table 1). Among phosphorus levels, significantly higher seed yield was recorded with 75% RDP through inorganics + 25% RDP through FYM + PSB @ 1.25 l ha^{-1} (P_2), followed by 100% RDP through inorganics (P_1), while 50% RDP through inorganics + 50% RDP through FYM + PSB @ 1.25 l ha^{-1} (P_3) recorded significantly the lowest seed yield. The superior performance of P, can be attributed to the synergistic effect of combining a substantial inorganic phosphorus base with the complementary benefits of organic matter and biological phosphorus solubilization, which sustained phosphorus availability during critical reproductive stages and favoured pod development, seed set and seed filling. The lower seed yield under 50% RDP through inorganics + 50% RDP through FYM + PSB @ 1.25 l ha^{-1} (P_3) may be ascribed to the slower rate of FYM mineralization, which limited the availability of the organic phosphorus fraction within the critical reproductive window. These findings were in agreement with Rathour *et al*. (2015), Pargi *et al*. (2018), Rekha *et al*. (2018) and Sejal *et al*. (2024).

Among foliar sprays, significantly the highest seed yield was recorded with 1% KNO_3 (F_4), followed by 2% urea (F_2), while 10% cow urine (F_3) and 1% seaweed extract (F_5) were statistically comparable and water spray (F_1) recorded the lowest seed yield. The dominant performance of 1% KNO_3 (F_4) can be attributed to the dual-nutrient advantage of potassium nitrate, which supplies both nitrogen and potassium directly through foliar absorption, enhancing phloem loading, assimilate translocation and seed filling during the reproductive phase. These results were in line with the findings of Yadav *et al*. (2019) and Jayashree and Umesha (2023).

Nutrient Uptake

Nitrogen, phosphorus and potassium uptake at harvest were significantly influenced by phosphorus levels and foliar sprays, with a non-significant interaction effect (Table 1). Among phosphorus levels, significantly the highest uptake of nitrogen, phosphorus and potassium was recorded with 75% RDP through inorganics + 25% RDP through FYM + PSB @ 1.25 l ha^{-1} (P_2), followed by 100% RDP through inorganics (P_1), while 50% RDP

Table 1 : Seed yield and nutrient uptake (N, P and K) of cowpea as influenced by phosphorus levels and foliar sprays.

Treatments	Seed yield (kg ha^{-1})	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
Phosphorus levels (P)				
P_1 : 100% RDP through inorganics	1546	95	14.1	25.7
P_2 : 75% RDP through inorganics + 25% RDP through FYM + PSB @ 1.25 l ha^{-1}	1687	100	15.3	28.5
P_3 : 50% RDP through inorganics + 50% RDP through FYM + PSB @ 1.25 l ha^{-1}	1424	91	12.8	24.1
SEm±	35.5	1.51	0.25	0.41
CD (P=0.05)	106	4.0	0.7	1.2
Foliar sprays (F)				
F_1 : Control (Water spray)	1224	84	10.9	22.7
F_2 : 2% Urea	1623	106	13.7	27.3
F_3 : 10% Cow urine	1482	93	12.6	25.6
F_4 : 1% KNO_3	1772	100	14.9	28.9
F_5 : 1% Seaweed extract	1470	92	12.3	24.8
SEm±	39.3	1.96	0.34	0.53
CD (P=0.05)	118	5.0	0.9	1.5
Interaction (P × F)				
SEm±	52.8	3.38	0.47	0.93
CD (P = 0.05)	NS	NS	NS	NS

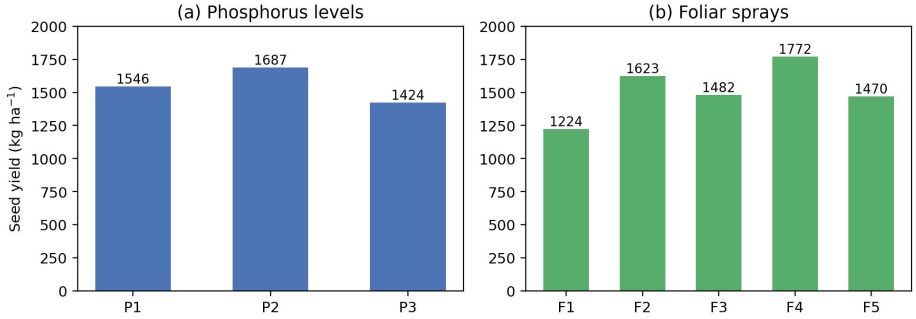


Fig. 1 : Seed yield of cowpea as influenced by phosphorus levels and foliar sprays.

through inorganics + 50% RDP through FYM + PSB @ 1.25 l ha^{-1} (P_3) recorded significantly the lowest uptake of all three nutrients. The superior nutrient uptake under 75% RDP through inorganics + 25% RDP through FYM + PSB @ 1.25 l ha^{-1} (P_2) can be attributed to the synergistic interplay between adequate inorganic phosphorus availability and the biologically-mediated enhancement of root growth, nodulation and rhizospheric nutrient solubilization under integrated nutrient management which together improved both biological nitrogen fixation and root-mediated uptake of phosphorus and potassium. The lowest nutrient uptake under 50% RDP through inorganics + 50% RDP through FYM + PSB @ 1.25 l ha^{-1} (P_3) reflects the constrained phosphorus availability arising from incomplete FYM mineralization, which limited nodule functioning and overall nutrient acquisition capacity. These findings were in agreement with Rani *et al*. (2016), Khan *et al*. (2017), Nadeem *et al*. (2017) and Singh *et al*. (2022).

Among foliar sprays, significantly the highest nitrogen uptake was recorded with 2% urea (F_2), followed by 1% KNO_3 (F_4), whereas F„ recorded significantly the highest phosphorus and potassium uptake, followed by 2% urea (F_2). 10% cow urine (F_3) and 1% seaweed extract (F_5) were statistically comparable and occupied an intermediate position for all three nutrients, while water spray (F_1) recorded significantly the lowest uptake. The higher nitrogen uptake under 2% urea (F_2) reflects the direct and abundant foliar nitrogen supply from urea, while the superior phosphorus and potassium uptake under 1% KNO_3 (F_4) can be explained by the role of potassium in activating root H^+ -ATPase pumps,

Table 2 : Post-harvest soil available nitrogen, phosphorus and potassium as influenced by phosphorus levels and foliar sprays.

Treatments	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})
Phosphorus levels (P)			
P_1 : 100% RDP through inorganics	227	39.4	162
P_2 : 75% RDP through inorganics + 25% RDP through FYM + PSB @ 1.25 l ha^{-1}	223	35.2	145
P_3 : 50% RDP through inorganics + 50% RDP through FYM + PSB @ 1.25 l ha^{-1}	251	44.1	173
SEm±	3.59	0.62	2.51
CD (P=0.05)	10	1.8	7.2
Foliar sprays (F)			
F_1 : Control (Water spray)	257	43.5	180
F_2 : 2% Urea	224	38.2	149
F_3 : 10% Cow urine	238	40.7	160
F_4 : 1% KNO_3	209	35.1	144
F_5 : 1% Seaweed extract	239	40.9	167
SEm±	4.64	0.79	3.24
CD (P = 0.05)	13	2.3	9.4
Interaction (P × F)			
SEm±	8.04	1.38	5.61
CD (P=0.05)	NS	NS	NS

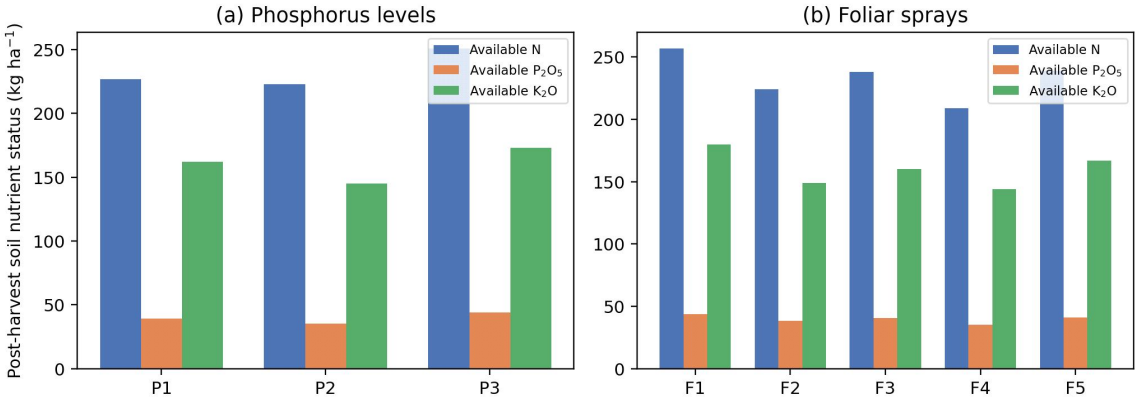


Fig. 2 : Post-harvest soil available N, P and K as influenced by phosphorus levels and foliar sprays.

which enhances phosphate desorption from soil colloids and by the direct foliar supply of potassium bypassing soil-mediated constraints. These results are in conformity with Jani *et al.* (2020), Sakpal *et al.* (2021), Priyanka *et al.* (2019) and Dhar *et al.* (2025).

Post-Harvest Soil Nutrient status

Post-harvest soil available nitrogen, phosphorus and potassium were significantly influenced by phosphorus levels and foliar sprays, while their interaction effect was non-significant (Table 2). Among phosphorus levels, significantly the highest post-harvest soil available nitrogen, phosphorus and potassium was recorded with 50% RDP through inorganics + 50% RDP through FYM + PSB @ 1.25 l ha^{-1} (P_3), while 75% RDP through inorganics + 25 % RDP through FYM + PSB @ 1.25 l ha^{-1} (P_2) recorded significantly the lowest available phosphorus and potassium, 100% RDP through inorganics (P_1) and P, were statistically comparable for available nitrogen. The higher residual soil fertility under 50% RDP through inorganics + 50% RDP through FYM + PSB @ 1.25 l ha^{-1} (P_3) can be attributed to two reinforcing factors

namely, the larger farmyard manure input under this treatment whose progressive mineralization continuously released nutrients into the soil and the comparatively lower crop nutrient uptake efficiency which resulted in reduced nutrient drawdown by the crop. Conversely, the lowest residual soil phosphorus and potassium under 75% RDP through inorganics + 25% RDP through FYM + PSB @ 1.25 l ha^{-1} (P_2) reflects its superior crop performance and maximal nutrient uptake resulting in the greatest depletion of soil nutrient reserves at harvest despite the continued solubilizing activity of PSB. These findings were in agreement with Kant *et al*. (2016), Ranpariya *et al*. (2017) and Rekha *et al*. (2018).

Among foliar sprays, significantly the highest post-harvest soil available nitrogen, phosphorus and potassium was recorded with water spray (F_1), while 1% KNO_3 (F_4) recorded significantly the lowest available nitrogen and phosphorus. 2% urea (F_2) and 1% KNO_3 (F_4) were statistically comparable in recording the lowest available potassium. The highest residual soil fertility under water spray (F_1) is a direct consequence of the lowest crop nutrient uptake in the absence of supplemental foliar nutrition whereas, the lowest residual soil nutrient status under 1% KNO_3 (F_4) and 2% urea (F_2) reflects the intensified root nutrient acquisition associated with the highest crop nutrient uptake under these treatments. These results are in conformity with Jani *et al*. (2020), Sakpal *et al*. (2021), Priyanka *et al*. (2019) and Dhar *et al*. (2025).

Conclusion

Based on the results of the present investigation, it can be concluded that application of 75% RDP through inorganics + 25% RDP through FYM + PSB @ 1.25 l ha^{-1} (P_2), combined with foliar spray of 1% KNO_3 (F_4) at 30 and 45 DAS, recorded the highest seed yield and nutrient (N, P and K) uptake in cowpea. However, these treatments also resulted in the greatest depletion of post-harvest soil available nutrients, indicating an inverse relationship between crop nutrient uptake efficiency and residual soil fertility. Since 50% RDP through inorganics + 50% RDP through FYM + PSB @ 1.25 l ha^{-1} (P_3) left behind the highest residual soil nutrient status despite lower crop performance, periodic replenishment of organic sources may be considered in continuous cropping systems to sustain long-term soil fertility alongside the yield advantages of integrated nutrient management. The application of 75% RDP through inorganics + 25% RDP through FYM + PSB @ 1.25 l ha^{-1}, along with foliar spray of 1% KNO_3, can be recommended for realizing higher seed yield and nutrient use efficiency in cowpea under similar agro-climatic conditions.

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