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# Growth and productivity of cowpea (*Vigna unguiculata* L.) as affected by different levels of nano DAP in north eastern dry zone of Karnataka

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**Abstract**
A field experiment was conducted at College of Agriculture, Bheemarayanagudi during *kharif* season 2023 with an objective to study the effect of nano DAP on growth and yield of cowpea (*Vigna unguiculata* L.). The soil was clayey in texture and experiment was laid out in randomized block design with three replications and comprised of seven treatments. The treatments comprise of rate of soil application of conventional (DAP) and foliar application of nano DAP fertilizers. Regional recommended N and K fertilizer rate is common for all the treatments. Results revealed that basal application of 100 per cent RDP + foliar spray of 4 ml $l^{-1}$ of nano DAP had resulted in higher seed yield (1940 kg $ha^{-1}$), however, it was statistically on par with application of 100 per cent RDP + 2ml $l^{-1}$ nano DAP spray at 30 and 45 DAS (1890 kg $ha^{-1}$), 75% per cent RDP + 4 ml $l^{-1}$ nano DAP spray (1871 kg $ha^{-1}$) and control treatment with RDF (1790 kg $ha^{-1}$). Further, similar trend has been followed in case of stover yield, gross returns, net returns and B C ratio of cowpea production. These results confirms that we can replace about 25 per cent of conventional DAP fertilizer with nano DAP application of 4 ml $l^{-1}$ at 30 and 45 DAS in increasing the P use efficiency and productivity of cowpea.

**Keywords:** Cowpea, conventional DAP, foliar spray, nano DAP

## 1. Introduction

Cowpea (*Vigna unguiculata* L.), a heat- and drought-tolerant legume, plays a crucial role in semiarid regions of Africa and Asia, thriving with minimal inputs. Its nitrogen-fixing ability enhances soil fertility, benefiting resource-poor farmers and making it ideal for intercropping. The entire plant is valuable, serving as both a protein-rich food source and forage for animals. With a protein content of 23-25%, cowpea provides essential amino acids, particularly in regions where animal protein is scarce. Its adaptability to poor soils and harsh climates contributes to sustainable agriculture by reducing the need for synthetic fertilizers

There are no records on area production and productivity statistics exclusively for cowpea. Nevertheless, rough estimates indicate that annual global production is around 2 M t from an area around 5 M ha. India accounts for about 0.5 M t production from around 1.5 M ha. The productivity of cowpea in Karnataka is low (420 kg $ha^{-1}$) as compared to the national productivity of 567 kg $ha^{-1}$. (Anon., 2023) [1]. This clearly indicates there is necessity to identify the reasons for low productivity in India in general and Karnataka in particular. The studies show that high yielding varieties of crop can contribute to an extent towards the improvement of crop yield.

Nanotechnology, particularly nano fertilizers like nano DAP, offers a potential solution to enhance cowpea yields. Nano DAP, a foliar spray developed by IFFCO, delivers nitrogen and phosphorus efficiently, reducing nutrient wastage and improving plant stress tolerance. Studies by Solanki *et al*. (2015) [2] and Singh *et al*. (2017) [3] show that nano DAP enhances nutrient uptake, boosts crop yields and reduces environmental impacts. Raliya (2015) [4] also notes that nano DAP helps crops withstand environmental stresses.

A study is proposed to assess the "Effect of nano DAP on the growth and yield of cowpea (*Vigna unguiculata* L.)," focusing on its influence on growth, nutrient uptake, yield and the economic viability of cowpea cultivation under nano DAP application.

## 2. Materials and Methods

The field experiment on the "Effect of nano DAP on growth and yield of cowpea (*Vigna unguiculata* L.)" was conducted during the *kharif* 2023 season at the Experimental Block of the College of Agriculture, Bheemarayanagudi, UAS, Raichur. The experimental site is located in the North Eastern Dry Zone of Karnataka at an altitude of 389 meters, with medium deep clay soil. Soil samples were analysed for physical and chemical properties before the experiment.

The experiment on the effect of nano DAP on cowpea growth and yield consisted of seven treatments in a randomized complete block design with three replications. The treatments included: $T_1$: Control with 100% RDF, $T_2$: 50% RDP with a foliar spray of nano DAP @ 2 ml $l^{-1}$ at 30 and 45 days after sowing (DAS), $T_3$: 50% RDP with foliar spray of nano DAP @ 4 ml $l^{-1}$ at 30 and 45 DAS, $T_4$: 75% RDP with foliar spray of nano DAP @ 2 ml $l^{-1}$ at 30 and 45 DAS, $T_5$: 75% RDP with foliar spray of nano DAP @ 4 ml $l^{-1}$ at 30 and 45 DAS, $T_6$: 100% RDP with foliar spray of nano DAP @ 2 ml $l^{-1}$ at 30 and 45 DAS and$T_7$: 100% RDP with foliar spray of nano DAP @ 4 ml $l^{-1}$ at 30 and 45 DAS. All treatments received the same recommended doses of nitrogen (25 kg $ha^{-1}$), phosphorus (50 kg $ha^{-1}$), potassium (25 kg $ha^{-1}$) and FYM @ 6 t $ha^{-1}$.

Growth parameters like plant height, number of leaves, leaf area and dry matter production were recorded at 30, 60 DAS and at harvest. Leaf area was measured using the disc method and leaf area index (LAI) was calculated by dividing the leaf area by the land area occupied by each plant. Yield parameters, including the number of pods $plant^{-1}$, number of seeds $pod^{-1}$, 100-seed weight, seed yield and stover yield, were recorded at harvest.

Economic analysis involved calculating the cost of cultivation, gross returns, net returns and benefit-cost (BC) ratio based on market rates and input costs. Statistical analysis of the data was performed using Fisher's method of analysis of variance at a 5% significance level, with critical differences estimated using the t-test. and variance technique as given by Panse and Sukhatme (1967) [5].

## 3. Results and Discussion

### 3.1 Effect of nano DAP on growth attributes

#### 3.1.1 Plant height

Plant height of cowpea was significantly influenced by the application of different levels of phosphorus and foliar spray of nano DAP in Table 1. The application of 100% RDP combined with foliar spray of nano DAP @ 4 ml $l^{-1}$ at 30 and 45 DAS resulted in significantly higher plant height (65.49 cm) as compared to other treatments. However, it was in comparable with the treatment receiving 100% RDP with nano DAP @ 2 ml $l^{-1}$ (63.72 cm), 75% RDP with nano DAP @ 4 ml $l^{-1}$ (62.54 cm) and the control treatment with RDF only (59.0 cm). In contrast, significantly lower plant height was recorded in treatment receiving 50% RDP combined with foliar applications of nano DAP @ 2 ml $l^{-1}$ (43.20 cm) at 30 and 45 DAS as compared to other treatments. The increase in plant height observed with higher doses of RDF and nano DAP foliar applications can be attributed to enhanced nitrogen and phosphorus uptake, with nanoparticles facilitating efficient absorption. Nitrogen promotes amino acid synthesis and cell division, while phosphorus aids nutrient and water uptake, boosting cellular growth. Similar findings were reported by Rattan and Ruiqiang (2014) [6] in soybean, showing a 32.6% increase in plant height with nanoparticle application. The effectiveness of apatite nanoparticles as phosphorus fertilizers has also been supported by Suriyaprabha *et al*. (2012) [7], Alqader *et al*. (2020) [8] and Mishra *et al*. (2020) [9], highlighting their potential to improve crop growth and yield.

#### 3.2.2 Number of leaves

Number of leaves of cowpea was significantly influenced by the application of different levels of phosphorus and foliar spray of nano DAP in Table 1. The application of 100% RDP combined with foliar spray of nano DAP @ 4 ml $l^{-1}$ at 30 and 45 DAS resulted in a significantly higher number of leaves $plant^{-1}$ (41.52) as compared to other treatments, which was in comparable to treatment receiving 100% RDP with foliar spray of nano DAP @ 2 ml $l^{-1}$ (39.80), 75% RDP with nano DAP @ 4 ml $l^{-1}$ (39.32) and the treatment receiving RDF alone (38.48). Conversely, the significantly lower number of leaves $plant^{-1}$ was recorded in treatment receiving 50% RDP combined with foliar application of nano DAP @ 2 ml $l^{-1}$ (26.32) at 30 and 45 DAS The increased leaf production in treatments with higher RDP and nano DAP applications is likely due to the enhanced nutrient availability, particularly phosphorus, which plays a key role in promoting plant growth and leaf development. Nano DAP foliar spray significantly improved the photosynthetic efficiency of cowpea plants, resulting in greater energy production, increased plant height and a higher number of leaves. This enhancement is due to the effective supply of nitrogen and phosphorus, which promote taller growth and more node development, leading to increased number of leaves. The use of nano fertilizers improves nutrient absorption and transport, fostering better crop growth. Merghany *et al*. (2019) [10] also found that the leaf count increased until 60 DAS, followed by a decline at harvest due to the translocation of nutrients to reproductive parts, causing older leaf senescence. Similar results were observed by Kurdekar (2021) [11], Pragathi (2023) [12] Prakash (2023) [13] and Srikanth (2023) [14] across various crops.

#### 3.3.3 Leaf area

Significant variation was observed in case of leaf area as influenced by the application of different levels of phosphorus and foliar spray of nano DAP in Table 1. The application of 100% RDP combined with foliar spray of nano DAP @ 4 ml $l^{-1}$ at 30 and 45 DAS recorded significantly higher leaf area (2174.54 $cm^2$ $plant^{-1}$) as compared to other treatments except treatment receiving 100% RDP with foliar spray of nano DAP @ 2 ml $l^{-1}$ (2056.12 $cm^2$ $plant^{-1}$), 75% RDP with foliar application of nano DAP @ 4 ml $l^{-1}$ (2036.59 $cm^2$ $plant^{-1}$) and the control treatment receiving RDF alone (2018.84 $cm^2$ $plant^{-1}$). The application of 100% RDP combined with foliar spray of nano DAP resulted in a higher leaf area, which has supported the initial establishment and growth of plants. The foliar application of nitrogen in its nano form, with its high concentration of nitrogen molecules and extensive surface area, facilitates enhanced nitrogen absorption. Since nitrogen is a crucial component of chlorophyll, an adequate supply at optimal concentrations promoted the production of more leaves by reducing inter-plant competition for nutrients. This in turn, lead to an increased leaf area. To sustain a larger leaf area, a higher number of leaves is essential, which is influenced by plant height and the number of primary and secondary branches (Rajesh., 2021) [15]. Similar finding was reported by Ajithkumar *et al*. (2021) [16], Mallikarjuna (2021) [17] and Pragathi (2023) [12] in various crops.

#### 3.3.4 Leaf area index

Leaf area index of cowpea was significantly influenced by the application of different levels of phosphorus and foliar spray of nano DAP in Table 1. The treatment receiving 100% RDP combined with foliar spray of nano DAP @ 4 ml $l^{-1}$ at 30 and 45 DAS recorded a significantly higher leaf area index (4.82) as compared to other treatments. However, this result was in comparable with the treatment receiving 100% RDP with foliar spray of nano DAP @ 2 ml $l^{-1}$ (4.56), 75% RDP with foliar spray of nano DAP @ 4 ml $l^{-1}$ (4.32) and the control treatment receiving RDF alone (4.26). In contrast, significantly lower leaf area index was observed in treatment receiving 50% RDP combined with foliar spray of nano DAP @ 2 ml $l^{-1}$ (2.66) at 30 and 45 DAS as compared to other treatments. The supply of nano DAP provided essential nitrogen and phosphorus, which are integral components of chlorophyll, proteins and various cell constituents. The foliar application of nitrogen and phosphorus in nano form facilitated more rapid absorption by the leaves compared to conventional nitrogen sources due to its increased surface area. The adequate availability of nitrogen during the vegetative stage promoted the production of highest number of leaves and a largest leaf area. With uniform growth space across all treatment, the highest leaf area index was recorded in treatment receiving 100% RDP combined with a foliar spray of nano DAP @ 4 ml $l^{-1}$ of water. These finding was similar with results reported by Rajesh (2021) [15], Reddy *et al*. (2022) [18] and Aniket (2023) [19].

### 3.2 Effect of nano DAP on yield attributes

#### 3.2.1 Number of pods plant$^{-1}$

The data on the number of pods plant$^{-1}$ is presented in Table 2. Indicates significant variations due to different levels of phosphorus and foliar application of nano DAP. The treatment receiving 100% RDP as a basal dosage coupled with foliar application of nano DAP @ 4 ml $l^{-1}$ at 30 and 45 DAS exhibited a significantly higher number of pods plant$^{-1}$ (22.42) as compared to other treatments except treatment receiving 100% RDP along with foliar spray of nano DAP @ 2 ml $l^{-1}$ at 30 and 45 DAS (21.76), 75% RDP with foliar spray of nano DAP @ 4 ml $l^{-1}$ (21.32) and the control treatment receiving RDF only (20.02). Foliar application of nano DAP significantly boosts the number of pods per cowpea plant by enhancing nutrient absorption, especially phosphorus and nitrogen. The nano-sized particles allow more efficient uptake compared to conventional fertilizers, promoting better reproductive growth reported a notable increase in pod formation with nano DAP spray, attributing it to improved nutrient availability. Similar finding was reported by Kaviyazhagan *et al*. (2022) [20], Sathyan (2022) [21], Bhakher *et al*. (2023) [22].

#### 3.2.2 Number of seeds pod$^{-1}$

The number of seeds pod$^{-1}$ exhibited significant variation among the treatments as influenced by varying levels of phosphorus and foliar application of nano DAP which is furnished in Table 2. The treatment receiving 100% RDP as a basal dosage combined with foliar application of nano DAP @ 4 ml $l^{-1}$ at 30 and 45 DAS exhibited marked variation in number of seeds pod$^{-1}$ (12.28) followed by the treatments receiving 100% RDP along with foliar application of nano DAP @ 2 ml $l^{-1}$ at 30 and 45 DAS (11.92), 75% RDP with foliar application of nano DAP @ 4 ml $l^{-1}$ (11.62) and the control treatment receiving RDF alone (11.84). The significant increase in seeds per pod with 100% RDP and nano DAP foliar application is due to enhanced phosphorus availability and efficient nutrient uptake. Nano DAP boosts nutrient absorption, especially phosphorus, which is crucial for reproductive development, leading to better seed formation compared to other treatments.

#### 3.2.3 100 seed weight

The data concerning the impact of varying levels of phosphorus and foliar application of nano DAP on the 100 seed weight of cowpea is presented in Table 2. Application of 100% RDP as a basal dose combined with foliar spray of nano DAP @ 4 ml $l^{-1}$ at 30 and 45 DAS produced significantly 100 seed weight (9.93 g) as compared to other treatments except treatment receiving 100% RDP with nano DAP @ 2 ml $l^{-1}$ at 30 and 45 DAS (9.60 g), 75% RDP with a nano DAP foliar application @ 4 ml $l^{-1}$ (9.34 g) and the control treatment with RDF only (8.88). The enhanced 100 seed weight in cowpea due to nano DAP foliar application is linked to improved phosphorus uptake, which boosts leaf area and light absorption, enhancing carbon assimilation. Increased 100 seed weight due to better phosphorus and nitrogen availability, promoting robust seed development. Similarly, studies by Samui *et al*. (2022) [23] and Pragathi (2023) [12] confirmed that nano DAP enhances seed quality and crop productivity through improved nutrient absorption.

### 3.3 Effect of nano DAP on yield

#### 3.3.1 Seed yield

The data regarding the effect of different levels of phosphorus and foliar application of nano DAP on the seed yield of cowpea is presented in Table 2. Among all the treatments, application of 100% RDP as a basal dosage combined with foliar spray nano DAP @ 4 ml $l^{-1}$ at 30 and 45 DAS resulted in a significantly higher seed yield of cowpea (1940 kg ha$^{-1}$) as compared to other treatments and recorded 8.37% increase in the yield as compared to RDF. This result was in comparable with the treatment 100% RDP along with foliar spray of nano DAP @ 2 ml $l^{-1}$ at 30 and 45 DAS (1890 kg ha$^{-1}$), 75% RDP with nano DAP @ 4 ml $l^{-1}$ (1871 kg ha$^{-1}$) and the control treatment receiving RDF alone (1790 kg ha$^{-1}$). In contrast, significantly lower seed yield was observed with treatment receiving 50% RDP combined with foliar spray of nano DAP @ 2 ml $l^{-1}$ (1278 kg ha$^{-1}$) at 30 and 45 DAS as compared to other treatments. The foliar application of nano DAP improved nutrient availability and extended the photosynthetic period, increasing leaf area and delaying senescence, which boosted dry matter production. This led to better translocation of photosynthates from leaves to pods, enhancing the number of pods per plant, seed yield and100 seed weight. Studies by Kumar *et al*. (2020) [24], El-Gewely *et al*. (2020) [25], Rajesh (2021) [15], Reddy *et al*. (2022) [18], Samui *et al*. (2022) [24] and Yasser *et al*. (2020) [26] confirmed that nano fertilizers, combined with conventional practices, optimize nutrient utilization, significantly improving crop yield and quality through better source-to-sink relationships.

#### 3.3.2 Stover yield

The data illustrating the influence of varying levels of phosphorus and foliar application of nano DAP on stover yield of cowpea plant height is presented in Table 2. The application of 100% RDP as basal dosage along with nano DAP spray @ 4.0 ml $l^{-1}$ at 30 and 45 DAS recorded significantly higher stover yield (3201 kg ha$^{-1}$) as compared to other treatments except treatments receiving 100% RDP along with foliar application of nano DAP @ 2 ml $l^{-1}$ at 30 and 45 DAS (3156 kg ha$^{-1}$), 75% RDP with a foliar application of nano DAP @ 4 ml $l^{-1}$ (3143 kg ha$^{-1}$) and the control treatment that received RDF alone (3001 kg ha$^{-1}$). The utilization of nano-scale nitrogen and phosphorus offered a notable advantage over conventional urea and DAP due to its reduced particle size, which increased the surface area for interaction and improved nutrient absorption efficiency. This enhanced absorption capability resulted in superior stover yield. The efficacy of nano-sized nutrients in promoting plant growth and yield has been corroborated by several studies, including those conducted by Kumar *et al*. (2020) [24], Yasser *et al*. (2020) [26] and Reddy *et al*. (2022) [18]. Their finding highlights the superior benefits of nano fertilizers in boosting both vegetative and reproductive aspects of plant development, reinforcing the critical role of advanced nutrient delivery systems in optimizing agricultural productivity.

**Table 1:** Growth parameters of cowpea as influenced by the application different levels of phosphorus and foliar spray of nano DAP

| Treatments | Plant height (cm) | Number of leaves | Leaf area ($cm^2$ $plant^{-1}$) | Leaf area index |
|---|---|---|---|---|
| $T_1$ | 59.00 | 37.03 | 1915.84 | 4.26 |
| $T_2$ | 43.20 | 26.32 | 1423.30 | 2.66 |
| $T_3$ | 45.15 | 29.83 | 1549.56 | 2.84 |
| $T_4$ | 52.10 | 33.52 | 1727.52 | 3.54 |
| $T_5$ | 62.54 | 39.32 | 2012.59 | 4.32 |
| $T_6$ | 63.72 | 39.80 | 2056.12 | 4.56 |
| $T_7$ | 65.49 | 41.52 | 2174.54 | 4.82 |
| S.Em. ± | 2.29 | 1.05 | 54.27 | 0.21 |
| CD @ 5% | 6.71 | 3.09 | 159.19 | 0.62 |

**Note:** Treatment details are mentioned in materials and methods

**Table 2:** Yield parameters and yield of cowpea as influenced by the application different levels of phosphorus and foliar spray of nano DAP

| Treatments | Number of pods $plant^{-1}$ | Number of seeds $pod^{-1}$ | 100 seed weight (g) | Seed yield (kg $ha^{-1}$) | Stover yield (kg $ha^{-1}$) |
|---|---|---|---|---|---|
| $T_1$ | 20.02 | 11.02 | 8.88 | 1790 | 3000 |
| $T_2$ | 14.56 | 8.50 | 6.36 | 1278 | 2160 |
| $T_3$ | 15.00 | 9.28 | 6.56 | 1376 | 2309 |
| $T_4$ | 17.52 | 10.28 | 7.72 | 1601 | 2634 |
| $T_5$ | 21.32 | 11.62 | 9.34 | 1871 | 3143 |
| $T_6$ | 21.76 | 11.92 | 9.60 | 1890 | 3156 |
| $T_7$ | 22.42 | 12.28 | 9.93 | 1940 | 3256 |
| S.Em. ± | 0.83 | 0.18 | 0.37 | 64 | 86 |
| CD @ 5% | 2.44 | 0.54 | 1.08 | 187 | 252 |

**Note:** Treatment details are mentioned in materials and methods

## 4. Conclusion

In conclusion, the application of 100% RDP as a basal dosage, coupled with a foliar spray of nano DAP at 4 ml $l^{-1}$ at 30 and 45 DAS, resulted in significantly enhanced growth and yield attributes, including plant height, number of leaves, leaf area, leaf area index, number of pods $plant^{-1}$, number of seeds $pod^{-1}$, seed yield and stover yield, compared to other treatments. This balanced approach, combining conventional soil-applied DAP fertilizer with the foliar application of nano DAP, increased nutrient availability for the plants, which played a crucial role in the observed improvements in growth and yield parameters. The synergistic effect of both nutrient sources facilitated better nutrient uptake and assimilation, ultimately leading to higher seed yield. This strategy underscores the effectiveness of integrating conventional and innovative fertilization techniques to optimize nutrient supply, enhance plant growth and improve overall crop productivity. The results clearly demonstrate that employing this dual-fertilization method significantly contributes to maximizing yield potential and achieving superior agricultural outcomes.

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