Plant Archives Vol. 25, No. 2, 2025 pp. 1897-1904 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.2.274

NANO DAP FOR ENHANCED GROWTH AND YIELD OF FIELD BEAN (*LABLAB PURPUREUS* L. SWEET) UNDER SOUTHERN TRANSITIONAL ZONE OF KARNATAKA INDIA

Sumukha N. Mavarkar[1], A. Y. Hugar[1], N. S. Mavarkar[1] and Ganapathi, M.[2]
[1]Department of Agronomy, College of Agriculture, KSNUAHS, Shivamogga, Karnataka, India
[2]Department of Crop Physiology, College of Agriculture, KSNUAHS, Shivamogga, Karnataka, India
*Corresponding author E-mail: annappayhugar@uahs.edu.in
(Date of Receiving : 16-07-2025; Date of Acceptance : 23-09-2025)

ABSTRACT

A field experiment was conducted during the late *kharif* season of 2024 at College of Agriculture, Navile, Shivamogga, Karnataka, to evaluate the effect of foliar-applied nano DAP on growth and yield of field bean (*Lablab purpureus* (L.) Sweet) under the Southern Transitional Zone of Karnataka. The experiment was laid out in a Randomized Complete Block Design (RCBD) with ten treatments and replicated thrice. Treatments comprised varying combinations of recommended dose of fertilizers (RDF: 100% and 75%) with foliar nano DAP sprays at 2- and 4-ml L^{-1} applied either once (30 DAS) or twice (30 and 60 DAS), along with an absolute control. The results revealed that among all the treatments, 100 per cent RDF + foliar spray of nano DAP @ 4 ml L^{-1} at 30 and 60 DAS (T_8) recorded significantly higher growth parameters *viz*., plant height (93.67 cm), number of branches $plant^{-1}$ (8.45), leaf area (972 cm² $plant^{-1}$), total dry matter (33.39 g/plant) at harvest. The same treatment also recorded significantly higher yield parameters *viz*., number of pods $plant^{-1}$ (26.56), seeds per pod (3.75), pod length (4.87 cm), dry pod weight (16.40 g/plant), seed yield (1234 kg/ha) and haulm yield (2035 kg/ha). However, treatment with 75 per cent RDF + two sprays of nano DAP @ 4 ml L^{-1} (T_{10}) produced comparable yields (1178 kg/ha), indicating the potential of nano DAP to reduce chemical fertilizer use by 25 per cent without significant yield loss. The harvest index ranged from 0.32 to 0.38, showing efficient partitioning of assimilates into seeds under nano DAP application. The study concludes that foliar application of nano DAP, particularly at 4 ml L^{-1} applied twice during crop growth, along with RDF, is an effective strategy to enhance growth and yield of field bean under the Southern Transitional Zone of Karnataka.
***Keywords* :** Field bean, Nano DAP, RDF, Growth, Yield.

Introduction

Field bean (*Lablab purpureus* (L.) Sweet), also known as hyacinth bean, dolichos bean or avare in South India, is an important multipurpose legume cultivated across tropical and subtropical regions. The crop is valued for its diverse uses as a vegetable, pulse, fodder and green manure, while also contributing to soil fertility through biological nitrogen fixation (Raghu *et al*., 2018). Karnataka accounts for nearly 80 per cent of the country's field bean area, with 0.52 lakh hectares under cultivation producing 0.28 lakh tonnes of grain (Anon., 2023). In Karnataka, particularly in the Southern Transitional Zone (STZ), field bean is integral to smallholder farming systems and local food cultures, thriving even under rainfed and marginal land conditions. Despite its adaptability and nutritional richness (20–25% protein with essential minerals), its productivity remains low and unstable compared to its genetic potential.

Phosphorus nutrition is a major limiting factor for achieving higher yields in legumes. Phosphorus plays a key role in root development, photosynthesis, energy transfer, flowering and pod setting. However, in Indian soils, a large fraction of applied phosphorus becomes unavailable due to fixation with calcium, iron and aluminium oxides. Consequently, the efficiency of conventional fertilizers like diammonium phosphate (DAP) remains poor (10-25%), necessitating higher applications that raise costs and environmental risks (Van de Wiel *et al*., 2016; Manjunatha *et al*., 2016).

Nanotechnology-based fertilizers offer a potential solution. Nano fertilizers, because of their nanoscale size, high surface area and reactivity, improve nutrient solubility, uptake and utilization efficiency, while minimizing losses through leaching and volatilization. Among them, nano DAP, containing 16 per cent P_2O_5 and 8 per cent N in nanoscale form, is especially effective as a foliar spray, allowing rapid absorption and translocation in plants (Mahil and Kumar, 2019). By improving phosphorus use efficiency, nano DAP can directly enhance crop growth and yield while reducing reliance on conventional fertilizers.

Several studies have demonstrated the benefits of foliar nano DAP in improving growth and yield attributes. In wheat, foliar nano DAP sprays in combination with basal fertilizers enhanced grain yield by up to 34.8% (Reddy *et al.,* 2025). In blackgram, nano DAP application improved seed yield and nutrient uptake compared to conventional fertilization (Pandey *et al*., 2025). Similar yield-enhancing effects of nano fertilizers have been reported in rice, maize, groundnut, soybean and cluster bean (Prakash *et al.,* 2023; Munir *et al.,* 2025). These improvements are often associated with better pod number, pod length, seed weight and overall biomass accumulation, which directly contribute to yield.

Despite positive results in other crops, limited research has been conducted on the response of field bean to nano DAP application under the STZ of Karnataka. Particularly, the effect of combining basal recommended fertilizer dose (RDF) with foliar sprays of nano DAP on growth and yield parameters of field bean remains underexplored. Therefore, the present study was undertaken to investigate the impact of nano DAP on the growth and yield performance of field bean, aiming to identify a nutrient management strategy that improves productivity and sustainability in the region.

Materials and Methods

The field experiment was conducted during the late Kharif season of 2024 at College of Agriculture, Navile, Shivamogga, Karnataka. The experimental site lies in the Southern Transitional Zone (Zone 7) of Karnataka at 13°56′N latitude, 75°34′E longitude and an altitude of 615 m above mean sea level. The region is characterized by a tropical climate. The total rainfall received during the cropping period was 644.2 mm. The mean maximum and minimum temperature during the cropping period was 29.7°C and 20.5°C, respectively. The soil of the experimental plot was sandy loam (Typic Haplustalf, Alfisol) with low organic carbon (0.45 percent), low in available nitrogen (230.47 kg ha^{-1}), medium in available phosphorus (38.20 kg ha^{-1}) and medium in available potassium (199.85 kg ha^{-1}). The soil reaction of the experimental field was slightly acidic (pH 5.23) with an electrical conductivity of 0.18 dSm^{-1}.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with ten treatments replicated thrice. Each gross plot measured 5.4 m × 2.7 m, while the net plot size was 3.6 m × 2.1 m. The field bean variety *Hebbal avare 5* (HA-5) was sown at 30 kg ha^{-1} with spacing of 45 cm × 15 cm. The treatments comprised varying combinations of 100% and 75% recommended dose of fertilizers (RDF: 25:50:25 kg N: P2O5:K2O) with foliar nano DAP sprays at concentrations of 2- and 4-ml l^{-1} applied either once (30 DAS) or twice (30 and 60 DAS). An absolute control without fertilizers was included. FYM at 7.5 t ha^{-1} was applied uniformly except absolute control, 15 days before sowing. Treatment wise nano DAP (IFFCO) with 8 per cent N and 16 per cent P_2O_5 content was sprayed at 500 l ha^{-1} spray volume and conventional fertilizers were applied.

The ten treatments were as follows:

T_1	: Absolute Control
T_2	: 100% RDF
T_3	: 100% RDF + foliar spray of nano DAP @ 2 ml L^{-1} at 30 DAS
T_4	: 100% RDF + foliar spray of nano DAP @ 4 ml L^{-1} at 30 DAS
T_5	: 75% RDF + foliar spray of nano DAP @ 2 ml L^{-1} at 30 DAS
T_6	: 75% RDF + foliar spray of nano DAP @ 4 ml L^{-1} at 30 DAS
T_7	: 100% RDF + foliar spray of nano DAP @ 2 ml L^{-1} at 30 and 60 DAS
T_8	: 100% RDF + foliar spray of nano DAP @ 4 ml L^{-1} at 30 and 60 DAS
T_9	: 75% RDF + foliar spray of nano DAP @ 2 ml L^{-1} at 30 and 60 DAS
T_{10}	: 75% RDF + foliar spray of nano DAP @ 4 ml L^{-1} at 30 and 60 DAS

Field preparation was carried out by tractor ploughing, followed by harrowing and levelling. Healthy seeds of field bean (HA-5) were sown manually in lines and thinned to maintain the required spacing. Standard agronomic practices for weed control, irrigation and plant protection were followed uniformly across treatments to ensure normal crop growth. Growth and yield parameters were computed using standard formulas from periodic measurements of plant height, number of branches, number of leaves, leaf area and dry matter (30 DAS, 60 DAS and harvest). As well as yield parameters such as number of pods, seeds, pod length, 100-seed weight, pod weight, seed yield, haulm yield and harvest index. The parameters studied included:

Growth parameters recorded at 30 DAS, 60 DAS and at harvest

Plant height (cm)

Five tagged plants were measured from ground level to tip of the main shoot of five plants and average plant height was recorded and expressed in centimetre (cm).

Number of branches per plant

The total number of branches per plant was counted periodically at 30, 60 days after sowing and at harvest from 5 tagged plants and average number of branches per plant was computed and recorded.

Number of leaves per plant

Fully opened and functional green leaves were counted in each plot from labelled plant and recorded at different growth stages.

Leaf area (cm^2/plant)

Leaf area per plant was measured using a Biovis PSM-L2000 leaf area meter. Fresh leaves were scanned and area was recorded in cm^2 using Biovis software after calibration. Measurements were taken for each treatment and averaged.

Total dry matter accumulation (g/plant)

Five plants were removed very carefully with least damage from destructive sampling area. These plants were washed in water, sun dried and afterwards dried in the oven at 65 ℃ till it attained a constant weight. Then these constant weights were recorded and expressed in gram plant^{-1}.

Yield and yield attributing parameters at harvest

Number of pods per plant

Total number of pods produced per plant were counted in randomly selected five plants and average number of pods per plant were worked out.

Number of seeds per pod

Total number of seeds produced per pod were counted in randomly selected five plants and average number of seeds per pod were worked out.

Pod length (cm)

Mean length of pod in centimetre (cm) averaged over five randomly selected pods in each labelled plant was recorded.

100 seed weight (g)

Seed samples were drawn from cleaned produce of each net plot. 100 seeds were counted and their weight was recorded in grams.

Dry pod weight (g/plant)

Mean weight of pod in grams (gm) averaged over five randomly selected plants in each labelled plant was recorded.

Seed yield (g/plant)

Seeds from pods of 5 sampled plants were separated and weighed and average was taken as seed yield per plant and expressed in grams.

Seed yield (kg/ha)

Pods from net plot were sun dried and threshed and seed yield per plot was recorded and expressed in kilogram per hectare.

Haulm yield (kg/ha)

Haulm yield obtained from net plot was used to estimate yield per hectare on area basis and expressed in kg ha^{-1}.

Harvest index

Harvest index is defined as the ratio of economic yield (seed yield) to total above-ground dry matter, indicating the efficiency of a plant in partitioning biomass into seeds. It is calculated using the formula given by Donald and Hamblin (1976).

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}}$$

Where,

Economic yield = Seed yield

Biological yield = Seed yield + Haulm yield

The data on physiological growth parameters, yield attributes and yield were subjected to analysis of variance (ANOVA) technique described by Gomez and Gomez (1984). Treatment means were compared using the critical difference (CD) test at 5 per cent probability level. Whenever the calculated ‘F’ value exceeded the table value at the corresponding error degrees of freedom, treatment differences were considered significant and the critical difference (CD) was computed to compare means. When the ‘F’ test was non-significant, the CD was omitted and denoted as ‘NS’.

Results and Discussion

Plant height

Plant height of field bean increased progressively across all stages, with significantly higher values (93.67 cm) recorded at harvest in T_8 (100% RDF + foliar spray of nano DAP @ 4 ml l^{-1} at 30 and 60 DAS), followed by (75% RDF + nano DAP @ 4 ml l^{-1}

at 30 and 60 DAS) and T_7 (100% RDF + nano DAP @ 2 ml l^{-1} at 30 and 60 DAS), while the lowest (65.53 cm) was observed in the absolute control (T_1) (Table 1). The superiority of T_8 may be attributed to enhanced nutrient availability due to the nano form of DAP, which, owing to its higher surface area and efficient absorption through both roots and leaves, improved metabolic efficiency and cell elongation. Similar findings were reported by Yasser *et al.* (2020) and Gupta *et al*. (2023), who observed increased plant height in legumes with nano fertilizer application. Likewise, Hagagg *et al.* (2018) ascribed enhanced plant growth to the improved uptake of water and nutrients by nano fertilizers application. These results are also supported by Gomaa *et al*. (2017), Poudel *et al*. (2023) and Aatkurwar *et al*. (2024), who demonstrated that nano fertilizers in combination with RDF enhanced plant stature in rice and pulses.

Number of branches per plant

The number of branches per plant also followed a similar trend in T_8 (100% RDF + Foliar spray of nano DAP @ 4 ml l^{-1} at 30 and 60 DAS) which recorded the maximum number of branchers per plant (8.45 at harvest) and is on par with (75% RDF + nano DAP @ 4 ml l^{-1} at 30 and 60 DAS) and T_7 (100% RDF + nano DAP @ 2 ml l^{-1} at 30 and 60 DAS), which was significantly superior over 100 per cent RDF alone (T_2) (Table 1). Branch proliferation is influenced by nutrient supply, particularly nitrogen and phosphorus, which are vital for meristematic activity and the initiation of axillary buds. The small particle size of nano fertilizers improves nutrient use efficiency, leading to better branching. This corroborates with the observations of Vaghar *et al*. (2020), Manjunath (2018) and Ramesh and Tarafdar (2013), who reported that nano fertilizers improved nutrient uptake and resulted in more number of branches per plant in legumes.

Number of leaves per plant

Leaf production, a direct reflection of photosynthetic surface, was also significantly influenced by nano DAP application. Maximum number of leaves was observed in T_8 (41.37 at 60 DAS and 31.59 at harvest) followed by T_{10} (75% RDF + nano DAP @ 4 ml l^{-1} at 30 and 60 DAS), while the absolute control recorded the lowest values. This increment may be due to the continuous supply of N and P through foliar feeding, which sustained photosynthetic activity and promoted leaf development even at later stages. Similar findings were reported by Abdel-Aziz *et al.* (2016), who emphasized the role of phosphorus in enhancing leaf expansion and photosynthetic capacity.

Table 1: Plant height (cm), number of branches and Number of leaves per plant of field bean at different growth stages as influenced by different levels of nano DAP application

Treatments	Plant height (cm)			No. of branches plant^{-1}			No. of leaves plant^{-1}		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
T_1	12.78	44.58	65.53	1.86	3.45	4.43	12.78	24.40	16.66
T_2	17.24	53.98	78.12	3.09	4.66	6.18	18.41	35.36	23.87
T_3	16.41	57.26	81.99	3.29	5.44	6.75	18.07	40.16	25.25
T_4	18.06	59.34	84.04	3.19	5.72	7.19	18.69	40.68	27.06
T_5	16.53	52.76	80.61	2.50	4.75	6.32	15.57	36.20	24.92
T_6	16.74	54.50	82.72	2.67	4.97	7.07	16.30	36.56	26.94
T_7	18.21	58.36	87.61	3.33	6.13	8.04	18.87	40.80	29.61
T_8	17.64	59.45	93.67	3.67	6.21	8.45	19.05	41.37	31.59
T_9	16.77	53.63	84.80	2.30	5.27	7.54	16.59	36.80	28.30
T_{10}	16.77	54.19	90.26	2.34	5.32	8.05	16.62	37.20	30.33
S.Em ±	0.98	1.65	2.18	0.08	0.17	0.29	0.82	1.08	1.02
C.D (P = 0.05)	2.87	4.82	6.36	0.24	0.51	0.84	2.40	3.15	2.96

Values are mean of three replications. DAS = Days after sowing. S.Em ± = Standard error of mean;
CD (P = 0.05) = Critical difference at 5% probability level.

Leaf area (cm^2/plant)

Leaf area were also significantly higher in T_8 (100% RDF + nano DAP @ 4 ml l^{-1} at 30 and 60 DAS) at all stages. The highest leaf area (1551 cm^2 at 60 DAS and 972 cm^2 at harvest) was observed in T_8, which was on par with T_7 and T_{10} and significantly superior to the RDF only and absolute control (Table 2). The higher leaf area with nano DAP treatments are attributed to better nutrient assimilation, particularly nitrogen for chlorophyll synthesis and phosphorus for energy metabolism, resulting in enhanced cell division, cell expansion and prolonged leaf activity. These results are in line with Saleem *et al.* (2021) and Reddy *et al*. (2022), who highlighted the improved nutrient availability from nano fertilizers leads to increased leaf area, thereby enhancing the source capacity of crops.

Total dry matter production (g/plant)

Dry matter accumulation is an integrative measure of plant growth, reflecting the cumulative effect of nutrient uptake, photosynthesis and assimilate partitioning. Significantly higher dry matter was recorded in T_8 (33.39 g/plant at harvest), followed by T_{10} and T_7, while the absolute control (T_1) recorded the lowest (17.00 g/plant). This indicates that combined application of RDF with nano DAP not only enhanced photosynthate production but also facilitated its efficient translocation to different plant organs, thereby increasing biomass accumulation. Similar results were reported by Villagomez *et al*. (2019), Alzreejawi and Al-Juthery (2020), Maheta *et al.* (2023) and Singh *et al*. (2025), who observed higher dry matter production under nano nutrient application.

Table 2: Leaf area (cm^2/plant) and Total dry matter (g/plant) of field bean at different growth stages as influenced by different levels of nano DAP application

Treatments	Leaf area (cm^2/plant)			Total dry matter (g/plant)		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
T_1	321	915	512	4.48	10.75	17.00
T_2	460	1317	735	5.98	15.96	24.37
T_3	452	1505	778	6.10	17.83	27.58
T_4	468	1525	833	6.20	18.03	27.91
T_5	388	1358	767	5.47	16.06	26.87
T_6	406	1372	829	5.58	16.24	28.00
T_7	471	1529	911	6.20	18.11	30.84
T_8	475	1551	972	6.29	18.37	33.39
T_9	409	1381	871	5.65	16.34	27.98
T_{10}	410	1394	933	5.76	16.48	31.50
S.Em ±	15.33	46.19	31.39	0.52	0.61	0.75
C.D (P = 0.05)	44.74	134.83	91.64	1.51	1.78	2.18

Values are mean of three replications. DAS = Days after sowing. S.Em ± = Standard error of mean;
CD (P = 0.05) = Critical difference at 5% probability level.

Number of pods per plant

The number of pods per plant was significantly influenced by nano DAP application. The highest pod count (26.56) was obtained in T_8 (100% RDF + foliar spray of nano DAP @ 4 ml l^{-1} at 30 and 60 DAS), which was 58.4 per cent higher than absolute control (16.76) and 26.3 per cent higher over RDF alone (21.03). The treatments T_{10} (75% RDF + foliar spray of nano DAP @ 4 ml l^{-1} at 30 and 60 DAS) with 25.43 pods plant^{-1} and T_7 (100% RDF + foliar spray of nano DAP @ 2 ml l^{-1} at 30 and 60 DAS) with 24.50 pods plant^{-1} were statistically comparable with T_8 (Table 3). The increase in pod number may be attributed to improved phosphorus availability, which enhanced flower initiation, reduced flower drop and ensured better pollen viability. Similar observations were made by Shaik *et al*. (2023) in soybean under nano DAP foliar sprays.

Number of seeds per pod

The number of seeds per pod also increased significantly, with T_8 recording the maximum (3.75 seeds/pod), 28.0 per cent higher than absolute control (2.93 seeds/pod) and 20.6 per cent higher than RDF alone (T_2) with 3.11 seeds pod^{-1}. Foliar application at two stages (T_8 and T_{10}) proved more effective than application at a single stage, suggesting that a sustained phosphorus supply during both flowering and seed filling stages improved assimilate partitioning and reproductive efficiency. These results are in line with Khemshetty *et al*. (2024) in chickpea and Prakash *et al*. (2023) in soybean.

Pod length (cm)

Pod length also showed significant improvement in T_8 (100% RDF + foliar spray of nano DAP @ 4 ml l^{-1} at 30 and 60 DAS) recording the longest pods (4.87 cm), which was 36.0 per cent higher than absolute control (3.58 cm) and 18.5 per cent higher than RDF alone (4.11 cm). Treatments T_{10} (4.60 cm) and T_7 (4.58 cm) were statistically at par with T_8. The improvement in pod length may be linked to better nutrient uptake and enhanced supply of photosynthates to developing pods, leading to elongation. Similar improvements were reported by Maurya *et al*. (2024) in French bean and Ruban *et al.* (2023) in cowpea.

100- seed weight (g)

The test weight of 100 seeds did not vary significantly across treatments, ranging from 13.53 g (T_1) to 14.70 g (T_8). Since seed weight is largely varietal in nature, the treatment effects were minimal, though a consistent increasing trend with nano DAP was noticed, suggesting better seed filling. Singh *et al*. (2024) also reported similar positive effects, though the differences were not significant.

Dry pod weight per plant

Dry pod weight per plant, responded strongly to nano DAP application. The maximum dry pod weight (16.40 g/plant) was observed in T_8 (100% RDF + foliar spray of nano DAP @ 4 ml l^{-1} at 30 and 60 DAS), which was 89.8 per cent higher than absolute control (8.64 g/plant) and 27.6 per cent higher over RDF alone (12.85 g/plant). Treatments T_{10} (15.50 g/plant) and T_7 (15.31 g/plant) were statistically on par with T_8 (16.40 g/plant). This improvement could be attributed to increased pod set, greater photosynthetic efficiency and better assimilate partitioning into reproductive organs. Similar results were reported by Al-Juthery *et al*. (2020) in legumes with nano P fertilization.

Table 3: Number of pods per plant, number of seeds per pod, pod length (cm), 100 seed weight (g) Dry pod weight (g/plant) of field bean as influenced by different levels of nano DAP application

Treatments	Number of pods plant^{-1}	Number of seeds pod^{-1}	Pod length (cm)	100 Seed weight (g)	Dry pod weight (g/plant)
T_1	16.76	2.93	3.58	13.53	8.64
T_2	21.03	3.11	4.11	13.84	12.85
T_3	22.17	3.25	4.12	13.97	13.96
T_4	23.48	3.40	4.32	14.08	14.26
T_5	22.11	3.21	4.12	13.91	13.96
T_6	23.19	3.35	4.25	14.02	14.09
T_7	24.50	3.57	4.58	14.34	15.31
T_8	26.56	3.75	4.87	14.70	16.40
T_9	24.13	3.43	4.39	14.26	14.56
T_{10}	25.43	3.63	4.60	14.42	15.50
S.Em ±	0.66	0.10	0.15	0.39	0.35
C.D (P = 0.05)	1.93	0.30	0.43	NS	1.02

Values are mean of three replications. DAS = Days after sowing. S.Em ± = Standard error of mean;
CD (P = 0.05) = Critical difference at 5% probability level.

Seed yield

The highest seed yield (1234 kg/ha) was recorded in T_8 (100% RDF + foliar spray of nano DAP @ 4 ml l^{-1} at 30 and 60 DAS), which was 25.0 per cent higher than RDF alone (987 kg/ha). Treatments T_{10} (75% RDF + nano DAP @ 4 ml l^{-1} at 30 and 60 DAS) and T_7 (100% RDF + nano DAP @ 2 ml l^{-1} at 30 and 60 DAS) were statistically at par with T_8, registering yields of 1178 and 1150 kg ha^{-1}, respectively (Table 4). Per plant basis too, T_8 produced the maximum seed yield (10.52 g/plant), showing an increment of 24.5 per cent over RDF alone (8.45 g/plant). The substantial yield enhancement in nano DAP treatments can be attributed to the combined effect of increased pod number, higher pod length, greater number of seeds per pod and higher dry pod weight per plant. Similar yield improvements with nano DAP application were also observed by Sarika *et al.* (2025) in chickpea, Pandey *et al*. (2025) in black gram, Veeramallu *et al.* (2024) and Prakash *et al.* (2023) in soybean.

Haulm yield

Haulm yield followed a similar trend, with the maximum value (2035 kg/ha) in T_8 (100% RDF + foliar spray of nano DAP @ 4 ml l^{-1} at 30 and 60 DAS), which was and 20.5 per cent higher over RDF alone (1689 kg/ha). The higher haulm yield could be explained by vigorous vegetative growth, greater dry matter accumulation and enhanced photosynthetic efficiency under nano DAP application. These findings are in conformity with Salama *et al.* (2022) in common bean and Ajithkumar *et al*. (2021) in cowpea.

Harvest index

The harvest index did not differ significantly among treatments, ranging from 0.32 (absolute control) to 0.38 (T_8), treatments receiving nano DAP consistently recorded higher HI values compared to RDF alone, indicating more efficient partitioning of assimilates into reproductive structures (Choudhary *et al.*, 2018 and Aniket *et al.*, 2023).

Overall, treatments with two foliar sprays of nano DAP (T_7, T_8, T_9 and T_{10}) outperformed those with single sprays. Among these, T_8 (100% RDF + 4 ml l^{-1} at 30 and 60 DAS) proved most effective. Remarkably, T_{10} (75% RDF + 4 ml l^{-1} at 30 and 60 DAS) yielded 1178 kg ha^{-1}, only 4.5 per cent lower than T_8 but 19.4 per cent higher than RDF alone, highlighting the potential of nano DAP to compensate for a 25 per cent reduction in RDF. The nutrient saving was mainly due to the use of nano fertilizers. Similar results were reported by Merghany *et al.* (2019) and Pandey *et al.* (2025) in pulses.

Table 4: Seed yield (g/plant), Seed yield (kg/plot), Seed yield (kg/ha), haulm yield (kg/ha) and harvest index of field bean as influenced by different levels of nano DAP application

Treatments	Seed yield (g/plant)	Seed yield (kg/plot)	Seed yield (kg/ha)	Haulm yield (kg/ha)	Harvest index
T_1	5.65	0.60	459	1012	0.32
T_2	8.45	1.29	987	1689	0.37
T_3	9.12	1.40	1064	1809	0.37
T_4	9.24	1.41	1078	1828	0.37
T_5	8.98	1.38	1049	1769	0.37
T_6	9.15	1.40	1070	1816	0.37
T_7	9.82	1.51	1150	1912	0.38
T_8	10.52	1.62	1234	2035	0.38
T_9	9.22	1.42	1082	1860	0.37
T_{10}	10.04	1.55	1178	1956	0.38
S.Em ±	0.26	0.04	30.17	52.50	0.02
C.D (P = 0.05)	0.75	0.11	88.06	153.24	NS

Values are mean of three replications. DAS = Days after sowing. S.Em ± = Standard error of mean;
CD (P = 0.05) = Critical difference at 5% probability level.

Conclusion

Two foliar sprays of nano DAP at 4 ml L^{-1} with 100 per cent RDF (T_8) significantly improved vegetative growth, yield attributes, seed yield (1234 kg/ha) and haulm yield (2035 kg/ha) in field bean. A comparable yield (1178 kg/ha) was achieved with T_{10} (75% RDF + nano DAP @ 4 ml L^{-1} at 30 and 60 DAS), saving 25 per cent RDF. These results demonstrate the potential of nano DAP to enhance growth, sustain productivity and promote resource optimization in field bean cultivation under the Southern Transitional Zone of Karnataka.

Acknowledgement

I sincerely acknowledge the guidance and support of the faculty members. I am also grateful to the Department of Agronomy, College of Agriculture, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, for providing the necessary facilities and support during my research.

References

Aatkurwar, B., Pandey, T. D., Sharma, G. and Chaure, N. K. (2024). Effect of nano-DAP on yield and yield attributes of transplanted rice (*Oryza sativa* L.) in Chhattisgarh plains. *Int. J. Res. Agron.*, **7(7)**, 262-265.

Abdel-Aziz, H. M. M., Hasaneen, M. N. A. and Omer, A. M. (2016). Influence of nano potassium and iron-coated DAP fertilizers on wheat. *Egypt. J. Agron.*, **38(2)**, 143-158.

Ajithkumar, K., Yogendra, K., Savitha, A. S., Ajayakumar, M. Y., Narayanaswamy, C., Ramesh, R., Krupashankar, M. R. and Bhat, S. N. (2021). Effect of IFFCO nano fertilizer on growth, grain yield and managing turcicum leaf blight disease in maize. *Int. J. Plant Soil Sci.*, **33(16)**, 19-28.

Al-Juthery, H. F., Al-Hammad, K. Y. and Al-Shammari, H. A. (2020). Nano nutrients and reproductive efficiency in legumes. *Plant Arch.*, **19(2)**, 1087-1096.

Alzreejawi, S. A. M. and Al-Juthery, H. W. A. (2020). Effect of spray with nano NPK, complete micro fertilizers and nano amino acids on growth and yield indicators of maize (*Zea mays* L.). *IOP Conf. Ser.: Earth Environ. Sci.*, doi:10.1088/1755-1315/553/1/012010.

Aniket, G., Anand, N., Siddaram, B. S. N. and Bellakki, M. A. (2023). Effect of nano-DAP on growth and yield of pigeonpea under rainfed condition. *Pharma Innov. J.*, **12(12)**, 1536-1539.

Anonymous (2023). Area and production statistics of field bean in Karnataka. Dept. of Agriculture, Govt. of Karnataka. https://raitamitra.karnataka.gov.in.

Choudhary, D. K., Karmakar, S. and Kumar, B. (2018). Intercession of legume based intercropping and nano phosphorus as managerial input for upland of Jharkhand. *Int. J. Adv. Res.*, **6(12)**, 1137-1143.

Donald, C. M. and Hamblin, J. (1976). The biological yield and harvest index of cereals as agronomic and plant breeding criteria. *Adv. Agron.*, **28**, 361-405.

Gomaa, M. A., Radwan, F. I., Kandil, E. E. and Al-Challabi, D. H. H. (2017). Comparison of some new maize hybrids response to mineral fertilization and some nano fertilizers. *Alex. Sci. Exch. J.*, **38(3)**, 506-514.

Gupta, P., Singh, V., Shakti, S., Shikhar, V., Sachin, K. Y., Jyotiprakash, M., Sweekruta and Mohapatra, (2023). Effect of nano-nutrient on growth attributes, yield, Zn content and uptake in wheat (*Triticum aestivum* L.). *Int. J. Environ. Clim. Change*, **12(11)**, 2028-2036.

Hagagg, L. F., Mustafa, N. S., Genaidy, E. A. E. and Elhady, E. S. (2018). Effect of spraying nano-NPK on growth performance and nutrients status for Kalamat cv. olive seedling. *Biosci. Res.*, **15**, 1297-1303.

Khemshetty, A., Patil, D. H., Rathod, P. S., Patil, A. S. and Basavaraj, K. (2024). Studies on nano DAP on growth, yield and quality of chickpeas under rainfed conditions of Northeastern Dry Zone of Karnataka. *J. Exp. Agric. Int.*, **46(3)**, 139-145.

Mahil, E. I. T. and Kumar, B. A. (2019). Foliar application of nanofertilizers in agricultural crops – A review. *J. Farm Sci.*, **32(3)**, 239-249.

Manjunatha, S. B., Biradar, D. P. and Aladakatti, Y. R. (2016). Nanotechnology and its applications in agriculture: A review. *J. Farm Sci.*, **29(1)**, 1-13.

Manjunath, G. (2018). Effect of nano nutrients on growth, seed yield and quality in cowpea [*Vigna unguiculata* (L.) Walp.]. M.Sc. (Agri.) Thesis, Univ. Agric. Sci., Bengaluru.

Maheta, A., Gaur, D., Bhanvadia, A. S., Ramani, V. P., Patel, S. and Amin, P. (2023). Influence of nano nitrogen and phosphorus fertilizer on yield and nutrient content of maize (*Zea mays* L.). *Int. J. Plant Soil Sci.*, **35(3)**, 51-59.

Maurya, P. K., Bahadur, V., Shukla, P. K., Topno, S. E. and Thakur, G. (2024). Response of nano NPK on growth, yield and quality of French bean (*Phaseolus vulgaris* L.). *Plant Arch.*, **24(2)**, 931-935.

Merghany, M., Shahein, M. M., Sliem, M. A., Abdelgawad, K. F. and Radwan, A. F. (2019). Effect of nano-fertilizers on cucumber plant growth, fruit yield and its quality. *Plant Arch.*, **19(2)**, 165-172.

Nongbet, A., Mishra, A. K., Mohanta, Y. K., Mahanta, S., Ray, M. K., Khan, M., Baek, K. H. and Chakrabartty, I. (2022). Nano fertilizers: A smart and sustainable attribute to modern agriculture. *Plants*, **11(19)**, 2587.

Pandey, K. P., Kalhapure, A., Mishra, S. and A. K. (2025). Influence of nano urea and nano DAP on crop nutrient content, uptake and soil fertility status in blackgram (*Vigna mungo*). *Plant Arch.*, **25(1)**, 2799-2806.

Poudel, A., Singh, S. K., Ballesta, R. J., Jatav, S. V., Abhik, P. and Astha, P. (2023). Effect of nano-phosphorus formulation on growth, yield and nutritional quality of wheat under semi-arid climate. *Agronomy*, **13(3)**, 768.

Prakash, A., Naik, S., Ravi, M. V. and Bellakki, M. A. (2023). Response of nano DAP on growth, yield and economics of soybean (*Glycine max* L.). *Pharma Innov. J.*, **12(12)**, 1985-1989.

Raghu, B. R., Samuel, D. K., Mohan, N. and Aghora, T. S. (2018). Dolichos bean: An underutilized and unexplored crop with immense potential. *Int. Multidiscip. Res. J.*, **5(12)**, 4338-4341.

Ramesh, R. and Tarafdar, J. C. (2013). ZnO nanoparticle biosynthesis and its effect on phosphorus-mobilizing enzyme secretion and gum contents in cluster bean (*Cyamopsis tetragonoloba* L.). *Agric. Res.*, **2(1)**, 48-57.

Reddy, B. M. S., Elankavi, Kumar, M. S., Vikram, S. M. and Divya, B. V. (2022). Effects of conventional and nano fertilizers on growth and yield of maize (*Zea mays* L.). *Bhartiya Krishi Anusandhan Patrika*, pp. 1-4.

Reddy, G. S., Rao, P. S. and Kumar, S. (2024). Impact of nano DAP on growth, yield and economics of summer pearl millet. *Int. J. Res. Agron.*, **8(6)**, 107-269.

Ruban, J. Sam, M., Nandinidevi, B., Naik, R. and Rajan, R. (2023). Effect of nano DAP on growth and yield of vegetable cowpea (yard-long bean). *Indian J. Agron.*, **60**, 70-76.

Salama, D. M., Abd El-Aziz, M. E., Shaaban, E. A., Osman, S. A. and Abd El-Wahed, M. S. (2022). The impact of nanofertilizer on agro-morphological criteria, yield and genomic stability of common bean (*Phaseolus vulgaris* L.). *Sci. Rep.*, **12**, 18552.

Saleem, I., Maqsood, M. A., Aziz, T., Bhatti, I. A. and Jabbar, A. (2021). Potassium ferrite nano coated DAP fertilizer improves wheat (*Triticum aestivum* L.) growth and yield under alkaline calcareous soil conditions. *Pak. J. Agric. Sci.*, **58(2)**, 485-492.

Sarika, K., Ramesh, G., Srinivasulu, K. and Latha, M. (2025). Effect of nano DAP on growth, yield attributes and yield of chickpea (*Cicer kabuli*). *Int. J. Res. Agron.*, **8(4)**, 20-25.

Shaikh, S. N., Waghmare, M. S., Avte, S. B., Ugile, S. K. and Ighare, O. A. (2023). Effect of nano-DAP on nutrient dynamics and yield of soybean. *Int. J. Adv. Biochem. Res.*, **8(11S)**, 595-602.

Singh, M., Goswami, S. P., Sachan, P., Sahu, D. K., Beese, S. and Pandey, S. K. (2024). Nanotech for fertilizers and nutrients – improving nutrient use efficiency with nano-enabled fertilizers. *J. Exp. Agric. Int.*, **46(5)**, 220-247.

Singh, Y., Pal, R. K., Kumar, M., Kumar, V., Chandel, R. S. and Chandel, A. (2025). Influence of nano DAP-based phosphorus application through seedling dipping and foliar spray on growth, yield attributes and yield of transplanted rice (*Oryza sativa* L.). *Int. J. Plant Soil Sci.*, **37(6)**, 516-525.

Vaghar, M. S., Sayfzadeh, S., Zakerin, H. R., Kobraee, S. and Valadabadi, S. A. (2020). Foliar application of iron, zinc and manganese nano-chelates improves physiological indicators and soybean yield under water deficit stress. *J. Plant Nutr.*, **43(18)**, 2740-2756.

Van de Wiel, C. C., Van, D. L. and Scholten, O. E. (2016). Improving phosphorus use efficiency in agriculture: Opportunities for breeding. *Euphytica*, **207**, 1-22.

Veeramallu, J., Deshmukh, M. S. and Pilewad, S. R. (2024). Studies on effect of nano DAP on yield and nutrient uptake of soybean grown on Vertisol. *Int. J. Res. Agron.*, **7(10)**, 441-448.

Villagomez, E. M., Libia, I., Trejo, Fernando, G.G.M., Manuel, S.V., Prometeo, S.G. and Miguel, A.M. (2019). Nanophosphorus fertilizer stimulates growth and photosynthetic activity and improves P status in rice. *J. Nanomater.*, doi:10.1155/2019/5368027.

Yasser, E., El-Ghobashy, Amira, A., El-Mehy, Kamal, A. and Eldouby, (2020). Influence of intercropping cowpea with some maize hybrids and N nano-mineral fertilization on productivity in salinity soil. *Egypt. J. Agron.*, **42(1)**, 63-78.