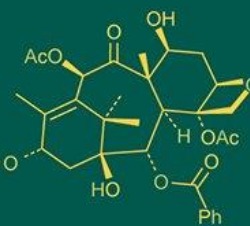
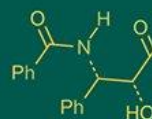


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Effect of nano urea and DAP on growth and yield of chickpea (*Cicer arietinum* L.)

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Abstract

The present experiment was conducted during the *rabi* season of 2025 at the Research farm of the Department of Agronomy, School of Agriculture Science, Technology & Research, Sardar Patel University, Balaghat (M.P.). The experiment was laid out in a Factorial Randomized Block design replicated three times with treatments of nano urea and DAP thereby making ten treatment combinations. The experiment consisted of ten treatments to study the effect of Nano Urea and Nano DAP on chickpea growth, yield, and quality. The treatments included T₁ (Control), T₂ (100% RDF through Nano DAP), T₃ (100% RDF through Nano Urea), T₄ (50% RDF Nano DAP + 50% RDF Nano Urea), T₅ (75% RDF Nano DAP + 25% RDF Nano Urea), T₆ (25% RDF Nano DAP + 75% RDF Nano Urea), T₇ (50% RDF Nano DAP + foliar spray of Nano Urea @ 2 ml/l at 30 and 45 DAS), T₈ (50% RDF Nano DAP + foliar spray of Nano Urea @ 4 ml/l at 30 and 45 DAS), T₉ (foliar application of Nano Urea @ 4 ml/l + Nano DAP @ 3 ml/l at 30 and 45 DAS), and T₁₀ (foliar application of Nano Urea @ 6 ml/l + Nano DAP @ 5 ml/l at 30 and 45 DAS). These treatments were designed to evaluate the efficiency of different combinations and application methods of Nano fertilizers on chickpea performance.

The study revealed that the combined foliar application of Nano Urea @ 6 ml/l and Nano DAP @ 5 ml/l at 30 and 45 DAS (T₁₀) significantly improved growth, yield, quality, and economic returns of chickpea. This treatment recorded the highest plant height (76.3 cm), seed yield (2245 kg/ha), protein content (20.35%), and B:C ratio (2.65). The enhanced performance was due to efficient nutrient absorption, better physiological activity, and improved productivity. Hence, the combined use of Nano Urea and Nano DAP proved to be the most effective and economically viable practice for sustainable chickpea cultivation.

Keywords: Chickpea, nano urea, nano DAP, foliar application, yield improvement

Introduction

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops in India, playing a vital role in national food and nutritional security. It contains 18-22% protein, essential amino acids, carbohydrates, and minerals, making it a crucial dietary component for predominantly vegetarian populations (Singh *et al.*, 2020; IIPR, 2023) [14]. India is the largest producer and consumer of chickpea globally; however, its national average productivity is lower than the crop's genetic potential. This yield gap is primarily due to poor nutrient management, cultivation under rainfed conditions, and low-fertility soils (Kumar *et al.*, 2022; IIPR, 2023) [12]. Among essential nutrients, nitrogen and phosphorus play a crucial role in chickpea growth, nodulation, photosynthesis, root development, and seed formation; however, early-stage nitrogen deficiency and phosphorus fixation in soils often limit optimal crop performance (Dotaniya *et al.*, 2014; Choudhary *et al.*, 2018) [5, 3].

Nano materials are defined as the materials with a single unit between one and a hundred nm in size in minimum of dimension. They are important because they are environmentally friendly and critical to promote sustainable agricultural development (Kantwa and Yadav, 2022) [10]. Nano urea is a nutrient (liquid) to provide nitrogen to plants as an alternative to the conventional urea. Effectively fulfils the nitrogen requirement when sprayed at critical stage. It has been indigenously developed at Nano Biotechnology Research Center, Kalol, Gujarat in line with Atmanirbhar Bharat and Atmanirbhar Krishi. Nano DAP liquid is an efficient source of nitrogen and phosphorus and helps in overcoming the nitrogen and phosphorus deficiencies in plants.

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The nano DAP liquid fertilizers developed by the Indian farmers fertilizers cooperative (IFFCO), the country's largest cooperative has been modified by ministry of agriculture and welfare under the fertilizer control order on March 2, 2023 and a gazate notification was issued allowing IFFCO to produce nano DAP liquid in India. It is biologically safe and ecofriendly fit for residual free green farming.

Di-Ammonium Phosphate (DAP) is widely used as a basal fertilizer in chickpea due to its provision of readily available nitrogen and phosphorus, which are essential for vigorous root growth, nodulation, and flowering. Adequate DAP application directly influences yield attributes and seed yield by supporting proper physiological and reproductive development (Sharma *et al.*, 2017; Meena *et al.*, 2020) [24, 14]. Despite its benefits, conventional DAP application sometimes results in nutrient losses or limited uptake efficiency, particularly under low-fertility and rainfed conditions. Therefore, optimising nutrient management practices, including timing, dosage, and application method, is crucial for maximising chickpea productivity and ensuring balanced plant nutrition.

In recent years, nano-fertilizer technology has emerged as an efficient alternative to conventional fertilizers. Nano urea, in particular, enhances nitrogen-use efficiency through higher foliar absorption, reduced losses, and improved physiological activity in plants (IFFCO, 2021; Subramanian *et al.*, 2021) [29]. One 500 mL bottle of nano urea can supplement the nitrogen supplied by a 45-kg bag of conventional urea, promoting better chlorophyll formation, vegetative growth, and productivity while reducing environmental pollution and fertilizer costs (IFFCO, 2021; Choudhary *et al.*, 2022) [4]. Recent studies have shown that the combined use of nano urea as foliar nutrition along with basal DAP significantly improves growth parameters, nodulation, nutrient uptake, and yield of pulses compared to conventional fertilization alone (Kumar *et al.*, 2023; Singh & Dwivedi, 2024) [13, 25]. Therefore, evaluating the effect of nano urea and DAP on the growth and yield of chickpea is essential for developing a sustainable, cost-effective, and eco-friendly nutrient management strategy that enhances productivity and nutrient-use efficiency.

Despite its significance, chickpea productivity in India remains below its potential, primarily due to nutrient deficiencies, especially nitrogen (N) and phosphorus (P) in rainfed soils. Although chickpea can meet a portion of its nitrogen requirement through biological nitrogen fixation, the initial growth stages require external N supplementation for vigorous vegetative development. Phosphorus, particularly in the form of DAP (Di-Ammonium Phosphate), plays a key role in root growth, nodulation, energy transfer (ATP), flowering and pod development, but its recovery from soil is often low due to fixation, making phosphorus a major limiting nutrient in chickpea-growing regions.

Recent advances in nano-fertiliser technology, especially nano urea, offer a promising alternative to conventional fertilizers. Nano urea contains ultra-small nitrogen particles (30-50 nm), which enhance leaf absorption, nitrogen-use efficiency (NUE), and reduce the environmental losses typically associated with granular urea. One 500 mL bottle of nano urea can effectively replace a 45-kg bag of conventional urea, while promoting improved chlorophyll formation, photosynthesis, and crop vigor. Studies have indicated that the combined or integrated application of

nano urea as a foliar spray along with basal phosphorus through DAP can improve nutrient availability, nodulation, yield attributes, and final seed yield in chickpea compared to the use of conventional fertilizers alone.

Materials and Methods

The present experiment was conducted during the rabi season of 2024-25 at the Research Farm of the Department of Agronomy, School of Agriculture Science, Technology & Research, Sardar Patel University, Balaghat (M.P.). The study was laid out in a Factorial Randomized Block Design with three replications and ten treatment combinations involving Nano Urea and Nano DAP in chickpea. The treatments included T₁ (Control), T₂ (100% RDF through Nano DAP), T₃ (100% RDF through Nano Urea), T₄ (50% RDF Nano DAP + 50% RDF Nano Urea), T₅ (75% RDF Nano DAP + 25% RDF Nano Urea), T₆ (25% RDF Nano DAP + 75% RDF Nano Urea), T₇ (50% RDF Nano DAP + foliar spray of Nano Urea @ 2 ml/l at 30 & 45 DAS), T₈ (50% RDF Nano DAP + foliar spray of Nano Urea @ 4 ml/l at 30 & 45 DAS), T₉ (foliar application of Nano Urea @ 4 ml/l + Nano DAP @ 3 ml/l at 30 & 45 DAS), and T₁₀ (foliar application of Nano Urea @ 6 ml/l + Nano DAP @ 5 ml/l at 30 & 45 DAS). Standard agronomic practices such as recommended seed rate (80 kg/ha), spacing (30 × 10 cm), and fertilizer dose (20:40:40 NPK kg/ha) were followed throughout the experiment along with irrigation, weed management, and plant protection measures.

The experimental soil was analyzed for its physico-chemical properties using standard procedures such as the International Pipette Method (Piper, 1966) [21] and Walkley and Black method (Jackson, 1973) [9]. Observations on growth and yield attributes included plant height, number of branches, nodulation, fresh and dry weight, pods per plant, seeds per pod, test weight, seed yield, straw yield, biological yield, harvest index, and protein content. The data were statistically analyzed using analysis of variance (ANOVA) as per Panse and Sukhatme (1985) [19], and treatment means were compared using the critical difference (CD) at 5% probability level. Economic analysis was also performed by calculating gross return, net return, and benefit: cost ratio based on prevailing market prices.

Results and Discussion

Effect of nano urea and nano dap on growth attributes of chickpea

The application of Nano Urea and Nano DAP significantly enhanced the growth attributes of chickpea such as plant height, number of branches per plant, and dry matter accumulation over the control and conventional fertilizer treatments. This improvement can be attributed to the efficient nutrient delivery system of nano fertilizers, which ensures higher nutrient use efficiency, rapid absorption, and sustained release of nitrogen and phosphorus throughout the growth period. Treatments receiving foliar applications of Nano Urea and Nano DAP, especially at higher concentrations (6 ml/l and 5 ml/l, respectively), recorded maximum plant height and biomass due to enhanced chlorophyll synthesis and improved photosynthetic efficiency. These results are in conformity with the findings of Khandare *et al.* (2024) [11], who reported that nano-based fertilizers significantly promoted vegetative growth of chickpea by improving nitrogen uptake and assimilation efficiency. Similarly, Challa *et al.* (2025) [2] observed that

foliar application of Nano Urea at 2-4 ml/l increased growth attributes due to enhanced nitrogen availability during critical growth stages. Moreover, Mirbakhsh (2023) [16] emphasized that the nano-sized nutrient particles improve root architecture and facilitate better nutrient translocation, resulting in vigorous vegetative growth. The synergistic effect of Nano DAP and Nano Urea was also reported by Pandao *et al.* (2025) [18], where combined application improved leaf area index, branching, and dry matter accumulation compared to single-nutrient application. The improved physiological performance under nano fertilizer treatments could also be linked to reduced nutrient losses through leaching and volatilization, ensuring sustained nutrient supply throughout the crop life cycle (Meena *et al.*, 2023) [15]. Hence, the combined foliar application of Nano Urea and Nano DAP proved superior in enhancing the overall growth performance of chickpea under field conditions.

Effect of nano urea and nano dap yield attributes and yield of chickpea

The yield attributes and yield of chickpea were significantly influenced by the application of Nano Urea and Nano DAP. Treatments receiving combined foliar applications of Nano Urea and Nano DAP exhibited notable improvements in the number of pods per plant, number of seeds per pod, test weight, and ultimately, the grain and stover yields. The highest seed yield (2245 kg/ha) and stover yield (3140 kg/ha) were obtained under the treatment comprising foliar application of Nano Urea @ 6 ml/l + Nano DAP @ 5 ml/l at 30 and 45 DAS, which was significantly superior to the control. This increase in yield parameters may be attributed to better nutrient availability, improved photosynthetic activity, enhanced translocation of assimilates, and prolonged physiological activity of the plants. Similar findings were reported by Patel *et al.* (2024) [20] and Ramesh *et al.* (2023) [22], who observed that foliar feeding of Nano Urea and Nano DAP increased pod setting percentage and seed development due to improved nitrogen and phosphorus utilization efficiency. Kumar *et al.* (2023) [13] also noted that nano-formulated fertilizers ensure targeted nutrient delivery and minimize losses, resulting in higher nutrient uptake efficiency and greater yield potential compared to conventional fertilizers. Moreover, Yadav *et al.* (2025) [30] emphasized that the synergistic effect of nitrogen and phosphorus supplied through nano formulations enhances reproductive efficiency and grain filling, leading to heavier grains and increased test weight. The improvement in yield attributes under nano fertilizer treatments might also be due to enhanced metabolic activity, balanced nutrient supply, and better root growth contributing to increased water and nutrient uptake (Meena *et al.*, 2023) [15]. Therefore, the combined foliar application of Nano Urea and Nano DAP not only improved yield attributes but also ensured higher productivity and economic returns in chickpea cultivation under limited resource conditions.

Effect of nano urea and nano dap quality character of chickpea

The quality parameters of chickpea, particularly protein content, were significantly influenced by the application of Nano Urea and Nano DAP. The treatment receiving foliar application of Nano Urea @ 6 ml/l + Nano DAP @ 5 ml/l at 30 and 45 DAS recorded the highest protein content

(20.35%), which was significantly superior to the control (18.62%). The improvement in protein percentage may be attributed to enhanced nitrogen assimilation and its translocation to the developing grains due to the increased availability and uptake of nitrogen and phosphorus in nano form. Nano fertilizers, owing to their ultra-small particle size and higher surface area, facilitate efficient absorption and slow release of nutrients, leading to prolonged availability and higher utilization efficiency (Kumar *et al.*, 2023) [13]. Similar findings were reported by Patel *et al.* (2024) [20], who observed that Nano Urea application enhanced the synthesis of amino acids and proteins by improving the activity of nitrate reductase and glutamine synthetase enzymes. Furthermore, Yadav *et al.* (2025) [30] noted that foliar application of Nano DAP improved phosphorus availability, which plays a crucial role in energy metabolism and protein synthesis, thereby improving grain quality. The balanced supply of nitrogen and phosphorus through Nano Urea and Nano DAP not only ensured better chlorophyll stability and photosynthetic efficiency but also promoted the accumulation of nitrogenous compounds in the seeds (Ramesh *et al.*, 2023) [22]. Meena *et al.* (2023) [15] further emphasized that the use of nano-formulated fertilizers improves nutrient use efficiency, reduces losses, and enhances the biochemical composition of pulse crops, resulting in superior seed quality. Thus, the combined foliar application of Nano Urea and Nano DAP significantly enhanced the protein content and overall quality of chickpea grains compared to conventional fertilization, indicating that nano-nutrient management is a promising approach for improving the nutritional value and marketability of chickpea under sustainable farming systems.

Economics

The economic analysis revealed that the application of Nano Urea and Nano DAP significantly influenced the profitability of chickpea cultivation. The maximum gross monetary return (₹1,20,800/ha), net income (₹75,300/ha), and benefit-cost ratio (2.65) were recorded under the treatment involving foliar application of Nano Urea @ 6 ml/l + Nano DAP @ 5 ml/l at 30 and 45 DAS, which was substantially superior to the control (B:C ratio 1.8). The improvement in economic returns is primarily attributed to enhanced growth, yield attributes, and ultimately higher grain yield obtained due to efficient nutrient absorption and utilization in nano-formulated fertilizers. Nano Urea and Nano DAP, with their controlled release and higher nutrient use efficiency, reduce input costs by minimizing fertilizer losses through volatilization and leaching while maintaining or improving crop productivity (Kumar *et al.*, 2023) [13]. Patel *et al.* (2024) [20] also observed that foliar feeding of Nano Urea in combination with Nano DAP led to a significant reduction in the cost of cultivation compared to conventional fertilizer application, due to the requirement of lower doses and targeted nutrient delivery. The higher profitability obtained in nano-fertilizer treatments indicates that nanotechnology-based nutrient management offers a cost-effective and eco-friendly alternative to traditional fertilization practices. Similar findings were reported by Singh *et al.* (2023), who found that Nano Urea application enhanced chickpea yield by 15-20% while reducing fertilizer cost by nearly 30%, thereby increasing the net return and B:C ratio. Moreover, Ramesh *et al.* (2023) [22] highlighted that nano-fertilizer use ensures better return per

rupee invested by improving nutrient efficiency, crop quality, and sustainability of production systems. Thus, the economic advantage demonstrated by combined foliar application of Nano Urea and Nano DAP underscores its

potential as an innovative, profitable, and sustainable strategy for chickpea cultivation under resource-limited farming conditions.

Table 1: Effect of Nano urea and DAP on growth and yield of chickpea (*Cicer arietinum* L.)

Tr. No.	Treatment	Plant Height	Branches/plant	Number of root nodules per plant	Dry weight per plant (g)	Number of Pods/plant	Seed yield (kg) per hectare	Stover yield per hectare	Protein (%)	Net income (₹/ha)	B:C ratio
T ₁	Control	48.6	7.8	21.4	2.41	29.3	1570	2520	18.62	32,000	1.8
T ₂	100% RDF through Nano DAP	62.8	9.8	27.6	3.54	34.8	1805	2710	19.1	50,500	2.2
T ₃	100% RDF through Nano Urea	60.5	9.4	26.8	3.62	36.1	1835	2735	19.27	53,400	2.27
T ₄	50% RDF Nano DAP + 50% RDF Nano Urea	65.9	10.3	29.3	3.95	38.9	1920	2840	19.38	55,300	2.29
T ₅	75% RDF Nano DAP + 25% RDF Nano Urea	68.7	10.9	31.7	4.06	40.4	1985	2895	19.52	57,300	2.32
T ₆	25% RDF Nano DAP + 75% RDF Nano Urea	64.2	10.1	28.9	3.83	39.7	1948	2860	19.6	59,000	2.36
T ₇	50% RDF Nano DAP + Foliar spray of Nano Urea @ 2 ml/l at 30 & 45 DAS	70.1	11.3	32.4	4.29	42.5	2050	2965	19.74	62,200	2.41
T ₈	50% RDF Nano DAP + Foliar spray of Nano Urea @ 4 ml/l at 30 & 45 DAS	72.4	11.9	34.1	4.53	44.2	2128	3028	19.92	65,800	2.48
T ₉	Foliar application of Nano Urea @ 4 ml/l + Nano DAP @ 3 ml/l at 30 & 45 DAS	74.1	12.3	35.3	4.71	45.8	2184	3082	20.1	69,600	2.55
T ₁₀	Foliar application of Nano Urea @ 6 ml/l + Nano DAP @ 5 ml/l at 30 & 45 DAS	76.3	12.7	36.5	4.93	47.3	2245	3140	20.35	75,300	2.65
	S.Em±	1.24	0.28	0.82	0.13	0.88	38.6	45.8	0.12	1,620	0.05
	CD(P=0.05)	3.58	0.83	2.42	0.37	2.53	112.5	132.9	0.36	4,870	0.14

Conclusion

The study revealed that the combined foliar application of Nano Urea @ 6 ml/l and Nano DAP @ 5 ml/l at 30 and 45 DAS (T₁₀) significantly improved growth, yield, quality, and economic returns of chickpea. This treatment recorded the highest plant height (76.3 cm), seed yield (2245 kg/ha), protein content (20.35%), and B:C ratio (2.65). The enhanced performance was due to efficient nutrient absorption, better physiological activity, and improved productivity. Hence, the combined use of Nano Urea and Nano DAP proved to be the most effective and economically viable practice for sustainable chickpea cultivation.

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