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Effect of nano DAP foliar application on growth and productivity of *rabi* groundnut

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Abstract

A field experiment was conducted during *rabi* season 2024-25 at Agricultural Research Station, Kadiri to study the effect of varied levels of phosphorus and nano DAP on groundnut. The experiment was conducted in a three-times replicated randomized block design (RBD) comprised of nine treatments. The treatments consist of phosphorus and nano DAP in different levels. The adoption of nano-DAP, a nanotechnology-based phosphorus fertilizer, has further improved phosphorus use efficiency in groundnut crops. Nano-DAP's ultra-fine particles ensure greater surface area and faster absorption, allowing for targeted and sustained nutrient delivery even at lower application rates. This leads to improved flowering, better pod setting, and enhanced kernel filling. Additionally, nano-DAP minimizes nutrient losses and maintains phosphorus availability during critical reproductive stages. The use of nano-DAP, a nano-formulation of Di-Ammonium Phosphate, further enhances this effect by ensuring better phosphorus availability and absorption, even under limited soil nutrient conditions. Nano-DAP delivers phosphorus in a more bioavailable form due to its nanoscale size, encouraging healthy and sustained vegetative growth. The results showed that 100% recommended dose of P_2O_5 + two sprays of Nano-DAP at 30-35 and 50-55 DAS recorded maximum plant height (35.10 cm), number of branches per plant (7.40), number of pods per plant (27.8), number of kernels per pod (2.10), Harvest index (39.61), seed yield (2738 kg ha⁻¹), shelling percentage (73.02%) and haulm yield (4753 kg ha⁻¹). The treatment also recorded maximum gross return (INR. 1,35,078/ha), net return (INR. 73,455/ha) and B: C ratio (2.72).

Keywords: Foliar nutrition, phosphorus, nano DAP, groundnut, yield

Introduction

Groundnut (*Arachis hypogaea* L.) is a major oilseed crop grown extensively in tropical and subtropical regions, contributing significantly to food security and rural livelihoods. As a legume, it plays a dual role in agriculture by providing edible oil and improving soil fertility through nitrogen fixation. Groundnut was introduced in India in the middle of the 19th Century on the east coast of the South Arcot district in Tamil Nadu. The crop grows best on Sandy loam soils with good Drainage. As heavy and stiff clays are unsuitable for groundnut cultivation. It is a versatile legume oil seed crop, belongs to the Leguminaceae family and originated in Brazil. Groundnut plays a role in meeting the demand of edible oil across the world. It is named as monkey nut, earth nut, goober, unpredictable legume and energy capsule. In India groundnut is cultivated in 22.98 lakh hectares of area with a production of 14.52 lakh tonnes and productivity of 1040 kg ha⁻¹. In Andhra Pradesh, groundnut is grown in an area of 8.8 lakh tonnes, production of 6.00 lakh tonnes and productivity of 20.67 during 2022- 2023. www.indiastat.com seed contains 47-50% oil, 26% protein and 11.5% of starch). Groundnut oil is sweet in flavour used in cooking and other purpose.

In India, pulses and oilseeds are predominantly cultivated on marginal soils that are often deficient in phosphorus. This nutrient limitation significantly hinders the growth and productivity of leguminous crops such as groundnut, which are highly sensitive to phosphorus availability. Phosphorus plays a critical role in early plant development by enhancing root system formation, nutrient uptake, and water absorption. Its presence is essential for robust seedling establishment and effective root nodulation, both of which are fundamental to the

overall health and yield of groundnut crops. Phosphorus adsorbed through leaves helps in partitioning of photosynthates from vegetative parts to reproductive parts, excess amount of assimilates are stored in the leaves and later translocated into seeds at the time of senescence, ultimately led to higher yield. Kumari *et al.* (2017) [12]. Phosphorus absorbed through leaves helps in efficient partitioning of photosynthates from vegetative part to reproductive parts. Nano DAP liquid is an advanced fertilizer that provides an efficient source of nitrogen and phosphorus, developed by the Indian Farmers Fertilizer Cooperative (IFFCO), India's largest cooperative, the formulation has been approved and modified under the Fertilizer Control Order by the Ministry of Agriculture and Farmers Welfare. Following the order issued on March 2, 2023, and an official Gazette notification, IFFCO was authorized to produce Nano DAP liquid in India. The product is biologically safe, ecofriendly, and suitable for sustainable, residue-free green farming. Foliar feeding is often most effective and economic way to improve plant nutrient deficiency (Dixit and Elamathi, 2007) [16].

Materials and Methods

The experiment was conducted at the Agricultural Research Station, Kadiri, during Rabi, 2024- 25. The research station is situated in the Southern Agro Climatic Zone Andhra Pradesh state at 14°11' North latitude and 78°14' East longitude with an altitude of 531 meters above mean sea level. The investigation site had sandy loam in texture, neutral pH (7.0) and non-saline (EC: 0.30 dSm⁻¹), low in organic carbon (0.27%), medium in available nitrogen (157 kg ha⁻¹), medium in available phosphorus (19.9 kg ha⁻¹) and medium in available potassium (267 kg K₂O ha⁻¹). The field experiment was conducted in a Randomized Block Design (RBD) involving nine treatments and three replications with a plot size of 4.5 m × 5.0 m respectively. The treatments consist of 50% recommended dose of P₂O₅ + One spray of Nano-DAP at 30-35 DAS (T₁), 50% recommended dose of P₂O₅ + Two sprays of Nano-DAP at 30-35 and 50-55 DAS (T₂), 75% recommended dose of P₂O₅ + One spray of Nano-DAP at 30-35 DAS (T₃), 75% recommended dose of P₂O₅ + Two sprays of Nano-DAP at 30-35 and 50-55 DAS (T₄), 100% recommended dose of P₂O₅ + One spray of Nano-DAP at 30-35 DAS (T₅), 100% recommended dose of P₂O₅ + Two sprays of Nano-DAP at 30-35 and 50-55 DAS (T₆), Foliar application of Nano-DAP @ 2.5 ml l⁻¹ twice at 30-35 and 50-55 DAS (T₇), 100% RDP (40 kg P₂O₅ ha⁻¹), (T₈) and absolute control (T₉). Nano DAP contains Nitrogen 8% w/v and 16% w/v. Recommended dose of fertilizer (30:40:50 kg of N: P₂O₅: K₂O ha⁻¹). Before sowing seeds were treated with Tebuconazole @1g/kg seed. Treated Seeds of groundnut (Kadiri-6) were sown in 22.5 × 10.0 cm spacing with ridge and furrow method. At the time of sowing N and K₂O (30: 50 kg ha⁻¹) was applied equally for all plots and P₂O₅ was applied as per the required quantities in 50, 75 and 100% doses. Five plants were randomly selected in each net plot was harvested separately and the values were converted into hectare basis and expressed in kilograms per hectare. The data was recorded on Dry matter production, Number of pods plant⁻¹, Test weight (100 kernel weight in grams), Shelling percentage, Pod yield (kg ha⁻¹), Kernel yield (kg ha⁻¹), Haulm yield (kg ha⁻¹) and Harvest index (HI%) statistically analyzed following the analysis of variance for randomized block design as suggested by Panse and Sukhatme (1985) [18]. Statistical significance was tested with 'F' value at five per cent level of probability. Critical difference (CD) for the

significant sources of variation was calculated at five per cent level of significance. The treatmental differences those were non-significant were denoted by "NS".

Results and Discussion

A. Yield attributes and yield

1. Number of pods/plant

Data recorded on number of pods/plant of under varied levels of phosphorus and nano DAP was represented in Table 1. Application of 100% recommended dose of P₂O₅ + two sprays of Nano-DAP at 30-35 and 50-55 DAS was statistically at par with application 100% recommended dose of P₂O₅ + One spray of Nano-DAP at 30-35 DAS Significant and maximum number of pods/Plant was due to recommended dose of fertilizers as basal dose along with supplementation of nutrients through foliar application at pod initiation stage can help to boost the yield of groundnut. This could be because the variety has better genotypic traits better genotypic traits account for its larger number of pods per plant. Similar findings were reported by Bhagavatha Priya (2014) [14]. Foliar fertilization has the potential to increase the efficiency and frequency by the nutrient utilized by the plant in order to maximize the growth and yield. This was mainly attributed to synergistic effect of conventional soil applied urea and SSP fertilizers, K₂O and foliar application of nano DAP which enhanced the uptake of nitrogen and phosphorus (Kumar, 2022) [14]. Nitrogen being a component of many amino acids helped in increasing the number of pods/plant and translocation of photosynthates from source to sink. The better source to sink relationship resulted in higher number of pods per plant, seed yield per plant, 100 seed weight resulted in higher seed yield in those treatments. Similar findings were recorded with Choudhary *et al.*, (2022) [5], Kumar *et al.*, (2021) [13] and Aziz *et al.*, (2021) [2]. The lowest number of total filled pods plant⁻¹ recorded with absolute control due to high temperatures during flowering and pod development stages caused poor pod set.

Dry matter production

Data recorded on dry matter production under varied levels of phosphorus and nano DAP was represented in Table 1. The data indicated that DMP of groundnut was significantly influenced by application of 100% recommended dose of P₂O₅ + two sprays of Nano-DAP at 30-35 and 50-55 DAS was statistically at par with 100% recommended dose of P₂O₅ + One spray of Nano-DAP at 30-35 DAS. The application of phosphorus and nano DAP resulted in a significant increase in dry matter production (DMP), likely due to improved dry weight accumulation as phosphorus is known to stimulate the development of a more extensive root system (Gobarah *et al.*, 2006) [8], enhancing the plants ability to absorb water and nutrients from deeper soil layers. This increased uptake supports greater assimilates production, which is reflected in the overall improvement in biomass. Similar findings have been reported by Hemalatha *et al.* (2013) [9] and Mouri *et al.* (2018) [16]. Chlorophyll synthesis resulting in higher plant height, improved photosynthetic area and vegetative growth, which ultimately reflected in the form of higher dry matter production Nano DAP was helpful for efficient nutrient transportation with enhanced nutrient availability directly to plant tissues, promoting better growth and higher dry matter production. Khandare *et al.* (2024) [11]. The lowest dry matter production recorded with absolute control due to excessive competition for light, nutrients, and water leads to stunted growth.

Test weight (100 kernel weight in grams)

Data pertaining to test weight of groundnut was significantly influenced by varied levels of phosphorus and nano DAP represented in Table 1. The highest 100- kernel weight was recorded with application of 100% recommended dose of P_2O_5 + two sprays of Nano-DAP at 30-35 and 50-55 DAS was statistically at comparable with treatment -5 100% recommended dose of P_2O_5 + One spray of Nano-DAP at 30-35 DAS due to continuous supply of energy facilitated by phosphorus through ATP generation and photosynthetic efficiency leads to greater production of photo assimilates (mainly carbohydrates), which are essential for seed development. The improved nitrogen and phosphorus availability at critical crop growth stages by foliar spraying of nano DAP (nitrogen and phosphorus) which helped to improve the uptake of nutrients because nano DAP having more surface to volume ratio during absorption. Application of phosphorus at optimum levels is essential for maximizing kernel weight and achieving higher yield potential in groundnut cultivation. Similar results were reported by Kabir *et al.* (2013) [10]. The hundred lowest kernel weight was recorded with absolute control due to poor translocation of assimilates.

Shelling percentage

Data pertaining to Shelling percentage of groundnut was significantly influenced by varied levels of phosphorus and nano DAP was represented in Table 1. The highest Shelling percentage was recorded with application of 100% recommended dose of P_2O_5 + two sprays of Nano-DAP at 30-35 and 50-55 DAS was statistically at par with treatment -5 100% recommended dose of P_2O_5 + One spray of Nano-DAP at 30-35 DAS due to the nano DAP contain phosphorus and nitrogen in nano-sized particles by enhancing their absorption efficiency. Adequate phosphorus ensures efficient energy transfer (ATP) and sugar translocation by promoting better grain filling and kernel development. Proper irrigation ensures better seed filling and higher shelling percentage. Similar findings were recorded with Everest *et al.* (2022) [7]. The application of phosphorus, particularly in the form of advanced fertilizers like nano-DAP, has shown significant improvement in crop performance and

shelling percentage. NanoDAP due to its ultra-fine particle size and ensures better nutrient absorption and targeted delivery to plant roots. This leads to enhanced flowering, better pod setting, and improved kernel filling. Additionally, phosphorus improves overall plant vigour and stress tolerance, which further supports uniform pod development and reduces the occurrence of empty or immature pods. The lowest shelling percentage was observed with absolute control due to inadequate amount of nutrients available for pod development.

Pod yield (kg ha⁻¹)

Data pertaining to pod yield of groundnut was significantly influenced by varied levels of phosphorus and nano DAP represented in Table 2. Significantly highest pod yield in groundnut was recorded with application of 100% recommended dose of P_2O_5 + two sprays of Nano-DAP at 30-35 and 50-55 DAS which was statistically at par with 100% recommended dose of P_2O_5 + One spray of Nano-DAP at 30-35 DAS due to timely irrigation and pest control minimized physiological stress and physical damage to pods, contributing to higher pod weight and better translocation of assimilates to the reproductive parts resulting higher pod yield. Similar results were reported by (Bhargavi and Sundari, 2023 [3] and Rajesh *et al.* (2021) [19]. The increase in growth and yield might be due to the fact that K influenced the physiological processes that were directly related to symbiotic N_2 fixation, photosynthesis, and carbohydrate translocation for pod growth as the increase in pod development improved pod weight per plant. These results are in accordance with the findings of Singh *et al.* (2007) [22]. Nano-DAP (nano-formulated DiAmmonium Phosphate) has further improved nutrient delivery and efficiency because of its nano-sized particles with larger surface area for absorption and ensures more precise and timely phosphorus availability to the plant. This results in improved plant vigor, higher pod setting, and better kernel development. Additionally, nano-DAP minimizes nutrient losses through leaching or fixation, allowing for more sustained nutrient availability during the crop's critical growth phases. The lowest pod yield was recorded with absolute control due to lower vegetative and reproductive potential of the plant and lower nutrient availability.

Table 1: Dry matter production, Yield attributes of groundnut as influenced by varied levels of phosphorus and nano DAP

Treatments	Dry matter production (kg ha ⁻¹)	Number of pods plant ⁻¹	Test weight (g)	Shelling percentage
T1: 50% recommended dose of P_2O_5 + One spray of Nano-DAP at 30-35 DAS	4922	21.0	32	62
T2: 50% recommended dose of P_2O_5 + Two sprays of Nano-DAP at 30-35 and 50-55 DAS	5034	21.6	34	63
T3: 75% recommended dose of P_2O_5 + One spray of Nano-DAP at 30-35 DAS	5904	25.5	38	66
T4: 75% recommended dose of P_2O_5 + Two sprays of Nano-DAP at 30-35 and 50-55 DAS	5942	25.7	41	67
T5: 100% recommended dose of P_2O_5 + One spray of Nano-DAP at 30-35 DAS	6744	28.3	47	72
T6: 100% recommended dose of P_2O_5 + Two sprays of Nano-DAP at 30-35 and 50-55 DAS	6868	28.5	48	73
T7: Foliar application of Nano-DAP @ 2.5 ml l ⁻¹ twice at 30-35 and 50-55 DAS	4046	20.8	27	57
T8: 100% RDP (40 kg P_2O_5 ha ⁻¹)	6050	25.8	44	68
T9: Absolute control	4021	20.1	26	54
S.Em ±	217.1	0.99	0.58	0.7
CD ($p = 0.05$)	651	3.0	1.7	2.4

Kernel yield (kg ha⁻¹)

Data pertaining to kernel yield of groundnut was significantly influenced by varied levels of phosphorus and nano DAP was represented in Table 2. Significantly highest kernel yield in groundnut was recorded with application of 100% recommended dose of P_2O_5 + two sprays of Nano-DAP at 30-35 and 50-55 DAS was on parity with 100% recommended dose of P_2O_5 +

One spray of Nano-DAP at 30-35 DAS. This increase in production is the main place to store carbohydrates in plants, that eventually led to an increased number of seeds per plant as a source and storage of carbohydrates, and increased yield (Afshar *et al.*, 2014) [1]. Optimal spacing, moisture management and pest-free environments ensured a higher number of well-developed kernels per pod. These conditions will enhance the

overall kernel-to-pod ratio, significantly increasing kernel yield. Similar findings were recorded with (Sahu, 2023) [21]. Nano-DAP fertilizers offer a higher surface area, to facilitate different metabolic functions in the plant system as a result of more photosynthates are being produced. The lowest kernel yield was observed with absolute control because of lower nutrient availability at critical growth stages.

Haulm yield (kg ha⁻¹)

Data pertaining to Haulm yield of groundnut was significantly influenced by varied levels of phosphorus and nano DAP was represented in Table 2. The significant increase in haulm yield was recorded with 100% recommended dose of P₂O₅ + two sprays of Nano-DAP at 30-35 and 50-55 DAS was comparable with 100% recommended dose of P₂O₅ + One spray of Nano-DAP at 30-35 DAS due to pronounced role of nitrogen and phosphorus in cell elongation and photosynthesis leads to higher growth parameters and higher haulm yield. Similar findings were reported with Rajput *et al.* (2022) [20] and Mallikarjuna (2021) [15]. The application of nutrients such as nitrogen, phosphorus and potassium may boost protoplasmic components, which are crucial for physiological processes like chlorophyll and protein synthesis, ultimately leading to increase in haulm yield. Application of phosphorus significantly contributes to enhanced vegetative growth by promoting robust root development and transfer of energy within the plant. This leads to stronger plant architecture and more extensive foliage.

This results in taller plants, thicker stems, and more branching that directly contribute to increased haulm yield. Moreover, improved haulm production supports better photosynthetic activity, which in turn benefits pod and kernel development, making phosphorus and nano-DAP essential for maximizing both grain and biomass yields in groundnut.

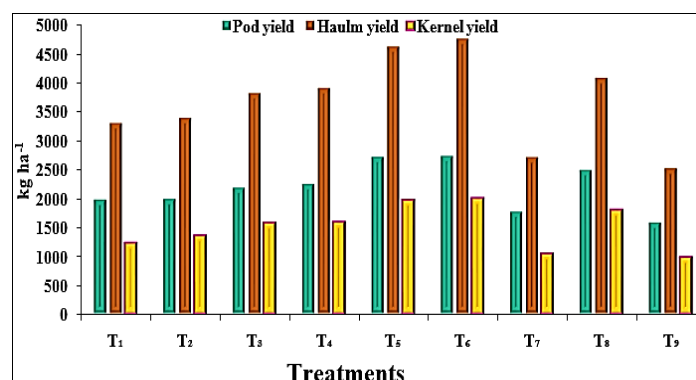


Fig 1: Effect of different treatments on pod, haulm, and kernel yields, with T₅ recording highest productivity.

The haulm production of groundnuts was eventually decreased by reductions in plant height, branches per plant, dry matter accumulation, and canopy development due to moisture stress Sounda *et al.* (2006) [23].

Table 2: Yield attributes of ground nut as influenced as varied levels of phosphorus and nano DAP

Treatments	Pod yield (kg ha ⁻¹)	Kernel yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)	Harvest index
T ₁ : 50% recommended dose of P ₂ O ₅ + One spray of Nano-DAP at 30-35 DAS	1878	1226	3292	36.57
T ₂ : 50% recommended dose of P ₂ O ₅ + Two sprays of Nano-DAP at 30-35 and 50-55 DAS	1886	1353	3384	37.01
T ₃ : 75% recommended dose of P ₂ O ₅ + One spray of Nano-DAP at 30-35 DAS	2219	1578	3812	37.07
T ₄ : 75% recommended dose of P ₂ O ₅ + Two sprays of Nano-DAP at 30-35 and 50-55 DAS	2313	1589	3902	37.55
T ₅ : 100% recommended dose of P ₂ O ₅ + One spray of Nano-DAP at 30-35 DAS	2721	1969	4619	38.74
T ₆ : 100% recommended dose of P ₂ O ₅ + Two sprays of Nano-DAP at 30-35 and 50-55 DAS	2738	1998	4753	39.61
T ₇ : Foliar application of Nano-DAP @ 2.5 ml l ⁻¹ twice at 30-35 and 50-55 DAS	1467	1011	2702	36.54
T ₈ : 100% RDP (40 kg P ₂ O ₅ ha ⁻¹)	2422	1774	4109	37.93
T ₉ : Absolute control	1445	981	2512	36.47
S.Em ±	82.0	62.5	163.2	2.02
CD (p = 0.05)	245	187	489	NS

Harvest Index

Data pertaining to Harvest index of groundnut was significantly influenced by varied levels of phosphorus and nano DAP was represented in Table 2. Application of 100% recommended dose of P₂O₅ + two sprays of Nano-DAP at 30-35 and 50-55 DAS was statistically at par with 100% recommended dose of P₂O₅ + One spray of NanoDAP at 30-35 DAS. Muldoon (1985) [17] reported that differences between cultivars were related to differences in harvest index and in the rate of pod filling. The movement of photosynthates (sugars, nutrients) from leaves and stems to developing pods enhances harvest index and efficient translocation of assimilates from vegetative parts to reproductive organs, resulting in greater pod yield relative to total biomass. Harvesting at the right maturity stage ensures full pod development and prevents losses due to overmaturity and leads to higher harvest index. Application of phosphorus alone improves root growth and enhances nutrient uptake, leading to better partitioning of assimilates towards pods. Foliar application of Nano DAP ensures timely nutrient supply during key growth stages (flowering and pod formation. As pod yield increases more than haulm, harvest index improves significantly with Nano DAP + phosphorus application. The lowest harvest index was recorded with absolute control which might be due to poor source to sink relationship.



T₅ - 100% recommended dose of P₂O₅ + One spray of Nano-DAP at 30-35 DAS.

Fig 2: T₆ - 100% recommended dose of P₂O₅ + two sprays of Nano-DAP at 30-35 and 50-55 DAS

Conclusion

The application of 100% recommended dose of P_2O_5 combined with two foliar sprays of Nano-DAP at 30-35 and 50-55 days after sowing (DAS) proved to be an effective nutrient management strategy for groundnut. This integrated approach not only ensured adequate phosphorus availability for root and early plant development but also supplied nitrogen efficiently during critical growth stages, enhancing overall plant vigor. The foliar application of Nano-DAP helped in quick nutrient absorption and minimized nutrient losses, contributing to improved dry matter accumulation, higher number of filled pods, and ultimately, increased pod yield. Therefore, this nutrient management practice is recommended for achieving better productivity and nutrient use efficiency in groundnut cultivation. Nano DAP offers the advantage of requiring smaller quantities while delivering when compared to the larger dose of traditional fertilizers. Its high surface area enables better absorption by plants, thereby promoting improved growth and higher yields of groundnut.

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