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Impact of Nano-DAP on soil available macro and micronutrient levels in pigeonpea cultivation under the vertisols of the North eastern dry zone of Karnataka

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Abstract
Phosphorus (P) is one of the three major nutrients required in crop nutrition, the other two being nitrogen (N) and potassium (K). Phosphorus plays many vital roles in crop growth and is referred to by many as the “king-pin” in Indian agriculture. Soluble P in the soil, whether it comes from apatite, fertilizer, manure or organic matter, will form compounds with Ca, iron (Fe), aluminium (AI) and manganese (Mn) and will bond with the reactive surfaces of certain clay minerals in soil reduce availability of P to plants because P is reverted or changed to fixed forms. Nanoscience coupled with nanotechnology emerged as possible cost-cutting approach to prodigal farming and environmental clean-up operations. Hence there is a need for a more innovative fertilizer approach that can increase the productivity of agricultural systems and more environmental friendly than synthetic fertilizers. Foliar nutrition is aimed to eliminate the problems of fixation and immobilization of nutrients. Hence, foliar nutrition is being recognized as a significant way of fertilizing modern agriculture, especially under rainfed conditions. Nano fertilizers because of smaller size and higher surface area are efficient as compared to conventional and produce better results when used in combined form.

Keywords: Pigeonpea, foliar nutrition, Nano-DAP, IFFCO

1. Introduction

Pulses are gaining more important position in Indian agriculture. After the green revolution, India has become self-sufficient in case of food grain production. However, India is still lagging in pulses production and is dependent on imports for domestic consumption particularly in recent years. Therefore, there is an immediate need for another revolution in the case of pulse production. Pigeonpea (*Cajanus cajan* L. Mill sp.) is an important legume crop, plays a vital role in the daily diet, and belongs to the family *Leguminosae*. It is also known as red gram, tur, and arhar. It is often cross-pollinated crop (20 to 70%). The food values of pigeonpea are 22.3% protein, 1.7% fat, 3.5% mineral, 1.5% fiber, and 57.5% carbohydrates in 100 g edible portions. Globally, pigeonpea is grown in an area of 63.57 lakh hectares with a production of 54.75 lakh tonnes and productivity of 861.25 kg/ha (FAO STAT, 2021). India ranks first in pigeonpea production globally with 43.4 lakh tonnes cultivated under 49.8 lakh hectares with a productivity of 871 kg/hectare in 2021-22 (agricoop.nic.in). In *Kharif* 2022, pigeonpea production was 38.9 lakh tonnes in an area of 46.2 lakh hectares (agricoop. nic)

The productivity of pulses in India (764 kg ha^{-1}) is far below the average productivity of the world (848 kg ha^{-1}). During the last four decades, the total area under pulses remained virtually stagnant (22 to 24 million ha^{-1}) with almost stable production (12 to 14 million tons), even though the population has increased by many folds. As a result, the present per capita availability of pulses has declined from 51.1 g day^{-1} in 1970-71 to less than 41.9 g day^{1} (2017) as against FAO/WHO’s recommendation of 80 g day^{-1}. It has led to a severe shortage of pulses in India, which has aggravated the problem of malnutrition in a large section of the vegetarian population. Thus, there is an urgent need to increase the production of pulses to meet the increasing demand by adopting the appropriate production technologies.

Pigeonpea is mainly cultivated in marginal lands which are low in fertility. The mineral nutrient deficiency limits nitrogen fixation and ultimately reduces the yield. Both major and micronutrients are important for nodulation. In pigeonpea, fertilizers are applied as basal doses. It is a long-duration crop and over the period the nutrients are lost and during its critical growth stages, nutrient deficiency is observed. In addition to causing losses, excessive use of fertilizer results in a decline in pulse nodulation.

To avoid this, foliar spraying of Nano DAP at critical stages could be a sustainable alternative practice. Nano fertilizers materials have a nanometer scale (1-100 nm), containing macro and micronutrients that are delivered to crops in a controlled mode. The main features of nano fertilizers are their small size. Their larger contact area and responsiveness facilitate nutrients to enter plants and improve nutrient use efficiency by minimizing losses.

Nano-DAP (N 8% & P 16%) fertilizer have been developed indigenously, for the first time in the world at IFFCO Nano Biotechnology Research Centre (NBRC), Kalol, Gujarat through a proprietary patented technology. Farmers are using DAP fertilizers for soil as well as foliar application to crops. However, the efficacy is lower. Thus, the goal of the current study is to determine the effect of Nano-DAP on growth, yield, of Pigeonpea in black soil under rainfed condition.

2. Materials and Methods

A field experiment was conducted during *kharif*, 2022 at Krishi Vigyan Kendra, Kalaburagi, on *Vertisol* having pH 8.23 and EC 0.21 dSm^{-1}. The soil was low in organic carbon content (4.32 g kg^{-1}) and available P_2O_5 (26.2 kg ha^{-1}), and low in available N (203 kg ha^{-1}) with high available K_2O content 362 kg ha^{-1}). The experimental site was located at a 17° 34' N latitude and 76° 79' E longitude. of 478 meters above mean sea level in North Eastern Dry Zone of Karnataka (Zone 2).

The research was arranged in Randomized complete block design, there were eight treatments consisting of different doses of RDF (two treatments with 100% RDF, two treatments 75% RDF, two treatments 50% RDF and one absolute control) with different doses of Nano-DAP sprayed at 45 and 60 days after sowing (DAS). After the previous crop was harvested, the ground was ploughed once again, followed by two harrowing. The field was prepped to a good seedbed and the fields were set out in preparation for sowing. The variety GRG-811 was used. The basal application of fertilizers in the form of urea, DAP and $ZnSo_4$ were applied as per treatments with recommended dose of (25:50:00:20 N: P_2O_5: K_2O: $ZnSo_4$ kg ha^{-1}) all treatment expect absolute control. The composite soil sample was collected to a depth of 0-15 cm from the experimental site before the start of the experiment for initial characterization. During the experiment, composite surface soil samples (0-15 cm) were drawn between rows from each plot after the crop harvest. The collected soil samples were air-dried, powdered with a wooden pestle and mortar, sieved (2 mm), and stored in air-tight polythene bags for further analysis. The soil samples collected were analyzed by adopting standard methods and procedures. Available nitrogen in the soil samples was determined by the alkaline potassium permanganate method as described by Subbaiah and Asija (1956) [1]. Available phosphorus was extracted with 0.5M sodium bicarbonate of P^H 8.5 (Olsen's reagent) and the amount of phosphorus in the extract was estimated at 660 nm using a spectrophotometer. The determined phosphorus was termed as available phosphorus by multiplying with the 2.29 factor to get P_2O_5 as outlined by Jackson (1973) [2]. Available potassium was extracted by neutral normal ammonium acetate (Jackson, 1973) [2]. Calcium and magnesium in the soil were determined by the rapid titration method (Jackson, 1973) [2] by using neutral ammonium acetate as an extractant. Sulphate sulphur in the soil was extracted by using a 0.15 per cent calcium chloride solution as described by Jackson (1973) [2]. Available micronutrients like Cu, Fe, Mn, and Zn were extracted by using DTPA extractant as explained by Lindsay and Norwell (1978) [3] The concentrations in the filtrate were estimated using atomic absorption spectrophotometer.

2.1 Statistical analysis

The data collected from the experiment at different growth stages and at harvest were subjected to statistical analysis as described by Gomez and Gomez (1984) [4]. The level of significance used in the "F" test was given at 5 per cent. Critical difference (CD) values are given in the table at a 5 per cent level of significance, wherever the "F- test was significant at a 5% level.

3. Results and Discussion

3.1 Available Marco nutrient in soil

After harvest, the N, P_2O_5 and K_2O availability in the soil showed significant differences across treatments in Pigeonpea. With the application of foliar sprays of Nano-DAP @ 4 ml per litre at 45 and 60 DAS with 100% RDF, significantly greater available N, P_2O_5 and K_2O (215, 33.75 and 356 kg ha^{-1} respectively) was observed. which was on par with 2 ml per litre Nano-DAP to 100% RDF at 45 and 60 DAS (212, 31.35 and 344 kg ha^{-1} respectively). In comparison to all other treatments. 100% RDF with Nano-DAP spray @ 4 ml per litre at 45 and 60 DAS was recorded maximum soil available nitrogen (215 kg ha^{-1}) compare to other treatment. recommended dose of fertilizer recorded (209 kg ha^{-1}). Lower was recorded in absolute control (168 kg ha-^{1}). It is because nitrogen fertilizer was not applied. (Table 1).

3.1.2 Exchangeable Calcium and Magnesium

Exchangeable calcium and magnesium content in soil after harvest was non-significantly influenced by the foliar application of Nano-DAP at varied concentration to Pigeonpea and data represented in Table (2). Treatment which received 100% RDF with 4 ml per litre Nano-DAP at 45 and 60 DAS recorded maximum Exchangeable calcium and magnesium in soil content (7.90, 3.40 respectively) cmol(p+) kg^{-1}.

3.1.3 Available Sulphur

After harvest, the sulphur availability in the soil showed significant differences across treatments in Pigeonpea. With the application of foliar sprays of Nano-DAP @ 4 ml per litre at 45 and 60 DAS with 100% RDF, significantly greater available sulphur (19.0 kg ha^{-1}) was observed. which was on par with 2 ml per litre Nano-DAP to 100% RDF at 45 and 60 DAS (17.69 kg ha^{-1}). compare to all other treatment. recommended dose of fertilizer recorded (16.32 kg ha^{-1}). Lower was recorded in absolute control 11.22 kg ha-^{1} (Table 2).

Nitrogen application in the form of nanoparticles increases nitrogen utilisation efficiency (NUE) at the right concentration and decreases nitrogen leaching loss in the form of nitrate. Application of nano nitrogen chelated fertilizer (NNC) significantly increased sugar output in sugarcane and NUE and decreased nitrate leaching (Mahmoud *et al*., 2020) [5].

A declining trend in soil P_2O_5 availability was observed across crop development stages, irrespective of N levels or nano N nutrition. This trend can be attributed to the continuous uptake of phosphorus by crops as their biomass increases during each successive crop growth stage. The decrease in available P_2O_5 indicates that pigeonpea plants utilize available phosphorus more intensively in the early stages of crop growth. This aligns with similar research findings, such as those by Sankalpa (2013) [6], Mala *et al.* (2017) [7], Singh and Kumar (2017) [8] and Dhansil *et al.* (2018) [9]. Which also observed a decline in soil-available P_2O_5 with crop development.

The data presented in Table 1 revealed that available N, P_2O_5 and K_2O were significantly influenced by the foliar application of nano nutrients. Absolute control recorded significantly lower available nutrients in soil. Available N was relatively higher where foliar spray Nano-DAP @ 4 ml per litre at 45 and 60 DAS with 100% RDF was applied than compared to other treatments, it might be due to higher loss of nitrogen. Available P_2O_5 was significantly higher in the treatments of Nano-DAP @ 4 ml per litre at 45 and 60 DAS with 100% RDF, compared to other treatments. Similar trend was observed in available K_2O the results were in agreement with findings of Apoorva *et al.* (2016) [10].

The available sulphur (SO^{-2}_4) and zinc content in the soil after pigeonpea harvest significantly increased with varying fertility levels compared to the control. This increase can be attributed to the fact that only a small portion of the applied S and zinc was utilized by the rainy season crops. As a result, the unutilized fertilizer S and zinc content in the soil led to an increase in the available S and zinc content of the soil. Additionally, zinc availability decreased with increasing phosphorus levels, aligning with findings reported by Shivran and Ahlawat (2000) [11].

3.2 Available micronutrient status

Results of the soil study showed that, with the exception of Zn, all treatments had non-significant availability of micronutrients. Zn levels in soil were substantially greater in the treatment 100% RDF with Nano-DAP spray @ 4 ml per litre at 45 and 60 DAS (0.45 mg kg^{-1}) than in the other treatments. recommended dose of fertilizer recorded (0.29 mg ha-^{1}). Lower was recorded in absolute control 0.20 mg ha^{-1} (Table 3).

Application of $ZnSO_4$ and RDF increase availability nutrient in soil after harvest of crop. Similar findings that Daphade *et al.* (2019) [12]. Devi *et al.* (2012) [13] and Poudel *et al.* (2023) [14].

Table 1: Influence of available soil nutrients (kg ha^{-1}) status in soil after harvest of Pigeonpea crop

Treatment	Available N kg ha^{-1}	Available P_2O_5 kg ha^{-1}	Available K_2O kg ha^{-1}
T_1: 100% RDF + 2 ml Nano-DAP foliar application @ 45 and 60 DAS	212	31.35	344
T_2: 100% RDF + 4 ml Nano-DAP foliar application @ 45 and 60 DAS	215	33.75	356
T_3: 75% RDF + 2 ml Nano-DAP foliar application @ 45 and 60 DAS	204	27.47	332
T_4: 75% RDF + 4 ml Nano-DAP foliar application @ 45 and 60 DAS	208	29.10	338
T_5: 50% RDF + 2 ml Nano-DAP foliar application @ 45 and 60 DAS	192	23.52	314
T_6: 50% RDF + 4 ml Nano-DAP foliar application @ 45 and 60 DAS	199	24.10	319
T_7: RDF (25:50:0 N: P_2O_5: K_2O)	209	29.23	327
T_8: Absolute control	168	20.09	306
S.Em±	1.79	0.83	4.02
CD@ 5%	5.45	2.53	12.19
Note: FYM @ 5 tonnes ha^{-1} & Zinc Sulphate @15kg ha^{-1} for all the treatments except T_8			

Table 2: Influence of available soil nutrients (kg ha^{-1}) status in soil after harvest of Pigeonpea crop

Treatment	Exchangeable Ca kg ha^{-1}	Exchangeable Mg kg ha^{-1}	Available SO_4 kg ha^{-1}
T_1: 100% RDF + 2 ml Nano-DAP foliar application @ 45 and 60 DAS	7.87	3.20	17.69
T_2: 100% RDF + 4 ml Nano-DAP foliar application @ 45 and 60 DAS	7.90	3.40	19.00
T_3: 75% RDF + 2 ml Nano-DAP foliar application @ 45 and 60 DAS	7.57	2.57	16.40
T_4: 75% RDF + 4 ml Nano-DAP foliar application @ 45 and 60 DAS	7.67	2.93	16.80
T_5: 50% RDF + 2 ml Nano-DAP foliar application @ 45 and 60 DAS	7.50	2.07	15.29
T_6: 50% RDF + 4 ml Nano-DAP foliar application @ 45 and 60 DAS	7.63	2.17	15.34
T_7: RDF (25:50:0 N: P_2O_5: K_2O)	7.27	2.83	16.32
T_8: Absolute control	7.20	2.03	11.22
S.Em ±	0.28	0.35	0.46
CD@ 5%	NS	NS	1.40

Note: FYM @ 5 tonnes ha^{-1} & Zinc Sulphate @15kg ha^{-1} for all the treatments except T_8

Table 3: Influence of available soil micronutrients status in soil after harvest of Pigeonpea crop

Treatment	Iron	Copper	Zinc	Manganese
T_1: 100% RDF + 2 ml Nano-DAP foliar application @ 45 and 60 DAS	4.34	1.25	0.35	4.35
T_2: 100% RDF + 4 ml Nano-DAP foliar application @ 45 and 60 DAS	4.46	1.27	0.45	4.39
T_3: 75% RDF + 2 ml Nano-DAP foliar application @ 45 and 60 DAS	4.14	1.20	0.31	4.25
T_4: 75% RDF + 4 ml Nano-DAP foliar application @ 45 and 60 DAS	4.23	1.22	0.33	4.28
T_5: 50% RDF + 2 ml Nano-DAP foliar application @ 45 and 60 DAS	3.87	1.16	0.26	4.17
T_6: 50% RDF + 4 ml Nano-DAP foliar application @ 45 and 60 DAS	3.92	1.18	0.27	4.19
T_7: RDF (25:50:0 N: P_2O_5: K_2O)	3.88	1.21	0.29	4.23
T_8: Absolute control	2.40	1.09	0.20	3.91
S.Em±	0.40	0.03	0.01	0.12
CD@ 5%	NS	NS	0.03	NS

Note: FYM @ 5 tonnes ha^{-1} & Zinc Sulphate @15kg ha^{-1} for all the treatments except T_8

4. Conclusion
Combined application of a higher dose of fertilizer 100% RDF with foliar spray of Nano-DAP increase soil available N, P_2O_5, K_20 and SO_4 also P_2O_5 antagonistic effect with Zn increase Zn content in soil.

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6. Competing Interests
Authors have declared that no competing interests exist

7. Authors' Contributions
This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

8. References
1. Subbaiah BV, Asija CL. A rapid procedure for the estimation of available nitrogen in soil. Curr Sci. 1956;25:259-260.
2. Jackson ML. Soil Chemical Analysis. New Delhi: Prentice Hall of India Pvt. Ltd.; 1973. p. 498.
3. Lindsay WL, Norvell WA. Development of DTPA soil test for Zn, Fe, Mn, and Cu. Soil Sci Soc Am J. 1978;42:421-428.
4. Gomez KA, Gomez AA. Statistical procedures for agricultural research (2nd ed.). New York: John Wiley and Sons; c1984. p. 680.
5. Mahmoud A, Ebrahim P, Abdali N. Assessing the effects of urea and nano-nitrogen chelate fertilizers on sugarcane yield and dynamic of nitrate in the soil. Soil Sci Plant Nutri. 2020;66(2):352-359.
6. Sankalpa CP. Effect of different levels of nitrogen on micronutrients (Zn, Fe, Mn, and Cu) availability, uptake and yield of paddy in Vertisols of TBP command. M. Sc. (Agri.) Thesis. Univ. Agric. Sci., Raichur; c2013.
7. Mala R, Selvaraj CAR, Sundaram BV, Rajan BSSR, Gurusammy MU. Evaluation of nano structured slow-release fertilizer on the soil fertility, yield and nutritional profile of Vigna radiata. Recent Pat Nanotechnol. 2017;11(1):50-62.
8. Singh MD, Kumar BA. Bio efficacy of nano zinc sulphide (ZnS) on growth and yield of sunflower (*Helianthus annuus* L.) and nutrient status in the soil. Int J Agric Sci. 2017;9(8):0975-3710.
9. Dhansil A, Zalawadia NM, Prajapati BS, Yadav K. Effect of nano phosphatic fertilizer on nutrient content and uptake by Pearl millet (*Pennisetum glaucum* L.) crop. Int J Curr Microbiol Appl Sci. 2018;7(12):2327-2337.
10. Apoorva MR, Rao PC, Padmaja G. Effect of zinc with special reference to nano zinc carrier on yield, nutrient content and uptake by rice (*Oryza sativa* L.). Int J Curr Microbiol App Sci. 2016;6(8):1057-1063.
11. Shivran DR, Ahlawat S. Crop productivity, nutrient uptake, and soil fertility as influenced by cropping system and fertilizers in pigeonpea (*Cajanus cajan*), wheat (*Triticum aestivum*) cropping system. Indian J Agric Sci. 2000;70(12):815-819.
12. Daphade ST, Hanwate GR, Gourkhede PH. Influence of Zn, Fe and B applications on nutrient availability in the soil at critical growth stages of maize (*Zea mays*) in Vertisol of Marathawada region of Maharashtra, India. Int J Curr Microbiol Appl Sci. 2019;8(1):206-12.
13. Devi KN, Singh LNK, Singh MS, Singh SB, Singh KK. Influence of sulphur and boron fertilization on yield, quality, nutrient uptake and economics of soybean (*Glycine max* L.) under upland conditions. J Agric Sci. 2012;4(4):1-18.
14. Poudel A, Singh SK, Jimenez-Ballesta R, Jatav SS, Patra A, Pandey A. Effect of Nano-Phosphorus Formulation on Growth, Yield and Nutritional Quality of Wheat under Semi-Arid Climate. Agronomy. 2023;13(3):768.