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Effect of Foliar Application of Nano DAP on Yield and N, P and K Uptakes and Post Harvest Soil Nutrient Status of Finger Millet

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Authors' contributions

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

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ABSTRACT

The present study aimed to determine the effect of foliar application of Nano DAP on yield and N, P and K uptakes and post-harvest soil nutrient status of finger millet. Finger millet is mostly grown in poor and marginal soils under low to no input supply conditions. Adequate plant nutrient supply is required to explore the full yield potential of improved varieties. Nano DAP application through seedling treatment followed by foliar sprays efficiently meets the crop's need for phosphorus and nitrogen. A field experiment was carried out during *rabi*, 2023-24 at Agricultural Research Station, Vizianagaram. The experiment was laid out in Randomized Complete Block Design with ten

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treatments *viz.,* T_1 : 100 % NPK , T_2 : 100 % NPK + foliar spray of nano DAP at Tillering stage, T_3 : 100 % NPK + foliar spray of nano DAP at PI stage, T_4 : 100 % NPK + foliar spray of nano DAP each at Tillering and PI stage, T_5 : 100 % NK only, T_6 : T_5 + foliar spray of nano DAP each at Tillering and PI stage, T_7 : T_5 + 50 % P + foliar spray of nano DAP each at Tillering and PI stage, T_8 : T_5 + 75 % P + foliar spray of nano DAP each at Tillering and PI stage, T_9 : T_5 + 75 % P + foliar spray of nano DAP at Tillering stage and T_{10} : T_5 + 75 % P + foliar spray of nano DAP at PI stage. Results revealed that 100 % NPK + foliar spray of nano DAP @ 2.5 ml L^{-1} at Tillering and PI stage (T_4) significantly enhanced the grain and straw yield, nitrogen, phosphorus and potassium contents and uptakes of both grain and straw, post-harvest soil available nitrogen, phosphorus and potassium, however, this treatment remained at par with 100 % NK + 75 % P + foliar spray of nano DAP each at Tillering and PI stage (T_8). Hence, 100 % NK + 75 % P + foliar spray of nano DAP each at the Tillering and PI stage (T_8) can be regarded as the best treatment as it saves 25 % of conventional phosphorus fertilizers in addition to environmental safety.

Keywords: Nano DAP; foliar spray; finger millet; nutrient uptake.

1. INTRODUCTION

Nanotechnology is emerging as a transformative tool in agriculture, particularly to overcome challenges such as declining soil fertility, nutrient imbalances and environmental degradation. Conventional fertilizers are often inefficient, with up to 50% of applied nutrients lost through leaching, volatilization, or runoff. This not only reduces crop productivity but also contributes to environmental problems like water pollution. Nanotechnology addresses these issues by delivering nutrients in a more controlled and efficient manner. Nano fertilizers, such as IFFCO's nano DAP, offer a breakthrough solution (Nandeesh et al., 2024). Finger millet (*Eleusine coracana* L. Gaertn) is an important food crop of semi-arid tropics particularly in India and East Africa. It is commonly known as a nutritious millet, as the grain is nutritionally superior to many cereals in providing proteins, minerals, phosphorus, iron, calcium, essential amino acids and vitamins in abundance. Finger millet is a drought-resistant crop and can be adaptable to all types of soils and climatic conditions. Being a C_4 crop it utilizes CO_2 and water very effectively. In India, finger millet is cultivated over an area of 10.37 lakh ha with a total production of about 13.86 lakh tonnes and with productivity of 1336 kg ha^{-1}. Andhra Pradesh produces nearly 0.33 lakh tones of finger millet in an area of 0.27 lakh ha with a productivity of 1222 kg ha^{-1} (Agricultural and Processed Food Products Export Development Authority, 2023-24).

Finger millet is mostly grown in poor and marginal soils under low to no input supply conditions. Adequate plant nutrient supply is required to explore the full yield potential of improved varieties. Phosphorus is the second most important element next to nitrogen and is particularly important for stimulation of the root development, increased stalk and stem strength, improved flower formation, seed production, grain filling and also improved crop quality. However, only 15-30 % of applied fertilizer phosphorus is taken up by crops in the year of its application (Syers et al., 2008) and the remaining P becomes part of the soil P pool, which is subsequently released to the crop over the following months and years (Roberts and Johnston, 2015). The P fertilizer prices are more than doubled in recent years and further increases in prices seem inevitable in the future by considering the non-renewable nature of rock-P resources (Cordell et al., 2009). Hence, increasing the phosphorus use efficiency in agricultural systems is therefore critical for sustainable food and fibre production. Urea and Di-Ammonium phosphate (DAP) are hugely consumed conventional fertilizers in India. In current fertilization practices involving conventional fertilizers, the nutrient use efficiency comprises 30 - 40 % for nitrogen-fertilizers and 18-20 % for phosphorous fertilizers (Tiwari et al., 2022). Nano scale materials can enhance the fertilizer use efficiency while foliar application can meet the crop nutrient requirement effectively as per its need. Whereas, the nano fertilizers are called as nutrient vectors that are developed by using nano scale raw material substrates that are ranging from 1-100 nm which have the ability to manipulate the materials to atom level, molecular and macromolecular scale (Reddy et al., 2024; Soundarya et al., 2024).

Nano DAP application through seedling treatment followed by foliar sprays efficiently meets the crop's need for phosphorus and nitrogen (Al-Khuzai and Al-Juthery, 2020). Foliar-applied nano DAP enters the leaf through stomatal and cuticular pores and increases the phosphorus concentration not only in shoots but also in the roots, which ultimately increases total uptake of phosphorus (Talboys et al., 2020). Applying nano DAP during later growth stages, along with basal phosphorus application, enhances nutrient availability throughout the growing period, leading to improved yield and nutrient uptake. Nano DAP is such fertilizer that supplies two of the primary nutrients (nitrogen and phosphorus) to improve the use efficiencies of both these nutrients. This product has been recently developed by IFFCO Ltd., which is expected to improve crop yields through higher nutrient use efficiency and is also assumed to save conventional fertilizer up to 25 %.

2. MATERIALS AND METHODS

The experiment was conducted at Agricultural Research Station, Vizianagaram, Acharya N.G Ranga Agricultural University, Andhra Pradesh, India, during *rabi*, 2023-2024. The experimental site was located at 180 º 07' N latitude and 83º 26' E longitude, with an altitude of 58.2 m above mean sea level in North Coastal Agroclimatic Zone of Andhra Pradesh. The initial soil analysis showed the texture of the soil was red sandy loam with a pH (1:2.5 in water) of 7.20, EC of 0.53 ds m^{-1}, OC of 0.40 %, available N_2 (201.6 kg ha^{-1}), available P_2O_5 (21.8 kg ha^{-1}) and available K_2O (205.4 kg ha^{-1}).

The field experiment was carried out in a Randomized Complete Block Design (RBD) with three replications in the plot size of 4.5 m * 3.6 m (19.8m^2). The experiment consisted of ten treatments *viz*., T_1 : 100 % NPK, T_2 : 100 % NPK + foliar spray of nano DAP at Tillering stage, T_3 : 100 % NPK + foliar spray of nano DAP at PI stage, T_4 : 100 % NPK + foliar spray of nano DAP each at Tillering and PI stage, T_5 : 100 % NK only, T_6 : T_5 + foliar spray of nano DAP each at Tillering and PI stage, T_7 : T_5 + 50 % P + foliar spray of nano DAP each at Tillering and PI stage, T_8 : T_5 + 75 % P + foliar spray of nano DAP each at Tillering and PI stage, T_9 : T_5 + 75 % P + foliar spray of nano DAP at Tillering stage and T_{10} : T_5 + 75 % P + foliar spray of nano DAP at PI stage. The variety VR 929 developed at the Agricultural Research Station, Vizianagaram was used in this experiment. The sowing of finger millet was done on 1st January, with a spacing of 30 cm x 10 cm, and was harvested during the third week of April. The Recommended Dose of Fertilizer (RDF) for finger millet was 60:40:30 kg N: P_2O_5:K_2O ha^{-1}. Half dose of N and the entire dose of P_2O_5 and K_2O were applied at the time of sowing through urea, di-ammonium phosphate and muriate of potash, respectively. The remaining half dose of N was applied at the tillering stage of the crop. Nano DAP was applied as a foliar spray at tillering and panicle initiation (PI) stages @ 2.5 ml L^{-1}.

Earheads were harvested separately from each plot and sun-dried for four to six days in the threshing yard. After threshing, grains were separated, cleaned and weighed. Straw yield from each plot was recorded after sun drying for 8-10 days. Later the yields per plot were computed on hectare basis and expressed in kg ha^{-1}. After the crop harvest, soil samples were taken from the depth of 0-15 cm from each plot and air-dried before being transferred through a 2 mm sieve. Soil samples were analysed for the determination of available nitrogen (N) by using the Alkaline potassium permanganate method, available phosphorus (P) by Olsen's extractant method, and available potassium (K) by Neutral normal ammonium acetate method. The grain and straw samples of finger millet were collected at the harvesting stage ground in a willey mill and passed through 2 mm sieve. The grounded material was collected in butter paper bags and later used for chemical analysis. Nitrogen and phosphorus were estimated by Micro kjeldhals method and Vanado molybdate phosphoric yellow colour method (Jackson,1973) respectively and potassium were determined by Flame photometer method (Jackson, 1973).

3. RESULTS AND DISCUSSION

3.1 Grain Yield (kg ha^{-1})

The grain yield of finger millet significantly varied among the treatments (Table 1). Among the treatments tested, the highest grain yield (3076 kg ha^{-1}) was recorded with T_4 (100 % NPK + foliar spray of nano DAP each at Tillering and PI stage), however, it was at par with T_8 (100 % NK + 75 % P + foliar spray of nano DAP each at Tillering and PI stage) (2978 kg ha^{-1}), T_3 (100 % NPK + foliar spray of nano DAP at PI stage) (2838 kg ha^{-1}) and T_2 (100 % NPK + foliar spray of nano DAP at Tillering stage) (2785 kg ha^{-1}). The grain yield recorded with T_4, T_8, T_3 and T_2 was 29.79 %, 25.65 %, 19.74 % and 17.51 % higher respectively, as compared to T_1, where 100 % P was applied only as basal through conventional DAP. Among all the treatments, the lowest grain yield was recorded with T_5 (1872 kg ha^{-1}), where no phosphorus was applied.

Phosphorus application as basal through conventional DAP and subsequent foliar applications through nano DAP might have created favourable nutritional environment below ground and above ground throughout the crop period in T_4, T_8, T_3 and T_2, which in turn positively influenced other nutrients absorption from the soil, leading to increased photosynthetic efficiency and higher assimilates production (Choudhary et al., 2019). These results are in line with the findings of Gomaa et al. (2020) in sorghum, Naveen et al. (2021), Deo et al. (2022) in rice and Poudel et al. (2023) in wheat.

3.2 Straw Yield (kg ha^{-1})

The highest straw yield was recorded with T_4 (6481 kg ha^{-1}), however, it remained on par with T_8, T_3, T_2 and T_{10}. Nano fertilizers, being quickly absorbed and easily translocated at a faster rate aided in a higher rate of photosynthesis and more dry matter accumulation which resulted in higher straw yield (Lahari et al.,2021). The lowest straw yield among all the treatments was recorded with T_5 (100 % NK) (4601 kg ha^{-1}), where no phosphorus application was done. Similar findings were reported by Kumar et al. (2020) in rice and Poudel et al. (2023) in wheat.

3.3 Nutrient Content (%) and Uptake (kg ha^{-1}) in Grain

Foliar application of nano DAP significantly enhanced nitrogen content and uptake in grain compared to 100 % NPK alone (T_1). Among all the treatments, T_4 (1.12 % and 34.44 kg ha^{-1}) had the highest grain nitrogen content and uptake, however, it was found on par with T_8 (1.10 % and 32.80 kg ha^{-1}), T_3 (1.08 % and 30.70 kg ha^{-1}) and T_2 (1.07 % and 29.91 kg ha^{-1}). Whereas, T_5 (100 % NK only) (0.83 % and 15.53 kg ha^{-1}), showed the lowest grain nitrogen content and uptake among all the treatments. These research findings are in close agreement with the findings of Kiran (2022) and Tilak (2022). Phosphorus content and uptake in finger millet grain were estimated to be highest with T_4 (0.32 % and 9.87 kg ha^{-1}), however, it was found on par with T_8 (0.29 % and 8.68 kg ha^{-1}), but significantly superior to rest of the treatments. The lowest phosphorus content and uptake (0.09 % and 1.67 kg ha^{-1}) in grain were recorded with T_5, where no phosphorus was applied. These findings were in close agreement with the findings of Pal et al. (2023), Singh et al. (2023), Villagomez et al. (2019) and Poudel et al. (2023) in wheat. Maximum nutrient availability due to the combined application of conventional and nano DAP as basal and foliar applications at later stages followed by quick absorption and rapid translocation increased the absorption of N and P nutrients. Another reason might be that increased availability of phosphorus nutrition to the crop plants throughout the life cycle promoted an efficient root system, which in turn promoted more nutrient uptake from the rhizosphere.

Among various treatments tested, the highest potassium content and uptake in grain were recorded with T_4 (0.48 % and 14.65 kg ha^{-1}), however, it was found on par with T_8 (0.45 % and 13.41 kg ha^{-1}). The lowest grain potassium content and uptake were recorded with T_5 (100 % NK only) (0.32 % and 5.91 kg ha^{-1}). Increased assimilation of nitrogen and phosphorus might have improved the absorption efficiency of the potassium. The proportional increase in potassium uptake alongside higher nitrogen and phosphorus uptake suggests that the plant absorbed these nutrients in correlation with the increased pool of available nutrients and increased dry matter accumulation. These results closely align with studies of Attrai (2023) in rice and Rashmi et al. (2022) in maize.

3.4 Nutrient Content (%) and Uptake (kg ha^{-1}) in Straw

Among the treatments tested, the highest nitrogen content in straw was observed with T_4 (0.64 %), however, it was found on par with T_8 and T_3. Nitrogen uptake in finger millet straw was estimated to be the highest with T_4 (41.5 kg ha^{-1}), however, it was on par with T_8 but significantly superior to the rest of the treatments. Enhanced root biomass and volume in the treatments with higher levels of conventional and nano sources of DAP during the vegetative and reproductive stages improved N and P absorption and translocation to above-ground and below-ground plant parts, resulting in higher nitrogen concentration in straw. The lowest nitrogen content and uptake in straw was observed with T_5, where no phosphorus was applied. These findings closely align with studies of Adhikari et al. (2014), Mallikarjuna (2021) in maize, Deo et al. (2022) in rice and Rajput et al. (2022) in little millet.

Table 1. Grain yield, straw yield, nutrient content (%) and uptake (kg ha^{-1}) in grain of finger millet as influenced by various treatments of nano DAP

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	N		P		K	
			Content (%)	Uptake (kg ha^{-1})	Content (%)	Uptake (kg ha^{-1})	Content (%)	Uptake (kg ha^{-1})
T_1	2370	5314	0.93	21.95	0.16	3.73	0.37	8.76
T_2	2785	6007	1.07	29.91	0.21	5.82	0.43	11.85
T_3	2838	6118	1.08	30.70	0.25	7.04	0.44	12.50
T_4	3076	6481	1.12	34.44	0.32	9.87	0.48	14.65
T_5	1872	4601	0.83	15.53	0.09	1.67	0.32	5.91
T_6	2218	5279	0.88	19.45	0.12	2.61	0.35	7.76
T_7	2354	5492	0.95	22.85	0.16	3.73	0.37	8.57
T_8	2978	6303	1.10	32.80	0.29	8.68	0.45	13.41
T_9	2603	5694	0.96	24.99	0.19	4.88	0.41	10.77
T_{10}	2645	5790	0.99	26.42	0.21	5.48	0.43	11.27
S. Em±	138.2	263.9	0.03	1.86	0.02	0.44	0.02	0.58
CD(P=0.05)	410	783	0.11	5.51	0.19	1.31	0.05	1.73

T_1 : 100 % NPK, T_2 : 100 % NPK + foliar spray of nano DAP at Tillering stage, T_3 : 100 % NPK + foliar spray of nano DAP at PI stage, T_4 : 100 % NPK + foliar spray of nano DAP each at Tillering and PI stage, T_5 : 100 % NK only, T_6 : T_5 + foliar spray of nano DAP each at Tillering and PI stage, T_7 : T_5 + 50 % P + foliar spray of nano DAP each at Tillering and PI stage, T_8 : T_5 + 75 % P + foliar spray of nano DAP each at Tillering and PI stage, T_9 : T_5 + 75 % P + foliar spray of nano DAP at Tillering stage and T_{10} : T_5 + 75 % P + foliar spray of nano DAP at PI stage

Table 2. N, P and K content (%) and uptake (kg ha^{-1}) in finger millet straw as influenced by various treatments of nano DAP

Treatments	N		P		K	
	Content (%)	Uptake (kg ha^{-1})	Content (%)	Uptake (kg ha^{-1})	Content (%)	Uptake (kg ha^{-1})
T_1	0.48	25.46	0.13	7.23	0.44	23.40
T_2	0.54	32.59	0.17	10.28	0.61	36.70
T_3	0.57	34.88	0.20	12.03	0.62	38.23
T_4	0.64	41.52	0.22	14.41	0.65	41.83
T_5	0.41	18.81	0.08	3.55	0.36	16.63
T_6	0.44	23.15	0.11	5.99	0.42	22.44
T_7	0.48	26.65	0.14	7.87	0.45	24.87
T_8	0.58	36.69	0.20	12.79	0.62	39.12
T_9	0.49	27.71	0.15	8.77	0.56	32.08
T_{10}	0.51	29.49	0.16	9.19	0.57	32.83

Treatments	N		P		K	
	Content (%)	Uptake (kg ha^{-1})	Content (%)	Uptake (kg ha^{-1})	Content (%)	Uptake (kg ha^{-1})
S. Em±	0.02	1.83	0.01	0.81	0.03	2.44
CD (P=0.05)	0.06	5.43	0.03	2.41	0.09	7.26

T_1 : 100 % NPK, T_2 : 100 % NPK + foliar spray of nano DAP at Tillering stage, T_3 : 100 % NPK + foliar spray of nano DAP at PI stage, T_4 : 100 % NPK + foliar spray of nano DAP each at Tillering and PI stage, T_5 : 100 % NK only, T_6 : T_5 + foliar spray of nano DAP each at Tillering and PI stage, T_7 : T_5 + 50 % P + foliar spray of nano DAP each at Tillering and PI stage, T_8 : T_5 + 75 % P + foliar spray of nano DAP each at Tillering and PI stage, T_9 : T_5 + 75 % P + foliar spray of nano DAP at Tillering stage and T_{10} : T_5 + 75 % P + foliar spray of nano DAP at PI stage

Table 3. Available N_2, P_2O_5 and K_2O status (kg ha^{-1}) of the soil after harvest of finger millet as influenced by various treatments of nano DAP

Treatments	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T_1	195.67	21.43	212.87
T_2	202.88	23.96	215.52
T_3	203.77	25.20	207.94
T_4	214.80	28.44	216.13
T_5	170.13	14.62	186.75
T_6	177.45	17.34	174.71
T_7	182.52	18.88	185.89
T_8	200.97	26.59	206.02
T_9	189.60	23.17	187.97
T_{10}	186.45	21.88	185.57
S. Em±	8.30	1.19	9.30
CD (P=0.05)	24.67	3.55	27.63

T_1 : 100 % NPK, T_2 : 100 % NPK + foliar spray of nano DAP at Tillering stage, T_3 : 100 % NPK + foliar spray of nano DAP at PI stage, T_4 : 100 % NPK + foliar spray of nano DAP each at Tillering and PI stage, T_5 : 100 % NK only , T_6 : T_5 + foliar spray of nano DAP each at Tillering and PI stage, T_7 : T_5 + 50 % P + foliar spray of nano DAP each at Tillering and PI stage, T_8 : T_5 + 75 % P + foliar spray of nano DAP each at Tillering and PI stage, T_9 : T_5 + 75 % P + foliar spray of nano DAP at Tillering stage and T_{10} : T_5 + 75 % P + foliar spray of nano DAP at PI stage

The treatments, which include foliar applications of nano DAP along with basal application of conventional DAP (T_4, T_8, T_3, T_2, T_{10}, T_9 and T_7) showed higher phosphorus content in straw as compared to 100 % P application as basal through conventional DAP (T_1). Among all treatments, the lowest phosphorus content in straw was recorded in T_5 (0.08 %), whereas the highest phosphorus content in straw was recorded in T_4 (0.22%). Phosphorus uptake in finger millet straw was highest with T_4 (14.41 kg ha^{-1}), but was found on par with T_8 (12.79 kg ha^{-1}) and T_3 (12.03 kg ha^{-1}). The lowest phosphorus uptake of straw was recorded with control T_5 (100 % NK only) (3.55 kg ha^{-1}). Lower phosphorus content in T_1 as compared to T_4, T_8 and T_3 might be attributed to the phosphorus fixation into insoluble complexes or root uptake by the plants. However, foliar sprays given in the later stages in T_4, T_8 and T_3 would have some favorable effects on root zone phosphorus availability and its uptake. These research findings are in close agreement with the findings of Kiran (2022) in paddy and Tilak (2022) in maize.

Among the treatments, T_4 (0.65 % and 41.83 kg ha^{-1}) had the highest potassium content and uptake of straw and it was found on par with T_8 (0.62 % and 39.12 kg ha^{-1}), T_3 (0.62 % and 38.23 kg ha^{-1}) and T_2 (0.61 % and 36.70 kg ha^{-1}). These results were in close agreement with the findings of Lahari et al. (2021) in rice and Patil et al. (2020) in wheat.

3.5 Soil Available Nutrient Status After Harvest

Soil-available nitrogen, phosphorus and potassium after harvest of the crop were significantly influenced by various treatments of nano DAP. Among the various treatments, the highest soil available nitrogen was recorded in T_4 (214.80 kg ha^{-1}), which was significantly superior over other treatments except T_3, T_2, T_8 and T_1. The lowest soil available nitrogen (170.13 kg ha^{-1}) was recorded with T_5. Prakash et al. (2023) reported similar results in soybeans.

Soil available phosphorus after harvest of finger millet varied significantly with various treatments. Analysis of the data on post-harvest soil available phosphorus showed that the maximum available phosphorus was recorded with T_4 (28.44 kg ha^{-1}). However, it was found at par with T_8 (26.59 kg ha^{-1}) and T_3 (25.20 kg ha^{-1}). The lowest post-harvest soil available phosphorus was registered with T_5 (14.62 kg ha^{-1}), where no phosphorus was applied. Application of phosphorus through conventional DAP and nano DAP at various growth stages of the crop might create favourable environment below ground and above ground, which in turn influences the soil available phosphorus. These results are in close conformity with the findings of Chinnappa et al. (2023) in sorghum and Poudel et al. (2023) in wheat.

Soil available potassium after harvest of finger millet varied significantly with various treatments of nano DAP. Data pertaining to available potassium after harvest of finger millet revealed that the highest available potassium was recorded with T_4 (216.13 kg ha^{-1}) which was statistically on par with T_2, T_1, T_3 and T_8. The lowest post-harvest soil available potassium was recorded with T_6 and T_5. Nano fertilizers raise the concentration of nutrients in soil solution, resulting in higher osmotic potential and a little reduction in nutrient uptake, therefore higher nutrient retention in soil after harvest of the crop (Hasaneen et al., 2016).

4. CONCLUSION

Grain yield, straw yield, nitrogen, phosphorus, and potassium contents and uptakes in finger millet grain and straw were considerably enhanced with 100% NPK + foliar spray of nano DAP @ 2.5 ml L^{-1} during the Tillering and PI stage (T_4), however, it remained on par with 100% NK + 75% P + foliar spray of nano @ 2.5 ml L^{-1} during the Tillering and PI stage (T_8). The analysis of post-harvest soil available nutrient data revealed that, of all the treatments, 100% NPK + foliar spray of nano DAP @ 2.5 ml L^{-1} at Tillering and PI stage (T_4) and 100% NK + 75% P + foliar spray of nano DAP each at Tillering and PI stage (T_8) had the highest levels of soil available nitrogen, phosphorus and potassium. Hence, 100 % NK + 75 % P + foliar spray of nano DAP each at Tillering and PI stage (T_8) can be regarded as the best treatment as it saves 25 % of conventional phosphorus fertilizers in addition to the environmental safety.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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