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RESEARCH PAPER

Studies on seed dressing and foliar application of Nano-DAP fertilizer on performance of Maize (*Zea mays* L.)

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Abstract: A field experiment was conducted at AICRP on Maize, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka during *kharif* 2022-23 on clay soil to know the effect of seed dressing and foliar application of Nano-DAP fertilizer on performance of maize (*Zea mays* L.)". The results showed that application of 75% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ two foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS, recorded significantly higher cob length, cob diameter, test weight, number of kernel rows per cob, number of kernels per row, number of kernels per cob and grain weight per cob (18.8 cm, 5.1 cm, 27.88 g, 15.67, 33.13, 519.15 and 133.80 g respectively). Further it also recorded significantly higher grain yield (78.20 q ha^{-1}), stover yield (94.85 q ha^{-1}) and higher gross returns (₹ 1,53,822 ha^{-1}), net returns (₹ 93,766 ha^{-1}) and B:C ratio (2.56). How ever, it was found on par with the application of 75% RDP + no seed dressing of Nano-DAP + two foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS.

Key words: Foliar application, Maize, Nano-DAP, Seed dressing

Introduction

Maize (*Zea mays* L.), commonly known as the "Queen of Cereals," is a versatile and globally important cereal crop cultivated in over 130 countries. It serves multiple purposes including food, feed, fodder and raw material for a wide range of industrial products such as ethanol, starch, oil, protein, alcoholic beverages, food sweeteners, livestock feed, biofuel, bioplastics, pharmaceutical, cosmetic, film, textile, gum, package and paper industries *etc*. (Arvaidiya *et al*., 2012). Globally, maize was cultivated on area of 206.26 million hectares and production of 1210.2 million tons. Maize ranks the most widely produced cereal globally and third in consumption after rice and wheat. In India, maize is the third most significant cereal crop after rice and wheat, covering 10.74 million hectares with a production of 38.09 million tons (Anon, 2022).

Maize is a nutrient-exhaustive crop, and effective nutrient management plays a crucial role in enhancing its productivity and sustainability. In general, a balanced application of 150:65:65 kg of N, P_2O_5 and K_2O $ha^{-1}$is recommended for irrigated maize in Northern transition zone of Karnataka. Nutrient management is a key component in achieving higher yield. Recently, high-yielding modern single cross maize hybrids have been shown to accumulate more biomass and respond better to fertilizers. This, combined with increased photosynthetic capacity, has been linked to increased grain yield and nitrogen use efficiency. Fertilizer use efficiency is a complex trait, which is associated with various morphological, physiological, molecular and biochemical changes in plants throughout the life cycle. Further for a clear understanding of this complex nature, studies of various traits and their close correlation with one or more economically important traits like grain yield is foremost critical (Datturam., 2021).

Traditional chemical fertilizers, though effective short-term, have led to soil degradation and environmental issues. Modern approaches such as foliar nutrient application and nano-fertilizers offer promising alternatives. Nano-fertilizers, due to their high efficiency, controlled release, and minimal environmental impact, can significantly enhance nutrient use efficiency and crop yields (Iyarin and Aravinda Kumar, 2019). Development and manufacture of nano-DAP from Indian Farmers Fertilizer Cooperative (IFFCO's) provides nitrogen and phosphorus in nanoscale form, highlight the shift towards sustainable agriculture aimed at improving soil health, reducing fertilizer usage and increasing farmers' income (Adarsh *et al*., 2023).

Material and methods

A field study was conducted during *kharif* 2022 at AICRP on maize, at main Agricultural Research Station, UAS, Dharwad. Soil type was clay soil.The mean annual rainfall received during 2022 was 1104.0 mm distributed in 76 rainy days. The rainfall received during crop growth period (July - November) was 1100.8 mm. The climatic conditions were favourable for the crop growth and development during the *kharif* 2022. There were ten treatments laid out in randomized complete block design (RBD) with three replications. Maize was sown on 21 June, 2022 with the spacing of 60 cm x 20 cm using seed rate of 25 kg ha^{-1}. The treatments were T_1:Application of 75% RDP + no seed dressing + one foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS, T_2: Application of 75% RDP + no seed dressing + two foliar sprays of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS, T_3:Application of 50% RDP + no seed dressing + one foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS, T_4:Application of 50% RDP + no seed dressing + two foliar sprays of Nano-DAP @ 2.0 ml l^{-}

Table 1. Grain yield, stover yield gross returns, net returns and B:C of maize as influenced by seed dressing and foliar application of Nano-DAP

Treatments	Grain yield	Stover yield	Gross returns	Net returns	B:C
	(q ha^{-1})	(q ha^{-1})	(₹ ha^{-1})	(₹ ha^{-1})	
T_1	71.96^{d}	87.30^{d}	141549^{d}	83330^{d}	2.43^{c}
T_2	76.71^{ab}	92.96^{ab}	150885^{ab}	90933^{ab}	2.52^{ab}
T_3	62.98^{fg}	76.46^{fg}	123889^{fg}	67192^{fg}	2.19^{f}
T_4	67.47^{e}	82.05^{e}	132732^{e}	74321^{e}	2.27^{de}
T_5	73.50^{cd}	88.98^{cd}	144563^{cd}	86236^{cd}	2.48^{bc}
T_6	78.20^{a}	94.85^{a}	153822^{a}	93766^{a}	2.56^{a}
T_7	64.31^{f}	78.36^{f}	126528^{f}	69738^{f}	2.23^{ef}
T_8	68.95^{e}	83.61^{e}	135625^{e}	77110^{e}	2.31^{d}
T_9	75.01^{bc}	90.98^{bc}	147547^{bc}	89610^{bc}	2.54^{ab}
T_{10}	59.60^{g}	72.97^{g}	117290^{h}	61618^{g}	2.11^{g}
S.Em±	0.99	1.13	1837	1381	0.03

^{1} at 25-30 DAS and 45-50 DAS, T_5:Application of 75% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ one foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS, T_6: Application of 75% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ two foliar sprays of Nano-DAP @ 2.0 ml l^{-1}at 25-30 DAS and 45-50 DAS, T_7:Application of 50% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ one foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS, T_8: Application of 50% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ two foliar sprays of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS, T_9:Application of 100% RDP through commercial DAP, T_{10}: Application of only two foliar spray of Nano-DAP @ 2ml l^{-1}.

Recommended nitrogen, potassium, zinc, and iron were applied at 150kg, 65, 65kg,15kg and 15 kgha^{-1}respectively) uniformly for all the treatments and phosphorous was applied in 100 per cent (65kg P_2O_5ha^{-1}), 75 per cent (48.75 kg P_2O_5ha^{-1}) and 50 per cent (32.50kg P_2O_5 ha^{-1}) RDP as per treatments.For seed dressing with Nano-DAP@ 0.5 per cent, the maize seeds were spread uniformly and thoroughly mixed with Nano- DAP @5ml kg^{-1} of seeds and shade dried for 30 minutes. Spray solution of 500 l ha^{-1} for foliar nutrition treatments. The variety used for the study was DKC 9133.

Results and discussion

Effect of seed dressing and foliar application of Nano-DAP on yield and quality of maize

The grain yield is an important parameter which is the integration of various biological events involving physiological, morphological and biochemical changes that take place during its development by using water, light, nutrients and temperature. The results indicated that, among the treatments application of 75% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ two foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS, recorded significantly higher length of the cob, diameter of the cob, test weight, number of kernel rows per cob, number of kernels per row, number of kernels per cob and grain weight per cob (18.8 cm, 5.1 cm, 27.88 g, 15.67, 33.13, 519.15 and 133.80 g respectively), grain yield (78.20 q ha^{-1}), stover yield (94.85qha^{-1}) and higher gross returns (₹ 1,53,822 ha^{-1}), net returns (₹ 93,766 ha^{-1}) and B:C ratio (2.56). Whereas, it was found on par with the application of 75% RDP + no seed dressing of Nano-DAP @ 5 ml kg^{-1}+ two foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS.

Yield parameters *viz*., length of the cob, diameter of the cob, test weight, number of kernel rows per cob, number of kernels per row, number of kernels per cob and grain weight per cob were significantly higher with application of 75% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ two foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS (18.8 cm, 5.1 cm, 27.88 g, 15.67, 33.13, 519.15 and 133.80 g respectively) (T6) as compared to other treatments and it was on par with application of 75% RDP + No seed dressing + Two foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS (18.4 cm, 5.0 cm, 27.37 g, 15.35, 32.44, 497.95 and 130.45 g respectively) (T2). Whereas application of two foliar sprays of Nano-DAP @ 2.0 ml l^{-1} (13.9 cm, 3.7 cm, 22.58 g, 11.72, 25.10, 294.17 and 97.57 g respectively) (T10) resulted in lower yield parameters compared to other treatments.

The observed improvements in yield parameters were attributed to enhanced phosphorus availability as phosphorus plays a vital role in ATP synthesis and energy production thus

Table 2. Cob length, cob diameter and test weight, Number of grain rows per cob, number of grains per rows, number of grains per cob and grains weight per cob of maize as influenced by seed dressing and foliar application of Nano-DAP

Treatment	Cob length (cm)	Cob diameter (cm)	Test weight (g)	Number of grain rows per cob	Number of grain per rows	Number of grains per cob	Grain weight per cob (g)
T_1	17.0^{d}	4.6^{d}	25.84^{c-e}	14.34^{c}	30.68^{c}	439.95^{c}	123.45^{c}
T_2	18.3^{ab}	5.0^{ab}	27.37^{ab}	15.35^{ab}	32.44^{ab}	497.95^{ab}	130.45^{ab}
T_3	14.6^{fg}	3.8^{fg}	23.39^{gh}	12.21^{fg}	26.30^{ef}	321.12^{f}	103.57^{ef}
T_4	15.8^{e}	4.2^{e}	24.63^{e-g}	13.27^{de}	28.34^{d}	376.07^{de}	113.51^{d}
T_5	17.5^{cd}	4.7^{cd}	26.35^{b-d}	14.62^{bc}	31.07^{bc}	454.24^{c}	123.77^{c}
T_6	18.8^{a}	5.1^{a}	27.88^{a}	15.67^{a}	33.13^{a}	519.15^{a}	133.80^{a}
T_7	15.1^{f}	3.9^{f}	23.91^{f-h}	12.57^{ef}	26.98^{e}	339.14^{ef}	106.90^{e}
T_8	16.3^{e}	4.3^{e}	25.14^{d-f}	13.62^{d}	29.02^{d}	395.25^{d}	116.83^{d}
T_9	17.9^{bc}	4.8^{bc}	26.90^{a-c}	14.97^{a-c}	31.75^{abc}	475.62^{bc}	127.11^{bc}
T_{10}	13.9^{g}	3.7^{g}	22.58^{h}	11.72^{g}	25.10^{f}	294.17^{f}	97.57^{f}
S.Em±	0.26	0.09	0.41	0.24	0.45	13.25	1.90

efficient translocation of photosynthates during the tasselling and silking stage facilitating the timely supply of nitrogen and phosphorus through a combination of conventional DAP and Nano DAP fertilizer to crop and also Nano-DAP as seed dressing at sowing and foliar spray during reproductive stages led to increased photosynthate production and enhanced the translocation of these photosynthates for grain development. As a result, the plant intensifies its photosynthetic activity by generating higher sugars and starch. Subsequently, these valuable resources are efficiently transported to the developing grains through translocation processes and augmented photosynthetic assimilation and translocation processes, resulting in increased grain formation and improvement in test weight. Consequently, this increased food conversion, resulted in complete filling grains and higher test weight, ultimately led to a higher length of the cob, diameter of the cob, test weight, number of kernel rows per cob, number of kernels per row, number of kernels per cob and grain weight per cob. The results are in consonance with the earlier findings of Al-Zreejawi *et al* and Al Juthery (2020), Ajithkumar *et al*. (2021) and Poudel *et al*. (2023).

Among the various treatments higher grain yield (78.20 qha^{-1}) and stover yield (94.85 qha^{-1}) recorded with application of 75% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ two foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS (T2) as compared to other treatments and which was on par with application of 75% RDP + No seed dressing + Two foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS (76.71 q ha^{-1}and 92.96 q ha^{-1}, grain and stover yield respectively). (T2) Whereas application two foliar sprays of Nano-DAP @ 2.0 ml l^{-1} recorded lower grain yield (59.60 q ha^{-1}) and stover yield (72.97 q ha^{-1}) (T10).

Quality of maize grain

Grain protein and starch content differed significantly (Table.3). It was observed that among all the treatments; significantly higher starch content was recorded with (T6) seed dressing with 5% nano-DAP +75% of RDP + two spray at 25-30 DAS and 45-50 DAS (78.25%) which was on par with the treatment (T2) no seed dressing +75% of RDP + two spray at 25-30 DAS and 45-50 DAS (76.33%). Whereas significantly lower starch content (58.55%) was recorded with control (T10). Similarly, significantly higher protein content was recorded with (T6) seed dressing with 5% nano-DAP +75% of RDP + two spray at 25-30 DAS and 45-50 DAS (9.85%) which was on par with the treatment (T2) no seed dressing +75% of RDP + two spray at 25-30 DAS and 45-50 DAS (9.69%) due to better uptake of nitrogen.

Iron uptake was significantly higher with application of 75 % RDP + seed dressing of Nano-DAP @ 5 ml kg^{-1} + two foliar sprays of Nano-DAP @ 2 ml l^{-1} at 25-30 DAS and 45-50 DAS (T_6) (4800 g ha^{-1}) which was on par with the application of 75% RDP + no seed dressing + two foliar sprays of Nano-DAP @ 2 ml l^{-1} at 25-30 DAS and 45-50 DAS (T_2) (4813 g ha^{-1}). Whereas significantly lower iron uptake by plant (4127 g ha^{-1}) was recorded with application of two foliar sprays of Nano-DAP @ 2 ml l^{-1}(T_{10}). Similarly Zinc uptake was significantly higher with application of 75% RDP + seed dressing of Nano-DAP @ 5 ml kg^{-1} + two foliar sprays of Nano-DAP @ 2 ml l^{-1} at 25-30 DAS and 45-50 DAS (T_6) (2986 g ha^{-1}) which was on par with the application of 75% RDP + no seed dressing + two foliar sprays of Nano-DAP @ 2 ml l^{-1} at 25-30 DAS and 45-50 DAS (T_2) (2924 g ha^{-1}). Lower zinc uptake by plant (2306 g ha^{-1}) was recorded with application of two foliar sprays of Nano-DAP @ 2 ml l^{-1}

Table 3. Protein, starch, iron and zinc uptake of maize as influenced by seed dressing and foliar application of Nano-DAP at harvest

Treatment		Protein content (%)	Starch content (%)	Fe uptake (g ha^{-1})	Zn uptake (g ha^{-1})
T_1	Application of 75% RDP + no seed dressing + one foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS	9.20^{d}	70.56^{d}	4611^{d}	2725^{d}
T_2	Application of 75% RDP + no seed dressing + two foliar sprays of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS.	9.69^{ab}	76.33^{ab}	4813^{ab}	2924^{ab}
T_3	Application of 50% RDP + no seed dressing + one foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS.	8.40^{gh}	60.8^{gh}	4247^{fg}	2442^{fg}
T_4	Application of 50% RDP + no seed dressing + two foliar sprays of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS.	8.82^{ef}	65.52^{ef}	4434^{e}	2577^{e}
T_5	Application of 75% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ one foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS.	9.36^{cd}	72.48^{cd}	4678^{cd}	2784^{cd}
T_6	Application of 75% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ two foliar sprays of Nano-DAP @ 2.0 ml l^{-1}at 25-30 DAS and 45-50 DAS.	9.85^{a}	78.25^{a}	4880^{a}	2986^{a}
T_7	Application of 50% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ one foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS.	8.57^{fg}	62.72^{fg}	4314^{f}	2504^{f}
T_8	Application of 50% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ two foliar sprays of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS.	8.98^{e}	67.44^{e}	4501^{e}	2637^{e}
T_9	Application of 100% RDP through commercial DAP	9.53^{bc}	74.40^{bc}	4745^{bc}	2853^{bc}
T_{10}	Application of two foliar spray of Nano-DAP @ 2ml/l	8.10^{h}	58.85^{h}	4127^{g}	2306^{g}
	S.Em±	0.11	1.02	44	30

Note: Means followed by the same alphabet (s) in a column do not differ significantly by DMRT (P=0.05). DAS - days after sowing, RDP- Recommended doses of phosphorus, DAP- Di-Ammonium Phosphate.

Table 4. Nitrogen, phosphorus and potassium uptake of maize as influenced by seed dressing and foliar application of Nano-DAP at harvest

Treatment		Nuptake (kg ha^{-1})	P_2O_5 uptake (kg ha^{-1})	K_2Ouptake (kg ha^{-1})
T_1	Application of 75% RDP + no seed dressing + one foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS.	167.82^{d}	68.29^{d}	125.90^{d}
T_2	Application of 75% RDP + no seed dressing + two foliar sprays of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS.	181.95^{ab}	76.10^{ab}	143.13^{ab}
T_3	Application of 50% RDP + no seed dressing + one foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS.	139.61^{fg}	52.76^{fg}	91.66^{fg}
T_4	Application of 50% RDP + no seed dressing + two foliar sprays . of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS	153.72^{e}	60.53^{e}	108.75^{e}
T_5	Application of 75% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ one foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS.	172.54^{cd}	70.88^{cd}	131.60^{cd}
T_6	Application of 75% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ two foliar sprays of Nano-DAP @ 2.0 ml l^{-1}at 25-30 DAS and 45-50 DAS.	186.67^{a}	78.70^{a}	148.90^{a}
T_7	Application of 50% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ one foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS.	144.32^{f}	55.35^{f}	97.37^{f}
T_8	Application of 50% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ two foliar sprays of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS.	158.41^{e}	63.12^{e}	114.48^{e}
T_9	Application of 100% RDP through commercial DAP	177.24^{bc}	73.48^{bc}	137.35^{bc}
T_{10}	Application of two foliar spray of Nano-DAP @ 2ml/l	132.70^{g}	50.15^{g}	83.29^{g}
	S.Em±	3.13	1.72	3.80

Note: Means followed by the same alphabet (s) in a column do not differ significantly by DMRT (P=0.05). DAS - days after sowing, RDP- Recommended doses of phosphorus, DAP- Di-Ammonium Phosphate.

(T_{10}). Mallikarjuna (2021) studied the effect of nano nitrogen and nano zinc nutrition on economics of irrigated maize and noticed higher micronutrient content in maize.

Effect of seed dressing and foliar application of Nano-DAP on economics of maize

Economic returns serve as an indicator of the profitability of a given system. Any enhancement in crop performance through agronomic practices need to be assessed in relation to the expenses associated with their application. This evaluation is crucial for the integration of the technology into the existing practices of farmers. Farmers tend to embrace approaches that offer higher profitability. It's important to note that the costs and revenues related to inputs and agricultural products vary over different periods and locations. As a result, the profitability of management system in crop production also adjusts accordingly. The findings of the economic analysis are discussed here. The higher grain yield resulted in significant higher gross returns (₹ 1,53,822 ha^{-1}), net returns (₹ 93,766 ha^{-1}) and B:C ratio (2.56) were recorded with the application of 75% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ two foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS (T6) and was on par with application of 75% RDP + No seed dressing + Two foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS (T2) recorded with gross returns (₹ 1,50,885 ha^{-1}), net returns (₹ 90,933 ha^{-1}) and B:C ratio (2.52). Whereas significantly lower gross returns (₹ 1,17,290 ha^{-1}), net returns (₹ 61,618 ha^{-1}) and B:C ratio (2.11) were recorded with application two foliar sprays of Nano-DAP @ 2.0 ml l^{-1} (T10) This might be due to higher grain and stover yield. The variations in net returns among different treatments which represent the total income generated, and the cultivation costs associated with each treatment was due to the variation in yield of maize. Similar results were reported by Sachin (2023).

Effect of seed dressing and foliar application of Nano-DAP on nutrient uptake of maize

Nutrient uptake is the vital process through which living organisms absorb essential nutrients from their surroundings to sustain life and maintain optimal plant health. The nutrient uptake is a product of dry biomass to that of content.

Among all the treatments significantly higher nutrient uptake by plant was recorded with application of 75% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ two foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS (T_6) (N, P, K, Fe and Zn at harvest 186.67 , 78.70, 148.90 , 4880 and 2986 g ha^{-1}, respectively) and was on par with application of 75% RDP + No seed dressing + Two foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS (T_2) (N, P K, Fe and Zn at harvest 181.95, 76.10, 143.13, 4813 and 2924 g ha^{-1} , respectively) as compared to all other treatments (Table 4). This might be due to soil application of commercial DAP and seed dressing of Nano-DAP before sowing enhanced nutrient absorption of initially available soil phosphorus and resulted in a significant increase in root biomass and volume and led to improved N and P absorption and translocation to above-ground plant parts. Thus resulted in higher dry matter accumulation. Additionally, when Nano DAP was applied via foliar application at both the vegetative and reproductive stages, there was further improvement in nitrogen and phosphorus translocation to economic plant parts. This enhanced effectiveness of Nano fertilizers, such as their larger surface area and smaller particle size, which allowed them to easily penetrate into root and leaf pores. Thus facilitated better nutrient uptake from the applied surfaces. The findings of these results closely align with studies of Adhikari *et al*. (2014) and Hena *et al*. (2022).

Table 5. Soil properties of soil as influenced by seed dressing and foliar application of Nano-DAP after harvest of maize.

	Treatment	pH	EC (dS m^{-1})	OC (%)	Avail N (kg ha^{-1})	Avail P_2O_5 (kg ha^{-1})	Avail K_2O (kg ha^{-1})
T_1	Application of 75% RDP + no seed dressing + one foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS.	7.72^{a}	0.32^{a}	0.47^{a}	228.4^{de}	28.7^{c}	328.7^{de}
T_2	Application of 75% RDP + no seed dressing + two foliar sprays of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS.	7.67^{a}	0.33^{a}	0.46^{a}	218.4^{fg}	31.9^{b}	319.1^{fg}
T_3	Application of 50% RDP + no seed dressing + one foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS	7.71^{a}	0.31^{a}	0.48^{a}	247.5^{a}	24.1^{ef}	349.5^{a}
T_4	Application of 50% RDP + no seed dressing + two foliar sprays of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS.	7.69^{a}	0.31^{a}	0.46^{a}	237.8^{bc}	25.4^{de}	340.5^{bc}
T_5	Application of 75% RDP + seed dressing of Nano-DAP 5ml kg^{-1}+ one foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS.	7.74^{a}	0.32^{a}	0.48^{a}	225.1^{ef}	29.9^{c}	325.6^{ef}
T_6	Application of 75% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ two foliar sprays of Nano-DAP @ 2.0 ml l^{-1}at 25-30 DAS and 45-50 DAS.	7.71^{a}	0.33^{a}	0.47^{a}	215.1^{g}	33.1^{ab}	316.2^{g}
T_7	Application of 50% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ one foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS.	7.67^{a}	0.31^{a}	0.47^{a}	244.2^{ab}	22.9^{fg}	346.4^{ab}
T_8	Application of 50% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ two foliar sprays of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS.	7.65^{a}	0.31^{a}	0.46^{a}	234.4^{cd}	26.6^{d}	334.5^{cd}
T_9	Application of 100% RDP through commercial DAP	7.71^{a}	0.32^{a}	0.47^{a}	221.8^{e-g}	34.3^{a}	322.5^{e-g}
T_{10}	Application of two foliar spray of Nano-DAP @ 2ml/l	7.73^{a}	0.30^{a}	0.47^{a}			
	S.Em±	0.12	0.01	0.01			

Effect of seed dressing and foliar application of Nano-DAP on Soil properties of maize

The application of different rates of commercial and Nano DAP did not result in significant variations in soil reaction (pH), electrical conductivity (EC), and organic carbon (OC) (Table 5).

Application of 75% RDP + seed dressing of Nano-DAP @ 5ml kg^{-1}+ two foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS (T_6) recorded lower amount of available nutrients (N, K, Fe and Zn at harvest 215.15, 316.29, 4.72 and 0.49 kg ha^{-1} , respectively) and was on par with application of 75 % RDP + No seed dressing + Two foliar spray of Nano-DAP @ 2.0 ml l^{-1} at 25-30 DAS and 45-50 DAS (T_2) (N, K, Fe and Zn at harvest 218.48,319.19, 4.88 and 0.54 kg ha^{-1}, respectively). It was due to more uptake of applied N, K, Fe and Zn and led to lower availability in soil after harvest. It has mainly due to synergistic effects in uptake between N and K. More availability of P (34.34 kg ha^{-1}) in with application of 100% RDP through commercial DAP was due to application of 100% phosphorous to the soil as a basal dose. It was less available to the plants due to fixation in soil. However, the higher availability of N, K, Fe and Zn in the soil showed lower uptake in two foliar spray of Nano-DAP (N, P K, Fe and Zn at harvest 250.90, 36.34, 352.67, 6.35 and 0.98 kg ha^{-1}, respectively) as compared to all other treatments. Similar results were reported by Hena *et al*. (2022) and Sachin (2023).

Conclusion

Application of 75% of recommended doses of phosphorous with seed dressing of 5 ml/kg Nano-DAP and two foliar sprays of Nano-DAP @ 2ml l^{-1} of water at 25-30 DAS and 45-50 DAS recorded significantly higher grain yield (78.20 q ha^{-1}), stover yield (94.85 q ha^{-1}), net returns (₹ 93766ha^{-1}) and benefit-cost ratio (2.56) indicating saving of 25 per cent of commercial DAP by two foliar spray of NanoDAPas compared to all the treatments. Further there was improvement in starch, protein, zinc and iron content in maize grain with seed dressing and foliar nutrition of Nano-DAP.

References

Adarsh V, Parida B, Balo S, Choudhury R K and Mukhopadhyay D, 2023, Nano-DAP: An implementation of nano science and technology in agriculture to secure a better fertilizer utilization and sustainable intensification in a Smart Way. *Current Trends and Advances in Agricultural Sciences*, 27.

Adhikari T, Kundu S, Meena V and Subba Rao A, 2014, Utilization of nano rock phosphate by maize (*Zea mays* L.) crop in a vertisol of central India. *Journal of Agricultural Sciences and Technology*, 4(5): 383-394.

Ajithkumar K, Kumar Y, Savitha A S, Ajayakumar M Y, Narayanaswamy C, Ramesh Raliya, 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. International *Journal of Plant and Soil Sciences*, 33(16): 19-28.

Al-Zreejawi, Safa Abd Ameer and Al-Juthery H, 2020, Effect of Spray with Nano NPK, complete micro fertilizers and nano amino acids on some growth and yield indicators of maize (*Zea mays* L.). *Earth and Environmental Science*. pp 553.

Anonymous, 2022, Annual report, Indian Institute of Maize research, New Delhi.

Arvaidiya L K, Raj V C, Patel T U and Arvadia M K, 2012, Influence of plant population and weed management on weed flora and productivity of sweet corn (*Zea mays* L.). *Indian Journal of Agronomy*, 57 (2): 162-167.

Datturam, 2021, Need-based nitrogen management using leaf colour chart in sweet corn genotypes (*Zea mays* L. saccharata). M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad, India.

Iyarin T M, Aravinda kumar B N, 2019, Foliar application of nanofertilizers in agricultural crops. *Journal of Farm Sciences*, 32(3): (239-249)

Hena R D, Chandrasekhar T, Srivatav L K, Nag N K and Akash T, 2022, Effect of nano-DAP on yield, nutrient uptake and nutrient use efficiency by rice under Bastar plateau. *Pharma Innovation Journal*, 11(9): 1463-1465.

Mallikarjuna P R, 2021, Effect of nano nitrogen and nano zinc nutrition on nutrient uptake, growth and yield of irrigated maize during summer in the southern transition zone of Karnataka. *M. Sc.* (*Agri.*) *Thesis,* University of Agricultural Sciences, Shivmogga.

Poudel A, Singh S K, Jimenez-Ballesta R, Jatav S S, Patra A and Pandey A, 2023, Effect of nano-phosphorus formulation on growth, yield and nutritional quality of wheat under semi-arid climate. *Agronomy*, 13(3): 768.

Sachin M L, 2023, Effect of conventional and nano DAP on growth and yield of maize (*Zea mays* L.). M.Sc. (Agri.) Thesis, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India.