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INFLUENCE OF NANO UREA AND NANO DAP ON NUTRIENT UPTAKE IN RABI MAIZE UNDER IRRIGATED CONDITIONS

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ABSTRACT

A field investigation was carried out at experimental Block, College of Agriculture, Bheemaranagudi, University of Agricultural Sciences, Raichur during *rabi* season of 2024-25 to study the influence of nano urea and nano DAP on nutrient uptake in *rabi* maize grown under irrigated conditions. The experiment consists of nine treatments with different combination of fertilizer and nano formulations applied at various growth stages. Among them, application of RDF + urea spray @ 2% at 30 and 60 DAS recorded significantly higher nitrogen uptake (124.68 and 85.48 kg ha⁻¹, respectively) and potassium uptake (56.06 and 134.22 kg ha⁻¹, respectively) by grain and stover. While uptake of phosphorus by grain and stover was found to be higher in the treatment receiving 75% RDN + nano urea @ 4 ml l⁻¹ at 30 and 60 DAS (33.67 and 27.92 kg ha⁻¹, respectively).

Keywords : Nano Urea, Nano DAP and Nutrient uptake.

Introduction

Maize (*Zea mays* L.) is considered as one of the most important food grains in India after rice and wheat. India ranks fifth in the area and third in production and productivity over other cereal crops and it is also regarded as the “Queen of Cereals”. It has a great potential to meet the food demands of both humans and animals. Maize is cultivated throughout the year in every state for different requirements like grains, fodder, green cobs, baby corn, sweet corn, popcorn etc. Maize is a dual-purpose crop. The grain is used as food for both human and livestock consumption. It has high nutritive value as it contains about 7.7-14.6% protein, 0.8-2.32% crude fibre, 69.7-74.5% carbohydrates, 3.2-7.7% fat and 0.7-1.3% ash (Anon., 2024 a). Maize is grown during *kharif* season, but it can also be grown during *rabi* and summer seasons because of its photo insensitive nature. Maize thrives well in warm temperatures, ideally between 20-30°C, though it can tolerate higher heat up to 35°C, which can impact pollination and yield. The crop requires approximately 500 to 600 mm of rainfall

during its growing season, typically provided by south-west monsoon from June to September. However, irrigation may be necessary in drier areas. Maize performs well in good drained, loamy to sandy soils with a pH of 5.5 to 7.0 and benefits from moderate humidity levels around 60-70%. Full sunlight is essential, requiring about 6-8 hours of direct exposure daily.

Indian agriculture is facing a wide spectrum of challenges in crop production systems such as crop yield stagnation, declining organic matter, multi nutrient deficiencies, low use efficiency of fertilizers, climate change, shrinking of arable land, restricted labour and water availability (Sinha and Singh, 2020). Social and economic issues such as non-availability of labours and escalating cost of cultivation forcing agricultural scientists to evolve technologies that target multifaceted problems of Indian agriculture. To address all these challenges, thinking of an alternate technology such as nano technology to detect precisely and deliver correct quantity of nutrients and other inputs required by crops in suitable proportion that

promote productivity while ensuring environmental safety.

Nano fertilizers have an effective alternative solution for addressing crop nutritional deficiencies through enhanced bio availability of nutrients and limited losses to the environment. 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 (Lal, 2008; Sharma, 2008) which have the ability to manipulate the materials to atom level, molecular and macromolecular scale. Nano particles have a large surface area and have the ability to retain an abundant amount of nutrients and release them slowly and stably for relatively longer time so as to facilitate the nutrient absorption that corresponds to the crop requirement without any shortcomings associated with specialized fertilizer inputs (Komarneni, 2009; Kothari *et al.*, 2019).

Nano urea is a source of nitrogen and contains about 4 per cent of nitrogen (40,000 ppm) which is an essential nutrient for crop growth and development. Nano DAP is a source of nitrogen and phosphorous. It contains about 8 per cent of nitrogen (80,000 ppm) and 16 per cent of phosphorous (1,60,000 ppm). The size of one nano fertilizers particle is about 30 nano metre (1 nm is one billionth of a meter) compared to the granular urea which has about 10,000 times more surface area to volume size. Further, due to ultra-small size and surface properties of nano urea, it gets absorbed by the plants when sprayed on the leaves. These products demonstrate nutrient use efficiency exceeding 90% under optimal field conditions. Furthermore, they are easy to store and transport (Anon., 2024).

Thus, nano fertilizers are emerging as an alternative to conventional fertilizers becoming important tools in agriculture for improving crop growth, yield and quality parameters and reduce wastage of fertilizers. Nanotechnology can reduce the rate of fertilizer nutrients loss through leaching and increase their availability to plants which ultimately leads to reduced water and soil pollution. The use of nitrogen nano fertilizer is essential for reducing higher requirement of fertilizer, cost and environment issues.

Material and Methods

A field experiment was conducted at Experimental Block, College of Agriculture, Bheemarayanagudi, University of Agricultural Sciences, Raichur which is situated in the North

Eastern Dry Zone of Karnataka (Zone 2) between 16° 43' North latitude and 76° 51' East longitude with an altitude of 419 m above mean sea level. An amount of 78.5 mm rainfall was received during crop growth period (*i.e.*, October to February). The mean maximum temperature varied from 31.1 to 32.2°C during *rabi* of 2024-25. The soil of the experimental site was medium to deep black with clay loam texture. Composite soil samples from 0-15 cm depth were collected before initiation of the experiments. The soil was air dried, powdered and allowed to pass through 2 mm sieve and later analysed for physical and chemical properties.

The experiment was laid out in randomized complete block design (RCBD) consisting of twelve treatments replicated thrice. Treatments consists of 50% RDN with nano urea spray @ 2 ml l⁻¹ at 30 and 60 DAS (T₁), 50% RDN with nano urea spray @ 4 ml l⁻¹ at 30 and 60 DAS (T₂), 75% RDN with nano urea spray @ 2 ml l⁻¹ at 30 and 60 DAS (T₃), 75% RDN with nano urea spray @ 4 ml l⁻¹ at 30 and 60 DAS (T₄), 50% RDNP with nano urea spray @ 2 ml l⁻¹ at 30 and 60 DAS (T₅), 50% RDNP with nano urea spray @ 4 ml l⁻¹ at 30 and 60 DAS (T₆), 75% RDN with Nano urea spray @ 2 ml l⁻¹ at 30 and 60 DAS (T₇), 75% RDN with nano urea spray @ 4 ml l⁻¹ at 30 and 60 DAS (T₈), RDF (150:65:65 kg N: P₂O₅: K₂O ha⁻¹) (T₉), RDF + DAP @ 1% foliar spray at 30 and 60 DAS (T₁₀) and RDF + Urea @ 2% foliar spray at 30 and 60 DAS (T₁₁).

Plant samples used for studying the dry matter production were used for estimating nitrogen, phosphorus and potassium content in the plant. The samples were powdered in the Willey grinding mill and stored in plastic containers. Plant sample of one gram was taken for digestion. The content was made to a known volume by using distilled water. A known quantity of aliquot was used for subsequent nutrient analysis. The following estimations were carried out with the digested samples. Finally, the uptake of nutrients was calculated by using the formula,

$$\text{Uptake of nutrient (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (\%)} \times \text{Dry Biomass (kg ha}^{-1}\text{)}}{100}$$

Plant nitrogen

Total nitrogen was determined by Kjeldahl's method of nitrogen determination as described by Jackson (1973). In this method, a powdered sample of 0.5 g was digested with concentrated H₂SO₄ in presence of digestion mixture (K₂SO₄: CuSO₄. 5H₂O: Se powder in the ratio of 100:20:1) and distilled under alkaline medium. Liberated NH₃ was trapped in boric

acid containing mixed indicator and titrated against standard H_2SO_4 . The per cent of nitrogen content was calculated from the volume of acid consumed by ammonia and expressed as kg ha^{-1} .

$$\text{Nitrogen (\%)} = \frac{\text{TV (ml)} \times \text{N.H}_2\text{SO}_4 \times \text{Volume of plant digest} \times 0.014}{\text{Aliquot taken} \times \text{weight of plant sample (g)}} \times 100$$

Plant phosphorus

Phosphorus was estimated by Vanadomolybdate method (Jackson, 1973). 0.5 g of dried plant sample was pre-digested with 5 ml of concentrated nitric acid. It was further digested with 10 ml di-acid mixture (concentrated nitric acid and perchloric acid at 10:4 proportions). The digested material was then made up to 100 ml with distilled water. 5 ml of aliquot was taken in a 50 ml volumetric flask along with 10 ml Vanadomolybdic acid reagent and the volume was made up to 50 ml with distilled water. Yellow colour developed was measured at 490 nm a reagent blank. The concentration of phosphorus in the sample was obtained by comparing with phosphorus standard curve and per cent phosphorus was calculated using following formula.

$$\text{Phosphorus (\%)} = \frac{\text{Graph ppm} \times \text{Volume of plant digest} \times \text{Volume made}}{10^6 \times \text{Aliquot taken} \times \text{weight of plant sample (g)}} \times 100$$

Plant potassium

The potassium concentration in the plant sample was estimated by Flame Photometer method (Jackson, 1973) and expressed as per cent.

$$\text{Potassium (\%)} = \frac{\text{Graph ppm} \times \text{Dilution factor} \times \text{Volume of digest}}{10^6 \times \text{weight of plant sample (g)}} \times 100$$

Results and Discussion

Nitrogen Uptake

There was a significant influence on nitrogen uptake due to applying different levels of fertilizers and foliar spray of nano urea and nano DAP (Table 1 and Fig. 1). Among all the treatments, RDF + urea spray @ 2% at 30 and 60 DAS recorded significantly higher N uptake by grain, stover and total (124.68, 85.48 and 210.15 kg ha^{-1} , respectively) and it was found statistically non-significant with RDF + DAP @ 1% foliar spray at 30 and 60 DAS (123.52, 84.36 and 207.88 kg ha^{-1} , respectively). However, among nano urea and nano DAP treatments significantly higher uptake of nitrogen by grain, stover and total uptake was recorded in 75% RDN + nano urea @ 4 ml l^{-1} at 30

and 60 DAS (108.63, 73.31 and 181.95 kg ha^{-1} , respectively) followed by 75% RDNP + nano DAP @ 4 ml l^{-1} at 30 and 60 DAS (108.53, 72.51 and 181.04 kg ha^{-1} , respectively) which was found on par with each other. Significantly lower uptake of nitrogen by grain, stover and total uptake was recorded with 50% RDNP + nano DAP @ 2 ml l^{-1} at 30 and 60 DAS (65.22, 42.04 and 107.26 kg ha^{-1} , respectively). Total nitrogen uptake was followed similar trend on that of grain and stover. Significantly higher total uptake of nitrogen recorded with RDF + urea @ 2% foliar spray at 30 and 60 DAS, along with RDF + DAP @ 1% foliar spray which might be attributed to timely and adequate supply of nitrogen during critical growth stages. Foliar-applied urea ensured rapid nitrogen absorption and assimilation, supporting enhanced chlorophyll synthesis, photosynthetic activity and protein formation, which collectively improved biomass production and nitrogen translocation to the grain. Similarly, DAP supplied both nitrogen and phosphorus, promoting root development, energy transfer and nutrient uptake efficiency. The combination of basal nutrient application with foliar sprays at peak physiological demand likely sustained canopy activity, improved radiation use efficiency and facilitated better nutrient partitioning, resulted higher nitrogen accumulation in both grain and stover. Nano fertilizer treatments showed a marked effect on nitrogen uptake. Higher doses of nano urea and nano DAP improved N assimilation in both grain and stover, reflecting better nutrient absorption and translocation efficiency. This can be attributed to their slow-release nature and enhanced foliar availability, which maintained adequate nitrogen supply throughout growth. In contrast, lower nano fertilizer levels restricted nutrient availability, leading to reduced uptake and overall efficiency. These results align with the findings of Dhansil *et al.* (2018) and Sharma *et al.* (2022).

Phosphorous Uptake

The data on phosphorus uptake (kg ha^{-1}) by maize, differed significantly due to different levels of fertilizers and foliar spray of nano urea and nano DAP (Table 1 and Fig. 1). However, among nano urea and nano DAP treatments significantly higher uptake of phosphorus by grain, stover and total uptake was recorded in 75% RDN + nano urea @ 4 ml l^{-1} at 30 and 60 DAS (33.67, 27.92 and 61.58 kg ha^{-1} , respectively) followed by 75% RDNP + nano DAP @ 4 ml l^{-1} at 30 and 60 DAS (33.63, 27.89 and 61.52 kg ha^{-1} , respectively) which was found on par with each other. Significantly lower uptake of phosphorus by grain, stover and total uptake was recorded with 50% RDNP

+ nano DAP @ 2 ml l⁻¹ at 30 and 60 DAS (18.14, 13.37 and 31.50 kg ha⁻¹, respectively). The treatment RDF + urea @ 2% foliar spray at 30 and 60 DAS, recorded significantly higher uptake of phosphorus by grain, stover and total uptake (40.04, 34.22 and 74.26 kg ha⁻¹, respectively) and this treatment was found statistically on par with RDF + DAP @ 1% foliar spray at 30 and 60 DAS (39.24, 33.32 and 72.57 kg ha⁻¹, respectively). Significantly higher uptake phosphorus by grain and stover. The total uptake was followed same trend can be attributed to RDF + urea @ 2% foliar spray at 30 and 60 DAS. Thus, it improved the nutrient availability and efficient absorption during key growth and reproductive stages. Adequate phosphorus supply promotes root proliferation, enhances energy transfer through ATP synthesis and supports various metabolic processes essential for grain development. The foliar application at 30 and 60 DAS likely synchronized phosphorus availability with peak physiological demand, improving assimilate production and translocation to both grain and stover. In the case of DAP, the direct supply of phosphorus, along with nitrogen, further enhanced nutrient use efficiency, sustained canopy activity, and facilitated better partitioning of phosphorus into structural and reproductive tissues, resulting in higher uptake values. The improved phosphorus uptake under nano fertilizer treatments can be attributed to their smaller particle size, which enhances foliar absorption and translocation within the plant system. Nano formulations offer controlled release and higher nutrient-use efficiency, ensuring a steady phosphorus supply during critical growth stages. This leads to better root activity, energy metabolism and enzyme function involved in phosphorus assimilation. The findings of Sahu *et al.* (2022) and Chavan *et al.* (2023) also explained similar results.

Potassium Uptake

The variation in potassium uptake in both grain and stover was observed among all the treatments due to application of different levels of fertilizers and foliar spray of either nano urea and nano DAP (Table 1 and Fig. 1). The treatment which received RDF + urea spray @ 2% at 30 and 60 DAS recorded significantly higher K uptake by grain, stover and total (56.06, 78.16 and 134.22 kg ha⁻¹, respectively) and it was found statistically on par with RDF + DAP @ 1% foliar spray at 30 and 60 DAS (55.22, 76.27 and 131.49 kg ha⁻¹, respectively). However, among nano urea and nano DAP treatments significantly higher uptake of potassium by grain, stover and total uptake was recorded in 75% RDN + nano urea @ 4 ml l⁻¹ at 30 and 60 DAS (47.50, 66.00 and 113.50 kg ha⁻¹, respectively)

followed by 75% RDNP + nano DAP @ 4 ml l⁻¹ at 30 and 60 DAS (46.86, 65.21 and 112.07 kg ha⁻¹, respectively) which was found on par with each other. Significantly lower uptake of potassium by grain, stover and total uptake was recorded with 50% RDNP + nano DAP @ 2 ml l⁻¹ at 30 and 60 DAS (25.39, 37.10 and 62.50 kg ha⁻¹, respectively). The significantly higher potassium uptake by grain, stover and total uptake was recorded with RDF + urea @ 2% foliar spray at 30 and 60 DAS, along with RDF + DAP @ 1% foliar spray. The higher potassium uptake can be attributed to improved nutrient availability and efficient root activity facilitated by adequate nitrogen and phosphorus supply. Potassium plays a vital role in regulating osmotic balance, enzyme activation and translocation of photosynthates, which are essential for grain filling and biomass development. Foliar feeding at 30 and 60 DAS of urea and DAP likely ensured that potassium absorption and utilization were optimized during peak vegetative and reproductive stages, resulting in better accumulation in both grain and stover. In the case of DAP, the balanced provision of nitrogen and phosphorus supported overall plant vigor and root health, indirectly enhancing potassium uptake efficiency and its effective partitioning into structural and reproductive tissues. The enhanced potassium uptake under nano fertilizer treatments may be attributed to their high surface reactivity and increased mobility, which facilitate efficient foliar absorption and internal redistribution. Nano urea and nano DAP likely improved potassium transport by maintaining ionic balance and supporting enzymatic functions associated with osmotic regulation and translocation. The reduced uptake at lower concentrations suggests insufficient potassium availability to meet crop physiological demand. Similar results were reported by Deo *et al.* (2022) and Chinnappa *et al.* (2023).

Conclusion

- Among all treatments, RDF + Urea @ 2% foliar spray at 30 and 60 DAS recorded higher nutrient uptake in both grain and stover which attributed to total uptake by plant.
 - Among nano urea applied treatments, the treatment 75% RDN + Nano urea @ 4 ml l⁻¹ at 30 and 60 DAS recorded higher nutrient uptake indicating potential of nano urea in producing higher photosynthates by extracting nutrients efficiently.
- Among nano DAP applied treatments, 75% RDNP + Nano DAP @ 4 ml l⁻¹ at 30 and 60 DAS showed better nutrient uptake depicting importance of nano formulations in increasing plant growth and yield.

Table 1 : Uptake of nitrogen, phosphorus and potassium in maize at maturity as influenced by varying levels of fertilizers and foliar spray of nano urea and nano DAP.

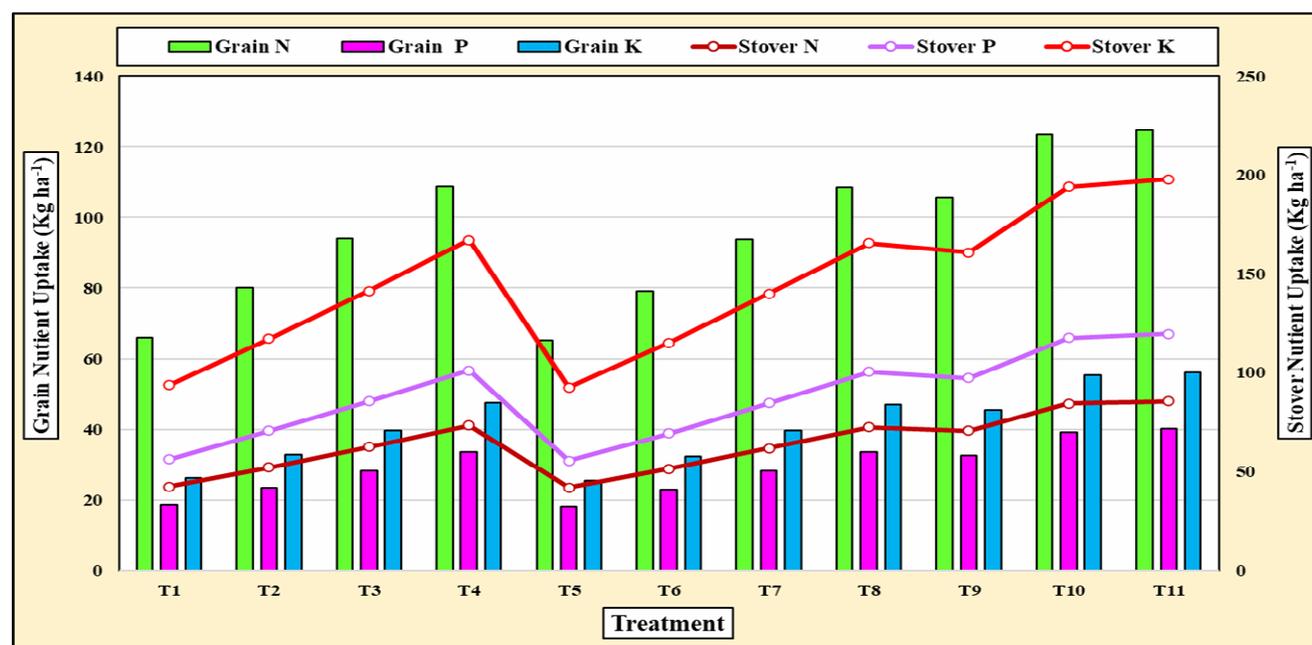
Treatment	N (kg ha ⁻¹)			P (kg ha ⁻¹)			K (kg ha ⁻¹)		
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
T ₁ : 50% RDN + Nano urea @ 2 ml l ⁻¹ at 30 and 60 DAS	65.98	42.37	108.35	18.51	13.79	32.30	26.15	37.44	63.59
T ₂ : 50% RDN + Nano urea @ 4 ml l ⁻¹ at 30 and 60 DAS	80.24	52.23	132.47	23.51	18.40	41.91	32.91	46.50	79.42
T ₃ : 75% RDN + Nano urea @ 2 ml l ⁻¹ at 30 and 60 DAS	94.05	62.50	156.55	28.35	23.04	51.40	39.59	55.93	95.52
T ₄ : 75% RDN + Nano urea @ 4 ml l ⁻¹ at 30 and 60 DAS	108.63	73.31	181.95	33.67	27.92	61.58	47.50	66.00	113.50
T ₅ : 50% RDNP + Nano DAP @ 2 ml l ⁻¹ at 30 and 60 DAS	65.22	42.04	107.26	18.14	13.37	31.50	25.39	37.10	62.50
T ₆ : 50% RDNP + Nano DAP @ 4 ml l ⁻¹ at 30 and 60 DAS	79.07	51.51	130.58	22.97	17.78	40.75	32.35	45.80	78.15
T ₇ : 75% RDNP + Nano DAP @ 2 ml l ⁻¹ at 30 and 60 DAS	93.91	61.90	155.81	28.31	22.82	51.13	39.53	55.39	94.92
T ₈ : 75% RDNP + Nano DAP @ 4 ml l ⁻¹ at 30 and 60 DAS	108.53	72.51	181.04	33.63	27.89	61.52	46.86	65.21	112.07
T ₉ : RDF (150:65:65 kg N: P ₂ O ₅ : K ₂ O ha ⁻¹)	105.64	70.62	176.26	32.49	26.68	59.18	45.50	63.42	108.92
T ₁₀ : RDF + DAP @ 1% foliar spray at 30 and 60 DAS	123.52	84.36	207.88	39.24	33.32	72.57	55.22	76.27	131.49
T ₁₁ : RDF + Urea @ 2% foliar spray at 30 and 60 DAS	124.68	85.48	210.15	40.04	34.22	74.26	56.06	78.16	134.22
S.Em.±	4.29	3.04	7.31	1.43	1.31	2.74	2.05	2.78	4.83
C.D.(P=0.05)	12.65	8.96	21.57	4.23	3.88	8.09	6.04	8.21	14.25

Note: DAS: Days after sowing

RDF: Recommended Dose of Fertilizer

RDN: Recommended Dose of Nitrogen through conventional fertilizer

RDNP: Recommended Dose of Nitrogen and Phosphorus through conventional fertilizer

**Fig. 1:** Influence of nano Urea and nano DAP on nutrient uptake in maize under irrigated condition

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