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Response of fodder maize growth and yield attributes to nano urea and nano dap application

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Abstract

An experiment was conducted to study the effect of Nano urea and Nano DAP on growth and yield of fodder maize at Main Forage Research Station, Anand and Main Maize Research Station, Godhra, Anand Agricultural University during *rabi* season of 2025-2026. Experiment consist of ten different Nano urea and Nano DAP treatments with three replications and experiment was laid out in Randomized Completed Block Design. According to two location experiment mean data revealed that effect of different Nano urea and Nano DAP treatment on plant population at 15 DAS, at harvest and plant height at 30 DAS, number of cobs per plant and shelling percentage were found non-significant. At Anand and Godhra, application of 75% RDF along with Nano DAP 5 ml/kg seed *fb* foliar spray of Nano urea and Nano DAP each 4 mL/lit at 25 and 50 DAS treatment recorded higher plant height at 60 DAS (245 and 223 cm) and at harvest (281 and 261 cm), number of leaves per plant at 30 DAS (11.2 and 9.5), at 60 DAS (13.2 and 13.1) and at harvest (13.5 and 14.7) at Anand and Godhra, respectively. Yield attributes like cob length (16.3 and 16.1 cm), cob girth (14.9 and 13.5 cm) and weight of cob (9.75 and 9.32 kg/plot) at Anand and Godhra respectively by application of 75% RDF along with Nano DAP 5 ml/kg seed *fb* foliar spray of Nano urea and Nano DAP each 4 mL/lit at 25 and 50 DAS.

Keywords: Nano DAP, Nano urea, foliar application, fodder maize

1. Introduction

Maize is considered the "Queen of Cereals" due to its high value and exceptional adaptability as a C4 crop for human food, animal feed, and fodder. Among various cultivated forage crops, maize is ideal for fodder and silage production because of its high yield potential and excellent nutritional profile. Furthermore, it can be safely fed to livestock at any growth stage without risk (Rashid *et al.*, 2025) ^[18].

Among the various fodder crops, fodder maize is the most preferred due to its high productivity and being free from anti-nutritional factors. Presently, cultivation of fodders is limited to only 4% of the entire cultivable land in the country. The performance of livestock and the economics of milk production are heavily dependent on the quantity and quality of fodder fed to animals. There is a current shortfall of 35.6% green fodder, 10.5% dry fodder, and 44% concentrate feed ingredients across the country. The opportunity for expanding the land area under fodder cultivation is very restricted. Consequently, it faces serious demands good nutrient management. Better quality fodder is important for milk production because it sends more crude protein and other nutrients to the small intestine. This improves the livestock's overall nitrogen balance. Low availability of nutrient-rich feeds and fodder results in unhealthy animals and poorer dairy yield. In maize, foliar application of nano urea has been shown to increase chlorophyll content, photosynthetic efficiency, and dry matter accumulation, resulting in higher green fodder yield (Kumar *et al.*, 2022) ^[10]. Similarly, studies on nano phosphorus fertilizers have indicated improved root proliferation, better nutrient acquisition, and increased yield attributes. The combined application of nano urea and nano DAP has been found to synergistically enhance growth and yield by optimizing nitrogen and phosphorus availability during critical growth stages.

2. Materials and Methods

2.1 Experiment study area and site

A field experiment was carried out to asses effect of nano urea and nano DAP on growth, yield

and nutrient content of Fodder Maize was conducted at Main Forage Research Station, Anand and Main Maize Research Station, Godhra, Anand Agricultural University during *rabi* 2025-26. Soil physicochemical properties and treatment details of experiment soil was reported in Table 1.

2.2 Experiment treatment details

Experiment was laid out in Randomized Complete Block Design consist of ten different Nano urea and Nano DAP treatments with three replications. Integration of Nano urea and Nano DAP treatments was reported in Table 2. For experiment purpose,

fodder maize (Gujrat Fodder Maize 1, Anand Tall) variety was used. Recommended dose of fertilizer for fodder maize is 80-40-0 NPK kg/ha. Nutrient was applied according to the pre define treatment. As per treatment, half dose of nitrogen through urea and full dose of phosphorus was applied as a basal and remaining half dose of nitrogen was applied at 30 days after sowing. The sources of Nano urea and Nano DAP was Indian Farmers Fertilizer Cooperative Limited (IFFCO). According to treatments, foliar application of Nano urea and Nano DAP was carried out at 25 and 50 DAS, coinciding with active vegetative and early reproductive stage of fodder maize.

Table 1: Physicochemical properties of soil

Sr No.	Particular	Value		Reference
		Godhra	Anand	
1	Texture class	Loamy Sand	Loamy Sand	
2	Soil pH (1:2.5 Soil: Water)	7.35	8.00	Potentiometric Method (Jackson, 1973) ^[4]
3	EC (dS/m) at 25 °C	0.18	0.18	Conductivity meter Method (Jackson, 1973) ^[4]
4	Organic carbon (%)	0.43	0.32	Walkley and Black Method (Walkley and Black, 1934) ^[24]
5	Available N (kg/ha)	205	200	Alkaline KMnO ₄ Method (Subbiah and Asija, 1956) ^[23]
6	Available P ₂ O ₅ (kg/ha)	58.0	48.0	Olsen's Method (Olsen <i>et al.</i> , 1954) ^[15]
7	Available K ₂ O (kg/ha)	240	167	Flame Photometry method (Jackson, 1973) ^[4]

2.3 Observations recorded

To measure growth and yield-attributing characters in fodder maize, tag five randomly selected plants within the net plot area. Record growth parameters, such as plant height and the number of leaves per plant, at regular intervals. Measure yield attributes,

including the number, length, and diameter of the cobs, during the experimental period. At harvest, collect the properly dried cobs, separating the border-row cobs first. Finally, harvest the cobs from the remaining net plot area to calculate the total grain yield on a per-hectare basis.

Table 2: Nano urea and Nano DAP treatment details

Tr		Treatment details
T ₁	:	100% recommended dose of fertilizer (RDF: 80-40-0 NPK kg/ha)
T ₂	:	ST with <i>Azospirillum</i> @ 5 mL/kg seed + Nano urea and Nano DAP 4 mL/litre at 25 & 50 DAS
T ₃	:	50% RDF & foliar spray of Nano urea 4 mL/litre at 25 & 50 DAS
T ₄	:	75% RDF & foliar spray of Nano urea 4 mL/litre at 25 & 50 DAS
T ₅	:	50% RDF + ST with Nano DAP @ 5 mL/kg seed <i>fb</i> foliar spray with Nano DAP 4 mL/ litre at 25 & 50 DAS
T ₆	:	75% RDF + ST with Nano DAP @ 5 mL/ kg seed <i>fb</i> foliar spray with Nano DAP 4 mL/litre at 25 & 50 DAS
T ₇	:	50% RDF+ ST with Nano DAP @ 5 mL/kg seed <i>fb</i> foliar spray with Nano urea and Nano DAP 2 mL/litre at 25 & 50 DAS
T ₈	:	75% RDF + ST with Nano DAP @ 5 mL/kg seed <i>fb</i> foliar spray with Nano urea and Nano DAP 2 mL/litre at 25 & 50 DAS
T ₉	:	50% RDF + ST with Nano DAP @ 5 mL/kg seed <i>fb</i> foliar spray with Nano urea and Nano DAP 4 mL/litre at 25 & 50 DAS
T ₁₀	:	75% RDF + ST with Nano DAP @ 5 mL/kg seed <i>fb</i> foliar spray with Nano urea and Nano DAP 4 mL/litre at 25 & 50 DAS

2.4 Cultural practices

To ensure a successful fodder maize experiment, all standard recommended cultivation practices were followed. Primary tillage operations were completed prior to laying out the field, and all unwanted stubbles were removed. Fodder maize seeds were sown with a spacing of 30 cm between rows and 10 cm between plants. In the integrated treatment plots, seeds were pre-treated with Nano DAP at a rate of 4 mL/kg of seed.

According to the fixed treatment schedule, Nano urea and Nano DAP were applied as foliar sprays at a rate of 4 mL/L at 25 and 50 days after sowing (DAS). Plant protection measures were strictly followed using CIB-approved agrochemicals; specifically, Chlorantraniliprole 18.5% SC and Emamectin benzoate 5% SG were applied to control fall armyworm. For optimal crop production, an initial common irrigation was applied immediately after sowing to ensure uniform germination, followed by subsequent irrigations at intervals of 10 to 12 days.

2.5 Statistical analysis of experiment data

Mean data were statistically analysed using Analysis of Variance (ANOVA) (Cochran and Cox, 1957) ^[2]. Treatment means were compared using the F-test and Critical Differences (CD) at 5%

level of significance were calculated where appropriate.

3. Results and Discussion

Integrated Nano urea and Nano DAP treatments did not significantly affect plant populations at 15 DAS or at harvest in Anand and Godhra (Table 3). A uniform plant population was observed across all treatments, meaning that the treatments had no effect on plant stand. Similar findings were reported by Kumar *et al.* (2021) ^[9], Rajesh *et al.* (2023) ^[17] who observed that nano fertilizers improved nutrient uptake and yield indices without altering plant population. Periodical plant height (Table 1) and number of leaves per plant (Table 4) at Anand and Godhra location, response of plant height at 30 DAS did not show significant effects on height (Table 3). This might be early vegetative growth in maize is largely dependent on seed reserves, initial soil fertility and environmental conditions, rather than external nutrient supplementation. Significant response of combined application of convential fertilizer with Nano fertilizer on growth parameter were found significant. Application of application of 75% RDF + ST with Nano DAP @ 5 mL/kg seed *fb* foliar spray with Nano urea and Nano DAP 4 mL/litre at 25 & 50 DAS treatment (T₁₀) recorded higher plant height at 60 DAS

(245 and 233 cm) and at harvest (281 and 261 cm) at Anand and Godhra, respectively over the rest of treatments. Improvement in plant height was significantly affected by the treatments. This reflects the stage when maize plants transition into rapid vegetative growth and nutrient demand increases. The greater plant height could be due to higher nutrient availability during the early vegetative and crop establishment stages, which supported vigorous growth. Particularly, nitrogen is crucial as it enhances nutrient uptake efficiency, chlorophyll synthesis, cell division, cell elongation, and photosynthetic activity, leading to faster and taller vegetative growth. This demonstrates that the integrated use of reduced RDF with nano DAP seed treatment and nano foliar sprays optimizes nutrient availability during critical growth stages, thereby enhancing plant height (Bhukya *et al.*, 2024, Manikandan and Subramanian., 2016 and Kumar *et al.*, 2021) ^[1, 12, 9]. Nutrients play a crucial role in plant growth and the application of nano fertilizers significantly enhances nutrient absorption and plant development (Kumar *et al.*, 2024) ^[7]. The number of leaves in fodder maize at 30 DAS, 60 DAS, and at harvest was significantly influenced by different treatments involving nano urea and nano DAP. Data presented in Table 4 revealed that application of 75% RDF + seed treatment with Nano DAP @ 5 mL/kg seed followed by foliar spray with Nano urea and Nano DAP @ 4 mL/litre at 25 & 50 DAS (T₁₀) consistently recorded higher number of leaves at 30 DAS (11.2 and 9.5) and 60 DAS (13.2 and 13.1) and at harvest (13.5 and 14.7) across Anand and Godhra locations, respectively. Erstwhile outcomes confirmed that reducing the recommended dose of fertilizer (75%) with seed treatment of Nano DAP along with combined application of nano urea and nano DAP as foliar spray were estimated with the maximum number of leaves due to its balanced and efficient nutrient supply. Nano fertilizers enhanced nutrient use efficiency by reducing losses and ensuring sustained nitrogen and phosphorus availability. Seed treatment with Nano DAP improved root vigor and nutrient uptake, while foliar sprays bypassed soil fixation, directly stimulating chlorophyll synthesis and photosynthesis. The synergy of reduced RDF with nano inputs optimized assimilation and metabolism, promoting rapid cell division and leaf proliferation. While, the minimum number

of leaves was proclaimed in plots with only seed treatment with biofertilizer as well as 50% RDF (Midde *et al.*, 2022, Sharma *et al.*, 2022, Lekshmi *et al.*, 2022, Reddy *et al.*, 2022, Prakash *et al.*, 2023, Sahithi *et al.*, 2023 and Khandare *et al.*, 2024) ^[14, 22, 11, 19, 16, 20, 6]. Essential nutrients drive plant growth, the application of nano-fertilizers drastically improves nutrient uptake efficiency and accelerates development (Kaur and Satpal., 2019 and Kumar *et al.*, 2024) ^[5, 8].

Perusal of data presented in Table 4 regarding cob length and weight of cob significantly influenced by different treatments (Table 4). The experiment finding revealed that all integrated nitrogen management treatments significantly influenced cob length and cob girth (Table 4). Higher number of cob length (16.30 and 16.10 cm) and weight of cob (9.75 and 9.32 kg/plot) at both locations, respectively was noted higher in treatment T₁₀ (75% RDF along with seed treatment with Nano DAP @ 5 mL/kg seed *fb* foliar spray with Nano urea and Nano DAP 4 mL/litre at 25 & 50 DAS). While results of variance analysis showed the both conventional and nano fertilizer applications non significantly effect on cob girth, number of cob per plant and shelling percentage (Table 5).

From the finding on growth parameters as cob length, cob girth and weight of cob of fodder maize, it can be culminated that a higher cob length, girth and weight of cob showed with reducing dose of fertilizer (75%) with seed treatment as well as foliar application of combined nano urea and nano DAP treatments perfectly kindred assessments were also described by several researchers. Application of nano fertilizers to maize activates enzymes by fusing with the formation of chlorophyll in most plants, promoting the formation of growth hormones such as tryptophan. This increased in production in the main place to store carbohydrates in plants, which eventually led to an increased cob length, girth and weight of cob as a source and storage of carbohydrates, and ultimately increased yield (Lekshmi *et al.*, 2022, Saitheja *et al.*, 2022 and Girigoud *et al.*, 2023) ^[11, 21, 3]. According to finding by Reddy *et al.*, 2022 ^[19] and Mehta *et al.*, 2026 ^[13], the improvement in yield parameter likely to linked better nutrient uptake and enhanced source-sink relationships, resulting in increased cob size.

Table 3: Effect of nano urea & nano DAP on plant population and plant height of fodder maize

Tr. No.	Plant population 15 DAS		Plant population at harvest		Plant height (cm)					
					at 30 DAS		at 60 DAS		at harvest	
	Anand	Godhra	Anand	Godhra	Anand	Godhra	Anand	Godhra	Anand	Godhra
T ₁	11.33	10.33	10.67	10.33	111	95	244	223	278	253
T ₂	10.67	10.33	10.33	10.33	104	87	146	161	189	193
T ₃	12.00	10.67	11.67	10.33	106	87	232	202	260	228
T ₄	10.67	11.00	10.67	10.67	106	90	235	203	269	239
T ₅	11.67	11.33	10.67	10.00	105	87	228	201	260	226
T ₆	11.00	10.67	11.00	10.33	106	88	232	202	267	231
T ₇	10.33	10.67	10.00	10.33	107	90	238	207	271	244
T ₈	11.00	10.67	10.67	9.67	107	95	242	220	277	250
T ₉	10.67	10.33	10.67	10.33	107	93	240	211	276	249
T ₁₀	10.67	10.33	10.33	10.00	113	96	245	223	281	261
S.Em.±	0.43	0.38	0.36	0.29	6	3	7	11	9	10
CD (P=0.05)	NS	NS	NS	NS	NS	NS	21	32	27	31
CV%	6.80	6.24	5.79	4.87	9.6	5.0	5.4	9.1	6.0	7.5

Table 4: Effect of nano urea & nano DAP on number of leaves, cob length and weight of cob of fodder maize

Tr. No.	Number of leaves						Cob length (cm)		Weight of cob (kg/plot)	
	30 DAS		60 DAS		At harvest		Anand	Godhra	Anand	Godhra
	Anand	Godhra	Anand	Godhra	Anand	Godhra				
T ₁	10.9	9.2	13.0	12.7	13.1	14.3	15.9	14.2	9.22	8.63
T ₂	7.3	7.9	10.9	10.1	10.9	12.3	11.9	10.9	4.05	4.02
T ₃	10.1	8.1	12.3	12.0	12.5	13.7	13.6	13.3	4.39	4.09
T ₄	10.3	8.5	12.8	12.4	12.9	14.0	14.1	13.4	6.68	6.19
T ₅	10.0	8.1	11.9	11.8	12.4	13.7	12.8	13.3	5.79	5.68
T ₆	10.2	8.1	12.5	12.4	12.7	13.7	13.9	13.3	6.39	6.33
T ₇	10.5	8.9	12.9	12.4	12.9	14.1	14.1	14.1	7.52	7.59
T ₈	10.9	9.2	12.9	12.6	13.1	14.2	14.6	14.2	8.52	8.51
T ₉	10.5	9.0	12.9	12.5	13.1	14.1	14.3	14.1	8.00	8.64
T ₁₀	11.2	9.5	13.2	13.1	13.5	14.7	16.3	16.1	9.75	9.32
S.Em.±	0.4	0.4	0.4	0.5	0.4	0.4	0.5	0.7	0.37	0.32
CD (P=0.05)	1.2	1.1	1.1	1.5	1.1	1.2	1.4	2.2	1.11	0.95
CV%	7.0	7.1	5.2	7.1	4.9	5.0	5.8	9.4	9.18	8.06

Table 5: Effect of nano urea and nano DAP on cob girth, number of cobs per plant and shelling percentage of fodder maize

Tr. No.	Cob girth (cm)		No. of cob per plant (kg/plot)		Shelling percentage (%)	
	Anand	Godhra	Anand	Godhra	Anand	Godhra
T ₁	14.5	13.3	1.00	1.00	66.5	44.0
T ₂	12.9	11.2	1.00	1.00	63.2	46.8
T ₃	13.4	12.7	1.00	1.00	64.2	42.5
T ₄	14.1	12.8	1.00	1.00	64.7	42.4
T ₅	13.2	11.9	1.00	1.00	61.9	38.5
T ₆	14.1	12.7	1.00	1.00	64.5	50.3
T ₇	14.2	12.9	1.00	1.00	66.2	31.5
T ₈	14.5	13.3	1.00	1.00	63.4	40.6
T ₉	14.5	12.9	1.00	1.00	61.3	37.0
T ₁₀	14.9	13.5	1.00	1.00	68.4	40.3
S.Em.±	0.6	0.6	0.00	0.00	2.2	3.49
CD (P=0.05)	NS	NS	NS	NS	NS	NS
CV%	7.2	7.8	0.00	0.00	6.0	14.59

Higher yield confirming the role of nutrient availability in enhancing vegetative and reproductive growth.

4. Conclusion

The plant population of fodder maize at 15 DAS and at harvest, number of cobs per plant, cob girth and shelling percentage was not significantly affected by different treatments at Anand and Godhra locations. However, the application of 75% RDF along with seed treatment with Nano DAP @ 5 mL/kg seed *fb* foliar spray with Nano urea and Nano DAP 4 mL/litre at 25 & 50 DAS (T₁₀) recorded significantly higher plant height at 60 DAS and at harvest, higher number of leaves at 30 DAS, 60 DAS and at harvest and cob length at Anand and Godhra.

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