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Fodder maize (*Zea mays* L.) growth, yield and quality as influenced by foliar application of nano urea and urea under varying levels of nitrogen

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Abstract
A field experiment on "Fodder maize (*Zea mays* L.) growth, yield and quality as influenced by foliar application of nano urea and urea under varying levels of nitrogen" was conducted during *kharif* 2022 at Zonal Agricultural Research Station, V. C. Farm, Mandya, Karnataka. The experiment was laid out in Randomized Complete Block Design with eleven treatments replicated thrice. Treatments include varied levels of recommended dose of N (50, 75 and 100%) along with foliar application of nano urea (0.2% and 0.4%) and urea (2%) spray at 20 and 40 DAS, in comparison with RDF alone and control (RDF without N). The application of 100% recommended dose of N + Urea @ 2% spray recorded significantly higher growth parameters such as leaf: stem ratio, SPAD reading, growth indices like leaf area index, absolute growth rate and crop growth rate, green fodder yield and dry matter yield over RDF alone and was on par with 100% recommended dose of N + Nano urea @ 0.4% spray at harvest. Significantly higher crude protein yield, total digestible crude protein yield and total carbohydrate yield was recorded in 100% recommended dose of N + Urea @ 2% spray and was on par with 100% recommended dose of N + Nano urea @ 0.4% spray. Higher net returns and B:C ratio (70,945 Rs ha^{-1} and 2.97 respectively) was observed with application of 100% recommended dose of N + Urea @ 2% spray over rest of the treatments.

Keywords: Fodder maize, nano urea, productivity, quality and economics

Introduction
The rural economy cannot function without livestock, which also supports farmer's livelihoods. The availability of high-quality forages forms an essential component of animal wealth and health in any country. In India, the situation of the production and use of fodder is different from that in other nations. The need for land for agricultural and non-agricultural uses is placing pressure on the grazing lands, which are gradually decreasing while, the number of cattle increase. The yearly production was 899.3 mt of fodder but the quantity of fodder needed to support the current cattle population is roughly 1820 mt. The nation can only meet green fodder resource requirement of 49.41% and facing a hortfall of 50.59% (Anon., 2019) [4].

Among the several fodder crops, maize (*Zea mays* L.), has a fodder productivity of 30-55 t ha^{-1} and is one of the most significant crops produced all around the world spread throughout the seasons annually for both grain and fodder purposes. Maize may be fed to animals safely at any stage of the crop growth due to its wide range of adaptation, quick growth, great fodder quality, succulence, palatability and lack of toxicants and can provide 9-11% crude protein, 60-64% neutral detergent fibre, 38-41% acid detergent fibre, 28-30% cellulose and 23-25% hemicellulose (Das *et al*., 2015) [7].

Nitrogen occupies an important place in plant metabolic system and is an essential constituent of protein and chlorophyll present in many major portions of the plant body. It plays a crucial role in various physiological processes (Leghari *et al*., 2016) [12] and helps in quantitative as well as qualitative improvement in forage crops by increasing leaf: stem ratio, chlorophyll content, succulent, better palatability and finally green fodder yield. Foliar application of nano urea and urea at critical crop growth stages of a plant effectively fulfils its nitrogen requirement and leads

to higher crop productivity and quality. In view of the above, this investigation was carried out to know the potential advantages of nano urea and urea spray at critical crop growth stage along with varied recommended nitrogen levels in fodder maize crop.

Materials and Methods

A field experiment on "Fodder maize (*Zea mays* L.) growth, yield and quality as influenced by foliar application of nano urea andr urea under varying levels of nitrogen" was carried out during *kharif* 2022 at Zonal Agricultural Research Station, V. C. Farm, Mandya, which is located in region III and Agro Climatic Zone-6 of Southern Dry Zone of Karnataka, lies between 12º 45' and 30º 57' North latitude and 76º 45' and 78 º 24' East longitude with 695 m above mean sea level. The soil of the experimental site is sandy loam in texture, with neutral in pH, low in soluble salts and having medium organic carbon, available P_2O_5 and K_2O and low available nitrogen. The fodder maize variety African tall with a seed rate of 100 kg ha^{-1} was sown in lines at a spacing of 30 cm ×10 cm. The recommended dose of fertilizer (150:75:40 kg ha^{-1}) was applied as per the package of zone.

The field experiment was laid out with eleven treatments replicated thrice in Randomized Complete Block Design. The treatments include Control (RDF without N) (T_1), RDF (N: P: K @ 150:75:40 kg ha^{-1}) (T_2), 100% recommended dose of N + Nano urea @ 0.2% spray (T_3), 75% recommended dose of N + Nano urea @ 0.2% spray (T_4), 50% recommended dose of N + Nano urea @ 0.2% spray (T_5), 100% recommended dose of N + Nano urea @ 0.4% spray (T_6), 75% recommended dose of N + Nano urea @ 0.4% spray (T_7), 50% recommended dose of N + Nano urea @ 0.4% spray (T_8), 100% recommended dose of N + Urea @ 2% spray (T_9), 75% recommended dose of N + Urea @ 2% spray (T_{10}) and 50% recommended dose of N + Urea @ 2% spray (T_{11}). Nitrogen was applied in two splits (50% N as basal and 50% N at 30 DAS). Nano urea and urea was sprayed at 20 and 40 days after sowing. The recommended dose of phosphorus and potassium was applied as basal for all treatments.

The observations on leaf: stem ratio and SPAD reading were recorded at 40 DAS and at harvest stage. The crop was harvested manually after attaining milky stage i.e., at 50% flowering and during harvesting a representative plant sample was collected from each plot to estimate dry matter and moisture content and quality analysis. Quality parameters are analysed and calculated according to the equations adopted by Iqbal *et al*. (2013) [10]. Leaf area index and crop growth rate (Watson., 1952) [17] and absolute growth rate (West *et al.*,1920) [18] was calculated. Statistical analysis was done using standard procedures of analysis of variance in randomized complete block design as described by Gomez and Gomez (1984) [8] for drawing conclusions on the effect of various treatments on different parameters studied and statistical mean differences were found by Fisher's protected least significant differences test at $p<0.05$.

Results and Discussion

Growth parameters: The data on the growth attributes like leaf: stem ratio and SPAD reading, growth indices like leaf area index, absolute growth rate (AGR g day^{-1}) and crop growth rate (CGR g m^{-2} day^{-1}) in fodder maize as influenced by varied levels of recommended dose of nitrogen along with foliar application of different concentrations of nano urea and urea (Table 1 and 2).

The increase in leaf: stem ratio with additional levels of nitrogen through foliar application of urea @ 2% and nano urea @ 0.4% was mainly due to rapid expansion of dark green foliage and which could intercept and utilize the incident solar radiation in the production of photosynthates and eventually resulting in higher meristematic activity and increased leaf: stem ratio of fodder maize. These results are in conformity with findings of Vimal *et al*. (2017) [16] and Lagad *et al*. (2020) [11].

Significantly higher SPAD reading (37.80 and 32.8) was recorded with application of 100% recommended dose of N + Urea @ 2% spray over all other treatments except application of 100% recommended dose of N + Nano urea @ 0.4% spray (35.29 and 31.87, respectively) at 40 DAS and harvest. However, lower SPAD reading of 26.16 and 22.27 was observed respectively with control (T_1) at 40 DAS and harvest.

The SPAD readings is an indicator of good photosynthesis and the foliar spray of urea @ 2% or with nano urea @ 0.4% with application of 100% recommended dose of N has performed better in measuring the leaf chlorophyll content of fodder maize. The chlorophyll content shows linear increase in proportion to the amount of nitrogen present in the leaf. Nano urea being nano sized particles depends on availability of leaf surface area at different days of growth for better absorption, permeability and penetration into plant leaves. So, increased N content may lead to more chlorophyll content. Thus, the increase in SPAD value and leaf N content might helped in continuous supply of sufficient nitrogen throughout the crop growth period (Benzon *et al*. (2015) [5] and Aljuthery and Almaamouri (2020)) [3].

Treatment with application of 100% recommended dose of N + Urea @ 2% spray recorded significantly maximum Leaf area index (10.90 and 15.60) at 40 DAS and harvest, respectively which was found to be on par with T_6. On the other hand, minimum LAI (10.60 and 15.18) at 40 DAS and harvest was observed in T_1 (Table 2).

Between 20 - 40 DAS and 60 DAS - harvest, significantly higher AGR (0.57 and 1.58 g day^{-1}) and CGR (18.87 and 52.69 g m^{-2} day^{-1}) was recorded in 100% recommended dose of N + Urea @ 2% spray and it was on par with 100% recommended dose of N + Nano urea @ 0.4% spray compared to all other treatments. At the same time, lower AGR (0.24 and 1.24 g day^{-1}) and CGR (7.97 and 37.30 g m^{-2} day^{-1}) was noticed in control plots.

Yield: The data on the green fodder yield and dry matter yield of fodder maize was significantly influenced by varied levels of recommended dose of nitrogen with different foliar concentrations of nano urea and urea (Table 3).

Green fodder yield was significantly increased from 375.27 q ha^{-1} in T_2 (recommended dose of fertilizer alone) to 427.70 q ha^{-1} in treatment T_9 (100% recommended dose of N along with foliar application of 2% urea) showing an increase of 13.97% (T_9) and 12.49% in T_6 than RDF alone. However, green fodder yield recorded in T_9 was on par with T_6 and T_6 was on par with T_3. Whereas, lower green fodder yield of 203.20 q ha^{-1} was observed in control and percent increase of green fodder yield over control (T_1) is depicted in Fig. 2.

At harvest, dry matter yield was significantly influenced by various treatments. The application of 100% recommended dose of N + Urea @ 2% spray recorded significantly higher dry matter yield (T_9: 91.64 q ha^{-1}), which was on par with application of 100% recommended dose of N + Nano urea @ 0.4% spray (T_6: 89.87 q ha^{-1}). However, T_6 was on par with 100% recommended dose of N + Nano urea @ 0.2% spray (T_3: 80.48 q ha^{-1}). Whereas lower dry matter yield of 36.85 q ha^{-1} was observed in control (T_1).

The application of 100% RDN along with 2% foliar spray of urea at 20 and 40 DAS resulted in significantly higher green fodder yield and dry matter yield compared to other treatments

except T_6. This can be mainly attributed to better growth parameters *viz*., plant height, leaf: stem ratio, leaf area and also resulted in more accumulation of dry matter as evidenced in present study. The beneficial effects of nitrogen on cell division and elongation, which led to increased photosynthetic area and in turn more production and accumulation of photosynthates yielding higher green fodder and that in terms yield dry matter. The findings of Bochare (2015) [6] and Meena *et al*. (2021) [13] were also confirmed the same results. Highest forage yield with nano urea foliar spray rates were in conformity with the findings of Abdel (2018) [1].

Quality parameters: The data on the quality parameters like crude protein yield (CPY), total digestible crude protein yield (TDCPY), total carbohydrate yield (Total CHO yield), dry matter content and moisture content of fodder maize as influenced by varied levels of recommended dose of nitrogen with different foliar concentrations of nano urea and urea are presented in Table 4.

The CPY and TDCPY was found significantly influenced by different levels of N with foliar spray treatments. The application of 100% recommended dose of N + Urea @ 2% spray showed significantly higher crude protein yield and total digestible crude protein yield (9.59 q ha^{-1} and 8.64 q ha^{-1}, respectively) followed by T_6. Whereas, lower CPY and TDCPY of 2.81 and 2.06 q ha^{-1} was observed in control respectively. Increasing levels of recommended dose of N along with foliar spray of urea or nano urea has performed effectively in increasing the protein content and yield of fodder maize crop and T_9 recorded higher crude protein yield followed by T_6 due to accumulation of more dry matter and protein content of plant, which in turn increased the protein yield. Similar results are also reported by Shekara *et al*. (2015) [15] and Meena *et al*. (2021) [13].

The total CHO yield was significantly influenced by different foliar nutrient management treatments. The application of 100% recommended dose of N + Urea @ 2% spray showed significantly higher CHO yield (74.60 q ha^{-1}) followed by T_6. Higher levels of nitrogen correspondingly increased meristematic activity due to which absorption of mineral salts increases leading to rapid respiration process and conversion of most of the carbohydrates into fat. Apart from that nitrogen plays a major role in protein synthesis, the nitrogen free extract is a part of carbohydrate (Harikesh *et al*. (2017)) [9]. This is evidenced by lower CHO yield in control.

At harvest, dry matter and moisture content was not significantly influenced by varied levels of recommended dose of nitrogen with different foliar concentrations of nano urea and urea. However, numerically higher dry matter and moisture content (21.40% and 13.67%) was observed in T_9 and T_5, respectively.

Economics: Economics in terms of net returns (NR) and benefit: cost ratio (BCR) varied with different treatments (Fig. 1). Application of 100% recommended dose of N + Urea @ 2% spray (70,945 Rs. ha^{-1} and 2.97, respectively) followed by 100% recommended dose of N + Nano urea @ 0.4% spray (67,829 Rs. ha^{-1} and 2.80, respectively) recorded higher net monetary returns and BCR over all the treatments and this has resulted in higher BCR as recorded in T_9. This may be attributed to lower cost of cultivation and higher net returns as reported by Yogendra *et al*. (2020) [19], Mohammad (2021) [14] and Ajithkumar *et al*. (2021) [2].

Table 1: Growth attributes of fodder maize as influenced by foliar application of nano urea and urea

Treatments	Growth attributes			
	Leaf: stem ratio		SPAD reading	
	40 DAS	At harvest	40 DAS	At harvest
T_1	0.53	0.30	26.16	22.27
T_2	0.79	0.40	31.89	27.95
T_3	0.80	0.41	32.38	28.41
T_4	0.66	0.35	31.61	27.19
T_5	0.56	0.34	27.98	24.73
T_6	0.86	0.45	35.29	31.87
T_7	0.68	0.37	32.15	26.73
T_8	0.58	0.35	30.25	26.60
T_9	0.89	0.47	37.80	32.81
T_{10}	0.76	0.39	31.60	28.02
T_{11}	0.59	0.34	28.62	25.12
S.Em.±	0.03	0.01	1.28	1.26
CD (P=0.05)	0.08	0.04	3.74	3.71

Table 2: Growth indices of fodder maize as influenced by foliar application of nano urea and urea

Treatments	Growth indices					
	LAI		AGR (g day^{-1})		CGR (g m^{-2} day^{-1})	
	40 DAS	At harvest	20-40 DAS	60 DAS-harvest	20-40 DAS	60 DAS-harvest
T_1	4.65	5.69	0.24	1.12	7.94	37.30
T_2	9.27	10.95	0.42	1.53	13.88	51.12
T_3	9.44	13.27	0.47	1.48	15.63	49.27
T_4	8.11	9.38	0.26	1.21	8.65	40.47
T_5	5.84	9.04	0.26	1.18	8.63	39.17
T_6	10.60	15.18	0.52	1.51	17.49	50.47
T_7	8.40	10.30	0.35	1.46	11.70	48.52
T_8	7.22	9.15	0.32	1.02	10.53	33.89
T_9	10.90	15.60	0.57	1.58	18.87	52.69
T_{10}	8.87	10.13	0.37	1.42	12.41	47.23
T_{11}	6.60	8.95	0.24	1.03	7.92	34.36
S.Em.±	0.30	0.41	0.02	0.14	0.69	4.56
CD (P=0.05)	0.89	1.21	0.06	0.40	2.03	13.37

Table 3: Green fodder yield and Dry matter yield as influenced by foliar application of nano urea and urea at harvest

Treatments	Yield (q ha^{-1})	
	Green fodder yield	Dry matter yield
T_1	203.20	36.85
T_2	375.27	78.12
T_3	386.40	80.48
T_4	316.80	63.20
T_5	275.10	51.89
T_6	422.17	89.87
T_7	321.40	65.06
T_8	293.50	58.07
T_9	427.70	91.64
T_{10}	357.80	73.17
T_{11}	293.60	56.46
S.Em.±	13.76	3.58
CD (P=0.05)	40.37	10.50

Table 4: Quality parameters of fodder maize as influenced by foliar application of nano urea and urea at harvest

Treatments	CPY (q ha^{-1})	TDCPY (q ha^{-1})	Total CHO yield (q ha^{-1})	Dry matter content (%)	Moisture content (%)
T_1	2.81	2.06	31.69	18.14	13.01
T_2	7.53	6.64	64.52	20.93	12.85
T_3	8.01	7.09	66.54	20.80	13.09
T_4	5.51	4.67	53.28	19.92	13.05
T_5	4.22	3.42	44.12	18.87	13.67
T_6	9.40	8.44	73.51	21.29	12.51
T_7	5.90	5.06	54.83	20.17	13.59
T_8	4.98	4.16	49.02	19.80	13.45
T_9	9.59	8.64	74.60	21.40	11.94
T_{10}	6.86	5.99	60.88	20.50	13.56
T_{11}	4.89	4.07	48.14	19.23	13.10
S.Em.±	0.29	0.28	5.13	0.73	0.63
CD (P=0.05)	0.84	0.82	15.04	NS	NS

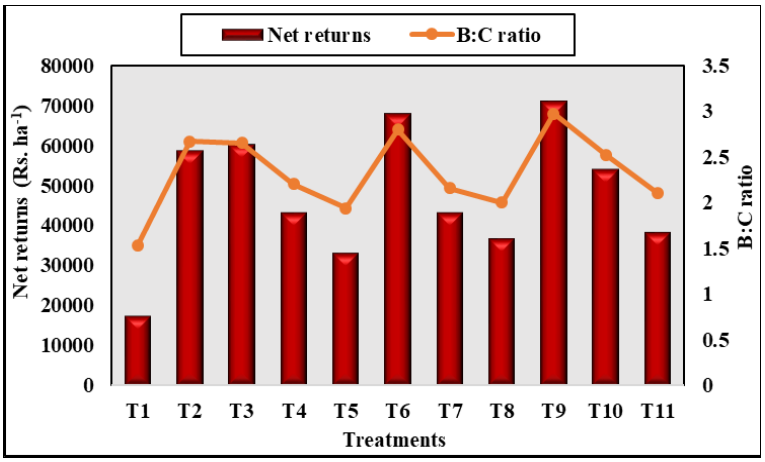

Fig 1: Economics of fodder maize cultivation as influenced by foliar application of nano urea and urea

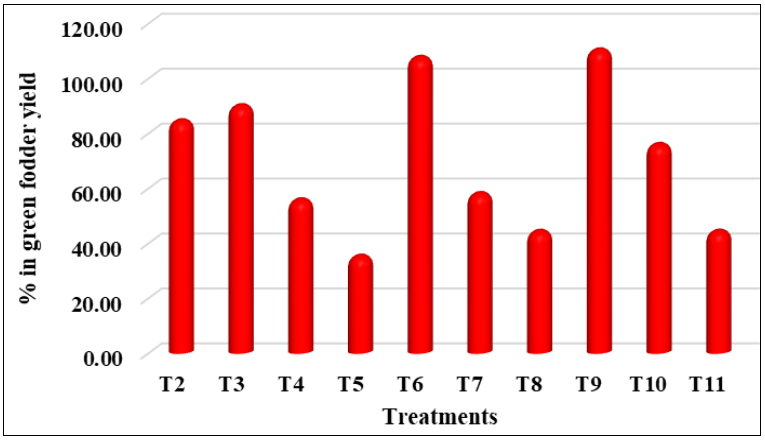

Fig 2: Per cent increase of green fodder yield over control (T_1) as influenced by nano urea and urea application in fodder maize

Conclusion

The results proved that application of 100% recommended dose of nitrogen along with urea @ 2% spray or nano urea @ 0.4 % at 20 and 40 DAS superior over different treatments tested in terms of growth, yield and quality as well as economics of fodder Maize.

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