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Response of Fodder Maize (*Zea mays* L.) to Urea and Nano Urea on Growth, Yield and Economics

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ABSTRACT: In order to meet the increasing demand for supply of quality forage due to increasing pressure on agricultural land for food and cash crops, quality fodder production for sustainability on limited space and time could be achieved from ideal forage crops and best management practices. Hence there is a need for nitrogen management with increasing use efficiency. In this regard present investigation was set to study the response of fodder maize (*Zea mays* L.) to urea and nano urea on growth, yield and economics. The experiment was carried out in randomised block design with 6 treatments and 4 replications at College farm, College of Agriculture, Rajendranagar, Hyderabad, Telangana, in sandy loam soils during *rabi* 2021. The study revealed that soil application of urea @33 kg N ha^{-1} each at basal, 20 & 40 DAS (T_2) recorded significantly at par with basal soil application of urea @33 kg N ha^{-1} + foliar spray of nano urea @3 ml l^{-1} each at 20 & 40 DAS with respect to growth and yield of fodder maize crop. 100 % RDN application through urea recorded higher with respect to economics over other treatments. Hence, nitrogen management through urea and also urea + nano urea foliar spray @3 ml l^{-1} might be the best combination among other foliar spray rates for attaining best use efficiency and sustainability.

Keywords: Nano urea, fodder maize, urea, foliar spray, leaf to stem ratio, nitrogen.

INTRODUCTION

Fodder crops are the plant species that are cultivated and harvested for feeding livestock in the form of forage (cut green and fed fresh), where livestock is an important asset and livelihood option for people in rainfed areas of India. Better feeding could be achieved by ensuring the adequate supply of good quality forage from improved varieties and best management practices (BMPs). Fodder production depends on the cropping pattern, climate and socio-economic conditions of the region. Total area under fodder crops in India is 9.58 m. ha (Indiastat, 2020) on individual crop basis. Which is only 4.2 to 4.4% of the total cultivated area and currently a net deficiency of 35.6% green fodder, 10.95% dry fodder and 44% concentrate feed materials in the country (IGFRI Vision, 2050). There is hardly any scope of expansion due to increasing pressure on agricultural land for food and cash crops. The solution, therefore, lies in increasing quality fodder production on limited space and time as green fodder is considered as the rich and cheapest source of protein, vitamins, carbohydrates and minerals for livestock (Kumar *et al*., 2020).

Among the cultivated forage crops, maize is an ideal crop for fodder as well as silage on account of its high yield potential and nutritional profile. It has highest fodder production potential, per day productivity, wider adaptability, succulent nature, excellent fodder quality with high digestibility and palatability. Hence it can be fed at any stage of growth without any risk to animals as it is free from anti metabolites. It is one of the most adaptable emerging crops having wider adaptability under varied agro climatic conditions (Arya *et al*., 2015). Nitrogen is the most important limiting factor for plant growth and its application increases the nitrogen, crude protein content and metabolizable energy besides improving succulency, palatability and digestibility of fodder maize (Patel *et al*., 2007).

Applied N through conventional fertilizers undergoes transformation processes. In order to improve the N use efficiency, several strategies have been suggested in the past few decades. Nano fertilizers are the important tools in agriculture to improve crop growth, yield and quality parameters, reduce wastage of applied fertilizers and cost of cultivation. Nano urea (Liquid) is a source of nitrogen, crucial towards proper crop growth and development. Typically, nitrogen content in a healthy plant is in the range of 1.5 to 4 %. Foliar application of Nano urea (Liquid) at critical crop growth stages effectively fulfills the nitrogen requirement and reflects higher crop productivity and quality in comparison to conventional urea. The present study was therefore, designed to analyze the response of fodder maize with urea and nano urea liquid on growth, yield and economics.

MATERIALS AND METHODS

The present field experiment was carried out at College Farm, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, Telangana during rabi 2021 which is geographically situated at 17°19'19.2" N Latitude and 78°24' 39.2" E longitude and at an altitude of 542.3 m above mean sea level. Experimental location falls under Southern Telangana Agro Climatic Zone of Telangana. The soil was sandy loam in texture having pH 7.5, electrical conductivity 0.67 dS/m and organic carbon 0.44 % with available nitrogen (187 kg ha^{-1}), phosphorus (64 kg ha^{-1}) and potassium (334 kg ha^{-1}). The total amount of rainfall received during the crop growth period was 2.59 mm in 2 rainy days. During crop growth period the average of weekly mean T_{max}, T_{min}, $RH_{(morning)}$, $RH_{(evening)}$ and evaporation recorded were 28.87°C, 16.07°C, 89.63 %, 52.87 % and 3.11 mm respectively. The experiment was laid out in a Randomized Block Design using six treatment combinations with four replications. In this experiment, Nitrogen was applied in three split doses with both forms of Urea and Nano urea liquid with different doses through soil and foliar application methods. P_2O_5 & K_2O were applied basally through SSP and MOP sources respectively. The standard RDF (100%) dose is 100:40:30 NPK Kg ha^{-1}. These six treatment combinations were laid out with four replications, among which nutrients 1/3rd dose of nitrogen (Urea), full dose of phosphorus and potassium were applied at the time of sowing. Remaining, 1/2 dose of nitrogen (soil application of urea and foliar spray of nano urea liquid) were applied each at 20 and 40 DAS respectively.

The other agronomic practices like irrigation, insect pests and weed control measures were done as per recommended practices of PJTSAU, Rajendranagar. All growth and yield parameters of fodder maize were recorded periodically on randomly selected and tagged plants. The plant samples were collected at crop harvest and analyzed for quality parameters following standard procedure. The data obtained from various parameters under study were analysed by the method of analysis of variance (ANOVA) as described by Gomez and Gomez (1984). The level of significance used in the "F" test was given at 5%.

The cost of cultivation and the gross returns were calculated using the green fodder yield of fodder maize and the market price of the produce at the time of marketing. The net returns per hectare were calculated by deducting the cost of cultivation per hectare from the gross returns per hectare.

Net monetary returns = Gross monetary returns - Total cost of cultivation

Benefit cost ratio was worked out for each treatment by using the formula given by Subba Reddy and Raghuram (1996).

$$\text{B: C} = \frac{\text{Gross returns (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

RESULTS AND DISCUSSION

Growth Parameters. The data pertaining to growth parameters *viz.,* plant height, number of leaves $plant^{-1}$ and stem diameter are presented in (Table 1). Highest plant height, number of leaves $plant^{-1}$ and stem diameter (178 cm, 15.15 and 3.08 cm respectively) were recorded with soil application of urea @33 kg N ha^{-1} each at basal, 20 & 40 DAS (T_2) which was statistically at par with basal soil application of urea @33 kg N ha^{-1} + foliar spray of nano urea @3 ml l^{-1} each at 20 & 40 DAS (T_4) (164 cm, 14 and 2.86 cm respectively). T_4 recorded at par with basal soil application of urea @33 kg N ha^{-1} + foliar spray of nano urea @3.5 ml l^{-1} each at 20 & 40 DAS (T_5) (157 cm, 13.75 and 2.80 cm respectively). While lowest growth parameters are recorded with no nitrogen application (105 cm, 9.75 and 2.01 cm respectively). Growth parameters increased by 16-36%, 11-30% and 11-30% respectively with the influence nano urea foliar spray in combination with urea application over control.

Results revealed that application of N through both sources (Urea and nano urea) either individually or in combination significantly increased growth parameters over control. Similar results were reported by Sumanta *et al.* (2022); Ajithkumar *et al.* (2021). The increase might be due to increased availability of nutrients for plant growth which may have increased chlorophyll formation, photosynthetic rate, dry matter production and thus resulted in improved overall growth of the plant. Increased plant height resulted in more nodes per plant which accommodated more leaves per plant. Again nitrogen helps in rapid growth and development of plants as they help in photosynthesis and various plant biochemical processes which respond towards growth (Jasim Iqbal *et al*., 2016). The middle nano urea foliar spray rates were in close agreement with the findings of Abdel Salam *et al*. (2018) in lettuce.

Leaf Stem ratio. Leaf stem ratio of fodder maize influenced by urea and nano urea applications presented in (Table 1) reveals that among the nano urea foliar spray applications, basal soil application of urea @33 kg N ha^{-1} + foliar spray of nano urea @3 ml l^{-1} each at 20 & 40 DAS recorded (0.59) L: S ratio and was

statistically at par with basal soil application of urea @33 kg N ha^{-1} + foliar spray of nano urea @3.5 ml l^{-1} each at 20 & 40 DAS (0.55) and significantly highest leaf: stem ratio was recorded with absolute control (0.73). Statistically lowest leaf: stem ratio (0.43) was recorded with soil application of urea @33 kg N ha^{-1} each at basal, 20 & 40 DAS. Lower leaf to stem ratio registered might be due to advancing in age of the crop from one stage to another stage, weight of stems increased more comparatively to weight of leaves. In comparison with urea to that of nano urea foliar sprays, maximum weight of stem was registered in plants fertilized with 100% urea application (T_2) which resulted in lower leaf to stem ratio. It ranged from 0.43 to 0.73. Similar findings were reported by Tiwana *et al*. (2005) in fodder pearl millet.

Yield. Perusal of yield data presented in (Table 1) revealed that green fodder yield and dry fodder yield were significantly influenced by urea and nano urea applications. Soil application of urea @33 kg N ha^{-1} each at basal, 20 & 40 DAS (T_2) recorded green and dry fodder yield (347 and 90.61 q ha^{-1} respectively) and was significantly similar with basal soil application of urea @33 kg N ha^{-1} + foliar spray of nano urea @3 ml l^{-1} each at 20 & 40 DAS (T_4) (322 and 82.59 q ha^{-1} respectively). (T_4) recorded on par yield with basal soil application of urea @33 kg N ha^{-1} + foliar spray of nano urea @3.5 ml l^{-1} each at 20 & 40 DAS (T_5) (308 and 76.55 q ha^{-1} respectively). While significantly lowest yield was recorded with no nitrogen (224 and 35.74 q ha^{-1} respectively). Yield *viz*., green and dry fodder yield increased by 11-30% and 37-57% with the influence of urea in combination with nano urea foliar sprays over absolute control respectively. This may be attributed that nitrogen is an essential constituent of plant tissue and is involved in cell division and cell elongation which reflected its beneficial effect on the growth characters *viz*., plant height, number of leaves per plant and stem diameter and yielding higher green and dry fodder. Almost similar findings were reported by Rajesh *et al*. (2021) and Abdel-Aziz *et al*. (2018). The middle nano urea foliar spray rates were in close agreement with the findings of Abdel-Salam *et al*. (2018) in lettuce.

Economics. On perusal of data (Table 2) gross returns and net returns influenced by urea and nano urea applications in fodder maize revealed that higher relative economics were realized with application of 100% RDN through soil application of urea @33 kg N ha^{-1} each at basal, 20 & 40 DAS (T_2) (69400 and 21900 Rs ha^{-1} respectively). The next best treatment was T_4 (basal soil application of urea @33 kg N ha^{-1} + foliar spray of nano urea @3 ml l^{-1} each at 20 & 40 DAS) (64100 and 14800 Rs ha^{-1} respectively) and the lowest were realized with T_1 (Absolute control) (44700 and 1000 Rs ha^{-1} respectively). Gross returns increased by 8-28% and 36% with 100 % RDN application through urea over urea in combination with nano urea foliar sprays and absolute control respectively and increased by 11-30% with the influence of urea in combination with nano urea foliar sprays over absolute control.

Table 1: Influence of urea and nano urea on growth, yield attributes and yield of fodder maize.

Treatments	Plant height (cm)	Number of leaves $plant^{-1}$	Stem diameter (cm)	Leaf: stem ratio	Green fodder yield (q ha^{-1})	Dry matter yield (q ha^{-1})
T_1- Control	105	9.75	2.01	0.73	224	35.74
T_2- Soil application of urea @33 kg N ha^{-1} each at basal, 20 & 40 DAS.	178	15.15	3.08	0.43	347	90.61
T_3- Basal soil application of urea @33 kg N ha^{-1} + foliar spray of nano urea @2.5 ml l^{-1} each at 20 & 40 DAS.	125	11.00	2.27	0.48	252	57.22
T_4- Basal soil application of urea @33 kg N ha^{-1} + foliar spray of nano urea @3 ml l^{-1} each at 20 & 40 DAS.	164	14.00	2.86	0.59	322	82.59
T_5- Basal soil application of urea @33 kg N ha^{-1} + foliar spray of nano urea @3.5 ml l^{-1} each at 20 & 40 DAS.	157	13.75	2.80	0.55	308	76.55
T_6- Basal soil application of urea @33 kg N ha^{-1} + foliar spray of nano urea @4 ml l^{-1} each at 20 & 40 DAS.	144	12.59	2.58	0.52	283	69.05
SEm±	4.96	0.39	0.08	0.02	8.86	2.84
CD (P=0.05)	14.95	1.19	0.24	0.05	26.70	8.56

Table 2: Influence of urea and nano urea on economics of fodder maize.

Treatments	Cost of cultivation (₹ha^{-1})	Gross returns (₹ha^{-1})	Net returns (₹ha^{-1})	B:C ratio
T_1- Control	43700	44700	1000	1.02
T_2- Soil application of urea @33 kg N ha^{-1} each at basal, 20 & 40 DAS.	47500	69400	21900	1.46
T_3- Basal soil application of urea @33 kg N ha^{-1} + foliar spray of nano urea @2.5 ml l^{-1} each at 20 & 40 DAS.	48900	50300	1400	1.03
T_4- Basal soil application of urea @33 kg N ha^{-1} + foliar spray of nano urea @3 ml l^{-1} each at 20 & 40 DAS.	49300	64100	14800	1.30
T_5- Basal soil application of urea @33 kg N ha^{-1} + foliar spray of nano urea @3.5 ml l^{-1} each at 20 & 40 DAS.	49800	61500	11700	1.23
T_6- Basal soil application of urea @33 kg N ha^{-1} + foliar spray of nano urea @4 ml l^{-1} each at 20 & 40 DAS.	50200	56600	6400	1.13

Note: Selling price of fodder maize @2 ₹ kg^{-1} green fodder.

Higher level of nitrogen application which might be owing to better nitrogen use efficiency increased green fodder yield resulting in higher gross returns and net returns. Similar results were also reported by Kumar *et al*. (2020b). The data on B: C ratio influenced by urea and nano urea applications in fodder maize presented in (Table 2) revealed that highest benefit-cost ratio was recorded with soil application of urea @33 kg N ha^{-1} each at basal, 20 & 40 DAS (T_2) (1.46), followed by T_4 (basal soil application of urea @33 kg N ha^{-1} + foliar spray of nano urea @3 ml l^{-1} each at 20 & 40 DAS) (1.30) and the lowest B: C ratio was realized with T_1 (Absolute control) (1.02).

B: C ratio increased by 1-22% with urea in combination with nano urea foliar spray over absolute control. Higher green fodder yield and net returns obtained with T_2 might be responsible for higher benefit-cost ratio. The present findings confirm with that of Ajithkumar *et al.* (2021).

CONCLUSION

Based on the present investigation, it can be concluded that basal application of urea @33 kg N ha^{-1} + foliar spray of nano urea @3 ml l^{-1} each at 20 & 40 DAS could be the best nitrogen management option. However soil application of urea @33 kg N ha^{-1} each at basal, 20 & 40 DAS as 100% RDN application through urea recorded statistically at par with urea + nano urea foliar sprays @3 ml l^{-1} each at 20 & 40 DAS with respect to growth & yield of fodder maize. 100% RDN application through urea recorded higher gross returns, net returns and B: C ratio over other treatments.

FUTURE SCOPE

Study on the effect of nano urea on multicut varieties and perennial fodders need to be focussed. Study of nano urea in combination with nano zinc and nano DAP needs to be emphasized.

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Conflict of Interest. None.

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