Comparative Evaluation of Nano Urea and Urea Foliar Sprays on Nutrient Uptake and Soil Fertility in Fodder Maize (*Zea mays* L.) Production

ABSTRACT

An investigation on "Comparative Evaluation of Nano Urea and Urea Foliar Sprays on Nutrient Uptake and Soil Fertility in Fodder Maize (*Zea mays* L.) Production" was conducted during *kharif* 2022 at ZARS, V. C. Farm, Mandya, on sandy loam soil. The experiment was laid out in RCBD with thirteen treatments replicated thrice. Treatments include combinations of basal application of urea at 50, 75 and 100% recommended dose of N with varied levels of nano urea and urea spray at 20 and 40 DAS, which were compared with RDF and control (RDF without N). Among the treatments tested, 100% recommended dose of N + Urea @ 2% spray recorded significantly higher green fodder yield (427.70 q ha^{-1}) and dry matter yield (91.64 q ha^{-1}), nutrient uptake (153.49 kg ha^{-1} of N, 33.37 kg $ha^{-1}$of P and 121.29 kg ha^{-1} of K) and was on par with 100% recommended dose of N + Nano urea @ 0.4% spray. Available N, P_2O_5 and K_2O status in the post-harvest soil varied significantly but pH, EC and OC was not significantly influenced by varied levels of recommended dose of nitrogen with different foliar concentrations of nano urea and urea. Higher soil available nitrogen, phosphorus and potassium was recorded 100% recommended dose of N + Urea @ 2% spray (213.25, 42.58, 189.06 kg ha^{-1}, respectively) followed by 100% recommended dose of N + Nano urea @ 0.4% spray (200.70, 40.87 and 187.95 kg ha^{-1}, respectively).

Key words: Nano Urea, Nutrient uptake, Available soil nutrients and Yield

1. INTRODUCTION

Agriculture plays a crucial role to provide bread and butter to more than half of the population of India despite its falling contribution to India's GDP. Among different enterprises under the giant umbrella of the agricultural production system, livestock is the most prominent one. Based on the 19th livestock census in world, India is having the largest livestock Population of 512 million, with an area of 8.30 m ha under fodder to feed them (Anon, 2018). It is posing a terrific pressure on livestock production for feed and fodder, as land available for fodder production is decreasing. Lower productivity of cattle and buffalos under Indian condition is accountable mainly due to unavailability of quality feed and fodder, improper nutrition, inadequate health-care and management. At present, the country faces a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44% concentrate feed ingredients (Anonymous 2013).

Maize (*Zea mays* L.) is one of the most important cereals, next to wheat and rice in the world as well as India. It is one of the most versatile crops and can be grown over diverse environmental conditions and also diversified uses in human food, animal feed and raw materials for large number of industrial products (Ayyar *et al*. 2019).

When fertilizers are applied to soil, it forms certain soil complexes, which affects the absorption of necessary elements by plants. While, fertilizer application to the soil continues to be the primary method of feeding the bulk of agricultural plants, foliar application of nutrients has made its importance in the production of crops. By foliar application, the nutrients are applied and taken-up directly by their target organs, providing a specific and rapid response. So that, foliar fertilization improves specific advantages over soil applied fertilizers. 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. Keeping these things in view, an investigation entitled "Comparative Evaluation of Nano Urea and Urea Foliar Sprays on Nutrient Uptake and Soil Fertility in Fodder Maize (*Zea mays* L.) Production" was conducted during *kharif* 2022.

2. MATERIAL AND METHODS

The study was carried out on-site at the Zonal Agricultural Research Station, Vishweshwaraiah Canal Farm, Mandya (Karnataka), which is situated 695 metres above mean sea level and lies between 12º 45' and 30º 57' North latitude and 76º 45' and 78 º 24' East longitude. The research station is located in Karnataka's Southern Dry Zone, or Agro Climatic Zone VI, Region III. The field experiment had the highest mean maximum air temperature in September and the highest recorded rainfall of 447.1 mm in August. During the growing season, the relative humidity fluctuated in the morning and afternoon from 88.7 to 90 percent and 66.4 to 69.0 percent, respectively. From August through December, the average number of bright sunshine hours ranged from 4.3 to 5.8 hours. The sandy loam soil found at the experimental location has a composition of 67.08% sand, 26.20% silt, and 6.72% clay. The soil's reaction temperature is neutral at 7.02, its soluble salt content is low at 0.17 dSm^{-1}, its organic carbon content is medium at 0.62%, its available P_2O_5 is 42.31 kg ha^{-1}, its available K_2O is 241.24 kg ha^{-1}, and its available nitrogen is low at 206.97 kg ha^{-1}.

The field experiment was conducted in Randomized Complete Block Design with three replication and eleven treatments. 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 at the rate of 75:40 P_2O_5 and K_2O kg ha^{-1}, respectively in the form of single super phosphate and muriate of potash, respectively were applied at the time of sowing for all treatments.

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 analyse the nutrients. The surface soil samples from 0 to 15 cm depth were also collected from every experimental plot after harvest of crop and were air dried in shade, powdered with wooden mallet and sieved and analysed for pH, EC, organic carbon, available nitrogen, phosphorus and potassium content of the soil. Nitrogen content was determined by modified Micro-Kjeldhal's method, phosphorus content in the digested plant sample was determined by vanadomolybdate phosphoric yellow colour method in nitric acid medium and the colour intensity was recorded at 660 nm wave length and potassium in the digested plant sample was determined by atomizing the diluted acid extract in a flame photometer as described by Jackson (1973). All data recorded were analysed with the help of analysis of variance (ANOVA) technique (Gomez and Gomez 1984) and least significant difference at 5% level of significance ($P<0.05$) was computed to compare the treatments.

3. RESULTS AND DISCUSSION

3.1 Yield: The data on the yield parameters like green fodder yield and dry fodder yield 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 Figure 1.

Green fodder yield was significantly influenced by various foliar spray treatments. The application of 100% recommended dose of N + Urea @ 2% spray recorded significantly higher green fodder yield (T_9: 427.70 q ha^{-1}) and which was found on par with application of 100% recommended dose of N + Nano urea @ 0.4% spray (T_6: 422.17 q ha^{-1}). However, T_6 was on par with 100% recommended dose of N + Nano urea @ 0.2% spray (T_3: 386.40 q ha^{-1}). Whereas lower green fodder yield of 203.20 q ha^{-1} was observed in control treatment 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 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 dry matter accumulation $plant^{-1}$ as evidence in present study. The beneficial effects of nitrogen on cell division and elongation, formation of nucleotides and coenzymes, which led to increased meristematic activity and photosynthetic area and in turn more production and accumulation of photosynthates yielding higher green fodder. The findings of Bhoya *et al.* (2013), Bochare (2015) and Meena *et al*. (2021) were also confirmed the same results. Highest forage yield with nano urea foliar spray rates were in conformity with the findings of Abdel (2018).

Dry fodder yield was significantly influenced by various foliar spray treatments. The application of 100% recommended dose of N + Urea @ 2% spray recorded significantly higher dry fodder yield (T_9: 91.64 q ha^{-1}), which was found 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 fodder yield of 36.85 q ha^{-1} was observed in control treatment T_1.

The treatment T_9 was recorded significantly higher dry fodder yield *fb* T_6 this mainly because of superior performance in vegetative growth with respect to plant height, a greater number of leaves, leaf area and leaf: stem ratio result in more accumulation of dry matter as evidence in present study. Nitrogen and phosphorus application through RDF and foliar spray of urea and nano urea treatments increase plant height, stem girth, leaf: stem ratio which ultimately increase dry fodder yield of forage maize. The results are in corroborate with the finding of Tariq *et al.* (2011), Singh *et al.* (2012) and Meena *et al.* (2021). The highest dry forage yield obtained with nano urea foliar spray rates were in conformity with the findings of Abdel (2018).

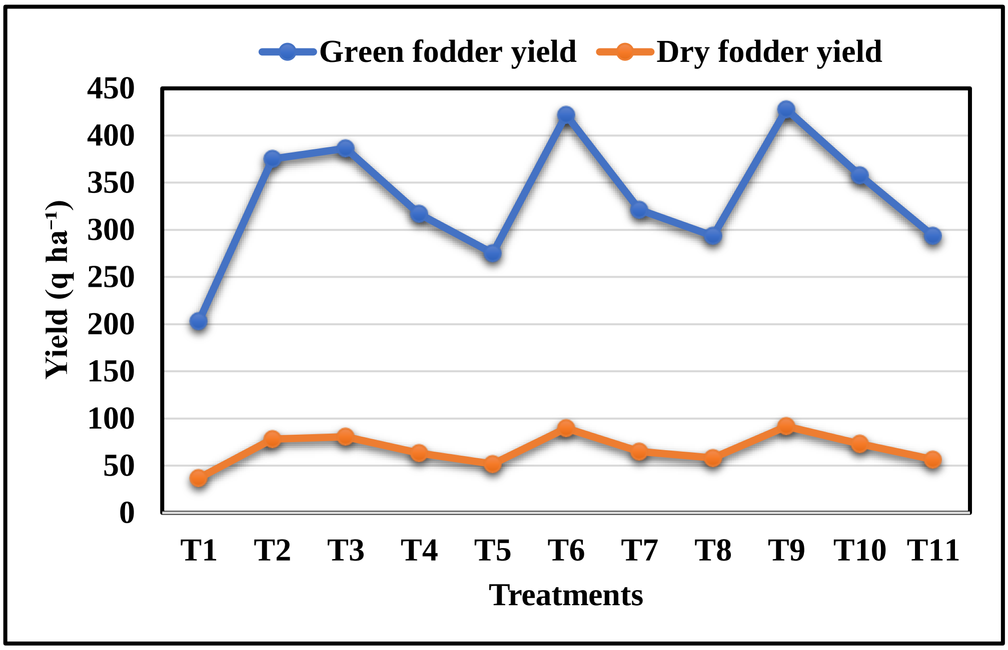

Fig. 1: Green fodder yield and Dry fodder yield as influenced by foliar application of nano urea and urea at harvest

3.2 Nutrient uptake*:* Varied levels of recommended dose of nitrogen with different foliar concentrations of nano urea and urea brought significant variations in nutrient uptake (Table 1). At harvest, supply of 100% recommended dose of N + Urea @ 2% spray recorded significantly higher N, P and K uptake (153.49, 33.37 and 121.29 kg ha^{-1}, respectively) and which was statistically on par with T_6 (145.47, 30.09 and 113.21 kg ha^{-1}, respectively) and significantly superior over the remaining treatments. The lower N, P and K uptake (44.96, 7.86 and 38.05 kg ha^{-1}, respectively) recorded with control.

The total nitrogen uptake by forage maize was linearly increased with an increase in RDF along with foliar application of urea and nano urea. The application of RDF along with foliar application of urea and nano urea known to increase the nutrient concentration in soil solution resulting in better extraction by roots and translocation within plant system. Similar trend was also indicated by Sheoran *et al*. (2008) and Bochare (2015). Highest nitrogen uptake with nano urea foliar spray rates were in conformity with the findings of Abdel (2018).

Increased uptake of phosphorus by fodder maize might be due to an increase in the amount of urea applied to the soil as nitrogen, which when nitrified produces hydrogen ions in addition to nitrate ions. Application of nano urea increased the uptake of N due to more surface area and permeability of nano urea which in turn increased the absorption of K nutrients also. The results were conformity with the findings Manjanagouda *et al*. (2017), Abdel (2018) and Upasana *et al*. (2022).

Table 1: Nutrient uptake as influenced by foliar application of nano urea and urea at harvest

Treatments	Nutrient uptake (kg ha^{-1})		
	Nitrogen	**Phosphorus**	**Potassium**
T_1	44.96	7.86	38.05
T_2	120.23	25.42	92.25
T_3	126.85	25.73	98.16
T_4	88.10	16.90	64.93
T_5	67.47	13.84	53.92
T_6	145.47	30.09	113.21
T_7	94.47	15.74	70.18
T_8	79.73	15.91	55.99
T_9	153.49	33.37	121.29
T_{10}	109.83	22.94	78.13
T_{11}	78.20	15.98	52.79
S.Em.±	**4.58**	**0.92**	**3.44**
CD (P=0.05)	**13.43**	**2.71**	**10.09**

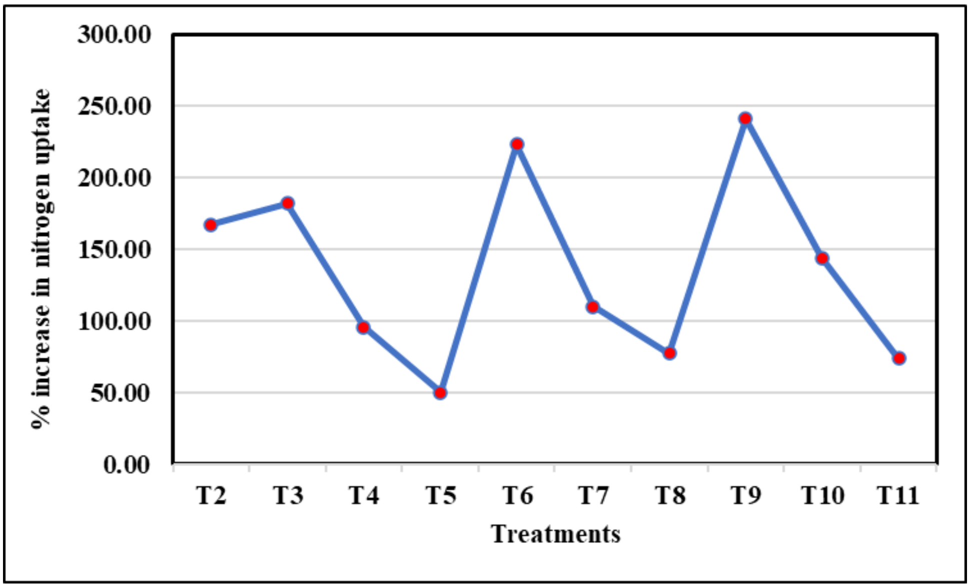

Fig. 2: Per cent increase of nitrogen uptake over control (T_1) as influenced by nano urea and urea application in fodder maize

3.3 Chemical properties of soil: The soil chemical properties were assessed in terms of soil pH, electrical conductivity (EC) and organic carbon (OC) content after harvest of fodder maize and represented in Table 2.

The soil pH was not significantly influenced by varied levels of recommended dose of nitrogen with different foliar concentrations of nano urea and urea. However, numerically higher soil pH was observed with 100% recommended dose of N + Urea @ 2% spray (T_9: 6.82). After harvest of fodder maize, soil electrical conductivity and organic carbon tested was not significantly influenced varied levels of recommended dose of nitrogen with different foliar concentrations of nano urea and urea. However, numerically higher EC and OC was observed with 100% recommended dose of N + Urea @ 2% spray (T_9: 0.19 dSm^{-1} and 0.61%, respectively).

The pH, electrical conductivity and organic carbon content of soil at the end of experimentation of fodder maize was found non-significant due to different treatments of foliar nutrient management.

Table 2: Soil chemical properties as influenced by foliar application of nano urea and urea at harvest

Treatments	Soil chemical properties		
	P^H (1:2.5)	**EC (dSm^{-1})**	**OC (%)**
T_1	6.72	0.17	0.57
T_2	6.76	0.16	0.60
T_3	6.80	0.18	0.56
T_4	6.78	0.15	0.59
T_5	6.75	0.16	0.60
T_6	6.78	0.17	0.55
T_7	6.77	0.16	0.53
T_8	6.76	0.15	0.57
T_9	6.82	0.19	0.61
T_{10}	6.80	0.15	0.56
T_{11}	6.75	0.17	0.56
S.Em.±	**0.33**	**0.01**	**0.03**
CD (P=0.05)	**NS**	**NS**	**NS**

3.4 Available soil nutrients: The available soil nutrients after harvest of fodder maize in respect to soil available nitrogen, phosphorus and potassium as influenced by varied levels of recommended dose of nitrogen with different foliar concentrations of nano urea and urea are presented in Table 3.

Available nitrogen content of soil, showed a significant difference among the treatments. The significantly greater available soil nitrogen (213.25 kg ha^{-1}) was recorded with 100% recommended dose of N + Urea @ 2% spray (T_9) and was on par with 100% recommended dose of N + Nano urea @ 0.4% spray (T_6: 200.70 kg ha^{-1}). However, T_6 was on par with 100% recommended dose of N + Nano urea @ 0.2% spray (T_3: 188.16 kg ha^{-1}). The lower (125.44 kg ha^{-1}) soil nitrogen was noticed in treatment control (T_1) and percent increase of nitrogen uptake over control (T_1) is depicted in Fig. 2.

After the harvest of fodder maize, available phosphorus content of soil showed a significant difference among the treatments. Significantly greater available soil phosphorus content (42.58 kg ha^{-1}) was recorded with 100% recommended dose of N + Urea @ 2% spray (T_9) and was on par with 100% recommended dose of N + Nano urea @ 0.4% spray (T_6: 40.87 kg ha^{-1}). However, T_6 was on par with 100% recommended dose of N + Nano urea @ 0.2% spray (T_3: 37.62 kg ha^{-1}), RDF (T_2: 37.10 kg ha^{-1}) and 75% recommended dose of N + Urea @

2% spray (T_{10}: 36.76 kg ha^{-1}). The lower soil phosphorus (27.87 kg ha^{-1}) was noticed with control (T_1).

Significantly difference was recorded with respect to available K_2O content of soil after the harvest of fodder maize crop. Higher greater available soil potassium content (189.06 kg ha^{-1}) was recorded with 100% recommended dose of N + Urea @ 2% spray (T_9) and was on par with 100% recommended dose of N + Nano urea @ 0.4% spray (T_6: 187.95 kg ha^{-1}) and significantly superior over remaining treatments. The lower (141.43 kg ha^{-1}) soil potassium was noticed with treatment control (T_1).

Available N, P and K status of soil after the harvest of fodder maize crop showed that available N content of soil was slightly improved due to increased rate of N incorporation. After fulfilling required nitrogen for plants, the additional nutrients as well as other nutrients on account of their mineralization from native source in soil caused increased nutrient status in soil. These results were in agreement with the findings of Sharma and Verma (2005) and Sheta *et al*. (2009), Khalil *et al*. (2019) and Meena *et al*. (2021).

Table 3: Soil available nutrients as influenced by foliar application of nano urea and urea at harvest

Treatments	Soil available nutrients (kg ha^{-1})		
	N	P_2O_5	K_2O
T_1	125.44	27.87	141.43
T_2	175.62	37.10	163.65
T_3	188.16	37.62	164.24
T_4	150.53	34.03	160.74
T_5	144.26	29.58	157.92
T_6	200.70	40.87	187.95
T_7	150.53	35.22	161.91
T_8	137.98	30.78	157.42
T_9	213.25	42.58	189.06
T_{10}	163.07	36.76	158.02
T_{11}	137.98	30.44	161.68
S.Em.±	**7.47**	**1.46**	**7.72**
CD (P=0.05)	**21.92**	**4.29**	**22.66**

4. CONLUSION

The combined application of application of RDF (150:75:40 N: P: K kg ha^{-1}) along with foliar spray of urea @ 2% or nano urea @ 0.4% at 20 and 40 days is more productive and sustainable in terms of green fodder yield (427.70 q ha^{-1}) and dry matter yield (91.64 q ha^{-1}). Moreover, the same treatment recorded higher nutrient uptake and available soil nutrients. Based on the present investigation, the study recommends to adopt the 100% recommended dose of N + urea @ 2% spray or nano urea @ 0.4% spray rather than RDF alone in fodder maize for sustaining the soil health and to achieve higher quantity and quality green fodder yield.

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