

# Study on the enhancement of forage quality of maize through Nano urea

## ABSTRACT

Nano-technology based nutrient management practices in fodder crops are still in their nascent stage of growth. Fodder crops require more nitrogen and meeting this demand through nano-urea raises questions about its suitability for long-term fodder production. Therefore, a field trial on enhancing forage quality of maize through nanourea and urea foliar application was conducted at ZARS, V. C. Farm, Mandya, during *kharif* season of 2022. The experiment was laid out in RCBD with eleven 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). The results indicated that application of 100% RDN (150 kg N ha<sup>-1</sup>) along with urea @ 2% spray led to significantly enhanced the fodder quality like crude protein, crude fibre, crude fat and carbohydrate and was on par with 100% recommended dose of N + Nano urea @ 0.4% spray.

**Key words:** Fodder maize, Nano urea, Crude protein, Crude fibre, Crude fat and Carbohydrates

## 1. INTRODUCTION

“Agriculture and animal husbandry are interwoven to each other. Livestock sector acts as cushion for the rural economy and contributes 6.2% to total GVA in 2020-21” (Anonymous, 2022a). “India ranks first in the world with a huge livestock population of 536.76 million and also ranks first in milk production” (Anonymous, 2022b). In order to sustain a large livestock population, a continuous supply of both green and dry fodder is essential. [15-18]

“Among the various fodder crops, fodder maize is the most preferred due to its high productivity and being free from anti-nutritional factors. The fodder maize mines high nutrients from the soil for its increased productivity, specifically requiring higher amounts of nitrogenous fertilizer along with other nutrients. 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) 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. However, applied nitrogen fertilizers are subjected to various kind of losses and the efficacy of applied fertilizer ranges between 30.2-53.2%” (Anaset al., 2020).

“On the other hand, nano-technology based nutrient management practices are gaining importance due to their higher efficiency, which reduced the dose of fertilizer from kilograms to milligrams. Recently, the Indian government gave approval for its use in agriculture, making nano-urea as first nano-technology based fertilizer for commercial use. The product has been included in schedule VII of the fertilizer control order 1985. Nano urea (liquid) contains 4.0% of total N (w/v) evenly dispersed in water. The size of the particles varies between 20-50 nm”(Kumar et al., 2020). Henceforth, the research has been conducted on high nitrogen-demanding fodder crops, specifically maize to obtain valid results. Fodder maize responds to both upper and lower levels of nitrogen. This research was focused on using nano-urea in fodder maize to enhance the fodder quality.

## **2. MATERIAL AND METHODS**

### **2.1 Site details**

A field trial was conducted at the Zonal Agricultural Research Station (ZARS), V. C. Farm, Mandya, University of Agricultural Sciences, Bengaluru (Karnataka) during 2022. Geographically, the experimental site situated at 12° 45' and 30° 57' North latitude and 76° 45' and 78 ° 24' East longitude and at an altitude of 695m above MSL (Mean sea level).

### **2.2 Soil status**

The soil of experimental site was neutral in pH (7.02), sandy loam in texture, medium in organic carbon (0.62%), low in available N (206.97 kg ha<sup>-1</sup>) and medium in available P (42.31 kg ha<sup>-1</sup>) and K (241.24 kg ha<sup>-1</sup>).

### **2.3 Treatments description**

The experiment was laid out in Randomized Complete Block Design (RCBD) consisting eleven treatment and replicated thrice. The treatments include Control (RDF without N) (T<sub>1</sub>), RDF (N: P: K @ 150:75:40 kg ha<sup>-1</sup>) (T<sub>2</sub>), 100% recommended dose of N +

Nano urea @ 0.2% spray (T<sub>3</sub>), 75% recommended dose of N + Nano urea @ 0.2% spray (T<sub>4</sub>), 50% recommended dose of N + Nano urea @ 0.2% spray (T<sub>5</sub>), 100% recommended dose of N + Nano urea @ 0.4% spray (T<sub>6</sub>), 75% recommended dose of N + Nano urea @ 0.4% spray (T<sub>7</sub>), 50% recommended dose of N + Nano urea @ 0.4% spray (T<sub>8</sub>), 100% recommended dose of N + Urea @ 2% spray (T<sub>9</sub>), 75% recommended dose of N + Urea @ 2% spray (T<sub>10</sub>) and 50% recommended dose of N + Urea @ 2% spray (T<sub>11</sub>). 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 fodder maize (African tall) was sown with seed rate of 100 kg ha<sup>-1</sup> with a spacing of 30 × 10 cm.

#### **2.4 Biometric data observations**

Plant samples from each treatment were collected at harvest, oven dried, powdered and used for the analysis of quality parameters. All the oven dried samples were powdered in willey mill using 2 mm sieve for crude protein, carbohydrate, fat and ash content, while 1 mm sieve for crude fibre analysis. Quality parameters are chemically analysed and calculated according to the equations adopted by [Iqbalet al. \(2013\)](#).

#### **2.5 Statistical analysis**

Experimental data obtained on various parameters were subjected to statistical analysis by adopting Fisher's method of analysis of variance (ANOVA) as described by [Gomez and Gomez \(1984\)](#). The level of significance used in "F" was P = 0.05. Critical difference (CD) values were calculated for the P = 0.05 whenever "F" test was found significant, if 'F' test was found non- significant, then the symbol 'NS' was used.

### **3. RESULTS AND DISCUSSION**

#### **3.1 Crude protein content and yield**

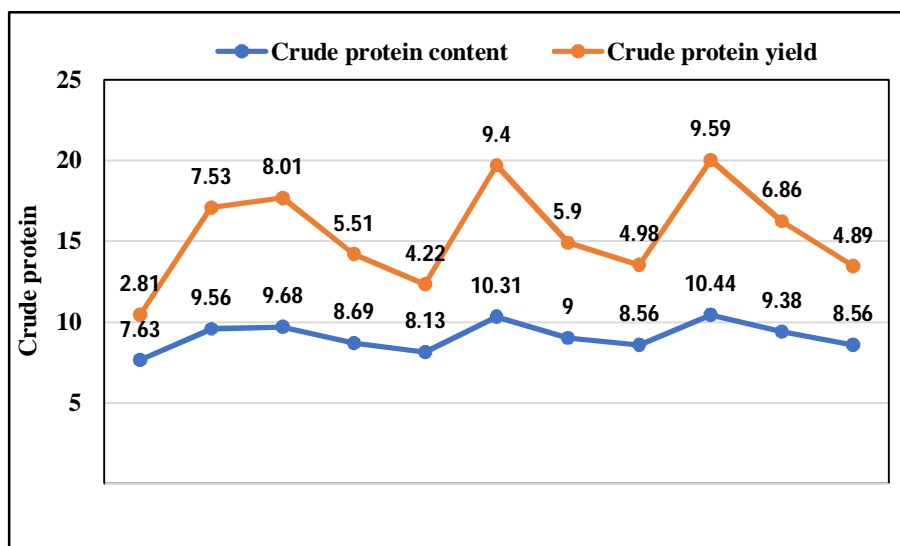
Data in respect of crude protein content and crude protein yield at harvest of fodder maize as influenced by varied levels of recommended dose of nitrogen with different foliar concentrations of nano urea and urea was presented in Fig. 1.

The crude protein content found significantly influenced by different levels of N with foliar spray treatments. The application of 100% recommended dose of N + Urea @ 2% spray (T<sub>9</sub>)

showed significantly higher crude protein content (10.44%) and however the application of 100% recommended dose of N + Nanourea @ 0.4% spray ( $T_6= 10.31\%$ ), 100% recommended dose of N + Nanourea @ 0.2% spray ( $T_3= 9.68\%$ ), RDF (N:P:K @ 150:75:40 kg ha<sup>-1</sup>) ( $T_2= 9.56\%$ ) and 75% recommended dose of N + Urea @ 2%pray ( $T_7= 9.38\%$ ) were found on par in respect to the crude protein content. Significantly it was obtained lower (7.63 %) by the treatment control ( $T_1$ ) where no nitrogen applied during the period of investigation.

The crude protein yield was found significantly influenced by different levels of N with foliar spray treatments. The application of 100% recommended dose of N + Urea @ 2% spray ( $T_9$ ) showed significantly higher crude protein yield (9.59 q ha<sup>-1</sup>) and which was found on par with 100% recommended dose of N + Nanourea @ 0.4% spray ( $T_6$ : 9.40 q ha<sup>-1</sup>). Whereas lower crude protein yield of 2.81 q ha<sup>-1</sup> was observed in control treatment ( $T_1$ ).

Increasing levels of recommended 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. As a component of amino acids, nitrogen transmits genetic information, controls the metabolism of amino acids and proteins that serve as structural building blocks in cells and acts as a biological catalyst for the phosphorylation of chemicals involved in energy conversions. It is a significant structural component of the cell and cell wall, enhancing the protein content and raising the quality of the feed. Because the crude protein content is computed by dividing the plant's nitrogen content by 6.25, an increase in nitrogen supply will increase the crude protein content. Application of higher levels of recommended of N (100%) with foliar application 2% urea recorded higher crude protein yield followed by  $T_6$  (100% recommended dose of N + nano urea @ 0.4% spray) due to accumulation of more dry matter and protein content of plant, which in turn increased the crude protein yield. Similar results are also reported by [Amrutkar et al. \(1985\)](#), [Almodares et al. \(2009\)](#), [Shekara et al. \(2015\)](#) and [Meena et al. \(2021\)](#).



**Fig. 1: Effect of foliar application of nanourea and urea on crude protein content (%) and crude protein yield (q ha<sup>-1</sup>) of fodder maize at harvest**

### **3.2 Crude fibre content and yield**

The crude fibre content was not significantly influenced by different foliar nutrient management treatments (Table 1). However, numerically the application of treatment control (T<sub>1</sub>) showed significantly highest crude fibre content (30.12%).

The crude fibre yield was found significantly influenced by different foliar spray treatments. The application of 100% recommended dose of N + Urea @ 2% spray (T<sub>9</sub>) showed significantly higher crude fibre yield (23.46q ha<sup>-1</sup>) and which was found on par with 100% recommended dose of N + Nanourea @ 0.4% spray (T<sub>6</sub>: 23.39q ha<sup>-1</sup>) and 100% recommended dose of N + Nano-urea @ 0.2% spray (T<sub>3</sub>: 21.26 q ha<sup>-1</sup>). Whereas, lower crude fibre yield of 11.10q ha<sup>-1</sup> was observed in control (T<sub>1</sub>).

This might be due to increased fertiliser treatment to fodder maize delays maturity, particularly through nitrogen, the crude fibre content decreased as nutrient input increased. Contrarily, a lower fertiliser dose results in forced maturity within a short period of time, which may be controlling the process of fibre synthesis. Therefore, the application of a 2% foliar urea spray coupled with the 100% required dose of N showed the lowest crude fibre concentration. Similar to that, crude fibre yield was calculated by multiplying dry matter yield by the crude

**Table 1: Effect of foliar application of nanourea and urea on crude fibrecontent and crude fibre yield of fodder maize at harvest**

<b>Treatments</b>	<b>Crude fibrecontent (%)</b>	<b>Crude fibre yield (q ha<sup>-1</sup>)</b>
T <sub>1</sub> : Control (RDF without N)	30.12	11.10
T <sub>2</sub> : RDF (N:P: K @ 150:75:40 kg ha <sup>-1</sup> )	26.51	20.70
T <sub>3</sub> : 100% recommended dose of N + Nanourea @ 0.2% spray	26.31	21.26
T <sub>4</sub> : 75% recommended dose of N + Nanourea @ 0.2% spray	27.37	17.35
T <sub>5</sub> : 50% recommended dose of N + Nanourea @ 0.2% spray	28.43	14.75
T <sub>6</sub> : 100% recommended dose of N + Nanourea @ 0.4% spray	25.95	23.39
T <sub>7</sub> : 75% recommended dose of N + Nanourea @ 0.4% spray	27.07	17.76
T <sub>8</sub> : 50% recommended dose of N + Nanourea @ 0.4% spray	27.82	16.19
T <sub>9</sub> : 100% recommended dose of N + Urea @ 2% spray	25.52	23.46
T <sub>10</sub> : 75% recommended dose of N + Urea @ 2% spray	26.87	19.67
T <sub>11</sub> : 50% recommended dose of N + Urea @ 2% spray	28.09	16.03
<b>S.Em.±</b>	<b>1.34</b>	<b>0.84</b>
<b>CD(P=0.05)</b>	<b>NS</b>	<b>2.46</b>

fibre content of fodder maize. Similar results in agreement with those were reported by [Tiwana et al. \(2009\)](#), [Pathan et al. \(2012\)](#) and [Singh et al. \(2012\)](#).

### 3.3 Carbohydrate (CHO) content and yield

Carbohydrate content was not significantly influenced by varied levels of recommended dose of nitrogen with different foliar concentrations of nano urea and urea (Table 2). However, application of 100% recommended dose of N + Urea @ 2% spray (T<sub>9</sub>) recorded numerically higher carbohydrate content (43.70%) over control (42.86%). 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<sup>-1</sup>) followed by T<sub>6</sub>. “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. \(2017\)](#)). This is evidenced by lower CHO yield in control.

### 3.4 Crude fat content and yield

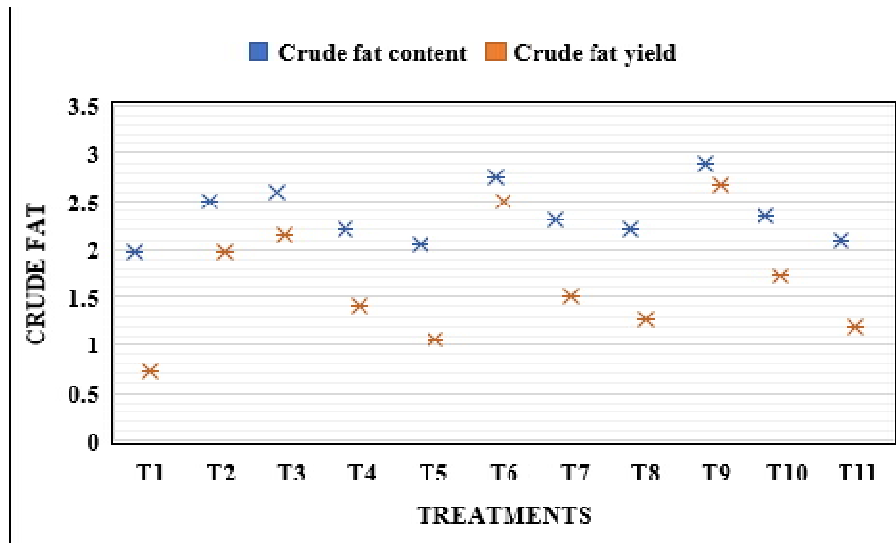
Data in respect of fat content and yield at harvest of fodder maize as influenced by varied levels of recommended dose of nitrogen with different foliar concentrations of nano urea and urea was presented in Fig. 2.

The fat content found significantly influenced by different foliar nutrient management treatments. The application of 100% recommended dose of N + Urea @ 2% spray (T<sub>9</sub>) showed significantly higher fat content (2.90%) and was on par with the application of 100% recommended dose of N + Nano-urea @ 0.4% spray (T<sub>6</sub>: 2.75%). Significantly, lower obtained (1.98%) in treatment control (T<sub>1</sub>) during the period of investigation. However, crude fat yield was found significantly influenced by different foliar spray treatments. The application of 100% recommended dose of N + Urea @ 2% spray (T<sub>9</sub>) showed significantly higher crude fat yield (2.67 q ha<sup>-1</sup>) and which was found on par with 100% recommended dose of N + Nano-urea @ 0.4% spray (T<sub>6</sub>: 2.51 q ha<sup>-1</sup>) and 100% recommended dose of N + Nano-urea @ 0.2% spray (T<sub>3</sub>: 2.15 q ha<sup>-1</sup>). Whereas, lower crude fibre yield of 0.73 q ha<sup>-1</sup> was observed in control (T<sub>1</sub>).

**Table 2: Effect of foliar application of nanourea and urea on Carbohydrate content and Carbohydrate yield of fodder maize at harvest**

Treatments	Carbohydrate content (%)	Carbohydrate yield (q ha <sup>-1</sup> )
T <sub>1</sub> : Control (RDF without N)	42.86	15.79
T <sub>2</sub> : RDF (N:P: K @150:75:40 kg ha <sup>-1</sup> )	43.28	33.79
T <sub>3</sub> : 100% recommended dose of N + Nanourea @ 0.2% spray	42.96	34.71
T <sub>4</sub> : 75% recommended dose of N + Nanourea @ 0.2% spray	43.64	27.66
T <sub>5</sub> : 50% recommended dose of N + Nanourea @ 0.2% spray	42.92	22.27
T <sub>6</sub> : 100% recommended dose of N + Nanourea @ 0.4% spray	43.10	38.84
T <sub>7</sub> : 75% recommended dose of N + Nanourea @ 0.4% spray	42.92	28.16
T <sub>8</sub> : 50% recommended dose of N + Nanourea @ 0.4% spray	42.97	25.01
T <sub>9</sub> : 100% recommended dose of N + Urea @ 2% spray	43.70	40.17
T <sub>10</sub> : 75% recommended dose of N + Urea @ 2% spray	42.72	31.28
T <sub>11</sub> : 50% recommended dose of N + Urea @ 2% spray	43.15	24.63
<b>S.Em.±</b>	<b>2.07</b>	<b>2.66</b>
<b>CD(P=0.05)</b>	<b>NS</b>	<b>7.81</b>

Nitrogen has failed to help plants develop cellulose and lignin, which are fibroid components. Higher nitrogen levels consequently boosted meristematic activity, which enhances mineral salt absorption and speeds up the respiration process, turning the majority of the carbs into fat. The increased nitrogen application by foliar and external supplies is the cause of the higher fat and ash content. This is in conformity with findings of Ibrahim et al.(2006), Ahmad et al. (2017) and Harikeshet al. (2017).



**Fig. 2: Effect of foliar application of nanourea and urea on crude fatcontent (%) and crude fat yield (q ha<sup>-1</sup>) of fodder maize at harvest**

### 3.5 Ash, dry matter and moisture content

The data on the ash, dry matter 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 was presented in Table 3.

Ash 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 (5.5%) was observed with application of 100% recommended dose of N + Urea @ 2% spray (T<sub>9</sub>) over the remaining treatments (5.36 to 4.4%).

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

**Table 3: Effect of foliar application of nanourea and urea on ash, moisture and dry matter content of fodder maize at harvest**

<b>Treatments</b>	<b>Ash content (%)</b>	<b>Moisture content (%)</b>	<b>Dry matter content (%)</b>
T <sub>1</sub> : Control (RDF without N)	4.40	13.01	18.14
T <sub>2</sub> : RDF (N:P: K @150:75:40 kg ha <sup>-1</sup> )	5.30	12.85	20.93
T <sub>3</sub> : 100% recommended dose of N + Nanourea @ 0.2% spray	5.36	13.09	20.80
T <sub>4</sub> : 75% recommended dose of N + Nanourea @ 0.2% spray	5.04	13.05	19.92
T <sub>5</sub> : 50% recommended dose of N + Nanourea @ 0.2% spray	4.80	13.67	18.87
T <sub>6</sub> : 100% recommended dose of N + Nanourea @ 0.4% spray	5.38	12.51	21.29
T <sub>7</sub> : 75% recommended dose of N + Nanourea @ 0.4% spray	5.12	13.59	20.17
T <sub>8</sub> : 50% recommended dose of N + Nanourea @ 0.4% spray	5.00	13.45	19.80
T <sub>9</sub> : 100% recommended dose of N + Urea @ 2% spray	5.50	11.94	21.40
T <sub>10</sub> : 75% recommended dose of N + Urea @ 2% spray	5.12	13.56	20.50
T <sub>11</sub> : 50% recommended dose of N + Urea @ 2% spray	5.00	13.10	19.23
<b>S.Em.±</b>	<b>0.24</b>	<b>0.63</b>	<b>0.73</b>
<b>CD(P=0.05)</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>

urea. However, numerically higher dry matter and moisture content (21.40% and 13.67%) was observed in T<sub>9</sub> and T<sub>5</sub>, respectively.

#### **4. CONCLUSION**

The fodder maize responded positively for higher levels of N through conventional N (100% RDN) and urea spray (2%) or higher concentration of nano-urea (4 ml l<sup>-1</sup>) at 20 and 40 days after sowing with respective green fodder quality. Among the interactions, 100% dose of conventional N, coupled with the inclusion of urea or nano-urea, led to a significant increasing quality parameter in green fodder.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc have been used during writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

- 1.
- 2.
- 3.

#### **5. ACKNOWLEDGEMENTS**

I am incredibly appreciative of the entire faculty and support team at the College of Agriculture, V. C. Farm, Mandya. I want to sincerely thank all of the field workers and lab technicians from the College of Agriculture, V. C. Farm, Mandya, for their assistance.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Ahmad AH, Wahid A, Khalid F, Fiaz N, Zamir MSI. Impact of organic and inorganic sources of nitrogen and phosphorus fertilizers on growth, yield and quality of forage oat (*Avena sativa* L.). Cercetari Agronomice în Moldova. 2017; **154**(3):147.
2. Almodares A, Jafarina M, Hadi, MR. The effect of nitrogen fertilizer on chemical composition in corn and sweet sorghum. American-Eurasian Journal of Agricultural & Environmental Sciences. 2009; **2**:889-899.
3. Amrutkar VR, Deshmukh AP, Desale JS. Effect of nitrogen phosphorus fertilization on chemical composition and in-vitro dry matter digestibility of Giant Bajra. Journal of Maharashtra Agricultural University. 1985; **10**(1):93-94.
4. Anas M, Liao F, Verma KK, Sarwar MA, Mahmood A, Chen ZL. Fate of nitrogen in agriculture and environment: agronomic, eco-physiological and molecular approaches to improve nitrogen use efficiency. Biological Research. 2020; **53**(1):1-20.
5. Anonymous. Annual Report. Department of Animal Husbandry and Dairying, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India, New Delhi. 2020a;1-2.
6. Anonymous. Annual Report. National Accounts Statistics, Ministry of Statistics and Programme Implementation, Government of India, New Delhi. 2022b.
7. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. John Wiley and Sons, Singapore. 1984;680.
8. Harikesh J, Kaushik MK, Nepalia V, Singh D. Effect of irrigation schedule and nitrogen fertilization on growth, yield and quality of fodder oat (*Avena sativa* L.). Journal of Pharmacognosy and Phytochemistry. 2017; **6**(4):2040-2042.
9. Ibrahim, M., Rafiq, M., Sultan, A., 2006. Green fodder yield and quality evaluation of maize and cowpea sown alone and combination. Journal of agricultural research. **44**(1):15-21.
10. Iqbal MA, Iqbal Z, Farooq M, Ali L, Fiaz M. Impact of nitrogenous fertilizer on yield and quality of oat. Pakistan Journal of Science. 2013; **65**:1-4.
11. Kumar Y, Tiwari KN, Singh T, Sain NK, Laxmi S, Verma. 2020. Nanofertilizers for enhancing nutrient use efficiency, crop productivity and economic returns in winter season crops of Rajasthan. Annals of Plant and Soil Research. 2020; **22**(4):324-335.
12. Leghari SJ, Mustafa BNGM, Hussain K. Role of nitrogen for plant growth and development. Advances in Environmental Biology. 2016; **10**:209-218.

13. Meena S, Shweta, Kumar S, Kumar R, Tokas J, Neelam, Devi U, Satpal. Response of spring planted fodder maize to nitrogen and phosphorus levels. *Forage Research*. 2021;**46**(4):363-367.
14. Pathan SH, Tumbare AD, Kamble AB. Impact of planting material, cutting management and fertilizer levels on nutritional quality of bajra × napier hybrid. *Forage Research*. 2012;**38**(2):74-79.
15. Shekara BG, Lohithaswa HC, Chikkarugi NM, Manasa N. Fodder production potential of maize grown for baby corn and green cob in different cropping systems. *Forage Research*. 2015; **41**(2):92-94.
16. Singh PUSHPENDRA, Sumeriya HK, Solanki NS, Murdia AZAD. Productivity, economics and quality of fodder sorghum under varying levels of nitrogen and phosphorus. *Annals of Plant and Soil Research*. 2012; **14**(2):127-129.
17. Tiwana US, Puri KP, Sukhpreet S. Fodder yield and quality of multicut pearl millet (*Pennisetum glaucum*) as influenced by N and P under Punjab conditions. *Forage Research*. 2009; **28**(4):190-193.
18. Kumar, Amit, Annjoe V. Joseph, and Vijay Bahadur. 2024. “Effect of Foliar Application of Nano Urea, Boron and Zinc Sulphate on Growth, Yield and Quality of Guava (*Psidium Guajava* L.) Cv. Allahabad Surkha”. *Journal of Advances in Biology & Biotechnology* 27 (6):285-92. <https://doi.org/10.9734/jabb/2024/v27i6887> .
  
19. Shree, Kaviya, Augustine R, Isaac Manuel R, Balaganesh B, and Dinesh Kumar. 2024. “Effect of Soil and Foliar Applications on Growth and Productivity of Pearl Millet (*Pennisetum glaucum* L.)”. *Asian Journal of Soil Science and Plant Nutrition* 10 (2):236-41. <https://doi.org/10.9734/ajsspn/2024/v10i2280>.
  
20. Flórez-Velasco, N., Balaguera-López, H. E., & Restrepo-Díaz, H. (2015). Effects of foliar urea application on lulo (*Solanum quitoense* cv. septentrionale) plants grown under different waterlogging and nitrogen conditions. *Scientia horticultrae*, 186, 154-162.
  
21. Hosseini, H., & Khoshgoftarmanesh, A. H. (2013). The effect of foliar application of nickel in the mineral form and urea-Ni complex on fresh weight and nitrogen metabolism of lettuce. *Scientia Horticulturæ*, 164, 178-182.

