

**Original Research Article**  
**EFFECT OF NANO UREA ON GROWTH, YIELD AND NUTRIENT UPTAKE OF**  
**FINGER MILLET (*Eleusine coracana* L.)**

**ABSTRACT**

**Aim:** The foliar application of nano urea is aimed at reducing the soil application of conventional urea. Nano fertilizers enhance crop growth and yield while enhancing nutrient uptake and reducing costs. They provide precise nutrient management, match crop growth stages, and offer an increased surface area for metabolic reactions. This boosts photosynthesis, leading to higher dry matter production and crop yield. Foliar application of nano urea (liquid) at tillering and booting stages in finger millet fulfills the nitrogen requirement and reflects higher crop productivity. Higher productivity of crops in a sustainable manner could be achieved by applying an appropriate combination of conventional fertilizers and nano fertilizers.

**Study design:** The experiment was laid out in split design with three replications.

**Place and Duration of Study:** A field experiment was conducted in deep black soils at Agricultural Research Station, Siruguppa, during *kharif 2022*.

**Methodology:** There were sixteen treatment combinations, consisting of different doses of nitrogen (no nitrogen, 50% RDN, 75% RDN and 100% RDN) with different concentrations of nano urea and conventional urea sprayed at tillering and booting stages for HR-13 variety of finger millet.

**Results:** Application of 100% RDN has recorded significantly higher plant height, tillers plant<sup>-1</sup>, total dry matter accumulation, grain yield and straw yield (129.82 cm, 10.10, 36.17 g plant<sup>-1</sup>, 36.87 q ha<sup>-1</sup> and 71.72 q ha<sup>-1</sup>, respectively) in comparison to no nitrogen and 50% RDN. However, 75% RDN (123.04 cm, 9.61, 34.02 g plant<sup>-1</sup>, 34.84 q ha<sup>-1</sup> and 68.01 q ha<sup>-1</sup>, respectively) found *on par* with 100% RDN. Among foliar nitrogen, spray of nano urea @ 4 ml L<sup>-1</sup> recorded significantly higher plant height (121.59 cm), tillers plant<sup>-1</sup> (9.37), total dry matter accumulation (33.16 g plant<sup>-1</sup>), grain yield (31.97 q ha<sup>-1</sup>) and straw yield (65.52 q ha<sup>-1</sup>) compared to 0.5% and 1% conventional urea. However, nano urea @ 2 ml L<sup>-1</sup> was *on par* with 4 ml L<sup>-1</sup> nano urea and 1% conventional urea. Similar trend was recorded with regard to nutrient uptake by finger millet. **Authors are requested to include post harvest soil nutrient availability in abstract**

**Conclusion:** Foliar application of nano urea reduced the dosage of conventional urea by 25 per cent.

**Keywords:** Nitrogen, Foliar application, Nano urea, Finger millet

## 1. Introduction

Finger millet (*Eleusine coracana* L.) is one of the most important small seeded crop with superior nutritional qualities grown in low rainfall areas of semi-arid tropics of the world and ranks third in importance among millets in India after sorghum and pearl millet. In India, finger millet is grown in an area of 1.19 million hectares with production of 1.98 million tonnes and an average productivity of 1661 kg per hectare (Sakamma *et al.*, 2018) and it is cultivated in Karnataka, Tamil Nadu, Andhra Pradesh, Odisha, Jharkhand, Maharashtra and Gujarat states.

Nitrogen (N) is a key nutrient source for food, biomass and fiber production in agriculture. It is considered as most important element in terms of the energy required for its synthesis, tonnage used and monetary value. However, compared with amounts of N applied to soil, the nitrogen use efficiency (NUE) by crops is very low in conventional fertilizers. Excessive and improper usage of N fertilizer causes problems to human and environment. It is essential for a suitable alternative source of N with reduced harm on the environment. Nano-N fertilizers are alternative to conventional fertilizers with slow and control release of N.

Nano urea as foliar spray helps in easy absorption of nitrogen through stomata, improves crop growth, yield and reduce production costs. Higher productivity of crops in sustainable manner could be achieved applying appropriate combination of conventional fertilizer and nano fertilizers. By foliar application of nano urea, can reduce the application of conventional urea. Combined application of conventional urea and foliar application of nano urea helps in obtaining higher yield, net returns and found economically feasible.

## 2. Material and Methods

A field experiment was conducted during *kharif* 2022-23 at Agricultural Research Station, Siruguppa, UAS, Raichur, Karnataka (15°38'N, 76°54' E, altitude 380 m). The soil of the experimental site was deep black with clayey in texture and had moderately alkaline pH (8.10), low in organic carbon content (4.41 g kg<sup>-1</sup>) and low in nitrogen (195.8 kg ha<sup>-1</sup>) and

was high in phosphorus (68.7) and potassium (385 kg ha<sup>-1</sup>). The experiment was laid out in split plot design with three replications.

The treatments consisting of four levels of soil nitrogen in the main plots (no nitrogen, 50%, 75% and 100% RDN), two doses of nano urea (2 ml L<sup>-1</sup> and 4 ml L<sup>-1</sup>) and two doses of conventional urea (0.5% and 1%) as foliar nitrogen at tillering and booting stages in the sub plots. Recommended dose of P & K was common for all the treatments except absolute control. (Recommended fertilizer schedule to be included) Absolute control was maintained separately outside the layout of the experiment for comparison. Why authors maintained absolute control outside the layout instead of including it in main and subplot The finger millet variety HR-13 was selected for the study. Seeds were hand dibbled at 30 cm row spacing in furrows (authors are requested to mentioned number of seeds sown per hole and plant to plant distance either 30 cm x 10 cm or 30 cm x 15 cm ). From randomly tagged five plants, plant height was measured on the five tagged plants (avoid repetition) individually from ground level to the base of fully opened top leaf. Biometric observations were recorded at 30 days interval. The observation on grain and straw yield was recorded at harvest. Nutrient uptake for all the major nutrients was calculated by the formula mentioned below.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (\%)} \times \text{Biomass (kg ha}^{-1}\text{)}}{100}$$

Biomass may be given as dry matter production in order to maintain uniformity

Data analysis and interpretation was done using Fisher's method of analysis and variance technique as given by Gomez and Gomez (1984). The level of significance used in 'F' was P = 0.05. Critical difference (CD) values were calculated wherever the 'F' test was found significant.

### 3. RESULTS AND DISCUSSION

#### 3.1 Growth attributes

Among main plots, application of 100% RDN recorded significantly higher plant height (129.82 cm), tillers plant<sup>-1</sup> (10.10) and total dry matter accumulation (36.17 g plant<sup>-1</sup>) in comparison to no nitrogen and 50% RDN. However, 75% RDN (123.04 cm, 9.61 and 34.02 g plant<sup>-1</sup>, respectively) found *on par* with 100% RDN. Among the sub plots, foliar spray of nano urea @ 4 ml L<sup>-1</sup> recorded significantly higher plant height (121.59 cm), tillers plant<sup>-1</sup> (9.37) and total dry matter accumulation (33.16 g plant<sup>-1</sup>) compared to 0.5% and 1%

conventional urea. However, nano urea @ 2 ml L<sup>-1</sup> was *on par* with 4 ml L<sup>-1</sup> nano urea and 1% conventional urea (Table 1). Plant height, number of tillers per plant (maintain uniformity – either number of tillers plant<sup>-1</sup> or number of tillers per plant) and total dry matter accumulation increased with increasing N levels. It was probably due to increased supply of nitrogen to plants, which intern accelerated the activity of enzymes involved in photosynthesis, carbohydrates metabolism, protein synthesis, cell division and cell elongation. These findings are in line with the work of Beeresha (2018) and Uma *et al.* (2019). It was observed that foliar spray of nano urea increased the growth attributes due to enhanced availability of nutrients through easy penetration of nano urea through stomata of leaves via gas uptake (Rajasekar *et al.*, 2017). Authors are requested to include interaction effect between N levels and foliar spray

**Table 1: Plant height (cm), number of tillers plant<sup>-1</sup> and total dry matter accumulation at harvest of finger millet as influenced by soil nitrogen levels and foliar nitrogen (stage or time of observations to be included in MM and in tables)**

Treatment	Plant height (cm)	No. of tillers plant <sup>-1</sup>	Total dry matter accumulation (g plant <sup>-1</sup> )
<b>Main plot: Soil nitrogen management</b>			
M <sub>1</sub> : no nitrogen	95.86	7.56	24.34
M <sub>2</sub> : 50% RDN	109.59	8.47	28.97
M <sub>3</sub> : 75% RDN	123.04	9.61	34.02
M <sub>4</sub> : 100% RDN	129.82	10.10	36.17
<b>S. Em.±</b>	<b>2.08</b>	<b>0.17</b>	<b>0.74</b>
<b>C.D. at 5 %</b>	<b>7.18</b>	<b>0.58</b>	<b>2.58</b>
<b>Sub plot: Foliar spray of nitrogen</b>			
N <sub>1</sub> : nano urea @ 2 ml L <sup>-1</sup>	117.76	9.15	32.05
N <sub>2</sub> : nano urea @ 4 ml L <sup>-1</sup>	121.59	9.37	33.16
N <sub>3</sub> : 0.5% urea	106.42	8.40	28.01
N <sub>4</sub> : 1% urea	112.55	8.82	30.27
<b>S. Em.±</b>	<b>1.99</b>	<b>0.11</b>	<b>0.63</b>
<b>C.D. at 5 %</b>	<b>5.80</b>	<b>0.36</b>	<b>1.84</b>
<b>Interaction</b>			
<b>M×N</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>
<b>Control vs Rest</b>			
Control	78.03	3.14	18.67
<b>S. Em.±</b>	<b>3.57</b>	<b>0.37</b>	<b>1.27</b>
<b>C.D. at 5 %</b>	<b>10.29</b>	<b>1.08</b>	<b>3.66</b>

The experiment was conducted at field level but DMP was given as  $\text{g plant}^{-1}$ . It may be given as  $\text{kg ha}^{-1}$

### 3.2 Yield attributes

Among different levels of N application, significantly higher number of ear heads  $\text{plant}^{-1}$  (3.60), length of ear head (6.54 cm), weight of ear head (8.49 g), grain weight  $\text{plant}^{-1}$  (12.29 g), grain yield ( $36.87 \text{ q ha}^{-1}$ ) and straw yield ( $71.72 \text{ q ha}^{-1}$ ) were recorded with 100% RDN in comparison to no nitrogen and 50% RDN. However, 75 % RDN (3.43, 6.26 cm, 8 g, 11.83 g,  $34.84 \text{ q ha}^{-1}$  and  $68.01 \text{ q ha}^{-1}$ , respectively) found *on par* with 100% RDN (Table 2). Give the sentence clearly

Among the foliar applications, foliar spray of nano urea @  $4 \text{ ml L}^{-1}$  recorded significantly higher number of ear heads  $\text{plant}^{-1}$  (3.25), length of ear head (6.21 cm), weight of ear head (7.94 g), grain weight  $\text{plant}^{-1}$  (11.66 g), grain yield ( $31.97 \text{ q ha}^{-1}$ ) and straw yield ( $65.52 \text{ q ha}^{-1}$ ) compared to 0.5% and 1% conventional urea. However, nano urea @  $2 \text{ ml L}^{-1}$  was *on par* with  $4 \text{ ml L}^{-1}$  nano urea and 1% conventional urea (Table 2).

Yield attributes *Viz.*, number of ear heads  $\text{plant}^{-1}$ , length of ear head, weight of ear head and grain weight  $\text{plant}^{-1}$  are the main contributors to the variation in finger millet production. All these parameters increased with the levels of N which may be attributed to the sufficient supply and availability of nitrogen and their transfer to the sink. Similar findings were made by Maitra *et al.* (2001), who noted greater values of yield contributing characteristics with application of N by chemical fertilizer. In case of foliar nitrogen,  $4 \text{ ml L}^{-1}$  of nano urea recorded significantly higher number of ear heads  $\text{plant}^{-1}$ , length of ear head, weight of ear head and grain weight  $\text{plant}^{-1}$  as compared to 0.5% and 1% conventional urea. This might be due to the smaller size and larger effective surface area of nano particles which could have easily penetrated into the plant and lead to better uptake of N.

Authors are requested to mention why nano urea surpassed over conventional urea spray. They also requested to mention interaction effects

**Table 2: Yield attributes of finger millet as influenced by soil nitrogen levels and foliar nitrogen**

Treatment	No. of ear heads plant <sup>-1</sup>	Length of ear head (cm)	Weight of ear head (g)	Grain Weight (g plant <sup>-1</sup> )	Grain yield (q ha <sup>-1</sup> )	Straw yield (q ha <sup>-1</sup> )
<b>Main plot: Soil nitrogen management</b>						
M <sub>1</sub> : no nitrogen	2.32	5.28	6.03	9.70	19.20	46.57
M <sub>2</sub> : 50% RDN	2.78	5.68	7.00	10.75	25.83	60.92
M <sub>3</sub> : 75% RDN	3.43	6.26	8.00	11.83	34.84	68.01
M <sub>4</sub> : 100% RDN	3.60	6.54	8.49	12.29	36.87	71.72
<b>S. Em.±</b>	<b>0.06</b>	<b>0.10</b>	<b>0.16</b>	<b>0.14</b>	<b>0.74</b>	<b>1.11</b>
<b>C.D. at 5 %</b>	<b>0.21</b>	<b>0.36</b>	<b>0.55</b>	<b>0.49</b>	<b>2.57</b>	<b>3.84</b>
<b>Sub plot: Foliar spray of nitrogen</b>						
N <sub>1</sub> : nano urea @ 2 ml L <sup>-1</sup>	3.16	6.08	7.68	11.43	29.93	63.86
N <sub>2</sub> : nano urea @ 4 ml L <sup>-1</sup>	3.25	6.21	7.94	11.66	31.97	65.52
N <sub>3</sub> : 0.5% urea	2.74	5.60	6.70	10.45	26.02	56.99
N <sub>4</sub> : 1% urea	2.98	5.88	7.21	11.03	28.82	60.84
<b>S. Em.±</b>	<b>0.08</b>	<b>0.09</b>	<b>0.16</b>	<b>0.16</b>	<b>0.74</b>	<b>1.10</b>
<b>C.D. at 5 %</b>	<b>0.23</b>	<b>0.26</b>	<b>0.48</b>	<b>0.48</b>	<b>2.15</b>	<b>3.20</b>
<b>Interaction</b>						
<b>M×N</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>
<b>Control vs Rest</b>						
Control	1.35	4.25	3.58	6.18	14.43	37.82
<b>S. Em.±</b>	<b>0.15</b>	<b>0.21</b>	<b>0.31</b>	<b>0.32</b>	<b>1.44</b>	<b>2.16</b>
<b>C.D. at 5 %</b>	<b>0.42</b>	<b>0.60</b>	<b>0.91</b>	<b>0.92</b>	<b>4.15</b>	<b>6.22</b>

### 3.3 Nutrient uptake and available nutrients in soil at harvest

Significantly higher uptake of nitrogen (103.75 kg ha<sup>-1</sup>), phosphorus (47.93 kg ha<sup>-1</sup>) and potassium (129.58 kg ha<sup>-1</sup>) was recorded by application of 100% RDN in comparison to no nitrogen and 50% RDN. However, 75% RDN (94.43 kg ha<sup>-1</sup>, 42.91 kg ha<sup>-1</sup> and 117.40 kg ha<sup>-1</sup>, respectively) found *on par* with 100% RDN among main plots. Among sub plot treatments, significantly higher nitrogen (88.74 kg ha<sup>-1</sup>), phosphorus (40.34 kg ha<sup>-1</sup>) and potassium uptake (112.73 kg ha<sup>-1</sup>) was recorded by treatment with foliar spray of 4 ml L<sup>-1</sup> nano urea compared to 0.5% and 1% conventional urea. However, nano urea @ 2 ml L<sup>-1</sup> was *on*

*par* with 4 ml L<sup>-1</sup> nano urea and 1% conventional urea (Table 3). The nutrient uptake of plant was significantly increased owing to the combined application of nitrogen fertilizer and nano fertilizers. Similar results were found by Fan *et al.* (2012), Manikandan and Subramanian (2016). **Proper justification needed**

Similarly, significantly higher available nitrogen (182.06 kg ha<sup>-1</sup>), phosphorus (55.52 kg ha<sup>-1</sup>) and potassium (361.89 kg ha<sup>-1</sup>) was recorded by application of 100% RDN in comparison to no nitrogen and 50% RDN. However, 75% RDN (175.31 kg ha<sup>-1</sup>, 51.85 kg ha<sup>-1</sup> and 356.38 kg ha<sup>-1</sup>, respectively) found *on par* with 100% RDN among main plots. Among sub plot treatments, significantly higher available nitrogen (170.85 kg ha<sup>-1</sup>), phosphorous (51.23 kg ha<sup>-1</sup>) and potassium (352.97 kg ha<sup>-1</sup>) was recorded by treatment with foliar spray of 4 ml L<sup>-1</sup> nano urea compared to 0.5% and 1% conventional urea. However, nano urea @ 2 ml L<sup>-1</sup> was *on par* with 4 ml L<sup>-1</sup> nano urea and 1% conventional urea (Table 3). Higher available soil nitrogen, phosphorus and potassium were noticed in 100% RDN treatment as compared to others.

Nutrient availability increases as fertilization levels are raises *i.e.*, 75% to 100%. Similar results were obtained by Thimmareddy *et al.* (2013), who observed elevated NPK availability (kg ha<sup>-1</sup>) in soil during harvest with increasing NPK levels.

**Authors are requested to clarify about higher nutrient uptake and higher nutrient availability in nano urea. How nano urea enhanced the soil nutrient availability**

**Table 3: Uptake of nutrients by finger millet and available nutrients in soil as influenced by soil nitrogen levels and foliar nitrogen**

Treatment	Uptake of nutrients (kg ha <sup>-1</sup> )			Available nutrients (kg ha <sup>-1</sup> )		
	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
<b>Main plot: Soil nitrogen management</b>						
M <sub>1</sub> : no nitrogen	48.32	21.88	65.24	143.39	38.49	329.47
M <sub>2</sub> : 50% RDN	70.38	31.80	92.06	156.99	45.27	342.80
M <sub>3</sub> : 75% RDN	94.43	42.91	117.40	175.31	51.85	356.38
M <sub>4</sub> : 100% RDN	103.75	47.93	129.58	182.06	55.52	361.89
<b>S. Em.±</b>	<b>2.71</b>	<b>1.77</b>	<b>4.34</b>	<b>2.51</b>	<b>1.11</b>	<b>1.81</b>
<b>C.D. at 5 %</b>	<b>9.39</b>	<b>6.12</b>	<b>15.03</b>	<b>8.70</b>	<b>3.84</b>	<b>6.28</b>
<b>Sub plot: Foliar spray of nitrogen</b>						
N <sub>1</sub> : nano urea @ 2 ml L <sup>-1</sup>	82.22	37.84	105.94	167.42	49.04	350.32
N <sub>2</sub> : nano urea @ 4 ml L <sup>-1</sup>	88.74	40.34	112.73	170.85	51.23	352.97
N <sub>3</sub> : 0.5% urea	69.73	31.75	89.56	156.54	44.12	341.08
N <sub>4</sub> : 1% urea	76.19	34.57	96.03	162.94	46.74	346.17
<b>S. Em.±</b>	<b>2.19</b>	<b>1.37</b>	<b>4.50</b>	<b>2.07</b>	<b>0.87</b>	<b>1.54</b>
<b>C.D. at 5 %</b>	<b>6.40</b>	<b>4.01</b>	<b>13.13</b>	<b>6.03</b>	<b>2.59</b>	<b>4.52</b>
<b>Interaction</b>						
M×N	NS	NS	NS	NS	NS	NS
<b>Control vs Rest</b>						
Control	32.85	14.82	47.59	129.10	29.19	315.25
<b>S. Em.±</b>	<b>4.49</b>	<b>2.83</b>	<b>8.67</b>	<b>5.76</b>	<b>1.15</b>	<b>2.54</b>
<b>C.D. at 5 %</b>	<b>12.92</b>	<b>8.15</b>	<b>24.98</b>	<b>16.61</b>	<b>3.32</b>	<b>7.33</b>

#### 4. CONCLUSION

From the results of the present study, it is concluded that there was significant response of 75 per cent of recommended dose of nitrogen along with foliar application of nano urea @ 4 ml L<sup>-1</sup> cent nano nitrogen at tillering and booting stages which recorded higher growth attributes, yield parameters and nutrient uptake by the plants.

**In the results, 100 % RND and nano urea @ 4 ml L<sup>-1</sup> recorded higher values for growth, yield, uptake and availability. Kindly clarify or modify**

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