International Journal of Environment and Climate Change

Volume 13, Issue 11, Page 3578-3585, 2023; Article no.IJECC.109038
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Effect of Foliar Application of Nano and Conventional Urea on Growth and Yield Attributes of Ragi (*Eleusine coracana* L. Gaertn)

Chandan, B. M. [a++], Sunil, C. [b#*], Girijesh, G. K. [c†], Thippeshappa, G. N. [d†] and Mallikarjuna, H. B. [e#]

[a] Department of Agronomy, College of Agriculture, KSNUAHS, Shivamogga, Karnataka, India.
[b] Department of Agronomy, KSNUAHS, Shivamogga, Karnataka, India.
[c] Department of Agronomy, College of Agronomy, KSNUAHS, Shivamogga, Karnataka, India.
[d] Department of Soil Science, College of Agronomy, KSNUAHS, Shivamogga, Karnataka, India.
[e] Department of Agricultural Statistics, College of Agronomy, KSNUAHS, Shivamogga, Karnataka, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i113533

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/109038

Original Research Article

Received: 08/09/2023
Accepted: 13/11/2023
Published: 23/11/2023

ABSTRACT

A field experiment was conducted at Agricultural and Horticultural Research Station, Bavikere, KSNUAHS, Shivamogga, India during Late *Kharif* 2022 to evaluate the effect of nano and conventional urea on growth and yield of ragi. The experiment was laid out in RCBD with eleven

[++] M.Sc. Scholar;
[#] Assistant Professor;
[†] Professor;
**Corresponding author: E-mail: csunil@uahs.edu.in;*

treatments replicated thrice. The treatments comprised of absolute control (T_1), recommended dose of fertilizer (T_2), 50 per cent RDN + two sprays of 0.4 per cent nano urea fertilizer at 30 & 45 DAT (T_3), 75 per cent RDN + one spray of 0.4 per cent nano urea fertilizer at 30 DAT (T_4), 75 percent RDN + two sprays of 0.4 percent nano urea fertilizer at 30 & 45 DAT (T_5), 100 per cent RDN + one spray of 0.4 percent nano urea fertilizer at 30 DAT (T_6), 50 percent RDN + two sprays of 2 per cent urea fertilizer at 30 & 45 DAT (T_7), 75 per cent RDN + one spray of 2 per cent urea fertilizer at 30 DAT (T_8), 75 percent RDN + two sprays of 2 percent urea fertilizer at 30 & 45 DAT (T_9), 100 per cent RDN + one spray of 2 per cent urea fertilizer at 30 DAT (T_{10}), four sprays of 0.4 per cent nano urea fertilizer at 15, 30, 45 & 60 DAT (T_{11}). The results revealed that the application of 100 per cent RDN + one spray of 0.4 per cent nano urea fertilizer at 30 DAT (T_6) recorded higher plant height (94.13 cm), number of tillers hill^{-1} (8.85), number of earheads per hill (7.86), finger length (8.46), grain yield (3812 kg ha^{-1}), straw yield (6453 kg ha^{-1}) and harvest index (37.13%), which was statistically on par with the T_{10} and T_5. Treatment T_6 produced 9.32 per cent higher grain yield compared to T_2.

Keywords: Finger millet; nitrogen; nano urea; growth; yield.

1. INTRODUCTION

"Finger millet (*Eleusine coracana* L. Gaertn) is a prominent millet grown extensively in various regions of Asia and is the predominant food crop of Southern India. It is an important staple food in several semi-arid and tropical regions of the world with excellent nutraceutical properties as well as ensuring food security in these areas even during harsh environment. It occupies an area of 1.21 m ha with a production of 1.70 m t and average productivity of 1396 kg ha^{-1} in India" [1]. "Of all the cereal and millets, finger millet has the highest amount of calcium (344 mg/100g) and potassium (408 mg/100g) and rich source of carbohydrates and comprises of free sugars (1.04%), starch (65.5%) and non-starchy polysaccharides" [2]. It has higher dietary fiber, minerals and sulphur containing amino acids compares to wheat and rice.

"Nutrient management is an approach aimed at preserving and augmenting soil fertility and also boosting crop productivity. The lack of efficient crop need based nutrient recommendation techniques is one of the major constraints in crop production. To achieve higher productivity, adequate supply of nutrients through a right source could be an appropriate approach. Among different nutrients, nitrogen is most important nutrient required by the plant. It is major constitute of chlorophyll which imparts green colour to the plant and helps for the production of proteins. It is one of the important macronutrients that plants require for their growth, development and yield. Nitrogen application has been found to increase the growth, dry matter production and yield of finger millet under irrigated conditions" [3]. "Urea is the most widely used commercial nitrogen fertilizer for increasing crop productivity. By virtue of its hydrolysis, urea elevates soil pH, resulting in massive ammonia volatilization and leaching losses". [4]. "Therefore, modern ideas of nano fertilizers are the most advanced technology in the way of supplying mineral nutrients to crops. Compared to chemical fertilizers their supplemental pattern of nutrients for plant needs minimizes leaching and improves fertilizer use efficiency" [5].

"Nano fertilizers are the new generation of synthetic fertilizers which contain readily available nutrients in the nano-scale range. Nanotechnology offers a great potential for fertilizer production with the desired chemical composition and higher nutrient use efficiency that may reduce environmental impact and boost plant productivity. Nano fertilizers are very effective for precise nutrient management in agriculture by matching the crop growth stages with nutrient demand thereby providing nutrients throughout the crop growth period. Nano urea is a novel and innovative form of urea fertilizer that has gained attention for its potential to improve nutrient use efficiency than conventional urea. Nano urea provide more surface area for different metabolic reactions in the plant which increase the rate of metabolic processes like, photosynthesis which leads to higher accumulation of photosynthates and its translocation towards the economic parts of the plant leads to higher crop growth and yield" [6]. The huge yield gap in the ragi can be narrowed by application of modern nitrogen management options, such as foliar feeding of nitrogen, nano urea application at appropriate stage etc. Nano urea has so far been found to have positive

effects on a variety of crops, but the use of nano urea on finger millet is scarce. Hence, the investigation to evaluate the effect of foliar applied nano and conventional urea on growth and yield attributes of ragi was undertaken.

2. MATERIALS AND METHODS

A field experiment was conducted at Agricultural and Horticultural Research Station, Bavikere, KSNUAHS, Shivamogga during late *Kharif* 2022 situated at longitude latitude of 75°51`E, 13°42`N & 695 m above the mean sea level. The investigation site had red sandy loam in texture, slightly acidic and non-saline (pH 5.75, EC: 0.24 dSm^{-1}), medium in organic carbon (0.56 %) [7], low in available nitrogen (224.63 kg ha^{-1}) [8], medium in available phosphorus (52.71 kg ha^{-1}) and medium in available potassium (294.65 kg K_2O ha^{-1}) [9]. The experiment was laid out in Randomized Completely Block Design with 11 treatments and 3 replications. The treatments comprised of absolute control (T_1), recommended dose of fertilizer (100:50:50 kg $N:P_2O_5:K_2O$ ha^{-1}) (T_2), 50 per cent RDN + two sprays of 0.4 per cent nano urea fertilizer at 30 & 45 DAT (T_3), 75 per cent RDN + one spray of 0.4 per cent nano urea fertilizer at 30 DAT (T_4), 75 per cent RDN + two sprays of 0.4 per cent nano urea fertilizer at 30 & 45 DAT (T_5), 100 per cent RDN + one spray of 0.4 per cent nano urea fertilizer at 30 DAT (T_6), 50 per cent RDN + two sprays of 2 per cent urea fertilizer at 30 & 45 DAT (T_7), 75 per cent RDN + one spray of 2 per cent urea fertilizer at 30 DAT (T_8), 75 per cent RDN + two sprays of 2 per cent urea fertilizer at 30 & 45 DAT (T_9), 100 per cent RDN + one spray of 2 per cent urea fertilizer at 30 DAT (T_{10}), four sprays of 0.4 per cent nano urea fertilizer at 15, 30, 45 & 60 DAT (T_{11}). Seeds of ragi (cv. GPU-28) were sown in rows of 10 cm apart in the raised beds. At the time of sowing 500 g MOP, 1 kg SSP and 500 g ammonium sulphate per bed were applied to the raised beds, then 12 days after sowing 250 g urea per bed was applied as top dress. Healthy and uniform seedlings of 25 days old were transplanted manually in the main field at 30 cm × 10 cm spacing. On the day of transplanting basal application of 50 per cent of the recommended dose of nitrogen and entire doses of P and K (50: 50 kg ha^{-1} of P_2O_5, K_2O) were calculated for the experimental plots and applied commonly to all the plots except T_1 (control) using urea, single super phosphate and muriate of potash as source. The remaining 50 per cent of the recommended dose of nitrogen was applied at 30 days after transplanting. Nitrogen in the form of nano urea was sprayed at different days after transplanting as per the treatment requirements. For recording various biometric observations *i.e.,* plant height (cm), number of tillers $hill^{-1}$, finger length (cm), number of ear head per hill, grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) and harvest index (%), a sample consisting of five plants was selected at random and tagged in net plot of each treatment. Observations on growth parameters were recorded at 60, 90 DAT and at harvest of the crop. The same plants were also used to record the yield components at harvest. The data recorded on various observations on growth and yield parameters were subjected to analysis of variance (ANOVA) as outlined by Gomez and Gomez [10]. The level of significance used in the 'F' test was at 5 per cent. The critical difference (CD) values were given in the table at 5 per cent level of significance, wherever the 'F' test was significant. Otherwise against CD values abbreviation NS (Non-significant) was indicated.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

3.1.1 Plant height (cm)

The response of foliar applied nano urea was found significant on growth of ragi (Table 1). Application of 100 per cent RDN + one spray of 0.4 per cent nano urea fertilizer at 30 DAT (T_6) recorded a maximum plant height (75.82, 92.39 and 94.13 cm) at 60, 90 DAT and at harvest, which was statistically on par with 100 per cent RDN + one spray of 2 per cent urea fertilizer at 30 DAT (T_{10} -73.12, 89.21 and 90.86 cm) and 75 per cent RDN + two sprays of 0.4 per cent nano urea fertilizer at 30 & 45 DAT (T_5-71.95, 87.85 and 89.46 cm). It might be due to the combined effect of foliar spray of nano urea along with soil application of conventional urea, which enhances the height of the plant since it boosts the metabolic and meristematic activities and increases apical growth and photosynthetic area [11]. The absolute control treatment noticed a minimum plant height (T_1-44.52, 52.76 and 53.62 cm) at 60, 90 DAT and at harvest, respectively.

3.1.2 Number of tillers per hill

Similarly, significant higher number of tillers $hill^{-1}$ was recorded in 100 per cent RDN + one spray of 0.4 per cent nano urea fertilizer at 30 DAT (T_6-7.58, 8.76 and 8.85 at 60, 90 DAT and at harvest), which was statistically on par with the

application of 100 per cent RDN + one spray of 2 per cent urea fertilizer at 30 DAT (T_{10}-7.32, 8.46 and 8.54) and 75 per cent RDN + two sprays of 0.4 per cent nano urea fertilizer at 30 & 45 DAT (T_5-7.16, 8.34 and 8.42). The significant increment in number of tillers was induced by nano fertilizers, which was attributed to increase the activity of chloroplast [12], rubisco enzyme [13], antioxidant enzyme system [14] and nitrate reductase [15], that could be underlying mechanism for increased growth and number of tillers. The lower number of tillers hill^{-1} was observed in absolute control (T_1-4.12, 4.75 and 4.78).

3.2 Yield and Yield Attributes

3.2.1 Finger length and number of earheads per hill

Yield components *viz.,* finger length (cm), number of earheads per hill, test weight, grain yield, straw yield and harvest index were recorded at harvest as influenced by the foliar application of nano urea and conventional urea are presented in Table 2 & 3. Significantly maximum finger length and number of earheads per hill (8.46 cm and 7.86) at harvest (Table 2) was recorded with the application of 100 per cent RDN + one spray of 0.4 per cent nano urea fertilizer at 30 DAT (T_6), which was found to be on par with 100 per cent RDN + one spray of 2 per cent urea fertilizer at 30 DAT (T_{10}-8.13 cm and 7.63) and 75 per cent RDN + two sprays of 0.4 per cent nano urea fertilizer at 30 & 45 DAT (T_5-7.98 cm and 7.52). The adequate nitrogen supply facilitates the partitioning of photosynthates to the primary culm, a source of nutrients and carbohydrates for the development of the fingers and ear heads [16]. The usage of nano urea, which makes nitrogen consistently and continuously available throughout the entire crop season, leads to an increase in the number of earheads and finger length [17]. However, the absolute control (T_1) treatment identified a minimum finger length and number of earheads per hill (4.62 cm and 4.21). No significant difference was observed among the various treatment combinations for test weight at harvest. However, numerically higher test weight (3.28 g)

Table 1. Plant height, number of tillers per hill of ragi as influenced by the foliar application of nano and conventional urea at different growth stages

Treatment details	Plant height (cm)			Number of tillers hill^{-1}		
	60 DAT	90 DAT	At harvest	60 DAT	90 DAT	At harvest
T_1 - Absolute control	44.52	52.76	53.62	4.12	4.75	4.78
T_2 - Recommended dose of fertilizer (100:50:50 kg N:P_2O_5:K_2O ha^{-1})	70.15	84.67	86.25	6.93	8.02	8.09
T_3 - 50 % RDN + Two sprays of 0.4 % nano urea fertilizer at 30 & 45 DAT	61.58	73.84	75.08	5.97	6.93	6.98
T_4 - 75 % RDN + One spray of 0.4 % nano urea fertilizer at 30 DAT	66.24	80.16	81.59	6.51	7.58	7.65
T_5 - 75 % RDN + Two sprays of 0.4 % nano urea fertilizer at 30 & 45 DAT	71.95	87.85	89.46	7.16	8.34	8.42
T_6 - 100 % RDN + One spray of 0.4 % nano urea fertilizer at 30 DAT	75.82	92.39	94.13	7.58	8.76	8.85
T_7 - 50 % RDN + Two sprays of 2 % urea fertilizer at 30 & 45 DAT	58.27	69.83	71.09	5.65	6.57	6.59
T_8 - 75 % RDN + One spray of 2 % urea fertilizer at 30 DAT	60.56	72.68	73.98	5.89	6.82	6.87
T_9 - 75 % RDN + Two sprays of 2 % urea fertilizer at 30 & 45 DAT	67.34	81.54	82.97	6.64	7.69	7.78
T_{10}- 100 % RDN + One spray of 2 % urea fertilizer at 30 DAT	73.12	89.21	90.86	7.32	8.46	8.54
T_{11} - Four sprays of 0.4 % nano urea fertilizer at 15, 30, 45 & 60 DAT	51.38	61.47	62.54	4.85	5.78	5.83
S. Em (±)	2.02	2.58	2.65	0.21	0.24	0.25
CD (p=0.05)	5.95	7.62	7.82	0.62	0.72	0.73

Table 2. Number of earheads hill^{-1}, finger length and test weight of ragi as influenced by the foliar application of nano and conventional urea at different growth stages

Treatment details	Finger length (cm)	Number of ear heads hill^{-1}	Test weight (g)
T_1 - Absolute control	4.62	4.21	3.12
T_2 - Recommended dose of fertilizer (100:50:50 kg N:P_2O_5:K_2O ha^{-1})	7.74	7.19	3.23
T_3 - 50 % RDN + Two sprays of 0.4 % nano urea fertilizer at 30 & 45 DAT	6.67	6.27	3.18
T_4 - 75 % RDN + One spray of 0.4 % nano urea fertilizer at 30 DAT	7.23	6.84	3.20
T_5 - 75 % RDN + Two sprays of 0.4 % nano urea fertilizer at 30 & 45 DAT	7.98	7.52	3.25
T_6 - 100 % RDN + One spray of 0.4 % nano urea fertilizer at 30 DAT	8.46	7.86	3.28
T_7 - 50 % RDN + Two sprays of 2 % urea fertilizer at 30 & 45 DAT	6.29	5.98	3.14
T_8 - 75 % RDN + One spray of 2 % urea fertilizer at 30 DAT	6.55	6.17	3.17
T_9 - 75 % RDN + Two sprays of 2 % urea fertilizer at 30 & 45 DAT	7.41	6.95	3.22
T_{10}- 100 % RDN + One spray of 2 % urea fertilizer at 30 DAT	8.13	7.63	3.26
T_{11} - Four sprays of 0.4 % nano urea fertilizer at 15, 30, 45 & 60 DAT	5.47	5.24	3.13
S. Em (±)	0.24	0.22	0.12
CD (p=0.05)	0.71	0.65	NS

was recorded in treatment with 100 per cent RDN + one spray of 0.4 per cent nano urea fertilizer at 30 DAT (T_6) as compared to other treatments. This might be because the combination of traditional fertilizers and nano fertilizers increased the food conversion, causing the grain to fill and increase its weight. In comparison, numerically least test weight (3.12 g) was recorded in the absolute control (T_1).

3.2.2 Grain yield (kg ha^{-1})

Higher grain yield (3812 kg ha^{-1}) (Table 3) was recorded with the application of 100 per cent RDN + one spray of 0.4 per cent nano urea fertilizer at 30 DAT (T_6), which was statistically on par with the application of 100 per cent RDN + one spray of 2 per cent urea fertilizer at 30 DAT (T_{10}-3664 kg ha^{-1}) and 75 per cent RDN + two sprays of 0.4 per cent nano urea fertilizer at 30 & 45 DAT (T_5-3589 kg ha^{-1}). The treatment 100 per cent RDN + one spray of 0.4 per cent nano urea fertilizer at 30 DAT produced 9.32 per cent higher grain yield compared to the recommended dose of fertilizer (T_2 -3487 kg ha^{-1}) (Fig. 1). Basal application of conventional urea improved the root establishment and increased foliar growth during the vegetative stage of the crop. This early optimum growth facilitates the efficient absorption of nano urea at later development stages and enhances the physiological and metabolic processes in the plant systems promoting the transport of photosynthates from source to sink [18]. The higher grain yield might be obtained because of the effective utilization of nitrogen resources. The nitrogen in nano form especially provided at the later phases of the plant life cycle might also have resulted in higher yield since that might have resulted in availability of nutrient for a longer period of time. However, lower grain yield (1428 kg ha^{-1}) was recorded in absolute control (T_1).

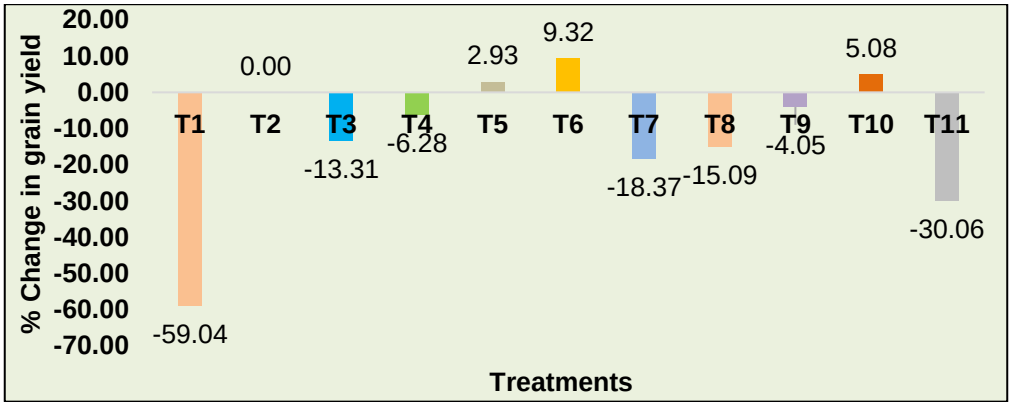
3.2.3 Straw yield (kg ha^{-1})

Treatment with the application of 100 per cent RDN + one spray of 0.4 per cent nano urea fertilizer at 30 DAT (T_6) has recorded higher straw yield (6453 kg ha^{-1}), which was found statistically on par with the application of 100 per cent RDN + one spray of 2 per cent urea fertilizer at 30 DAT (T_{10}-6235 kg ha^{-1}) and 75 per cent RDN + two sprays of 0.4 per cent nano urea

fertilizer at 30 & 45 DAT (T_5-6105 kg ha^{-1}) (Table 3). The increase in the straw yield with the foliar spray of nano urea might be due to their rapid uptake by the plants and translocation at a faster pace, which aided in a higher rate of photosynthesis and more dry matter accumulation which resulted in higher straw yield. These findings were in agreement with the reports of Khalil et al. [19] in maize and Sahu et al. [20] in rice. Nano urea formulations are often developed to improve nutrient uptake efficiency. By enhancing the availability and uptake of nutrients, including nitrogen, nano urea has the potential to promote plant growth, including straw biomass production. However, compared to treatments that received an application of either only conventional urea or a combination of both conventional and nano urea, the treatment with four sprays of nano urea at 15, 30, 45, and 60 DAT (T_{11}-4386 kg ha^{-1}) exhibited lower straw yield and was significantly higher compared to absolute control (T_1-2741 kg ha^{-1}).

Table 3. Grain yield, straw yield and harvest index of ragi as influenced by the foliar application of nano and conventional urea

Treatment details	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
T_1 - Absolute control	1428	2741	34.25
T_2 - Recommended dose of fertilizer (100:50:50 kg $N:P_2O_5:K_2O$ ha^{-1})	3487	5926	37.04
T_3 - 50 % RDN + Two sprays of 0.4 % nano urea fertilizer at 30 & 45 DAT	3023	5268	36.46
T_4 - 75 % RDN + One spray of 0.4 % nano urea fertilizer at 30 DAT	3268	5624	36.75
T_5 - 75 % RDN + Two sprays of 0.4 % nano urea fertilizer at 30 & 45 DAT	3589	6105	37.02
T_6 - 100 % RDN + One spray of 0.4 % nano urea fertilizer at 30 DAT	3812	6453	37.13
T_7 - 50 % RDN + Two sprays of 2 % urea fertilizer at 30 & 45 DAT	2846	5012	36.22
T_8 - 75 % RDN + One spray of 2 % urea fertilizer at 30 DAT	2961	5157	36.47
T_9 - 75 % RDN + Two sprays of 2 % urea fertilizer at 30 & 45 DAT	3345	5749	36.78
T_{10}- 100 % RDN + One spray of 2 % urea fertilizer at 30 DAT	3664	6235	37.01
T_{11} - Four sprays of 0.4 % nano urea fertilizer at 15, 30, 45 & 60 DAT	2439	4386	35.73
S. Em (±)	107.41	161.63	1.12
CD (p=0.05)	316.86	476.82	NS



Please check this figuer

Fig. 1. Per cent variation change in grain yield over the recommended dose of fertilizer as influenced by foliar application of nano and conventional urea in ragi

Note: Treatment details are provided in materials and methods

4. CONCLUSION

The study concluded that, application of 100 per cent RDN + one spray of 0.4 per cent nano urea fertilizer at 30 DAT recorded higher plant height, number of tillers per hill, number of ear heads per hill and finger length as compared to recommended dose of fertilizer. Higher grain (9.32%) and straw yield (8.89%) was obtained in the treatment with the application of 100 per cent RDN + one spray of 0.4 per cent nano urea fertilizer at 30 DAT over the recommended dose of fertilizer.

ACKNOWLEDGEMENT

The authors are thankful to Agricultural and Horticultural Research Station, Bavikere and Department of Agronomy, College of Agriculture, Shivamogga for providing necessary facilities to undertaken the studies.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anonymous. Indiastat. Area, production and yield of principal crops, Directorate of Economics and Statistics, Department of Agriculture and Cooperation report, Government of India, New Delhi; 2022. Available:www.indiastat.com
2. Shobana S, Krishnaswamy K, Sudha V, Malleshi NG, Anjana RM, Palaniappan L, Mohan V. Finger millet (Ragi, *Eleusine coracana* L.): a review of its nutritional properties, processing and plausible health benefits. Advances in food and nutrition research. 2012;69:1-39.
3. Hari PK. Nutritional importance and cultivation aspects. Indian Institute of Millets Research, Rajendranagar, Hyderabad, Telangana, India. Indian Farming. 2016;65(12):25-29.
4. Fan MX, Mackenzie AF. Urea and phosphate interaction in fertilizer microsites: Ammonia volatilization and pH changes. Soil Science Society of America Journal. 1993;57(1):839-844
5. Subbarao CV, kartheek G, Sirisha D. Slow release of potash fertilizer through polymer coating. International Journal of Applied science and engineering. 2013;11(1): 25-30.
6. Baboo P. Nano Urea the Philosophy of Future, Research Gate; 2023. Available:https://www.researchgate.net/publication/353260539
7. Walkley A, Black CA. An examination of digestion methods for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science. 1934;37:29-38.
8. Subbaiah B, Asija. A rapid procedure for the determination of available nitrogen in soils. Current Science. 1956;25(1):259-260.
9. Jackson M. Soil chemical analysis: Prentice Hall of India Pvt. Ltd, New Delhi; 1973.
10. Gomez Kwanchai A, Arturo A Gomez. Statistical procedures for agricultural research. John Wiley and Sons; 1984.
11. Samanta S, Maitra S, Shankar T, Gaikwad D, Sagar L, Panda M, Samui S. Comparative performance of foliar application of urea and nano urea on finger millet (*Eleusine coracana* L. Gaertn). Crop Research. 2022;57(3):166-170.
12. Hong F, Zhou J, Liu C, Yang F, Wu C, Zheng L. Effect of nano titanium oxide on phytochemical reaction of chloroplast of spinach. Biological trace element research. 2005;105(3):269-279.
13. Gao F, Hong F, Liu C, Zheng L, Su M, Wu X. Mechanism of nano anatase TiO_2 on promoting photosynthetic carbon reaction of spinach. Biological trace element research. 2006;111(3):239-253.
14. Nekrasova GF, Ushakova OS, Ermakov AE, Uimin MA, Byzov IV. Effects of copper ions and copper oxide nanoparticles on Elodea densa planch. Russian Journal of Ecology. 2011;42(6):458-463.
15. Lu CM, Zhang CY, Wen JQ, Wu GR, Tao MX. Research of the effect of nanometer materials on germination and growth enhancement of *Glycine max* and its mechanism. Soybean Science. 2002; 21(3):168-171.
16. Choudhary RC, Kumaraswamy RV, Kumari S, Sharma SS, Pal A, Raliya R, Biswas P, Saharan V. Zinc encapsulated chitosan nanoparticle to promote maize crop yield. International journal of biological macromolecules. 2019;127(1): 126-135.
17. Kumar R, Sharmili K, Balaganesh B, Manuel RI. Comparative evaluation of neem coated urea and nano urea on the growth and physiological attributes of

finger millet (*Eleusine coracana* L. Gaertn). International Journal of Environment and Climate Change. 2023;13(8):785-792.

18. Kumar Y, Tiwari KN, Singh T, Sain NK, Laxmi S, Verma R. Nano fertilizers 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.
19. Khalil MH, Abou AAF, Abdrabou RTH, Abdalhalim SH, Abdelmaaboud MSH. Response of two maize cultivars (*Zea mays* L.) to organic manure and mineral nano nitrogen fertilizer under siwa oasis conditions. AUJAS, Ain Shams Univ., Cairo, Egypt. 2019;27(1):299-312.
20. Sahu TK, Manish Kumar, Narendra Kumar, T Chandrakar, DP Singh. Effect of nano urea application on growth and productivity of rice (*Oryza sativa* L.) under midland situation of Bastar region. The Pharma Innovation. 2022;11(6): 185-187.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/109038