E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2025; SP-8(3): 38-43
Received: 23-12-2024
Accepted: 29-01-2025

Manjunath
M.Sc. Scholar, Department of Agronomy, College of Agriculture, Raichur, University of Agricultural Sciences, Raichur, Karnataka, India

Hiremath KA
Professor and Head, Department of Agronomy, College of Agriculture, Bheemarayangudi, University of Agricultural Sciences, Raichur, Karnataka, India

Likhita Nekkanti
M.Sc. Scholar, Department of Agronomy, College of Agriculture, Raichur, University of Agricultural Sciences, Raichur, Karnataka, India

Koppalkar BG
Professor and Head, Department of Agronomy, College of Agriculture, Raichur, University of Agricultural Sciences, Raichur, Karnataka, India

Shyamrao Kulkarni
Assistant Professor, Department of Agronomy, College of Agriculture, Bheemarayangudi, University of Agricultural Sciences, Raichur, Karnataka, India

Barikara Umesh
Assistant Professor, Department of Soil and Water Engineering & Extension Leader, Agricultural Extension Education Centre (AEEC), Nalwar, University of Agricultural Sciences, Raichur, Karnataka, India

Corresponding Author:
Manjunath
M.Sc. Scholar, Department of Agronomy, College of Agriculture, Raichur, University of Agricultural Sciences, Raichur, Karnataka, India

Effect of nano urea on nutrient uptake and economics of pearl millet

Manjunath, Hiremath KA, Likhita Nekkanti, Koppalkar BG, Shyamrao Kulkarni and Barikara Umesh

DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i3Sa.2614

Abstract
A field experiment was conducted at College of Agriculture, Bheemarayanagudi during *kharif*, 2023 to study the effect of nano urea on growth and yield of pearl millet. The experiment was laid out in RCBD with eight treatments and replicated thrice. The treatments consist of different doses of RDF with different doses of nano urea sprayed at 30 and 45 DAS. The results revealed that application of 75% RDN as basal + nano urea spray @ 4.0 ml l^{-1} at 30 and 45 DAS recorded significantly higher uptake of nitrogen, phosphorus and potassium (12.7, 43.4 and 56.1 kg ha^{-1}, respectively) and higher gross returns, net returns and BC ratio. It was found on par with recommended dose of fertilizers and 75% RDN as basal + nano urea spray @ 3.0 ml l^{-1} at 30 and 45 DAS. The absolute control was recorded with lower uptake of all the major nutrients and lower gross returns, net returns and BC ratio (₹ 91,373 ha^{-1}, ₹ 55,316 ha^{-1} and 2.53, respectively).

Keywords: Pearl millet, nano urea, nutrient uptake, economics

Introduction

Pearl millet (*Pennisetum glaucum* L.) is an annual tillering diploid (2n=14) crop which belongs to family *gramineae* and subfamily *panicoideae*. Pearl millet is widely grown in the world. It has been grown in Africa and Indian subcontinent since pre-historic time. Pearl millet is commonly known as candle millet, horse millet, bulrush millet and bajra. It is a major crop of arid and semi-arid regions of India and mostly grown as rainfed crop during *kharif* season.

In India, pearl millet is a primary source of dietary energy (360 kcal kg^{-1}) for rural population and fourth most important cereal after rice, wheat and sorghum. It is rich source of protein, calcium, phosphorous and iron. Pearl millet contain fairly high amount of thiamine, riboflavin and niacin. Pearl millet is also used as poultry feed, cattle feed and alcohol extraction. Pearl millet provide grain for human consumption and for livestock in the arid and semi-arid tropics.

Pearl millet is a drought resistant crop extensively grown in arid and semi-arid regions of the world so that it is called as tropical cereal. Among major cereals, pearl millet is highly tolerant to heat, drought, saline and acid soils and it is easy to grow in arid regions where rainfall is insufficient for maize or even sorghum (FAO, 2004) [1]. Pearl millet requires a minimum temperature of around 25 °C for germination and thrives well in hot climates, displaying resilience to high temperatures. The crop has ability to withstand low and erratic rainfall. Pearl millet performs well with an ideal rainfall range of 400 to 600 mm during the growing season optimizes its growth and yield. The crop prefers red, medium deep black and sandy soils with good drainage and a pH range of 6.0 to 8.5. Due to its warm-season nature and sensitivity to frost, it is typically cultivated in low to medium altitude areas.

Pearl millet is world's sixth most valuable cereal crop after wheat, rice, maize, barley and sorghum. In India, it is grown on an area of 6.8 million ha with production of 9.8 million tonnes and productivity of 1441 kg ha^{-1}, during the year 2021-22 (Anon., 2024) [2]. In the year 2022-2023, total production was 11.4 million tonnes and expected to produce 10.3 million tonnes in the year 2023-24. The productivity was 904 kg ha^{-1}. Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana are the major pearl millet growing states. Among them, Karnataka stands sixth in the country that produced 1.71 lakh tonnes of grains from 1.48 lakh ha area (Anon., 2024a) [3]. The average productivity of the state is 1158 kg ha^{-1} which is much below than its production potential that vary greatly with rainfall intensity and its distribution.

Plant nutrition for cultivation of pearl millet is critical for increased productivity. Nitrogen is one of the most important macronutrients which is essential for their growth, development and yield (Tremblay *et al*., 2011) [33]. Nitrogen is acknowledged as a vital and fundamental nutrient for enhancing crop growth rates, development and achieving optimal grain yields. Various ecological factors including temperature which influences greatly on crop growth and plant development. Augmentation of nitrogenous fertilizer levels to pearl millet are found to be a very effective for enhancing crop growth and development due to increased rate of photosynthesis (Fayyaz-ul-Hassan *et al*., 2005) [14].

Loss of nutrients from fields by way of leaching and gaseous emissions have been contributing to the environmental pollution and climate change, this can be reduced by the application of nano urea which has no residual effect. Urea forms 82 per cent of the total nitrogenous fertilizers consumed in India and it has recorded exponential increase in consumption over the years. It is expected that urea consumption will touch 35 million tonnes during 2020-21. Around 30-50 per cent of nitrogen from urea is utilized by plants and the rest gets wasted due to quick chemical transformation as a result of leaching, volatilization and run off losses thereby low use efficiency. The excess application of urea contributes to the greenhouse gas in form of nitrous oxide leads to global warming.

The conventional nitrogenous fertilizer industries generally produce synthetic ammonia, nitric acid, ammonium nitrate, urea and urea-ammonium nitrate (UAN). These fertilizers may also contain sulphur, chlorine, potassium, calcium, carbon besides the major nutrient nitrogen. However, the percentage of nitrogen taken up by the plants is far less than the quantity of fertilizer applied. Thereby the farmers are forced to apply more fertilizers to satisfy the plant needs. The present drawbacks forced the agricultural scientists to develop new fertilizer formulation with higher efficiency and having lesser soil, water and air pollution.

Nanotechnology is a rising field of science capable of resolving issues and problems that are impossible to tackle in engineering and biological sciences. Among the advancement in sciences, nanotechnology is being visualized as a rapidly evolving field that has potential to revolutionize agriculture and food systems as well as to improve the condition of the poor. Nanotechnology has emerged as an innovative solution with the production of nano agri-inputs for addressing the issue of low or declining nutrient use efficiency (NUE) with minimal environmental footprint. Therefore, nanotechnology is gradually moving from the experimental stage to the operational and application stage. This will lead to more tangible presence of the technology in the agricultural sector (Baruah and Dutta, 2009) [7]. In this regard, using nano fertilizer to control release of nutrients can be an effective step towards achieving sustainable agriculture and environment (Cui *et al*., 2010) [13].

Nano fertilizers have an effective alternative solution for addressing crop nutritional deficiencies through enhanced bioavailability of nutrients and limited losses to the environment. Nano scale materials can enhance the fertilizer use efficiency while foliar application can meet the crop nutrient requirement effectively as per its need. Whereas, the nano fertilizers are called as nutrient vectors that are developed by using nano scale raw material substrates that are ranging from 1-100 nm (Lal, 2008; Sharma, 2008) [19, 29] which have the ability to manipulate the materials to atom level, molecular and macromolecular scale. Nano particles have a large surface area and have the ability to retain an abundant amount of nutrients and release them slowly and stably for relatively longer time so as to facilitate the nutrient absorption that corresponds to the crop requirement without any shortcomings associated with specialized fertilizer inputs (Komarneni, 2009; Kothari *et al*., 2019) [17, 18].

Nano urea is a source of nitrogen which is an essential nutrient for crop growth and development. The size of one nano urea particle is about 30 nano metre (1 nm is one billionth of a meter) compared to the granular urea which has about 10,000 times more surface area to volume size. Further, due to ultra-small size and surface properties of nano urea, it gets absorbed by the plants when sprayed on the leaves.

Thus, nano fertilizers are emerging as an alternative to conventional fertilizers becoming important tools in agriculture for improving crop growth, yield and quality parameters and reduce wastage of fertilizers. Nanotechnology can reduce the rate of fertilizer nutrients loss through leaching and increase their availability to plants which ultimately leads to reduced water and soil pollution. The use of nitrogen nano fertilizer is essential for reducing higher requirement of fertilizer, cost and environment issues.

Materials and Methods

The experimental site was geographically situated in North Eastern Dry Zone (Zone - II) of Karnataka at a Latitude of 16º15′ North, Longitude of 77º21′ East with an Altitude of 389 meters above mean sea level. The soil of the experimental site was medium black to deep black with clay loam texture. The College of Agriculture, Bheemarayanagudi (UAS Raichur) comes under UKP command where rice-rice, chilli, cotton and redgram are predominant crops.

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications and eight treatments comprising of different doses of RDF with different doses of nano urea sprayed at 30 and 45 DAS. The treatments consisting of T_1: 50% RDN as basal + nano urea spray @ 2.0 ml l^{-1} at 30 and 45 DAS, T_2: 50% RDN as basal + nano urea spray @ 3.0 ml l^{-1} at 30 and 45 DAS, T_3: 50% RDN as basal + nano urea spray @ 4.0 ml l^{-1} at 30 and 45 DAS, T_4: 75% RDN as basal + nano urea spray @ 2.0 ml l^{-1} at 30 and 45 DAS, T_5: 75% RDN as basal + nano urea spray @ 3.0 ml l^{-1} at 30 and 45 DAS, T_6: 75% RDN as basal + nano urea spray @ 4.0 ml l^{-1} at 30 and 45 DAS, T_7: RDF (100:50:25 kg N: P_2O_5: K_2O ha^{-1}: FYM @ 6.0 t ha^{-1}) and T_8: Absolute control (No NPK).

Results and Discussion

Nutrient content and uptake by pearl millet

Nitrogen content (%) and uptake (kg ha^{-1})

There was a significant influence on nitrogen content (%) and uptake (kg ha^{-1}) by pearl millet by applying different levels of nitrogenous fertilizer and foliar spray of nano urea and it is represented in Table 1.

Significantly higher nitrogen content was noticed with the treatment which received 75% RDN as basal + nano urea spray @ 4.0 ml l^{-1} at 30 and 45 DAS in both grain and stover (1.62 and 0.73%, respectively), it was found on par with the treatment which received recommended dose of fertilizers (1.58 and 0.70%, respectively) and 75% RDN as basal + nano urea spray @ 3.0 ml l^{-1} at 30 and 45 DAS (1.55 and 0.69%, respectively). Lower nitrogen content in both grain and stover was noticed with absolute control (1.40 and 0.49%, respectively).

Among all the treatments, significantly lower uptake of nitrogen by grain, stover and total uptake was recorded with absolute control (32.3, 36.8 and 69.1kg ha^{-1}, respectively). The treatment T_6: 75% RDN as basal + nano urea spray @ 4.0 ml l^{-1} at 30 and 45 DAS recorded significantly higher uptake of nitrogen by grain, stover and total uptake (58.5, 62.6 and 121.1 kg ha^{-1}, respectively) and this treatment was found statistically on par with application of recommended dose of fertilizers (56.1, 60.5 and 116.6 kg ha^{-1}, respectively) and 75% RDN as basal + nano urea spray @ 3.0 ml l^{-1} at 30 and 45 DAS (53.6, 58.1 and 111.7 kg ha^{-1}, respectively).

Table 1: Nitrogen content and uptake by pearl millet as influenced by different levels of nitrogenous fertilizer and foliar spray of nano urea at harvest

Treatment	Nitrogen content (%)		Nitrogen uptake (kg ha^{-1})		
	Grain	Stover	Grain	Stover	Total
T_1: 50% RDN as basal + nano urea spray @ 2.0 ml l^{-1} at 30 and 45 DAS	1.45	0.54	36.6	42.2	78.8
T_2: 50% RDN as basal + nano urea spray @ 3.0 ml l^{-1} at 30 and 45 DAS	1.47	0.57	40.4	45.3	85.7
T_3: 50% RDN as basal + nano urea spray @ 4.0 ml l^{-1} at 30 and 45 DAS	1.50	0.58	44.0	47.5	91.5
T_4: 75% RDN as basal + nano urea spray @ 2.0 ml l^{-1} at 30 and 45 DAS	1.52	0.63	48.1	51.8	99.9
T_5: 75% RDN as basal + nano urea spray @ 3.0 ml l^{-1} at 30 and 45 DAS	1.55	0.69	53.6	58.1	111.7
T_6: 75% RDN as basal + nano urea spray @ 4.0 ml l^{-1} at 30 and 45 DAS	1.62	0.73	58.5	62.6	121.1
T_7: RDF	1.58	0.70	56.1	60.5	116.6
T_8: Absolute control (No NPK)	1.40	0.49	32.3	36.8	69.1
S.Em. ±	0.03	0.02	1.8	1.8	3.3
C.D. at 5%	0.08	0.07	5.6	5.4	10.0

Note: RDN - Recommended Dose of Nitrogen (100 kg ha^{-1}) RDF -100:50:25 kg $N:P_2O_5:K_2O$ ha^{-1}; FYM @ 6 t ha^{-1} DAS: Days After Sowing

Phosphorus content (%) and uptake (kg ha^{-1})

Application of different levels of nitrogenous fertilizer and foliar spray of nano urea has significantly influenced the phosphorus content (%) and uptake (kg ha^{-1}) on grain and stover and represented in the Table 2.

The treatment which received 75% RDN as basal + nano urea spray @ 4.0 ml l^{-1} at 30 and 45 DAS was recorded with higher phosphorus content in both grain and stover (0.70 and 0.33%, respectively). The treatment which received recommended dose of fertilizers (0.68 and 0.32%, respectively) and 75% RDN as basal + nano urea spray @ 3.0 ml l^{-1} at 30 and 45 DAS (0.67 and 0.30%, respectively) were found on par with 75% RDN as basal + nano urea spray @ 4.0 ml l^{-1} at 30 and 45 DAS for phosphorus content in both grain and stover. The lower phosphorus content in both grain and stover was noticed with absolute control (0.53 and 0.19%, respectively).

Significantly higher phosphorus uptake by grain, stover and total uptake was noticed with 75% RDN as basal + nano urea spray @ 4.0 ml l^{-1} at 30 and 45 DAS (26.9, 28.9 and 55.8kg ha^{-1}, respectively) and it was found on par with the treatments which received recommended dose of fertilizers (24.5, 27.2 and 51.7 kg ha^{-1}, respectively) and 75% RDN as basal + nano urea spray @ 3.0 ml l^{-1} at 30 and 45 DAS (23.9, 25.8 and 49.7 kg ha^{-1}, respectively). The absolute control recorded significantly lower phosphorus uptake by grain, stover and total uptake (12.7, 14.3 and 27.0 kg ha^{-1}, respectively).

Potassium content (%) and uptake (kg ha^{-1})

The variation in potassium content (%) and uptake (kg ha^{-1}) in both grain and stover was observed among the treatments due to application of different levels of nitrogenous fertilizer and foliar spray of nano urea and presented in Table 3.

Among the treatments, significantly higher potassium content in both grain and straw was observed with the treatment which received 75% RDN as basal + nano urea spray @ 4.0 ml l^{-1} at 30 and 45 DAS (0.31 and 0.49%, respectively) and the treatments recommended dose of fertilizers (0.29 and 0.48%, respectively) and 75% RDN as basal + nano urea spray @ 3.0 ml l^{-1} each at 30 and 45 DAS (0.27 and 0.46%, respectively) were found on par with 75% RDN as basal + nano urea spray @ 4.0 ml l^{-1} at 30 and 45 DAS. Significantly lower potassium content in both grain and stover was noticed with absolute control (0.19 and 0.30%, respectively).

With respect to uptake, the lower potassium uptake by grain, stover and total uptake was recorded with absolute control (4.4, 22.5 and 26.9 kg ha^{-1}, respectively). Significantly higher potassium uptake by grain, stover and total uptake was recorded with the treatment which received 75% RDN as basal + nano urea spray @ 4.0 ml l^{-1} at 30 and 45 DAS (12.7, 43.4 and 56.1 kg ha^{-1}, respectively) and it was found on par with recommended dose of fertilizers (11.6, 40.9 and 52.5 kg ha^{-1}, respectively) and 75% RDN as basal + nano urea spray @ 3.0 ml l^{-1} at 30 and 45 DAS (11.1, 38.7 and 49.8 kg ha^{-1}, respectively).

The application of organic manure like FYM @ 6 t ha^{-1} and the combined application of nitrogenous fertilizer and foliar spray of nano urea might have increased the availability of nutrients in the root zone as well as in the plant system that led to increased uptake of major nutrients like nitrogen, phosphorus as well as potassium Further, it resulted its accumulation in different reproductive parts like grain and stover which increased the nutrient content of grain and stover. The higher content of all the major nutrients like nitrogen, phosphorus and potassium was found with application of higher dose of nano fertilizers as foliar spray which might have increased the nutrient availability to the plants and absolute control recorded lower nitrogen, phosphorus and potassium content because there was no addition of any chemical or nano fertilizers that might be made lesser availability of nutrients to the plants.

The uptake of nutrient is function of grain and stover yield as well as the nutrient content present in the reproductive parts. The higher content of nutrients might be due to higher uptake that might have resulted from well-developed root system of the plants and increased availability of nutrients in the root zone. The increased nutrient uptake by both grain and stover was seen with foliar application of nano fertilizers because of their higher surface area of the nano particles and decreased particle size which was lesser than that of pore size of leaves and have increased the penetration of particles into the plant system resulted in higher nutrient content and uptake. The similar results were obtained by Singh *et al.* (2022) [32] in wheat, Sahu *et al.* (2022) [26] in rice, Sharma *et al.* (2022) [31] in pearl millet and Chavan *et al*. (2023) [11] in little millet.

Table 2: Phosphorus content and uptake by pearl millet as influenced by different levels of nitrogenous fertilizer and foliar spray of nano urea at harvest

Treatment	Phosphorus content (%)		Phosphorus uptake (kg ha^{-1})		
	Grain	Stover	Grain	Stover	Total
T_1: 50% RDN as basal + nano urea spray @ 2.0 ml l^{-1} at 30 and 45 DAS	0.61	0.24	15.6	18.7	34.3
T_2: 50% RDN as basal + nano urea spray @ 3.0 ml l^{-1} at 30 and 45 DAS	0.64	0.26	17.6	20.7	38.3
T_3: 50% RDN as basal + nano urea spray @ 4.0 ml l^{-1} at 30 and 45 DAS	0.65	0.27	19.1	21.7	40.8
T_4: 75% RDN as basal + nano urea spray @ 2.0 ml l^{-1} at 30 and 45 DAS	0.66	0.29	20.7	23.8	44.5
T_5: 75% RDN as basal + nano urea spray @ 3.0 ml l^{-1} at 30 and 45 DAS	0.67	0.30	23.9	25.8	49.7
T_6: 75% RDN as basal + nano urea spray @ 4.0 ml l^{-1} at 30 and 45 DAS	0.70	0.33	26.9	28.9	55.8
T_7: RDF	0.68	0.32	24.5	27.2	51.7
T_8: Absolute control (No NPK)	0.53	0.19	12.7	14.3	27.0
S.Em. ±	0.04	0.04	1.0	1.1	2.1
C.D. at 5%	0.12	0.12	3.1	3.4	6.6

Note: RDN - Recommended Dose of Nitrogen (100 kg ha^{-1}) RDF -100:50:25 kg $N:P_2O_5:K_2O$ ha^{-1}; FYM @ 6 t ha^{-1} DAS: Days After Sowing

Table 3: Potassium content and uptake by pearl millet as influenced by different levels of nitrogenous fertilizer and foliar spray of nano urea at harvest

Treatment	Potassium content (%)		Potassium uptake (kg ha^{-1})		
	Grain	Stover	Grain	Stover	Total
T_1: 50% RDN as basal + nano urea spray @ 2.0 ml l^{-1} at 30 and 45 DAS	0.21	0.37	5.3	28.9	34.2
T_2: 50% RDN as basal + nano urea spray @ 3.0 ml l^{-1} at 30 and 45 DAS	0.23	0.40	6.3	31.8	38.1
T_3: 50% RDN as basal + nano urea spray @ 4.0 ml l^{-1} at 30 and 45 DAS	0.23	0.42	6.7	33.8	40.5
T_4: 75% RDN as basal + nano urea spray @ 2.0 ml l^{-1} at 30 and 45 DAS	0.26	0.44	9.2	36.2	45.4
T_5: 75% RDN as basal + nano urea spray @ 3.0 ml l^{-1} at 30 and 45 DAS	0.27	0.46	11.1	38.7	49.8
T_6: 75% RDN as basal + nano urea spray @ 4.0 ml l^{-1} at 30 and 45 DAS	0.31	0.49	12.7	43.4	56.1
T_7: RDF	0.29	0.48	11.6	40.9	52.5
T_8: Absolute control (No NPK)	0.19	0.30	4.4	22.5	26.9
S.Em. ±	0.05	0.04	0.7	1.7	2.1
C.D. at 5%	0.16	0.12	2.1	5.1	6.5

Note: RDN - Recommended Dose of Nitrogen (100 kg ha^{-1}) RDF -100:50:25 kg $N:P_2O_5:K_2O$ ha^{-1}; FYM @ 6 t ha^{-1} DAS: Days After Sowing

Economics

Significantly higher gross returns, net returns and BC ratio were noticed with application of 75% RDN as basal + nano urea spray @ 4.0 ml l^{-1} at 30 and 45 DAS (₹ 91,373 ha^{-1}, ₹ 55,316 ha^{-1} and 2.53, respectively) and it was found on par with recommended dose of fertilizers (₹ 86,287 ha^{-1}, ₹ 51,895 ha^{-1} and 2.51, respectively) and 75% RDN as basal + nano urea spray @ 3.0 ml l^{-1} at 30 and 45 DAS (₹ 85,026 ha^{-1}, ₹ 49,459 ha^{-1} and 2.39, respectively). Lower gross returns, net returns and BC ratio were noticed with absolute control (₹ 53,802 ha^{-1}, ₹ 25,002 ha^{-1} and 1.87, respectively) (Fig. 1).

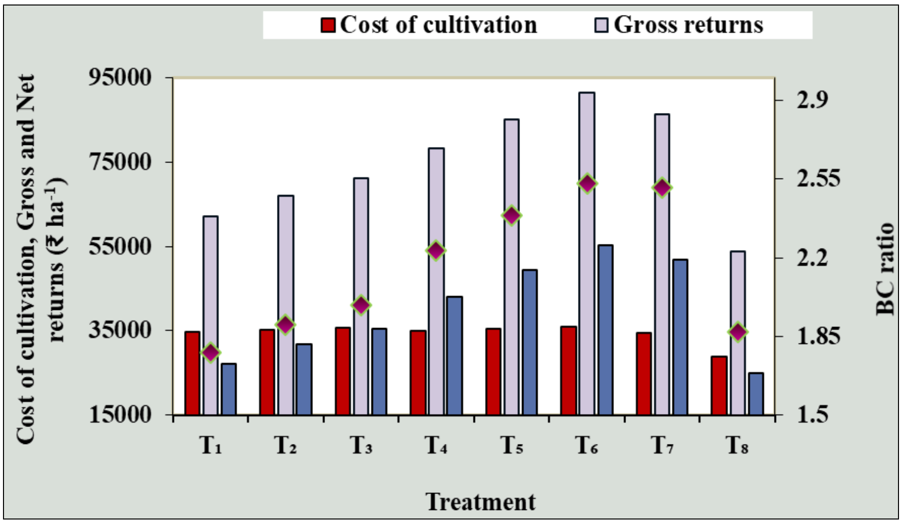

Fig 1: Economics of pearl millet as influenced by different levels of nitrogenous fertilizer and foliar spray of nano urea

Conclusion

Application of 75 per cent RDN along with nano urea spray @ 4 ml l^{-1} at 30 and 45 DAS was found beneficial for effective management of nitrogen requirement of pearl millet and recorded higher growth parameters,yield parameters and yield of pearl millet. With the application of both conventional and nano nitrogen fertilizer, yield and yield parameters of pearl millet can be boosted. Higher economic returns were also found with the treatment 75 per cent RDN along with nano urea spray @ 4 ml l^{-1} at 30 and 45 DAS and this was found on par with recommended dose of fertilizers and 75% RDN as basal + nano urea spray @ 3.0 ml l^{-1} at 30 and 45 DAS.

Acknowledgement
This research was a part of M. Sc. thesis and the author greatly appreciate research facilities and support provided from the College of Agriculture, Raichur for conducting this research study. The author is grateful to members of the advisory committee, major advisor, Dr. Kumaraswamy Hiremath, Professor and Head, Department of Agronomy, College of Agriculture, Bheemarayanagudi and members Dr. B. G. Koppalkar**,** Professor and Head, Department of Agronomy, College of Agriculture, Raichur, Dr. Shyamrao Kulkarni, Assistant Professor, Department of Agronomy, College of Agriculture, Bheemarayanagudi and Dr. Barikara Umesh, Assistant Professor (Soil and Water Engineering) & Extension Leader, Agricultural Extension Education Centre, Nalwar for their engrossing guidance, incessant encouragement, constructive suggestions propitious assistance, keen and sustained interest, kind and gracious patronage during the entire course of investigation and preparation of this manuscript. I also thank Director of SC/ST cell, UAS, Raichur for supporting me in publishing this article.

References
1. FAO. The State of Food Insecurity in the World. FAO, Rome; 2004.
2. Anonymous. USDA, Foreign Agriculture Service. India - Area, yield and production for the year 2022-23. [Internet] Available from: https://ipad.fas.usda.gov. 2024.
3. Anonymous. Indiastat, Karnataka - Area, Yield and Production for the year 2023-24. [Internet] Available from: https://www.indiastat.com/. 2024.
4. Arya GR, Manivannan V, Marimuthu S, Sritharan N. Effect of foliar application of nano-urea on yield attributes and yield of pearl millet (*Pennisetum glaucum* L.). Int J Plant Soil Sci. 2022;34(21):502-507.
5. Babubhai BD, Solanki MS, Rani B, Gaurangbhai VF. Effect of different levels of chemical and nano potassic fertilizer on yield and yield attribute of maize crop (*Zea mays* L.) cv. Amber. J Pharmacogn Phytochem. 2019;8(5):58-61.
6. Balachandar N, Sharmili K, Balaganesh B, Manuel RI. Impact of neem-coated urea and nano urea on sorghum (*Sorghum bicolor* (L.) Moench.) growth and yield. Biol Forum Int J. 2023;15(10):55-58.
7. Baruah S, Dutta J. Nanotechnology applications in sensing and pollution degradation in agriculture. Environ Chem Lett J. 2009;7:191-204.
8. Benzon HRL, Rubenecia MRU, Ultra Jr VU, Lee SC. Nano-fertilizer affects the growth, development, and chemical properties of rice. Int J Agron Agril Res. 2015;7(1):105-117.
9. Bhargavi G, Sundari A. Effect of nano urea on the growth and yield of rice (*Oryza sativa* L.) under SRI in the Cauvery delta zone of Tamil Nadu. Crop Res. 2023;58(1 & 2):12-17.
10. Bhavani P, Prakash SS, Harinikumar KM, Thimmegowda MN, Benherlal PS, Yoganand SB. Performance of slow release hydroxyapatite coated urea nanofertilizer on aerobic paddy. Int J Curr Microbiol App Sci. 2020;9(11):1320-1330.
11. Chavan PM, Waghmare YM, Maindale SD, Chaudhari BK. Studies on effect of foliar application of nano N fertilizer on yield and economics of sorghum (*Sorghum bicolor* L.). PharmaInnov Int J. 2023;12(3):1498-1500.
12. Chinnappa SA, Krishnamurthy D, Ajayakumar MY, Ramesha YM, Ravi S. Response of nano fertilizers on growth, yield and economics of kharif sorghum. J Pharm Innov. 2023;12(9):761-765.
13. Cui HX, Sun CJ, Liu Q, Jiang J, Gu W. Applications of nanotechnology in agrochemical formulation, perspectives, challenges and strategies. In: International conference on Nanoagri, Sao Pedro, Brazil; 2010. p. 28-33.
14. Fayyaz-ul-Hassan G, Qadir M, Cheema MA. Growth and development of sunflower in response to seasonal variations. Pakistan J Bot. 2005;37(4):859-864.
15. Karanjikar PN, Patange MJ, Waghamre PK, Jadhav DB. Impact of N-nano fertilizer on yield attributes, economic and quality of pearl millet (*Pennisetum glaucum* L.) under rainfed condition. Int J Res Agron. 2024;7(1):420-423.
16. Khan R, Chandra S, Nagar R, Khatana RS, Nagar V. Response of pearl millet [*Pennisetum glaucum* (L.) R. Br.] to foliar application of nano nitrogen fertilizer (nano urea). J Progress Agric. 2023;14(1):69-73.
17. Komarneni S. Potential of nanotechnology in environmental soil science. Proc 9th Int Conf East Southeast Asia Fed Soil Sci Soc. 2009;16-20.
18. Kothari R, Khursheed AW. Environmentally friendly slow-release nano-chemicals in agriculture: a synoptic review. In: Research anthology on synthesis, characterization and applications of nanomaterials. IGI Global; 2019. p. 409-425.
19. Lal R. Soils and India's food security. J Indian Soc Soil Sci. 2008;56(2):129-138.
20. Mallikarjuna PR. Effect of nano nitrogen and nano zinc nutrition on nutrient uptake, growth and yield of irrigated maize during summer in the southern transition zone of Karnataka. M.Sc. (Agri.) Thesis, Keladi Shivappa Nayaka Univ Agric Sci, Shivamogga, India; 2021.
21. Mehta S, Bharat R. Effect of integrated use of nano and non-nano fertilizers on yield and yield attributes of wheat (*Triticum aestivum* L.). Int J Curr Microbiol App Sci. 2019;8(12):598-606.
22. Midde SK, Perumal MS, Murugan G, Sudhagar R. Performance of different sources of nitrogen under different establishment methods of rice (*Oryza sativa*). Crop Res. 2022;57(5 & 6):292-296.
23. Rajesh H, Yadahalli GS, Chittapur BM, Halepyati AS, Hiregoudar S. Growth, yield and economics of sweet corn (*Zea mays* L. Saccharata) as influenced by foliar sprays of nano fertilisers. J Farm Sci. 2021;34(4):381-385.
24. Rajput JS, Thakur AK, Nag NK, Chandrakar T, Singh DP. Effect of nano fertilizer in relation to growth, yield and economics of little millet (*Panicum sumatrense* Roth) under rainfed conditions. J Pharm Innov. 2022;11(7):153-156.
25. Rathnayaka RMNN, Iqbal YB, Rifnas LM. Influence of urea and nano-nitrogen fertilizers on the growth and yield of rice (*Oryza sativa* L.) Cultivar Bg 250. Int J Res Publ. 2018;5(2):7-15.
26. Sahu TK, Kumar M, Kumar N, Chandrakar T, Singh DP. Effect of nano urea application on growth and productivity of rice (*Oryza sativa* L.) under midland situation of Bastar region. J Pharm Innov. 2022;11(6):185-187.
27. 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 Res. 2022;57(3):166-170.
28. Samui S, Sagar L, Sankar T, Manohar A, Adhikary R, Maitra S, *et al*. Growth and productivity of rabi maize as influenced by foliar application of urea and nano-urea. Crop Res. 2022;57(3):136-140.
29. Sharma PD. Nutrient management: Challenges and options.

J Indian Soc Soil Sci. 2008;55(4):395-403.
30. Sharma SK, Lahari S, Hussain SA, Parameswari YS. Grain yield and nutrient uptake of rice as influenced by the nano forms of nitrogen. Int J Environ Climate Change. 2021;11(7):1-6.
31. Sharma SK, Sharma PK, Mandeewal RL, Sharma V, Chaudhary R, Pandey R, *et al*. Effect of foliar application of nano-urea under different nitrogen levels on growth and nutrient content of pearl millet (*Pennisetum glaucum* L.). Int J Plant Soil Sci. 2022;34(20):149-155.
32. Singh BV, Singh S, Verma S, Yadav SK, Mishra J, Mohapatra S, *et al*. Effect of nano-nutrient on growth attributes, yield, Zn content and uptake in wheat (*Triticum aestivum* L.). Int J Environ Clim Chang. 2022;12(11):2028-2036.
33. Tremblay N, Fallon E, Ziadi N. Sensing of crop nitrogen status: Opportunities, tools, limitations and supporting information requirements. Hort Technol. 2011;21(3):274-281.
34. Yasser E, El-Ghobashy Elmehy AA, El-Douby KA. Influence of Intercropping Cowpea with some maize hybrids and N nano mineral fertilization on productivity in salinity soil. Egyptian J Agron. 2020;42(1):63-78.