**Effect of Liquid nanourea application on yield, post-harvest plant and soil nutrient status in finger millet (*Eleusine coracana* L.) production**

## ABSTRACT

A field experiment was conducted at department of Agronomy, PAJANCOA & RI, Karaikal, during Kharif 2021.The experiment carried out in Randomized Block Design (RBD) with eleven treatments replicated thrice. The results proved that combined application of conventional urea and liquid nano urea significantly influenced most of yield parameters of finger millet. Among different treatments, application of 50 % RDN as conventional urea + RD with LNU showed maximum Yield parameters. Experimental results also revealed that 50 % RDN as conventional urea + RD with LNU recorded higher grain yield of 1783 kg ha-1 which was 56.8 and 127.3 per cent increased yield over100% RDN as conventional urea and absolute control. Maximum straw yield (9146 kg ha-1) was observed in100% RDN as conventional urea. The treatment also proved the uptake of nitrogen and potassium increased by 23.8 and39.61per cent, respectively over100

% RDN as conventional urea and 79.8 and 107 per cent, respectively over absolute control. Application of liquid nano urea improved the nitrogen use efficiency by 20 per cent compared to conventional fertilization. An overview of the study revealed that 50%RDN as conventional urea

+RD with LNU@1000 ml ha-1saved 50per cent of conventional urea and significantlyimproved the yield of finger millet.

**Keywords:** Fingermillet, Liquid nanourea, seed treatment, root dip, foliar spray.

# INTRODUCTION:

Small millets are commonly known as‘Nutri-cereals’and climate resilient Crop which can withstand under aberrant climate change also ensuring food and nutritional security for increasing population, especially in rainfed areas (Brahmachari *et al.,* 2019; Kumar *et al.,* 2019). Among various small millets, finger millet (*Eleusine coracana L.*), known as ‘Ragi’the most important crop for its higher production and productivity with wider adaptability. Finger millet is cultivated predominantly in India and African countries (Banerjee and Maitra, 2020) under optimal resource management conditions. It is an important staple crop in several semi-arid and tropical regions of the world with excellent nutritional properties.

FAOSTAT, 2020 reported that, In total area of 1.19 million hectares under finger millet cultivation, India alone accounts highest production of 1.98 million tons with an average productivity of 1661 kg/ha In India Karnataka alone accounts area (56.21%) and production (59.52%) of finger millet followed by Tamil Nadu (area 9.94% and production 18.27%), Uttarakhand (area 9.40% and production7.76%) and Maharashtra (area10.56% and production7.16%) respectively (India stat, 2021).

Nitrogen is the most limiting factor in crop production, where finger millet has good response to nitrogen even under rainfed condition (Shukla *et al.,* 2004). Nitrogen application increased the growth, dry matter and yield of finger millet under rainfed conditions (Hariprasanna, 2016).Conventional nitrogen is subjected to loss in soil by different means also it has low nutrient use efficiency. Volatilization of nitrogen causes global warming by releasing greenhouse gases. The goal of researcher is to achieve sustainability in agriculture with elevated yield and maintaining the health and eco system. Under such situation, optimum utilization of nutrients through a right source could be an appropriate strategy.The term nanomaterial is based on the prefix nano which originates from Greek word meaning dwarf which means one billionth of a meter. The term generally used for materials with a size ranging between 1 and 100 nm. Nano urea developed by IFFCO is a huge step towards sustainable agriculture and food systems which includes precision and smart farming. It contains nano scale nitrogen particles which have more surface area and number of particles which makes it more impactful. It is used in place of conventional urea and other nitrogenous fertilizers for better environment, reduced input storage cost, improve soil health and farmers profitability.

# MATERIALS AND METHOD:

The field experiment was conducted in B7 field of Agronomy farm, PAJANCOA & RI Karaikal which is located at10˚55’N latitude and79˚49’E longitude with an altitude of four meters above MSL during June to September (2021). The variety chosen for this investigation was TRY 1(Tiruchirappalli-1), a short duration variety (110-125days).The randomized complete block design (RCBD) was adopted for the field trial with eleven treatments and three replications. The treatment used in this investigation were 50% RDN as conventional urea+ ST with LNU (T1), 50

% RDN as conventional urea + RD with LNU(T2), 50 % RDN as conventional urea + FS with LNU(T3),75% RDN as conventional urea + ST with LNU(T4), 75% RDN as conventional urea

+ RD with LNU(T5), 75 % RDN as conventional urea + FS with LNU(T6),0 % RDN + ST with LNU(T7),0% RDN + RD with LNU (T8), 0% RDN + FS with LNU(T9),100% RDN as conventional urea (T10), Absolute control (T11). To obtain a fine tilth, the main field was ploughed twice using mould board plough and cultivator. The layout of the experimental plot was made into beds and channels as per the specified size. Irrigation channels were formed around the experimental field. Two seedlings per hill were planted by adopting a spacing of 30cmx10cm.A blanket recommendation of 60:30:30 kgha-1of N, P2O5 and K2O was

adopted. 50% of Nitrogen respect to the treatments and full dose of phosphorus and potassium was applied basally. The remaining half dose of nitrogen was applied twice viz; one at active tillering stage (20 DAT) and other at 40DAT (before flowering).The liquid nano urea was applied in three methods; seed treatment, root dip and foliar application. Seed treatment: At the time of sowing, seeds were treated with LNU @ 1000 ml/ha of seed, shade dried for 30 minutes and sown in nursery bed. Seedling root dip: The root dip was given at the time of transplanting the seedling. The seedling pulled out were soaked in the solution containing liquid nanourea @ 1000 ml/ha of seedling for 30 minutes. Foliar spray: Spray was given twice viz; first at active tillering stage (20DAT) and second spray before flowering (40DAT) by adopting @0.1% (500ml in 500 lit of water ha-1). The data was were statistically analyzed using single factor RBD by using F value (Gomez and Gomez, 1984). The critical difference was worked for 5 per cent level and represented as ‘\*’. In case of non-significant treatment, it was denoted as ‘NS’. The correlation and regression coefficients were calculated for DMP and grain yield with yield parameter and nitrogen, phosphorus and potassium uptake using the method given by Snedecor and Cochran (1968).

# RESULTS AND DISCUSSION:

## Effect on yield parameters Grain yield:

The results of the experiment clearly indicated that, root dip showed significant more grain yield . Similarly different levels of nitrogen 50 per cent nitrogen along with liquid nano urea showed significantly higher yield. Among the treatment 50% RDN as conventional urea + RD with LNU (T2) recorded higher grain yield (1783 kg ha-1) which was 56.79 per cent higher over 100 % RDN as conventional urea (T10) followed by (T5) 75% RDN as conventional urea + RD with LNU (1432.8kg ha-1) but were statistically on par with each other. The significantly lower grain yield of 781.66 kg ha-1 was recorded under absolute control (T11) followed by 0 % RDN + FS with LNU (T9), 0 % RDN + ST with LNU (T7), 0% RDN + RD with LNU (T8), 100% RDN as conventional urea (T10), and 50% RDN as conventional urea + FS with LNU (T3) (Table 1.). Increase in number of productive tillers and number of earheads are probably the reason for higher achievement in grain yield of finger millet. These results are in conformity with Gokul and Kumar (2019) in ragi and Das and Jana (2015) in green gram. Eliminating the effect of nitrogen levels and considering only the method of application of liquid nano urea the results clearly showed that root dip significantly performed better over other two methods. This is due to quick uptake of nano nitrogen at the time of root dipping. The study by Miller and Smith (1996, 2008) registered that, once nitrogen has been taken up into root epidermal and cortical cells it can be either reduced or stored in the vacuole and utilized later. Irrespective of method of application of liquid nano urea, nitrogen level at 0 % had significantly lesser yield which was near to yield in control. These results are also in accordance with Rani *et al.* (2019), who revealed that the application of nano fertilizer combined with conventional nitrogen fertilizer significantly increased the yield of sorghum.

## Straw yield:

Application of liquid nano urea and nitrogen levels did not bring significant difference in straw yield. The investigation depicted that 100 % RDN as conventional urea (T10) recorded numerically higher straw yield (9146 kg ha-1) but was on par with all the treatments indicating non-significant result (Table1.). The lowest was recorded in absolute control (T11) (4644.4 kg ha-1). This could be attributed by increased plant height and a greater number of tillers hill-1. Straw yield is often limited by factors other than nitrogen, such as water stress, disease, or pest infestations. These factors can overshadow any benefit provided by nano urea, resulting in little to no increase in straw yield.

## Harvest index:

Harvest index of finger millet was found to be significant for application of liquid nano urea with different levels of conventional urea is given in the (Table1.) Higher HI (0.24) was obtained by 50 % RDN as conventional urea + ST with LNU (T1) which was on par with the harvest index of 0.22, 0.19, 0.18 and 0.17 under 50% RDN as conventional urea + RD with LNU (T2), 75% RDN as conventional urea + ST with LNU (T4), 0% RDN +ST with LNU (T7) and 0

% RDN + RD with LNU (T8) respectively. A lower HI (0.11) was noticed with T10; which was on par with T6,T5, T9, T11, T3 and T8 (Table 1.) supported by nano fertilizer benefits.

## Nutrient uptake and Available Nutrients in Soil at Harvest

Significantly higher uptake of nitrogen was recorded by application of 50 % RDN as conventional urea + RD with LNU (T2) with101.6 kgha-1 followed by 75% RDN as conventional urea + RD with LNU (T5) and remained at par with each other. Higher uptake of phosphorous (28.59 kg ha-1) were recorded with 75 % RDN as conventional urea + RD with LNU (T5). Potassium uptake had same trend as of nitrogen uptake in plants. Higher uptake was in 50% RDN as conventional urea + RD with LNU (T2). However lower uptake of nitrogen, phosphorous and potassium was by absolute control (T11) (Table 2.). Application of nano urea recorded higher nutrient uptake compared to other treatments mainly due to higher availability of nutrients and also due to its nano size particles. The results are in accordance with Wen *etal.* (2014),who studied the effects of combined application of conventional urea with controlled-release Nano urea on nutrient uptake by winter wheat. The results showed that combined applications of conventional urea with controlled-release Nano urea increased nitrogen uptake by wheat. Nano-fertilizers have a large surface area, small size which is less than the pore size of root, resulting in the high number of particles per unit weight and specific surface area and thus high reactivity increases the contact of fertilizer with plant, leading to an increase in nutrient uptake was early reported by Herrera and Bazaga (2016) and Lahari *etal.* (2021).Phosphorous and potassium uptake also followed similar trend as nitrogen uptake. This clearly indicated that uptake of nitrogen has direct impact on the uptake of other nutrients. Similarly, Leghari *etal.*(2016) revealed that nitrogen boosts the uptake of other nutrients and controls overall growth of plant.

Similarly, significantly higher available nitrogen (118.5 kg ha-1) was recorded by application of 75%RDN as conventional urea + RD with LNU (T5) which was on par with50% RDN as conventional urea + RD with LNU(T2), 50% RDN as conventional urea + ST with LNU (T1),75% RDN as conventional urea + ST with LNU (T4).The available phosphorus was higher (94.02 kg ha-1) in plots treated with 100 % RDN as conventional urea (T10) and available potassium level in soil did not significantly differ due to the method of application of liquid nano urea in combination with conventional urea. The available N content ranged from 80 to118.46 kg ha-1. Interestingly treatment combination with 50% and 75% nitrogen levels and root dip and seed treatment method of application showed high quantity of available N compared to 0 % nitrogen (Table 3.). Lower loss of nutrients due to the slow nutrient-releasing nature of nano-fertilizer might be responsible for an increase in available nutrients in soil. Surprisingly, treatment with 100 % RDN as conventional urea (T10) had similar quantity of available N as that of conventional urea free plots. This might be due to quick loss of conventional urea. This was supported by Phillip *et al.* (2015) that rapid conversion by soil urease to ammonium that is susceptible to volatilization as ammonia makes it particularly vulnerable to losses when broadcast on the soil or soil–water surface. The maximum available P in soil was recorded in100% RDN as conventional urea (T10). This might be due to poor utilization of nutrients throughout its crop growth period which is evidenced with least uptake of P. There was no significant difference in available K due to the application of liquid nano urea and nitrogen levels. This result supports the findings of Alimohammadi *et al*. (2020) in their study with nano nitrogen chelate.

**Table 1.** Effect of various methods of application of liquid nano urea with different levels of conventional urea on grain yield (kg ha-1), straw yield (kg ha-1) and harvest index of finger millet

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **Grain yield (kg ha-1)** | **Straw yield (kg ha-1)** | **Harvest Index** |
| T1:50%RDNas conventionalurea+ST withLNU | 1350.4 | 4756 | 0.24 |
| T2:50%RDNasconventional urea+RDwithLNU | 1783.0 | 7042 | 0.22 |
| T3:50%RDNasconventional urea+FSwithLNU | 1159.5 | 7245 | 0.15 |
| T4:75 %RDNasconventional urea+ST withLNU | 1303.8 | 5721 | 0.19 |
| T5:75%RDNasconventional urea+RDwithLNU | 1432.8 | 8849 | 0.14 |
| T6:75%RDNasconventional urea+FSwithLNU | 1223.9 | 8223 | 0.14 |
| T7:0 %RDN+STwith LNU | 981.1 | 4730 | 0.18 |
| T8:0 %RDN+RDwith LNU | 991.2 | 4960 | 0.17 |
| T9:0 %RDN+FS withLNU | 906.7 | 5593 | 0.14 |
| T10:100 %RDNas conventional urea | 1137.2 | 9146 | 0.11 |
| T11:Absolute control | 784.5 | 4644 | 0.14 |
| **S**  **Ed** | **186.43** | **1876.8** | **0.034** |
| **C.D (p=0.05)** | **388.9** | **NS** | **0.07** |

RDN:RecommendedDoseofNitrogen;NS:Notsignificant

**Table2.**Effect of various methods of application of liquid nano urea with different levels of conventional urea on N,P and K uptake of in finger millet at the time of harvest

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **Nitrogen uptake**  **(kgha-1)** | **Phosphorus**  **uptake**  **(kgha-1)** | **Potassium**  **uptake**  **(kgha-1)** |
| T1:50%RDNas conventionalurea+ST withLNU | 69.8 | 17.58 | 303.06 |
| T2:50%RDNasconventional urea+RDwithLNU | 101.6 | 26.31 | 578.64 |
| T3:50%RDNasconventional urea+FSwithLNU | 89.6 | 27.62 | 419.48 |
| T4:75 %RDNasconventional urea+ST withLNU | 75.0 | 20.54 | 370.27 |
| T5:75%RDNasconventional urea+RDwithLNU | 100.3 | 28.59 | 469.90 |
| T6:75%RDNasconventional urea+FSwithLNU | 90.3 | 28.48 | 466.35 |
| T7:0 %RDN+STwith LNU | 60.6 | 18.37 | 303.71 |
| T8:0 %RDN+RDwith LNU | 68.1 | 17.91 | 296.91 |
| T9:0 %RDN+FS withLNU | 63.1 | 22.60 | 356.99 |
| T10:100 %RDNas conventional urea | 82.1 | 31.15 | 414.64 |
| T11:Absolute control | 56.5 | 16.91 | 279.60 |
| **SEd** | **10.31** | **5.80** | **55.19** |
| **C.D(p=0.05)** | **16.2** | **NS** | **17.4** |

RDN:RecommendedDoseofNitrogen;NS:Notsignificant

**Table 3.**Effect of various methods of application of liquid nano urea with different levels of conventional urea on soil available nutrient of N, P and K in post-harvest sample

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **Available N (kg ha-1)** | **AvailableP (kgha-1)** | **Available K (kg ha-1)** |
| T1:50%RDNas conventionalurea+ST withLNU | 106.9 | 78.02 | 92.0 |
| T2:50%RDNasconventional urea+RDwithLNU | 114.6 | 80.65 | 80.4 |
| T3:50%RDNasconventional urea+FSwithLNU | 91.4 | 78.10 | 66.4 |
| T4:75 %RDNasconventional urea+ST withLNU | 105.8 | 89.25 | 69.6 |
| T5:75%RDNasconventional urea+RDwithLNU | 118.5 | 79.11 | 76.0 |
| T6:75%RDNasconventional urea+FSwithLNU | 84.2 | 76.94 | 67.2 |
| T7:0 %RDN+STwith LNU | 82.9 | 92.88 | 87.2 |
| T8:0 %RDN+RDwith LNU | 84.2 | 77.39 | 109.5 |
| T9:0 %RDN+FS withLNU | 83.2 | 85.24 | 83.6 |
| T10:100 %RDNas conventional urea | 82.8 | 94.02 | 78.8 |
| T11:Absolute control | 80.5 | 74.34 | 78.8 |
| **SEd** | **12.51** | **13.30** | **21.72** |
| **C.D(p=0.05)** | **26.1** | **NS** | **NS** |

RDN:RecommendedDoseofNitrogen;NS:Notsignificant

# CONCLUSION

Based on the results of the experimentation, it is observed that the treatments 50 % RDN as conventional urea + RD with LNU@1000 ml per hectare of seedling and 75 %RDN as conventional urea + RD with LNU@1000ml per hectare of seedling were equally effective in increasing grain and straw yield of finger millet. These treatments were also equally remunerative. From the enlightenment of the study, it can be concluded and recommended that application of 50% RDN as conventional urea + Root dip with LNU@1000ml per hectare of seedling could be a viable option for enhancing the yield and nutrient uptake in finger millet productivity.

# DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares 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 this manuscript.

# REFERENCES

1. Alimohammadi, M., Panahpour, E. and Naseri, A. 2020. Assessing the effects of urea and nano-nitrogen chelate fertilizers on sugarcane yield and dynamic ofnitrate in soil. *Soil Sci. Plant Nutr.,* **66**(2): 352-359.
2. Banerjee, P. and Maitra, S. 2020. The role of small millets as functional food to combat malnutrition in developing countries. *Ind. J. Nat. Sci.,* **10**: 20412-0417.
3. Brahmachari, Koushik, Sukamal Sarkar, Dipak K. Santra, and Sagar Maitra. "Millet for food and nutritional security in drought prone and red laterite region of Eastern India." *Int J Plant Soil Sci* 26, no**. 6** (2019): 1-7.
4. Das, S. K. and Jana, K. 2015. Effect of foliar spray of water soluble fertilizer at pre flowering stage on yield of pulses. *Agric. Sci. Dig.,* **35**: 275-79.
5. Gokul, G. and Kumar, S.N. 2019. Effect of foliar feeding technique on growth and yield of ragi. *Plant Arch.,* **19**: 2889-892.
6. Hariprasanna,K.2016.Nutritionalimportanceandcultivationaspects,Indianinstituteof Millets Research, Rajendranagar, Hyderabad 500030,Telangana,India. *Indian Farming,* **65**(12): 25-29.
7. Herrera, C. M. and Bazaga, P. 2016. Genetic and epigenetic divergencebetween disturbed and undisturbed subpopulations of a Mediterranean shrub: A 20‐year field experiment. *Ecol. Evol.,* **6**(11): 3832-3847.
8. Kumar,P.D., Maitra,S., Shankar,T.and Pushpalatha,G.2019.Effect of cropgeometry and age of seedlings on productivity and nutrient uptake of finger millet (*Eleusine coracana*L. Gaertn), *Int. J. Agric. Environ. Biotechnol*, **12**: 267-72.
9. Lahari, S., Hussain, S. A., Parameswari, Y. S., and Sharma, S. H. K. 2021. Grain yield and nutrient uptake of rice as influenced by the nano forms of nitrogen and zinc. *International Journal of Environment and Climate Change*.
10. Leghari, S. J., Wahocho, N. A., Laghari, G. M., Hafeezlaghari, A., Mustafabhabhan, G., Hussaintalpur, K., Bhutto, T. A., Wahocho, S. A. and Lashari, A. A. 2016. Role of nitrogen for plant growth and development: A review. *Adv. Environ. Biol.,* **10**(9): 209- 219.
11. Miller,A.J.and Smith, S.J.1996.Nitrate transport and compartmentation in cereal root cells. *Journal of Experimental Botany,* **47**: 843–854.
12. Miller, A. J. and Smith S. J. 2008. Cytosolic nitrate ion homeostasis: Could it have a role in sensing nitrogen status. *Annals of Botany,* **101**: 485–489.
13. Phillip,M.C.,Eric,T.C.,Jose´,C.P.,Deli,C.2015.Fate and efficiency of 15N-labelled slow- and controlled release fertilizers. *Nutr. Cycl. Agroecosyst.,* **102**:167–178
14. Rani, B., Zalawadia, N.M., Buha, D.and Rushang, K.2019.Effect of different levels of chemical and nano nitrogenous fertilizers on content and uptake of N, P, K by sorghum crop. *J. Pharmacogn. Phytochem.,* **8**(5): 454-458.
15. Shukla,A.K.,Ladha,J.K.,Singh,V.K.,Dwivendi,B.S.,Balasubramanian,V.,Gupta,R. K.,Sharma,S.K.,Singh,Y.,Pathak,H.,Pandey,P.S.,Padre,A.T.andYadav, R.

L. 2004. Calibrating the leaf color chart for nitrogen management in differentgenotypes ofriceandwheatinasystemsperspective. *Agronomy Journal,* **96**:1606-1621.

1. \*Snedecor, GW and Cochran WG. Statistical methods, The Iowa State University Press, Ames and Oxford and IBH publishing Co Pvt Ltd, New Delhi, 1968.
2. Wen,Sun,Z.,Wu,L.,Shi,G.F.,Zhu,G.L.,Li,Y.X.,Gu,J.L.andXu,Q.M.2014.

Effects of coated controlled release urea combined with conventional urea onwinter wheat growth and soil NO3- -N. *Chin. J. Appl. Ecol.,* **22**(3): 687-693.

\*Original not found