Original Research Article

Comparative Evaluation of Neem-Coated Urea and Nano Urea on the Growth and Physiological Attributes of Finger Millet (*Eleusine coracana L. Gaertn*)

ABSTRACT

An experimental study was conducted to investigate the effects of nitrogen fertilization on finger millet, with Significant nutrient losses, especially for nitrogen (N) fertilizers, occurring when chemical fertilizers are directly incorporated into the field. These losses primarily result from leaching and volatilization processes under this practice, crops tend to utilize only a fraction of the applied N fertilizers, typically ranging from 30 to 40%. These observations highlight the inefficiency of traditional fertilizer application methods and the need for improved nutrient management strategies to maximize nutrient utilization by crops and minimize environmental impacts. The study was conducted in Karunya Institute of Technology and Sciences Coimbatore. The experiment was laid out in Randomized block design (RBD) with seven treatments and replicated three times. The results of the study demonstrated that the treatment combining 50% neem-coated urea (NCU) and 50% nano urea (NU) in addition to phosphorus (P) and potassium (K) (T_5) exhibited exceptional performance compared to the other treatments. This particular treatment displayed significant outcomes, including an increase in plant height of (93.7cm), improved leaf area index (3.95), greater total dry matter production (6443 kg/ha), a higher number of tillers (161.24/m^2), increased productive tillers (94.2/m^2), enhanced grain yield (4350 kg/ha), higher straw yield (5829 kg/ha), improved gross returns (143313 Rs/ha), a net return of (Rs. 88,247/ha), and a benefit-cost ratio of 2.60. On the other hand, the application of (75% Neem coated urea + 25% Nano urea + P and K) can be considered as a second option for obtaining higher yield and economics of growing finger millet.

Keywords: Finger millet, Nano urea, Neem-coated urea, Nitrogen, Yield, Economics

1. INTRODUCTION

Finger millet, scientifically known as (*Eleusine coracana L. Gaertn*) is a prominent millet crop in India. It is a significant small millet crop that ranks third in India in terms of area and production. In India, finger millet is cultivated across an extensive area of 6.93 million hectares, resulting in a production of 8.61 million tonnes during the 2020-21 season. The average productivity of finger millet stands at 1243 kg/ha, emphasizing its significance in contributing to the country's agricultural output.

(Anonymous 2020-21) [1]. Finger millet has the third-highest productivity among millets, after sorghum and pearl millet. It is an annual plant of the *Poaceae* family that is commonly cultivated as a millet in the arid regions of Asia and Africa. Finger millet holds a prominent position as one of the primary staple food crops in India. It is cultivated for its grains, which are consumed as food, as well as for fodder purposes. This crop demonstrates remarkable adaptability to impoverished and marginal upland areas where other crops struggle to thrive.

It is cultivated in a wide range of soil types and weather conditions, including areas with varying levels of rainfall which is highly regarded as one of the most resilient field crops, particularly in terms of drought resistance. Despite challenging environmental circumstances, finger millet exhibits a remarkable capacity for high production, making it a valuable crop with significant potential (Murthy, 2016) [2]. In general nutrient management plays a vital role in crop production to achieve higher yields. However, the excessive and indiscriminate use of chemical fertilizers by farmers has become a significant concern. This widespread use is not only considered a leading cause of environmental pollution but also leads to the degradation of soil health. It is crucial to address this issue and promote sustainable nutrient management practices that maintain a balance between crop nutrient requirements and the preservation of environmental and soil health. By adopting responsible and judicious approaches to nutrient management, farmers can optimize yields while minimizing the negative impacts on the environment and ensuring the long-term productivity of the soil. (Rekha *et al*., 2018) [3].

The development of nanotechnology-based fertilizers involves encapsulating or creating plant nutrients in nano-sized forms and delivering them in the form of emulsions with nanoscale particles. These innovative formulations, utilizing nanostructured materials, possess modified physicochemical properties. The utilization of such nanostructured formulations in fertilizers holds great potential as a viable solution to address the ongoing challenges associated with environmental pollution. By employing nanotechnology in fertilizers, it becomes possible to enhance nutrient uptake efficiency and minimize nutrient losses, thereby promoting sustainable and environmentally-friendly agricultural practices. (Baboo, 2021) [4].

. By adopting more targeted and efficient fertilizer application techniques, farmers can optimize nutrient uptake by crops, reduce losses, and enhance overall agricultural sustainability (Ahmad *et al*., 2008) [5]. Considering these factors, a study was conducted to evaluate the impact of neem-coated and nano urea on the growth, yield, and economic parameters of finger millet cultivation under tropical conditions. The investigation aimed to assess the effects of these innovative fertilizer formulations on the overall performance and profitability of finger millet production in tropical regions.

2. MATERIALS AND METHODS

The field experiment was conducted during the *rabi* season of 2022 at Karunya Institute of Technology and Sciences, Coimbatore. The experimental site is situated in the western agro-climatic zone of Tamil Nadu and can be found at approximately 10°56'N latitude and 76°44'E longitude. The site has an elevation of 474 meters above mean sea level. The soil at the site was classified as a clay loam and a pH of 7.0. Furthermore, the soil at the experimental field exhibited an electrical conductivity (EC) of 0.16 dS m^{-1}, a nitrogen content of 182 kg/ha, a phosphorus content of 17.2 kg/ha, and a potassium content of 495 kg/ha.

The experimental design followed a randomized block design (RBD) comprising of seven treatments with three replications each. The experimental data were analyzed statistically by applying the technique of analysis of variance prescribed for the design to test the significance of overall difference among treatments by the F test and conclusions were drawn at 5% probability level (Gomez and Gomez, 1984) [6]. The selected finger millet variety for the experiment was CO13, which is known to have a growth duration of 95-100 days. The recommended fertilizer dosage of N: P_2O_5:K_2O at 60:30:30 kg/ha was applied using urea, single super phosphate, and muriate of potash. The experimental treatments consisted of the following T_1: Control, T_2: P and K only, T_3: 100% Neem coated urea + P and K, T_4: 75% Neem coated urea + 25% Nano urea + P and K, T_5: 50% Neem coated urea + 50% Nano urea + P and K, T_6: 25% Neem coated urea + 75% Nano urea + P and K, and T_7: 100% Nano urea + P and K. Nitrogen and phosphorus levels were adjusted accordingly based on the treatment combinations.

3. RESULTS AND DISCUSSION

3.1. Effect of Nitrogen on plant growth of finger millet

The analysis of the results indicated that the application of nitrogenous fertilizers had a significant impact on the plant height of finger millet at various stages of growth. The higher mean plant height was observed in treatment T_5(93.7 cm), which consisted of a combination of 50% Neem coated urea, 50% Nano urea+ P, and K fertilizers compared to other treatments. The lower mean plant height was recorded in the control group T_1(83.2 cm), where no nitrogenous fertilizers were used. Abdullahi *et al*., (2014) [7] reported that enhanced nitrogen availability and soil integration may have contributed to the increase in plant height by facilitating a continuous, steady release of nutrients that improved crop growth. This could have accelerated the growth of the plant.

The results demonstrated the application of a notable influence on the leaf area index of finger millet at different growth. The treatment with the higher leaf area index mean value was T_5(3.95), which comprised of 50% Neem coated urea + 50% Nano urea + P and K. Conversely, the control group (T_1) exhibited a lower leaf area index of (2.84). These findings suggest the use of nitrogenous fertilizers, particularly in combination with appropriate levels of P and K, can enhance the leaf area index of finger millet during the growth stages. The leaf area index (LAI) is a significant parameter that demonstrates crop development and estimates crop yield. Higher crop yields are an indication of an effective LAI as it balances the growth of each component in crops and regulates the interaction between their source (Hebbal *et al*., 2018) [8].

The results of the investigation showed that the application of fertilizers had a significant impact on the dry matter production of finger millet during various phases of the crop's growth. Treatment T_5 (50% neem coated urea + 50% + nano urea + phosphorus and potassium) fertilizers, demonstrated the higher average dry matter production (6443 Kg ha^{-1}) throughout all stages. Conversely, the control group (T_1) exhibited a lower average dry matter production. Revathi, (2016) [9] documented that the enhanced dry matter production observed can be attributed to the combined impact of increased plant height, and improved dry matter production. Moreover, the enhancement in leaf area index (LAI) likely played a crucial role in augmenting the photosynthetic efficiency of finger millet, thereby facilitating the synthesis of a greater amount of dry matter production.

A significantly higher number of tillers/m^2 was observed in T_5 (50% Neem coated urea+ 50% Nano urea + P and K) (161.24/m^2). These results indicate that the application of specific nutrient combinations, such as 50% Neem coated urea + 50% Nano urea + P and K (T_5) and 75% Neem coated urea + 25% Nano urea + P and K (T_4), can significantly improve the number of tillers/m^2 in finger millet at the harvesting stage. These findings highlight the importance of balanced nutrient management for maximizing tiller development and potentially improving crop yield. The increase in the number of tillers observed at higher nitrogen (N) dosages may be related to the competition for nutrients which is initiated by an adequate nitrogen supply. Due to the increased competition, the soil's nutrients are more effectively assimilated (Patil *et al*., 2018) [10].

The yield attributing characters such as the number of productive tillers m^{-2} was statistically higher in treatment T_5, with 50% Neem coated urea + 50% Nano urea + P and K, had the highest number of productive tillers with (94.2/m^2). Which is statistically on par with T_4 (75% Neem coated urea + 25% Nano urea + P and K). A balanced diet nutrients increased the growth of roots and tillering, which in turn raised the amount of photosynthetically active radiation and enhanced crop photosynthesis. The abundant nitrogen in neem coated urea might be responsible for its better performance over normal urea. This adequate nitrogen supply facilitates the partitioning of photosynthates to the primary culm, a source of nutrients and carbohydrates for the growth of tillers. The usage of neem coated urea, which made nitrogen consistently and continuously available throughout the entire crop season, is responsible for the increased productive tillers (Kumari and Chaudhary, 2018) [11].

3.2. Effect of Nitrogen on Yield and Economics of finger millet

The analysis of the grain yield data revealed that various treatments significantly influenced the grain yield of finger millet. Notably, treatment T_5, which involved a combination of 50% neem coated urea (NCU), 50% nano urea (NU), and phosphorus (P) and potassium (K) fertilizers, exhibited a higher grain yield (4350 Kg/ha^{1}) which was significantly superior over all other treatments. It serves as a key metric to assess the productivity and efficiency of finger millet production. Samanta *et al*., (2022) [12] reported that the significantly higher grain production of finger millet was greatly attributed to better nitrogen utilization, which produced increased yield-attributing characteristics.

The higher straw yield (5829 kg/ha) was recorded in treatment T_5 (50% Neem coated urea + 50% Nano urea + P and K), which is significant with T_4 (75% Neem coated urea + 25% Nano urea + P and K) (5798 kg/ha). The finger millet experienced substantial expansion across all stages of crop development, which was characterized by an increased number of leaves. This rapid development in turn enabled a greater amount of photosynthetic activity, causing the crop to synthesize more energy, when the straw yield of finger millet dramatically increased with an increase in nitrogen level (Camara *et al*., 2003) [13].

The data on the cultivation costs and gross returns for each treatment suggested that the treatments T_5 and T_4 have the higher gross returns (Rs. 1,43,313/ha and Rs. 1,40,141/ha respectively). On the other hand, treatments T_6 and T_7 have comparatively lower gross returns (Rs. 1,38,980/ha and Rs. 1,29,451/ha respectively). These results highlight the economic aspects of different treatments and their impact on the profitability of finger millet cultivation. Further analysis and interpretation of the data can provide valuable insights into the cost-effectiveness and financial viability of various nutrient management strategies in finger millet production. Increased biomass accumulation and efficient nutrient translocation to the area of reproduction, provided possibly by an adequate food supply, and the contributing factors to the development of higher yield, which attributes consequently, the agricultural production experienced better gross returns. Patil *et al*. (2015) [14] and Pallavi *et al*. (2016) [15].

The higher net return is substantially reported in T_5-50% neem coated urea + 50% nano urea + P and K of about 88247 Rs/ha[1], which is followed by T_4 (85040 Rs/ha). Whereas a higher benefit cost ratio was observed with the application of T_5 (2.60) which was followed by T_4 (2.54). The higher benefit-cost ratio could be due to lower cultivation costs and improved grain and straw yield. The fluctuations observed in economic returns across different years can be attributed to the varying performance of respective crops in terms of grain yield when implementing improved practices in frontline demonstrations. Thakur *et al*., (2017) [16] also reported higher net returns and benefit-cost ratio in finger millet crops, when implementing better practices in primary demonstrations.

4. CONCLUSION

The findings of the present study well demonstrated the positive effects of neem coated urea and nano urea on various growth and yield parameters of finger millet with a combination of T_5 (50% Neem coated urea + 50% Nano urea + P and K) resulted in higher productivity and economic feasibility. This treatment showed several advantages, including improved nutrient absorption, vigorous plant growth, and increased yield. Additionally, the study suggests that treatment T_4, consisting of 75% neem coated urea and 25% nano urea, supplemented with P and K, can also be recommended for achieving good yields. This treatment exhibited favourable outcomes in terms of nutrient uptake, plant growth, and yield. These findings highlight the potential benefits of incorporating these fertilizers in finger millet cultivation, contributing to improved agricultural practices and increased crop productivity.

5. FUTURE SCOPE

A comparative study can investigate innovative approaches to control the release of nutrients from nano urea and neem-coated urea, ensuring a sustained and balanced nutrient supply to finger millet plants throughout the growth stages. This can enhance fertilizer use efficiency and minimize nutrient losses to the environment. Further research can focus on refining the formulations of nano urea and neem coated urea specifically for finger millet.

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Table 1. Effect of Nitrogen on plant growth of finger millet

Treatments	Plant height(cm)	Leaf area index	Dry matter production (kg ha^{-1})	No of tillers m^{-2}	productive tillers m^{-2}
T_1 – Control	83.2	2.84	4574	128.65	69.3
T_2 - P and K alone	84.5	2.96	4645	135.26	75.7
T_3 - 100% Neem coated urea + P and K	87.7	3.54	5645	148.26	81.3
T_4 - 75% Neem coated urea + 25% Nano urea + P and K	89.0	3.75	6231	158.25	92.5
T_5 - 50% Neem coated urea + 50% Nano urea + P and K	93.7	3.95	6443	161.24	94.2
T_6 - 25% Neem coated urea + 75% Nano urea + P and K	89.4	3.65	5446	155.20	88.2
T_7 - 100% Nano urea + P and K	86.1	3.25	4821	142.56	79.6
Mean	**87.6**	**3.42**	**5401**	**147.1**	**83.0**
SEd	**2.09**	**0.073**	**102**	**3.39**	**1.52**
CD (*p*=0.05)	**4.38**	**0.153**	**213**	**7.08**	**3.17**

Table 2. Effect of nitrogenous fertilizers yield and economics of finger millet

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B: C ratio
T_1 – Control	3958	4967	113020	74870	2.25
T_2 - P and K alone	3985	5054	126231	71868	2.32
T_3 - 100% Neem coated urea + P and K	4157	5680	134050	78904	2.43
T_4 - 75% Neem coated urea + 25% Nano urea + P and K	4325	5798	140147	85040	2.54
T_5 - 50% Neem coated urea + 50% Nano urea + P and K	4350	5829	143313	88247	2.60
T_6 - 25% Neem coated urea + 75% Nano urea + P and K	4280	5687	138980	83956	2.52
T_7 - 100% Nano urea + P and K	4058	5254	129451	74463	2.35
Mean	**4159**	**5467**	-	-	-
SEd	**67.1**	**131.1**	-	-	-
CD (*p*=0.05)	**140.2**	**273.8**	-	-	-

Fig. 1. The Gross returns (Rs. ha^{-1}), Net returns (Rs. ha^{-1}), benefit-cost ratio on the economics of finger millet