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Impact of Neem-Coated Urea and Nano Urea on Sorghum (*Sorghum bicolor* (L.) Moench.) Growth and Yield

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ABSTRACT: A field experiment was conducted at Karunya University in Coimbatore during the *Rabi* (2022) growing season to evaluate the impact of nano urea and neem-coated urea on the growth and yield parameters of sorghum. The experiment employed a Randomized Block Design with seven treatments and three replications. Among the treatments, the application of 50% N through neem-coated urea (NCU) + 50% N through nano urea (NU) + P and K demonstrated superior results, comparable to the treatment with 75% N through NCU + 25% N through NU + P and K. These treatments exhibited significant improvements, in plant height (242.1 cm), total dry matter production (14,481 kgha^{-1}), leaf area index (0.95), grain yield (3,375 kgha^{-1}), straw yield (9,843 kgha^{-1}), higher gross return (Rs. 149,764ha^{-1}), net return (Rs. 95,903 ha^{-1}), and a benefit-cost ratio of 2.78.

Keywords: Sorghum, Neem-coated urea, Nano urea, Nitrogen, Yield, Economics.

INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench.) holds a unique position as the fifth-largest cereal grain globally and stands out as the sole grain capable of thriving in the world's most food-insecure regions. Its remarkable ability to endure extreme heat and resist drought makes it a potential game-changer in addressing chronic food insecurity, particularly in arid and semiarid areas. In 2020, the world grappled with the plight of 811 million undernourished individuals, with over 700 million residing in the dry and semiarid regions of Asia and Africa. Sorghum, cultivated across more than 40 million hectares in over 105 countries, plays a pivotal role in ensuring food security in South Asia and sub-Saharan Africa (Kumar *et al*., 2011). The hardiness of sorghum makes it a beacon of hope in regions prone to extreme climatic challenges, such as heat and drought.

However, to harness its full potential in alleviating food insecurity, optimizing nitrogen (N) utilization becomes paramount. Nitrogen is a fundamental limiting nutrient for crop growth, and sorghum, more than any other crop, benefits significantly from nitrogen fertilization to enhance both yield and quality. Over the past six decades, sorghum yields have experienced an annual increase of approximately 50 kg ha^{-1}, with cultural practices, including N fertilizer usage, contributing to 60% to 65% of this improvement. Therefore, to maximize sorghum yields, precise N application rates must be complemented with adaptive N management strategies. Ensuring an adequate nutrient supply from the correct sources holds the key to substantially enhancing productivity. Nitrogen, playing a pivotal role in crop growth, assumes critical significance (Ramya *et al*., 2020). Nonetheless, environmental factors can hinder the efficiency of soil-applied nitrogenous fertilizers, limiting nutrient uptake (Van Eerd *et al*., 2017). In such circumstances, the application of nitrogen through foliar spray emerges as a potentially more efficient alternative (Liu and Lal 2015).

The advent of nano urea by the Indian Farmers Fertilizer Cooperative (IFFCO) marked a significant milestone in harnessing nanotechnology for agriculture. Nano fertilizers, characterized by their high surface area and minute particle size, offer improved nutrient availability (Lu *et al*., 2016). Previous research by Suri *et al*. (2004), involving the coating of prilled urea with environmentally friendly neem, revealed substantial enhancements in sorghum's growth parameters, including the number of effective tillers per hill, panicle length, panicle weight, grain and straw yields, and nitrogen uptake.

Recent agricultural studies have underscored the potential of combining urea with neem cake as a promising approach to enhance nitrogen use efficiency and boost the apparent recovery of fertilizer, as highlighted by (Suganya *et al*., 2007). Furthermore, (Suri *et al*., 2004) demonstrated noteworthy improvements in various critical parameters, such as the number of effective tillers per hill, panicle length, panicle weight, grain and straw yields, and nitrogen uptake, through the application of environmentally friendly neem-coated urea. It is important to note that this method exhibited a decline in agronomic nitrogen use efficiency (NUE), as indicated in their research. These findings underscore the promising potential of neem-based interventions in optimizing nitrogen utilization in agriculture, ultimately contributing to enhanced crop productivity and sustainability. In this study, we investigate the growth and yield parameters of sorghum using various combinations of nano urea and neem-coated urea.

MATERIALS AND METHODS

The field experiment was conducted at Karunya Institute of Technology and Sciences in Coimbatore during the 2022-23 *Rabi* season. The experimental site, located in the western agro-climatic zone of Tamil Nadu, with coordinates of 10°56'N latitude and 76°44'E longitude and at an elevation of 474 meters above sea level. Throughout the cropping period, temperatures ranged from 18.4°C to 26.2°C, with a total recorded rainfall of 436.8 mm. The soil at the site was classified as clay loam, with a pH value of 7.0, electrical conductivity (EC) of 0.16 dSm^{-1}, organic carbon (OC) content of 1.38%, nitrogen content of 182 $kgha^{-1}$, phosphorus content of 17.2 $kgha^{-1}$, and potassium content of 495 $kgha^{-1}$.

The experiment was carried out in a Randomized Block Design with seven treatments and three replications. Sorghum variety CO 30, with a growth duration of 95 - 110 days, was selected for the study. The treatments included: Control (T_1), P and K alone (T_2), 100% N through neem-coated urea (NCU) + P and K (T_3), 75% N through NCU + 25% N through NU + P and K (T_4), 50% N through NCU + 50% N through NU + P and K (T_5), 25% N through NCU + 75% N through NU + P and K (T_6), and 100% N through NU + P and K (T_7).

Data Analysis. Data analysis was conducted following the standard procedure for analysis of variance (ANOVA) as described by Gomez and Gomez (1984), and differences in treatment means were tested using the critical difference (CD) at a 5% level of probability.

RESULTS AND DISCUSSION

A. Growth Attributes

The analysis of the results indicated that the application of nitrogenous fertilizers had a significant impact on the plant height of sorghum at various stages of growth. The data represent in Table 1 demonstrated the plant height, dry matter production (DMP), and leaf area index (LAI) at the harvest stage. These measurements were obtained based on the application of nano urea and neem-coated urea. The most substantial values for plant height (242.1 cm), dry matter production (14,481 kg ha^{-1}), and leaf area index (0.95 cm^2) were documented when 50% of nitrogen was applied through neem-coated urea, paired with 50% nitrogen through nano urea, along with phosphorus and potassium (T_5), during the tillering and pre-flowering stages. In contrast, the control group exhibited significantly lower plant height, dry matter production, and leaf area index. Amanullah *et al*. (2009) reported a positive effect of higher nitrogen rates on maize plant height, with maize plants potentially growing up to 280 kg Nha^{-1}. However, further increases in nitrogen rates did not significantly affect plant height, a finding consistent with Ullasa *et al*. (2016); Mehmud *et al*. (2003).

B. Yield

The analysis of the grain yield revealed that various treatments significantly influenced the grain yield of sorghum in Table 2 presents notable results, showing the highest grain yield (3,375 kg ha^{-1}), straw yield (9,843 kg ha^{-1}), and harvest index (25.5%) achieved when 50% of nitrogen was applied through neem-coated urea and the remaining 50% through nano urea, in combination with phosphorus (P) and potassium (K). This specific treatment exhibited statistical equivalence with the application of 75% nitrogen through neem-coated urea, 25% through nano urea, and additional P and K, administered during the tillering and pre-flowering stages. In contrast, the control group exhibited significantly lower grain yield ($kgha^{-1}$), straw yield ($kgha^{-1}$), biological yield ($kgha^{-1}$), and harvest index (%). The overall increase in productivity, primarily attributed to the influence of yield-contributing factors, aligns with the findings of Tadesse *et al*. (2013). Similar results were observed in green gram by Das and Jana (2015). These results support the findings of Nyagumbo *et al*. (2019); Kubiku *et al*. (2022); Kugedera *et al*. (2022). The results also align with Gavade (2010), who observed rapid development in the straw yield of finger millet with increased nitrogen levels, likely due to increased photosynthetic activity. These findings are consistent with those of Gokul and Kumar (2019) in green gram. Benzon *et al*. (2015) similarly found that applying recommended rates of conventional and nano fertilizers enhanced plant height, chlorophyll content, number of reproductive tillers, panicles, and spikelets compared to the full recommended rate of conventional fertilizers.

C. Economics

The gradual increase in net return observed with higher nitrogen and phosphorus levels suggests a positive correlation between enhanced grain yield, increased straw yield, and the economic aspects of sorghum cultivation. The application of 50% N through neem-coated urea + 50% N through nano urea + P and K recorded the highest net return (Rs. 95,903ha^{-1}), followed by 75% N through neem-coated urea + 25% N through nano urea + P and K (Rs. 85,385ha^{-1}). The lowest net return was recorded in the control group (Rs. 11,447 ha^{-1}). The application of 50% N through neem-coated urea + 50% N through nano urea + P and K also showed a higher benefit-cost ratio of 2.78, indicating favourable economic returns compared to all other treatments. Mishra *et al*. (2018) reported that foliar nano fertilizer application resulted in higher returns and a more favourable benefit-cost ratio compared to conventional fertilizer application. Variations in the benefit-cost ratio were attributed to differences in crop yields and associated costs associated with different input methods. Furthermore, combining nano fertilizer with conventional fertilizer led to even more profitable income.

Table 1: Effect of various N fertilizer treatment on sorghum.

Treatments	Plant height (cm)	Dry matter production (kg ha^{-1})	Leaf area index (cm^2)
T_1 - Control	223.1	10859	0.75
T_2 - P and K alone	228.7	11993	0.81
T_3 - 100%NCU + P and K	232.1	12965	0.84
T_4 - 75% NCU + 25% NU + P and K	240.7	14001	0.94
T_5 - 50% NCU + 50% NU + P and K	242.1	14481	0.95
T_6 - 25% NCU + 75% NU + P and K	238.4	12878	0.92
T_7 - 100% NU + P and K	235.7	12456	0.90
Mean	**234.4**	**12805**	**0.87**
SE(d)	**14.13**	**466**	**0.04**
CD (*p*=0.05)	**28.9**	**987**	**0.09**

Table 2: Effect of various nitrogenous fertilizers on yield and Economics of sorghum.

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)	Net return (Rs. ha^{-1})	B:C ratio
T_1 - Control	1250	7865	13.71	11,447	**1.22**
T_2 - P and K alone	2802	8642	24.48	71,885	**2.35**
T_3 - 100% NCU + P and K	2968	8832	25.15	78,289	**2.45**
T_4 - 75% NCU + 25% NU + P and K	3116	9155	25.45	85,385	**2.58**
T_5 - 50% NCU + 50% NU + P and K	3375	9843	25.53	95,903	**2.78**
T_6 - 25% NCU + 75% NU + P and K	3078	9067	25.34	82,901	**2.54**
T_7 - 100% NU + P and K	3105	9765	24.12	84,149	**2.56**
Mean	**2813**	**9024**	-	-	-
SE(d)	**127**	**315**	-	-	-
CD (*p*=0.05)	**269**	**668**	-	-	-

CONCLUSIONS

Based on the field research findings, the application of 50% N through neem-coated urea + 50% N through nano urea, along with P and K, resulted in significantly higher grain and straw yields for sorghum in the southern region of Coimbatore. Additionally, the application of 75% N through neem-coated urea + 25% N through nano urea + P and K can be considered as the second option for achieving higher yields and improved economic returns in sorghum cultivation. 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 sorghum cultivation, contributing to improved agricultural practices and increased crop productivity.

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Conflict of Interest. None.

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