Effect of Foliar Application of Nano-urea on Yield Attributes and Yield of Pearl Millet (*Pennisetum glaucum* L.)

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Authors' contributions

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

Original Research Article

ABSTRACT

To evaluate the effect of different doses of Nano-urea on yield attributes and yield of pearl millet a field experiment was conducted at Eastern Block Farm of Tamil Nadu Agricultural University, Coimbatore during the Summer of 2022. This field experiment was laid out in Randomized Block Design (RBD) with ten treatments and three replications. In this experiment different doses of Nano-urea were applied along with the Recommended Dose of Nitrogen (RDN) as per the Crop Production Guide, 2020 of TNAU, Coimbatore. The study revealed that yield of pearl millet was significantly differed with treatments imposed. Among these treatments, application of 50% RDN as basal + 0.5% Nano-urea foliar spray @ panicle initiation and booting stage recorded a significantly higher number of productive tillers plant^{-1} (3.79), earhead length (26.82 cm), earhead girth (7.9 cm), number of grains earhead^{-1} (2,462), test weight (15.64 g), grain yield (3,314 kg ha^{-1}) and stover yield (5,136 kg ha^{-1}). Which was at par with treatment 50% RDN as basal + 25% RDN @ panicle initiation + 25% RDN @ booting stage (T$_{10}$).

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1. INTRODUCTION

Pearl millet is the world's fifth most significant crop after rice, wheat, maize and sorghum. It is frequently farmed as a rainfed crop in Africa and Southern Asia's arid and semi-arid regions and can be grown in areas where rainfall is insufficient for maize and sorghum growth [1]. Pearl millet ranks fourth among cereal crops in India, behind rice, wheat and sorghum. Pearl millet may be an alternative crop with superior physiological properties to other cereals, such as drought resistance, low fertility, high salinity and high temperature tolerance. Rajasthan is the most productive state in India, producing 4.68 million tonnes from 4.28 million hectares with a productivity of 1,093 kg ha^{-1}. It has covered 0.67 L ha in Tamil Nadu, with a production of 1.85 L t and a productivity of 2,743 kg ha^{-1} [2].

In pearl millet, plant nutrition is critical for increased development and productivity. Nitrogen is one of the important macronutrients that plants require for their growth, development and yield [3]. The national average yield and the potential achievable yield in pearl millet are substantially different. One of the reasons for such a large discrepancy in pearl millet yields is a lack of key minerals [4]. 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 losses [5,6].

Various fertilizer businesses in India created nanotechnology based Nano Urea (Liquid) fertilizer to address the unbalanced and excessive usage of conventional prilled urea. Nano-urea comprises nitrogen particles (18-30 nm) with a surface area (10,000 times that of a 1 mm urea prill) and a greater number of particles (55,000 nitrogen particles over 1 mm urea prill). At important crop growth phases, spraying Nano-urea at a rate of 2 to 4 ml per litre of water initiates crop response, meets nutritional requirements and enhances nutrient availability in the rhizosphere. Two applications of Nano-urea to crops in a season enough to meet the plant's nitrogen requirements in above-ground tissues [7]. According to Jakhar et al. [8] 50% Recommended Dose of Nitrogen (RDN) as basal + 25% Recommended Dose of Nitrogen at panicle initiation stage + 25% Recommended Dose of Nitrogen at booting stage was recorded maximum grain yield in pearl millet crop. Hence,

present investigation was designed based on this schedule of fertilizer recommendation in which different doses of Nano-urea was applied at panicle initiation and booting stage to analyse the optimum dose of Nano-urea which gives higher productivity.

2. MATERIALS AND METHODS

A field experiment was conducted at Eastern Block Farm of Tamil Nadu Agricultural University, Coimbatore during Summer, 2022 to learn the effect of foliar nutrition of Nano-urea on yield attributes and yield of pearl millet crop. The experiment field falls under Western Agro Climatic Zone of Tamil Nadu. The texture of experiment soil is sandy clay loam, which contains 28.7% clay, 18.4% silt, 30.5% coarse sand and 22.4% fine sand particles [9]. The soil was slightly alkaline with pH of 7.9 and with low soluble salts of 0.59 dS m^{-1} [10]. The nutrient status of soil was found to be low in available nitrogen (265 kg ha^{-1}) [11], medium range of available phosphorus (17.5 kg ha^{-1}) (Olsen, 1954) and high in available potassium (766 kg ha^{-1}) (Stanford and English). Randomized Block Design with three replication and ten treatments were followed in this experiment. The treatments detailed are as follows.

T_1 - 50% RDN as basal + 0.3% Nano-urea FS @ P.I + 25% RDN @ booting stage
T_2 - 50% RDN as basal + 25% RDN @ P.I + 0.3% Nano-urea FS @ booting stage
T_3 - 50% RDN as basal + 0.3% Nano-urea FS @ P.I and booting stage
T_4 - 50% RDN as basal + 0.4% Nano-urea FS @ P.I + 25% RDN @ booting stage
T_5 - 50% RDN as basal + 25% RDN @ P.I + 0.4% Nano-urea FS @ booting stage
T_6 - 50% RDN as basal + 0.4% Nano-urea FS @ P.I and booting stage
T_7 - 50% RDN as basal + 0.5% Nano-urea FS @ P.I + 25% RDN @ booting stage
T_8 - 50% RDN as basal + 25% RDN @ P.I + 0.5% Nano-urea FS @ booting stage
T_9 - 50% RDN as basal + 0.5% Nano-urea FS @ P.I and booting stage
T_{10} - Control (50% RDN as basal + 25% RDN @ P.I + 25% RDN @ booting stage)

Pearl millet variety CO 10 was sown at a seed rate of 5 kg ha^{-1} with a spacing of 45 cm × 15 cm to study the effect of Nano-urea. For this experiment as per the blanket recommendation

of TNAU, 70:35:35 N, P_2O_5, K_2O kg ha^{-1} [12] were supplied through urea, single super phosphate and muriate of potash, respectively. Full recommended dosage of P and K and 50% dose of N were applied as basal. Remaining 50% dose of N was applied on panicle initiation stage and booting stage in the form of Nano-urea foliar spray at different doses and prilled urea as per the treatment plan. In this study we have used IFFCO Nano-urea (liquid), which is included in the Fertilizer Control Order (FCO) issued by the Government of India. It has a particle size of 20-50 nm, more surface area (10,000 times over 1 mm urea prill), number of particles (55,000 nitrogen particles over 1mm urea prill) and contains 4% total nitrogen (w/v) evenly dispersed in water (IFFCO).

For taking the yield attributes *viz*., number of productive tillers plant[-1], ear head length, ear head girth, number of grains earhead[-1] and test weight (1000 grain weight), five plants from each treatment plots were selected randomly and tagged. Grain and stover yield were taken from net plot area and converted to per hectare. Data collected and analysed statistically with procedure described by Gomez and Gomez [13]. Critical differences were worked at 5% probability level and significant differences among treatments were determined.

3. RESULT AND DISCUSSION

3.1 Effect on yield attributes and yield

Yield attributing characters in pearl millet were found to be significantly influenced by application of different doses of Nano-urea (Table 1).

3.1.1 Number of productive tillers plant[-1]

The number of productive tillers plant[-1] were significantly influenced by the different dose of nano-fertilizer. Among all the treatment combinations, application of 50% RDN as basal + 0.5% Nano-urea FS @ P.I and booting stage (T_9) resulted in significantly higher number of productive tillers plant[-1] (4.09). It was statistically on par with T_{10} - Control (50% RDN as basal + 25% RDN @ P.I + 25% RDN @ booting stage) showed a mean value of 3.65. while the lowest number of productive tillers plant[-1] (3.17) was found with (T_2) -50% RDN as basal + 25% RDN @ P.I + 0.3% Nano-urea FS @ booting stage (Table 1). When Nano-urea was applied twice to the leaves, it increases the nutrient uptake through the stomatal openings and nutrient translocation within the plant. This increased nutrient uptake resulted in increased cell division, meristematic activity and cell elongation stimulation, producing more productive tillers plant[-1]. Similar results were revealed by Meena et al. [14] and Jassim et al. [15] in rice. The number of effective tillers produced is a good indicator as it is the major yield determinant. According to Benzon et al. [16], the number of reproductive tillers was significantly affected by applying conventional fertilizer in combination with nano fertilizer.

3.1.2 Earhead length and girth (cm)

The earhead length and girth is influenced by the different dose of Nano-urea foliar spray. Among these treatments, T_9 (50% RDN as basal + 0.5% Nano-urea FS @ P.I and booting stage) resulted in significantly higher earhead length (26.82 cm) and earhead girth (7.9 cm). This treatment is on par with T_{10} (50% RDN as basal + 25% RDN @ P.I + 25% RDN @ booting stage). Which resulted in an earhead length and girth of 25.23 cm and 7.41 cm, respectively. While the lowest earhead length (18.70 cm) and earhead girth (5.9 cm) were found with (T_2) -50% RDN as basal + 25% RDN @ P.I + 0.3% Nano-urea FS @ booting stage (Table 1). Because of the faster growth rate and photosynthetic assimilation rate brought on by the improved availability and translocation of nutrients, which in turn encouraged a greater partitioning of photosynthates, there has been a considerable rise in earhead length and girth. Similar findings were reported by Choudhary et al. [17] in corn.

3.1.3 No. of grains earhead[-1]

Data revealed that significantly higher No. of grains earhead[-1] (2472) were reported in T_9 (50% RDN as basal + 0.5% Nano-urea FS @ P.I and booting stage). Whereas significantly lowest no. of grains earhead[-1] (1775) were found in (T_2) - 50% RDN as basal + 25% RDN @ P.I + 0.3% Nano-urea FS @ booting stage (Table 1). The considerable increase in grain earhead[-1] counts may be attributable to the increase in overall plant growth brought on by the increased availability of nutrients due to fertiliser foliar spraying. In addition, timely nitrogen delivery increases the start of grain formation by increasing photosynthate uptake and translocation from source to sink. These results were in relation with findings of Algym et al. [18] in corn.

Table 1. Effect of foliar application of Nano-urea on yield attributes of pearl millet

Treatments		Productive tillers plant^{-1}	Earhead length (cm)	Earhead girth (cm)	No. of grains earhead^{-1}
T$_1$	50% RDN as basal + 0.3% Nano-urea FS @ P.I + 25% RDN @ booting stage	3.24	19.19	6.20	1790
T$_2$	50% RDN as basal + 25% RDN @ P.I + 0.3% Nano-urea FS @ booting stage	3.17	18.70	5.90	1775
T$_3$	50% RDN as basal + 0.3% Nano-urea FS @ P.I and booting stage	3.24	19.64	6.41	1795
T$_4$	50% RDN as basal + 0.4% Nano-urea FS @ P.I + 25% RDN @ booting stage	3.33	21.43	6.92	1862
T$_5$	50% RDN as basal + 25% RDN @ P.I + 0.4% Nano-urea FS @ booting stage	3.25	20.79	6.90	1797
T$_6$	50% RDN as basal + 0.4% Nano-urea FS @ P.I and booting stage	3.35	22.43	7.06	1893
T$_7$	50% RDN as basal + 0.5% Nano-urea FS @ P.I + 25% RDN @ booting stage	3.48	24.55	7.21	1992
T$_8$	50% RDN as basal + 25% RDN @ P.I + 0.5% Nano-urea FS @ booting stage	3.41	23.60	7.20	1958
T$_9$	50% RDN as basal + 0.5% Nano-urea FS @ P.I and booting stage	4.09	26.82	7.90	2472
T$_{10}$	Control (50% RDN as basal + 25% RDN @ P.I + 25% RDN @ booting stage)	3.65	25.23	7.41	2120
S.Ed		0.24	1.34	0.40	193
CD (p=0.05)		0.52	2.82	0.85	407

Table 2. Effect foliar application of Nano-urea on Test weight, Grain yield and Stover yield of Pearl millet

Treatments		Test weight (g)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T$_1$	50% RDN as basal + 0.3% Nano-urea FS @ P.I + 25% RDN @ booting stage	12.31	2568	4169
T$_2$	50% RDN as basal + 25% RDN @ P.I + 0.3% Nano-urea FS @ booting stage	12.26	2552	4160
T$_3$	50% RDN as basal + 0.3% Nano-urea FS @ P.I and booting stage	12.68	2665	4333
T$_4$	50% RDN as basal + 0.4% Nano-urea FS @ P.I + 25% RDN @ booting stage	13.64	2826	4597
T$_5$	50% RDN as basal + 25% RDN @ P.I + 0.4% Nano-urea FS @ booting stage	13.26	2825	4552
T$_6$	50% RDN as basal + 0.4% Nano-urea FS @ P.I and booting stage	14.14	2844	4581
T$_7$	50% RDN as basal + 0.5% Nano-urea FS @ P.I + 25% RDN @ booting stage	14.19	3016	4902
T$_8$	50% RDN as basal + 25% RDN @ P.I + 0.5% Nano-urea FS @ booting stage	14.18	2922	4597
T$_9$	50% RDN as basal + 0.5% Nano-urea FS @ P.I and booting stage	15.71	3413	5662
T$_{10}$	Control (50% RDN as basal + 25% RDN @ P.I + 25% RDN @ booting stage)	14.20	3377	5481
S.Ed		0.95	270.05	425.34
CD (p=0.05)		2.01	567.36	893.63

3.1.4 Test weight

In this field trial, test weight (1000 grain weight) was significantly influenced by different doses of Nano-urea (Table 2). Application of 50% RDN as basal + 0.5% Nano-urea FS @ P.I and booting stage (T_9) had produced a maximum test weight of 15.71 g, which is on par with T_{10} (50% RDN as basal + 25% RDN @ P.I + 25% RDN @ booting stage) (14.20 g). The lower test weight of 12.26 g was recorded with in (T_2) -50% RDN as basal + 25% RDN @ P.I + 0.3% Nano-urea FS @ booting stage. This results from the enhanced level of Nano-urea foliar spray, which may have guaranteed nitrogen supply at later phases of grain filling. Foliar application of nutrients may promote assimilate build-up in the grain and increasing grain weight as reported by Manikandan and Subramanian [19] in wheat and Naveenaa et al. [20] in maize crop.

3.1.5 Grain and stover yield

In this field investigation, grain and stover yield followed similar trends as yield attributes. The yield of pearl millet was significantly influenced by different dose of Nano-urea as presented in Table 2.

A significantly higher yield of 3413 kg ha^{-1} was observed with the treatment 50% RDN as basal + 0.5% Nano-urea FS @ P.I and booting stage (T_9). Which is statistically on par with T_{10} (50% RDN as basal + 25% RDN @ P.I + 25% RDN @ booting stage) (3377 kg ha^{-1}). The lowest grain yield was recorded with (T_2) -50% RDN as basal + 25% RDN @ P.I + 0.3% Nano-urea FS @ booting stage (2552 kg ha^{-1}). Due to the improvement in yield attributes, a considerable increase in grain yield was seen with greater foliar application of nano-nutrients. It leads to higher photosynthates accumulation and translocation to the economic parts of the plants. These findings were reported by Kumar et al. [21].

The application of Nano-urea significantly influenced data noted on stover yield. Higher stover yield was observed in 50% RDN as basal + 0.5% Nano-urea FS @ P.I and booting stage (T_9) (5662 kg ha^{-1}). Which is statistically on par with the treatment T_{10} (50% RDN as basal + 25% RDN @ P.I + 25% RDN @ booting stage) (5481 kg ha^{-1}). Treatment T_2 (50% RDN as basal + 25% RDN @ P.I + 0.3% Nano-urea FS @ booting stage) recorded the lowest stover yield of 4160 kg ha^{-1}. The increase in the stover yield with the foliar spray of higher dose of Nano-urea might be due to their rapid uptake by plants and ease of translocation at a faster pace, that aided in higher rate of photosynthesis and more dry matter accumulation which resulted in higher stover yield. These findings were in agreement with the reports of Khalil et al. [22] in maize and Sahu et al. [23] in rice [24-26].

4. CONCLUSION

From the field experiment, it was concluded that significantly higher yield attributes and yield character of pearl millet were observed with application of 50% RDN as basal + 0.5% Nano-urea foliar spray @ panicle initiation and booting stage (T_9). Which was at par with treatment 50% RDN as basal + 25% RDN @ panicle initiation + 25% RDN @ booting stage (T_{10}).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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