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**Ramzan Mohammed**
M.Sc. Scholar, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India
officialramzan1999@gmail.com

**Victor Debbarma**
Assistant Professor, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

**Corresponding Author:**
**Ramzan Mohammed**
M.Sc. Scholar, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

# Effect of zinc and nano urea on growth and yield of pearl millet (*Pennisetum glaucum* L.)

**Ramzan Mohammed and Victor Debbarma**

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**Abstract**
A field experiment was conducted during *Kharif* season of 2023 at Crop Research Farm Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Sciences and Technology. To determine "Effect of zinc and nano urea on Growth and yield of Pearl Millet". The treatments consisted of three different levels of zinc (15 kg/ha, 20 kg/ha, 25 kg/ha) respectively and three different levels of nano urea (2 ml, 3 ml, 4 ml) respectively. The result revealed that treatment 9 ($ZnSO_4$-25 kg/ha + Nano urea-4 ml/l) recorded significantly higher plant height (162.6 cm), plant dry weight (61.39 g), ear head length (29.63 cm), number of grain/earhead (1616), test weight (9.5 g), grain yield (2.96 t/ha) and straw yield (11.96 t/ha). The aforesaid treatment also recorded cost of cultivation (38977.7 INR/ha) gross return (136812.86 INR/ha), net return (97835.16 INR/ha) and B:C ratio (2:5).

**Keywords:** Pearl millet, zinc, nano urea, growth, yield, and economics

## 1. Introduction

The nutritive value of grains of pearl millet is high and used for human consumption. Apart from grain, the forage and Stover is an important secondary product for resource poor farmer that can be used as animal feed and fuel. Pearl millet a tropical cereal and most drought resistant crop it is extensively grown in the arid and semi-arid regions of the world. Pearl millet's resistance to drought, low soil fertility, high salinity, and high temperature tolerance make it a potentially valuable alternative crop when compared to other cereals. Because pearl millet has a mechanism to with stand drought, it can grow in regions that experience extended dry spells. Compared to applying nutrients alone or in combination, balanced fertilization improves the crop's growth, development, and biological yield in a number of ways. Amongst the major cereals, pearl millet is highly tolerant to heat and drought, to saline and acid soils and is easy to grow in arid regions where rainfall is not sufficient for maize or even sorghum. India produces more than half the world's pearl millet and contributing 42% of total world production. Pearl millet is the most widely cultivated millet crop, occupying prominent positionin global agriculture.

Global millet production was 30.08 million metric tones, the average yield of millet is 1,229 kg/ha, and the area sown to millet around 38 million hectares. India is the largest producer of pearl millet in world occupying about 9.4 in addition to its grain consumption as human feed, it is also as green fodder. In India cultivable area under Pearl millet was 70.08 lakh ha with production of 95.31 lakh tonnes and productivity of 1360 kg/ha. In Uttar Pradesh Pearl millet was cultivated in 10.10 lakh ha area with production of 21.95 lakh tonnes and productivity of 2173 kg/ha.

Pearl millet may be an alternative crop that exhibits great advantages in physiological characteristics when compared to other cereals as it is yield loss is a major constraint to the success of pearl millet crop. Loss of nutrients is because of non availability or lesser availability of nutrients in the soil. yield loss is greater without effective management. A nitrogen deficit in the soil is one of the main causes of low crop productivity and poor crop health including chlorotic leaves, less fertile tillers, shorter plant height, and poor growth. Growth may be prevented if cell division declines because of low photosynthetic activity. A shortage of Zn severely impairs the plant's ability to regulate P accumulation. Loss of zinc reduces enzymatic activity resulting in disruption of the basic operations of plant metabolism, causing growth retardation and leaf chlorosis in the plants. The balanced fertilization as shown in positive effects on various aspects of growth development and biological yield of the crop in comparison to nutrient use in single or in combination.

Zinc absence can reduce grain yields by up to 80%. Lower zinc levels in the grain can also be seen. $ZnSO_4$ is applied to poor soil at rates ranging from 5 to 25 kg/ha to address Zn deficiency and prevent crop production losses. Crops sensitive to Zn deficiency, alkaline or calcareous soil, and broadcasting (rather than banding) are linked to higher rates. Soil Zn application rates vary depending on crop type, soil conditions, and mode of application. To boost Zn content in cereals, produce Zn-rich cultivars or apply Zn fertilizers. (Cakmak and Kutman. 2018) [3].

Zinc is necessary for photosynthesis, nitrogen metabolism, and auxin regulation in plants. (Marngar and Dawson *et al.* 2017) [7].

Precision agriculture has found great success with nano-fertilizers because they allow for accurate nutrient management by matching the supply of nutrients to the demands of different crop growth stages throughout the course of the growing season. Despite being widely used, the traditional technique of fertilizer application to the soil has a number of drawbacks, chief among which is its effect on plant accessibility to nutrients. Rainfall or irrigation can cause inorganic nutrients to leak since they often build up in the soil in insoluble forms. These limitations are overcome by treating the seeds and applying nano urea topically. (Udapudi *et al*., 2023) [28].

Plants can use nutrients more efficiently when treated with nano urea, requiring less input and causing less environmental harm. Because of their nano size, they have increased profitability and nutrient use efficiency, making it easier for them to absorb nutrients from leaves while also having high availability and absorption, all of which satisfy the 4R principles and increase agricultural photosynthesis and biomass output. When compared to conventional fertilizers, nano urea has various advantages, including simplicity of administration (less input), a slow release mechanism, lower transportation and application costs, and little soil salt formation. These give increased nutrient bio availability while still meeting crop nutrient requirements. Nano urea enhances the nutritional quality and efficiency of nitrogen use in crops by biofortifying them. Nano urea crops are more nutritious and have a greater protein content than standard urea crops. Furthermore, by applying two sprays of nano urea throughout important growth stages, the nitrogen demand is met, reducing the need for pesticides. Because nano urea is given topically to plants as a liquid, these liquid-based bottles are quite affordable to ship, store, and operate in terms of logistics and storage costs. Farmers find it easier to transport bottles on top of urea sacks (Ojha *et al.* 2023) [17]. Keeping in view the above fact, the experiment was conducted to find out the ‘‘Effect of zinc and nano urea on growth and yield of Pearl Millet”.

## 2. Materials and Methods

The experiment was conducted during *kharif* season 2023 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of the experimental field was sandy loam in texture, with soil (pH 7.8), low level of organic carbon (0.72%), available N (178.48 Kg/ha), P (27.80 kg/ha), K (233.24 kg/ha), and Zn (0.70 mg/kg). The treatments consisted of three different levels of zinc (15 kg/ha, 20 kg/ha, 25 kg/ha) respectively and three different levels of nano urea (2 ml, 3 ml, 4 ml) respectively. The experiment was laid out in RBD with 10 treatments each replicated thrice. The treatment combinations are $T_1$- $ZnSO_4$ - 15 kg/ha + Nano urea - 2 ml/l, $T_2$- $ZnSO_4$ - 15 kg/ha + Nano urea - 3 ml/l, $T_3$- $ZnSO_4$ - 15 kg/ha + Nano urea - 4 ml/l, $T_4$ - $ZnSO_4$ - 20 kg/ha + Nano urea - 2 ml/l, $T_5$ - $ZnSO_4$ - 20 kg/ha + Nano urea - 3 ml/l, $T_6$ - $ZnSO_4$ - 20 kg/ha + Nano urea - 4 ml/l, $T_7$- $ZnSO_4$ - 25 kg/ha + Nano urea - 2 ml/l, $T_8$ - $ZnSO_4$ - 25 kg/ha + Nano urea - 3 ml/l, $T_9$- $ZnSO_4$ - 25 kg/ha + Nano urea - 4 ml/l, $T_{10}$- Control N:P:K (80:40:40 Kg/ha). Data recorded on different aspects of crop, viz., growth, yield attributes and yield were subjected to statistically analysed by analysis of variance method as described by Gomez and Gomez (1976) [10].

## 3. Results and Discussion

### 3.1 Growth Attributes

#### 3.1.1 Plant height (cm)

Significantly higher plant height (162.27 cm) was recoded in the treatment 9 ($ZnSO_4$ - 25 kg/ha + Nano urea - 4 ml/l). However, treatment 6 ($ZnSO_4$ – 20 kg/ha + Nano urea - 4 ml/l) were found to be statistically at par with treatment 9 ($ZnSO_4$ - 25 kg/ha + Nano urea- 4 ml/l). Significant and higher increased in plant height was observed with application of Zinc may be due to biosynthesis of indole 3- acetic acid a growth hormone involved in stem elongation hence the increased in the plant height. These results are similar to that reported by Rakesh *et al.* (2021) [21]. Further, significant and higher plant height was with the application of nano urea may be due to enhancing plant biology can improve nutrient availability by increasing the solubility and dispersion of insoluble nutrients which leads to more efficient absorption. Similar results were also reported by Veronica *et al.* (2015) [30].

#### 3.1.2 Plant dry weight (g)

Significantly higher plant dry weight (61.38 g) was observed in treatment 9 ($ZnSO_4$ 25 kg/ha + Nano urea 4 ml/l). However, treatment 3 ($ZnSO_4$ 15 kg/ha + Nano urea 4 ml/l), treatment 6 ($ZnSO_4$ 20 kg/ha + Nano urea 4 ml/l) was found to be statistically at par with treatment 9 ($ZnSO_4$ 25 kg/ha + Nano urea 4 ml/l). Significant and higher plant dry weight was with the application of zinc might be due to micronutrients support ferredoxin and electron transport in chloroplasts which helps in accelerating photosynthesis and promotes vegetative development, plant development and biomass accumulation by activating the synthesis of tryptophan and IAA precursors. Similar results were noticed by Jitarwal *et al*. (2024) [13]. Further significant and higher plant dry weight was with the application of nano urea might be due to nano fertilizers were quickly absorbed by the leaf epidermis and transported to the stems by increasing the intake of active molecules. These findings were similar to Shree *et al.* (2024) [25].

#### 3.1.3 Crop Growth Rate (g/m /day)

The data revealed that during 60-80 DAS intervals the highest crop growth rate (50.72 g/m2/day) was observed in treatment 9 ($ZnSO_4$ 25 kg/ha + Nano urea 4 ml/l) though these data was no significant among the treatments.

#### 3.1.4 Relative Growth Rate (g/g/day)

The data revealed that during 60-80 DAS intervals the highest relative growth rate (0.0355 g/g/day) was observed in treatment treatment-8 ($ZnSO_4$ - 25 kg/ha + Nano urea - 3 ml/l) though, there was no significant difference among the treatments.

### 3.2 Yield and Yield Parameters

#### 3.2.1 Ear head length (cm)

Significant and higher ear head length (29.63 cm) was recorded in treatment-9 ($ZnSO_4$ 25 kg/ha + Nano urea 4 ml/l). However, treatment 6 ($ZnSO_4$ 20 kg/ha + Nano urea 4 ml/l) was found to be statistically at par with treatment 9 ($ZnSO_4$ 25 kg/ha + Nano urea 4 ml/l). The significant and higher ear head length was with the application of zinc might be due to important role in physiological and metabolic processes, including tryptophan production. These results are similar to that reported by Reddy *et al.* (2022) [23]. Further significant and higher ear head length was obtained with the application of nano urea might be due to the improved food availability and translocation have led to faster growth and photosynthetic absorption, resulting in increased partitioning of photosynthates. These results are in conformity with those of Arya *et al.* (2022) [1].

### 3.2.2 Number of grains/ear head (g)

Significant and maximum number of grains/ear head (1616.00 g) was recorded in treatment 9 ($ZnSO_4$ 25 kg/ha + Nano urea 4 ml/l). However, treatment 3 ($ZnSO_4$ 15 kg/ha + Nano urea 4 ml/l) and treatment 6 ($ZnSO_4$ 20 kg/ha + Nano urea 4 ml/l) were found to be statistically at par with treatment 9 ($ZnSO_4$ 25 kg/ha + Nano urea 4 ml/l). The significant and maximum number of grains/ear head was with the application of zinc may be due to its enrichment and chelation to organics boosted nutrient uptake and crop growth. These finding are similar with those of Reddy *et al.* (2021) [22]. Further, significant and higher grains/ear head was obtained with the application of nano urea may be due to nano particles significantly improves photosynthesis and nutrient utilization efficiency. These results are in conformity with those of Udapudi *et al* (2023) [28].

### 3.2.3 Test weight (g)

Significant and higher test weight (9.50 g) was recorded in treatment 9 ($ZnSO_4$ 25 kg/ha + Nano urea 4 ml/l). However, treatment 3 ($ZnSO_4$ 15 kg/ha + Nano urea 4 ml/l), treatment 6 ($ZnSO_4$ 20 kg/ha + Nano urea 4 ml/l) and treatment 8 ($ZnSO_4$ 25 kg/ha + Nano urea 3 ml/l) were found to be statistically at par with treatment 9 ($ZnSO_4$ 25 kg/ha + Nano urea 4 ml/l). The significant and higher test weight with the application of zinc is may be due to improved enzyme activity boosted photosynthetic efficiency, perhaps increasing the weight of the thousand grains. These results are similar to that reported by Bhargavi *et al.* (2023) [2]. Further, significant and higher test weight was obtained with the application of nano urea may be due to metabolic activities such as photosynthesis that boost the accumulation and transport of photosynthates to the plant's commercially productive sections. These results are in conformity with those of Chinnappa *et al.* (2023) [5].

### 3.2.4 Grain yield (t/ha)

Significant and higher grain yield (2.96 t/ha) was recorded in treatment 9 ($ZnSO_4$ 25 kg/ha + Nano urea 4 ml/l). However, treatment 3 ($ZnSO_4$ 15 kg/ha + Nano urea 4 ml/l) and treatment 6 ($ZnSO_4$ 20 kg/ha + Nano urea 4 ml/l) were found to be statistically at par with treatment 9 ($ZnSO_4$ 25 kg/ha + Nano urea 4 ml/l). The significant and higher grain yield was obtained with the application of zinc might be due to it plays a role in the production of indole acetic acid (IAA) and the allocation of photosynthates to reproductive regions of primordia, resulting in improved grain yield. These results are similar to that reported by Girish *et al.* (2023) [8]. Further, significant and higher grain yield with the application of nano urea may be due to it causes more photosynthates to accumulate and translocate to the plant's economic parts. These results are similar with those of Arya *et al.* (2022) [1].

### 3.2.5 Straw yield (t/ha)

Significant and higher straw yield (11.96 t/ha), was observed in treatment 9 ($ZnSO_4$ 25 kg/ha + Nano urea 4 ml/l). However, treatment 3 ($ZnSO_4$ 15 kg/ha + Nano urea 4 ml/l) and treatment 6 ($ZnSO_4$ 20 kg/ha + Nano urea 4 ml/l) were found to be statistically at par with treatment 9 ($ZnSO_4$ 25 kg/ha + Nano urea 4 ml/l). The significant and higher straw yield was with the application of zinc may be due to longer availability and uptake of primary nutrients, as well as the addition of zinc, improved the assimilatory surface and increased photosynthesis, protein synthesis, and growth hormone production. These results are similar to that reported by Swaroop *et al.* (2023) [15]. Further significant and higher in straw yield was obtained with the application of nano urea may be due to It easily enters the leaf infrastructure via stomata, where it is digested by plants, transferred by phloem from source to sink, and utilized according to plant needs. These results are in agreement with those of Chavan *et al.* (2023) [4].

### 3.2.6 Harvest Index (%)

Significant and higher harvest index (21.37%), was observed in treatment 6 ($ZnSO_4$ 20 kg/ha + Nano urea 4 ml/l). However, treatment 1 ($ZnSO_4$ 15 kg/ha + Nano urea 2 ml/l), treatment 2 ($ZnSO_4$ 15 kg/ha + Nano urea 3 ml/l) and treatment 4 ($ZnSO_4$ 20 kg/ha + Nano urea 2 ml/l) were found to be statistically at par with treatment 6 ($ZnSO_4$ 20 kg/ha + Nano urea 4 ml/l). The significant and higher harvest index with the application of zinc is may be due to impacted these processes by its capacity to transport a variety of nutrients, from the intake of nutrients via the roots to the penetration and movement of nutrients through the foliage of the plant. These results are similar to that reported by Ojha *et al.* (2023) [17]. Further significant and higher harvest index was obtained with the application of nano urea may be due to it enhances nutrient absorption by plant cells, leading to optimal development and higher harvest index. These results are in conformity with those of Rajput *et al.* (2022) [12].

### 3.3 Economics

The data revealed that maximum cost of cultivation (38977.7 INR/ha), gross return INR/ha), net returns (97835.16 INR/ha), benefit cost ratio (2.51) were recorded in treatment 9 ($ZnSO_4$ 25 kg/ha + Nano urea 4 ml/l) as compare to other treatments. Higher Gross returns, net returns, benefit cost ratio was recorded with application of zinc which might be due to enhanced grain filling, strength the crop's growth and development, and eventually raised the yield of pearl millet while preserving economics by maximizing the net return and B:C ratio. These results are in conformity with those of Kavya *et al.* (2023) [33]. Further, increase in B:C ratio was with the application of nano urea is due to enhanced higher cost was offset by the substantial gains in grain and straw yields, ultimately resulting in higher returns and a more favourable benefit- cost (BC) ratio. The result was in collaboration with Udapudi *et al.* (2023) [28]

**Table 1:** Effect of zinc and nano urea on growth attributes of pearl millet.

| Sr. No. | Treatment combinations | Plant height (cm) | Plant dry weight (g) | Crop Growth Rate (g/m2/day) | Relative Growth Rate (g/g/day) |
|---|---|---|---|---|---|
| 1. | $ZnSO_4$ - 15 kg/ha + Nano urea - 2 ml/l | 157.42 | 52.57 | 46.35 | 0.0353 |
| 2. | $ZnSO_4$ - 15 kg/ha + Nano urea - 3 ml/l | 160.11 | 56.68 | 47.38 | 0.0348 |
| 3. | $ZnSO_4$ - 15 kg/ha + Nano urea - 4 ml/l | 160.87 | 59.45 | 48.58 | 0.0345 |
| 4. | $ZnSO_4$ - 20 kg/ha + Nano urea - 2 ml/l | 159.28 | 54.02 | 44.05 | 0.0336 |
| 5. | $ZnSO_4$ - 20 kg/ha + Nano urea - 3 ml/l | 160.28 | 57.44 | 48.54 | 0.0353 |
| 6. | $ZnSO_4$ - 20 kg/ha + Nano urea - 4 ml/l | 161.37 | 60.05 | 48.01 | 0.0337 |
| 7. | $ZnSO_4$ - 25 kg/ha + Nano urea - 2 ml/l | 159.61 | 54.95 | 46.93 | 0.0350 |
| 8. | $ZnSO_4$ - 25 kg/ha + Nano urea - 3 ml/l | 160.67 | 59.26 | 49.60 | 0.0355 |
| 9. | $ZnSO_4$ - 25 kg/ha + Nano urea - 4 ml/l | 162.27 | 61.38 | 50.72 | 0.0342 |
| 10. | Control (RDF) | 130.79 | 38.71 | 43.35 | 0.0344 |
| | F Test | S | S | NS | NS |
| | SEm (±) | 0.47 | 0.69 | 1.57 | 0.0008 |
| | CD (p=0.05) | 1.39 | 2.06 | -- | -- |

**Table 2:** Effect of zinc and nano urea on yield and yield attributes of pearl millet.

| Sr. No. | Treatment combinations | Ear head length (cm) | Number of grains/ear head (g) | Test weight (g) | Grain yield (t/ha) | Straw yield (t/ha) | Harvest index (%) |
|---|---|---|---|---|---|---|---|
| 1. | $ZnSO_4$ - 15 kg/ha + Nano urea - 2 ml/l | 26.03 | 1431.33 | 7.52 | 2.04 | 7.77 | 20.80 |
| 2. | $ZnSO_4$ - 15 kg/ha + Nano urea - 3 ml/l | 27.32 | 1497.78 | 8.24 | 2.29 | 8.91 | 20.45 |
| 3. | $ZnSO_4$ - 15 kg/ha + Nano urea - 4 ml/l | 28.30 | 1595.00 | 8.82 | 2.79 | 11.70 | 19.25 |
| 4. | $ZnSO_4$ - 20 kg/ha + Nano urea - 2 ml/l | 26.70 | 1458.11 | 7.79 | 2.14 | 8.02 | 21.07 |
| 5. | $ZnSO_4$ - 20 kg/ha + Nano urea - 3 ml/l | 27.63 | 1507.89 | 8.59 | 2.31 | 9.74 | 19.17 |
| 6. | $ZnSO_4$ - 20 kg/ha + Nano urea - 4 ml/l | 28.64 | 1599.44 | 9.25 | 2.94 | 10.93 | 21.37 |
| 7. | $ZnSO_4$ - 25 kg/ha + Nano urea - 2 ml/l | 27.01 | 1475.22 | 8.04 | 2.10 | 8.74 | 19.36 |
| 8. | $ZnSO_4$ - 25 kg/ha + Nano urea - 3 ml/l | 27.83 | 1545.67 | 8.74 | 2.59 | 10.74 | 19.44 |
| 9. | $ZnSO_4$ - 25 kg/ha + Nano urea - 4 ml/l | 29.63 | 1616.00 | 9.50 | 2.96 | 11.96 | 19.78 |
| 10. | Control (RDF) | 22.21 | 1236.22 | 6.76 | 1.56 | 6.76 | 18.74 |
| | F Test | S | S | S | S | S | S |
| | SEm (±) | 0.33 | 11.59 | 0.30 | 0.09 | 0.40 | 0.46 |
| | CD (p=0.05) | 0.99 | 34.43 | 0.89 | 0.27 | 1.18 | 1.38 |

**Table 3:** Effect of zinc and nano urea on economics of pearl millet.

| | | Economics | | | |
|---|---|---|---|---|---|
| | | Cost of cultivation | Gross Return | Net Return | Benefit cost ratio |
| Sr. No. | Treatment combinations | (INR/ha) | (INR/ha) | (INR/ha) | (B:C) |
| 1 | $ZnSO_4$ - 15 kg/ha + Nano urea - 2 ml/l | 37517.7 | 104058.43 | 66540.73 | 1.77 |
| 2 | $ZnSO_4$ - 15 kg/ha + Nano urea - 3 ml/l | 37697.7 | 112769.0 | 75072.20 | 1.99 |
| 3 | $ZnSO_4$ - 15 kg/ha + Nano urea - 4 ml/l | 37877.7 | 131027.68 | 93149.98 | 2.46 |
| 4 | $ZnSO_4$ - 20 kg/ha + Nano urea - 2 ml/l | 38067.7 | 107604.72 | 69537.02 | 1.83 |
| 5 | $ZnSO_4$ - 20 kg/ha + Nano urea - 3 ml/l | 38247.7 | 115479.16 | 77231.46 | 2.02 |
| 6 | $ZnSO_4$ - 20 kg/ha + Nano urea - 4 ml/l | 38427.7 | 133794.34 | 95366.64 | 2.48 |
| 7 | $ZnSO_4$ - 25 kg/ha + Nano urea - 2 ml/l | 38617.7 | 108606.57 | 69988.87 | 1.81 |
| 8 | $ZnSO_4$ - 25 kg/ha + Nano urea - 3 ml/l | 38797.7 | 125021.75 | 86224.05 | 2.22 |
| 9 | $ZnSO_4$ - 25 kg/ha + Nano urea - 4 ml/l | 38977.7 | 136812.86 | 97835.16 | 2.51 |
| 10 | Control (RDF) | 35507.7 | 88033.61 | 52525.91 | 1.48 |

## 4. Conclusion
It is concluded that in pearl millet with the combination of $ZnSO_4$ (25 kg/ha) along with Nano urea (Treatment 9) was observed higher growth attributes, yield attributes and benefit cost ratio.

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