*Original Research Article*

Effect of PROM and nano urea on growth and yield of pearl millet

ABSTRACT

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| PROM is the alternate source of the phosphatic fertilizers. It is well documented that during composting process of organic waste a variety of organic acids are released. The interaction of organic acids released during composting results in P solubilization from RP for plant uptake. The present study aimed to determine the effect of PROM and nano urea on growth and yield of pearlmillet. A field experiment was conducted during *kharif-rabi*, 2022-23 and 2023-24 at the Agronomy Instruction Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India. The study comprised fifteen treatment combinations involving five levels PROM and three treatments of nano urea, tested in a randomized block design with factorial concept in three replications. Bartlett’s test was applied to examine the homogeneity of variance due to error. The variance obtained due to season x treatment components were tested against joint estimate of error variance with the objective to find out whether season x treatment interaction. The pooled results indicated that application of 200% RDP through PROM recorded significantly higher growth, yield attributes and yield parameters *viz*., plant height at 45 DAS and at harvest, effective tillers per plant, earhead length, grain and straw yields of pearlmillet. Nano urea spray did not exert any significant on plant height, number of effective tillers per plant and earhead length of peralmillet, but the application of 100% RDN through neem coated urea (N1) gave significantly the highest plant height at 45 and at harvest and earhead length of pearlmillet. The interaction effect of PROM and nano urea did not exert any significant effect on plant height at 45 DAS and at harvest, number of effective tillers per plant and earhead length of pearlmillet.The effectiveness of nano urea is lower compared to full nitrogen application through neem-coated urea. Thus, for maximizing pearlmillet yield, higher doses of PROM coupled with adequate nitrogen via NCU are recommended. |

*Keywords: PROM, Nano urea, Neem coated urea, Pearlmillet*

1. INTRODUCTION

Nanotechnology is a rising field of science capable of resolving issues and problems that are impossible to tackle in engineering and biological sciences. Among the advancement in sciences, nanotechnology is being visualized as a rapidly evolving field that has potential to revolutionize agriculture and food systems as well as to improve the condition of the poor. Nanotechnology has emerged as an innovative solution with the production of nano agri-inputs for addressing the issue of low or declining nutrient use efficiency with minimal environmental footprint (Arya *et al.,* 2022). Phosphorus (P) is the major plant nutrient and considered as one of the primary factors limiting crop yield (Zaidi *et al.,* 2009). In India 60% soil is low to medium status in soil available P content (Motsara, 2002) and based on nutrient index value, the soils of Banaskantha district are marginal in available phosphorus (Panchal *et al.,* 2018). Therefore, application of phosphatic fertilizers is essentially required to maximize crop yields. The nutrient availability from chemical fertilizers is not more than 20% and has forced the poor farmers to add two times more than the optimum application rate of P-fertilizers. PROM is the alternate source of the phosphatic fertilizers. It is well documented that during the composting process of organic waste, a variety of organic acids are released. The interaction of organic acids released during composting results in P solubilization from RP for plant uptake. The use of organic fertilizers made up of various composted materials is now established as a key strategy not only for improving soil organic matter contents and nutrients supply to plants but also for reducing the input cost of mineral fertilizers and promoting healthier environments (Ahmad *et al*., 2006).

 The use of nano fertilizers is the most important application of nanotechnology in agriculture so far (Agrawal and Rathore, 2014; Naderi *et al.,* 2011). Nano urea may be a sustainable option for farmers towards smart agriculture and combating climate change. Nano urea may fulfil the plant nutrient requirement as a fertilizer since it is bioavailable to plants because of the size of one nano urea liquid particle is 30 nanometers and it has about 10,000 times more surface area as compared to conventional granular urea. Hence, nano urea increases its availability to the crop by more than 80% resulting in higher nutrient use efficiency (Lakshman *et al.,* 2022). In addition to this, nano urea helps in minimizing the environmental footprint by reducing the loss of nutrients from agriculture fields in the form of leaching and gaseous emissions which used to cause environmental pollution and climate change.

Pearlmillet is the sixth most important cereal in the world and it is the fourth most widely grown food crop in India after rice, wheat and corn. As a traditional arid and semi-arid crop, it is an important component of dry land agriculture. In India it is grown under 75.72 lakh ha with the production of 114.31 lakh tonne and productivity 1510 kg/ha(DA and FW, 2022-23). Pearl millet requires a minimum temperature of around 25°C for germination and thrives well in hot climates, displaying resilience to high temperatures. The crop has ability to withstand low and erratic rainfall. Pearl millet performs well with an ideal rainfall range of 400 to 600 mm during the growing season optimizes its growth and yield. The crop prefers red, medium deep black and sandy soils with good drainage and a pH range of 6.0 to 8.5. Due to its warm-season nature and sensitivity to frost, it is typically cultivated in low to medium altitude areas (Patel *et al.,* 2024; Manjunath *et al.,* 2025). The productivity of pearlmillet, which is much lesser than its production potential, varies greatly with rainfall quantity, intensity and its distribution. Hence, the research effort should be diverted to overcome the constraints that are responsible for its productivity. To bring millets into mainstream for exploiting the nutritionally rich properties and promoting their cultivation, Govt. of India has declared Year 2018 as the “Year of Millets” and the Year 2021 was declared as “International Year of Millets” by Food and Agriculture Organization Committee on Agriculture (COAG) forum.

2. materials and methods

The field experiment was laid out at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha (Gujarat). Geographically, Sardarkrushinagar is situated at 24º19ʹ North latitude and 72º19ʹ East longitude with an elevation of 154.42 m above the mean sea level. It is situated in the North Gujarat Agro-climatic Zone - IV. The soil of the experimental plot was loamy sand in texture, low in organic carbon and available N, medium in available P2O5, K2O, S and DTPA-extractable Zn. The experiment consisted of 15 treatment combination which comprises of five levels of phosphorous sources *i.e.,* P1 (100% RDP through DAP), P2 (50% RDP through PROM), P3 (100% RDP through PROM), P4 (150% RDP through PROM) and P5 (200% RDP through PROM) and three treatments of nano urea N1 (100% RDN through NCU), N2 (75% RDN through NCU + foliar spray of nano-urea @ 0.4% at 35 and 50 DAS) and N3 (50% RDN through NCU + foliar spray of nano-urea @ 0.4% at 35 and 50 DAS) which were laid out in a factorial randomized block design (FRBD) and replicated thrice. Recommended dose of fertilizer (RDF) for *kharif* pearlmillet was 80-40-00 kg N-P2O5-K2O/ha. 50% RDN of pearlmillet was applied as basal and the remaining amount of RDN was applied at 30 DAS. Seed treatment of pearlmillet was made with *Azospirillum* and PSB each @ 5ml/kg seed. Common application of zinc sulphate (21% Zn) @10 kg/ha was applied as basal and FYM @ 5 t/ha was applied 10 days before the sowing of pearlmillet. The plot size was maintained at 7.2 m × 5.0 m. The variety GHB 1129 @ 3.75 kg/ha was used in the study. Seed rate of pearlmillet was 3.75 kg/ha. Plant spacing was maintained at 45 cm (row to row). PROM was applied at the time of sowing in granular form, which contains 10.4% P2O5. Foliar spray of nano-urea as per treatment was carried out at 35 and 50 DAS**.** For the preparation of 0.4% nano urea solution 4 ml of nano urea was used per one litre of water.

2.1 STATISTICAL ANALYSIS

The pooled analysis of the kharif pearlmillet crop for two years was worked out as per the method described by Panse and Sukhatme (1985). Bartlett’s test was applied to examine the homogeneity of variance due to error. The variance obtained due to season x treatment components was tested against joint estimate of error variance with an objective to find out whether season x treatment interaction exist or otherwise.

3. results and discussion

3.1 growth parameters

The data on different plant growth parameters like plant height at 45 DAS and at harvest, number of effective tillers per plant and earhead length of pearlmillet as influenced by PROM and nano urea levels are presented in table 1 and 2.

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| Table 1: Effect of PROM and nano urea on plant height of pearlmillet |
| **Treatments** | **Plant height (cm)** |
| **At 45 DAS** | **At harvest** |
| **2022** | **2023** | **Pooled** | **2022** | **2023** | **Pooled** |
| **A: Levels of PROM (P)**  |  |
| P1: 100% RDP through DAP | 105.2 | 121.7 | 113.5 | 182.8 | 204.3 | 193.5 |
| P2: 50% RDP through PROM  | 91.6 | 106.6 | 99.1 | 175.5 | 190.7 | 183.1 |
| P3: 100% RDP through PROM | 101.7 | 118.9 | 110.3 | 180.6 | 200.2 | 190.4 |
| P4: 150% RDP through PROM  | 107.3 | 124.1 | 115.7 | 184.1 | 206.2 | 195.2 |
| P5: 200% RDP through PROM  | 112.7 | 129.7 | 121.2 | 188.6 | 213.5 | 201.1 |
| S.Em.± | 2.93 | 3.04 | 2.11 | 2.73 | 3.25 | 2.12 |
| CD @ 5% | 8.48 | 8.80 | 9.43 | 7.91 | 9.43 | 9.50 |
| **B: Nano urea spray (N)** |
| N1: 100% RDN through NCU | 109.8 | 126.1 | 117.9 | 189.4 | 209.1 | 199.2 |
| N2: 75% RDN through NCU + foliar spray of nano urea @ 0.4% at 35 and 50 DAS | 103.3 | 124.1 | 113.7 | 181.5 | 200.2 | 190.9 |
| N3:50% RDN through NCU + foliar spray of nano urea @ 0.4% at 35 and 50 DAS | 98.1 | 110.4 | 104.2 | 176.1 | 199.7 | 187.9 |
| S.Em.± | 2.27 | 2.35 | 1.63 | 2.11 | 2.52 | 1.65 |
| CD @ 5% | 6.57 | 6.82 | 7.31 | 6.13 | 7.30 | 7.36 |
| Interactions(P×N) (Y×P) (Y×N) (Y×P×N) | NS | NS | NS | NS | NS | NS |
| CV% | 8.47 | 7.58 | 7.99 | 4.49 | 4.81 | 4.68 |

**Table 2. Effect of PROM and nano urea on number of effective tillers per plant and**

 **earhead length of pearlmillet**

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| --- | --- | --- |
| **Treatments** | **Number of effective tillers per plant** | **Earhead length (cm)** |
|  | **2022** | **2023** | **Pooled** | **2022** | **2023** | **Pooled** |
| **A: Levels of PROM (P)**  |
| P1: 100% RDP through DAP | 2.75 | 2.93 | 2.84 | 21.15 | 24.74 | 22.95 |
| P2: 50% RDP through PROM  | 2.56 | 2.58 | 2.57 | 17.53 | 20.57 | 19.05 |
| P3: 100% RDP through PROM | 2.68 | 2.74 | 2.71 | 20.09 | 23.78 | 21.94 |
| P4: 150% RDP through PROM  | 2.71 | 3.15 | 2.93 | 21.71 | 25.28 | 23.50 |
| P5: 200% RDP through PROM  | 2.91 | 3.23 | 3.07 | 23.21 | 26.92 | 25.07 |
| S.Em.± | 0.07 | 0.12 | 0.07 | 0.89 | 0.95 | 0.65 |
| CD @ 5% | 0.20 | 0.35 | 0.31 | 2.56 | 2.75 | 2.90 |
| **B: Nano urea spray (N)**  |
| N1: 100% RDN through NCU | 2.79 | 3.07 | 2.93 | 22.78 | 26.09 | 24.44 |
| N2: 75% RDN through NCU + foliar  spray of nano urea @ 0.4% at  35 and 50 DAS | 2.73 | 2.99 | 2.86 | 20.74 | 23.77 | 22.26 |
| N3:50% RDN through NCU + foliar  spray of nano urea @ 0.4% at  35 and 50 DAS | 2.64 | 2.71 | 2.67 | 18.70 | 22.91 | 20.81 |
| S.Em.± | 0.05 | 0.09 | 0.05 | 0.69 | 0.74 | 0.50 |
| CD @ 5% | NS | 0.27 | 0.24 | 1.99 | 2.13 | 2.25 |
| Interactions(P×N) (Y×P) (Y×N) (Y×P×N) | NS | NS | NS | NS | NS | NS |
| CV% | 7.58 | 12.53 | 10.54 | 12.81 | 11.75 | 12.25 |

The result shows that significantly higher plant height at 45 DAS and at harvest, number of effective tillers per plant and earhead length of pearlmillet were obtained due to the application of 200% RDP through PROM (P5). The increase in growth parameter could be attributable to continuous optimum supply of phosphorous through the whole plant growth period at higher levels of PROM. The similar results were also reported by Singh *et al*. (2015).

Nano urea spray did not exert any significant on plant height, number of effective tillers per plant and earhead length of peralmillet, but the application of 100% RDN through neem coated urea (N1) gave the highest plant height at 45 and at harvest and earhead length of pearlmillet. The treatment N1 increased the effective tillers per plant by 2.33 and 10.00% over treatment N2 and N3, respectively. It might be due to fact that an application of 100% RDN through neem-coated urea provides optimum nitrogen which improves the plant growth Similar results were also reported by Mehta and Bharat (2019).

The interaction effect of PROM and nano urea did not exert any significant effect on plant height at 45 DAS and at harvest, number of effective tillers per plant and earhead length of pearlmillet.

**3.2 GRAIN AND STRAW YIELD**

A perusal of data presented in Table 3 revealed that at higher doses of PROM (200% RDP) significantly improved grain yield (2275 kg/ha) of pearlmillet over rest of treatments but it remained at par with treatment P4 (150% RDP through PROM) and P1 (100% RDP through DAP) during both the individual year as well as in pooled results. On a pooled basis, the application of 200% RDP through PROM (P5) increased grain yield by 10.75, 24.95, 14.47 and 8.36% over P1, P2, P3 and P4 treatments, respectively. The straw yield (5448, 5689 and 5569 kg/ha) of pearlmillet significantly influenced under the treatment of P5 (200% RDP through PROM). But it remained at par with P1, P3 and P4 in pooled analysis. An increase in grain and straw yield might be due to the fact that at higher dose of PROM provides optimum P to plant results in root development which provides strength to the plant and also increases area for more absorption of nutrients. These results are in close agreement with those described by Raut *et al.* (2018), Chaudhari (2019), Jagadeesha *et al*. (2019), Aechra *et al.* (2021) and Ranjha *et al*. (2023).

It is explicated from the data presented in Table 4 that the application of 100% RDN through NCU gave the highest grain yield i.e. 2101, 2383 and 2242 kg/ha during 2022, 2023 and in pooled results, respectively over the rest of the treatments. The application of 100% RDN through NCU (N1) gave the highest straw yield 5319, 5572 and 5446 kg/ha over rest of the treatment but in the pooled result it remained at par with treatment N2. Significantly the higher grain yield was recorded at 100% RDN due to fact that the optimum application of nitrogen increases the growth of plant part and metabolic processes such as photosynthesis leads to higher photosynthates accumulation and their translocation towards the economic parts of plant. Moreover, it directly involved in energy transformation, activation of enzyme in carbohydrate metabolism and consequently greater translocation of photosynthates towards vegetative and reproductive parts led to overall improvement in growth and yield attributes (earhead length and effective tillers per plant) which ultimately reflects on grain yield. The results are close, conforming with the results of Chavan *et al.* (2023) and Dokhe *et al*. (2024).

The interaction effect between PROM and nano failed to show its significant effect on grain and straw yield of pearlmillet during both the individual years as well as in pooled analysis.

**3.3 TEST WEIGHT**

The data regarding the test weight of pearlmillet as influenced by PROM and nano urea are given in Table 4. It indicated that the different level of PROM and nano urea did not exert any significant effect on test weight of pearlmillet during both the individual years and in pooled results.

**Table 3. Effect of PROM and nano urea on grain and straw yield of pearlmillet**

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| **Treatments** | **Grain yield (kg/ha)** | **Straw yield (kg/ha)** |
|  | **2022** | **2023** | **Pooled** | **2022** | **2023** | **Pooled** |
| **A: Levels of PROM (P)**  |
| P1: 100% RDP through DAP | 1950 | 2158 | 2054 | 5033 | 5204 | 5119 |
| P2: 50% RDP through PROM  | 1726 | 1915 | 1821 | 4619 | 4854 | 4737 |
| P3: 100% RDP through PROM | 1895 | 2080 | 1987 | 4880 | 5109 | 4995 |
| P4: 150% RDP through PROM  | 2009 | 2190 | 2099 | 5157 | 5369 | 5263 |
| P5: 200% RDP through PROM  | 2154 | 2396 | 2275 | 5448 | 5689 | 5569 |
| S.Em.± | 73.3 | 88.7 | 57.5 | 174.6 | 188.2 | 128.3 |
| CD @ 5% | 212 | 257 | 257 | 506 | 545 | 574 |
| **B: Nano urea spray (N)**  |
| N1: 100% RDN through NCU | 2101 | 2383 | 2242 | 5319 | 5572 | 5446 |
| N2: 75% RDN through NCU + foliar spray of nano urea @ 0.4% at 35 and 50 DAS | 1932 | 2147 | 2039 | 4900 | 5125 | 5012 |
| N3:50% RDN through NCU + foliar spray of nano urea @ 0.4% at 35 and 50 DAS | 1807 | 1914 | 1861 | 4864 | 5038 | 4951 |
| S.Em.± | 56.8 | 68.7 | 44.6 | 135.2 | 145.8 | 99.4 |
| CD @ 5% | 164 | 199 | 199 | 392 | 422 | 445 |
| Interactions (P×N) (Y×P) (Y×N) (Y×P×N) | NS | NS | NS | NS | NS | NS |
| CV% | 11.29 | 12.39 | 11.92 | 10.42 | 10.76 | 10.60 |

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| Table 4. Effect of PROM and nano urea on test weight of pearlmillet  |
| **Treatments** | **Test weight (g)** |
|  | **2022** | **2023** | **Pooled** |
| **A: Levels of PROM (P)**  |
| P1: 100% RDP through DAP | 8.53 | 8.62 | 8.58 |
| P2: 50% RDP through PROM  | 8.11 | 8.30 | 8.16 |
| P3: 100% RDP through PROM | 8.24 | 8.50 | 8.37 |
| P4: 150% RDP through PROM  | 8.66 | 8.74 | 8.70 |
| P5: 200% RDP through PROM  | 8.70 | 8.80 | 8.75 |
| S.Em.± | 8.35 | 8.08 | 9.32 |
| CD @ 5% | NS | NS | NS |
| **B: Nano urea spray (N)**  |
| N1: 100% RDN through NCU | 8.73 | 8.76 | 8.74 |
| N2: 75% RDN through NCU + foliar spray of nano urea @ 0.4% at 35 and 50 DAS | 8.35 | 8.64 | 8.50 |
| N3: 50% RDN through NCU + foliar spray of nano urea @ 0.4% at 35 and 50 DAS | 8.20 | 8.39 | 8.29 |
| S.Em.± | 0.15 | 0.12 | 0.10 |
| CD @ 5% | NS | NS | NS |
| Interactions(P×N) (Y×P) (Y×N) (Y×P×N) | NS | NS | NS |
| CV% | 7.00 | 5.23 | 6.16 |

**4. CONCLUSION**

On the basis of two years experimental findings, it is concluded that 200% RDP through PROM and 100% RDN through neem-coated urea are the most effective treatments for enhancing the growth and yield of pearlmillet under North Gujarat conditions. While effectiveness of nano urea is lower compared to full nitrogen application through neem-coated urea. Thus, for maximizing pearl millet yield, higher doses of PROM coupled with adequate nitrogen via NCU are recommended.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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