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EFFECT OF NANO DAP APPLICATION ON GROWTH AND YIELD OF PEARL MILLET (*PENNISETUM GLAUCUM* L.)

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ABSTRACT
A field experiment was conducted during kharif 2025 at the National Agricultural Research Project, Chhatrapati Sambhajinagar, Maharashtra, to evaluate the effect of Nano diammonium phosphate (Nano DAP) on the growth and yield of pearl millet (Pennisetum glaucum L.). The experiment was laid out in a randomized block design with ten treatments and three replications using hybrid AHB 1200 Fe. The experimental soil was clayey and alkaline (pH 8.01), with 0.41% organic carbon, low available nitrogen (158 kg ha^{-1}), medium available phosphorus (14.63 kg ha^{-1}) and high available potassium (360 kg ha^{-1}). Treatments included the recommended NPK dose (60:30:30 kg ha^{-1}), reduced fertilizer doses, Nano DAP seed treatment and foliar sprays. The recommended NPK treatment (T_2) recorded the maximum plant height (185.80 cm), leaf area (152.37 dm^2), dry matter accumulation (154.67 g plant^{-1}), grain yield (2546.28 kg ha^{-1}) and dry fodder yield (5908.53 kg ha^{-1}). Among Nano DAP treatments, T_9, comprising 75% of the recommended dose of phosphorus, seed treatment at 5 mL kg^{-1} seed and foliar sprays at 5.0 mL L^{-1} at 3 and 5 weeks after sowing, recorded the highest grain yield (2291.65 kg ha^{-1}) and was statistically at par with T_2. Integrated Nano DAP application showed potential to improve pearl millet productivity, although the recommended NPK treatment recorded the highest grain and dry fodder yields under the experimental conditions.

KEYWORDS: Pearl millet, Nano DAP, hybrid AHB 1200 Fe, nutrient management, soil fertility, growth, grain yield, dry fodder yield.

1. INTRODUCTION
Pearl millet (*Pennisetum glaucum* (L.) R. Br.) is an important cereal crop cultivated in the arid and semi-arid regions of Asia and Africa. It serves as a major source of food and livestock fodder and is valued for its nutritional composition, containing 9–13% protein, 5–7% fat and essential minerals. Its adaptability to drought, high temperatures and limited rainfall makes it suitable for cultivation under adverse environmental conditions. Pearl millet occupied 7.36 million hectares in India during 2024–25, with a production of 11.20 million tonnes and an average productivity of 1,523 kg ha^{-1}. In Maharashtra, it covered approximately 0.44 million hectares, producing 0.56 million tonnes. (Agricultural Statistics at a Glance, 2025)[1].
Balanced nutrient management is essential for maintaining soil fertility and improving crop productivity. However, imbalanced and excessive use of chemical fertilizers can deteriorate soil health and reduce nutrient-use efficiency due to nutrient losses through leaching, volatilization, runoff and fixation. Recent advances in nanotechnology have introduced Nano diammonium phosphate (Nano DAP), containing 8% nitrogen and 16% phosphorus, as a potential approach to improving nutrient delivery (Kantwa and Yadav, 2022)[6]. Its formulation and role in crop nutrition have been described by IFFCO (2023/2024). Nano-fertilizers may improve nutrient utilization and crop performance (Mahil and Kumar, 2019)[8], while Patil et al. (2024)[10] investigated the response of pearl millet to foliar application of Nano DAP.
The effectiveness of Nano DAP in pearl millet requires evaluation under different agro-climatic conditions. Its application through foliar spraying, in combination with different fertilizer doses, may provide an alternative nutrient-management strategy. Therefore, the present investigation was undertaken to evaluate the effects of different Nano DAP application strategies on the growth and productivity of pearl millet.

2. MATERIALS AND METHODS
A field experiment was conducted during the Kharif season of 2025 at the National Agricultural Research Project, Chatrapati Sambhajinagar, Maharashtra (19°54′ N, 75°21′ E; 568 m above sea level). The experimental soil was clayey, with pH 8.01, organic carbon 0.41%, available nitrogen 158 kg ha^{-1}, phosphorus 14.63 kg ha^{-1} and potassium 360 kg ha^{-1}. Pearl millet hybrid AHB 1200 Fe was sown at a spacing of 45 × 10 cm.
The experiment was laid out in a randomized block design (RBD) comprising ten treatments and three replications. The treatments were as follows: T_1: Control, T_2: Recommended dose of NPK (60:30:30 kg ha^{-1}), T_3: 75% of the recommended dose of phosphorus (RDP) + Nano DAP seed treatment at 5 mL kg^{-1} seed, T_4: 50% of RDP + Nano DAP seed treatment at 5

mL kg^{-1} seed, T_5: T_3 + foliar spray of Nano DAP at 2.5 mL L^{-1} at 3 weeks after sowing (WAS), T_6: T_3 + foliar spray of Nano DAP at 5.0 mL L^{-1} at 3 WAS, T_7: T_3 + foliar sprays of Nano DAP at 2.5 mL L^{-1} at 3 and 5 WAS, T_8: T_4 + foliar sprays of Nano DAP at 2.5 mL L^{-1} at 3 and 5 WAS, T_9: T_3 + foliar sprays of Nano DAP at 5.0 mL L^{-1} at 3 and 5 WAS, T_{10}: T_4 + foliar sprays of Nano DAP at 5.0 mL L^{-1} at 3 and 5 WAS.

The experiment consisted of 30 plots, each measuring 5.0 × 4.5 m, with a net plot size of 4.8 × 3.6 m. Growth, yield attributes, grain yield and dry fodder yield were recorded using standard procedures. The data were analyzed using analysis of variance (ANOVA) appropriate for RBD, and treatment means were compared at the 5% significance level following Panse and Sukhatme (1967)[11].

3. RESULT AND DISCUSSION

3.1 Effect of different treatments on growth characteristics

The results presented in Table 1. and Fig. 1. revealed that different nutrient-management treatments significantly influenced plant height, number of functional leaves, leaf area and dry matter accumulation in pearl millet. The recommended dose of NPK (T_2) consistently recorded the highest values for these growth attributes, while Nano DAP-based treatments, particularly T_9 and T_7, also showed improved performance compared with the control (T_1).

Plant height (cm). Plant height was significantly influenced by nutrient-management treatments at all growth stages. At harvest, the maximum plant height (185.80 cm) was recorded under T_2, followed by T_9 (178.67 cm) and T_7 (177.67 cm), whereas the minimum height (165.00 cm) was observed in the control. The superior performance of T_2 may be attributed to the balanced supply of nitrogen and phosphorus, which supports cell division, internodal elongation and vegetative growth. Nano DAP application through seed treatment and foliar sprays also improved plant height compared with the control. Similar findings were reported by Shree *et al.* (2024)[13] and Patil *et al.* (2024)[10].

Number of functional leaves plant^{-1}. The number of functional leaves differed significantly among treatments throughout crop growth. At harvest, T_2 recorded the maximum number of leaves (5.57 plant^{-1}), followed by T_9 (5.32) and T_7 (5.27), while the minimum (4.80) was recorded under T_1. The increase in leaf number under Nano DAP-based treatments may be associated with improved nutrient availability and utilization, particularly nitrogen and phosphorus, which promote leaf initiation and development. Similar findings were reported by Benzon *et al.* (2015)[4], Prakash *et al.* (2023)[12] and Mahalakshmi *et al.* (2024)[7].

Leaf area (dm^2 plant^{-1}). Leaf area was significantly affected by different nutrient-management treatments at all growth stages. At harvest, the maximum leaf area (152.37 dm^2 plant^{-1}) was recorded under T_2, followed by T_9 (146.60 dm^2) and T_7 (145.77 dm^2), whereas the minimum (135.00 dm^2) was observed in the control. The greater leaf area under T_2 and Nano DAP-based treatments may be attributed to improved nutrient uptake, leaf expansion and photosynthetic activity, resulting in better canopy development. Similar observations were reported by Mahalakshmi *et al.* (2024)[7].

Dry matter accumulation (g plant^{-1}). Dry matter accumulation was significantly influenced by nutrient-management treatments at all observation stages. At harvest, T_2 recorded the highest dry matter accumulation (154.67 g plant^{-1}), followed by T_9 (150.00 g) and T_7 (144.00 g), while the lowest value (115.00 g) was recorded under T_1. The greater biomass accumulation under the recommended NPK dose and Nano DAP-based treatments may be associated with improved nutrient uptake, photosynthetic activity and translocation of photosynthates to different plant parts. Similar findings were reported by Maloth *et al.* (2024)[9], and Prakash *et al.* (2023)[12].

3.2 Effect of different treatments on yield-contributing characters

The results presented in Table 2. and Fig. 2. indicate yield-contributing characters such as numbers of tillers plant^{-1}, and yield of pearl millet, except harvest index. The recommended dose of NPK (T_2) generally recorded the highest values, followed by Nano DAP-based treatments, particularly T_9 and T_7.

The maximum number of total tillers (6.13 plant^{-1}) and effective tillers (5.13 plant^{-1}) was recorded under T_2, which was statistically at par with T_9, recording 5.77 total tillers and 4.63 effective tillers plant^{-1}. The minimum values for both parameters were observed in the control (T_1), with 3.80 total tillers and 2.90 effective tillers plant^{-1}. Improved nutrient availability and photosynthetic activity may have contributed to greater tiller production. Similar findings were reported by Maloth *et al.* (2024)[9] and Akash *et al.* (2025)[2].

T_2 recorded the maximum grain weight (45.08 g plant^{-1}), followed by T_9 (44.80 g), T_7 (44.52 g) and T_6 (43.96 g), whereas the minimum (35.00 g plant^{-1}) was recorded under T_1. Better nutrient uptake and efficient translocation of photosynthates towards developing grains may have contributed to increased grain weight. Similar results were reported by Patil *et al.* (2024)[10].

Grain yield was significantly influenced by the nutrient-management treatments. T_2 recorded the highest grain yield (2546.28 kg ha^{-1}) and was statistically at par with T_9 (2291.65 kg ha^{-1}) and T_7 (2199.06 kg ha^{-1}). The lowest yield (1475.68 kg ha^{-1}) was recorded under the control. Among the Nano DAP-based treatments, T_9 performed best, followed by T_7. Improved nitrogen and phosphorus availability and better assimilate translocation to developing grains may have contributed to increased yield. Similar findings were reported by Arya *et al.* (2022)[3], Chavan *et al.* (2023)[5] and Patil *et al.* (2024)[10].

The maximum dry fodder yield (5908.53 kg ha^{-1}) was obtained under T_2, followed by T_9 (5314.40 kg ha^{-1}) and T_7 (5131.14 kg ha^{-1}), whereas the minimum (3427.84 kg ha^{-1}) was recorded under T_1. Greater vegetative growth and dry matter accumulation under these treatments may have contributed to higher fodder production. Similar results were reported by Patil *et al.* (2024)[10].

Harvest index was not significantly affected by nutrient-management treatments. Numerically, the highest value (43.59%) was recorded under T_1, followed by T_9 (43.35%) and T_2 (43.07%), whereas the lowest value (42.47%) was observed under

T_8. This indicates that nutrient management improved grain and fodder yields without significantly altering the proportion of biomass partitioned to grain.

Table 1: Growth Characteristics of Pearl millet as influenced by various treatments

Treatments	Growth characteristics At Harvest			
	Plant height (cm)	Number of leaves plants^{-1}	Leaf area plant^{-1} (dm^2)	Dry matter accumulation plant^{-1} (g)
T_1: Control	165.00	4.80	135.00	115.00
T_2: Recommended dose of NPK (60:30:30) NPK Kg/ha	185.80	5.57	152.37	154.67
T_3: 75% of RDP + Seed Treatment of Nano DAP 5 ml/kg of Seeds.	174.00	5.12	142.00	135.00
T_4: 50% of RDP + Seed Treatment of Nano DAP 5ml/kg of Seeds.	172.00	4.90	138.30	127.00
T_5: T3 + Foliar Spray of Nano DAP 2.5 ml/L at Three Weeks After Sowing.	175.17	5.18	143.23	139.00
T_6: T3 + Foliar Spray of Nano DAP 5.0 ml/L at Three Weeks After Sowing.	175.67	5.22	144.77	141.00
T_7: T3 + Foliar Spray of Nano DAP 2.5 ml/L at 3 & 5 Weeks After Sowing.	177.67	5.27	145.77	144.00
T_8: T4 + Foliar Spray of Nano DAP 2.5 ml/L at 3 & 5 Weeks After Sowing.	173.33	4.99	140.27	130.00
T_9: T3 + Foliar Spray of Nano DAP 5.0 ml/L at 3 & 5 Weeks After Sowing.	178.67	5.32	146.60	150.00
T_{10}: T4 + Foliar Spray of Nano DAP 5.0 ml/L at 3 & 5 Weeks After Sowing.	173.67	5.04	141.30	133.00
SE±	1.90	0.13	0.85	0.21
C.D at 5%	5.66	0.39	2.52	0.60
G.M.	175.09	5.14	142.96	136.87

Table 2: Yield attributing characters of Pearl millet influenced by various treatments

Treatments	No. of effective tillers plant^{-1}	Grain weight plant^{-1}(g)	Grain yield (kg ha^{-1})	Fodder yield (kg ha^{-1})	Harvest Index (%)
T_1: Control	2.90	35.00	1475.68	3427.84	43.59
T_2: Recommended dose of NPK (60:30:30) NPK Kg/ha	5.13	45.08	2546.28	5908.53	43.07
T_3: 75% of RDP + Seed Treatment of Nano DAP 5 ml/kg of Seeds.	4.10	42.09	1979.15	4610.31	42.85
T_4: 50% of RDP + Seed Treatment of Nano DAP 5ml/kg of Seeds.	3.60	39.76	1539.34	3607.23	42.53
T_5: T3 + Foliar Spray of Nano DAP 2.5 ml/L at Three Weeks After Sowing.	4.20	42.84	2025.45	4706.76	42.95
T_6: T3 + Foliar Spray of Nano DAP 5.0 ml/L at Three Weeks After Sowing.	4.30	43.96	2089.11	4841.79	43.06
T_7: T3 + Foliar Spray of Nano DAP 2.5 ml/L at 3 & 5 Weeks After Sowing.	4.50	44.52	2199.06	5131.14	42.76
T_8: T4 + Foliar Spray of Nano DAP 2.5 ml/L at 3 & 5 Weeks After Sowing.	3.90	41.44	1591.43	3732.62	42.47
T_9: T3 + Foliar Spray of Nano DAP 5.0 ml/L at 3 & 5 Weeks After Sowing.	4.63	44.80	2291.65	5314.40	43.35
T_{10}: T4 + Foliar Spray of Nano DAP 5.0 ml/L at 3 & 5 Weeks After Sowing.	4.00	42.00	1921.29	4484.93	42.73
SE±	0.19	1.28	134.71	240.74	2.22
C.D at 5%	0.56	3.80	400.26	715.32	NS
G.M.	4.13	42.15	1965.84	4576.56	42.94

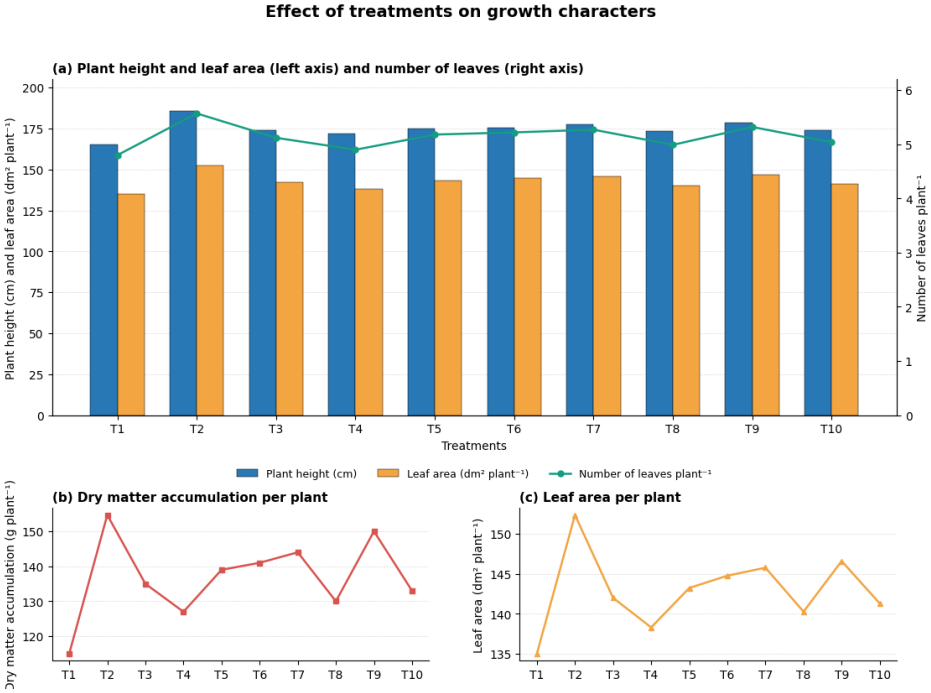


Fig. 1. Growth Characteristics of Pearl millet as influenced by various treatments

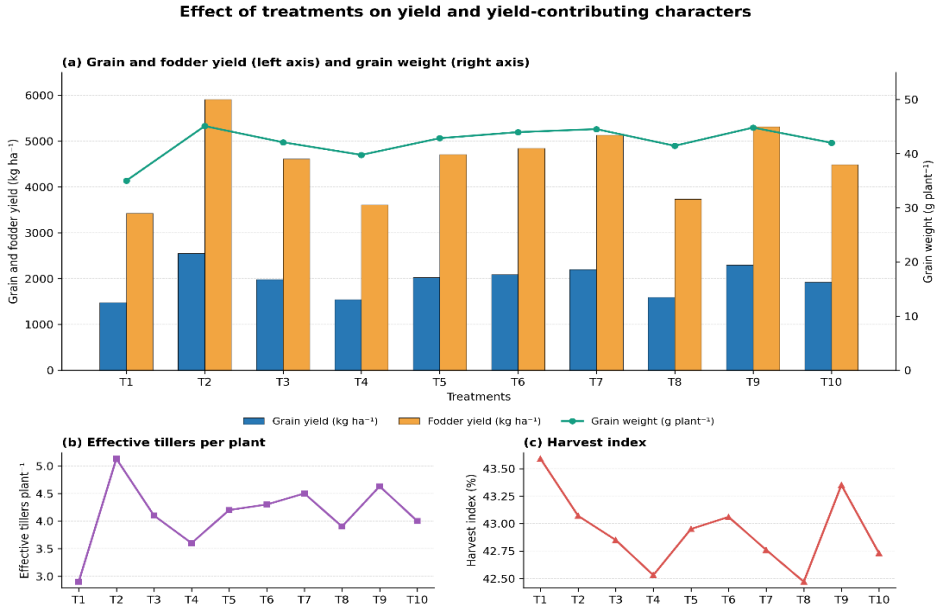


Fig. 2. Yield attributing characters of Pearl millet influenced by various treatments

4. CONCLUSION

The recommended dose of NPK (T_2: 60:30:30 kg ha^{-1}) recorded the highest plant height (185.80 cm), functional leaves (5.57 plant^{-1}), leaf area (152.37 dm^2 plant^{-1}) and dry matter accumulation (154.67 g plant^{-1}) at harvest. It also recorded the highest total tillers (6.13 plant^{-1}), effective tillers (5.13 plant^{-1}), grain weight (45.08 g plant^{-1}) and test weight (16.10 g). The highest grain yield (2546.28 kg ha^{-1}) and dry fodder yield (5908.53 kg ha^{-1}) were also recorded under T_2. Among the Nano DAP treatments, T_9 (75% RDP + Nano DAP seed treatment @ 5 mL kg^{-1} seed + foliar sprays @ 5 mL L^{-1} at 3 and 5 WAS) performed best. T_9 remained statistically at par with T_2 for grain yield and several growth and yield attributes. Thus, the integrated application of Nano DAP under T_9 showed potential for improving the growth and productivity of pearl millet.

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