Effect of Soil and foliar applications on growth and productivity of Pearl Millet (*Pennisetum glaucum* L.)

ABSTRACT

The field experiment was conducted during the *Rabi* season of 2023in the experimental farm of Karunya Institute of Technology and Sciences, Coimbatore "Effect of soil and foliar applications on growth and productivity of Pearl Millet (*Pennisetum glaucum* L)." Factorial Randomized Block Design was used with two factors and 3 replications. The treatment combination consists of 10 treatments *viz*., T_1- 100% RDF+ Nano-DAP, T_2 - 100% RDF + Nano-Urea foliar sprays at 30 and 45 DAS, T_3 – 100% RDF + FYM at 10 t ha^{-1} + Nano-DAP foliar sprays at 30 and 45 DAS, T_4 – 100% RDF + FYM at 10 t ha^{-1} + Nano-Urea foliar sprays at 30 and 45 DAS, T_5 – 100% RDF + VC at 5 t ha^{-1} + Nano-DAP foliar sprays at 30 and 45 DAS, T_6 - 100% RDF + VC at 5 t ha^{-1} + Nano-Urea foliar sprays at 30 and 45 DAS, T_7 – 75% RDF + FYM at 10 t ha^{-1} + Nano-DAP foliar sprays at 30 and 45 DAS, T_8 - 75% RDF + FYM at 10 t ha^{-1} + Nano-Urea foliar sprays at 30 and 45 DAS, T_9 - 75% RDF + VC at 5 t ha^{-1} + Nano-DAP foliar sprays at 30 and 45 DAS, T_{10}- 75% RDF + VC at 5 t ha^{-1} + Nano-Urea foliar sprays at 30 and 45 DAS.The results indicated that the application of 75% RDF + Vermicompost at 5 t ha^{-1} + Nano-Urea increased the growth parameters (plant height and Leaf Area Index), physiological parameters (Crop Growth Rate and Chlorophyll Index) and yield (grain and stover yield) of pearl millet.

Keywords: Pearl millet; Vermicompost; Nano-Urea, Nano- DAP, Crop Growth Rate, SPAD, Leaf area index

1. INTRODUCTION

Pearl millet is India's fifth most important multipurpose grain next to rice, wheat, maize and sorghum, and is a staple diet for millions of people in dry land areas. More than 95% of bajra production is used as food and rest is being used as cattle feed and other uses (seed, bakery products and snacks etc.). Pearl millet outperforms all other cereals, allowing it to survive even at a temperature as high as 42°C during the reproductive stage and making it a climate-resilient crop. Pearl millet is also referred as bajra, bulrush millet, spiked millet and poor man's crop. Because the grain is used for human consumption and the fodder is used for livestock feeding, and it is proved to be an important component of the agricultural and animal husbandry-dominated rural economy of India's dryland areas [4]. Farmers are using excess and imbalance chemical fertilizer, which leads to nutrient deficiency other than applied and declined organic carbon levels [5]. At present nutrient mining is a major threat to agricultural productivity as there is a wide gap between the quantum of nutrient applied and nutrient utilized by crop, one of the major reasons for lower production is blanket use of fertilizers by the farmers and improper nutrient management.

The basic concept determining the principles of integrated nutrient management (INM) is the maintenance and improvement of sustaining crop productivity on long term basis. This may be achieved through combined use of all possible sources of nutrients and their scientific management for optimum growth, yield and quality of different crops and cropping systems. But the appropriate combination of different sources of nutrients varies according to the system; land use, ecological, social and economic condition at the local level. The application of nitrogen helps in better vegetative growth of plants, phosphorous is used for better proliferation, which extracts moisture from the deep layers of the soil, particularly during moisture stress conditions. Potassium increases the potential and improving the quality of grains. The gap created between the removal and addition of nutrient will not be bridged by fertilizer alone. This can be achieved by integrated nutrient management. The soil physical properties can be improved by FYM application. Vermicompost is a rich mixture of macro and micro plant nutrients which increases microbial availability of nitrogen and phosphorus and improves microbial action in the soil. It improves not only the soil fertility but also increases efficiency of chemical fertilizer.The soil application of nutrient in the form of chemical fertilizer might be subjected to various losses like fixation, leaching and volatilization, etc. The foliar application of fertilizers reduces the usage as compared to soil application. Nitrogen is the most limiting macro-nutrient that determines the crop productivity. Phosphorus (P) is also a limiting macronutrient that regulates plant growth and development. The reduced particle size and increased specific surface area makes Nano-DAP physically more available than chemical DAP, and is preferred for agricultural sustainability [14].

In most of the Indian soils, Nitrogen is lacking which is the most important constituent for plant growth. Nitrogen application is important for synthesis of proteins, nucleic acids, growth hormones. Foliar application of Nano-Urea is a well-known technique to reduce acute deficiency at any crop growth stage [8]. [11] stated that the application of 500 ml of Nano-Urea is equal to the 45 kg of urea. It has the greater ability to reduce the imports of urea. The Nano-Urea application is considered as the greatest substitution of urea granules. Hence, it helps in better utilization of nitrogen and reducing the soil chemical residue.

2. MATERIALS AND METHODS

In the *Rabi* season of 2023, a field study utilizing pearl millet was carried out at the Karunya Institute of Technology and Sciences' instructional farm in the northern region of Coimbatore, Tamil Nadu. The experimental site's geographic coordinates are 10◦56’N latitude, 76◦44’E longitude, and 474 m above sea level. (At 474 meters above mean sea level; latitude 10056' N, longitude 76044' E). *Rabi* 2023–2024 saw 91 rainy days with a total rainfall of 58.2 mm during the growth period. At the experimental site, the soil (0–15 cm) had a clay loam texture, pH 8.42, EC 0.52 dS m^{-1}, organic carbon 1.78%, and accessible N, P, and K 305.2, 16.9, and 42.56 kg ha^{-1}, in that order. The study area is located in Tamil Nadu’s Western Agro-Climatic Zone. The experiment was conducted using Factorial Randomised Block Design with 3 replications and 10 treatments. The treatment combinations were, T_1 - 100% RDF + Nano-DAP foliar sprays at 30 and 45 DAS, T_2 - 100% RDF + Nano-Urea foliar sprays at 30 and 45 DAS, T_3 – 100% RDF + FYM at 10 t ha^{-1} + Nano-DAP foliar sprays at 30 and 45 DAS, T_4 – 100% RDF + FYM at 10 t ha^{-1} + Nano-Urea foliar sprays at 30 and 45 DAS, T_5 – 100% RDF + VC at 5 t ha^{-1} + Nano-DAP foliar sprays at 30 and 45 DAS, T_6 - 100% RDF + VC at 5 t ha^{-1} + Nano-Urea foliar sprays at 30 and 45 DAS, T_7 – 75% RDF + FYM at 10 t ha^{-1} + Nano-DAP foliar sprays at 30 and 45 DAS, T_8 - 75% RDF + FYM at 10 t ha^{-1} + Nano-Urea foliar sprays at 30 and 45 DAS, T_9 - 75% RDF + VC at 5 t ha^{-1} + Nano-DAP foliar sprays at 30 and 45 DAS, T_{10}- 75% RDF + VC at 5 t ha^{-1} + Nano-Urea foliar sprays at 30 and 45 DAS. Three divided doses of nitrogen are administered at 0, 15, and 30 DAS. Every time a significant result from the "F" test was obtained at the five percent level, critical difference (CD) values were computed.

3. RESULTS AND DISCUSSION

3.1. Growth attributes

3.1.1. Plant height

The maximum plant height was recorded under the application of75 percent RDF + VC at 5 t ha^{-1} + Nano-Urea at 45 and 60 DAS than all the other treatments. The data (Table.1) showed that the application of 75 percent RDF + VC at 5 t ha^{-1} + Nano-Urea foliar (T_{10}) sprays at 30 and 45 DAS increased the plant height by 139.78 and 146.43cm at 45 and 60 DAS due to the growth characteristics that were enhanced through foliar spraying of Nano-Urea as it made nutrients more readily available and were easier to absorb through the stomata of leaves [12]. The lowest plant height was recorded under 100 percent RDF + Nano-DAP (T_1). The application of Nano fertilizers was easily absorbed by the leaf epidermis and moved to the stems, where they promoted the uptake of active molecules and improved growth in little millet Rajput *et al.* (2022)[9]. Amino acids, proteins, vitamins, hormones, and enzymes all are based on nitrogen, which made an instant impact on cell division and growth of plant Udapudi*et al*. (2022)[18]. According to Abdel-Aziz *et al*. (2018)[1], Nano fertilizers promoted the uptake of active molecules and also improved the growth attributes. Similar findings were reported by Khan *et al*. (2023)[8].

3.1.2. Leaf Area Index

The application of T_{10}- 75 percent RDF + VC at 5 t ha^{-1} + Nano-Urea foliar sprays at 30 and 45 DAS increased the leaf area index of 3.57 and 4.34 at 45 and 60 DAS in pearl millet(Table.1). This was due to the direct application of nitrogen to the leaves which made a significant impact in cell multiplication, cell expansion and cell metabolism which increased the number of leaves Jadav *et al*. (2022)[7]. The increased leaf area index was due to the Nano fertilizers which caused increased concentrated surface area and density of leaves Rajput *et al.* (2022)[9]. The lowest leaf area index of 2.8and 3.4 at 45 and 60 DAS was recorded under 100 percent RDF +Nano-DAP (T_1).

3.2. Physiological attributes

3.2.1. Crop growth rate

The data showed that the treatment (T_{10}) shows higher Crop Growth Rate of 5.98$g^{-1}m^{2}$ d^{-1}up to 60 DAS afterwards it got declined (Table.1). The lowest crop growth rate was recorded under 100 percent RDF +Nano-DAP (T_1).Application of nano- fertilizers increased the plant height, leaf area, no. of leaves plant^{-1}, dry matter production, chlorophyll content, photosynthetic rate which induces the transformation of photosynthetic materials to various parts of the plant. This increased the Crop Growth Rate of the plant Rajput *et al*. (2022) [9].

3.2.1. Chlorophyll index

The chlorophyll Index was recorded at various stages of crop growth 45 and 60 DAS across various fertilizer treatments (Table.1). The treatment combination of 75 percent RDF + Vermicompost at 5 t ha^{-1} + Nano-Urea showed the higher chlorophyll index of 48.70 and 53.2 at 45 and 60 DAS. The higher amount of nitrogen was supplied to pearl millet through Nano-Urea which resulted in higher amount of chlorophyll content in plants Benzon *et al*. (2015)[3]. The Nano-Urea has larger surface area and the particle size is less than the pores of root and leaves of plant which increased the quick absorption of nutrients and led to the increased rate of photosynthesis in pearl millet Sharma *et al*. (2022)[13]. The Nano-Urea increased the plant metabolic activities such as chlorophyll synthesis and photosynthetic activity Sudha *et al*. (2023)[16]. The vermicompost enhanced the availability of nitrogen in soil which leads to higher photosynthetic rate to plants through the slow rate of mineralization. The vermicompost contains higher amount of Nitrogen, Phosphorous and Potassium Thakare and Wake, (2014)[17]. The combined application of RDF, Vermicompost and Nano-Urea increased the chlorophyll index in pearl millet. Similar results were conformity with Rundan*et al.* (2021)[10]. The lowest Chlorophyll index of 41.6 and 44.14 at 45 and 60 DAS was recorded under 100 percent RDF +Nano-DAP (T_1).

3.3. Yield

3.3.1. Grain yield

The treatment combination of 75 percent RDF + Vermicompost at 5 t ha^{-1} + Nano-Urea showed the higher grain yield of 29.75 q ha^{-1}. The lowest grain yield was recorded under 100 percent RDF +Nano-DAP (T_1- 22.46 q ha^{-1})(Table.1). The increased yield was due to the higher accumulation of photosynthates and transferred to economic parts of pearl millet Arya *et al*. (2022) [2]. The increase in yield of little millet was due to the application of Nano-Urea which increased the area needed for several metabolic activities, such as photosynthesis Chavan *et al*. (2023)[6]. Crop yield of rice was increased with nano fertilizers. It was mostly caused by the plant's sections growing larger and by metabolic processes like photosynthesis, which increases the amount of photosynthates accumulated and transferred to the parts of the plant that were useful Sahu *et al*. (2022)[11]. Increased productivity was due to the Nano-Urea application by increasing the absorption in little millet Rajput *et al*. (2023) [9]. Similar findings were reported by Khan *et al*. (2023) [8].

3.3.2. Stover yield

The treatment combination of 75 percent RDF + Vermicompost @ 5 t ha^{-1} + Nano-Urea showed the higher stover yield of 77.71 q ha^{-1} (Table.1). The lowest stover yield of 65.11 q ha^{-1}was recorded under 100 percent RDF +Nano-DAP (T_1). The Nano-Urea was easily absorbed and rapidly translocated which caused the higher photosynthetic rate and higher dry matter production which leads to increased stover yield Arya *et al.* (2022) [2]. The increased stover yield was due to the efficient nitrogen utilization in finger millet Samanta *et al*. (2022)[12]. The application of Nano-Urea increased the growth parameters which leads to increase in stover yield of pearl millet Khan *et al*. (2023) [8].

4. CONCLUSION

Based on the above findings, it is found that application of Nano-Urea along with RDF and vermicompost positively improved the growth, physiological and yield attributes of pearl millet. These findings are based on the one season crop; further research findings should be done under this field of study.

REFERENCES

1. Abdel-Aziz HMM, Mohammed NAH, Aya MO. Effect of Foliar Application of Nano Chitosan NPK Fertilizer on the Chemical Composition of Wheat Grains. Egypt. J Bot. 2018;58(1):87-95
2. Arya, G. R., Manivannan, V., Marimuthu, S., & Sritharan, N. (2022). Effect of Foliar Application of Nano-Ureaon Yield Attributes and Yield of Pearl Millet (Pennisetum glaucum L.). *International Journal of Plant & Soil Science*, *34*(21), 502-507.
3. Benzon, H. R. L., Rubenecia, M. R. U., Ultra Jr, V. U., & Lee, S. C. (2015). Nano-fertilizer affects the growth, development, and chemical properties of rice. *International Journal of Agronomy and Agricultural Research*, *7*(1), 105-117.
4. Bijarnia, A. L., Singh, U., &Sutaliya, R. (2020). Influence of integrated nutrient management on fodder pearl millet in transitional plain of Luni Basin. International Journal of Economic Plants, 7(4), 193-196.
5. Divya, G., Vani, K. P., Babu, P. S., & Devi, K. S. (2017). Yield attributes and yield of summer pearl millet as influenced by cultivars and integrated nutrient management. *International Journal of current microbiology and applied sciences*, *6*(10), 1491-1495.

6. Chavan, S. R., Patil, J. B., Shinde, R. H., Gedam, V. B., & Patil, M. J. (2023). Impact of nano fertilizer and nitrogen levels on yield attributing characters, yield and quality of little millet (Panicum sumatrence L.).
7. Jadhav, V. D., Bainade, S. P., &Birunagi, S. M. (2022). Chlorophyll meter (SPAD) based Nano-Urea fertilization in maize (Zea mays L.). *Pharma Innov J*, *11*, 5617-5619.
8. Khan, R., Chandra, S., Nagar, R., Khatana, R. S., & Nagar, V. (2023). Response of pearl millet [Pennisetum glaucum (L.) R. Br.] to foliar application of nano nitrogen fertilizer (Nano-Urea). *Journal of Progressive Agriculture*, *14*(1), 69-73.
9. Rajput, J. S., Thakur, A. K., & Dongre, A. (2023). Impact of nano fertilizer in relation to growth indices and yield of little millet (Panicum sumatrense Roth) under rainfed conditions.
10. Rundan, V., Kubsad, V. S., Shivakumar, B. G., Kuligod, V. B., &Mummigatti, U. V. (2023). Foliar nutrition of Nano-Ureawith conventional urea on the productivity and profitability of fodder maize.
11. Sahu, T. K., Kumar, M., Kumar, N., Chandrakar, T., & Singh, D. P. (2022). Effect of Nano-Urea application on growth and productivity of rice (Oryza sativa L.) under midland situation of Bastar region. The Pharma Innovation Journal, 11(6), 185-187.
12. Samanta, S., Maitra, S., Shankar, T., Gaikwad, D., Sagar, L., Panda, M., & Samui, S. (2022). Comparative performance of foliar application of urea and Nano-Urea on finger millet (Eleusine coracana L. Gaertn). *Crop Research*, *57*(3), 166-170.
13. Sharma, S. K., Sharma, P. K., Mandeewal, R. L., Sharma, V., Chaudhary, R., Pandey, R., & Gupta, S. (2022). Effect of foliar application of Nano-Ureaunder different nitrogen levels on growth and nutrient content of pearl millet (Pennisetum glaucum L.). *International Journal of Plant & Soil Science*, *34*(20), 149-155.
14. Singh, N. R. R., Sarma, S. S., Rao, T. N., Pant, H., Srikanth, V. V. S. S., & Kumar, R. (2021). Cryo-milled Nano-DAP for enhanced growth of monocot and dicot plants. *Nanoscale Advances*, *3*(16), 4834-4842.
15. Singh, S., Jhorar, B. S., Sheoran, H. S., Bhat, M. A., Grewal, D., & Grewal, K. S. (2016). Prospects of long-term FYM application on physical properties of sandy loam soil under pearl millet-wheat rotation. Indian journal of ecology, 43(1), 420-423.
16. Sudha, E. J., Gill, R., Ahmad, J., Patel, M., Reddy, K. V. R., Mazengo, T. E. R., ... & Sandilya, D. H. Comparative Study on the Efficacy of Various Nano Fertilizer Levels, NPK Foliar, and Soil Applications in Enhancing the Growth and Yield of Kharif Maize (Zea mays L.).
17. Thakare, R., & Wake, A. (2014). Changes in soil enzymes and nutrients under organically grown rainfed pearl millet in Vertisol. International Journal of Research in Agriculture Sciences, 1, 363-367.
18. Udapudi, P., Pushpa, K., Sukanya, T. S., Yogesh, T. C., & Krishnamurthy, R. (2023). Influence of nano nitrogen on growth and yield of finger millet under rainfed condition.

Table.1 Effect of soil and foliar applications on growth, physiological attributes and yield of pearl millet

		Plant height (cm)		Leaf area index (LAI)		Chlorophyll index		CGR ($g^{-1} m^2 d^{-1}$)	Yield	
	Treatment	**45 DAS**	**60 DAS**	**45 DAS**	**60 DAS**	**45 DAS**	**60 DAS**	**45-60 DAS**	**Grain yield ($q\ ha^{-1}$)**	**Stover yield ($q\ ha^{-1}$)**
A.	**SOIL APPLICATION**									
S1	100% RDF	80.02	80.99	2.04	2.51	29.42	31.23	3.90	16.03	45.02
S2	100% RDF + FYM at 10 t ha^{-1}	80.6	82.35	2.07	2.55	29.48	31.64	3.92	16.43	45.68
S3	100% RDF + VC at 5 t ha^{-1}	81.36	83.59	2.08	2.59	29.58	31.85	3.96	16.68	45.97
S4	75% RDF + FYM at 10 t ha^{-1}	82.88	85.17	2.11	2.59	29.66	32.10	3.98	16.76	46.59
S5	75% RDF + VC at 5 t ha^{-1}	85.69	89.24	2.17	2.66	30.31	33.05	4.05	17.69	48.12
	S.E (d) ±	1.54	1.33	0.04	0.04	0.26	0.31	0.05	51.54	92.49
	CD at 5%	**3.24**	**2.8**	**0.08**	**0.07**	**0.55**	**0.65**	**0.11**	**108.29**	**194.32**
B.	**FOLIAR APPLICATION**									
F1	Nano- DAP	115.59	116.21	2.9	3.59	41.92	45.15	5.53	22.97	65.71
F2	Nano- Urea	130.74	136.6	3.38	4.15	47.15	50.78	6.36	27.17	73.11
	S.E.(d) ±	1.54	1.33	0.04	0.04	0.26	0.31	0.05	51.54	92.49
	CD at 5%	**3.24**	**2.8**	**0.08**	**0.07**	**0.55**	**0.65**	**0.11**	**108.29**	**194.32**
C.	**INTERACTION (A×B)**									
	S.E. ±	2.18	1.89	0.05	0.05	0.37	0.44	0.07	72.89	130.81
	CD at 5%	**4.58**	**3.96**	**0.11**	**0.10**	**0.78**	**0.92**	**0.16**	**153.14**	**274.81**