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Influence of nitrogen management practices on economics and yield of pearl millet (*Pennisetum glaucum* L.) Hybrid

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Abstract

A field experiment was conducted in Crop Research Farm during Zaid Season 2025 to study the “Influence of Nitrogen Management Practices on economics and yield of Pearl millet (*Pennisetum glaucum* L.) Hybrid” at SHUATS, Department of Agronomy, SHUATS, Prayagraj (U.P) India. The treatment combination details are as different variety 86M25, 86M15 US 7306, P A 9666, RBX 6066 and MP 739 along with 100% RDN and 75% RDN + *Azotobacter* seed inoculation. The experiment was laid out in a randomized block design with twelve treatments replicated thrice. The soil of experiment plot was sandy loamy in texture, nearly neutral in soil reaction (pH 6.8), low in organic carbon (0.46%), available Nitrogen (225.42 kg/ha), available Phosphorus (38.2 kg/ha) and available Potassium (240.7 kg/ha). The results revealed that significantly higher yield attributes of Pearl millet at harvest i.e., Number of ear head (71.81), grains/head (3154.59) and yield attributes and yield Grain yield (3.58 t/ha) and Stover yield (4.71 t/ha) were recorded in treatment 3 (86 M 15 along with 100% RDN) compared to other treatments. Maximum gross return (INR 1,21,983.33/ha), net return (INR 89,871.33/ha) and B:C ratio (2.80) were also recorded in treatment - 3 (86 M 15 along with 100% RDN). It performed better in terms of yield and economic returns.

Keywords: Azotobacter, economics, nitrogen, pearl millet, varieties and yield

Introduction

Pearl millet (*Pennisetum glaucum* L.) is one of the most important cereal crops cultivated in arid and semi-arid regions of Asia and Africa. It belongs to the family *Poaceae* or *Gramineae*. It is popularly known as Bajra or Bajri in India. Pearl millet originated in tropical western Africa and is widely adapted to harsh agro-climatic conditions such as drought, high temperature, and low soil fertility. Due to its excellent adaptability and resilience, it is regarded as a climate-smart and climate-resilient crop (Reddy *et al.*, 2022) ^[14]. Among cereals, pearl millet ranks fifth in global importance after rice, wheat, maize, and sorghum. Pearl millet is a C4 plant possessing higher photosynthetic efficiency and better dry matter production under limited resource conditions. It performs well under adverse environmental situations because of its ability to tolerate moisture stress and high temperatures up to 42°C during the reproductive stage. The crop requires comparatively fewer agricultural inputs and matures early, making it highly suitable for cultivation in dryland farming systems (Reddy *et al.*, 2022) ^[14]. These characteristics make pearl millet an important crop for sustaining food and fodder production in the face of climate change.

Pearl millet is cultivated for both grain and fodder purposes. The cultivated species *Pennisetum glaucum* (2n=14) is

mainly grown for grain production, whereas *Pennisetum purpureum* (2n=28) is commonly utilized as green fodder. The crop serves as a staple food for millions of people in resource-poor regions and contributes significantly to nutritional security. Pearl millet grains are rich in carbohydrates, proteins, minerals, dietary fiber, and energy. According to the Directorate of Millets Development (2021–22) ^[3], 100 g of pearl millet grain contains approximately 67 g carbohydrates, 12 g protein, 5 g fat, and 360 calories of energy. Owing to its high nutritional value, pearl millet has been designated as a “Nutri-cereal” by the Government of India and included in the Public Distribution System (PDS) (Gazette of India, 2018) ^[5].

Among various agronomic practices, nutrient management plays a vital role in improving crop productivity and profitability. Nitrogen is one of the most essential and yield-limiting nutrients in pearl millet production. It is a major constituent of chlorophyll, amino acids, proteins, nucleic acids, enzymes, and hormones, thereby directly influencing plant growth and development. Adequate nitrogen availability promotes vigorous vegetative growth, increased leaf area, higher photosynthetic activity, and better grain formation (Ayub *et al.*, 2007) ^[1]. Nitrogen deficiency results in stunted growth, poor tillering, delayed flowering, and reduced grain yield. Although pearl millet is traditionally

cultivated under low-input conditions, several studies have demonstrated significant positive responses of the crop to nitrogen fertilization. Application of nitrogen improves growth attributes, yield components, grain yield, and fodder quality in pearl millet (Singh *et al.*, 2016) ^[18]. Sharma *et al.* (2008) ^[15] reported that progressive increase in nitrogen levels significantly enhanced ear head length, number of grains per ear head, and overall grain yield. Similarly, Srinivasarao *et al.* (2013) ^[19] observed that nitrogen fertilization substantially improved productivity of pearl millet under dryland conditions.

Efficient nitrogen management practices are essential not only for maximizing yield but also for improving nitrogen-use efficiency and reducing environmental losses. Split application of nitrogen synchronized with crop growth stages helps in minimizing nitrogen losses through leaching and volatilization while ensuring continuous nutrient availability during critical growth periods. Proper nitrogen management therefore contributes to higher productivity and economic returns.

Azotobacter is attributed with varied benefits viz., nitrogen fixation, stimulates the growth of plants and build up the soil matter. Ability of these bacteria to contribute to yields in crops is only partly a result of biological N₂-fixation. The mechanisms involved have a significant plant-growth promotion potential. Economic and environmental benefits can include increased income from reduced fertilizer cost, reduced leaching of Nitrate N to ground water as well as reduced emission of greenhouse gas, the global warming effect of which is 300 times more than CO₂ (Singh *et al.* 2016) ^[18].

In recent years, integrated nutrient management involving biofertilizers has gained considerable attention for sustainable crop production. Among various biofertilizers, Azotobacter plays a significant role in enhancing soil fertility and crop productivity. Azotobacter is a free-living nitrogen-fixing bacterium capable of fixing atmospheric nitrogen and producing growth-promoting substances such as vitamins, hormones, and amino acids. Inoculation with Azotobacter improves seed germination, root development, nutrient uptake, and plant growth. Furthermore, it reduces dependence on chemical nitrogen fertilizers and minimizes environmental pollution (Singh *et al.*, 2016) ^[18]. Different pearl millet hybrids vary in their response to nitrogen fertilization due to differences in genetic makeup, nutrient uptake efficiency, and growth behaviors. Therefore, evaluation of hybrids under varying nitrogen management practices is essential for identifying suitable combinations for higher yield and profitability under specific agro-climatic conditions.

Keeping these facts in view, the present investigation titled “Influence of Nitrogen Management Practices on Economics and Yield of Pearl Millet (*Pennisetum glaucum* L.) Hybrids” was undertaken to evaluate the performance of different pearl millet hybrids under varying nitrogen management practices and to identify the most suitable nutrient management strategy for enhancing productivity and economic returns under Prayagraj agro-climatic conditions

Materials and Methods

An experiment was conducted during the *Zaid* season of 2025. It was conducted in alluvial soil at the Department of Agronomy's Crop Research Farm, SHUATS, Prayagraj, U.P. It is situated 98 meters above mean sea level at latitude 25° 24' 42" N, longitude 81° 50' 56" E. About five kilometres from Prayagraj city, this location lies on the right bank of the Yamuna River beside Prayagraj Rewa Road. At a depth of 0–30 cm, a composite soil sample was taken. It underwent crushing, air drying, and physical and chemical testing. The soil of experiment plot was sandy loamy in texture, nearly neutral in soil reaction (pH 6.8), low in organic carbon (0.46%), available Nitrogen (225.42 kg/ha), available Phosphorus (38.2 kg/ha) and available Potassium (240.7 kg/ha). On 25th March 2025, Pearl millet variety 86M25, 86M15 US 7306, P A 9666, RBX 6066 and MP 739, Seeds were planted with a 45 cm x 15 cm spacing. The experiment was laid out in a Randomized block design with twelve treatments replicated thrice. The treatment details are as follows T₁ - 86 M 25 + 100% RDN, T₂ - 86 M 25 + 75% RDN + Azotobacter seed inoculation, T₃ - 86 M 15 + 100% RDN, T₄ - 86 M 15 + 75% RDN + Azotobacter seed inoculation, T₅ - US 7306 + 100% RDN, T₆ - US 7306 + 75% RDN + Azotobacter seed inoculation, T₇ - P A 9666 + 100% RDN T₈ - P A 9666 + 75% RDN + Azotobacter seed inoculation, T₉ RBX 6066+ 100% RDN, T₁₀ - RBX 6066 + 75% RDN + Azotobacter seed inoculation, T₁₁ - MP 7393 + 100% RDN, T₁₂ - MP 7393 + 75% RDN + Azotobacter seed inoculation. To apply nutrients as a spreading method, 4-5 cm deep furrows were dug along the seed rows using a hand hoeing. Ten days after sowing, the gaps were filled by transplanting once germination took place. Where necessary, seedlings were trimmed out to maintain 25 cm x10 cm spacing. In order to reduce crop density, weed competition, intercultural operations were carried out between 25 and 45 days intervals. On 18th June 2025, harvesting of the crop was done. At regular intervals from germination to harvest. At harvest, yield metrics such as Ear head length (cm), No. of Grains/ear head, test weight (g), seed yield (kg/ha), straw yield (kg/ha), and harvest index (%) were measured at 20, 40, 60 and 60 DAS. Whereas, Economics analysis i.e., cost of cultivation, gross return, net return and benefit cost ratio was observed. Statistically analysis of variance (ANOVA), as it relates to randomized block design, was used to statistically examine the observed data of ten treatments (Gomez and Gomez, 1984 and Mohan *et al.* 2024) ^[6].

Results and Discussion

Yield attributes

The data pertaining to yield-attributing characters are presented in Table 1. A significant impact was experiential by the statistical analysis of ear head length (cm). at the time of harvest treatment -3 (86 M 15 + 100% RDN) was recorded highest ear head length (71.15 cm) which was found to be statistically at par to all treatment. The increase in ear head density with higher nitrogen levels may be attributed to enhanced tillering capacity and improved survival of tillers. Nitrogen plays a vital role in promoting

vegetative growth, leading to increased formation of tillers, many of which develop into productive ear heads. Sharma *et al.* (2012)^[16] and Sharma *et al.* (2008)^[15]. Significant effect was observed by the statistical analysis of number of grains/ear head. Treatment 3 (86 M 15 + 100% RDN) recorded significant and highest number of grains/ear head (3154.59) were statistically at par with the highest. The improvement in grain number with higher nitrogen application may be attributed to enhanced vegetative growth and better development of reproductive structures. Adequate nitrogen supply during critical growth stages promotes panicle development, floret initiation, and reduces floret abortion, thereby increasing the number of grains per ear head. These results are in agreement with Chouhan *et al.* (2015)^[2]. The statistical analysis on test weight was found to be non-significant. However, highest test weight (16.90 g) was recorded with treatment - 3 (86 M 15 + 100% RDN) and lowest test weight (11.21g) was recorded in treatment – 8 (RBX 6066 + 75% RDN + *Azotobacter* seed inoculation). Test weight was not influenced by the application of different Varieties and nitrogen effect which might be due to characters highly influenced by its genetic make-up. The increase in grain yield with higher nitrogen levels can be attributed to enhanced vegetative growth, improved leaf area index, and higher photosynthetic activity, which ultimately led to better assimilate production and translocation towards reproductive organs (Malhotra *et al.*, 2018)^[9].

Grain yield

The statistical data in Table 1. A significant impact of experiment by the statistical analysis on grain yield was obtained due to Different hybrid varieties and Nitrogen management treatment combinations. The highest grain yield (3.58 t/ha) was obtained in treatment - 3 (86 M 15 + 100% RDN) which was statistically at par highest. These results might be due to better seed germination and a larger root system for nutrient uptake, which are the results of the early nourishment offered to the seeds. Applying nitrogen might be applied to improve vegetative development, probably uptake and utilization of other elements fascinated by its wide root system developed by NPK imitation. The increase in grain yield with higher nitrogen levels can be attributed to enhanced vegetative growth, improved leaf area index, and higher photosynthetic activity, which ultimately led to better assimilate production and translocation towards reproductive organs. Nitrogen also plays a crucial role in the formation of yield-attributing characters such as number of effective tillers, earhead length, and grain weight. Similar findings were previously published by Sharma *et al.*, (2012)^[16] and Singh *et al.*, (2016)^[18].

Straw Yields

The data in Table 1. showed that application of different varieties and Nitrogen management has significantly impact on stover production of the Pearl millet. At treatment -3 (86

M 15 + 100% RDN), the highest stover yield (4.71t/ha) was obtained found to be statistically at par with the highest. The application of nitrogen resulted in significantly higher stover yield this might be due to improved growth in terms of seedling emergence, plant height, and dry matter accumulation, which raises photosynthetic efficiency. Greater photosynthetic accumulation in vegetative components leads to superior vegetative development and hence the stover yield increases is similar to Yadav *et al.* and Mohan *et al.* (2024)^[21]. Application of different varieties and Nitrogen management could be attributed to increase vegetative growth, possibly the result of effective uptake and utilization of other nutrients absorbed through its extensive root system developed under different fertilization. The biological yield is a function of grain and straw yield. Ranjan *et al.*, (2024) found the same results in their research.

Harvest Index (%)

The data showed in Table 1. Significant difference in harvest index, However, treatment - 2 (86 M 25 + 75% RDN + *Azotobacter* seed inoculation) was recorded highest value of (48.44%) and lowest value (39.22%) was recorded in treatment - 10 (US 7306 + 75% RDN + *Azotobacter* seed inoculation) respectively. Application of different varieties and Nitrogen management could be attributed to increase vegetative growth, possibly the result of effective uptake and utilization of other nutrients absorbed through its extensive root system developed under different fertilization. The biological yield is a function of grain and straw yield. The increase in grain and stover yields may be attributed to role of varieties as a catalyst or stimulant in most of the physiological and metabolic processes and metal activator or enzymes resulting in increased growth and development of plant. Similar results were also reported by Reddy *et al.*, (2021)^[13] and Kumar *et al.*, (2018)^[8].

Economics

Observations regarding economics of different treatments of Pearl millet hybrid on nitrogen management are given in Table 2.

The lowest cost of cultivation was found in the treatment – 1 with 86 M 25 + 100% RDN (32,112.00 INR/ha) and maximum gross returns (121983.33INR/ha) were found in treatment - 3 with (86 M 15 + 100% RDN. Whereas higher net returns (89,871.33 INR/ha) was found in treatment - 3 with (86 M 15 + 100% RDN) and highest Benefit cost ratio (2.80) was found highest in treatment -3 with application of 86 M 15 + 100% RDN as compare to other treatments. The higher economic returns under this treatment may be attributed to increased grain and straw yields resulting from better growth, improved nutrient uptake, and enhanced yield attributes under optimum nitrogen application. Thus, cultivation of hybrid 86 M 15 with 100% RDN proved to be the most economically viable treatment under the agro-climatic conditions of Prayagraj, Uttar Pradesh.

Table 1: Response of Pearl millet hybrids to Nitrogen management practices on yield and yield attribute.

S. No.	Treatment combinations	Yield attribute and yield					
		No. ear head/m ²	Grains/Head (no.)	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index (%)
1.	86 M 25 + 100% RDN	68.26	2974.15	15.24	3.28	4.25	44.27
2.	86 M 25 + 75% RDN + <i>Azotobacter</i> seed inoculation	68.85	2964.36	14.58	3.27	3.75	48.44
3.	86 M 15 + 100% RDN	71.15	3154.59	16.90	3.58	4.71	43.23
4.	86 M 15 + 75% RDN + <i>Azotobacter</i> seed inoculation	70.30	3138.77	15.51	3.47	4.36	45.06
5.	PA 9666 + 100% RDN	65.49	2531.15	12.81	2.35	3.43	46.25
6.	PA 9666 + 75% RDN + <i>Azotobacter</i> seed inoculation	64.35	2448.67	12.06	2.19	2.75	43.78
7.	RBX 6066+ 100% RDN	63.71	2337.46	11.57	1.95	2.71	42.38
8.	RBX 6066 + 75% RDN + <i>Azotobacter</i> seed inoculation	64.17	2275.60	11.21	1.93	2.48	45.11
9.	US 7306 + 100% RDN	66.11	2699.74	14.10	2.50	3.50	48.32
10.	US 7306 + 75% RDN + <i>Azotobacter</i> seed inoculation	65.09	2627.33	13.25	2.34	3.23	39.22
11.	MP 7793 + 100% RDN	67.49	2843.50	14.18	2.55	3.57	41.49
12.	MP 7793 + 75% RDN + <i>Azotobacter</i> seed inoculation	67.13	2815.06	14.46	2.39	3.24	43.54
	F-test	S	S	NS	S	S	NS
	S.Em(±)	0.40	24.05	1.31	0.12	0.21	2.26
	CD (p=0.05)	1.19	70.54	-	0.35	0.63	-

Table 2: Response of Pearl millet hybrids to Nitrogen management practices on economics.

S. No.	Treatment combinations	Economics			
		Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C ratio
1.	86 M 25 + 100% RDN	32,112.00	1,11,375.00	79,263.00	2.47
2.	86 M 25 + 75% RDN + <i>Azotobacter</i> seed inoculation	32,212.00	1,08,675.00	76,463.00	2.37
3.	86 M 15 + 100% RDN	32,112.00	1,21,983.33	89,871.33	2.80
4.	86 M 15 + 75% RDN + <i>Azotobacter</i> seed inoculation	32,212.00	1,17,150.00	84,938.00	2.64
5.	PA 9666 + 100% RDN	32,112.00	81,758.33	49,646.33	1.55
6.	PA 9666 + 75% RDN + <i>Azotobacter</i> seed inoculation	32,212.00	73,991.67	41,779.67	1.30
7.	RBX 6066+ 100% RDN	32,112.00	67,191.67	35,079.67	1.09
8.	RBX 6066 + 75% RDN + <i>Azotobacter</i> seed inoculation	32,212.00	65,475.00	33,263.00	1.03
9.	US 7306 + 100% RDN	32,112.00	86,141.67	54,029.67	1.68
10.	US 7306 + 75% RDN + <i>Azotobacter</i> seed inoculation	32,212.00	80,500.00	48,288.00	1.50
11.	MP 7793 + 100% RDN	32,112.00	87,883.33	55,771.33	1.74
12.	MP 7793 + 75% RDN + <i>Azotobacter</i> seed inoculation	32,212.00	81,816.67	49,604.67	1.54

Conclusion

From the results, it is concluded that application of 86 M 15 along with 100% RDN in treatment - 3 was recorded highest Grain yield, gross return, net return and benefit cost ratio in Pearl millet crop which performed better in terms of yield and economic returns.

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