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Effect of azotobacter and nitrogen application on growth and yield of pearl millet (*Pennisetum glaucum* L.)

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Abstract
The field experiment entitled "Effect of Azotobacter and Nitrogen application on Growth and Yield of Pearl millet (*Pennisetum glaucum* L.)" was conducted during Kharif season of 2023 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.) India. To study the Response of Azotobacter and Nitrogen on growth and yield of Pearl millet. The experiment was laid out in a Randomized Block Design with ten treatment which have replicated thrice. The treatment details are as follow T_1: Azotobacter (seed treatment) 20 g/kg + N: 40 kg/ha, T_2: Azotobacter (seed treatment) 20 g/kg + N: 60 kg/ha, T_3: Azotobacter (seed treatment) 20 g/kg + N: 80 kg/ha, T_4: Azotobacter (soil inoculation) 5 kg/ha + N: 40 kg/ha, T_5: Azotobacter (soil inoculation) 5 kg/ha + N: 60 kg/ha, T_6: Azotobacter (soil inoculation) 5 kg/ha + N: 80 kg/ha, T_7: Azotobacter (seed + soil) + N: 40 kg/ha, T_8: Azotobacter (seed + soil) + N: 60 kg/ha, T_9: Azotobacter (seed + soil) + N: 80 kg/ha, T_{10}: Control (RDF) 80:40:40 NPK. The results obtained that the Application of Azotobacter (soil inoculation) 5 kg/ha along with N: 80 kg/ha (Treatment 6) recorded significantly higher plant height (201.31 cm), higher plant dry weight (79.19 g/plant), higher crop growth rate (16.76 g/m^2/plant), higher number of tillers (3.08 tiller/plant), higher number of ear heads/plant (1.13), higher grain ear per head (1948.98 ear/head), higher test weight (8.05 g), higher grain yield (2.63 t/ha), higher stover yield (5.56 t/ha) higher harvest index (32.10%) and higher gross return (66279.5 INR/ha), higher net return (41736.5 INR/ha) and B:C ratio (1.70) were recorded in treatment-6 (Azotobacter (soil inoculation) 5 kg/ha + Nitrogen 80 kg/ha).

Keywords: Pearlmillet, azotobacter, nitrogen, growth parameters and yield attributes

Introduction

Pearl millet, also known as 'Bajra' in Hindi, 'Sajje' in Kannada, 'Kambu' in Tamil, 'Bajeer' in Kumaoni, and 'Maiwa' in Hausa, is the most extensively grown type of millet (Balkrishna *et al.*, 2024) [4]. It has been cultivated in Africa and the Indian subcontinent from prehistoric times. The crop is most diverse and likely to be domesticated in West Africa's Sahel region. Archaeobotanical research confirms the presence of pearl millet in Northern Mali's Sahel zone from 2500 to 2000 BC. Pearl millet (*Pennisetum glaucum* L.) is a monocot plant with a tiny diploid genome (2n=14). This plant belongs to the Monocotyledones class, order Poales, family Poaceae, subfamily Panicoideae, tribe Paniceae, and genus Cenchrus. India is the greatest producer of pearl millet. Pearl millet cultivation in India dates back to 1500-1100 BC (Fuller *et al.*, 2021) [5].

Pearl millet, which accounts for around two-thirds of millet output in India, is planted mostly in arid regions like Rajasthan, Maharashtra, Gujarat, Uttar Pradesh, and Haryana. Pearl millet is India's fourth most produced food crop, following rice, wheat, and maize (Yadav and Rai, 2013) [29]. The US Department of Agriculture reports that global millet production will be 30.802 mt in 20232024, a 4.1% decrease from the previous year. Crop output has decreased in India (10% to 12.2 mt) and Niger (7% to 3.4 mt), as well as in Nigeria (1.5% to 2 mt), Mali (1.8% to 1.8 mt), and Sudan (4.5% to 1.6 mt).

Pearl millet is cultivated on approximately 31 million ha worldwide, primarily in dry and semi arid tropical regions of Asia, Africa, and Latin America. India is the world's largest producer of pearl millet, accounting for 50% of global production at about 8.61 million tons. In Uttar Pradesh, the pearl millet cultivation area is around 0.93 million ha, with a yield of

1.8 million tons and a productivity of 1941 kg/ha in 2018-19 (Louhar *et al*., 2020) [12]. Pearl millet is the most often grown crop in the country's arid and semi-arid regions. This crop is grown in dry regions of the country with harsh climate conditions. According to Awala *et al*., (2023) [3], this crop is the most drought-tolerant among cereals and millet. This crop thrives in both dry and warm climates and is drought-tolerant, requiring only 40-60 cm of yearly rainfall. The optimal temperature for pearl millet cultivation is from 200C to 300C. According to Shrestha *et al*., (2023) [24], pearl millet can be used as quality animal fodder.

Pearl millet is a high-protein, mineral, B-vitamin, and fiber-rich cereal that promotes overall health. Pearl millet accounts for roughly 69.4% of carbohydrates and 20% of dietary calories. It is more nutritious than most cereals. This food is strong in protein (12.6% digestibility) and has a somewhat superior amino acid profile. It also contains 5% fat, 2.8% iron, 69.4% carbohydrates, 2.3% minerals, riboflavin (Vit B2), and niacin (Vit B4). Pearl millet has 295-360 calories, 8.65-12.00 g of water, 10.96-11.60 g of protein, 1.70-5.43 g of fat, 61.78-73.00 g of total carbohydrate, 8.50-11.49 g of fiber, and 3.25 g of ash per 100 g. Ca: 8 mg, P: 270-285 mg, Fe: 6.0-8.0 mg, K: 195 mg, Thiamine: 0.42 mg, and Riboflavin: 0.58 mg Malik (2015) reported 4.70mg of niacin.

Bio fertilizers can reduce reliance on inorganic nitrogenous fertilizers in developing countries like India, where organic soil fertilization is becoming more significant. Nitrogen-fixing bacteria, such as Azotobacter, are now being used in Indian agriculture (Kumar *et al*., 2007) [10] to improve plant productivity.

Azotobacter, a nitrogen-fixing bacteria, is an important biofertilizer in non-leguminous crops. Azotobacter has been shown to improve plant development and agricultural productivity in different soil conditions. The bacteria is Gram-negative and has polymorphism, including different sizes and forms. These cells typically range in size from 210x1-2.5 µm. Initially, these cells use peritrichous flagella to move about. Older bacterial cells are enclosed and more resistant to heat, desiccation, and harsh circumstances. Under ideal conditions, the cyst grows and produces vegetative cells. Polysaccharides are also produced. Azotobacter spp. are sensitive to acidic pH, high salt concentrations, and temperatures above 35ºC. Azotobacter spp. are bacteria that grow in nitrogen-free environments. It is classed as a free-living bacteria. Bacteria use atmospheric nitrogen to produce proteins for their cells. After the Azotobacter cells die, their protein is mineralized in the soil. Sherpa *et al*. (2019) [32] found that this method improves nitrogen availability for crop plants.

Material and Methods

The investigation was carried out at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture Science and Technology (SHUATS), Naini, Prayagraj, UP, during *kharif* 2023-24. The treatment consists of T_1: Azotobacter (seed treatment) 20 g/kg + N: 40 kg/ha, T_2: Azotobacter (seed treatment) 20 g/kg + N: 60 kg/ha, T_3: Azotobacter (seed treatment) 20 g/kg + N: 80 kg/ha, T_4: Azotobacter (soil inoculation) 5 kg/ha + N: 40 kg/ha, T_5: Azotobacter (soil inoculation) 5 kg/ha + N: 60 kg/ha, T_6: Azotobacter (soil inoculation) 5 kg/ha + N: 80 kg/ha, T_7: Azotobacter (seed + soil) + N: 40 kg/ha, T_8: Azotobacter (seed + soil) + N: 60 kg/ha, T_9: Azotobacter (seed + soil) + N: 80 kg/ha, T_{10}: Control (RDF) 80:40:40 NPK. The experiment was laid out in Randomized Block Design, with ten treatments replicated thrice. The observations were recorded for plant height, dry weight of plant, crop growth rate, number of tillers/plant, number of ear head/plant, grain ear per head, test weight, grain yield, stover yield, harvest index and cost of cultivation, gross return net return benefit. The collected data was subjected to statistical analysis by analysis of variance method.

Results and Discussion

A. Growth Parameter

Plant Height: At harvest, the treatments showed significant differences. The tallest plants, measuring (201.31) cm, were found in Treatment 6 (Azotobacter (soil inoculation) 5 kg/ha + Nitrogen 80 kg/ha). Treatment 9 (Azotobacter (seed + soil) + Nitrogen 80 kg/ha) had a similar plant height, statistically comparable to Treatment 6.The shortest plants, with a height of (124.93 cm), were observed in the control plot.

Plant Dry Weight: At harvest, significant differences in plant dry weight were observed among the treatments. The highest plant dry weight, (79.19 g), was recorded in Treatment 6 (Azotobacter (soil inoculation) 5 kg/ha + Nitrogen 80 kg/ha). Treatment 9 (Azotobacter (seed + soil) + Nitrogen 80 kg/ha) was statistically similar to Treatment 6. The lowest plant dry weight, (50.10 g), was found in the control plot.

Crop Growth Rate: At harvest, significant differences in crop growth rate (CGR) were observed among the treatments. The highest crop growth rate, (16.76 g/m2/day), was recorded in Treatment 6 (Azotobacter (soil inoculation) 5 kg/ha + Nitrogen 80 kg/ha). Treatment 9 (Azotobacter (seed + soil) + Nitrogen 80 kg/ha) was statistically similar to Treatment 6. The lowest crop growth rate, (8.78 g/m2/day), was found in the control plot.

Tillers per plant: At harvest, significant differences in the heigher number of tillers were observed among the treatments. The highest number of tillers, (3.08 tiller/plant), was recorded in Treatment 6 (Azotobacter (soil inoculation) 5 kg/ha + Nitrogen 80 kg/ha). However, Treatment 9 (Azotobacter (seed + soil) + Nitrogen 80 kg/ha) had a statistically comparable number of tillers to Treatment 6. The lowest number of nodules, (2.70 tiller/plant), was found in the control plot.

B. Yield Parameter

Number of ear head/plant: The significant and higher number of ear head/plant (113.00) was recorded in Treatment 6 (Azotobacter (soil inoculation) 5 kg/ha + Nitrogen 80 kg/ha), which was significantly superior over rest of the treatment. However, Treatment 9 (Azotobacter (seed + soil) + Nitrogen 80 kg/ha), was found to be statistically at par with Treatment 6 (Azotobacter (soil inoculation) 5 kg/ha + Nitrogen 80 kg/ha).

Grains /ear head: The significant and higher grains /ear head (1948.98 g) was recorded in Treatment 6 with (Azotobacter (soil inoculation) 5 kg/ha + Nitrogen 80 kg/ha), which was significantly superior over rest of the treatments. However, Treatment 9 (Azotobacter (seed + soil) + Nitrogen 80 kg/ha) was found to be statistically at par with Treatment 6 (Azotobacter (soil inoculation) 5 kg/ha + Nitrogen 80 kg/ha).

C. Economics

Gross return, net return and benefit cost ratio were influenced due to different treatments.

Cost of Cultivation (INR/ha)

The highest cost of cultivation, amounting to 24543 INR per hectare, was associated with Treatment-6, which involved applying Azotobacter (soil inoculation) 5 kg/ha in combination with Nitrogen at 80 kg/ha. This treatment had a greater expense compared to all other treatments.

Gross return (INR/ha)

The highest gross returns, total 66279.50 INR per hectare, were achieved with Treatment-6, which involved applying Azotobacter (soil inoculation) 5 kg/ha in combination with Nitrogen at 80 kg/ha. This treatment generated the greatest revenue compared to all other treatments.

Net return (INR/ha)

The net returns of 41736.5 INR per hectare were recorded for Treatment-6, which involved applying Azotobacter (soil inoculation) 5 kg/ha in combination with Nitrogen at 80 kg/ha. This treatment produced the highest net returns when compared to the other treatments.

Benefit cost ratio (B:C)

In this study, the highest benefit-cost ratio of 1.70 was observed in Treatment-6, which involved applying Azotobacter (soil inoculation) 5 kg/ha in combination with Nitrogen at 80 kg/ha. This ratio was notably superior to those of all other treatments.

Table 1: Effect of Azotobacter and Nitrogen application on Growth attributes of Pearl millet (*Pennisetum glaucum* L).

Treatment No.	Treatment Combination	Plant height (cm)	Dry weight (g)	CGR ($g/m^2/day$)	No. of tiller / plant (No.)
		80 DAS	80 DAS	60-80 DAS	80 DAS
T_1	Azotobacter (seed treatment) 20 g/kg + Nitrogen 40 kg/ha	134.25	52.81	9.48	2.72
T_2	Azotobacter (seed treatment) 20 g/kg + Nitrogen 60 kg/ha	142.79	56.17	10.32	2.78
T_3	Azotobacter (seed treatment) 20 g/kg + Nitrogen 80 kg/ha	146.36	57.57	10.82	2.81
T_4	Azotobacter (soil inoculation) 5 kg/ha + Nitrogen 40 kg/ha	164.87	64.86	12.72	2.90
T_5	Azotobacter (soil inoculation) 5 kg/ha + Nitrogen 60 kg/ha	182.79	71.90	14.67	2.99
T_6	Azotobacter (soil inoculation) 5 kg/ha + Nitrogen 80 kg/ha	201.31	79.19	16.76	3.08
T_7	Azotobacter (seed + soil) + Nitrogen 40 kg/ha	155.32	61.10	11.73	2.87
T_8	Azotobacter (seed + soil) + Nitrogen 60 kg/ha	174.91	68.81	13.76	2.96
T_9	Azotobacter (seed + soil) + Nitrogen 80 kg/ha	193.10	75.96	15.79	3.05
T10	Control (RDF) 80:40:40 NPK	124.93	50.10	8.78	2.70
	F-test	S	S	S	S
	S.E. (m) (±)	2.81	1.64	1.01	0.01
	CD (P=0.05)	8.34	4.86	2.99	0.04

Table 2: Effect of Azotobacter and Nitrogen application on Yield attributes of Pearl millet (*Pennisetum glaucum* L.).

Treatment No	Treatment Combination	Number of ear head/plant (No.)	Grains per ear head (g)	Test weight (g)	Grains yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
T_1	Azotobacter (seed treatment) 20 g/kg + Nitrogen 40 kg/ha	1.02	1746.20	7.63	2.01	5.13	28.18
T_2	Azotobacter (seed treatment) 20 g/kg + Nitrogen 60 kg/ha	1.03	1773.43	7.66	2.07	5.17	28.63
T_3	Azotobacter (seed treatment) 20 g/kg + Nitrogen 80 kg/ha	1.04	1801.50	7.69	2.13	5.21	29.05
T_4	Azotobacter (soil inoculation) 5 kg/ha + Nitrogen 40 kg/ha	1.07	1850.66	7.85	2.30	5.33	30.19
T_5	Azotobacter (soil inoculation) 5 kg/ha + Nitrogen 60 kg/ha	1.10	1899.82	7.95	2.46	5.45	31.13
T_6	Azotobacter (soil inoculation) 5 kg/ha + Nitrogen 80 kg/ha	1.13	1948.98	8.05	2.63	5.56	32.10
T_7	Azotobacter (seed + soil) + Nitrogen 40 kg/ha	1.06	1833.58	7.76	2.23	5.28	29.74
T_8	Azotobacter (seed + soil) + Nitrogen 60 kg/ha	1.09	1882.74	7.92	2.41	5.45	30.65
T_9	Azotobacter (seed + soil) + Nitrogen 80 kg/ha	1.12	1931.90	8.02	2.57	5.55	31.66
T10	Control (RDF) 80:40:40 NPK	1.01	1714.14	7.56	1.94	5.05	27.74
	F-test	S	S	S	S	S	S
	S.E. (m) (±)	0.01	7.21	0.02	0.03	0.06	0.17
	CD (P=0.05)	0.02	21.43	0.05	0.08	0.02	0.52

Table 3: Effect of Azotobacter and Nitrogen application on Economics of Pearl millet (*Pennisetum glaucum* L.).

S. No.	Treatment Combination	Cost of cultivation (INR/ha)	Gross Return (INR/ ha)	Net Return (INR/ha)	Benefit Cost Ratio (B:C)
1	Azotobacter (seed treatment) 20 g/kg + Nitrogen 40 kg/ha	23565	50783	27218	1.16
2	Azotobacter (seed treatment) 20 g/kg + Nitrogen 60 kg/ha	23866	52385.5	28519.5	1.19
3	Azotobacter (seed treatment) 20 g/kg + Nitrogen 80 kg/ha	24174	53861.5	29687.5	1.23
4	Azotobacter (soil inoculation) 5 kg/ha + Nitrogen 40 kg/ha	23934	58111.5	34177.5	1.43
5	Azotobacter (soil inoculation) 5 kg/ha + Nitrogen 60 kg/ha	24235	62068	37833	1.56
6	Azotobacter (soil inoculation) 5 kg/ha + Nitrogen 80 kg/ha	24543	66279.5	41736.5	1.70
7	Azotobacter (seed + soil) + Nitrogen 40 kg/ha	23940	56474.5	32534.5	1.36
8	Azotobacter (seed + soil) + Nitrogen 60 kg/ha	24241	60773	36532	1.51
9	Azotobacter (seed + soil) + Nitrogen 80 kg/ha	24549	64878.5	40329.5	1.64
10	Control (RDF) 80:40:40 NPK	24168	49017.5	24849.5	1.03

Conclusion

From the results, it is concluded that application of Azotobacter (soil inoculation) 5 kg/ha along with Nitrogen 80 kg/ha (Treatment 6) in Pearl millet has recorded highest Grain yield, gross return, net return and benefit cost ratio.

References

1. Aasfar A, Bargaz A, Yaakoubi K, Hilali A, Bennis I, Zeroual Y, *et al*. Nitrogen Fixing *Azotobacter* Species as Potential Soil Biological Enhancers for Crop Nutrition and Yield Stability. Frontiers in Microbiology. 2021;12:628379.
2. Awala SK, Hove K, Valombola JS, Nafuka HN, Simasiku EK, Chataika B, *et al*. Co-Cultivation and Matching of Early- and Late-Maturing Pearl Millet Varieties to Sowing Windows Can Enhance Climate-Change Adaptation in Semi-Arid Sub-Saharan Agro-ecosystems. Climate. 2023;11(11):227.
3. Ahmed T, Noman M, Qi Y, Shahid M, Hussain S, Masood HA, *et al*. Fertilization of Microbial Composts: A Technology for Improving Stress Resilience in Plants. Plants. 2023;12(20):3550.
4. Balkrishna A, Shankar R, Prajapati UB, Srivastava A, Joshi RA, Tripathi P. A review on Bajra/ Pearl millet (*Cenchrus americanus* (L.) Morrone). Journal of Scientific and Innovative Research. 2024;13(1):1-8.
5. Fuller DQ, Barron A, Champion L, Dupuy C, Commelin D, Raimbault M, *et al*. Transition From Wild to Domesticated Pearl Millet (*Pennisetum glaucum*) Revealed in Ceramic Temper at Three Middle Holocene Sites in Northern Mali. African Archaeological Review. 2021;38:211-30.
6. Fathi A. Role of nitrogen (N) in plant growth, photosynthesis pigments, and N use efficiency: A review. Agrisost. 2022;28:1-8.
7. Gayethri G, Umesha C, Keerthi B, Gowthami S, Rachel CS. Influence of Bio-fertilizers and Potassium Levels on Growth and Yield of Pearl Millet (*Pennisetum glaucum* L.). International Journal of Plant & Soil Science. 2022;34(17):76-82.
8. Hasan MH, Rashid QA, Rahman, Al-mamun MH. Influence of seed rates and levels of NKP fertilizers on dry matter accumulations and yield performance of foxtail millet (*Setaria italica* L.). Bangladesh Journal of Agricultural Research. 2013;38(4):689-704.
9. Jain D, Sharma J, Kaur G, Bhojiya AA, Chauhan S, Sharma V, *et al*. Phenetic and Molecular Diversity of Nitrogen Fixating Plant Growth Promoting *Azotobacter* Isolated from Semiarid Regions of India. BioMed Research International. 2021;1-9.
10. Kumar P, Singh H, Hooda RS, Singh VP. Effect of different nitrogen levels and biofertilizers on crop productivity, soil properties and rhizosphere microflora under Pearl millet-wheat cropping system. Research on Crops. 2007;8(1):72-76.
11. Kumar P, Hooda RS, Kumar S, Singh K. Effect of nitrogen levels and biofertilizer strains on dry matter production and attraction index in pearl millet. Haryana Journal of Agronomy. 2012;28(1-2):34-37.
12. Louhar G, Bana RS, Kumar V, Kumar H. Nutrient management technologies of millets for higher productivity and nutritional security. Indian Journal of Agricultural Sciences. 2020;90(12):2243-2250.
13. Malik S. Pearl millet-nutritional value and medicinal uses. International Journal of Advance Research and Innovative Ideas in Education. 2015;1(3):2395-4396.
14. Munir N, Hanif M, Abideen Z, Sohail M, El-Keblawy A, Radicetti E, Mancinelli DR, Haider G. Mechanisms and Strategies of Plant Microbiome Interactions to Mitigate Abiotic Stresses. Agronomy. 2022;12(9):2069.
15. Morya R, Trivedia SK, Yadav SS, Gupta N. Effect of Different Sources of Nitrogen and Phosphorus and Application Methods on Yield and Quality of Hybrid Pearl Millet. International Journal of Environment and Climate Change. 2023;13(12):166-172.
16. Patel PR, Patel BJ, Vyas KG, Yadav BL. Effect of integrated nitrogen management and biofertilizer in *kharif* pearl millet (*Pennisetum glaucum* L.). Advance Research Journal of Crop Improvement. 2014;5(2):122-125.
17. Peinado-Torrubia P, Álvarez R, Lucas M, Franco-Navarro JD, Durán-Gutiérrez FJ, Colmenero-Flores JM, Miguel A. Nitrogen assimilation and photorespiration become more efficient under chloride nutrition as a beneficial macronutrient. Frontiers in Plant Science. 2022;13:1058774.
18. Patil AS, Patel KH, Chauhan NP. Yield, quality and monetary returns of summer pearl millet (*Pennisetum glaucum* L.) as influenced by integrated nitrogen management and sowing methods. Crop Research. 2014;47(1, 2 & 3):24-28.
19. Singh R, Gupta AK, Ram T, Choudhary GL, Sheoran AC. Effect of integrated nitrogen management on transplanted pearl millet (*Pennisetum glaucum* L.) under rainfed condition. Indian Journal of Agronomy. 2013;58(1):81-85.
20. Shekhawat RPS, Kumawat N, Rathore PS, Yadav PK, Om H. Effect of nitrogen levels and biofertilizers on growth and yield of pearl millet (*Pennisetum glaucum* L.) under north western Rajasthan. Annals of Agricultural Research New Series. 2014;35(3):311-314.

21. Sumbul A, Ansari RA, Rizvi R, Mahmood I. *Azotobacter*: A potential bio-fertilizer for soil and plant health management. Saudi Journal of Biological Sciences. 2020;27(12):3634-3640.
22. Singh AK, Kaur J, Gandhi N. Effect of *Azotobacter*, FYM (Farmyard manure) and PSB (Phosphorus solubilizing bacteria) on the yield and yield attributing characters on pearl millet (*Pennisetum glaucum*). Journal of Pharmacognosy and Phytochemistry. 2019;1:505-507.
23. Sagar A, Ramteke PW, Ramakrishna P, Poczai P, Al Obaid S, Ansari MJ. Synergistic Effect of *Azotobacter nigricans* and Nitrogen Phosphorus Potassium Fertilizer on Agronomic and Yield traits of Maize (*Zea mays* L.). Frontiers in Plant Science. 2022;13:952212.
24. Shrestha N, Hu H, Shrestha K, Doust AN. Pearl millet response to drought: A review. Frontiers in Plant Science. 2023;14:1059574.
25. Thomas E, Rathore I, Tarafdar JC. Bio-Inspired Synthesis of Nitrogen Nanoparticles and Its Application on Pearl Millet (*Pennisetum americanum* L) cv. HHB 67. Journal of Bionanoscience. 2016;10:1-7.
26. Tiwari H, Naresh RK, Singh PK, Kumar Y, Purushottam V. Effect of Integrated Nutrient Management on Growth and Productivity of Wheat (*Triticum aestivum* L.) in Typic Ustochrepts Soils of Western U.P., India. International Journal of Plant & Soil Science. 2023;35(11):129-142.
27. Togas R, Yadav LR, Choudhary SL, Shisuvinahalli GV. Effect of *Azotobacter* on growth, yield and quality of pearl millet. Journal of Pharmacognosy and Phytochemistry. 2017;6(4):889-891.
28. Xin C, Qing-wei Y, Jia-lin S, Shuang X, Fu-chun X, Ya-jun C. Research progress on nitrogen use and plant growth. Journal of Northeast Agricultural University. 2014;21(2):68-74.
29. Yadav OP, Rai KN. Genetic Improvement of Pearl Millet in India. Agricultural Research. 2013;2:275-92.
30. Yang H, Li Y, Cao Y, Shi W, Xie E, Mu N, Du G, Shen Y, Tang D, Cheng Z. Nitrogen nutrition contributes to plant fertility by affecting meiosis initiation. Nature Communications. 2022;13:485.
31. Zayed O, Hewedy OA, Abdelmoteleb A, Saad M. Improving Plant Resilience to Nitrogen Limitation with Microbial Fertilizers: Current Understanding and Future Prospects. Journal of Plant Growth Regulation. 2023;42:1-12.
32. Sherpa S, Blum MG, Capblancq T, Cumer T, Rioux D, Després L. Unravelling the invasion history of the Asian tiger mosquito in Europe. Molecular Ecology. 2019 May;28(9):2360-2377.