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Effect of Need-based Nitrogen Scheduling on the Growth and Productivity of Pearl Millet (*Pennisetum glaucum*)

Subhrajyoti Dalal[1], Tanmoy Shankar[1], Sagar Maitra[1], Lalichetti Sagar[1], Rahul Adhikary[2]

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ABSTRACT

Background: Under the present context of global warming and climate change, the choice of an ecologically hardy crop is having prime importance. Nutrient management is an important approach for improving crop growth and productivity. Among all the nutrients, nitrogen helps in the overall growth of the plant. Nitrogen helps to synthesize chlorophyll and thereby supports building the protein units that enhance plant growth. As nitrogen is highly mobile, it is lost through different ways such as volatilization, leaching, nitrification, *etc*. Split application of nitrogen through proper scheduling is an important approach to reduce nitrogen loss as well as to improve nitrogen use efficiency. Hence, the investigation was conducted to find out how the scheduling of nitrogen is affecting pearl millet growth and productivity.

Methods: The present study was conducted in *kharif* season of 2022 on pearl millet at Post Graduate Experimental Farm, M. S. Swaminathan School of Agriculture. The experiment was carried out in randomized complete block design with 3 replications and 9 treatments, namely, T_1: control, T_2: 50% basal RDN, T_3: 100% basal RDN, T_4: 50% basal RDN + 50% at 30 DAS, T_5: 50% basal RDN + 25% at 30 DAS and 45 DAS, T_6: 50% nitrogen as basal + topdressing @10 kg nitrogen/ha at sufficiency index <95%, T_7: 50% nitrogen as basal + topdressing @ 10 kg nitrogen/ha at sufficiency index <90%, T_8: 50% nitrogen as basal + topdressing @ 10 kg nitrogen/ha at sufficiency index <85%, T_9: 50% nitrogen as basal + topdressing @ 10 kg nitrogen/ha at sufficiency index <80%.

Result: The results showed that the application of 50% nitrogen as basal + topdressing @ 10 kg nitrogen/ha at sufficiency index <95% gave the maximum growth, yield and income was also significantly higher with this application. So, it could be recommended to the farmers for growing pearl millet during *kharif* season in southern Odisha to achieve higher growth and productivity.

Key words: Growth, Nitrogen, Split application, Sufficiency index, Yield.

INTRODUCTION

At present, agriculture is under huge pressure because of the growing demand for enhanced production in tune with the ever-increasing human population. On the other side, degradation and pollution of natural resources, global warming as well and climate change-associated abiotic and biotic stresses are causing negative impacts on farm productivity (Sairam *et al*., 2023; Sagar *et al*., 2023). Under these contexts, present agriculture should be climate-resilient where ecologically hardly crops are to be chosen. In this regard, millets can be selected for fragile ecological conditions (Maitra *et al*., 2022) and pearl millet (*Pennisetum glaucum*) is one of the most important millets, belongs to the *Poaceae* family, considered a climate-resilient and drought-tolerant crop. In India, it is cultivated over an area of 6.93 million ha with an average production of 8.61 million tons and the productivity is 1243 kg/ha during 2018-19 (GoI, 2019). In Odisha, pearl millet is grown over an area of 1870 ha with a production of 1160 tons and a productivity of 620 kg/ha (Odisha Agricultural Statistics, 2020). It provides the staple food to the poor people in a very short period and called as poor man's food crop (Gautam and Singh, 2020). The grains consumed by cooking like rice or chapatis are made from flour. It is also used as poultry feed and green fodder is used for cattle.

To boost the production of the crop, nutrient management is essential (Shankar *et al*., 2020). Among all the nutrients, nitrogen is the most important primary nutrient which helps in the overall growth and development of the plant (Reddy *et al*., 2022). It helps in chlorophyll synthesis and building the unit of protein which ultimately leads to the growth of the plant (Chouhan *et al*., 2015, Samui *et al*., 2022). But nitrogen is lost through different ways such as volatilization, denitrification, leaching, etc. in the form of NH_4^+, NO_3^-, respectively, gaseous losses of different nitrogen oxides like N_2O, NO_2 and NO (Pal *et al*., 2020; Hoang *et al*., 2022). Moreover, farmers apply nitrogen through their visual

[1]Department of Agronomy and Agroforestry, Centurion University of Technology and Management, Paralakhemundi-761 211, Odisha, India.
[2]Department of Soil Science and Agricultural Chemistry, Centurion University of Technology and Management, Paralakhemundi-761 211, Odisha, India.

Corresponding Author: Tanmoy Shankar, Department of Agronomy and Agroforestry, Centurion University of Technology and Management, Paralakhemundi-761 211, Odisha, India.
Email: tanmoy@cutm.ac.in

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analysis or simply by following the recommended dose and they do not adopt any precision option. As a result, nitrogen use efficiency is reduced. So, maintaining the synchronization between the crop demand and nitrogen application is required to improve nitrogen use efficiency. Split application of nitrogen is an important approach to enhance nitrogen use efficiency, as it ensures its judicious utilization (Karthik *et al*., 2020; Ishfaq *et al*., 2021; Shankar *et al*., 2021). Split application of nitrogen schedule can be determined by using some precision tools such as leaf color chart (LCC), chlorophyll content meter (CCM), green seeker, *etc*. (Mohanta *et al*., 2021). Among all, CCM-200 is one of those that help to identify the appropriate stage of application of nitrogen, which can be considered as a proper nutrient management tool. Based on the above facts, the current investigation was carried out to determine the effect of nitrogen scheduling on the growth and yield of pearl millet in southern Odisha conditions.

MATERIALS AND METHODS

The field experiment was carried out at Post Graduate Experimental Farm, M.S. Swaminathan School of Agriculture, Gajapati, Odisha (18°48′16″N latitude, 84°10′48″E longitude and at 64 m altitude above mean sea level) during *kharif* season of 2022. The experiment was conducted under sandy loam soil which was slightly acidic (pH 6.0) and electrical conductivity was low (0.6 dS/m). The organic carbon content status was low (0.39%). The available nitrogen status was low (234 kg/ha); however, available phosphorus and available potassium content were medium (14 kg/ha and 127 kg/ha, respectively). Pearl millet seeds were sown on 9th July 2022 and the crop was harvested on 21st October 2022. During the crop growth period the minimum and maximum temperature ranged between 22°C and 34°C with a weekly relative humidity ranged between 74% and 92%. The experiment was conducted in a randomized complete block design (RBD) with 3 replications and 9 treatments, namely, T_1: Control, T_2: 50% basal recommended dose of nitrogen (RDN), T_3: 100% basal RDN, T_4: 50% basal RDN + 50% at 30 days after sowing (DAS), T_5: 50% basal RDN + 25% at 30 DAS and 45 DAS, T_6: 50% nitrogen as basal + topdressing @ 10 kg nitrogen/ha at sufficiency index <95%, T_7: 50% nitrogen as basal + topdressing @ 10 kg nitrogen/ha at sufficiency index <90%, T_8: 50% nitrogen as basal + topdressing @ 10 kg nitrogen/ha at sufficiency index <85%, T_9: 50% nitrogen as basal + topdressing @ 10 kg nitrogen/ha at sufficiency index <80%. The recommended fertilizer dose of 60:40:40 kg/ha ($N:P_2O_5:K_2O$) was given in the form of urea, SSP and MOP. The total dose of P and K were applied as basal dose while N was applied in different splits as per the treatment. Pearl millet cultivar Vijayapur hybrid-14 was sown by maintaining a 45 cm distance from row to row and 10 cm distance from plant to plant with a seed rate of 3 kg/ha and all the recommended agronomic practices were adopted for the successful raising of the crop. Each plot size was 5 m × 4 m and every plot was separated by a bund of 25 cm width and an irrigation channel of 1 m. After 14 days of sowing in every 7-day interval, the CCM-200 value was observed and the application of nitrogen was scheduled by using the sufficiency index as expressed in the following equation.

Sufficiency index (%) =

$$\frac{\text{Chlorophyll meter reading in treatment}}{\text{Chlorophyll meter value in well fertilized plot}} \times 100$$

The destructive plant samples were collected from each plot in frequent intervals for the recording of data. The yield attributes and yield recorded from the sub-samples were drawn from each treatment plot. The nitrogen content in digested seeds/plant was determined by Kjeldahl distillation method (Jackson, 1973) by using Kel Plus Kjeldahl Distillation unit and expressed the concentration in percentage. The data were analyzed statistically by using the standard ANOVA techniques (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of nitrogen scheduling on the growth of pearl millet

The growth parameters of pearl millet such as plant height (cm), dry matter accumulation (g/m^2), crop growth rate (g/m^2/day) and leaf area index were influenced significantly by the scheduling of nitrogen (Table 1). It has been noticed that the highest plant height of pearl millet (203.1 cm) was obtained with the application of 50% nitrogen as basal + topdressing @10 kg nitrogen/ha at sufficiency index <95% which was significantly superior to all the treatments. However, it was closely followed by the application of 50% nitrogen as basal + topdressing @10 kg nitrogen/ha at sufficiency index <90% (185.2 cm). The shortest plant height (124.5 cm) was obtained with control (no nitrogen). A similar trend was obtained in dry matter accumulation and crop growth rate at harvest. In case of leaf area index (LAI), the maximum value was obtained with the application of 50% nitrogen as basal + topdressing @10 kg nitrogen/ha at sufficiency index <95% and it was at par with 50% basal RDN + 25% at 30 DAS + 25% at 45 DAS, 50% nitrogen as basal + topdressing @10 kg nitrogen/ha at sufficiency index <90% and 50% nitrogen as basal + topdressing @ 10 kg nitrogen/ha at sufficiency index <85%. The split application of nitrogen has increased the nitrogen availability to the plant which resulted in the improved chlorophyll synthesis that leads to rapid cell division and ultimately it helps in achieving maximum plant growth. Similar results were reported by Ali (2010) and Mathukia *et al*. (2014).

Effect of nitrogen scheduling on the yield attributes of pearl millet

Scheduling of nitrogen significantly affected all the yield attributes except 1000 grains weight (Table 2). Among all the treatments, the application of 50% nitrogen as basal + topdressing @ 10 kg nitrogen/ha at a sufficiency index <95% performed superior over all the other treatments. The maximum number of effective tillers/plant (3), length of the ear head (26.1 cm), the girth of the ear head (8.3 cm), number of grains ear head^{-1} (1308), the weight of grains ear head^{-1} (9.30 g) were obtained with the application of 50% nitrogen as basal + topdressing @10 kg nitrogen/ha at sufficiency index <95%. Among all the treatments, the least number of effective tillers/ plant (1.4), length of the ear head (10.5 cm), girth of the ear head (5.4 cm), number of grains ear head^{-1} (991), weight of grain ear head^{-1} (5.8 g) were recorded with no application of nitrogen. Scheduling of nitrogen helps to reduce the loss of applied nitrogen and therefore, improves the nitrogen use efficiency which leads to the extent of supply and sufficient availability of nitrogen during different growth stages of pearl millet that ultimately facilitates attaining the higher values of yield attributes. However, 1000 grains weight is directly influenced by the genetic makeup of pearl millet and treatments studied did not influence it. Similar findings were also reported by Tadesse *et al.* (2013); Choudhary and Prabhu (2014) and Khatik *et al.* (2020).

Effect of nitrogen scheduling on the yield of pearl millet

The perusal of data on yield differed significantly by the scheduling of nitrogen (Table 3). The highest grain yield (4528 kg/ha) was obtained with the application of 50% nitrogen as basal + topdressing @ 10 kg nitrogen/ha at a sufficiency index <95% and the minimum grain yield (1302 kg/ha) was recorded with control (no application of nitrogen). A similar trend was recorded in straw yield and biological yield. There was no significant difference among the treatments in the expression of harvest index. However, the harvest index was maximum (32.1%) with the application of 50% nitrogen as basal + topdressing @ 10 kg nitrogen/ha at a sufficiency index <95% and was minimum (25.1%) with no application of nitrogen. The application of nitrogen in different splits resulted in an increased nitrogen availability

Table 1: Effect of nitrogen scheduling on growth parameters of pearl millet.

Treatments	Growth parameters			
	Plant height (cm) at harvest	Dry matter accumulation (g/m^2) at harvest	Crop growth rate (g/m^2/day) 60-90 DAS	Leaf area index 90 DAS
T1: Control	124.5	590.5	8.4	2.51
T2: 50% basal RDN	146.8	651.4	9.1	2.56
T3:100% basal RDN	152.3	721.6	9.8	2.79
T4: 50% basal RDN + 50% at 30 DAS	161.3	872.2	12.9	3.34
T5: 50% basal RDN + 25% at 30 DAS + 25% at 45 DAS	164.5	928.2	13.5	3.61
T6: 50% basal RDN + Top dressing @ 10 kg/ha at sufficiency index <95%	203.1	1304.2	18.1	4.01
T7: 50% basal RDN + Top dressing @ 10 kg/ha at sufficiency index <90%	185.2	1293.2	16.9	3.77
T8: 50% basal RDN + Top dressing @ 10 kg/ha at sufficiency index <85%	176.3	1084.7	14.9	3.69
T9: 50% basal RDN + Top dressing @ 10 kg/ha at sufficiency index <80%	155.4	803.4	11.2	3.09
S.Em.(±)	6.3	42.7	1.0	0.20
CD (5%)	19.0	128.0	2.9	0.60

Table 2: Effect of nitrogen scheduling on yield attributes of pearl millet.

Treatments	Yield attributes					
	Number of effective tillers/ plant	Length of ear head (cm)	Girth of ear head (cm)	Number of grains/ ear	Weight of grains/ ear (g)	Test weight (g)
T1: Control	1.4	10.5	5.4	991.2	5.8	5.9
T2: 50% basal RDN	1.5	13.4	5.8	1038.6	6.2	6.0
T3: 100% basal RDN	1.7	17.5	6.1	1095.8	6.6	6.1
T4: 50% basal RDN + 50% at 30 DAS	1.8	20.9	6.9	1145.6	7.2	6.3
T5: 50% basal RDN + 25% at 30 DAS + 25% at 45 DAS	1.9	21.4	7.1	1168.5	7.4	6.3
T6: 50% basal RDN + Top dressing @ 10 kg/ha at sufficiency index <95%	3.0	26.1	8.3	1308.8	9.3	7.1
T7: 50% basal RDN + Top dressing @ 10 kg/ha at sufficiency index <90%	2.6	24.2	7.8	1289.4	9.1	7.0
T8: 50% basal RDN + Top dressing @ 10 kg/ha at sufficiency index <85%	2.4	23.5	7.6	1257.1	8.7	7.0
T9: 50% basal RDN + Top dressing @ 10 kg/ha at sufficiency index <80%	1.8	19.8	6.7	1127.5	7.3	6.3
S.Em.(±)	0.1	1.0	0.2	68.3	0.6	0.3
CD (5%)	0.4	3.0	0.7	204.7	1.8	NS

Table 3: Effect of nitrogen scheduling on yield of pearl millet.

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
T1: Control	1302	3892	5194	25.1
T2: 50% basal RDN	1465	4097	5562	26.6
T3: 100% basal RDN	1735	4632	6367	27.2
T4: 50% basal RDN + 50% at 30 DAS	2549	6127	8676	29.5
T5: 50% basal RDN + 25% at 30 DAS + 25% at 45 DAS	3140	7367	10507	30.1
T6: 50% basal RDN + Top dressing @ 10 kg/ha at sufficiency index <95%	4528	9535	14063	32.6
T7: 50% basal RDN + Top dressing @ 10 kg/ha at sufficiency index <90%	4217	9336	13553	31.1
T8: 50% basal RDN + Top dressing @ 10 kg/ha at sufficiency index <85%	3589	8100	11689	30.8
T9: 50% basal RDN + Top dressing @ 10 kg/ha at sufficiency index <80%	2242	5164	7406	30.3
S.Em.(±)	116.7	503.9	505.4	1.6
CD (5%)	349.7	1510.3	1514.9	NS

Table 4: Effect of nitrogen scheduling on nitrogen content (%) and nitrogen uptake (kg/ha) of pearl millet.

Treatments	Nitrogen content (%)		Nitrogen uptake (kg/ha)	
	Grain	Straw	Grain	Straw
T1: Control	1.15	0.15	14.93	5.72
T2: 50% basal RDN	1.17	0.21	17.2	8.56
T3:100% basal RDN	1.24	0.25	21.5	11.42
T4: 50% basal RDN + 50% at 30 DAS	1.35	0.35	34.33	21.79
T5: 50% basal RDN + 25% at 30 DAS + 25% at 45 DAS	1.38	0.36	43.34	26.47
T6: 50% basal RDN + Top dressing @ 10 kg/ha at sufficiency index < 95%	1.48	0.45	67.16	43.45
T7: 50% basal RDN + Top dressing @ 10 kg/ha at sufficiency index < 90%	1.46	0.41	61.39	38.7
T8: 50% basal RDN + Top dressing @ 10 kg/ha at sufficiency index < 85%	1.45	0.4	51.92	32.53
T9: 50% basal RDN + Top dressing @ 10 kg/ha at sufficiency index < 80%	1.29	0.31	28.91	15.85
S.Em.(±)	0.02	0.02	1.64	2.85
CD (5%)	0.06	0.05	4.9	8.55

which might have ascribed to higher grain yield in pearl millet. Similarly, the dry matter accumulation at harvest was also influenced by increased nitrogen availability which might have contributed to the increase in the straw and biological yield. Similar results were also confirmed by Singh *et al*. (2013) in wheat, Mathukia *et al*. (2014) in wheat and Sagar *et al.* (2023) in rice.

Effect of nitrogen scheduling on nitrogen content (%) and nitrogen uptake (kg/ha) of pearl millet

Nitrogen content and uptake in both grain and straw were highly influenced by the scheduling of nitrogen (Table 4). The highest nitrogen content and nitrogen uptake were found in pearl millet with 50% basal RDN + topdressing @ 10 kg at sufficiency index <95% and the minimum nitrogen content and nitrogen uptake were recorded with no nitrogen application. Split application of nitrogen facilitated to reduce the nitrogen loss which improved nitrogen availability during different growth periods resulting in increased nitrogen content and uptake. Similar findings were also reported by Kharub and Chander (2010) in wheat and Chaudhary *et al*. (2013) in pearl millet.

CONCLUSION

Based on the above findings obtained from the experiment, it was clearly revealed that the growth and yield of pearl millet were highly influenced by the increase in the number of splits. Among all the treatments, the application of 50% nitrogen as basal + topdressing @ 10 kg nitrogen/ha at sufficiency index <95% performed well in every aspect of growth and yield. Therefore, the application of 50% nitrogen as basal + Topdressing @ 10 kg nitrogen/ha at sufficiency index <95% could be recommended to the farmers of southern Odisha to obtain higher growth and productivity of pearl millet.

Conflict of Interest

Authors do not have any conflict of interest.

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