International Journal of Plant & Soil Science

33(21): 161-169, 2021; Article no.IJPSS.76020
ISSN: 2320-7035

Standardization of Varied Sowing Windows and Nitrogen Levels for Pearl Millet (*Pennisetum glaucum* L.) under Rainfed Conditions of Tamil Nadu

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2021/v33i2130668
Editor(s):
(1) Dr. Hon H. Ho, State University of New York, USA.
Reviewers:
(1) Roxana Horoias, University of Agricultural Sciences and Veterinary Medicine, Romania.
(2) Dayanidhi Mishra, Odisha University of Agriculture & Technology, India.
Complete Peer review History: https://www.sdiarticle4.com/review-history/76020

Original Research Article

Received 08 August 2021
Accepted 16 October 2021
Published 21 October 2021

ABSTRACT

A field experiment was conducted during k*harif*-2017 at Agricultural College and Research Institute, Madurai in a factorial randomized block design. The present research was designed by nine treatment combinations considering three dates of sowing D_1: II fortnight of June, D_2 : I fortnight of July and D_3 : II fortnight of July and three nitrogen levels N_1: RDN (80 kg ha^{-1}), N_2 : 75% RDN (60 kg ha^{-1}) and N_3 : 125% RDN (100 kg ha^{-1}) to study the growth and yield components of pearlmillet grown with variety CO (Cu) 10. The crop sown on I fortnight of July with 125 % RDN recorded maximum growth parameters, yield components and recorded significantly highest grain yield. The lowest was recorded in crop sown on II fortnight of July with application of 75% RDN.

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Keywords: Pearl millet; dates of sowing; nitrogen; yield.

1. INTRODUCTION

Pearl millet (*Pennisetum glaucum* L.) is one of the most important coarse grain crops grown throughout the world and ranks next to sorghum and is considered as poorman's food. It is believed to be the native of Africa. The crop is endowed with greater ability to withstand harsh weather parameters like temperature, precipitation, CO_2 concentration etc., and needs yield sustainability under open field [1]. Among millets, sorghum accounts for 19 per cent of the total production of millets in the country, followed by pearl millet (8.2 per cent). The crop is mostly grown in marginal lands in India. In southern India the millets are mostly grown in dry lands and semi arid regions in both *kharif* and *rabi* seasons. In Tamil Nadu state, it is grown in 0.06 million hectares with a production of 0.17 million tonnes which nearly contributes by 0.83 per cent of India's total production.

Grain production in pearl millet is dependent on various factors, among them climate is one which adversely affects crop at flowering and grain setting if coincides with rains and low temperatures, respectively [2]. Generally, low yields in pearl millet are noticed under late sown situations coupled with aberrant monsoon behavior and early cessation. Selection of sowing window is one of the most important non - monetary inputs that influences crop yield even in photo and thermo-insensitive crops [3]. Decline in both temperature and length of photo-period over successive sowing dates from July to September had a drastic effect on phenology and yield potential of the crop [4]. Late sowing beyond July results in poor germination and plant stand due to low soil temperature. As the farmers use more nitrogenous fertilizers which ultimately increases the cost of cultivation, so there is a need to address the problem. Hence, a field experiment was carried to study the effect of different sowing windows and nitrogen doses on the growth parameters and yield components on pearl millet.

2. MATERIALS AND METHODS

The field trail was carried out at Agricultural College and Research Institute, Madurai during *kharif* – 2017. The experimental site was sandy clay loam having pH of 7.4 and organic carbon of 0.42 per cent. The available nitrogen, phosphorus and potassium contents were 289.25, 15.57, and 311.12 kg ha^{-1}, respectively. The experiment was conducted in factorial RBD with three replications. Nine treatment combinations were formed considering three sowing windows *i.e*., 2nd fortnight of June (D_1), 1st fortnight of July (D_2) and 2nd fortnight of July (D_3) and three nitrogen levels *i.e*., RDN (N_1) (80 kg ha^{-1}), 75% RDN (N_2) (60 kg ha^{-1}) and 125% RDN (N_3) (100 kg ha^{-1}).

During the Crop growing period, the weekly mean maximum temperature ranged from 29.77˚C to 37.42˚C with an average of 33.22˚C and weekly mean minimum temperature ranged between 17.36˚C to 26.18˚C with an average of 24.14˚C. The weekly mean relative humidity ranged from 45.67 to 82.48% with an average of 70.52%. A total rainfall of 366.52 mm was received in 24 rainy days during the crop period. The weekly mean bright sunshine hours ranged between 0.82 to 7.91 hours day^{-1} with an average of 5.6 hours day^{-1}. All the data was recorded on randomly selected five plants in each treatment. The destructive samples like LAI and DMP are collected in gross plot, then the non-destructive (plant height and number of tillers $plant^{-1}$) samples were recorded by tagging plants and also for post-harvest parameters. All the data recorded were subjected to statistical analysis using ANOVA for factorial RBD suggested by Panse and Sukhatme [5].

3. RESULTS

3.1 Growth Parameters

3.1.1 Plant height

The data (Table 1) recorded from the crop revealed that the crop sown in 1st FN of July (D_2) produced taller plants in all the stages of observations. But, the analysis of variance didn't show much significant difference in plant height. . At early stage (30 DAS), the plants were at height of 61.59 cm, at developmental (60 DAS) and maturity stages the plants are at height of 109.00 and 183.20 cm respectively. The late sown crops D_3 (II FN of July) was shorter at all stages (57.78, 106.67and 177.78 cm on 30 DAS, 60 DAS and at harvest, respectively). main effect due to nitrogen levels was not affected in 30 DAS, but the observation at 60 DAS and harvest produced taller plants in N_3 (125 % RDN) (106.67, 184.20 cm) followed by N_1 (RDN). The

interaction effect of dates of sowing and N levels at all stages of crop are not significantly affected.

3.1.2 Number of tillers plant^{-1}

The individual effect of dates of sowing on mean number of tillers per plant was influenced only at 30 DAS found unaffected at 60 DAS and harvest. The data (Table 2) revealed that crop sown in D_2 (I FN of July) recorded more number of tillers per plant (3.74) which was at par with both D_1 (I FN of June) and D_3 (II FN of July). The nitrogen levels influenced the total number of tillers per plant at all stages of crop, the application of 100 kg N ha^{-1}(N_3) produced more number of tillers per plant (3.77, 4.66 and 4.89) whereas less number of tillers with application of 60 kg N ha^{-1}(N_2). The interaction dates of sowing and nitrogen levels on number of tillers per plant was unaffected in all stages of crop.

3.1.3 Leaf Area Index (LAI)

The observed data (Table 3) of pearl millet indicated that the main effects of dates of sowing influenced the LAI at 60 DAS and at harvest stage of crop, the sowing window of I FN of July (D_2) recorded significant maximum LAI (7.36 and 15.74) and minimum LAI was observed in sowing window of II FN of July (D_3). The individual effect of nitrogen levels significantly influenced the LAI at all stages. higher LAI was recorded in N_3 (125 % RDN) (0.56) and least LAI was noticed in N_2 (75 % RDN) (0.45). Similar trend was observed in remaining 60 DAS and harvesting stages. There was no significant interaction of sowing dates and nitrogen levels on leaf area index.

3.1.4 Dry Matter Production (DMP)

The results (Table 4) from the pearl millet shows that the DMP was affected by dates of sowing and nitrogen levels in all the stages of crop. The data from sowing dates revealed that the higher DMP was recorded in crop sown on I FN of July (D_2) (1208.77, 3392.79 and 4565.18 kg ha^{-1}at 30, 60 DAS and harvest, respectively) and lowest was observed in D_1(II FN of July). The main effect of nitrogen levels noted that the application of 125% RDN (N_3) accumulated more dry matter (1201.53, 3574.46 and 4574.29 kg ha^{-1}) in all respective stages of observation and lower DMP was registered with application of 75% RDN (N_2). The DMP of pearl millet was not influenced by interaction of sowing dates and nitrogen levels.

3.2 Crop Phenology

The phenophases of the crop was split into different phases (first flowering, 50% flowering and days to maturity) to have better understanding. Variation among the phenophases was very negligible. The duration of seedling phase was uniform (17 days) in all treatments. Number of days required to attain first flowering ranged between 52 to 55 days. Fifty per cent flowering was noticed around 57 to 60 DAS. Days to maturity was around 86 to 89 DAS.

3.3 Yield Components and Yield

3.3.1 Total number of productive tillers per plant

The total number of productive tillers per plant (Table 5) was not influenced by dates of sowing. However, higher number of productive tillers in D_2 (I FN of July) (2.57) and lower number of productive tillers was noticed in D_3 (II FN of July). Among the nitrogen doses, the higher doses of N (N_3: 125 % RDN) produced more productive tillers (2.61) and it was at par with treatments of both RDN(N_1) and 75% RDN (N_2). The interaction was non-significant on total number of productive tillers per plant in pearl millet.

3.3.2 Number of ear heads per plant

The main effects of dates of sowing and nitrogen dosages doesn't influence the number of ear heads per plant and the interaction was also found non-significant. However, the treatments of I FN of July sown crop (D_2) and higher dose of N (N_3) performed better when compared to rest of treatments.

3.3.3 Ear head length

The main and interaction effects of sowing windows and nitrogen levels were unaffected in pearl millet (Table 6). But, the longer ear heads were registered in I FN of July (D_2) among the sowing windows and application of 125% RDN (N_3) recorded longer ear heads with in the treatments of nitrogen levels.

3.3.4 Ear head girth

The main and interaction effects of sowing windows and nitrogen doses were unaffected for ear head girth character in pearl millet (Table 6). However, the higher values of ear head girth data were registered in I FN of July (D_2) and the thicker ear heads were recorded in N_3 (125% RDN) among the treatments of nitrogen doses.

Table 1. Effect of dates of sowing and nitrogen doses on mean plant height (cm) at different stages of pearl millet

Treatments	30 DAS				60 DAS				Harvest			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
D_1	59.28	58.04	61.60	59.52	104.00	103.00	106.00	105.26	180.00	177.03	183.00	180.11
D_2	62.27	60.67	63.42	61.59	107.00	108.77	109.00	108.85	182.00	179.00	191.60	183.20
D_3	58.60	56.09	61.22	57.78	103.00	102.00	106.67	103.33	181.33	174.00	184.20	177.78
Mean	59.52	58.27	61.22		105.26	104.59	106.67		180.11	176.68	184.20	
	S Ed	CD (P = 0.05)			S Ed	CD (P = 0.05)			S Ed	CD (P = 0.05)		
D	1.16	2.58			1.92	3.77			2.14	4.83		
N	1.18	NS			1.95	3.98			2.22	5.14		
DxN	1.89	NS			3.60	NS			4.79	NS		

Table 2. Effect of dates of sowing and nitrogen doses on mean number of tillers per plant at different stages of pearl millet

Treatments	30 DAS				60 DAS				Harvest			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
D_1	3.67	3.36	3.78	3.60	4.35	4.11	4.69	4.38	4.61	4.19	4.83	4.54
D_2	3.78	3.56	3.88	3.74	4.46	4.06	4.90	4.47	4.73	4.26	5.02	4.68
D_3	3.47	3.31	3.66	3.48	4.27	4.02	4.59	4.23	4.51	4.15	4.81	4.49
Mean	3.64	3.41	3.77		4.36	4.06	4.66		4.62	4.20	4.89	
	S Ed	CD (P = 0.05)			S Ed	CD (P = 0.05)			S Ed	CD (P = 0.05)		
D	0.27	0.63			0.67	NS			0.79	NS		
N	0.23	0.61			0.64	1.49			0.76	1.14		
DxN	0.68	NS			1.29	NS			1.48	NS		

Table 3. Effect of dates of sowing and nitrogen doses on mean LAI at different stages of pearl millet

Treatments	30 DAS				60 DAS				Harvest			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
D_1	0.48	0.45	0.58	0.50	7.27	6.89	7.41	7.19	15.48	14.78	16.43	15.56
D_2	0.51	0.48	0.59	0.53	7.48	7.05	7.54	7.36	15.59	14.87	16.75	15.74
D_3	0.44	0.43	0.50	0.46	7.05	6.23	7.33	6.87	15.25	14.33	15.33	14.97
Mean	0.48	0.45	0.56		7.27	6.72	7.43		15.44	14.66	16.17	
	S Ed	CD (P = 0.05)			S Ed	CD (P = 0.05)			S Ed	CD (P = 0.05)		
D	0.04	NS			0.47	1.28			0.62	1.32		
N	0.04	0.08			0.42	1.13			0.51	1.19		
DxN	0.06	NS			1.09	NS			1.32	NS		

Table 4. Effect of dates of sowing and nitrogen doses on mean DMP (kg ha^{-1}) at different stages of pearl millet

Treatments	30 DAS				60 DAS				Harvest			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
D_1	1164.24	1019.85	1146.42	1110.17	3373.82	2903.48	3556.97	3278.09	4510.70	4289.39	4601.90	4467.33
D_2	1275.12	1004.78	1346.4	1208.77	3487.16	2977.82	3713.39	3392.79	4602.20	4312.75	4780.60	4565.18
D_3	1050.9	999.01	1111.77	1053.89	3268.88	2703.84	3453.02	3141.91	4267.06	4075.82	4340.37	4227.75
Mean	1163.42	1007.88	1201.53		3376.62	2861.71	3574.46		4459.99	4225.99	4574.29	
	S Ed	CD (P = 0.05)			S Ed	CD (P = 0.05)			S Ed	CD (P = 0.05)		
D	42.27	86.71			58.63	117.87			40.12	89.08		
N	37.94	77.11			56.17	124.64			38.97	78.49		
DxN	65.72	NS			78.04	NS			66.47	NS		

Table 5. Effect of dates of sowing and nitrogen doses on mean number of productive tillers plant^{-1}and number of ear heads plant^{-1} of pearl millet

Treatments	No. of productive tillers plant^{-1}				No. of ear heads plant^{-1}			
	N_1	N_2	N_3	Mean	23.76	23.5	24.44	23.90
D_1	2.45	2.37	2.62	2.48	1.83	1.61	1.86	1.77
D_2	2.57	2.45	2.69	2.57	1.86	1.63	2.05	1.85
D_3	2.44	2.25	2.51	2.40	1.7	1.56	1.78	1.68
Mean	2.49	2.36	2.61		1.80	1.60		1.90
	S Ed	CD (P = 0.05)			S Ed	CD (P = 0.05)		
D	0.09	NS			0.05	NS		
N	0.12	0.29			0.06	NS		
DxN	0.17	NS			0.11	NS		

Table 6. Effect of dates of sowing and nitrogen doses on mean ear head lengthand ear head girth of pearl millet

Treatments	Ear head length (cm)				Ear head girth (cm)			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
D_1	23.76	23.5	24.44	23.90	7.44	7.42	7.53	7.46
D_2	24.54	24.13	24.98	24.55	7.58	7.57	7.96	7.70
D_3	23.74	23.34	23.79	23.62	7.44	7.26	7.59	7.43
Mean	24.01	23.66	24.40		7.49	7.42	7.69	
	S Ed	CD (P = 0.05)			S Ed	CD (P = 0.05)		
D	0.19	NS			0.21	NS		
N	0.19	NS			0.22	NS		
DxN	0.21	NS			0.27	NS		

3.3.5 Number of grains per panicle

The recorded data (Table 7) from the crop of pearl millet resulted that the individual and interaction effects of sowing windows influenced the number of grains panicle $^{-1}$. The main effect of dates of sowing indicated that the crop sown in I FN of July (D_2) recorded more number of grains per panicle (2642.81) and was comparable with the D_1. The individual effect of nitrogen levels influenced the total number of grains per panicle. Among them, the application of 100 kg N ha^{-1} (N_3) registered maximum number of grains (2622.53) in their panicles and is on par with treatment RDN (N_2). With regard to interaction effect of sowing dates and N levels, D_2N_3 accounted highest (2785.09) mean number of grains per panicle and lowest (2325.31) recorded in D_3N_2.

3.3.6 1000-seed weight

The current study revealed that the main effects of all factors were influenced the test weight (Table 7) of pearl millet. Among sowing windows, D_2 (I FN of July) registered highest test weight (8.58g) as compared to the rest of two dates. With reference to N levels, the treatment with extra dose of N (N_3) exhibited maximum 1000-seed weight (8.57g) and the lowest in limited dose treatments. The interaction effect of dates of sowing and nitrogen levels influenced the test weight and D_2N_3 recorded highest test weight (8.63g) and the lowest was found in D_3N_2 (8.40g).

3.3.7 Grain yield

The results on grain yield revealed that the individual and interaction effects of the two factors influenced the grain yield Table 8). Among the dates of sowing, the crop sown in I FN of July (D_2) exhibited significantly highest grain yield (2275.67 kg ha^{-1}) and the lowest (1720.02 kg ha^{-1}) in crop sown in II FN of July (D_3) which was comparable with D_1 (1815.32 kg ha^{-1}). In case of main effect of N levels, the application of 100 kg N ha^{-1} (N_3) produced significantly higher grain yield (2231.43 kg ha^{-1}) and the lowest was noted in N_2 (1645.58 kg ha^{-1}). The interaction effect of dates of sowing and nitrogen doses was significant and produced higher grain yield (2451.35 kg ha^{-1}) in plots with combination of dates of sowing on I FN of July and application of 100 kg N ha^{-1}(D_2N_3), then the lowest grain yield was found in D_3N_2 (1394.64 kg ha^{-1}).

Table 7. Effect of dates of sowing and nitrogen doses on mean number of grains panicle $^{-1}$ and test weight of pearl millet

Treatments	No. of grains panicle $^{-1}$				Test weight (cm)			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
D_1	2453.47	2361.47	2586.56	2467.17	8.50	8.43	8.56	8.50
D_2	2596.67	2546.67	2785.09	2642.81	8.59	8.51	8.63	8.58
D_3	2357.67	2325.31	2495.93	2392.97	8.47	8.40	8.53	8.47
Mean	2469.27	2411.15	2622.53		8.52	8.45	8.57	
	S Ed	CD (P = 0.05)				CD (P = 0.05)		
D	82.17	178.23				0.14		
N	74.34	163.52				0.11		
DxN	103.12	224.76				0.19		

Table 8. Effect of dates of sowing and nitrogen doses on mean grain and straw yield (kg ha^{-1}) of pearl millet

Treatments	Grain yield (kg ha^{-1})				Straw yield (kg ha^{-1})			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
D_1	1755.17	1515.73	2175.22	1815.32	3355.12	3115.73	3675.22	3381.98
D_2	2349.03	2027.26	2451.35	2275.67	3549.23	3327.25	3951.14	3609.00
D_3	1698.91	1394.64	2068.07	1720.02	3298.47	2994.63	3468.07	3253.36
Mean	1934.00	1645.58	2231.43		3400.67	3145.58	3698.10	
	S Ed	CD (P = 0.05)			S Ed	CD (P = 0.05)		
D	82.58	172.23			64.14	134.46		
N	76.24	165.17			72.56	165.17		
DxN	131.45	277.54			147.68	309.23		

3.3.8 Straw yield

The observed data resulted that the individual and interaction effects of sowing windows and nitrogen levels influenced the straw yield (Table 8). The individual effect of dates of sowing revealed that the crop sown in I FN of July (D_2) registered significantly maximum straw yield (3609.00 kg ha^{-1}) and lower straw yield in crop sown in II FN of July (D_3) (3253.36 kg ha^{-1}). In case of main effect of N levels, the application of 100 kg N ha^{-1} (N_3) produced significantly higher stover yield (3698.10 kg ha^{-1}) and the lowest in N_2 (3145.58 kg ha^{-1}). While the interaction between dates of sowing and nitrogen doses was significant and recorded the highest (3951.14 kg ha^{-1}) in treatment with combination of dates of sowing on I FN of July and application of 100 kg N ha^{-1}(D_2N_3) which was at par with same date of sowing with application of 80 kg N ha^{-1} (D_1N_3) (3675.22kg ha^{-1}) then the lowest straw yield was found in D_3N_2 (2994.63 kg ha^{-1}).

4. DISCUSSION

The selected dates of sowing and nitrogen levels influenced the growth parameters of pearl millet. The findings from the present investigation revealed that the maximum mean for plant height, more number of tillers per plant, high LAI and higher dry weight throughout the growth phases of the crop was observed in the treatments of crop sown on I FN of July with 125 % RDN. The increase in these parameters was due to increased nitrogen, which promoted the growth of the crop [6] 120 kg N ha^{-1}; [7] (90 kg N ha^{-1}) and [8] (120 kg N ha^{-1})and the same results was reported by Chavan *et al.,*[9]; Rathore et al. [10] and Obeng et al. [11]. The late sown crops revealed that decrease in the growth because of the critical stages of plant growth get exposed to unfavorable weather conditions and early sown crop had grown well due to radiation or photo period on phenological behavior of the crop and were in conformity with the results of Swathi et.al. [12] and Sumathi et.al. [13].

Yield is the index of morphological, physiological and biochemical parameters which comprises the interaction of internal and external factors [14]. It largely depends on the production and mobilization of carbohydrates, uptake of water and nutrients from the soil, in addition to the environmental factors to which the plant is exposed during growing period. The present study revealed that I FN of July crop applied with

125 % RDN recorded higher yield and yield components. The yield and yield components were high due to nitrogen application which increased the activity of cytokines in plant which lead to the increased cell-division and elongation. Nitrogen is a component of porphyrins of chloroplasts and hence, increased nitrogen fertilization increased the growth and yield of crop due to increased photosynthates production. This response was reported by Gautam and Kaushik, [15] Munirathnam and Gautam, [7] (90 kg N ha^{-1}); Rana et al. [16] (90 kg N ha^{-1}); Yadav et al. [17] Jadhav et al. [18] (120 kg N ha^{-1}). The optimum date of sowing with correct dose of nitrogen would have good growth, yield parameters and grain yield in pearl millet.

5. CONCLUSION

Pearl millet is harsh crop which can withstand the weather aberrations which will cleanly observed in rainfed farming. The farming community in the rainfed regions can cultivate the pearl millet under the contingency crop planning due to bad behavior of weather parameters. In these conditions also the crop can fetch the good yields by following the some monitory and non monitory inputs which were investigated in this research. From the above study it is concluded that I FN of July with application of 100 kg N ha^{-1} performed well with good growth, yield attributing components and yield. It is recommended that crop sown on I FN of July with application of 100 kg N ha^{-1} will acquire superior yields in pearl millet under the rainfed conditions in Tamil Nadu.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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