International Journal of Environment, Agriculture and Biotechnology
Vol-9, Issue-5; Sep-Oct, 2024
Peer-Reviewed International Journal
Journal Home Page Available:https://ijeab.com/
Journal DOI:10.22161/ijeab

Effect of different fertilizer doses and spacing on performance of Pearl Millet (*Pennisetum glaucum* L.) under Tripura Agro-Climatic Condition

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Received: 10 Sep 2024; Received in revised form: 09 Oct 2024; Accepted: 15 Oct 2024; Available online: 25 Oct 2024

Abstract— *A field experiment was conducted to study the effect of fertilizer and spacing on performance of Pearl Millet under Tripura agro-climatic condition during pre-kharif season in 2024 at the Experimental Farm of College of Agriculture, Tripura Lembucherra(23º56′ N latitude and 91º10′ E longitude, 160 m.s.l.) in a sandy loam soil with 12 treatment combinations (fourfertilizer level in main plot and three level of spacingin sub-plot) in a split plot design replicated thrice.Recommended Dose of Fertilizer (RDF) is 80:40:40 kg ha^{-1} as N: P_2O_5: K_2O. The main plot treatments are F_1: RDF 100%, F_2: RDF 75%, F_3: RDF 125%, F_4: RDF 150%. The sub-plot treatments were S_1: 30 cm X 20 cm, S_2: 45 cm X 20 cm, S_3: 60 cm X 20 cm. The study revealed that both the levels of fertilizer and spacing significantly influenced almost all the growth parameters, yield attributing characters, thegrain yield(kg ha^{-1}) and stover yield (kg ha^{-1}). The highest values of growth parameters, yield attributing characters, thegrain yield (kg ha^{-1}) and stover yield (kg ha^{-1}) were recorded when fertilizer applied @ 125% RDF (F3) in combination with spacing of 45cm x 20 cm (S_2).*

Keywords—***Fertiliser, Spacing, Pearl Millet, Yield, Tripura.***

I. INTRODUCTION

Pearl millet is an important dual-purpose, staple crop in the crop-livestock production systems of the arid zones of Rajasthan, North-West India. Globally, dry and semi-arid climates cover about 40% of the land area (Gamo, 1999). The hardest warm-season cereal crop in the world is pearl millet (*Pennisetum glaucum* L.) (Reddy *et al*., 2013). In terms of area, it comes in sixth place globally behind rice, wheat, maize, barley, and sorghum (Khairwal*et al*., 2007), and it accounts for 42% of global production (Ramesh *et al*., 2006). According to Ramesh *et al*. (2006), pearl millet is an essential semi-arid and dry crop grown in India for both food and feed on more than 8.3 million hectares of land. It ranks fourth among all grains (Yadav *et al*., 2011).

Efficient fertilizer management plays important role in increasing the crop yield through efficient utilization of limited moisture/water supply. The soils of these areas are deficient in various nutrient elements in general and nitrogen in particular. It is, therefore, imperative to have better understanding of growth, yield and quality of this crop in relation to nitrogen for promoting its adoption by farmers of these regions. (Singh *et al*.,2013).

Nutrient management, encompassing the application of fertilizers and soil amendments, directly affects the growth and productivity of pearl millet. The right balance of essential nutrients can enhance plant vigor, improve resistance to pests and diseases, and ultimately increase grain and yield. Similarly, plant spacing—the distance between individual plants and rows—plays a crucial role in determining the plant's access to resources such as light, water, and nutrients, which can influence both vegetative growth and grain production. Generally, pearl millet has been known for growing under low N management (Gascho *et al*., 1995) but, several studies showed that N application can increase millet production efficiency (Singh *et. al*., 2010).

Despite their importance, the optimal nutrient doses and spacing for maximizing pearl millet yield are not uniformly established and can vary based on local soil conditions, climate, and cultivar characteristics. Therefore, this study aims to evaluate the effects of different nutrient doses and spacing configurations on the yield of pearl millet. By systematically assessing these factors, the research seeks to provide actionable insights and recommendations for improving pearl millet cultivation practices.

Understanding the interplay between nutrient management and plant spacing will not only contribute to higher yields but also support sustainable agricultural practices by optimizing resource use and minimizing environmental impact. Through this investigation, the study aspires to enhance the productivity and economic viability of pearl millet farming, thereby contributing to global food security and agricultural sustainability.

The climate of Tripura is Warm and humid sub-tropical with average annual rainfall of 2200 mm. But there are no scientific agronomical cultivation practices of Pearl millet in Tripura condition. In view of the above facts, one field experiment was conducted on *"Effect of fertilizer and spacing on performance of Pearl Millet under Tripura Agro-Climatic Condition"* to find out the effect of fertilizer doses spacing and their interaction effect on growth, yield attributes and yield of Pearl millet.

II. MATERIALS AND METHOD

A field experiment was conducted during two consecutive *pre-Kharif* seasons of 2024 at the research farm of College of Agriculture, Tripura situated at 23º56' N latitude and 91º10' E longitude, with an altitude of 160 m from mean sea level. The Lateritic red soils (Tilla Lands) of the experimental site in Tripura was sandy loam having pH of 5.45, 0.45% organic carbon, 8.56 kg available phosphorus, 152 kg available potash and 15 kg available sulphur per hectare. The experiment was conducted during pre-kharif season where the climate of hilly zone is sub-tropical with distinctive characteristics of high rainfall, high humidity with a prolonged winter. The bulk density of soil was 1.40 mg/m^3 and pore space was 39%.Recommended Dose of Fertilizer (RDF) is 80:40:40 kg ha^{-1} as N: P_2O_5: K_2O. Half dose of nitrogen (N) and full dose of P_2O_5 and K_2O were applied as basal and remaining half dose of nitrogen (N) was applied at 30 Days after sowing.Twelve treatments comprising of 4 different fertilizer doses and 3 different spacing were considered as main plot and sub plot, respectively, and replicate thrice in Split Plot design. The main plot treatments are F_1= RDF 100%, F_2= RDF 75%, F_3= RDF 125%, F_4= RDF 150%. The sub-plot treatments were S_1= 30 cm X 20 cm, S_2= 45 cm X 20 cm, S_3= 60 cm X 20 cm.

The experimental data pertaining to each parameter of study were subjected to statistical analysis by using the technique of analysis of variance and their significance was tested by "F" test (Gomez and Gomez, 1984). Standard error of means (SEm+) and critical difference (CD) at 5% probability (p=0.05) were worked out for each parameter studied to evaluate differences between treatment means.

III. RESULTS AND DISCUSSION

Plant Height

The plant height of pearl millet was significantly affected by the different level of fertilizers at the time of harvesting. The tallest plant of Pearl millet (151.0 cm) was produced by the F_4 treatment (150% RDF) (Table 1) followed by F_3 treatment (125% RDF) and they are statistically at par. The shortest plant height (115.2 cm) was recorded in F_1 treatment (100% RDF).

The different levels of spacing non-significantly affected the plant height of pearl millet. However the S_1 treatment (30 cm x 20 cm) recorded the tallest plant (138.2 cm) (table-1) followed by the S_3 treatment (60 cm x 20 cm). The shortest plant (126.5 cm) was recorded in treatment S_2 (45 cm x 20 cm).

Moreover, the interaction effect between different fertilizer levels and spacing on plant height of Pearl millet was significant at harvest (Table2). Within the same level of spacing, the tallest plant (151.0 cm) of Pearl millet was recorded under F_4 treatment (RDF 150%) followed by F_3 (RDF 125%) and they are statistically at par. The F_1 treatment (RDF 100%) showed the shortest plant height (115.3 cm).

Table 1: Effect of levels of fertilizer and spacing on Growth attributes of Pearl millet

Treatments	Plant Height (cm)	Plant Population
Fertilizer Doses		
F_1(100% RDF)	**115.2**	**115065**
F_2(75% RDF)	**124.2**	**115600**
F_3(125% RDF)	**143.5**	**114530**
F_4(150% RDF)	**151.0**	**116670**
SEm($\pm$)	**6.51**	**17.60**
CD	**22.53**	**60.94**
CV	14.64	0.046
Spacing		
S_1(30 cm x20 cm)	**138.2**	**160556**
S_2(45 cm x20 cm)	**126.5**	**105565**
S_3(60 cm x20 cm)	**135.7**	**80278**
SEm($\pm$)	**4.58**	**396**
CD	**NS**	**1186**
CV	11.88	1.19

Table 2: Interaction effect of fertilizer and spacing on plant height (cm) of Pearl millet

Spacing Treatments	Plant height (cm)				
	Fertilizer Treatments				
	F_1	**F_2**	**F_3**	**F_4**	**Mean**
S_1(30 cm x20 cm)	**115.4**	**158.1**	**132.1**	**147.3**	**131.4**
S_2(45 cm x20 cm)	**102.0**	**86.4**	**157.9**	**159.74**	**130.9**
S_3(60 cm x20 cm)	**128.4**	**128.1**	**140.6**	**146.0**	**137.2**
Mean	**115.3**	**124.2**	**143.5**	**151.0**	
	F*S		**S*F**		
$SE_{m\,(\pm)}$	**9.16**		**9.92**		
CD at 5%	**27.45**		**31.71**		

With same level of fertilizer doses different spacing levels are significantly affected. The tallest plant (138.2 cm) was observed in S_1 (30 cm X 20 cm) followed by S_3 (60 cm X 20 cm) and they are statistically at par to each other. The shortest plant (126.5 cm) was recorded in S_2 (45 cm X 20 cm).

Plant Population

Plant Population of Pearl millet was affected significantly by different fertilizer doses as well as different spacing levels (Table1). The maximum numbers of plants (116279 nos) were recorded in F_4 (RDF 150%) treatment followed by F_2 (RDF 75%) and they are statistically significant. The minimum numbers of plant (113777 nos) were recorded in F_3 (RDF 125%). In case of different spacing level maximum population of plant (159947 nos) were counted in S_1 (30 cm X 20 cm) treatment followed by S_2 (45 cm X 20 cm) and also significant to each other. The minimum population (80006 nos) was counted in S_3 treatment (60 cm X 20 cm).

The interaction effect of different fertilizer doses and different levels of spacing on Plant Population were significant (Table 3**)**. With the same level of spacing, the maximum population of plants (116279 nos) was observed in F_4 (RDF 150%) followed by F_2 (RDF 75%) and they are statistically at par. The lowest one (113777 nos) was observed in F_3 (RDF 125%). With same level of fertilizer the maximum number of plants (159947 nos) was recorded in S_1 (30 cm X 20 cm) treatment followed by S_2 (45 cm X 20 cm) and they are statistically significant. The lowest plant population (80006 nos) was recorded in S_3 treatment (60 cm X 20 cm).

Table 3: Interaction effect of fertilizer and spacing on plant population of Pearl millet

Spacing Treatments	Plant Population				
	Fertilizer Treatments				
	F_1	**F_2**	**F_3**	**F_4**	**Mean**
S_1(30 cm x20 cm)	**160556**	**160556**	**160556**	**160556**	**160556**
S_2(45 cm x20 cm)	**104361**	**105967**	**102756**	**109178**	**105566**
S_3(60 cm x20 cm)	**80278**	**80278**	**80278**	**80278**	**80278**
Mean	**115065**	**115600**	**114530**	**116671**	
	F*S		**S*F**		
$SE_{m\,(\pm)}$	**791**		**646**		
CD at 5%	**2372**		**1938**		

These results of growth attributes were in conformity with the findings of Shahin *et al*., (2013) and Prasad *et al*., (2014)

Yield attribute

No. of ears ha^{-1}.

Number of ears per ha were significantly influenced by different levels of fertilizer and different levels of spacing (Table 4). In case of different fertilizer doses, the highest number of ears ha^{-1} (100196) was recorded in F_1 treatment (RDF 100%) followed by F_4 (RDF 150%) treatment and they are significant. The lowest number (89122) was counted in treatment F_3 (RDF 125%). In different levels of spacing the highest ears (115396) were counted S_1 (30 cm X 20 cm) followed by S_2 (45 cm X 20 cm) and they are significant. The lowest one (73632) is treatment S_3 (60 cm X 20 cm).

In interaction effect, level of fertilizer doses and level of spacing were significant (Table5). With the same level of spacing the highest number of ears (100196) were found in the treatment F_1 (RDF 100%) followed by F_4 (RDF 150%) and they are statistically at par. The lowest number of ears (89122) was observed in treatment F_3 treatment (RDF 125%).

With same level of fertilizer the highest ears number (115396) was recorded in S_1 treatment (30 cm X 20 cm) followed by S_2 (45 cm X 20 cm) and they are significant to each other. The lowest number (73632) was found in S_3 (60 cm X 20 cm).

No. of grains ear^{-1}

The number of grains per ear was non-significant (Table 4). With different fertilizer doses, the highest grain numbers ears^{-1} (479.9) was observed in F_3 (RDF 125%) followed by F_1 (RDF 100%) and the lowest one (429.4) was F_2 (RDF 75%). With different spacing levels, the highest grain number (474.4) was recorded in S_1 treatment (30 cm X 20 cm) followed by S_3 (60 cm X 20 cm) and lowest number of ears (402.6) was recorded in S_2 (45 cm X 20 cm).

In interaction effect, the main plots and sub plots were significantly correlated (Table 6). With same spacing level the highest grain number per ears (479.9) was recorded in F_3 treatment (RDF 125%) followed by F_1 (RDF 100%) and they are statistically at par. The lowest grain number (429.4) was recorded in treatment F_2 (RDF 75%). With same fertilizer doses S_1 treatment was recorded as highest grain number per ears (474.4) followed by S_3 (60 cm X 20 cm) and they are statistically at par. The lowest number of grains per ears (402.6) was recorded in S_2 treatment (45 cm X 20 cm).

The improvement of yield attributes with progressive increase of nitrogen levels was also reported by Ali, (2010) and (Cakmak *et al*., 2010).

Yield

Grain yield (kg ha^{-1})

The grain yield of Pearl millet was significantly affected by different level of fertilizer doses and spacing (Table 7). In main plots, the highest grain yield (1526.1 kg ha^{-1}) was recorded in the F_3 treatment (RDF 125%) followed by F_1 (RDF 100%) and they are significant. The lowest grain yield (1028.9 kg ha^{-1}) was recorded in treatment F_4.

In sub plots, the highest grain yield (1482.9) was observed in S_2 treatment (45 cm X 20 cm) followed by S_1 and they are significant. The lowest grain yield (1147.3 kg ha^{-1}) was observed in S_3 (60 cm X 20 cm) treatment.

In interaction effect, the main plot and sub plot treatments are significant (Table 8). With same level of spacing the highest grain yield (1526.1 kg ha^{-1}) was recorded in F_3 treatment (RDF 125%) followed by F_1 treatment (RDF 100%) and they are statistically at par. The lowest grain yield (1028.9 kg ha^{-1}) was recorded in F_4 treatment (RDF 150%). With same level of fertilizer the highest grain yield (1482.9 kg ha^{-1}) was observed in S_2 treatment (45 cm X 20 cm) followed by S_1 (30 cm X 20 cm) and they are statistically at par. The lowest grain yield (1147 kg ha^{-1}) was observed in S_3 treatment (60 cm X 20 cm).

Table 4: Effect of levels of fertilizer and spacing on No. of ears per sq. m and no of grains per ear of Pearl millet

Treatments	No. of ears per sq. m.	No. of grains per ear	Seed index (g)
Fertilizer Doses			
F_1(100% RDF)	**100196**	**449.4**	**11.27**
F_2(75% RDF)	**89500**	**429.4**	**8.84**
F_3(125% RDF)	**89122**	**479.9**	**10.68**
F_4(150% RDF)	**93739**	**438.4**	**11.93**
SEm(±)	**1218**	**32.74**	**0.294**
CD	**4214**	**NS**	**1.018**
CV	3.92	21.86	3.4604559
Spacing			
S_1(30 cm x20 cm)	**115396**	**474.4**	**9.47**
S_2(45 cm x20 cm)	**90390**	**402.6**	**10.77**
S_3(60 cm x20 cm)	**73632**	**470.8**	**11.80**
SEm(±)	**4152**	**31.44**	**0.323**
CD	**12448**	**NS**	**0.969**
CV	26.52	24.24	2.9979988

Table 5. Interaction effect of fertilizer and spacing on seed index of Pearl millet

Spacing Treatments	No. of ears per sq. m				
	Fertilizer Treatments				
	F_1	F_2	F_3	F_4	Mean
S_1(30 cm x20 cm)	**8.93**	**7.93**	**13.10**	**7.90**	**9.47**
S_2(45 cm x20 cm)	**11.07**	**8.25**	**10.33**	**13.43**	**10.77**
S_3(60 cm x20 cm)	**13.80**	**10.33**	**8.60**	**14.47**	**11.80**
Mean	**11.27**	**8.84**	**10.68**	**11.93**	
	F*S		**S*F**		
$SE_{m (\pm)}$	**0.646**		**0.604**		
CD at 5%	**1.937**		**1.877**		

Table 6: Interaction effect of fertilizer and spacing on No. of ears per sq. m of Pearl millet

Spacing Treatments	No. of ears per sq. m				
	Fertilizer Treatments				
	F_1	F_2	F_3	F_4	Mean
S_1(30 cm x20 cm)	**127294**	**96311**	**127844**	**110133**	**115396**
S_2(45 cm x20 cm)	**97994**	**98000**	**66450**	**99117**	**90390**
S_3(60 cm x20 cm)	**75300**	**74189**	**73072**	**71967**	**73632**
Mean	**100196**	**89500**	**89122**	**93739**	
	F*S		**S*F**		
$SE_{m (\pm)}$	**8304**		**6889**		
CD at 5%	**24896**		**20752**		

Table 7: Interaction effect of fertilizer and spacing on no of grains per ear of Pearl millet

Spacing Treatments	No of grains per ear				
	Fertilizer Treatments				
	F_1	**F_2**	**F_3**	**F_4**	**Mean**
S_1(30 cm x20 cm)	**535.5**	**556.0**	**295.0**	**511.2**	**474.4**
S_2(45 cm x20 cm)	**354.2**	**360.1**	**640.1**	**256.0**	**402.6**
S_3(60 cm x20 cm)	**458.7**	**372.0**	**504.7**	**548.0**	**470.9**
Mean	**449.5**	**429.4**	**479.9**	**438.4**	
	F*S		**S*F**		
$SE_{m\,(\pm)}$	**62.88**		**60.89**		
CD at 5%	**188.5**		**190.7**		

Table 8: Effect of levels of fertilizer and spacing on grain weight and Stover yield of Pearl millet

Treatments	Grain Yield (*kg ha⁻¹*)	Stover Yield (*kg ha⁻¹*)
Fertilizer Doses		
F_1(100% RDF)	**1308.9**	**21746**
F_2(75% RDF)	**1191.3**	**23328**
F_3(125% RDF)	**1526.1**	**27149**
F_4(150% RDF)	**1028.9**	**23246**
SEm($\pm$)	**63.69**	**772**
CD	**220.38**	**2670**
CV	15.12	9.69
Spacing		
S_1(30 cm x20 cm)	**1161.2**	**25844**
S_2(45 cm x20 cm)	**1482.9**	**23724**
S_3(60 cm x20 cm)	**1147.3**	**22034**
SEm($\pm$)	**63.14**	**463**
CD	**189.30**	**1389**
CV	17.31	6.73

Stover yield

Stover yield of Pearl millet was significantly affected by different fertilizer doses and different spacing levels (Table 7). With different fertilizer doses, the highest stover yield (27149 kg ha^{-1}) was produced by the treatment F_3 (RDF 125%) followed by F_2 (RDF 75%) and they are statistically significant. Treatment F_1 (RDF 100%) produced the lowest stover yield (21746 kg ha^{-1}).

In sub plot treatments, the highest stover yield (25844 kg ha^{-1}) was recorded S_1 treatment (30 cm X 20 cm) followed by S_2 (45 cm X 20 cm) and they are significant. The lowest stover yield (22034 kg ha^{-1}) produced by S_3 treatment (60 cm X 20 cm).

In interaction effect, main plot and sub plot treatments are significant (Table 9). With same spacing level the highest stover yield (27148 kg ha^{-1}) produced by F_3 treatment (RDF 125%) followed by F_4 (RDF 150%) and they are significant. The lowest stover yield (21746 kg ha^{-1}) was produced by F_1 treatment (RDF 100%). With same level of fertilizer doses the highest stover yield (25843 kg ha^{-1}) was produce by treatment S_1 (30 cm X 20 cm) followed by S_2 (45 cm X 20 cm) and they are statistically at par. The lowest stover yield (22034 kg ha^{-1}) was recorded in S_3 (60 cm X 20 cm) (Table 10).

Kennedy *et al*., (2002) and Prasad *et al*., (2014) also observed linear increase in grain yield and biological yield of pearl millet with increased nitrogen levels.

Table 9: Interaction effect of fertilizer and spacing on grain yield (kg ha^{-1}) of Pearl millet

Spacing Treatments	Grain Yield (*kg ha^{-1}*)				
	Fertilizer Treatments				
	F_1	**F_2**	**F_3**	**F_4**	**Mean**
S_1(30 cm x20 cm)	**1333.0**	**1051.4**	**1464.7**	**795.7**	1161.2
S_2(45 cm x20 cm)	**1304.0**	**1680.6**	**1807.0**	**1139.8**	1482.9
S_3(60 cm x20 cm)	**1289.6**	**841.8**	**1306.5**	**1151.3**	1147.3
Mean	1308.9	1191.3	1526.1	1028.9	
	F*S		**S*F**		
$SE_{m\ (\pm)}$	**126.28**		**121.19**		
CD at 5%	**378.60**		**378.81**		

Table 10: Interaction effect of fertilizer and spacing on stover yield (kg ha^{-1}) of Pearl millet

Spacing Treatments	**stover yield** (*kg ha^{-1}*)				
	Fertilizer Treatments				
	F_1	**F_2**	**F_3**	**F_4**	**Mean**
S_1(30 cm x20 cm)	**23193**	**25359**	**27963**	**26858**	25843
S_2(45 cm x20 cm)	**20701**	**24138**	**26688**	**23367**	23724
S_3(60 cm x20 cm)	**21343**	**20485**	**26794**	**19512**	22034
Mean	21746	23327	27148	23246	
	F*S		**S*F**		
$SE_{m\ (\pm)}$	**927**		**1081**		
CD at 5%	**2778**		**3495**		

IV. CONCLUSION

Thus, it could be concluded that fertilizer applied @125% RDF (F_3) in combination with spacing of 45cm x 20 cm (S_2) gave the best result with maximum grain yield. This implies that under optimum plant population condition, the fertilizers might be properly utilized by the plants. The optimum fertilizer dose might have positive impact on higher grain yield and higher fertilizer dose might have toxic effect on plant system. However, this is one year data. Further research work is needed for final conclusion of the experiment.

ACKNOWLEDGEMENT

The financial assistance received for this research work from **AICRP on "Pearl Millet", ICAR- Indian Institute of Millet Research, Hyderabad,** is gratefully acknowledged.

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