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Determination of Appropriate Fertilizer Rate and Intra Row Spacing for Biomass of *Pennisetum pedicellatum* in South Omo Zone, South Western Ethiopia

Denbela Hidosa*, Worku Bedeke

Department of Agricultural Research, Southern Agricultural Research Institute, Jinka, Ethiopia

ABSTRACT

This study was conducted at on station of Jinka agricultural research center with objective of identifying appropriate fertilizer rate and spacing for *Pennisetum pedicellatum* grass. The splits of grass were planted on plot area of 4 m × 3 m=12 m^2 under fertilizers rate of 50 kg ha^{-1} DAP and 50 kg ha^{-1} urea (R1); 100 kg ha^{-1} DAP and 150 kg ha^{-1} urea (R2) and 100 kg ha^{-1} DAP and 200 kg ha^{-1} urea respectively with spacing 0.25 cm × 0.5 cm (L1), 0.5 cm × 0.75 cm (L2), 0.75 cm × 1 m (L3) and 1 m × 1.25 m (L4) in randomized completed block design with three replications in factorial arrangements. The results indicated that dry matter yield and tillers per plant were significantly affected ($P<0.05$) by intra row spacing between the L1 and L2, L1 and L3, and L1 and L4; but it was not significantly ($P<0.05$) affected intra row spacing among L2, L3 and L4. The results from the current study also revealed that significantly ($P<0.05$) highest dry matter yield and tillers per plant were obtained for application of 100:150 kg ha^{-1} DAP and urea and but it was not significant ($P>0.05$) for plots that had fertilized with 50:50 kg ha^{-1} DAP and urea and 100:150 kg ha^{-1} DAP and urea respectively. The promising dry matter yield t/ha was obtained from intra row spacing L1 with application of fertilizer rate R2. Therefore, it was recommended that those farmers who live within area where land shortage problem to use finding from our study in order to improve the dry matter production. Whereas, it is better to apply 100:150 kg ha^{-1} DAP and urea for youth/non-employed group and investors who are participated in forage seed production.

Keywords: Dry matter yield; Fertilizer rate; *Pennisetum pedicellatum* grass; Row spacing

INTRODUCTION

Ethiopia is one of the highest livestock populations in Africa. However, its contribution to the national economy and herders' livelihood is low due to different reasons. Among these, the poor nutrition is the most limiting one. Similarly, in to the study area the livestock nutrition is entirely depended on feed from natural pasture. It is apparent that the natural pasture based, livestock production are greatly influenced by the nutritional dynamics of pasture forages, especially during the dry seasons [1]. This is triggering to high mortality, longer calving intervals and substantial weight loss of livestock. In this regards, pursuing a locally adaptable feeds is one of the appropriate strategies to improve dry matter and nutrient supply in to study area. The *Pennisetum pedicellatum* is one which indigenous to the Ethiopia and belonging to the family

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Corresponding author: Denbela Hidosa, Department of Agricultural Research, Southern Agricultural Research Institute, Jinka, Ethiopia; E-mail: denbelahidosa@gmail.com

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of *Poaceae*. The research findings indicated that grass is a perennial which has an extensive root system that anchors well with the soil and has high green biomass production potential which ranging from 30 t/ha-109 t/ha [2]. It grows upright with the potential of reaching up to 90 cm-120 cm based on soil fertility. Conversely, it has been currently utilized as means of soil conservation practices, rehabilitate degraded land, animal feed improve grazing land and provides a small business opportunity.

Moreover, previous findings had been demonstrated that the biomass production potential of *Pennisetum pedicellatum* grass can be influenced by forage management tools such as date of harvesting, height at harvesting and plant spacing. However, with this promising potential, the biomass production potential and agronomic parameter of *Pennisetum pedicellatum* under different fertilizer rate and spacing has not evaluated in to the study area. Therefore, this study was initiated with objective of identifying appropriate fertilizer rate and spacing for production of *Pennisetum pedicellatum* grass [3].

MATERIALS AND METHODS

Description of Study Site

This study was conducted at on station of Jinka agricultural research center in 2015 main cropping seasons. The Jinka agricultural research center was located between 40°43'North to 60°46'North latitude and 350°79'East to 360°06'East longitude and 1450 m above sea level. The average annual rainfall of the study area is 840 mm and the average annual minimum and maximum temperatures are ranging between 16.8°C and 27.8°C. The main rainy fall has been started from March and extends up to June and interrupted by some dry periods in July and August. The soil of the experimental site is loam (**Figures 1 and 2**) [4].

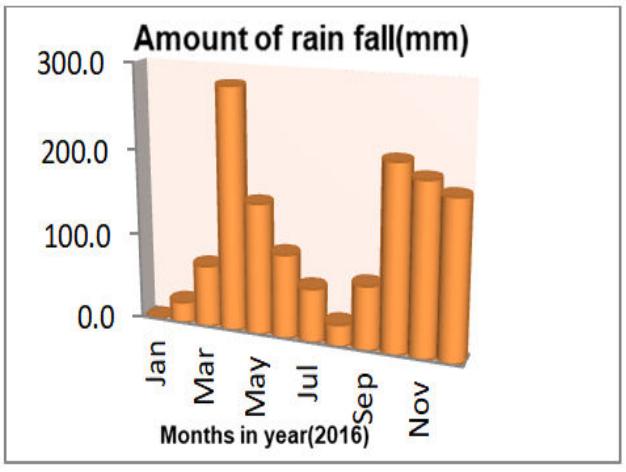

Figure 1: Cumulative amount of rain fall (mm) in to study area during trial period.

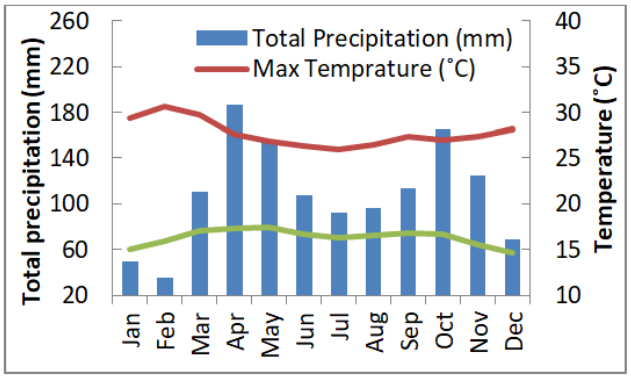

Figure 2: The mean temperature (Temp (°C)) and cumulative precipitation (mm) in to study area during trial year.

Experimental Design and Treatments

The *Pennisetum pedicellatum* grass splits were planted on plot area of 4 m × 3 m=12 m^2 under fertilizer rate 50 kg ha^{-1} DAP and 50 kg ha^{-1} urea (R1); 100 kg ha^{-1} DAP and 150 kg ha^{-1} urea (R2); and 100 kg ha^{-1} DAP and 200 kg ha^{-1} (R3) urea respectively. The intra row spacing used in this study was 0.25 cm × 0.5 cm (L1), 0.5 cm × 0.75 cm (L2), 0.75 cm × 1 m (L3) and 1 m × 1.25 m (L4) between plants and row respectively. The experimental design used in this study was randomized completed block design with fertilizer rate and spacing replicated three times in factorial arrangements [5].

Data Collection and Site Managements

The site managements and harvesting was done according to the recommendations. The growth data like tillers per plant and plant height were measured when plant was at 50%flowering by taking five plants from middle of two rows per plots. Conversely, in order to measure, dry matter yield at 50% flowering, the sample per treatment was taken by randomly placing three quadrants per plot which had an area 0.5 m × 0.5 cm=0.25 m^2 by using the sickle. The harvested samples were measured right in the field and had brought to Jinka agricultural research center and manually chopped in to small pieces using sickle made pooled in to one representative and 500 g allotted in to oven dried at 105°C for overnight. The DM yield was calculated by final oven dried weight was divided for the fresh weight before oven and then multiplied by 100 [6].

Data Analysis

The data such as plant height, tillers per plant and DM yield were subjected to Analysis of Variances (ANOVA) using the General Linear Model (GLM) procedure of Statistical Analysis System (SAS) software. The significant differences among the means of treatments was declared at $P \leq 0.05$ and means were separated using Duncan's Least Significant Difference (LSD) test with model of $Yijk=\mu+Fi+Sj+Hi^{*}Sj+eijk$, where; yijk=all dependent variables (plant height, tiller number per plant and dry matter yield); μ=overall mean; Fi=the effect of i^{th} fertilizer rate; Sj=the effect of j^{th} spacing between plants

and rows; Fi*Sj=the interaction effects of fertilizers rate and spacing and eijk=random error [7].

RESULTS AND DISCUSSION

Dry Matter Yield, Plant Height and Tiller per Plant Affected by Spacing

The dry matter yield, plant height and tillers per plant affected by fertilizer rate and spacing are presented in **Table 1** below. The result revealed that significantly higher (P<0.05) dry matter yield obtained from our study for L1 than L2, L3 and L4 but it was not significant difference (P>0.05) among the L2, L3 and L4. From this study it was observed that the more dry matter yield (t/ha) obtained for closer spacing area than wider spacing areas. This is due to higher plant populations per unity area. The study reported by shown that dry matter yield for *Pennisetum pedicellatum* grass was decrease from 16.5 t/ha to 15.70 t/ha when as spacing area was increased from 10 cm × 50 cm to 50 cm × 50 cm between plant which is corresponds to the results from our study. Meanwhile, also, the from the central rift valley Ethiopia reported that the dry matter yield of the Napier grass was increased from 8.87 t/ha to 11.84 t/ha as spacing between plant decreases from 1 m × 0.5 m to 0.5 m × 0.5 m. While, the study reported by had indicated that the dry matter yield of Napier grass was increased from the 3,383 kg/ha to 4, 209 kg/ha as spacing increased from 50 cm × 50 cm to 75 cm × 7 cm which is contradicted to our result from the current study [8].

The tillering performance is an important morphological characteristic to be considered during selection of appropriate forage crops to improve production and productivity. The findings had obtained from this study shown that the number of tillers per plant were not significantly (P>0.05) differed among the spacing L2, L3 and L4 but significant (P<0.05) between L1 and L2, L1 and L3, and L1 and L4. The maximum tillers per plant were observed from the widest area (1 m × 1.25 m) while the minimum tillers per plant were from the narrowest area (0.25 cm × 0.5 cm). This is clearly exhibited that there was positive correlation which showed that as area of spacing between plants and row increased, the number of tillers were increased. This is due to increases area between plant and rows had allowed the availability of nutrients to the plants freely through reducing competitions among the plant populations. Report had demonstrated that tillers per plant for *Pennisetum pedicellatum* grass were increased from 73.3 to 83.9 when as plant spacing increased from 10 cm × 50 cm to 50 cm × 50 cm respectively which is analogous to results from the our study. Meanwhile, reported that when sufficient space is available to the individual plant, there is capacity to increase the tillers per plant. Moreover, observed the lowest number of tillers at spacing of 10 cm × 10 cm and the highest number of tillers observed at 20 cm × 20 cm spacing which corresponding to results from our study [9].

Plant height is an important component which helps in the determination of growth potential of forage species. The result obtained from this study revealed that there is significance difference (P<0.05) for the plant height between L1 and L2, L1 and L3 and L1 and L4 and but not significance difference (P>0.05) among L2, L3 and L4. The taller plant height for narrowest spacing from this study is due to higher plant populations which lead higher competition for the nutrients which is tends to be longer in height than spread growth. Reported that plant height of *Pennisetum pedicellatum* grass decreased from 67.30 cm to 65.70 cm as plant spacing increased from 10 cm × 50 cm to 50 cm × 50 cm respectively which is similar to results from the our finding. Moreover, reported that a narrow intra-row spacing of 10 cm produced taller height in finger millet plants than 20 cm intra row spacing which is corroborated to finding from our study. On the other hands, the study reported by different authors who demonstrated that at wider plant spacing higher plant height than narrowest spacing which is contradicted to results obtained from our study. In general, findings obtained from the current study for height of *Pennisetum pedicellatum* grass L1 was relatively comparable to values of 90 cm-120 cm under different management practices in Ethiopia conditions [10].

Table 1: The main effect of spacing on dry matter, tillers per plant and plant height of Desho grass.

	Plant spacing					
Parameters	**0.25 × 0.5 cm**	**0.5 × 0.75 cm**	**0.75 × 1 m**	**1 m × 1.25 m**	**CV**	**LSD**
DM t/ha	27.195^{a}	22.013^{b}	20.84^{b}	21.592^{b}	5.7	3.62
Plant height (m)	105.67^{a}	78.12^{b}	77.88^{b}	69.46^{b}	4.89	19.95
Tiller per plant	88.08^{b}	105.98^{ab}	111.63^{a}	120.08^{a}	5.29	27.25

Dry Matter Yield, Plant Height and Tillers per Plant Affected by Fertilizer Rate

The effect of fertilizer rate on dry matter yield, tillers per plant and plant height are presented in **Table 2** below. The result from this study revealed that significantly (P<0.05) highest dry matter yield was obtained from the land fertilized with 100:200 kg ha^{-1} DAP and urea and but not significant (P>0.05) for land had received 50:50 and 100:150 kg ha^{-1} DAP and urea respectively. The highest dry matter yield for the plots fertilized with 100 kg ha^{-1} DAP and 200 kg ha^{-1} urea is due to sufficient provision of nitrogen and phosphorus that enhances photosynthetic process by the plants and hence more vegetative production and dry matter yield. The study made by indicated that the dry matter

yield of oat was significantly increased from 15.85 t/ha to 23.07 t/ha as nitrogen fertilizer rate increased from the 40 kg ha-^{1} to 80 kg ha^{-1} respectively which supports the findings from the our study [11]. Conversely, significantly higher (P<0.05) tillers per plant were observed for the land fertilized with 100 kg ha-^{1} DAP and 200 kg ha^{-1} urea than land fertilized with 50:50 kg ha^{-1} and 100:150 kg ha^{-1} DAP and urea but not significant (P>0.05) for land received 50:50 kg ha^{-1} and 100:150 kg ha^{-1} DAP and urea. The higher tillers per plant for land fertilized with 100 kg ha-1 DAP and 200 kg ha^{-1} urea is due to higher amount of fertilizer enhanced the production vegetative growth and allowed to cover more space on ground which promoted absorption of sun light and hence the assimilation process. The report had demonstrated that tillers per plant was significantly increased as nitrogen fertilizer rate increased which is supports findings from our study. Likewise, also, observed the higher increment tillers per onion plant as increasing nitrogen fertilizer rates. In general, higher tillersper plant of Desho grass from the current study than the values of 48 and 50 reported for the same plant. The longer plant height (P<0.05) was observed for the land fertilized with 50 kg ha^{-1} DAP and 50 kg ha^{-1} urea respectively than land fertilized with 100:150 and 100:200 kg ha^{-1} DAP and urea. The longer in height (cm) for land fertilized with 50 kg ha^{-1} DAP and 50 kg ha^{-1} and urea than land fertilized with 100:150 and 100:200 kg ha^{-1} DAP and urea from this study might be due to either difference in soil parameters or agroecology difference in experimental site. They had been observed that land fertilized with 69 kg ha^{-1} increased plant height by about 10% but further application did not triggering the further increments in plant height. In contradicting to results from our study, the earlier research reports were shown that increments in plant height of crops as increase nitrogen rates [12].

Table 2: The main effect of fertilizer rate (DAP: Urea) on dry matter, tillers per plant and plant height.

Parameters	Fertilizer rate					
	50:50 kg ha^{-1}	100:150 kg ha^{-1}	100:200 kg ha^{-1}	0:0	CV	LSD
DM yield t/ha	23.97^{a}	24.89^{a}	28.64^{b}	15.15^{c}	8.98	5.67
Plant height (cm)	135^{a}	93.5^{b}	96.87^{b}	73^{c}	9.52	41.23
Tillers per plant	110^{a}	115^{a}	140^{b}	84^{c}	12.33	32.45

Interaction Effects of Spacing and Fertilizer Rates on Plant Height

The least square means of interaction effect of fertilizer rate and spacing on plant height is presented in **Table 3** below. The results from this study indicated that plant height was significantly affected by fertilizer rate and intra row spacing. However, dry matter and tillers per plant were not affected by fertilizer rate and intra row pacing and it is not presented under this section. The result obtained from this study shown that plant height is significantly (P<0.05) decrease as intra row spacing was increased by the keeping the constancy in fertilizer rate and while, plant height is increased as fertilizer rate increased by keeping intra row spacing as constant. Generally from the this study, the interaction effect of fertilizer rate and intra row spacing indicated that higher plant height was observed for closer area with higher fertilizer rate application while the shortest plant height was observed for widest area with fertilizer rate of 100:150 kg ha^{-1} DAP and urea respectively. The tallest plant height at closer area with higher dose of fertilizer rate is due to combination effect which attributed to increasing fertilizer rate may be the increase availability of nitrogen in the soil for uptake by plant roots that may have enhanced vegetative growth through increasing cell division and elongations. The study made by were confirmed that increased rate of nitrogen application and intra row spacing had induced an increase in plant height of onion plant which is corresponds to findings from our study [13].

Table 3: Interaction effects of spacing and fertilizer rates on plant height (cm).

Spacing	Fertilizer rate				
	50:50 kg ha^{-1}	100:150 kg ha^{-1}	100:200 kg ha^{-1}	00:00	LSD
0.25 m × 0.5 m	105.28^{b}	103.73^{b}	155.48^{a}	80.21^{c}	62.3
0.5 m × 0.75 m	97.85^{bc}	90.63^{bc}	104.00^{ade}	76.15^{f}	8.34
0.75 m × 1 m	87.48^{bc}	68.17^{de}	102.2^{a}	65.68^{e}	16.78
1 m × 1.25 m	71.33^{de}	64.92^{de}	86.67^{ac}	58.33^{ef}	18.54

CONCLUSION

Result from this study revealed that the dry matter yield and plant height were decreased as increase intra row spacing between plant but tillers per plant increased as intra row spacing increases. Moreover, also, dry matter yield and tillers per plants increased as fertilizer rate increase but plant decreased as fertilizer rate increase. The promising dry matter yield t/ha was obtained from intra row spacing (0.25 cm × 0.5 cm) with application of fertilizer rate 100:150 kg ha^{-1} DAP and urea respectively. Therefore, it was recommended that those farmers who live within area where land shortage problem to use finding from our study in order to improve the dry matter production. Whereas, it is better to apply 100:150 kg ha^{-1} DAP and urea for youth/non-employed group and investors who are participated in forage seed production. Moreover, the information such as chemical compositions, leaf to stem ratio and feeding values of *Pennisetum pedicellatum* grass under different spacing and fertilizer rate which is not studied in the current study due to lack of budgets should be studied in future in order to fill this research gaps.

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