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EFFECTS OF PLANTING DENSITY ON THE GROWTH AND FORAGE YIELD OF TWO VARIETIES OF MILLET (*PENNISETUM TYPHOIDES* BURM. F.) GROWN IN EKPOMA, NIGERIA.

EFECTOS DE LA DENSIDAD DE SIEMBRA EN EL CRECIMIENTO Y RENDIMIENTO DE FORRAJE DE DOS VARIEDADES DE MIJO (*PENNISETUM TYPHOIDES* BURM. F.) CULTIVADAS EN EKPOMA, NIGERIA.

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ABSTRACT

A field study was carried out during the 2016 cropping season to determine the effect of planting density on the growth and yield performance of two varieties of millet at Ekpoma. Gero Badeggi and Gero Bida varieties were sown at three densities (111,111, 222,222 and 333,333 plants ha^{-1}). The experiment was a 2 x 3 factorial scheme laid out in a randomized complete block design (RCBD) with three replicates. The result shows that planting density had no significant effect on the growth parameters measured. However, Gero Badeggi planted at 111,111 plants ha^{-1} had the tallest plants, highest number of leaves/plant and stem girth while Gero Bida planted at 333,333 plants ha^{-1} gave the shortest plants, least number of leaves/plant and stem girth, respectively. There was no significant difference in flowering trait amongst densities, but the varieties differed markedly in days to 50% flowering. Increasing planting density significantly ($P<0.05$) increased the forage yield. However, crops sown at higher densities had higher forage yield than the low density. The differences observed between varieties were significant in some of the studied characters and thus millet sown at 111,111 and 333,333 plants/ha is recommended for millet production in the area.

Keywords: Millet, planting density, growth and forage yield.

RESUMEN

Se llevó a cabo un estudio de campo durante la temporada de cultivo de 2016 para determinar el efecto de la densidad de siembra en el crecimiento y el rendimiento del rendimiento de dos variedades de mijo en Ekpoma. Las variedades Gero Badeggi y Gero Bida se sembraron en tres densidades (111,111, 222,222 y 333,333 plantas ha-1). El experimento fue un esquema factorial 2 x 3 establecido en un diseño de bloques completos al azar (RCBD) con tres repeticiones. El resultado muestra que la densidad de siembra no tuvo un efecto significativo sobre los parámetros de crecimiento medidos. Sin embargo, Gero Badeggi sembrado en 111,111 plantas ha-1 tenía las plantas más altas, el mayor número de hojas / planta y circunferencia del tallo, mientras que Gero Bida sembró en 333,333 plantas ha-1 dio las plantas más cortas, el menor número de hojas / planta y circunferencia del tallo, respectivamente. . No hubo diferencias significativas en el rasgo de floración entre las densidades, pero las variedades diferían notablemente en días a 50% de floración. El aumento significativo de la densidad de siembra (P <0.05) aumentó el rendimiento del forraje. Sin embargo, los cultivos sembrados a densidades más altas tuvieron un mayor rendimiento de forraje que la baja densidad. Las diferencias observadas entre las variedades fueron significativas en algunos de los caracteres estudiados y, por lo tanto, el mijo sembrado en 111,111 y 333,333 plantas / ha se recomienda para la producción de mijo en el área.

Palabras clave: mijo, densidad de siembra, crecimiento y rendimiento de forraje.

INTRODUCTION

Millet (*Pennisetum typhoides* Burm .F.) is a crop of the driest regions of the world grown mainly for grain and forage yield for both human and livestock consumption (Van Oostern et al. 2002). There seems little doubt that tropical Africa is the home of millet, but reported to have originated in the semi-arid savannah of Africa, where the greatest numbers of wild and cultivated forms occur (Andrew and Kumar 1992). Millet thrives well where other cereals (maize, sorghum, wheat etc.) cannot grow because of drought. Millet is an erect annual grass, reaching up to 3m in height with a profuse root system. It can be found in regions where annual rainfall ranges from 250-900 mm and temperature from 21^{o}C -35^{o}C. Millet is known to tolerate acid sandy soils and is able to grow on saline soils (Amodu et al. 2005).

Most farmers in the humid tropics grow their crops at wide and random spacing because of the system of cropping, which involves growing two or more crops together.

These crops are introduced onto a piece of land at various times, and allowance is usually made for such introductions. However, as management practices improve and more farmers grow their crops sole, specific plant populations are more likely to be used (Kamal et al. 2013).

Millet has great potentials in the tropics and forage yield of up to 74.31 t/ha can be obtained in the savanna zones of Nigeria if the crop is properly managed (Saifullah et al. 2011). Unfortunately, yields are still generally low. Forage yield differences in tropical areas have been attributed, among other factors, to excessive plant height, leafiness and inefficient transfer of assimilates to the flowers (Raslan et al. 2016). This is partly due to the fact that plants with efficient architecture with erect leaves capable of responding to high density and other improved cultural practices have not been developed in the tropics.

Planting population density exerts a strong influence on millet growth and forage yield. The density of planting depends on variety, the cropping system to be adopted, climatic and soil conditions. The importance of plant density as a factor determining growth and forage yield of millet has been well established elsewhere (Abd El-latlef 2011 and Ahmed et al. 2011) but only a few reports are available in the tropics. In deciding on the optimum population level for a particular variety, the agronomist has to take into consideration the total agro-ecosystem with special reference to such factors as soil moisture and fertility. Millet is a crop of northern Nigeria as food for humans and forage for livestock. There is tremendous increase in ruminant herding which has brought Hausa/Fulani herdsmen who have become residents in this zone (Omoregie 2015). In recent time, uncontrolled grazing by these herds has brought conflict between herdsmen and crop farmers in the area of study. However, there is need to produce forage crops to meet the forage requirements for the increasing livestock population in the forest- savanna transition zone. Hence, this study, examined the effect of planting density on growth and forage yield of two local varieties of millet in Ekpoma, Nigeria.

MATERIALS AND METHODS

Experimental site: A field study was carried out during the 2016 rainy season in a forest-savannah transition zone of Edo State (Lat. 6^{o} 45^{I} N and Long. 6^{o} 08^{I} E). The area has a mean air temperature of 29^{o}C, relative humidity of 70%, sunshine of about 5-7 hours/day and a mean annual rainfall of 1200-1500 mm (Ighalo and Remison 2010).

Gero Bida and Gero Badeggi varieties of millet used were obtained from National Cereals Research Institute Badeggi, Niger State, Nigeria. The seeds were sown on 10th May 2016, using a 2 x 3 factorial scheme fitted into a Randomized Complete Block Design (RCBD) with three replicates. The two varieties were sown at three densities (10 x 30, 15 x 30 and 30 x 30 cm) to give populations of about 111,111, 222,222 and 333,333 plants/ha, respectively, after thinning. A total of eighteen (18) plots were involved.

The plot size was 1.5 m x 2 m with a spacing of 1 m within plots and between replicates. A land area of 6 × 9 m to give a total of 54 m^2 (0.01 ha) was used. Weeds were controlled by hoe weeding at 3 and 7 weeks after planting.

Growth Attributes: A sample of four plants per plot was taken at two middle rows at two weeks intervals until crops were harvested to measure the following parameters. Plant height (cm) was taken as the height of the main culm from ground level to the tip of the plant. This was taken with a measuring tape, while the number of leaves per plant was determined by visual counting. The stem girth (cm) was measured by using a digital vernier caliper at 2 cm above ground level.

Total leaf area per plant (cm^2) was estimated from leaf length multiplied by the greatest width, multiplied by a constant 0.75 (Remison and Lucas 1981, Remison 1990 and Omoregie and Nwajei 2015) and there after multiplied by total number of leaves/plant.

Flowering Trait: Days to 50% flowering were taken as the number of days from sowing to the time when 50% of the plants population produced flowers.

Yield Attribute: After flowering, four plants were harvested at 2 cm above ground level from two middle rows in all plots to determine the forage yield. The final forage yield (t/ha) was determined as:

$$\text{Forage yield (t/ha)} = \frac{\text{Forage weight (kg) of plot}}{\text{Harvested plot area (m}^2\text{)}} \times \frac{10000\ \text{m}^2}{1000}$$

Data analysis: Data on growth and forage yield obtained were computed using GenStat Version 15.2 (2012) software programme and the means separated using Duncan's Multiple Range Test (DMRT) at 5% level of probability.

RESULTS AND DISCUSSION

Vegetative parameters - Plant height: Plant population had no significant difference on plant height throughout the weeks sampled, but the varieties differed significantly (Table 1). This observation supports the work of Kamal et al. (2013) who reported that planting density had no significant effect on plant height. At 10 WAP, Gero Badeggi planted at 111,111 plants/ha had the tallest plants (183.33 cm) while Gero Bida sown at 333,333 plants/ha had the shortest plants (152.61 cm). Generally, Gero Badeggi variety had significant taller plants than Gero Bida. The differences among varieties in plant height had been reported by Uzoma et al. (2010).

Number of leaves/plant: The number of leaves/plant increased with the advancement of plant growth from 2-10 WAP in both varieties except in Gero Bida from 8 – 10 WAP (Table 2). The lower plant populations had higher number of leaves/plant than plants with higher population. At 10 WAP, Gero Badeggi planted at 111,111 plants/ha had the highest number of leaves/plant (11.25) while Gero Bida at 333,333 plants/ha had the

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least (8.42). In all, Gero Badeggi had higher number of leaves than the Gero Bida variety. The higher number of leaves/plant produced at low population was due to competition among crowded plants for light, water and nutrients. The observation in this study conforms with the results of Maas et al. (2007) and Kamal et al. (2013) who reported that plant spaced equidistantly from each other compete minimally for height and nutrients. The variation in number of leaves/plant between varieties might be due to genotype.

Table 1: Effects of planting density on the plant height (cm) of two varieties of millet

Crop variety	Planting density (Plants/ha)	Weeks after planting				
		2	4	6	8	10
Gero Badeggi	111,111	4.72^{a}	7.31^{ab}	27.82	96.26	183.33^{a}
	222,222	4.04^{ab}	6.40^{bc}	24.98	73.96	162.42^{ab}
	333,333	4.22^{ab}	7.43^{a}	25.57	79.87	168.75^{ab}
	Mean	4.33	7.05	26.12	83.36	171.50
Gero Bida	111,111	3.81^{b}	6.53^{abc}	34.08	112.46	160.00^{ab}
	222,222	3.80^{b}	6.77^{c}	43.07	112.77	153.17^{b}
	333,333	3.77^{b}	6.52^{abc}	35.63	111.35	152.61^{b}
	Mean	3.79	6.61	37.59	112.19	155.26
	SL					
	Variety	*	*	*	*	*
	Planting density	ns	*	ns	ns	ns
	Interaction (VxP)	*	*	ns	ns	*

Values with same superscript(s) indicated in columns are not significantly different at 50% level of probability using Duncan's multiple range tests; SL: Significant level; *: Significant at 5% level; ns: not significant; V: Variety; P: Planting density.

Total leaf area: Planting density did not significantly affect the total leaf area/plant of millet. The total leaf area/plant increased from 2 – 10 WAP in both varieties (Table 3). At 10 WAP, Gero Badeggi at 111,111 plants/ha had the highest (5229.15 cm^2) total leaf area/plant while Gero Bida at 222,222 plants/ha had the least (3981.48 cm^2). In all, Gero Badeggi had higher value than Gero Bida. Increasing population density decreased total leaf area. However, crops sown at low density had greater leaf area than those at higher populations. The greater total leaf surface area observed in crops sown at low density may be due to fewer canopy cover which permits light penetration for photosynthesis. Similar results were reported by Maas et al. (2007) and Saifullah et al. (2011) that planting density did not significantly affect leaf area of millet.

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Table 2: Effects of planting density on the number of leaves/plant of two varieties of millet

Crop variety	Planting density (Plants/ha)	Weeks after planting				
		2	4	6	8	10
Gero Badeggi	111,111	4.38	5.50	9.00[ab]	10.58	11.25[a]
	222,222	4.25	5.83	8.17[bc]	10.17	11.00[a]
	333,333	4.08	5.58	9.83[a]	10.67	9.83[ab]
	Mean	4.22	5.64	9.00	10.47	10.69
Gero Bida	111,111	4.42	6.08	7.36[c]	11.00	9.52[ab]
	222,222	4.50	5.75	9.75[a]	11.00	8.92[b]
	333,333	4.08	5.33	7.35[c]	10.83	8.42[b]
	Mean	4.33	5.72	8.16	10.4	8.97
	SL					
	Variety	ns	ns	*	ns	*
	Planting density	ns	ns	ns	ns	ns
	Interaction (VxP)	ns	*	*	ns	*

Values with same superscript(s) indicated in columns are not significantly different at 5% level of probability using Duncan's multiple range tests. SL: Significant level; *: Significant at 5% level; ns: not significant; V: Variety; P: Planting density

Table 3: Effects of planting density on the total leaf area/plant (cm^2) of two varieties of millet

Crop variety	Planting density (Plants/ha)	Weeks after planting				
		2	4	6	8	10
Gero Badeggi	111,111	27.54	339.39	2496.78	4840.80[a]	5229.15
	222,222	28.69	318.71	1771.83	2988.57[b]	4850.20
	333,333	26.76	336.53	2115.34	2592.90[b]	4291.63
	Mean	27.66	331.54	1493.32	3474.09	4790.33
Gero Bida	111,111	31.94	354.60	2459.53	3988.40[ab]	5139.71
	222,222	28.96	381.74	2221.55	2981.48[ab]	3447.92
	333,333	27.49	321.99	2625.62	4335.48[a]	4425.67
	Mean	29.60	352.78	2435.57	3768.45	4337.77
	SL					
	Variety	Ns	ns	ns	*	ns
	Planting density	Ns	ns	ns	ns	ns
	Interaction (VxP)	Ns	ns	ns	*	ns

Values with same superscript(s) indicated in columns are not significantly different at 5% level of probability using Duncan's multiple range tests; SL: Significant level; *: Significant at 5% level; ns: not significant; V: Variety; P: Planting density.

Stem girth: In this study, planting density exerts no significant effect on stem girth (Table 4). The stem girth increased from 2 – 10 WAP in both varieties. At 10 WAP, Gero Badeggi planted at 111,111 plants/ha had the highest (1.92 cm) stem girth while Gero Bida at 333,333 plants/ha had the least (1.32 cm). On the whole, Gero Badeggi had higher stem girth than Gero Bida. The dominance of lower densities over the high population may be attributed to the better soil moisture availability, decreased plant competition and increased light penetration. This is in line with Posental et al. (1993) who attributed this result to moisture availability, decreased population and increased light penetration through plant canopy at a lower plant population.

Days to 50% flowering: The results on days to 50% flowering and forage yield of millet are presented in Table 5. Planting density had no significant effect on days to 50% flowering. Gero Badeggi planted at 111,111 plants/ha took more days (76.33 days) to 50% flowering while Gero Bida at 333,333 plants/ha had the least (61 days). On the whole, Gero Badeggi flowered later and differed significantly from Gero Bida. Differences among varieties in respect of time to 50% flowering were reported by Posental et al. (1993), Mass et al. (2007).

Table 4: Effects of planting density on the stem girth cm of two varieties of millet

Crop variety	Planting density (Plants/ha)	Weeks after planting				
		2	4	6	8	10
Gero Badeggi	111,111	0.33[ns]	0.68[ns]	1.31[ns]	1.62[ns]	1.92[a]
	222,222	0.29	0.54	1.33	1.45	1.59[ab]
	333,333	0.33	0.73	1.29	1.46	1.60[ab]
	Mean	0.32	0.65	1.31	1.51	1.70
Gero Bida	111,111	0.32	0.66	1.36	1.48	1.60[ab]
	222,222	0.35	0.65	1.28	1.30	1.32[ab]
	333,333	0.28	0.66	1.35	1.32	1.29[b]
	Mean	0.32	0.66	1.33	1.37	1.41
	SL					
	Variety	ns	ns	Ns	ns	ns
	Planting density	ns	ns	Ns	ns	ns
	Interaction (VxP)	ns	ns	Ns	ns	*

Values with same superscript(s) indicated in columns are not significantly different at 5% level of probability using Duncan's multiple range test. SL: Significant level; Significant at 5% level; ns: not significant; V: Variety ; P: Planting density

Forage yield: Forage yield of millet was significantly affected by planting density (Table 5). Increasing population density significantly (P<0.05) increased forage yield. Millet sown at higher populations had a higher forage yield than those at lower populations. However, Gero Badeggi planted at 333,333 plants/ha had the highest forage yield (61.45 t/ha) while Gero Bida at 111,111 plants/ha had the least (31.99 t/ha). In summary, Gero Badeggi had higher forage yield than Gero Bida. This result is in agreement with the findings of Jimba and Adedeji (2003), Sneider et al. (2012) who reported significant differences in forage yield among planting densities.

Generally, increasing plant density reduced individual components size presumably due to inter-plant competition. Number of leaves/plant was not only reduced with increasing planting density in Gero Bida, but also with time due to leaf senescence. Posental et al. (1993) reported that leaves senesced faster with increased plant density due, apparently, to increased shading of the lower leaves at higher densities. The dominance of low density over higher densities in growth characters were as a result of adequate moisture and increased light penetration while the supreme performance of higher densities with forage yield was due to rapid transfer of assimilates to flowering sites and remobilization of stem assimilates.

Table 5: Effects of planting density on days to 50% flowering and forage yield of two varieties of millet

Crop variety	Planting density (Plants/ha)	Days to 50% flowering	Forage yield (t/ha)
Gero Badeggi	111,111	76.33[a]	22.06[c]
	222,222	68.33[ab]	49.42[ab]
	333,333	68.09[ab]	61.45[a]
	Mean	70.89	43.64
Gero Bida	111,111	64.67[b]	13.75[c]
	222,222	63.67[b]	31.99[bc]
	333,333	61.00[b]	53.05[a]
	Mean	63.11	31.75
	SL		
	Variety	*	ns
	Planting density	ns	*
	Interaction (VxP)	*	*

Values with same superscript(s) indicated in columns are not significantly different at 5% level of probability using Duncan's multiple range tests; SL: Significant level; *: Significant at 5% level; ns: not significant; V: Variety; P: Planting density

It can be concluded from the study that planting millet at 333,333 plants/ha was more favourable for fresh forage yield and thus recommended for forage production for feeding ruminants in the area.

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