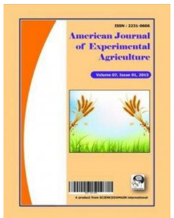

American Journal of Experimental Agriculture
7(6): 373-381, 2015, Article no.AJEA.2015.137
ISSN: 2231-0606

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Growth Response of Guinea Grass (*Panicum maximum*) to Cutting Height and Poultry Manure

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Authors' contributions

This work was carried out in collaboration between all authors. Authors CCO and CCN designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors CCO and CCN reviewed the experimental design and all drafts of the manuscript. Authors CCO and CCN managed the analyses of the study. Author CCN performed the statistical analysis. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEA/2015/16424
Editor(s):
(1) Anonymous.
Reviewers:
(1) Valentin Ivanov Kosev, Institute of Forage Crops, Pleven, Bulgaria.
(2) Lucas R. Petigrosso, National University of Mar del Plata, Argentina.
(3) Anonymous, Brazil.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=920&id=2&aid=8572

Original Research Article

Received 1st February 2015
Accepted 23rd February 2015
Published 24th March 2015

ABSTRACT

A field experiment conducted in 2014 at Nsukka, Nigeria was aimed to study the effect of cutting height and poultry manure on the growth of *Panicum maximum.* Nine treatments were evaluated as factorial combinations of poultry manure applied at 0, 5 and 10 ton ha^{-1} and cutting heights of 5, 10 and 15 cm. The treatments were fitted into in a randomized complete block design (RCBD), replicated three times. The research was conducted during the period of March to September, 2014 at the Teaching and Research Farm of the Department of Crop Science, Faculty of Agriculture, University of Nigeria, Nsukka. Grass cover and tiller number were significantly increased with 10 ton ha^{-1} poultry manure compared with the control. Dry matter content and bare ground area reduced with increased application of poultry manure. Cutting at 15 cm significantly produced taller plants than 5 cm but statistically the same with 10 cm height of cut. A combination of 10 cm cutting height and 10 ton ha^{-1} of poultry manure gave greater tiller population per m^2 than 5 cm with zero poultry manure. However application of 10 ton ha^{-1} of poultry manure with harvest at either 10 or 15 cm produced higher growth establishment of the grass.

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Keywords: *Panicum maximum; poultry manure; cutting height; growth; Nigeria.*

1. INTRODUCTION

Panicum maximum is an extremely variable species; loosely to densely tufted, shortly rhizomatous, erect or geniculately ascending, rooting at the lower nodes [1]. Leaf blades linear to narrowly lanceolate; panicle open, oblong or pyramidal, with secondary branches well developed and flexuous; spikelets oblong, blunt or acute, rounded on the back [1]. It remains one of the best cultivated grasses for the tropics and is used extensively for forage purposes [2]. In the last 10 years, clashes have occurred between the herdsman and farmers in many parts of the country Nigeria. Incessant clashes between Fulani herdsman and local farmers from North to south of the country has claimed many lives [3]. Climate change has partly been blamed. About 35 percent of land that was cultivable 50 years ago is now desert in 11 of Nigeria's northern states [4]. The root of the conflict has been path of grazing / encroachment of grazing land. Shortage of pastures has compelled these herdsmen to allow their cattle, graze in cultivated farmlands. Most pastures in Nigeria lack proper management in terms of optimum defoliation and fertilization. They are often subjected to burning and extreme grazing, which have been shown to result in serious deterioration of pastures [5]. The ultimate panacea to this problem is the establishment of sown and maintained pastures. There is also the need to improve pastures through good management. Such management practices include the use of fertilizers and cutting management [6]. Improved management practices require many inputs which are not commonly used in natural grassland livestock production system. Therefore to be more readily acceptable, the system must not be capital intensive and must require little new technology [7]. Under such circumstances, improvement of pastures through application of poultry manure and cutting management could be useful alternatives.

The regrowth after defoliation is one of the most important physiological processes and it determines the sward structure [8]. Grasses form the foundation of forage–livestock systems around the world because they can be consumed and converted by animals into useful products. Consumption assumes the grass is harvested directly through grazing, or by machine for green chop, silage, or hay. Knowing when and how to harvest for optimal forage quantity and quality while safeguarding the persistence of stands require an understanding of grass growth and regrowth mechanism [9]. Grasses can be most productive when clipped with mowers or bitten by animals. Defoliation can be productive or destructive. The effect on grass productivity of differential cutting heights is conflicting. For optimum growth following defoliation there must be cell division and expansion in certain meristem systems. Knowledge about the location and specific function of these meristems is critical for successful forage management [10].

Poultry manure is a valuable source of plant nutrients and organic matter and when used as a fertilizer, will improve crop and forage production and soil quality [11]. The use of inorganic fertilizer has not been helpful under intensive agriculture because it is often associated with reduced crop yield, soil acidity and nutrient imbalance [12-14]. Soil degredation which is brought about by loss of organic matter accompanying continuous cropping becomes aggravated when inorganic fertilizer are applied repeatedly. This is because crop response to applied fertilizer depends on soil organic matter [15]. The rising cost of inorganic fertilizers coupled with their inability to recondition the soil has directed attention to organic manures in recent times [16]. Poultry manure is very cheap and effective as a good source of N for fertilization, but its availability remain an important issue due to its bulky nature, while inorganic fertilizer is no longer within the reach of poor resource farmers due to its high cost [17]. Moreover, the need and utilization of poultry manure has overtaken the use of other animal wastes, because of its high content of nitrogen, phosphorus and potassium [18]. Furthermore, poultry manure is preferred amongst other animal wastes because of its high concentration of macro nutrients [19-21]. The quantity of organic material which can be introduced into the soil either by natural returns through roots, stubbles, slough off root nodules and root exudates or by artificial application in the form of organic fertilizer, determines crop growth response [22].

Nevertheless poultry manure differs in quality and pasture response to poultry manure fertilization also differs to soils and among location. Consequently, recommendation for organic fertilizer based on result from a particular experiment may not always be suitable for all growing conditions in every location [23]. Therefore, the objective of this study is to determine the effect of cutting height, poultry manure and the best combination of the two on the growth of *Panicum maximum* grown in Nsukka, Nigeria.

2. METHODOLOGY

2.1 Study Area and Sampling

The experiment was conducted at the Teaching and Research Farm of the Department of Crop science, faculty of Agriculture, University of Nigeria, Nsukka. Nsukka is located at latitude 06º52'N and longitude 07º24'E, and altitude of 447.2m above sea level. It is characterized by the low land humid tropical conditions. The soil is classified as an ultisol [24]. The guinea grass (*Panicum maximum*) experiment was established in 2014 (March-April). The experiment was a 3x3 factorial laid out in a Randomized Complete Block Design and was replicated three times. Treatments comprised three cutting heights of 5, 10, and 15 cm and three levels of poultry manure (PM) at 0, 5, and 10 ton ha^{-1}. The land measuring 22.5 meters long by 10 meters wide with an area of 225 m2 was marked out into three blocks of 20.5 m x 2 m each. Each block was further divided into 9 plots of 2 m x 1.8 m. Each block was separated by 1 m pathway, while the plots were demarcated by 0.5 m pathway within the blocks. The three levels of poultry manure were applied to their respective plots and rooted cuttings of *Panicum maximum* with height of 15 cm planted with the spacing of 20 cm x 30 cm. Manure treatment effect alone was considered during the establishment period (first general harvest). Plant scoring of the plots was done before any harvest to determine the extent of cover by the grass species, the weed species and bare ground cover. Scoring was done using five grading score for subjective evaluation [25]. Cutting was carried out every 5 weeks with shears, aided by a wooden block at varying heights. A quadrant of 1 m x1 m square was used to determine the sampling area.

2.2 Data Collection Technique

Plant height was taken using the mean of three readings taken at random from the sample area in each plot. Tiller counts were made in each plot using a 25 cm square quadrant. The mean of three throws per plot was used to calculate tiller population per m^2. Sub samples of the grass species weighing 100 g were put in a paper envelop and dried in a force air oven set at 80ºC and weighed after attaining constant dry weight. These were used to calculate the dry matter content of grass species as follow:

$$\text{Dry matter content \%} = \frac{\text{Dry weight of sample (g)}}{\text{Sample fresh weight (g)}} \times \frac{100}{1}$$

2.3 Statistical Analysis

All data collected were statistically analyzed using GENSTAT (2008) statistical package [26]. Separation of treatment means for statistical significance was done using the least significant difference (LSD) as outlined by Obi [27].

3. RESULTS

Increased application rate of poultry manure gave higher grass height and tiller number of *Panicum maximum* during the first general harvest (Table 1). The extent of weed cover was significantly ($P < .05$) high with no application of poultry manure. Bare ground cover was highest at 0 ton ha^{-1} compared to 5 or 10 ton ha^{-1} of poultry manure. Grass cover increased with higher rates of poultry manure (Table 1).

Grass dry matter content was not significantly influenced by either cutting height or poultry manure application in the second and third harvest periods (Table 2). However, interaction of cutting height at 10 cm with 5 ton ha^{-1} of poultry manure, significantly gave highest dry matter content compared to harvest at 5 cm with application of poultry manure at 10 ton ha^{-1}.

Table 1. Treatments effect on the growth parameters measured at the first general harvest

PM ($tonha^{-1}$)	PH	TN	GDMC	GC	WC	BG
0	72.67	130.2	20.6	2.4	1.67	1.4
5	91.9	180.6	23.7	3.2	1.44	1.0
10	89.9	198.0	30.3	4.0	1.56	1.0
$LSD_{0.05}$	11.87	35.54	2.88	0.54	NS	0.33

PM = poultry manure; PH = plant height; GDMC = grass dry matter content; TN = tiller number; GC = grass cover; WC = weed cover; BG = bare ground cover; NS = Non- Significant F- test at 5% probability level

Increase in height of cut above ground significantly increased grass height in the second and third harvest periods (Table 3). Cutting height of 15 cm gave higher grass height over 5 cm. However harvest at 15 and 10 cm were statistically the same. Grass height increased with higher application of poultry manure. Furthermore, Poultry manure and cutting height interaction significantly affects the grass height. Harvesting at height of either 10 or 15 cm with application of poultry manure at 10 ton ha-^{1} significantly increased height of grass compared to harvest at 5 cm above ground with no poultry manure application. Moreover, during the second and third harvest period, the grass heights were highest when harvested at 15 cm above ground and poultry manure applied at rate of 10 ton ha-^{1}.

Grass tiller number per square meter was reduced (P > .05) with lower cutting height (Table 4). There was a significant increase in the number of tillers per square meter with application of poultry manure compared to control. Meanwhile, the highest tiller number was obtained in both periods when harvest was done at 10 cm above ground and poultry manure applied at 10 ton ha-^{1} and was significant compared to cutting height of 5 cm with no application of poultry manure.

Bare ground and weed cover were not significantly affected by either cutting height, poultry manure or their interaction (Tables 5 and 6).

Table 2. Treatments effect on grass dry matter content

	Poultry manure (ton ha^{-1})			
Cutting height (cm)	**0**	**5**	**10**	**Mean**
	2nd harvest period (4 – 7 – 2014)			
5	23.2	18.8	20.3	20.7
10	21.8	20.5	22.1	21.5
15	21.0	22.9	21.7	21.9
Mean	22.0	20.7	21.3	21.4
	3rd harvest period (8 – 8 – 2014)			
5	26.2	25.3	21.1	24.2
10	26.4	27.8	25.1	26.4
15	27.3	24.8	24.7	25.6
Mean	26.7	26.0	23.6	21.4
			2nd harvest period	**3rd harvest period**
$LSD_{0.05}$ between two cutting height mean (C):			NS	NS
$LSD_{0.05}$ between two poultry manure mean (P):			NS	NS
$LSD_{0.05}$ between two (C) x (P):			NS	5.69

NS, Non- Significant F- test at 5% probability level

Table 3. Height response of guinea grass to the treatments

	Poultry manure (ton ha^{-1})			
Cutting height (cm)	**0**	**5**	**10**	**Mean**
	2nd harvest period (4 – 7 – 2014)			
5	103.6	117.7	127.3	116.2
10	128.0	111.9	139.4	126.4
15	117.0	142.9	149.8	136.6
Mean	116.2	124.2	138.8	126.4
	3rd harvest period (8– 8 – 2014)			
5	69.3	82.3	77.9	76.5
10	80.4	77.9	87.6	82.0
15	84.9	88.1	89.5	87.5
Mean	78.2	82.8	87.5	82.0
			2nd harvest period	**3rd harvest period**
$LSD_{0.05}$ between two cutting height mean (C):			17.23	9.07
$LSD_{0.05}$ between two poultry manure mean (P):			17.23	9.07
$LSD_{0.05}$ between two (C) x (P):			29.84	15.71

NS, Non- Significant F- test at 5% probability level

Harvesting at 15 cm above ground other than at 5 cm gave the highest grass cover (Table 7). Meanwhile, higher poultry manure rate significantly increased the grass cover. However, interaction of either 10 or 15 cm height of cut with application of poultry manure at 10 ton ha-[1] gave more grass cover during the second harvest period than where the 5 cm cutting was combined with zero poultry manure.

4. DISCUSSION

Plant height decreased (P > .05) with lower cutting height but increased (P > .05) progressively with higher cutting heights. Adams et al. [28] reported that close cutting of grassland above ground level reduced the ability of the grass to replenish leaf area, set seeds and store food reserves in their root, thereby reducing grass growth. Increase in application of poultry manure increased the grass height. This could be attributed to the increase in the nutrient content of the soil with essential nutrient elements from poultry manure such as nitrogen, phosphorus and potassium in plants, leading to formation of plant metabolites that helped to build the plant tissue. This is in accordance with Feisal et al. [22] with Sorghum bicolor, and in line with the findings of Farhed et al. [29] who attributed the increase of plant height in maize to the increase in the rate and availability of poultry manure throughout the growing season.

Table 4. Plant tiller number (per m2) calculated for each treatment during the harvest periods

	Poultry manure (ton ha^{-1})			
Cutting height (cm)	**0**	**5**	**10**	**Mean**
	2nd harvest period (4 – 7 – 2014)			
5	241.6	341.3	387.7	323.6
10	323.7	263.5	468.8	352.0
15	318.4	448.0	457.1	407.8
Mean	294.6	350.9	437.9	361.1
	3rd harvest period (8 – 8 – 2014)			
5	206.4	293.3	301.9	267.2
10	252.8	216.0	323.7	264.4
15	272.5	304.0	298.7	291.7
Mean	243.9	271.3	308.1	274.4

	2nd harvest period	3rd harvest period
$LSD_{0.05}$ between two cutting height mean (C):	NS	NS
$LSD_{0.05}$ between two poultry manure mean (P):	97.90	60.89
$LSD_{0.05}$ between two (C) x (P):	169.57	105.46

NS, Non- Significant F- test at 5% probability level

Table 5. Bare ground cover estimated for the treatments at the harvest periods

	Poultry manure (ton ha^{-1})			
Cutting height (cm)	**0**	**5**	**10**	**Mean**
	2nd harvest period (4 – 7 – 2014)			
5	1.0	1.0	1.0	1.0
10	1.0	1.0	1.0	1.0
15	1.3	1.0	1.0	1.1
Mean	1.1	1.0	1.0	1.0
	3rd harvest period (8 – 8 – 2014)			
5	1.0	1.0	1.0	1.0
10	1.0	1.0	1.0	1.0
15	1.0	1.0	1.0	1.0
Mean	1.0	1.0	1.0	1.0

	2nd harvest period	3rd harvest period
$LSD_{0.05}$ between two cutting height mean (C):	NS	NS
$LSD_{0.05}$ between two poultry manure mean (P):	NS	NS
$LSD_{0.05}$ between two (C) x (P):	NS	NS

NS, Non- Significant F- test at 5% probability level

Table 6. Estimated weed cover in response to the treatments

	Poultry manure (ton ha^{-1})			
Cutting height (cm)	**0**	**5**	**10**	**Mean**
		2nd harvest period (4 – 7 – 2014)		
5	2.3	2.0	2.0	2.1
10	2.0	2.3	2.0	2.1
15	2.0	2.0	2.0	2.0
Mean	2.1	2.1	2.1	2.1
		3rd harvest period (8 – 8 – 2014)		
5	2.0	1.7	2.0	1.9
10	1.7	2.0	2.0	1.9
15	1.7	1.7	1.7	1.7
Mean	1.8	1.8	1.9	1.8
			2nd harvest period	**3rd harvest period**
$LSD_{0.05}$ between two cutting height mean (C):			NS	NS
$LSD_{0.05}$ between two poultry manure mean (P):			NS	NS
$LSD_{0.05}$ between two (C) x (P):			NS	NS

NS, Non- Significant F- test at 5% probability level

Table 7. *Panicum maximum* response to the treatments on grass cover

	Poultry manure (ton ha^{-1})			
Cutting height (cm)	**0**	**5**	**10**	**Mean**
		2nd harvest period (4 – 7 – 2014)		
5	3.0	4.0	4.0	3.7
10	4.0	3.0	5.0	4.0
15	3.3	5.0	5.0	4.4
Mean	3.4	4.0	4.4	4.0
		3rd harvest period (8 – 8 – 2014)		
5	2.0	3.0	2.3	2.4
10	2.3	2.0	2.7	2.3
15	2.7	3.0	3.0	2.9
Mean	1.3	2.7	2.7	2.6
			2nd harvest period	**3rd harvest period**
$LSD_{0.05}$ between two cutting height mean (C):			NS	0.60
$LSD_{0.05}$ between two poultry manure mean (P):			0.76	0.60
$LSD_{0.05}$ between two (C) x (P):			1.32	NS

NS, Non- Significant F- test at 5% probability level

Grass tiller number per square meter was not significantly influenced by height of cutting as was reported by Wijitphan et al. [30]. This also concurred with Onyeonagu and Ugwuanyi on *Panicum maximum* [31]. Tillering in grasses is a very dynamic process, and time of sampling can strongly influence the situation encountered [32]. However, Carlassare and Karsten reported increase in grass tiller population with reduction in height of cut above ground in orchad grass (*Dactylis glomerata*) [33]. This contradicts with result observed with *Panicum maximum* in the study, though a number of studies have found that when orchard grass, a tall growing bunch – grass was grazed or cut frequently close to the ground level, its tiller density, stand persistence and productivity were limited by short grazing height regimes [34]. The present study revealed increase (P<.05) in grass tiller number with poultry manure application. Barbosa et al. [35] obtained a similar result with *Panicum maximum*. They reported that application of nitrogen a major component of poultry manure significantly increased grass tiller numbers. The same result was obtained in perennial ryegrass as reported by Wiliam and Asiegbu [36].

Dry matter content generally decreased with higher poultry manure application. Onyeonagu and Asiegbu revealed a decrease in dry matter content of herbage with nitrogen application compared with where no nitrogen (a major nutrient element of poultry manure) was applied in *Panicum maximum* pasture [37]. Dry matter content of forage is the fraction or remains after all moisture content has been removed. This contains the nutritional components of energy, protein, fibre, minerals and vitamins. Fresh pasture has high water content and will have a lower percentage of dry matter than an equivalent weight of dryer feed. However, cutting height had no effect on dry matter content.

Weed cover were found to decrease with higher application of poultry manure and vice versa for grass cover. This could be attributed to nitrogen fertilizer application effect in stimulating greater growth of desired species and denser vegetative cover than broad–leaved weeds thus limiting weed invasion [37].

5. CONCLUSION

The higher plant height observed with the 15 cm cutting height compared with 5 or 10 cm height indicates an advantage in a 15 cm cutting height. Grass cover, tiller number, as well as plant height were generally increased with application of poultry manure. Increase in poultry manure application resulted to decrease in the dry matter content of grass and bare ground area. A combination of 10 cm cutting height with 10 ton ha^{-1} poultry manure significantly produced greater tiller population per m^2. The 10 ton ha^{-1} manure combined with either the 10 cm or 15 cm cutting significantly increased the extent of grass cover compared with where the 0 ton ha^{-1} was combined with the 5 cm cutting.

ACKNOWLEDGEMENTS

We humbly appreciate the breathtaking effort of all that contributed immensely to the successful completion of this work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=920&id=2&aid=8572