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Research Article

Response of *Megathyrsus maximus* to Organic Fertilizer Application Rate and Age at Harvest in the Humid Zone of Nigeria

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Abstract

Background and Objective: Tropical soil has been reported to be low in essential nutrients required by plants. Inorganic fertilizers are expensive and scarce and this has necessitated shifting to the use of organic fertilizers such as animal manure since they have the potential to supply required nutrients to plants and are readily available and cost-effective. **Materials and Methods:** An experiment was conducted to evaluate the influence of manure rates and age at harvest on the growth, dry matter yield and nutritive quality of *Megathyrsus maximus*. The study was laid out in a 4×2 factorial design with four manure rates (Control (0), 60, 120 and 240 kg N/ha) and 2 ages at harvest (6 and 8 weeks after planting) (WAP). **Results:** Significant increase was recorded in the height of the grass with an increase in manure rate application up to 120 kg N/ha as well as with the increase in the age of the grass except for grass with the application of 240 kg N/ha. The number of leaves of grass increased with increased manure rates and age of growth. Dry matter yield increased with advancing age as well as an increase in the rates of poultry manure applied. At both ages of harvest, fertilized grass had higher CP content than the unfertilized grass with an increase in the rate of manure. **Conclusion:** *Megathyrsus maximus* with an application rate of up to 240 kg N/ha poultry manure and at 8 WAP is, therefore, recommended to be used in place of expensive inorganic fertilizer by the resource-poor farmers in the humid zone of Nigeria.

Key words: Agronomy, Guinea grass, nutritive value, organic fertilizer, stage of growth

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Livestock usually derives most of their dietary nutrients from plant materials. However, as a result of the high-temperature regime in the tropics, it stimulates the growth and aging of the plants with a consequent fall in nutrients and digestibility. These changes in nutritional quality result in very irregular growth and marked fluctuations in seasonal weight gains of the animals[1]. As a result of inadequate feed both in quality and quantity that is available to animals mostly in the dry season, has led to major problems in the livestock industry[2]. In order to provide a solution, there is a need to mitigate the problem with the use of sown and purposely managed pastures. The shortage of feed for ruminants can be curbed by the deliberate cultivation of high-quality forage than low-quality feed that is available during the off-season.

Marcillo *et al.*[3] reported that *Megathyrsus maximus* (Guinea grass) plays a vital role in livestock production due to its persistence, growth and quality under proper management. However, many grasslands are characterized by low productivity. To maintain the quality of the grass, there is a need for a supply of nutrients for their growth and nutritive quality. Ewetola *et al.*[4] reported that despite the improvement in pasture productivity through the use of inorganic fertilizers, it has been implicated in soil toxicity, environmental pollution, mineral imbalance, high cost of purchase and scarcity among many adverse effects. Because of this, attention is now on the use of organic manure by researchers to investigate the responses of crops to it, since it is not costly to come by and because it is readily available[5]. It also improves the nutrient status of the soil and provides the plants with better nutrient uptake and also helps in addressing the problem of manure disposal[6]. This study evaluated the effects of ages at harvest and organic fertilizer rates on the growth, yield and nutritive quality of *Megathyrsus maximus*.

MATERIALS AND METHODS

Location: The experiment was conducted during the rainy season in 2021 at the Pasture Experimental Unit of the Federal University of Agriculture, Abeokuta (FUNAAB) Farm, Ogun State, Nigeria (7°58'N, 3°20'E and 75 masl). The site is situated in the derived savannah agro-ecological zone of Southwest Nigeria with an average annual rainfall of 1,037 mm. The mean monthly temperature ranges from 25.7°C in July to 30.2°C in February (Google Earth 7.1 http://www.google.com/earth). The rainfall, temperature and humidity data of the experimental period were presented in Table 1.

The land was cleared, followed by ploughing after which the land was allowed to rest for a period of 2 weeks before harrowing. The land was divided into three blocks, each measuring 3 m×36 m (108 m^2) and a total of 24 plots were mapped out each measuring 3 m×3 m (9 m^2) with a 1 m buffer zone between plots and blocks. This was replicated three times. Soil samples were randomly collected from the plots before planting for soil analysis using a soil auger at a depth of 0-15 cm to determine the physicochemical properties of the soil (Table 2).

Layer poultry manure without wood shavings was collected from the battery cage of the Poultry Section of the Directorate of University Farms, FUNAAB which was air-dried for 2 weeks. Sub-samples were taken from the manure for analysis before application to determine the nutrient composition (Table 2).

Table 1: Meteorological data for the experimental area during June-December, 2021

Month	Rainfall (mm)	Temperature (°C)	Relative humidity (%)
June	148.3	27.1	78.0
July	157.9	26.7	74.3
August	197.4	26.3	82.8
September	93.5	26.3	93.5
October	139.0	27.2	139.0
November	52.6	28.9	52.6
December	0.0	26.8	0.0

Source: Department of Agro-meteorology and Water Resources, FUNAAB, Nigeria

Table 2: Physico-chemical characteristics of soil samples taken at 0-15 cm depth from the experimental site at the onset of the study and mineral composition of organic fertilizer (Poultry manure)

Chemical properties	Soil	Organic fertilizer (Poultry manure)
pH	6.85	
Total nitrogen (g kg^{-1})	0.16	31.1
Organic carbon (g kg^{-1})	1.60	
Available P (mg kg^{-1})	11.86	10.7
Exchangeable cations (cmol kg^{-1})		
Sodium (Na)	0.34	
Potassium (K)	0.49	10.3
Calcium (Ca)	0.24	37.4
Magnesium (Mg)	0.35	17.7
Na (g kg^{-1})		2.2
Fe (mg kg^{-1})		631
Zn (mg kg^{-1})		75.4
Cu (mg kg^{-1})		32.7
Mn (mg kg^{-1})		218
Particle size (g kg^{-1})		
Sand	84.8	
Silt	5.28	
Clay	9.92	

Experimental design: The study was laid out in a 4×2 factorial design. Factors considered were four manure rates (Control (0), 60, 120 and 240 kg N /ha) and 2 ages at harvest (6 and 8 weeks after planting) with 8 treatments replicated three times. A buffer zone of 1 m between plots was kept weed free throughout the experimental period.

In line with the study structure, manure was applied in a single application per plot and raked manually into the soil. After 2 weeks of manure application, the grass was planted.

Crown splits of *Megathyrsus maximus* were harvested from an already established plot. The grass was then planted at a spacing of 0.5×0.5 m. The crown was separated into 2 daughter tillers which were used for planting. Planting of the tillers was done on the same day of collection. This was done to ensure optimal re-growth of the plant. Dead tillers that refused to grow were re-supplied during the 1st week of planting.

Forage measurement and harvesting: At 6 and 8 WAP growth data such as plant height (cm), leaf length (cm), leaf width (cm) and number of leaves were taken. Grasses were harvested at 6 and 8 WAP within a 1.0×1.0 m quadrant and thrown 3 times from 15 cm above ground level using a sickle. Following harvesting, the fresh weight was recorded and sub-samples of the harvested herbage mass weighing 500 g was oven dried at 65°C until a constant weight was attained to obtain the dry matter percentage. Dry matter yield was calculated as dry matter percent weight of fresh sample from 1.0 m^2 which was afterward extrapolated in tons per hectare.

Quality analyses: After forage drying, the samples were then milled and passed through a 1 mm sieve. The proximate composition (dry matter, crude protein, ether extract and ash) was carried out according to Adeyemi *et al.*[7] while fiber fractions (neutral detergent fiber and acid detergent fiber) were carried out according to van Soest *et al.*[8]. Hemicellulose content was determined as the difference between neutral detergent fiber and acid detergent fiber.

Organic matter was calculated as 100-Ash[9] while carbohydrate content-CHO (g kg^{-1} DM) was calculated as OM content-(CP+EE)[10].

Statistical analysis: Data collected were analyzed using a two-way analysis of variance. Significant means were separated using Duncan's Multiple Range Test. A significant level of 5% was used to express statistical differences between means. All data were analyzed using the Anele *et al.*[11] procedure.

RESULTS

Effect of manure rates and age at harvest on the growth, fresh and crude protein yield of *M. maximus*: A significant increase was recorded in the height of the grass with an increase in manure rates application up to 120 kg N/ha as well as with the increase in the age of the grass while there was no further growth with additional further increase of manure above 120 kg N/ha (Table 3). The number of leaves of grass increased with increased manure rates and age of growth.

Effect of manure rates and age at harvest on the dry matter yield of *M. maximus*: Dry matter yield increased with advancing age as well as an increase in the rates of poultry manure applied. The highest yield was recorded for grass fertilized with 240 kg ha^{-1} and harvested at 8 weeks after planting (Fig. 1).

Effect of manure rates and age at harvest on the nutrient quality of *M. maximus*: At both ages of harvest, fertilized grass had higher ($p<0.05$) CP content than the unfertilized

Table 3: Effects of organic manure rates and age at harvest on the growth, fresh and crude protein yield of *M. maximus*

Factors								
Age at harvest (WAP)	Manure rate (kg N ha^{-1})	Plant height (cm)	Leaf number	Leaf area (cm^2)	Leaf (%)	Stem (%)	Fresh matter yield (t ha^{-1})	Crude protein yield (t ha^{-1})
6	0	68.25^{e}	18.17^{d}	210.96^{b}	39.79^{e}	60.21^{a}	7.26^{h}	0.66^{f}
	60	97.67^{de}	46.50^{b}	211.51^{b}	49.32^{d}	50.68^{b}	21.40^{f}	0.31^{de}
	120	120.95^{d}	49.50^{b}	216.68^{b}	45.77^{d}	54.23^{b}	18.90^{g}	0.24^{e}
	240	120.50^{cd}	49.17^{b}	171.35^{b}	38.06^{e}	61.93^{a}	22.60^{e}	0.38^{d}
8	0	145.67^{bc}	31.33^{c}	195.03^{b}	62.50^{c}	37.50^{c}	22.90^{d}	0.35^{d}
	60	168.83^{b}	48.67^{b}	485.13^{a}	69.75^{b}	30.25^{d}	33.95^{c}	0.71^{c}
	120	203.67^{a}	50.50^{b}	207.91^{b}	76.52^{a}	23.47^{e}	46.90^{b}	0.86^{b}
	240	148.17^{bc}	71.17^{a}	184.99^{b}	77.55^{a}	22.45^{e}	55.00^{a}	1.24^{a}
SEM		6.82	2.71	17.37	15.59	15.59	15.02	0.37
p-value		0.000	0.000	0.000	0.000	0.000	0.000	0.000

$^{a-h}$Means in each column with different superscripts are significant ($p<0.05$), SEM: Standard error of the mean and WAP: Weeks after planting

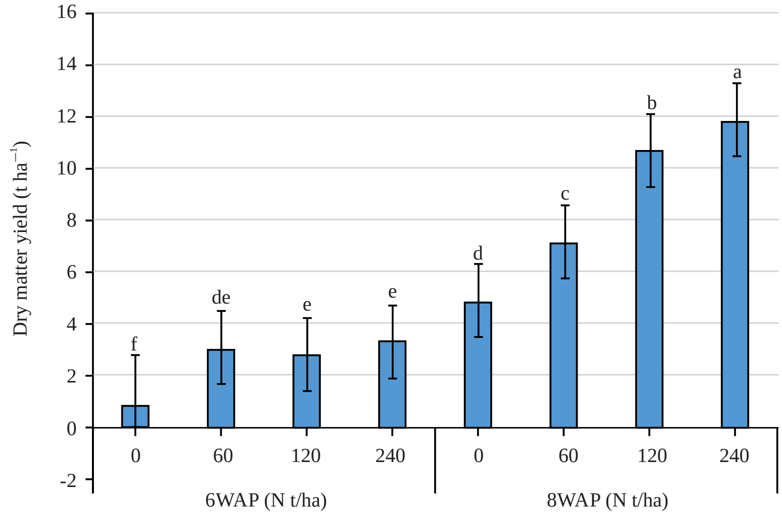

Fig. 1: Yields of *Megathyrsus maximus* as affected by the rate of manure and age at harvest, Values for columns with different letters are significantly (p<0.05) different

Table 4: Effects of age at harvest and organic manure rates on the proximate composition of *M. maximus*

Factors						
Age (WAP)	Manure (kg N/ha)	Dry matter (g kg^{-1})	Ether extract (g kg^{-1})	Crude protein (g kg^{-1})	Ash (g kg^{-1})	NFC (g kg^{-1})
6	0	92.09	5.40	69.00^{d}	105.00^{bc}	184.52
	60	91.02	4.07	75.00^{cd}	125.00^{a}	123.18
	120	89.41	4.46	95.00^{b}	120.00^{a}	187.09
	240	88.41	4.49	100.00^{ab}	115.00^{ab}	155.44
8	0	91.75	5.25	71.00^{d}	95.00^{cd}	134.93
	60	92.06	3.60	80.00^{c}	100.00^{cd}	102.92
	120	92.74	3.13	98.00^{b}	90.00^{d}	206.42
	240	93.71	3.84	104.00^{a}	95.00^{cd}	107.06
SEM		0.68	0.37	2.83	2.81	12.81
p-value		0.570	0.897	0.000	0.000	0.325

$^{a-d}$Means in each column with different superscripts are significant (p<0.05), SEM: Standard error mean, WAP: Weeks after planting and NFC: Nonfibre carbohydrate

Table 5: Effects of age at harvest and organic manure rates on the fiber, organic matter and carbohydrate contents of *M. maximus*

Factors						
Age (WAP)	Manure (kg N/ha)	Neutral detergent fiber (g kg^{-1})	Acid detergent fiber (g kg^{-1})	Hemicellulose (g kg^{-1})	Organic matter (g kg^{-1})	CHO (g kg^{-1})
6	0	591.11^{b}	346.29^{b}	89.50^{bc}	895.00^{bc}	775.60
	60	636.14^{ab}	377.58^{ab}	87.50^{d}	875.00^{d}	759.33
	120	553.30^{b}	326.52^{b}	88.00^{d}	880.00^{d}	740.39
	240	584.62^{ab}	328.88^{b}	88.50^{d}	885.00^{cd}	740.06
8	0	646.54^{ab}	393.89^{ab}	90.50^{ab}	905.00^{ab}	781.48
	60	681.12^{a}	435.21^{a}	90.00^{ab}	900.00^{ab}	784.04
	120	574.27^{a}	353.45^{ab}	91.00^{a}	910.00^{a}	780.68
	240	655.47^{ab}	354.45^{ab}	90.50^{ab}	905.00^{ab}	762.38
SEM		13.55	10.36	15.24	2.81	5.27
p-value		0.179	0.113	0.966	0.000	0.154

$^{a-d}$Means in each column with different superscripts are significant (p<0.05) and SEM: Standard error mean

grass (Table 4) with a corresponding increase in the CP content of the grass with an increase in the rate of manure applied. Higher ash content was recorded at 6 WAP with fertilized grass above unfertilized and at a higher age.

There were no consistent patterns between treatments in NDF and ADF while higher hemicellulose was recorded for the grass at 8 WAP above 6 WAP with a lower level of hemicellulose at 6 WAP for unfertilized forage (Table 5).

No significant difference was recorded for the organic matter at 8 WAP despite the increase in the rate of manure applied. Meanwhile, there was a higher value of organic matter in 8 WAP than in 6 WAP.

DISCUSSION

The increase in plant height with an increase in manure rate except at the highest rate of inclusion (240 kg N/ha) of manure, could be as a result of high nutritive content in the manure, especially with high nitrogen content which has accelerated the grass growth. A similar result was reported by Fokom *et al.*[12] that *Pennisetum clandestinum* plant growth was improved with an increase in the level of fertilization with hens' droppings.

The increase in the number of leaves with grass fertilized with 240 kg N/ha manure, could be traced to the increase in manure rate. The grasses were able to grow more leaves than other treatments. The reason could be credited to the nutrient uptake in higher proportion and also as a result of improved root systems and photosynthetic activity as the plants mature in age. However, Ewetola *et al.*[13] did not record any difference in leaf number with the application of different fertilizer types on *M. maximus* (Ntchisi). The difference could be a result of the season of the year and soil types.

The increase in the dry matter yield with an increase in manure rate at 8 WAP could be that nitrogen in poultry manure profoundly affects dry matter accumulation in *M. maximus.* A close result has been reported by Fois *et al.*[14] that application of 120 N kg/ha fertilizer generated a significant increase in above-ground dry matter at a higher maturity stage in grain crops. This study further revealed that planting *M. maximus* with a higher rate of manure with an increase in age at harvest resulted in an increase in DM yield compared with the unfertilized grass. The higher DM yield recorded for grass fertilized with a higher manure rate could be the result of higher nutrient use efficiency[15] as a result of more nutrient availability in the soil over the available surface for the uptake by the plants.

The increase in the level of manure rate gradually increased the CP content in the grass. This could be because of the additional concentration of nutritive content in the manure. Fokom *et al.*[12] reported a similar observation that the CP content of *P. clandestinum* fertilized with poultry manure had a significant increase in the rates. The more the manure rate, the higher the crude protein content in *M. maximus*.

A similar increase in CP% up to 20.1% was recorded in *Panicum maximum* cvv. Local and Ntchisi by Jimoh *et al.*[16] with the application of swine manure when compared with the control in Nigeria. The higher CP content in the grass might be the result of greater N uptake because of the high P in the manure that was applied. This is because P availability has been reported to influence N uptake in plants[17,18].

The CP concentrations in the grass were quite satisfactory for ruminant feeding at 8.6-12.4%. The higher values for CP in this study except for unfertilized grass and the one with a manure rate of 60 kg N/ha at 6 WAP, are high enough to provide maintenance levels of protein for ruminants.

The trend observed in the present study indicated that ash content decreased with an increase in grass age. The decline in the total ash content of forages could have been brought about by the dilution effect of minerals responsible for the vegetative part that is, the leaf and translocation to the root of the plant at maturity[19]. Elsewhere, it has been reported that the movement of minerals to seed formation and the roots of the plants could be responsible for the decline in mineral composition of the plant with an increase in age[20,21]. Also, Bhattacharya[22] reported that deficit in soil water with other factors influencing plant growth, have been responsible for minerals decline in plants as the plants mature.

The value recorded for NDF for *M. maximus* in this study was below 650 g kg^{-1} while values above this level will hinder intake and degradability of feeds by ruminants[23]. A higher value of NDF recorded for grass with manure rates of 60 and 240 kg N/ha might be due to an increase in the age of the grass which could have led to lignification, thereby leading to increased fiber concentration. This corroborates the report of Ojo *et al.*[24] that as grass matures, they become fibrous, thus leading to higher NDF value. Binuomote *et al.*[25] reported that the ADF of forages should be within 22-50% and that the lower the ADF, the higher the energy level in the forage. The levels found in this study were within the range, indicating that the diets have the potentials to supply needed energy to the animal that will feed on them.

The grass based on age and manure rates had moderate levels of hemicellulose. The digestion of hemicellulose has been reported to depend on microbial enzymes because of its complex structure. Hemicellulose is associated intimately with lignin, which exerts a strong negative influence on fiber digestion[26].

The carbohydrate content was high enough to meet the need of the animals. This could be traced to green plant behavior of producing more green pigment for chlorophyll and storing more food as starch which is later broken down to carbohydrates. Grasses with a higher maturity stage of growth will give more energy when fed to livestock. A similar observation has been reported by Isah *et al.* [27] that older plants accumulate more structural materials.

Planting of grass such as *Megathyrsus maximus* with a nitrogen application rate of up to 240 kg N ha^{-1} of poultry manure and harvesting at 8 weeks after planting is recommended for growing of *M. maximus* as forage for ruminant's farmers in the humid zone of Nigeria. This will help to reduce the cost of livestock production and the manure that ought to constitute pollution to the environment will find a profitable usage.

CONCLUSION

This study has revealed that the application of poultry manures up to 240 kg N/ha and harvesting at 8 WAP improved herbage yield and nutritive quality of *Megathyrsus maximus*. The manure rate applied has the potential to improve pasture and hence, ruminant production for sustainable agriculture and the production of animal protein for the populace.

SIGNIFICANCE STATEMENT

From the study, it was discovered that the growth, yield and nutritive quality of *Megathyrsus maximus* were influenced by the application of poultry manure with an increased rate of application, coupled with an increase in the age of harvest. Through the study, it was discovered that application of up to 240 kg N/ha poultry manure and harvesting at 8 weeks of growth, will produce a higher yield of *Megathyrsus maximus* with appreciable quality that will benefit animals that consume the grass.

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