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Effect of Manure or Fertilizer Application on Height of *Sorghum almum* Harvested at Different Maturity Stages

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Abstract: This study was conducted in Naivasha, Kenya over a period of 15 weeks to determine the effect of manure or fertilizer application on height of Columbus grass (*Sorghum almum*). After field preparation, representative soil samples were taken for mineral profiling. Sixty plots of 2×2 sq. m size were then demarcated and further divided into 5 similar units comprising of 4 blocks of 3 plots each. The plots in each block were independently allotted to 3 treatments in a Randomized Complete Block (RCB) design. Treatments were T_1-control (without fertilization), T_2 and T_3 received dry beef cattle manure and inorganic fertilizer, respectively. All the 4 blocks (weed free) in each of the five (randomly distributed) units were planted on the same day. Harvesting was done at 6, 8, 10, 12 and 14 weeks in a sequential manner starting with unit 1 to 5. All the blocks in each unit were harvested on the same day (at 5 cm height). Results showed that manure or fertilizer application had significant ($p<0.0001$; $r^2 = 0.9769$) effect on height of *Sorghum almum*. ANOVA revealed high effect of cutting interval ($p<0.0001$) and cutting-treatment interaction ($p<0.001$). At 6 weeks the mean height in T_2 ($p<0.01$) and T_3 ($p<0.001$) were 12.74 and 19.05% higher than in T_1. At 14 weeks T_2 ($p<0.01$) and T_3 ($p<0.01$) recorded 12.1 and 12.5% higher height than T_1. At the same age however T_2 and T_3 were not different ($p>0.05$). The observed increases in the grass height between 6 and 14 weeks represented growth rate of 3.2, 3.6 and 3.5 cm d^{-1} for the 3 treatments respectively. Results further showed that height growth rates in T_1, T_2 and T_3 were higher between 6 and 10 weeks (3.83, 3.77 and 3.95 cm d^{-1}) compared to that recorded between 10 and 14 weeks (2.58, 3.4 and 3.12 cm d^{-1}). The results also showed that height was strongly correlated with concentration of essential nutrients in the plant tissue. Gauging from the results of this study, availability and the known long-term residual effect, this study concluded that though both manure and fertilizer had significant effect on height, manure would be the best cost effective option for enhancing *Sorghum almum* growth rate and therefore yield on smallholder farms in Kenya.

Key words: Columbus grass, smallholder farmers, manure, fertilizer, harvest, nitrogen

INTRODUCTION

It is generally advocated that grass pastures/forages should be maintained or harvested at a target sward height to optimize on herbage utilization by ruminants[1]. This is primarily because numerous studies have shown that grass sward height is strongly correlated with both dry matter yield and concentration of essential nutrients[2,3]. Muia, *et al.*[4] and Snijders, *et al.*[5] also reported that dry matter yield and quality of Napier grass (*Pennisetum purpureum* var Bana) strongly correlated with its height. This agreed to the findings of Wouters[2] who clearly showed that Napier grass height is strongly correlated with dry matter yield ($r^2 = 0.918$; $p<0.001$), crude fibre ($r^2 = 0.94$; $p<0.001$), crude protein ($r^2 = 0.929$; $p<0.001$) and digestible organic matter ($r^2 = 0.959$; $p<0.0001$). Morrison[6] also reported that live weight gain per ha of beef cattle grazing grass/clover sward was higher when the sward was maintained at an overall height of 6 cm rather than either 4 or 8 cm. This therefore implies that because of flux in the concentration of essential nutrients with advancing forage maturity, identification of an optimum growth height when these nutrients are at compromise concentrations is essential. In Kenya, Napier grass is the most popular grass forage on smallholder farms and the existing recommendation of 60-100 cm height, as its optimal maturity stage for feeding to dairy cattle, is still the primary quality guideline on

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these farms[4]. Grass forage height has also been shown to increase with level of Nitrogen (N) in the soil. Kallah, *et al.*[3], through his study conducted in Zaria, Nigeria reported that *Sorghum almum* fertilized at the rate of 100 kg N ha^{-1} recorded significantly higher height compared to non fertilized which concurred with Wouters[2] who reported between 21.7 and 33.9% higher height for fertilized than non fertilized Napier grass. In Kenya, however, the effect of manure or fertilizer application on height of *Sorghum almum* has not been studied. This study attempted to examine the influence of animal manure and fertilizer application on height of *Sorghum almum*.

MATERIALS AND METHODS

This study was conducted at the National Animal Husbandry Research Centre in Naivasha, Kenya over a period of 15 weeks to determine the effect of manure or fertilizer application on height of Columbus grass (*Sorghum almum*). A 0.5-acre plot was prepared thoroughly and then representative soil samples were taken longitudinally and diagonally for mineral profiling. Subsequently, 60 plots of 2×2 sq. m size were demarcated and further divided into 5 similar units (N = 12) comprising of 4 blocks of 3 plots each. The 3 plots in each block were independently allotted to 3 treatments in Randomized Complete Block (RCB) design throughout all units. The treatments were: T_1-control (without fertilization), T_2 and T_3 received dry free grazed beef cattle manure and inorganic fertilizer, respectively. In T_2 and T_3, each plot received 2 kg of 5-day old cattle manure (93.17% DM, 1.711% N, 1.32% Ca and 1.12% P) and 50 g Di-Ammonium Phosphate (DAP - 18: 46: 0), respectively. Manure was applied by mixing it thoroughly with top (20-30 cm thick) soil layer and fertilizer was drilled with the seed. During planting, 5 rows of 2 m length, 30 cm apart and 10 cm deep were drilled on each plot and a total of 25 g of seed were sown with each row receiving exactly 5 g of evenly distributed seeds. All the plots in the five (randomly distributed) units (N = 60) were planted on the same day and kept weed free throughout the trial. Within each unit, guard rows of 30 and 60 cm between plots and blocks, respectively, were provided and also kept weed free. Harvesting was done at 6, 8, 10, 12 and 14 weeks in a sequential manner beginning with unit 1 to 5. All the plots in each unit were harvested on the same day at 5 cm height. Immediately thereafter forage height measurements (cm) per line in each plot were taken using a measuring tape. This was done by laying the freshly harvested material on a polythene sheet stratified according to lines per plot and taking the measurements from the base to the tip of the straightened swards. Data was stored in MS-Excel and analyzed using SAS[7] to determine the effect of treatments and age on grass height. Analysis of variance to determine effect of treatment on height was done according to a randomized complete block design with 3 treatments and 4 replicates. The statistical model applied was: $Y_{ijk} = D_i+C [D]_{ij}+N_k+D_i* N_k+e_{ijk}$; where, Y_{ijk} is the height (cm); D_i is the treatment (i = 1, 2, 3); C is the cut number nested into D_i to test the treatment effect (j = 1, 2, 3, 4, 5), N_k is the number of measurement (k = 1, 2, ..., 11, 12), $D_i* N_k$ is the treatment-measurement interaction and e_{ijk} is error of the mean. Treatment means at different harvests were compared using General Linear Model (GLM) procedure of SAS[7].

RESULTS

The height growth pattern of *Sorghum almum* measured November 3, 2006 November 3, 2006at different maturity stages are presented in Fig. 1 and 2, respectively. As shown in Fig. 1, height change pattern, differed markedly between treatments. Height in control tended to be lower than in manure and fertilizer treatments. In contrast, fertilizer displayed rapid height change pattern than manure for much of the experimental period. The models describing the change pattern in height of *Sorghum almum* with advancing grass maturity fitted the data closely (Control: r^2 = 0.961; Manure: r^2 = 0.971 and Fertilizer: r^2 = 0.974; Fig. 1). In Table 1 mean height of grass at different cutting intervals are presented. The mean height of fertilized *Sorghum almum* was substantially higher than the non-fertilized throughout the experimental period. At 6 weeks the mean height in T_2 ($p<0.01$) and T_3 ($p<0.001$) were 12.74 and 19.05% higher than in T_1. At the same age, T_2 and T_3 were also different ($p<0.05$). The same trend was observed up to the 12th week (Table 1). At 14 weeks T_2 ($p<0.01$) and T_3 ($p<0.01$) recorded 12.1 and 12.5% higher height than T_1. At the same age however T_2 and T_3 were not different ($p>0.05$). The observed increases in the grass height between 6 and 14 weeks represented growth rate of 3.2, 3.6 and 3.5 cm d^{-1} for the 3 treatments respectively.

Results further showed that height growth rates in T_1, T_2 and T_3 were higher between 6 and 10 weeks (phase I) (3.83, 3.77 and 3.95 cm d^{-1}) compared to that recorded between 10 and 14 weeks (phase II) (2.58, 3.4 and 3.12 cm d^{-1}). Interestingly however T_2 showed comparatively lower height growth rate in phase I and higher in phase II. Those of T_1 and T_3 were high in phase I and registered a sharp drop in phase II.

Table 1: Effect of manure or fertilizer application on height (cm) of *Sorghum almum* harvested at different maturity stages

		Control (T_1)			Manure (T_2)			Fertilizer (T_3)		
Age	N	Mean±S.D.	S.E	C.V	Mean±S.D.	S.E	C.V	Mean±S.D.	S.E	C.V
6	12	58.17^a±3.24	0.94	5.58	65.58^b±4.48	1.29	6.83	69.25^c±3.6	1.04	5.19
8	12	73.08^a±6.54	1.89	8.95	84.17^b±6.73	1.95	7.99	92.17^c±5.73	1.66	6.22
10	12	165.42^a±8.23	2.38	5.33	171.08^b±10.79	3.12	6.31	179.75^c±6.01	1.73	3.34
12	12	172.83^a±6.59	1.91	3.81	199.92^b±23.7	6.84	11.86	221.25^c±21.64	6.25	9.78
14	12	237.51^a±17.11	4.94	7.21	266.25^b±12.26	3.54	4.61	267.08^b±12.42	3.59	4.65

Age -Age at harvest (weeks); S.D-Standard deviation from mean; S.E -Standard error of the mean; C.V -Coefficient of variation; Means with different super scripts ($^{a, b, c}$) within the same row are significantly different

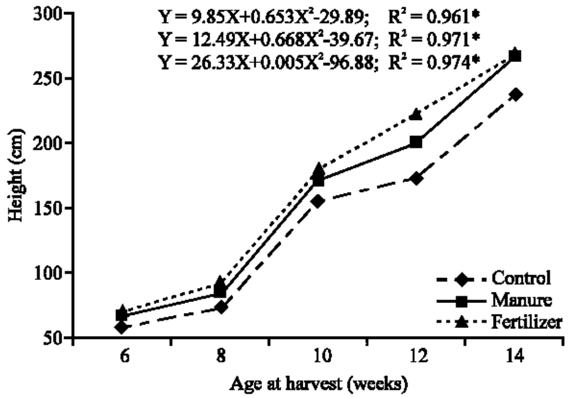

Fig. 1: Effect of manure or fertilizer application on height of *Sorghum almum* harvested at different growth stages

Table 2: Analysis of variance test of the treatment and age at harvest effect on height of *Sorghum almum*

	Sorghum almum height (cm)				
Source	DF	SS	MS	F	Pr>F
Model	14	956784.83	68341.77	498.69	0.0001
Treatment	2	22327.6	11163.8	81.46	0.0001
Cut	4	928896.06	232224.02	1694.53	0.0001
Cut*Treatment	8	5561.18	695.15	5.07	0.0001
Error	165	22612.17	137.04		

R^2 = 0.9769 and C.V = 7.59

Table 3: Correlation coefficients of *Sorghum almum* height (cm) with concentration of essential nutrients and age at harvest

	Sorghum almum height (cm)		
Parameter	Control (T_1)	Manure (T_2)	Fertilizer (T_3)
Age at harvest (weeks)	0.9842**	0.9846**	0.9912***
Dry matter content (g kg^{-1} DM)	0.9383*	0.8911^{ns}	0.9185*
Crude protein content (g kg^{-1} DM)	- 0.9672**	- 0.9243*	-0.9371*
Crude fibre content (g kg^{-1} DM)	0.8652^{ns}	0.8753^{ns}	0.9161*
Org. matter digestibility (g kg^{-1} DM)	- 0.9765**	-0.9923***	- 0.9912***
Metabolizable Energy (MJ kg^{-1} DM)	- 0.9451*	- 0.9488*	- 0.9019*
Calcium (%)	- 0.7367^{ns}	- 0.7432^{ns}	0.7168^{ns}
Phosphorus (%)	- 0.9831**	- 0.9555**	-0.9829**

Means with different super scripts ($^{*, **, ***}$) within the same row are significantly different (at 0.05, 0.01 and 0.001, respectively), ns -correlation not significant

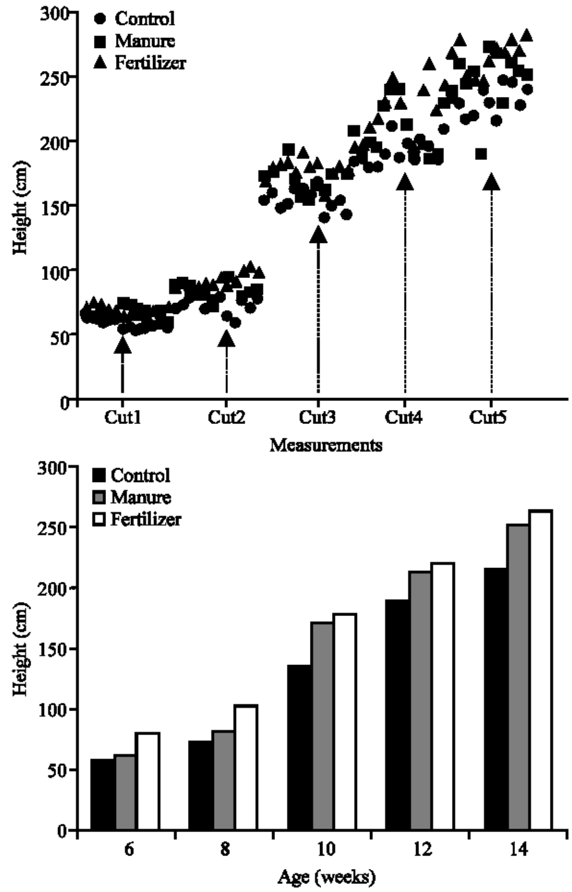

Fig. 2: Effect of manure or fertilizer application on height (cm) of *Sorghum almum* harvested at different growth stages

Analysis of variance showed that manure or fertilizer application had significant ($p<0.0001$; r^2 = 0.9769) effect on height of *Sorghum almum* Table 2. From the statistical model applied, treatment was significant ($p<0.0001$). The same was observed for cutting interval ($p<0.0001$) and cutting-treatment interaction ($p<0.0001$).

The correlation of height with concentration of essential nutrients in the grass was also investigated Table 3. The results revealed that height was strongly correlated with all the nutrients studied. Dry matter and crude fibre were positively correlated with height across the 3 treatments. Crude protein, organic matter digestibility, metabolizable energy, calcium and phosphorus were negatively correlated with *Sorghum almum* height. The results further showed that most of the correlations considered were significant. Correlation of height with Calcium concentration in the plant tissue was however not significant across the 3 treatments. Crude fibre correlation with height was also not significant in T_1 and T_2 Table 3.

DISCUSSION

Soil nutrients and water plays a critical role in the yield and quality of grasses and other ephemeral forbs[8]. Wouters[2] in his two experiments conducted in Naivasha Kenya, reported that height of Napier grass (*Pennisetum purpureum* var Bana) responded positively to the N-fertilization. In the first trial where 0 and 75 kg N ha^{-1} were compared, the mean heights were 84.8 and 108.3 cm at 12 weeks. This represented 27.7% higher height for the fertilized grass compared to non fertilized. In the second trial, where the author further compared 0, 50 and 100 kg N ha^{-1}, the mean heights recorded at 12 weeks were 69.1, 84.1 and 92.5 cm. The two levels of N resulted in 21.7 and 33.9% higher height compared to the non-fertilized grass. The author explained the difference in the mean height between the 2 trials as due to their differences in soil moisture level. The results of this study also showed that *Sorghum almum* height responded significantly to fertilization Fig. 1 and 2; Table 2. Grass plots provided additional soil nutrients through either manure or inorganic fertilizer recorded significantly higher mean height compared to non-fertilized Table 1. The comparatively lower height growth rate observed in T_2 in phase I (between 6 and 10 weeks) indicated that the release of manure bound nutients was slow at the onset. The observed differences in height growth rate between T_1 and T_2 in phase I further suggest that the newly applied dry manure may have masked the availability of some parent soil nutrients (including N) for plant growth. In phase II however, the height growth rate in T_2 was considerably higher than both T_1 and T_3, suggesting that as soil nutrients in T_1 and T_3 gets exhausted, those in T_2 were being released continuously in sufficient quantities from the manure. The strong correlations observed between *Sorghum almum* height and concentration of essential nutrients in the plant tissue suggest that an optimal height (as indicator of quality) should be identified to maximize on forage production and utilization by ruminants. Results of this study clearly showed that, height growth rate and therefore tiller production (herbage yield) were rapid up to 10 weeks of age. From this observation, it can be deduced that 150 to 180 cm (8 to 10 weeks post planting) would be the ideal maturity height for harvesting *Sorghum almum*. In comparison, results showed that manure is very competitive in terms of its effect on growth rate the grass under study. The advantage of manure over fertilizer is that manure has a long-term residual effect. This further implies that when sufficient quantity of quality manure is applied to grass forage, there would be no need for top dressing after the first and probably second harvest. This particular aspect is very relevant considering the low economic status of majority of smallholder farm households in Kenya.

CONCLUSION

In ruminant livestock production systems, high forage productivity is essential for maintaining the desired animal performance. Compared to the mean height of Napier grass harvested at the same age the results of this study indicates that *Sorghum almum* (Columbus grass) is a rapidly growing forage capable of producing large amount of herbage within the year of its establishment. Considering this aspect, it was therefore concluded that *Sorghum almum* has considerable potential for contributing the alleviation of ruminant feed shortage on these farms. Results clearly showed that height as an indicator of herbage yield of *Sorghum almum* was significantly increased by the addition of manure or fertilizer. Gauging from the results of this study, its availability and its known long-term residual effect, this study further concluded that manure would be the best cost effective option for enhancing *Sorghum almum* yield on smallholder farms in Kenya.

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