

Effects of some animal manure and rate of application on growth, herbage and seed yields of Rhodes grass (*Chloris gayana* var. Callide)

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Abstract

*An experiment was conducted twice concurrently at Vom in Plateau State Nigeria in 2011 to evaluate the effects of three animal based organic fertilizers and three rates of application on the growth, seed and herbage yields of Rhodes grass (Chloris gayana var. Callide). This study involved three types (poultry, rabbit and sheep dung) of animal fertilizer and three rates (0, 25 and 50 t ha^{-1}) of application in a 3 x 3 factorial arrangement fitted into randomized complete block design and replicated three times. Animal fertilizers significantly ($p < 0.05$) increased growth, seed, fresh herbage and dry matter yields of Rhodes grass. Generally, fertilizers from poultry and rabbit were similar and better ($p < 0.05$) than that of sheep in the enhancement of the measured variables. At 6 weeks after fertilizer application (WAF), fresh herbage yield was in the range of 14.6 – 48.3 t ha^{-1} whereas dry matter yield ranged from 4.7 – 13.9 t ha^{-1} while seed yield was 1.8 – 2.3 t ha^{-1}. At 12 WAF, rabbit fertilizer produced significantly higher values than sheep fertilizer by 21.2 % for sward height, 70.1 % for fresh herbage yield and 61.4 % for dry matter yield. The correlation coefficients among the measured variables were positive and highly significant. The highest correlation recorded (0.937**) was between fresh herbage and dry matter yields. The study indicated that application of either rabbit or poultry fertilizer can suitably enhance Rhodes grass growth for higher herbage and seed yields. The study also showed that 25 and 50 t ha^{-1} of animal fertilizers on Rhodes grass yielded similar results. With adequate fertilizer application, Rhodes grass can produce sufficient herbage to meet the nutritional requirement of several ruminant livestock. It is not economical to apply more than 25 t ha^{-1} of animal fertilizers to Rhodes grass if they contain more than 1.21 % of nitrogen.*

Keywords: Rhodes grass, animal fertilizer, growth, fresh herbage, dry matter, seed yield

Introduction

Forage grasses such as *Chloris gayana* depend on the soil for mineral nutrients which promote their growth, whereas ruminants rely on grasses for much of the energy and minerals they require for maintenance and reproduction. Inadequate fertilizer application reduces the herbage yields and quality of pasture grasses (Humphrey, 1987) with negative impact on ruminant nutrition. Proper fertilizer application to grasses could sustain the interdependency of grasses and ruminants in a fragile pasture-animal eco-system (M.S. Kallah, personal communication). *Chloris gayana* is popular and widely cultivated in Kenya as a forage crop. In the rainy season, the crude protein concentration of Rhodes grass exceeded 11.1 % while its crude fibre (CF) concentration (21.1 %) was lower than that of signal grass (23.4 %), pangola grass (25.3 %) and kikuyu grass (39.9 %) based on an evaluation at Vom. Digestible crude protein and metabolic energy of Rhodes grass was adequate for the maintenance and growth of sheep (Kevelenge *et al*., 1999). The crop exhibits high seed and dry matter (DM) yields, good sward persistence, high pure germinating seed (PGS) content and is relatively easy to establish from seeds (Bogdan, 1977).

A huge drop in the fresh herbage yield of Rhodes grass at the National Veterinary Research Institute, Vom, was attributable to improper fertilization practices aggravated by insufficient application of inorganic fertilizer (A. Ahmed, personal communication). Although fertilizer application improves the growth and yield of grasses, there is no fertilizer recommendation in place for NVRI pastures. In a three year study in Cameroun, NPK fertilizer consistently increased the yield of *Brachiaria ruziziensis* (ruzi grass) over the control treatment by 133 %, 134 % and 93 %, respectively in 1985, 1986 and 1987 (Pamo and Pieper, 1995). At the end of a three year study at Shika-Zaria, differences in the yield of *Brachiaria decumbens* (signal grass) was attributed to the rate (100 or 200 kg ha^{-1}) of nitrogen fertilization (Okeagu and Agishi, 1990). Akinola *et al*. (1971) noted that in most grass species, tiller production and dry matter yield is significantly influenced by rate of nitrogen fertilizer. Although, applications of inorganic fertilizers have been the primary focus of pasture scientists, animal based organic fertilizers give satisfactory results when applied to pasture grasses. Sukkasem *et al*. (2000) reported that *Brachiaria humidicola* (humidicola grass) supplied with 4 t ha^{-1} of cattle manure and cut at 50 day intervals yielded 2 tonnes DM ha^{-1} $year^{-1}$. In view of the ever increasing cost of procuring inorganic fertilizers, coupled with the fact that animal fertilizers (poultry, rabbit and sheep dung) are readily available at Vom, this research was designed to study their effects on the growth, fresh herbage, dry matter and seed yields of *Chloris gayana*. An animal fertilizer recommendation for Rhodes grass could evolve from the study.

Materials and Methods

A randomised complete block design (RCBD) experiment was conducted twice concurrently on a year old Rhodes grass pasture established in 2010 at Vom, Plateau State, Nigeria. The experimental site was located at latitude 09^{o} 44' E and longitude 08^{o} 44'N at an elevation of 1,239.4 m above sea level. The soil of the field was of ferallictic cambisol developed from volcanic rocks (Enweazor *et al*., 1990) and classified under inceptisol (Jones, 2003). The experimental plots were 3 m x 3 m in dimension. Plots were separated from each other by 1 m boarders and replicates by 2 m boarder. Factorial combinations of three animal fertilizers (poultry, rabbit and sheep dung) and three rates of application (0, 25 and 50 t ha^{-1}), formed the 9 treatments for the experiment and these were replicated three times. The pasture was uniformly cut to a height of 3 cm above soil surface before the treatments were randomly assigned to the respective plots. Routine chemical analysis (Mylaravapus and Kennelley, 2002) of the soil and animal fertilizers was carried out before imposition of treatments. The parameters measured at 6 and 12 weeks after fertilizer application (WAF), were sward height (cm), seed yield (t ha^{-1}), fresh herbage and dry matter yields (t ha^{-1}). Growth measurements at 6 WAF were taken before cutting the pasture; whereas measurements obtained at 12 WAF were of pasture that re-grew after cutting at 6 WAF. Sward height was determined by measuring from the ground level to the top of the sward's canopy with a metre ruler. Seed panicles were manually harvested by cutting with a sickle, after which they were air dried, before threshing and weighing with a sensitive industrial balance. Fresh herbage yield was obtained by cutting herbage within a 1 m^2 quadrat up to 3 cm above ground level with a hand sickle, before weighing with a hanging spring balance scale set on a tripod. A sub sample of the fresh herbage was dried to constant weight in a Gallenkamp oven (model ov-440) at 70 °C and re-weighed to estimate dry matter yield (Muhammad and Abubakar, 2004). The data collected from both experiments were combined and subjected to two way Analysis of Variance (ANOVA) using the SAS statistical software version 9.0 (SAS, Institute, 2002) to determine the significance of treatment effects at 5 % level of probability. The Least Significant Difference (LSD) test was used to detect differences among treatment means at 5 % level of probability. Pearson correlation coefficients were worked out for the measured parameters using the SAS statistical software (SAS Institute, 2002).

Results and Discussion

The chemical analysis of the soil and animal fertilizers are presented in Table 1. The Rhodes grass was established on a relatively fertile soil because total nitrogen (2.11g kg^{-1}), available P (8.64 mg kg^{-1}), exchangeable K (0.78 cmol kg^{-1}) and organic carbon (30.2 g kg^{-1}) were generally high (Enwezor *et al*., 1989). However, the acidic reaction of the soil (pH 5.27) presupposes that nutrients may not be readily available for plant uptake (Jones, 2003). This justified the application of the animal fertilizers which enriched the nutrient pool and increased the organic matter concentration of the soil. Among the animal fertilizers, nitrogen concentration ranged from 11.80 - 12.02 g kg^{-1} (Table 1).

Table 2 shows that the effects of fertilizer and rate of application on sward height at 6 and 12 WAF and seed yield at 6 WAF were significant. The effect of fertilizer on sward height and seed yield was consistent. Poultry and rabbit dung were statistically at par and higher than sheep dung. Similarly, rate of application exhibited a consistent trend whereby 25 and 50 t ha^{-1} treatments were at par and significantly greater than the control treatment. Interaction between fertilizer and rate of application for sward height at 12 WAF was highly significant. The results further confirmed that animal fertilizers improve both growth and seed yield of Rhodes grass. This implies that animal fertilizers can suitably replace or complement inorganic fertilizer for Rhodes grass production. It also infers that the mineralization of sheep dung was probably slower than that of poultry and rabbit fertilizers. Sheep fertilizer possesses a dry

Table 1: Chemical composition of the soil and organic fertilizers used in the experiment

Variable	Soil	Rabbit dung	Cattle dung	Poultry dung
Nitrogen (g kg^{-1})	2.11	11.8	12.02	12.01
Available P (mg kg^{-1})	8.64	1.21	0.53	1.08
K (cmol kg^{-1})	0.78	0.95	1.05	1.21
Ca (cmol kg^{-1})	0.67	2.01	0.78	0.89
Mg (cmol kg^{-1})	0.42	0.45	0.57	1.53
Organic C (g kg^{-1})	30.2	282	124.3	280.3
pH	5.27	6.74	6.82	6.67

Table 2: Effect of organic fertilizer and rate of application on sward height (cm) at 6 and 12 weeks after fertilization (WAF), and seed yield (t ha^{-1}) at 6 WAF for Rhodes grass

Treatment	Sward height (cm)		Seed yield (t ha^{-1})
Fertilizer	**6 WAF**	**12 WAF**	**6 WAF**
Sheep dung	51.2c	84.3b	1.8b
Poultry dung	63.3ab	99.1a	2.2a
Rabbit dung	69.5a	102.2a	2.3a
LSD (0.05)	9.46	11.46	0.41
Rate of application (t ha^{-1})			
0	39.7b	58.5b	1.2b
25	72.4a	99.1a	2.5a
50	67.4a	106.1a	2.6a
LSD (0.05)	8.19	9.93	0.36
Interaction			
F x R	ns	**	ns

Means in the same column followed by the same letter(s) are not significantly different (P>0.05). ** = Significant at 0.01 % level of probability. ns =Not significant.

hard nature unlike poultry and rabbit fertilizers that are friable and more soluble. Consequently, sheep fertilizer might require physical breakage to aid early mineralization. (Akanni and Ojeniyi, 2008) when applied to Rhodes grass. Furthermore, the study connotes that fertilizer application is required to replenish soil nutrients which pasture grasses remove when grazed or cut. Without adequate fertilizer application, quantity and quality of pasture grasses are compromised (Bogdan, 1977). According to Youssif and Ibrahim (2013), Rhodes grass fertilized with farmyard manure (FYM) exhibited a sward height range of 45.4 – 121.1 cm while those that received chicken manure (CHM) displayed a sward height range of 48.4 – 121.4 cm. In the current study, sward height ranged from 55.1 – 126.7 cm. The difference in the results from both studies was probably due to variation in the fertilizers and rates of application among other factors. This infers that Rhodes grass responded more favourably to 25 t ha^{-1} of the animal fertilizer in this study than to 5 t ha^{-1} of FYM plus100 kg N ha^{-1} urea and 3 t ha^{-1} of CHM plus 100 kg N ha^{-1} urea employed by Youssif and Ibrahim (2013). The implication is that straight animal fertilizer rather than mixtures of animal and inorganic fertilizers is sufficient for Rhodes grass productivity. The seed yield obtained at 6 WAF (1.8 – 2.6 t ha^{-1}) indicates that Callide is an early heading variety of Rhodes grass (Kevelenge *et al*., 1999). This trait will ensure multiple harvests for overall higher seed yield required for Rhodes grass expansion.

The effects of organic fertilizer and rate of application on fresh herbage and dry matter yields at 6 and 12 WAF is presented in Table 3. Generally, poultry and rabbit fertilizers produced similar fresh herbage and dry matter yields that were significantly greater than that of sheep dung. However, at 12 WAF rabbit dung produced significantly heavier fresh herbage and dry matter yields

Table 3: Effect of animal fertilizer and rate of application on fresh herbage and dry matter yields (t ha^{-1}) of Rhodes grass at 6 and 12 weeks after fertilization (WAF).

Treatment	Fresh herbage (t ha^{-1})		Dry matter (t ha^{-1})	
Fertilizer	6 WAF	12 WAF	6 WAF	12 WAF
Sheep dung	21.1b	22.3b	6.1b	5.7ab
Poultry dung	41.1a	31.1ab	11.9a	8.1ab
Rabbit dung	48.3a	37.9a	13.9a	9.2a
LSD (0.05)	7.16	13.3	2.93	3.65
Rate of application (t ha^{-1})				
0	14.6b	10.4b	4.7b	2.6b
25	39.6a	36.4a	11.9a	9.5a
50	45.1a	36.1a	12.8a	8.8a
LSD(0.05)	6.2	11.56	2.53	3.16
Interaction				
F x R	**	*	**	ns

Means in the same column followed by the same letter(s) are not significantly different (P>0.05). *, ** = Significant at 5 and 1 % levels of probability, respectively. ns=Not significant.

than sheep dung. Rate of application followed a linear trend for fresh herbage and dry matter yields across the sampling intervals. However, the 25 and 50 t ha^{-1} treatments were similar and greater than the control treatment. The fertilizer x rate of application interaction on fresh herbage yield was significant at both intervals of harvest whereas for dry matter yield significance occurred at 6 WAF. The fresh herbage yields obtained at 6 WAF in the current study were similar and within the range of fresh fodder yield (26.9 t ha^{-1} with FYM and 44.05 t ha^{-1} with CHM) reported by Youssif and Ibrahim (2013). This signifies that the fresh herbage yield potential of Rhodes grass is within this threshold. On the other hand, in Saudi Arabia, Bakhashwain (2010) reported 87.3 cm for plant height, 1.6 t ha^{-1} for fresh fodder and 0.2 t ha^{-1} for dry matter yields of Rhodes grass. These values were considerably lower than those obtained in this study. This variation is ascribable to differences in soil type and the ecology under which the crops were grown. Soil type is an important determinant of grass adaptation and yield (Michalk *et al*., 1993). Moreover, the dry matter yields in this study were 11.9 and 13.9 t ha^{-1} at 6 WAF and 8.1 and 9.2 t ha^{-1} at 12 WAF for plants fertilized with poultry and rabbit fertilizers, respectively. The implication of this result is that Rhodes grass can furnish sufficiently large quantities of herbage for ruminant livestock production. Vaisman *et al*. (1982) obtained an optimum dry matter yield of 12.0 t ha^{-1} when Rhodes grass was fertilized with municipal waste water in Israel. The nitrogen concentration of the waste water was 18 mg litre^{-1} but an additional 250 kg N ha^{-1} was supplied with $(NH_4)_2SO_4$. The proximity of the dry matter yields from both studies implies that these animal fertilizers provided sufficient nutrients comparable to those in the study at Israel.

The interaction between fertilizer and rate of application on fresh herbage and dry matter yields at 6 WAS and sward height and fresh herbage yield at 12 WAF is presented in Table 4. There were significant differences within poultry and rabbit fertilizers for all the parameters. The yields increased as rate of application increased. However, the 25 and 50 t ha^{-1} treatments were at par. Similarly, within rates of application there were significant differences among fertilizers when either 25 or 50 t ha^{-1} was applied. In both cases, poultry and rabbit fertilizers were statistically similar and produced significantly greater fresh herbage and dry matter yields than sheep fertilizer. The interaction infers that a positive response is guaranteed if Rhodes grass is supplied with 25 t ha^{-1} of either poultry or rabbit fertilizer. Furthermore, the statistical similarity between 25 and 50 t ha^{-1} implies that 25 t ha^{-1} of animal fertilizer is sufficient to meet the nutritional needs of Rhodes grass. The animal fertilizers evaluated had on average 11.9 g N kg^{-1} or 1.21 % of total nitrogen. This corresponds to about 280 and 560 kg N ha^{-1} for the 25 and 50 t ha^{-1} treatments, respectively. Rhodes grass production increased beyond 300 kg N ha^{-1} (Boschma, 2010) and *Brachiaria decumbens* exhibited a positive linear response for tillers and herbage yield up to 400 kg N ha^{-1} (Okeagu *et al*., 1989). However, in the current study, 280 and 560 kg N ha^{-1} were similar implying that a quadratic effect was eminent. The variation between the results may be due to the fact that animal fertilizers in this study released nutrients slower and were less prone to leaching losses for which inorganic fertilizers, in the other study, are notorious. Consequently, animal fertilizers sustain pasture growth longer than inorganic fertilizers. This is another reason in favour of animal fertilizers for pasture production.

The matrix of correlation coefficients (Table 5) revealed a positive and highly

Table 4: Interaction between fertilizer and rate of application on fresh and dry matter yields (t ha^{-1}) at 6 WAT and sward height (cm) and fresh herbage yield (t ha^{-1}) at 12 WAT.

		6 WAF		12 WAF	
Fertilizer	**Rate (t ha^{-1})**	**Fresh herbage**	**Dry matter**	**Sward height**	**Fresh herbage**
Sheep dung	0	14.5cd	5.2c	61.1d	11.7d
	25	25.4cd	6.9c	85.0c	24.4cd
	50	23.0cd	6.4c	106.8b	30.7bcd
Poultry dung	0	13.6d	4.1c	57.5d	8.6d
	25	48.7b	14.4b	113.0ab	34.9abc
	50	61.0a	17.2ab	126.7a	49.9ab
Rabbit dung	0	15.8cd	4.5c	55.1d	9.7d
	25	58.7ab	17.8ab	126.4a	49.7abc
	50	70.3a	19.4a	125.3ab	54.3a
LSD (0.05)		12.61	5.1	20.4	23.7

Means in the same column followed by the same letter(s) are not significantly different (P>0.05).

Table 5: Matrix of correlation coefficients for some Rhodes grass parameters

	Sward height	Seed yield	Fresh herbage	Dry matter
Sward height	1	0.705**	0.915**	0.815**
Seed yield		1	0.825**	0.826**
Fresh herbage			1	0.937**
Dry matter				1

**=Significant at 1 % level of probability

significant association between the measured variables. The correlation between sward height and seed yield (r = 0.705*) was lower than that of seed and fresh herbage yields (r = 0.825**). However, the correlation between sward height and fresh herbage yield was 0.915** while the highest correlation recorded was between fresh herbage and dry matter yields (r = 0.937**). The implication is that these parameters work in concert to increase growth and yields of Rhodes grass. Factors that affect these parameters negatively would subsequently reduce herbage and seed yields.

Conclusion

The study revealed that rabbit and poultry fertilizers were similar and better than sheep fertilizer for Rhodes grass production. Application of 25 and 50 t ha^{-1} of animal fertilizer was similar and statistically superior to the control treatment. It is not economical to apply over 25 t ha^{-1} of animal fertilizer to Rhodes grass if it contains 1.21 % or more of nitrogen.

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