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Effects of Fertilizers and Rates of Application on Growth and Yields of Rhodes Grass (*Chloris gayana* Cv. Callide)

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Target Audience: Pasture Agronomists, Animal scientists, Livestock farmers

Abstract

Two field experiments were conducted at Dagwom farm, National Veterinary Research Institute (NVRI), Vom, Plateau State, Nigeria. The objective of the research was to compare the effects of three fertilizers (urea, NPK and poultry manure) and four rates of application (coded 1^{st}, 2^{nd}, 3^{rd} and 4^{th} to represent either 0, 150, 300 and 450 kg N ha^{1} for urea and NPK or 0, 25, 50 and 75 t ha^{1} for poultry manure) on the growth, fresh herbage and dry matter yields of a 2 year old Rhodes grass (Chloris gayana cv. *Callide) pasture. Twelve factorial treatments were fitted into a Randomized Complete Block Design (RCBD) and replicated 3 times. The variables measured were sward height (cm), fresh herbage and dry matter yields (t ha^{1}). Poultry manure was comparable to NPK and furnished significantly better growth, higher fresh herbage and dry matter yields than urea. The significantly ($p<$ 0.05) tallest sward (58.10 cm) was obtained from poultry fertilizer. Similarly, the significantly heaviest dry matter yields of 15.30 and 18.20 t ha^{1} were produced with the 3^{rd} and 4^{th} rates of poultry fertilizer application, respectively. Rhodes grass could provide substantial quantities of fodder for ruminant nutrition if fertilizer application is adequate. Poultry manure should therefore be harnessed for increased production of Rhodes grass at NVRI, Vom.*

Keywords: Rhodes grass, poultry manure, urea

Description of Problem

Rhodes grass (*Chloris gayana*) originated in Rhodesia, now (Zimbabwe) and is widely cultivated as a livestock crop. Its seed and dry matter yields, sward persistence, pure germinating seed (PGS) content are high (1). The grass is relatively easy to establish and the fodder quality is high. In the peak rainy season at Vom, the crude protein (CP) concentration of *Rhodes grass* was 11.1 % while the crude fibre (CF) concentration was 21.1 %. The hay with CP concentration of 4.1 % is fed to livestock in the dry season. At the National Veterinary Research Institute (NVRI), Vom, Plateau State, Nigeria, Rhodes grass occupied a significant portion of the paddocks but steadily deteriorated in productivity and occurrence. Poor soil fertility was implicated as the reason for its decline. At Vom, pastures are fertilized arbitrarily without regard to recommended rates. Furthermore, there is no consistency in the types and rates of fertilizers applied to the soil to improve pasture productivity (S. A. Ogedegbe, personal observation). Moreover, there is an over dependency on inorganic fertilizers that are often scarce and expensive. Poultry manure which is readily available in Vom could replace or supplement inorganic fertilizer application for pasture production. Organic manures are vital in sustaining soil fertility, soil health and crop production (2). Similarly, inorganic fertilizers improve soil fertility and increase crop yields but are more deleterious to soil health (3).

Under good nitrogen fertilization, Rhodes grass furnishes DM yields between 7-12 t ha^{-1} (44) and responds to phosphorus application in low fertility soils. It exhibited a linear herbage yield of up to 300 kg N ha^{-1} when other nutrients were sufficient (5). In Israel, Rhodes grass attained an optimum DM yield of 12.0 t ha^{-1} when 250 kg N ha^{-1} was applied to nutrient rich (18 mg kg^{-1} nitrogen) waste water (6). Humidicola grass (*Brachiaria humidicola*) supplied with 4 t ha^{-1} of cattle manure and cut at 50 day intervals yielded 2 t DM ha^{-1} $year^{-1}$ (7). The objective of the research therefore was to compare three types of fertilizer (urea, NPK and poultry manure) and four rates of application (coded 1st, 2nd, 3rd and 4th to represent either 0, 150, 300 and 450 kg N ha^{-1} for urea and NPK or 0, 25, 50 and 75 t ha^{-1} for poultry manure) on the growth, fresh herbage and dry matter yields of *Chloris gayana*.

Materials and Method

In 2012, twelve fertilizer treatments were evaluated on a 2-year old Rhodes grass pasture in two separate experiments. The studies were carried out at Dagwom farm, NVRI, Vom, Plateau State, Nigeria. The farm is located at latitude 09^{o} 44'E and longitude 08^{o} 44'N on an elevation of 1,239.4 m above sea level. The pasture was established on a ferallictic cambisol that originated from volcanic rocks (8) and classified as Inceptisol (9). Plots of 3 m x 3 m (9 m^2) were marked out on the pasture and separated by 1 m while replications were separated by 2 m alley. Three fertilizers (urea, NPK and poultry manure) and four rates of application (1st, 2nd, 3rd and 4th) were combined to form twelve treatments. Fertilizer application rates were coded 1st, 2nd, 3rd and 4th to represent 0, 150, 300 and 450 kg N ha^{-1} for urea and NPK or 0, 25, 50 and 75 t ha^{-1} for poultry manure. The treatments were arranged in a randomized complete block design (RCBD) and replicated three times. Routine analysis of the soil and poultry manure was carried out (10) before fertilizers were applied to the plots. Pasture within plots was cut to a uniform height of 3 cm above soil surface with a hand sickle before fertilizers were applied. Subsequently, the plots were re-cut at 8 weeks after fertilizer application (WAF).

Sward height (cm) was measured at 4, 8 and 12 WAF while fresh herbage (FH) and dry matter (DM) yields (t ha^{-1}) were measured at 8 WAF. To determine fresh herbage yield, plants within a plot were cut to 3 cm above ground level and weighed with a spring balance scale set on a tripod. A weighed subsample of the fresh herbage was dried to constant weight in an oven set to 70° C and reweighed to estimate DM yield (11). The values obtained for fresh herbage and dry matter yields plot^{-1} were converted into t ha^{-1}(12). Data collected were subjected to a two-way Analysis of Variance (ANOVA) to test the significance of treatment effects at 5 % level of probability using the Statistical Analysis System software (13). The treatment means were separated with the Least Significant Difference (LSD) method at 5 % level of probability. Pearson correlation coefficients were worked out for the measured variables using the same statistical software and 5% level of probability.

Results

The sandy loam soil used was slightly acidic (pH 5.5) with organic matter and total nitrogen concentrations of 0.96 and 0.28 %, respectively (Table 1) However, poultry manure was slightly alkaline in reaction (pH 7.7) with organic matter content of 1.52 % and total nitrogen content of 1.04 %.

Table 1: Chemical composition of the experimental soil and poultry dung

Parameter	Soil	Poultry manure
pH (0.01 M $CaCl_2$)	5.5	7.7
Organic carbon (%)	2.16	1.32
Total nitrogen (%)	0.28	1.04
Available phosphorus (mg kg^{-1})	29.88	45
Cation exchange capacity	6.5	na
Textural class	Sandy loam	
Calcium (g kg^{-1})	na	3.5
Magnesium (g kg^{-1})	na	0.89
Potassium (g kg^{-1})	na	0.75
Sodium (g kg^{-1})	na	0.87

na = not applicable

Sward height was significantly ($p < 0.05$) affected by fertilizer application (Table 2). Poultry and NPK fertilizers produced taller sward heights than urea (by 54.2 % at 4 WAF and by 38.5 % at 8 WAF). At 12 WAF, sward height of grasses treated with poultry manure was significantly ($p < 0.05$) taller (by 36.2 %) than those of grasses treated with NPK and urea fertilizers. Rate of application exacted similar effects on sward height at 4 and 8 WAF. Generally, the highest rates of application (3rd and 4th) produced the tallest swards whereas the control (1st rate) produced the shortest swards. At 12 WAF, the 4th application rate furnished significantly taller sward than the other rates. The interaction between fertilizer and rate of application on sward height was significant at 8 and 12 WAF.

Table 2: Sward height of Rhodes grass

Fertilizer (F)	Sward height (cm) 4 WAF	8 WAF	12 WAF
Poultry	45.1^{a}	99.7^{a}	42.1^{a}
NPK	40.2^{a}	90.1^{a}	32.0^{b}
Urea	27.7^{b}	68.5^{b}	29.7^{b}
LSD (0.05)	7.93	11.21	4.04
Rate of application (R)			
1st	25.9^{c}	49.2^{c}	30.8^{b}
2nd	38.3^{b}	91.0^{b}	31.6^{b}
3rd	40.4^{ab}	102.1^{ab}	34.0^{b}
4th	47.4^{a}	108.0^{a}	42.4^{a}
LSD (0.05)	9.18	12.98	4.68
Interactions			
F X R	ns	*	**

WAS=Weeks after sowing, ^{a,b,c} Means with different superscripts within a row are significantly different ($p < 0.05$), ns= Not significant , F x G= Interaction between fertilizer and grasses

Poultry and NPK fertilizers produced similar fresh herbage yields which on average were significantly greater (by 95.2 %) than that produced with urea fertilizer (Table 3). In addition, dry matter yield followed a significant order of poultry > NPK (by 46.60 %) and NPK > urea (by 73.80 %). Rate of application affected fresh herbage and dry matter yields significantly ($p < 0.05$) in a linear manner (Table 3). The differences between the 4th and 1st rates of fertilizer application were 275.90 % and 333.30 % for fresh herbage and dry matter yields, respectively.

Table 3: Fresh herbage and dry matter yields of Rhodes grass

Fertilizer (F)	Fresh herbage (t ha^{-1})	Dry matter (t ha^{-1})
Poultry	35.1^{a}	10.7^{a}
NPK	29.3^{a}	7.3^{b}
Urea	16.5^{b}	4.2^{c}
LSD (0.05)	6.02	2.16
Rate of application (R)		
1st	10.8^{d}	2.7^{c}
2nd	25.4^{c}	6.5^{b}
3rd	33.5^{b}	9.4^{a}
4th	40.6^{a}	11.7^{a}
LSD (0.05)	6.87	2.51
Interactions		
F X R	**	*

^{a,b,c} Means with different superscripts within a row are significantly different ($p < 0.05$), ns= Not significant , F x G= Interaction between fertilizer and grasses

The interactions between fertilizer and rate of application on sward height, fresh herbage (FH) and dry matter (DM) yields are presented in Table 4. At 8 WAF, grasses in the control (1st rate of application) had significantly shorter sward than those in the other treatments which were similar. This trend was consistent in all fertilizers. Within rates of application, NPK and poultry fertilizers produced a similar sward that was significantly ($p < 0.05$) higher than that from urea. At 12 WAS, sward height differed significantly within NPK and poultry fertilizers. In NPK, the 4th rate of application furnished significantly higher sward than the 1st and 2nd rates of application. In the case of poultry manure, the 4th rate of application produced the significantly tallest sward height (58.10 cm) followed by the 3rd rate which produced significantly higher sward than the 1st and 2nd rates of application. Within the 1st and 2nd rates, sward height was similar among fertilizers. However, in the 3rd rate, poultry manure yielded significantly higher sward than NPK and urea fertilizers. In the 4th rate, poultry manure was statistically better than NPK which enhanced sward height significantly more than urea.

Fresh herbage (FH) yield differed significantly among rates of application within NPK and poultry fertilizers. In both cases, the control (1st rate) produced the significantly lowest FH yield while the 3rd and 4th rates of application were at par in FH yield. Within rates of application, FH yield was similar at the 1st rate. With the 2nd and 4th rates of application, NPK and poultry fertilizers produced similar but significantly ($p < 0.05$) heavier fresh herbage than urea fertilizer.

Table 4: Interaction between fertilizer and rate of application on sward height, fresh herbage (FH) and dry matter (DM)

Fertilizer	Rate of application	Sward height (cm)		FH (t ha^{-1})	DM (t ha^{-1})
		8 WAF	12 WAF	8 WAF	8 WAF
NPK	1st	37.2^{g}	28.2^{d}	6.9^{g}	1.9^{f}
	2nd	96.5^{bc}	30.1^{d}	28.4^{cde}	6.5^{de}
	3rd	112.3^{ab}	31.1^{cd}	37.4^{bc}	9.8^{cd}
	4th	114.5^{ab}	38.8^{c}	44.4^{ab}	10.8^{c}
Poultry	1st	62.9^{ef}	34.6^{cd}	15.6^{fg}	3.5^{ef}
	2nd	109.0^{ab}	33.6^{cd}	32.8^{cd}	9.6^{cd}
	3rd	123.0^{a}	46.3^{b}	50.2^{a}	15.3^{ab}
	4th	124.0^{a}	58.1^{a}	53.4^{a}	18.2^{a}
Urea	1st	42.9^{fg}	28.4^{d}	8.4^{g}	2.5^{ef}
	2nd	67.5^{de}	30.0^{d}	15.0^{fg}	3.3^{ef}
	3rd	78.1^{cde}	29.9^{d}	18.3^{fg}	4.9^{ef}
	4th	85.4^{cd}	30.5^{d}	24.2^{d-g}	6.1^{de}
	LSD (0.05)	23.03	8.31		

WAF=Weeks after fertilizer application, ^{a,b,c} Means with different superscripts within a row are significantly different ($p < 0.05$), ns= Not significant , F x G= Interaction between fertilizer and grasses

Dry matter yield differed significantly among rates of application within NPK and poultry fertilizers. In the NPK treatment, dry matter yield produced with the 4th rate of application was significantly higher than those of the 1st and 2nd rates. In poultry fertilizer, the 3rd and 4th rates produced similar but significantly greater DM than the 2nd rate which produced heavier dry matter than the 1st rate. The correlation coefficients among the measured variables were positive and highly significant. The highest correlation (r = 0.895**) was between fresh herbage and dry matter yields.

Table 5: Matrix of correlation coefficients of the measured variables

	FH	DM
Sward height,	0.700**	0.753**
Fresh herbage yield		0.895**

FH= Fresh herbage, DMY=Dry matter, **=Significant at 1 % level of probability.

Discussion

Despite the high soil nitrogen concentration (14), the control (1st rate of application) furnished significantly lower values than the other treatments in all the variables measured. This clearly indicates that pastures require fertilizer application for higher productivity. Stakeholders should therefore be encouraged to embrace the concept of fertilizer application for enhanced pasture productivity. Rhodes grass growth and yield were positively influenced by fertilizer application. Poultry manure was comparable to NPK and superior to urea in boosting the measured attributes. This implies that NPK and poultry fertilizers were more suitable for Rhodes grass than the single nutrient urea fertilizer. Pasture grasses rely on multiple nutrients (N, P and S) for optimum growth and yield (5). The practical implication is that application of urea fertilizer alone will not adequately meet the nutritional requirements of Rhodes grass. Consequently, NPK rather than urea should be the inorganic fertilizer of choice for Rhodes grass pastures. Comparatively, poultry manure enhanced dry matter (DM) yield of Rhodes grass better than NPK and urea fertilizers. This is a paramount reason for the utilisation of poultry manure for Rhodes grass production. The highest plant density and dry matter yield of Rhodes grass was obtained with poultry manure (15). Furthermore, poultry manure releases its nutrients slowly, but adds organic matter, which improved soil tilth and retained moisture better than mineral fertilizer (16). Moreover, Rhodes grass produced high fresh herbage and dry matter yields with 25 t ha^{-1} of poultry manure (17) whereas in this study, the best poultry manure rate was 50 t ha. This difference may be due to the nitrogen content of the manure which in this case was 1.04 % and 1.45 % in the other study. The study also revealed that the higher rates of application increased Rhodes grass growth and yields more than the lower rates. A similar trend was reported by (18) who observed that grass production doubled with an increase in fertilizer rate. Moreover, biomass accumulation of Pangola grass (*Digitaria eriantha*) was significantly increased with higher rates of sulphur fertilizer (19). In addition, dry matter yield of *Sorghum almum* was significantly influenced by rate of nitrogen fertilizer (20). According to (21), rate of nitrogen fertilizer rather than spacing accounted for differences in dry matter yield of *Brachiaria decumbens*. These reports imply that high rates of fertilizer application to pastures are preferable. However, the statistical similarity of the 3rd and 4th rates of application in this study connotes that the 3rd rate of application may be the suitable level for Rhodes grass production. This implies that fertilizer application to Rhodes grass should not exceed 300 kg NPK ha^{-1} or 50 t ha^{-1} of poultry fertilizer. It is noteworthy that nutrient quantities of poultry fertilizer may differ considerably between farms. This should be borne in mind when applying poultry manure to pastures.

Interaction between fertilizer and rate of application confirmed the suitability of NPK fertilizer and poultry manure for Rhodes grass. It also asserted that the 3rd and 4th rates of application were statistically similar. This infers that the 3rd rate of application is adequate for Rhodes grass production. Consequently, when 50 t ha^{-1} of poultry manure or 300 kg N ha^{-1} as NPK is applied to Rhodes grass, a substantial 15.3 t ha^{-1} of DM could be harvested and utilized for higher ruminant production (22). The significant positive correlations among the measured variables infer that taller Rhodes grass pastures will furnish higher fresh herbage and dry matter yields. This means that nitrogen fertilizer application to pastures is mandatory to ensure higher growth and yields. However, a single nutrient fertilizer such as urea will not guarantee the desired levels of Rhodes grass yields. Nitrogen fertilizer application balanced with other nutrients ensures increased forage quality and production (16).

Conclusion and Applications

From the result of this study,

1. Fertilizer application increased the growth and dry matter yield of Rhodes grass significantly.
2. Poultry manure was statistically superior to NPK which was significantly better than urea in enhancing the measured variables of Rhodes grass.
3. The 3rd and 4th rates of fertilizer application were similar and significantly better than the 1st and 2nd rates for dry matter production.
4. The optimum rate of fertilizer application for Rhodes grass at Vom may be 50 t ha^{-1} of poultry manure or 300 kg N ha^{-1} of NPK fertilizer.
5. Rhodes grass could provide substantial quantities of fodder for ruminant nutrition if fertilizer application is adequate.

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