Effect of Fertilization and Cutting Frequency on the Yield of *Brachiaria Ruziziensis* Germain and Evrard in Adamawa Plateau-Cameroon

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Keywords : *Brachiaria ruziziensis* — Fertilization — Cutting frequency — Yield — Cameroon.

Summary

A study of the effect of nitrogen fertilizer (in the presence of potassium and phosphorus) and cutting frequency on the yield of Brachiaria ruziziensis *was undertaken at the Wakwa animal Research Station on ferralitic soil. A 7x3 factorial design was used. The treatments were seven levels of nitrogen fertilizer (0, 40, 50, 60, 70 and 90 units of nitrogen) and three cutting frequencies (heavy : 30 days, moderate : 45 days and light : 60 days). Single application of 100 units of triple superphosphate and potassium sulfate per hectare and nitrogen at the above mentioned rates was made at the beginning of each rainy season. Later, after each cutting nitrogen alone was applied. Results of three years of study indicate that fertilization consistently increased the yield of* Brachiaria ruziziensis *compared to non-fertilized plots by as much as 132.8 %, 133.7 % and 92.83 % respectively in 1985, 1986 and 1987. Polynomial adjustment of means equally gave very good results as shown by the relatively hight coefficient of determination as* R^2 *(0.93 in 1985, 0.99 in 1986 and 0.76 in 1987). Herbage yield was greater from plots clipped every 30 days than from those clipped every 45 or 60 days. This suggests that productivity of* Brachiaria ruziziensis *seeded pastures can be improved when rotational grazing with a rest period of about thirty days is practiced.*

Résumé

La réponse de Brachiaria ruziziensis *à la fertilisation azotée (en présence du potassium et du phosphore) et à différentes fréquences de coupe a été entreprise à la Station de Recherche Zootechnique de Wakwa sur un sol ferralitique. Un essai factoriel avec sept doses d'azote (0, 40, 50, 60, 70, 80 et 90 unités d'azote/ha) et trois fréquences de coupes (30 jours, fortes ; 45 jours, moyennes et 60 jours, faibles) a été utilisé. L'application en une seule fois de 100 unités de superphosphate triple, de sulfate de potassium et d'azote aux doses ci-dessus indiquées était réalisée au début de chaque saison des pluies. Après chaque coupe, l'azote était réappliquée seul. Les résultats de trois années d'étude ont montré que la fertilisation a régulièrement augmenté la production de* Brachiaria ruziziensis *comparé aux témoins de 132,8 %, 133,7 % et 92,83 % en 1985, 1986 et 1987 respectivement. L'ajustement polynomial des données moyennes a fourni de bons résultats comme le montrent les coefficients de détermination* R^2 *(0,93 en 1985 ; 0,99 en 1986 et 0,76 en 1987) relativement élevés. La production fourragère était plus élevée sur les parcelles coupées tous les 30 jours comparés aux parcelles coupées tous les 45 ou 60 jours. Ce qui suggère que la productivité de* Brachiaria ruziziensis *peut être améliorée avec un système de pâture autorisant 30 jours de repos en saison des pluies.*

Introduction

The alternation of relatively long dry and short rainy seasons, as one moves from the south to the north in the - Sahel-Sudan region of West Africa, has a great influence on the productivity and quality of rangeland. During the rainy season, range plants grow rapidly and, although their quality may be good early in the season, they mature rapidly with a resulting decline in quality. In the dry season, grasses become dry and scorched. Their decline in quality impairs the productivity of ruminant livestock that depend mainly on grassland. Often this decline in nutritive value of range forage plants is so drastic that animals experience serious reduction in protein, energy, mineral and vitamin intake. This generally leads to the loss of weight (20 % for mature cows (4), 30 % (28), 28 % for a lactating local Foulbé cow (9), reduction or cessation of growth, and a sharp decline in milk production for lactating cows. Consequently, nutrition has frequently been cited as the most limiting factor in animal production in the tropics of Africa (1, 27, 28). Alternate weight gain and weight loss force animals to take 5-6 years to reach slaughter weight (23, 28, 29).

Supplementation of feed or available high-quality conserved forage (hay or silage) with a relative high energy and protein content during the dormant period can enable animals to maintain and even increase weight acquired during the wet season. While the technique of silage conservation still has to be learnt and adopted, especially by farmers on a large scale, the technique of hay conservation has been introduced and is currently being used by several farms of the Adamawa plateau. Related to the expansion of hay production is the need to have a very high quality forage and a sound management technique to help farmers obtain the optimum from this production system.

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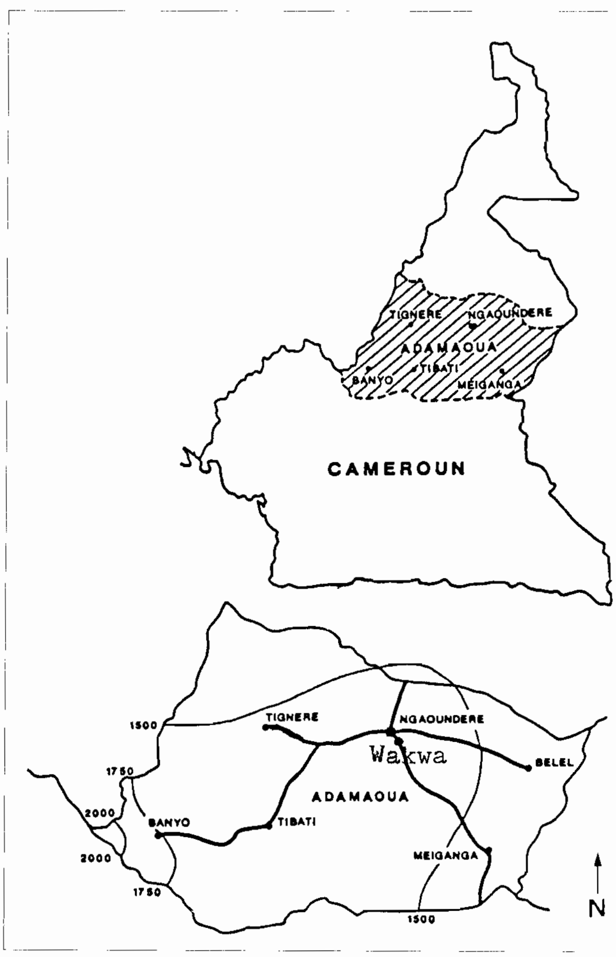
Fertilizers have been shown to increase forage yields under some range conditions (6, 11, 14, 15) but very little under others (20, 23). Thus, in recent years, a great deal of attention has been directed to the possibilities of increased forage production by fertilization. Various studies (17, 31) have been conducted on the response of *Brachiaria ruziziensis* GERMAIN and EVRARD, one of the best perennial forage grasses of the region, to fertilization at the Wakwa Animal Research Station. The study by Yonkeu (31) indicated that application of phosphorus to improve the yield of *Brachiaria ruziziensis* on ferralitic soil of the region was not efficient. Hence the use of about 50 units of P_2O_5/ha would seen adequate for maintaining the production potentials of the soil. The study by Pamo (17) indicated that nitrogen fertilization significantly increase the production of *Brachiaria ruziziensis* ; although this increase was not consistent from year to year. Several previous unpublished data collected at the Wakwa Animal Research Station equally indicated that *Brachiaria ruziziensis* responded to the application of nitrogen fertilizer. However, the quantity of nitrogen needed to give maximum yield of this forage in the presence of potassium and phosphorus was neither known nor was the optimum cutting frequency. As a result, this study was undertaken to determine the effect of nitrogen fertilization in the presence of potassium and phosphorus and cutting frequency on the productivity of *Brachiaria ruziziensis* GERMAIN and EVRARD.



Location of the study area

Material and Methods

The study was conducted on the Wakwa Animal Research Station located on the Adamawa plateau, 7 km south of Ngaoundere, at an altitude of about 1200 m. The climate of the region is classified as Sudan-guinean type. The long term mean annual precipitation in the station is 1706.2 mm (16); however, during the study period (1985-1987), the annual precipitation varied between 1570 mm (1985) and 1451.5 mm (1987) indicating a drop of about 7.5 % while the number of rainy days for a growing season of about 240 days decreased from 133 days (1985) to 114 days (1987) or a drop of 14.2 %. The pentadaily distribution of precipitation (fig. 1 a, b and c) however appears normal indicating potential regular moisture availability for forage growth during the growing season despite the reduction in quantity. More than 80 % of this moisture falls between May and October.

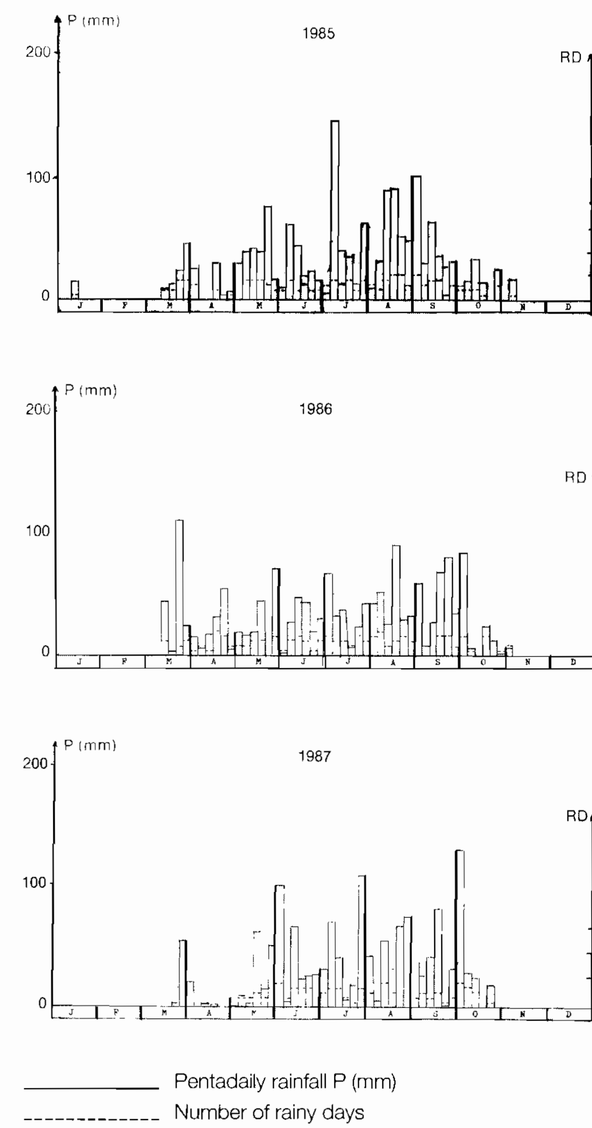


Figure 1 - Pentadaily rainfall and Number of Days in 1985 - 1986 - 1987.

The soil of the experimental site is classified as ferralitic on recent basaltic substratum. It is a relatively acidic (pH = 5.55) soil, rich in organic matter with the favorable C/N ratio: 17. However, it is very low in exchangeable bases as well as assimilable phosphorus reserve (P. Olsem = 26 ppm).

The field study started in May at the onset of the 1985 rainy season. The design was a completely randomized 7x3 factorial with four replicates. The treatments were seven levels of nitrogen in the form of ammonium sulfate at 21 % N (0, 40, 50, 60,70, 80, 90 units of nitrogen/ha) and three cutting frequencies (F_1 = 30 days, heavy; F_2 = 45 days, moderate; F_3 = 60 days, light). A single application of 100 units of triple superphosphate at 47 % and potassium sulfate at 50 % per hectare was made at the beginning of each rainy season after the zero timing of Brachiaria ruziziensis on each plot at 5 cm above the ground level.

The trial was carried out on a fine seed-bed which has been prepared by ploughing and harrowing with a disc and toothed harrow. On each replicate twenty one plots (2x10m) were demarcated with iron pegs. Plots were separated from each other by a one meter buffer interval. In each plot, four seed bed lines were dug with a hoe at 40 cm spacing and handseeded a about 3 cm depth. About two months after planting the experiment was zero timed by cutting back all the plots at 15 cm above ground level. Nitrogen as well as potassium and phosphorus at the above mentioned rate was then applied and later nitrogen alone after each cutting.

During each cutting period, a one meter strip of the plot was removed from each end and about 47 cm on each side, such that the grasses were cut over an area of 1.06 x 8 m and the total fresh herbage weights were recorded. Sub-samples of 500 g were randomly hand-picked after thorough mixing and furnate-driet at 90°-95°C during 24 h. These weights were used as the dry matter (DM)-factor to estimate the yield in dry matter per hectare. Analysis of variance was carried out on the data and significant differences among treatments were tested with Duncan's multiple range test (24).

Results and Discussion

Brachiaria ruziziensis establishment was excellent. About two weeks after seeding in 1985, most if not all seeds had germinated and plants grew uniformly until zero timing about two months later. During the subsequent years, about two months after the first rains, the plots had resumed growth and were zero timed.

The analysis of variance of the total dry matter of *Brachiaria ruziziensis* GERMAIN and EVRARD shows that the application of nitrogen fertilization improves the yield of the forage considerably. Differences due to fertilization and cutting frequency were all significant ($P<0.05$) but their interactions were not ($P>0.05$). This indicates that both treatments react consistently in the same way. The standard deviation of the various mean yields at different rates and cutting frequencies (Table 1) appears in some cases to be large. This was due to the fact that within the year after fertilization following cutting, evidence of *Brachiaria ruziziensis* burning by nitrogen was observed on certains parts of some plots. This generally happened when, after fertilization, rain did not fall for one or two days. Consequently, this burning

Table 1
Forage and their means in kg of dry matter per hectare under different fertilization rates and cutting frequencies.

Years	Units of N/ha Cutting frequency	0	40	50	60	70	80	90	Means**
1985	F_1=30 days	2079.5a	4830.3b	4901.5ba	5361.5b	7076.3c	7346.3c	7050.bc	5520.8 ±1862a
	F_2=45 days	3464a	3774a	2590.8a	2639.5a	3700.8a	4241.5a	4627.8a	3576.9 ±760b
	F_3=60 days	1752.3a	3712ab	3620.5ab	4690b	5107.3b	5142.5b	5307.3b	4190.3 ±1274b
	MEANS*	2431.9 ±908.6a	4105.4 ±628.4cd	3704.3 ±1158cd	4230.5 ±1418cd	5294.8 ±1695bc	5576.8 ±1593.9b	5661.5 ±1249.4b	
1986	F_1=30 days	1382.8a	3610.5b	4219b	3782b	4062.3b	4824b	4399.8b	3754.3 ±1119.5ab
	F_2=45 days	2488.8a	4010.3b	4195.3b	4516.3b	4281b	4419b	4464.5b	4055 ±712b
	F_3=60 days	1846.3a	3439b	3173.3ab	3821.3b	4147.5b	4122.5b	3818.3b	3481.4 ±801a
	MEANS*	1906.6 ±555.3a	3686.6 ±292.9b	3862.5 ±597b	4039.8 ±413b	4163.6 ±110.2b	4455.2 ±352.1b	4227.5 ±355.5b	
1987	F_1=30 days	3574.3a	5151.8ab	5993bc	7795.3c	6764.5bc	6478bc	5645.5b	5914.6 ±1336a
	F_2=45 days	2684.8a	4702.5ab	5338.3ab	4988.8ab	4612.5ab	4513ab	6125.5b	4859.3 ±756.5b
	F_3=60 days	2429.3a	4022.8ab	3624.8a	5988.8b	3642.5a	4462ab	4267ab	4062.4 ±1076c
	MEANS*	3229.4 ±695.1a	4625.6 ±568.4ab	4983.3 ±1223bc	6257.6 ±1422.4c	5006.5 ±1598bc	5151 ±1149bc	5346 ±964.7bc	

* Means in the same raw bearing the same subscripts are not significantly different ($p<0.05$)
** Means in the column bearing the same subscripts are not significantly different ($p<0.05$).

probably delayed growth resumption and then, influenced the production of the forage during the subsequent evaluation period.

During the three-year period of study, there were significant differences in herbage yields between the control and the fertilized plots (Table 1).

Unfertilized plots produced an average 2.4, 1.9 and 3.2 tons of dry matter herbage per hectare in 1985, 1986 and 1987 respectively ; while fertilized plots yielded an average of 5.7, 4.5 and 6.2 tons with 90, 80 and 60 units of nitrogen per hectare in 1985, 1986 and 1987. This shows an increase as compared to the control of 132.8 %, 133.7 % and 92.9 % for the respective years. Mader (11) in True Prairie and Owensby and al. (14) have obtained similar results. The results of the study by al. (14) have obtained similar results. The results of the study by Mader were attributed only to nitrogen although nitrogen fertilization was used in combination with phosphorus and potassium.

In 1985, maximum forage yields of 7.3, 4.6 and 5.3 tons of dry matter per hectare were obtained with a fertilization rate of 80, 90 and 90 units of nitrogen per hectare for heavy, moderate and light cutting frequencies, respectively (Table 1).

Within the same cutting frequency, there were no significant differences ($P>0.05$) in yield obtained between fertilization rates of 40 and 80 units of nitrogen per hectare. However, significant differences ($P<0.05$) were found to exists for yields obtained with fertilization rate of 40-60 and 70-90 units of nitrogen per hectare. No significant differences ($P>0.05$) between the yields were found at various fertilization rates at the moderate cutting frequency while under the light cutting frequency a significant difference ($P<0.05$) could mainly be observed between the fertilized and unfertilized plots.

Polynomial adjustment in 1985 of the yield under different fertilization rates for the three cutting frequencies as indicated below gave variable results :

$F_1 : Y = 2045.04 + 69.39\ N - 0.10\ N^2 \quad R^2 = 0.94$

$F_2 : Y = 3577.64 - 38.61\ N + 0.56\ N^2 \quad R^2 = 0.60$

$F_3 : Y = 1717.42 + 54.32\ N - 0.14\ N^2 \quad R^2 = 0.96$

These adjustments were quite good for heavy and light cutting frequencies as shown by the relatively high coefficient of determination which indicates the proportion of total variation in forage production which can be explained by the regression curve. This coefficient was however relatively low under moderate cutting frequency. Optimum production could not be derived from these adjustments indicating that there was still good potential for increasing forage production under this experimental condition.

In 1986, surprisingly, there was a general decrease in forage yield (52.3 %, 2.5 % and 28 %) (Table 1) at heavy, moderate and light cutting frequencies as compared to the maximum production of the previous years ; despite the fall of similar amount of precipitation (1570 and 1568 mm in 1985 and 1986 respectively) distributed over the same number of months. In all the three cutting frequencies significant differences ($P<0.05$) were observed between fertilized and unfertilized plots, but none between fertilized plots (Table 1).

This indicates that in 1986, the difference in yield obtained with fertilization rate between 40 and 90 units of nitrogen per hectare was not more than that expected by chance. It equally shows how erratic is the species response to the environment even under experimental conditions which are assumed to be relatively «uniform».

Adjusted yields under the different fertilization rates in 1986 are indicated by the equation below as well as the coefficient of determination (R^2) :

$F_1 : Y = 1413.53 + 69.12\ N - 0.39\ N^2 \quad R^2 = 0.94$

$F_2 : Y = 2495.83 + 50.88\ N - 0.33\ N^2 \quad R^2 = 0.98$

$F_3 : Y = 1824.66 + 48.26\ N - 0.27\ N^2 \quad R^2 = 0.92$

Although the production was low in 1986, the adjustment gave better results compared to 1985 indicating that there were relatively small variabilities which could not be explained by the regression equations. The 1986 data equally appears to be more consistent. An optimum production of 4.5 tons DM/ha with 77 units of nitrogen/ha was obtained under moderate cutting frequency. However, under heavy and light cutting frequencies, optimum production could not be achieved. This seems to indicate a good potential for improvement under this condition.

A better result was obtained in 1987 with a sizeable increase in herbage yield of 61.6 %, 35.6 % and 44.4 % for heavy, moderate and light cutting with 60, 90 and 60 units of nitrogen per hectare respectively as compared to the maximum production of 1986 despite a decrease in rainfall of about 117 mm. This increase was only 6 %, 32.4 % and 13 % for the respective frequencies as compared to the 1985 maximum production. The soil water content could have been used more efficiently by *Brachiaria ruziziensis*. In fact, nitrogen fertilization increases moisture-use efficiency (14). This has been attributed to greater root development of the soil mass stimulated by added nitrogen (12). Lorenz and Roger (10) in the Northern Great Plains found increased root weight with nitrogen fertilization of native range. They hypothesized that increased root exploration enhanced both water-use efficiency and nitrogen recovery.

Yield adjustment under different fertilization rates in 1987 are indicated by the following equations :

$F_1 : Y = 3306.06 + 97.98\ N - 0.75\ N^2 \quad R^2 = 0.73$

$F_2 : Y = 3789.21 + 22.55\ N - 0.05\ N^2 \quad R^2 = 0.52$

$F_3 : Y = 2385.30 + 61.99\ N - 0.46\ N^2 \quad R^2 = 0.48$

These adjustments were not as good as those of the previous years, and indicates that most variation in production could not be explained by the regression equation only. Optimum production (6.55 and 4.5 tons of DM/ha obtained with 65 units of nitrogen/ha under heavy and light cutting from the frequencies) derived from those curves were quite different from the field maximum production (fig. 2). These variations reflect the difference that normally exists between the actual experimental observations and predicted results derived rather from experimental data.

Fertilized plots maintained green cover up to the end of November about four weeks after the last rains. Although this has been little documented, desert grassland in Arizona was observed to remain green one week longer when fertilized (7) while fertilized *Stipa virudula* matures four weeks later than when unfertilized (30).

Brachiaria ruziziensis productivity is affected by harvesting. Depending on time and frequency of herbage removal, *Brachiaria ruziziensis* growth may be reduced or enhaced within a given growing season of subsequent seasons. The primary concern of range managers is the amount of the remaining photosynthetic material for growth within the growing season and for replenishment of the reserve system following initial growth or harvesting. Grazing or cutting of *Brachiaria ruziziensis* removes leaf area necessary for energy production. Frequency and amount removed will determine the effect on plant productivity. Three cutting frequencies leading to more or less harvests per season were used in this study to simulate grazing at a single stubble height, 15 cm above the soil level. Given the structure of the plant this cutting height was judged to be relatively moderate and would not seriously affect *Brachiaria ruziziensis*. This has been confirmed by Pamo (18) on rangeland.

During the study period, a cutting frequency of thirty days significantly ($P<0.05$) out yielded that for forty-five and sixty-five days in 1985 and 1987 (Table 1).

In 1986, the forty-five days cutting frequencies provided the best results ; however, there were no significant differences ($P>0.05$) in herbage yield between the thirty and forty-five days cutting frequencies. The plots that were clipped monthly yielded 31.8 % and 45.6 % more than those clipped every six weeks in 1985 and 1987 respectively. The data that were basically in agreement with data of previous researchers (3, 5, 13, 19, 26) which indicate that some clipping during the growing season can increase herbage yield although clipping too frequently can decrease herbage yield. Monthly clipping appeared to be the optimum frequency since in the study by Undersander and Naylor (26) plots clipped weekly or biweekly gave a lower yield compared to those clipped monthly. *Brachiaria ruziziensis* plots clipped bi-monthly consistently gave a low result : 31.8 %, 45.6 % less compared to the plots clipped monthly. This is in agreement with a previous study by Hunt (8) which indicate that infrequent cutting and high leaf area index's can increase tissue death decay within a sward, often without any accompanying new growth. This occured in the alfata grass swards of Davies et al (2) where two cuts per season yielded less than the three cuts per season and also in the experiment by Reid (21, 22) who found that defoliation frequency did not affect the production of perennial rye grass-white clover or cocksfoot-white clover which was allowed to regrow to 20 cm high and defoliated to 6 cm high.

Conclusion

This study shows that nitrogen fertilization in the presence of phosphorus and potassium influences the productivity of *Brachiaria ruziziensis* GERMAIN and EVRARD on ferralitic soil in the Adamawa plateau. On average a greater yield (5.66 tons DM/ha) was obtained with a fertilization rate of 90 units nitrogen per hectare in 1985.

This indicates an increase of 132.80 % as compared to the yield of the control. There were however no significant differences between yield with fertilization rate between 70 and 90 units of nitrogen per hectare and the optimum production could not be derived from the equation of the adjusted means ($Y = 2446.69 + 28.37\ N - 0.10\ N^2$, $R^2 = 0.93$).

It seems therefore that there was still potential for increasing forage production under these conditions. In 1986, 80 units of nitrogen per hectare yielded on average a maximum production of 4.45 tons DM/ha and the adjusted means, $Y = 1911.34 + 56.09\ N - 0.33\ N^2$ ($R^2 = 0.99$) gave an optimum production of 4.3 tons DM/ha with a fertilization rate of 85 units of nitrogen per hectare.

In 1987, 60 units of nitrogen per hectare produced 6.22 tons DM/ha while mean yield adjustment provided by the following equation $Y = 3180.49 + 60.41\ N - 0.42\ N^2$ ($R^2 = 0.76$) gave an optimum production of 5.4 tons DM/ha with a fertilization rate of 73 units of nitrogen per hectare. These variable results indicate that there is still potential for improvement under these experimental conditions. Forage produced could be grazed on site, cut and carted away for stall feeding or cut and preserved as hay for subsequent feeding during times of grass shortage. I case of field grazing, cattle could have the opportunity to select the more palatable portion of the species offered. It seems therefore advantageous in this case to graze at intervals yielding a maximum forage production of good quality and sustained maintenance of the pasture.

Among the various range operator controlled factors, grazing frequency simulated in this study by cutting frequency seems to be one of the most important which could allow animals to have access to good and nutritious forage. Thirthy days cutting frequency in this study outyield the other two cutting frequencies and since it equally provides a relatively yound forage, it could better meet the requirements of grazing livestock in terms of energy and protein content. This implies that rotational grazing schemes with a thirty day rest period would result in higher herbage production and likely, higher return in terms of red meat production.

Literature

1. Conrad J.H., McDowell L.R. & Loosli J.R., 1981. Mineral deficiencies, toxicities for grazing ruminants in tropics. In : International Symposium - Animal production in Tropics, p. 1-31, Univ. of Gezira, Wad Medani, Sudan.
2. Davies W.E., Davies R.O. & Harvard A., 1960. The yields and composition of lucerne grass and clover under different systems of management. III. The effect of nitrogen and frequency of cutting. J. Br. Grassl. Soc. 15:106-15.
3. Drawe D.L., Grumbles J.B. & Hooper J.F., 1972. Clipping effects on seeded foothill range in Utah. J. Range Manage. 25:426-429.
4. Dumas R. & Lhoste P., 1969. La production de viande en Adamaoua Camerounais. In : Colloque sur l'élevage : Fort-Lamy. Tchad n° 35 Sec. 8.2:799-805.
5. Eck H.V., Mecully W.G. & Stubbendieck J., 1975. Response of shortgrass plains vegetation to clipping, precipitation and soil water. J. Range Manage. 28:194-179.
6. Gay C.W. & Dwyer D.D., 1965. Effects of one year's nitrogen fertilizatio, on native vegetation under clipping and burning. J. Range Manage. 18:273-276.
7. Holt G.A. & Wilson D.G., 1961. The effect of commercial fertilizers on forage production and utilization on desert grassland site. J. Range Manage. 14:252-256.
8. Hunt L.A., 1965. Some implications of death and decay in pasture production. J. Br. Grass Soc. 20:27-31.
9. Lhoste P., 1967. Comportement saisonnier du bétail zébu en Adamaoua Camerounais. I. Etude des femelles adultes : Comparaison de la race locale aux métis demi-sang Brahma. Rev. Elev. Méd. Vét. Pays Trop. 20:329-342.
10. Lorenz R.J. & Rogler G.A., 1966. Root growth of Northern Plains grasses under various fertilizer and management practices. Proc. Amer. Forage and Grassland council, p. 1-11.
11. Mader E.L., 1956. The influence of certain fertilizer treatments on native vegetation of Kanas prairie. Ph. D. Dissertation. University of Nebraska. 166 p.
12. McKell C.M., Jones M.B. & Perrier E.R., 1962. Root production and accumulation of root material on fertilizer range. Agron. J. 59:459-461.
13. Mutz I.L. & Drawe D.L., 1983. Clipping frequency and fertilization influence herbage yields and crude protein content 4 grasses in South-Texas. J. Range Manage. 36:582-585.
14. Owensby C.E., Hyde R.M. & Anderson K.L., 1969. Effects of clipping and supplement nitrogen and water on loamy upland bluestem range. J. Range Manage. 23:341-346.
15. Owensby C.A. & Smith J.L., 1975. Nitrogen fertilization on bluestem range. KAES Rept of prog. 244:5-12.
16. Pamo T.E. & Yonkey S., 1986. Etude de l'évolution de quelques paramètres climatiques de l'environnement pastoral de Wakwa, Adamaoua, Cameroun. Rev. Sc. et Techn. Ser. Sc. Zootech. **2**(3):19-35.
17. Pamo T.E., 1991. Réponse du *Brachiaria ruziziensis* à la fertlization azotée et à différents rythmes d'exploitation en Adamaoua, Cameroun. Revue Elev. Méd. Vét. Pays Trop. **4**(3):373-380.
18. Pamo T.E., 1989. Rangeland response to low levels of nitrogen fertilization and cutting intensities on the Admawa plateau - Cameroon. Rev. Elev. Méd. Vét. Pays Trop. **42**(4):591-598.
19. Pitman W.D. & Holt E.C., 1963. Herbage production and quality of grasses with livestock and wildlife value in Texas. J. Range Manage. 36:52-54.
20. Ranzi F., Long R.L. & Painter L.T., 1968. Effects of nitrogen fertilization on native grassland. J. Range Manage. 21:287-291.
21. Reid D., 1966. Studies on the cutting management of grassclover swards. IV. The effects of close and lax cutting on yield of herbage from swards cut at different frequencies. J. Agric., Camb. 66:101-106.
22. Reid D., 1968. Studies on the cutting managements of grassclover swards. VI. The effects of different closenes and frequency of cutting treatments on yield and quality of herbage from a cocksfoot-white clover sward. J. Agric. Sci. Camb., 70:330-336.
23. Rhodes F.B., 1956. The effect of feeding mineral protein and carbohydrate supplement to growing cattle in Mashonaland. Rhod. Agric. J. 53:969.
24. Stell R.G. & Torrie J.H., 1980. Principales and Procedures of Statistics. McGraw-Hill Book Co. Inc., New-York, 633 p.
25. Stoddart L.A., Smith A.D. & Bos T.W., 1975. Range Management. McGraw-Hill Book Co. Inc. New-York, 532 p.
26. Undersander D.J. & Naylor C.H., 1987. Influence of clipping frequency on herbage yield and nutrient content of Tall Wheatgrass. J. Range Manage. 40:31-35.
27. Van Niekerk B.D.H., 1975. Supplementation of grazing cattle. Potential to increase beef production in Tropical America. CIAT CE N° 10, p. 83-87.
28. Van Niekerk B.D.H., 1978. Limiting nutrients : Their identification and supplementation in grazing ruminants. In: J.H. Conrand and L.R. McDowell (ed.) Proc. Latin American Symposium on Mineral Nutrition Research with Grazing Ruminants. p. 194-200. Univ. of Florida, Gainesville, Florida.
29. Walker C.A., 1957. Studies of cattle of northern Rhodesia. I. The growth of steers under normal veld grazing and supplemented with salt and protein. J. Agric. Sci. 49:394.
30. White L.M., Cooper C.S. & Brown J.H., 1972. Nitrogen fertilization and clipping effect on green needle grass (*Stipa viridula* Trin). I. Development, growth, yield and quality. Agron. J. 64:328-331.
31. Yonkeu Rippstein S.G., & Pamo E.T., 1986. Effet des doses croissantes de phosphore sur la production fourragère du *Brachiaria ruziziensis* Germain et Evrad sur sol basaltique récent en Adamaoua. Rev. Sc. et Tech. Ser. Sc. Zootech. **2**(4):39-49.

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