Rangeland response to low levels of nitrogen fertilization and cutting intensities on the Adamawa Plateau, Cameroon

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PAMO (E. T.). Influence de faibles taux de fertilisation azotée et de coupes intensives sur les pâturages naturels du Plateau de l'Adamaoua au Cameroun. *Revue Élev. Méd. vét. Pays trop.*, 1989, 42 (4) : 591-598.

Il a été démontré dans bien des régions que la fertilisation et l'intensité de pâture ou de coupe affectent le rendement et la qualité des espèces fourragères des pâturages ; mais les données similaires font défaut sur la plupart des parcours de l'Adamaoua. Une étude a donc été conduite à la station de Recherches Zootechniques de Wakwa pour évaluer la réponse des pâturages naturels sur sol ferralitique avec de faibles doses d'azote et d'intensités de coupe. Un essai factoriel avec sept doses d'azote (0, 40, 50, 60, 70, 80 et 90 unités d'azote/ha) et trois intensités de coupes (5 cm, forte ; 10 cm, moyenne et 15 cm au-dessus du sol, faible) a été utilisé à un mois d'intervalle. L'azote était appliqué après la coupe de régularisation et plus tard après chaque coupe. En moyenne, la fertilisation a régulièrement augmenté la production du pâturage naturel, comparé aux témoins de 88 p. 100 en 1985 et 59 p. 100 en 1986. L'ajustement polynomial des données moyennes a également fourni de bons résultats comme le montrent les coefficients de détermination R^2 (0,91 en 1985 et 0,78 en 1986) relativement élevés. Lors de la première année d'étude il n'est apparu aucune différence significative entre les trois intensités de coupe. En 1986, en raison de problèmes observés sur le terrain, les différentes intensités de coupe ont produit des résultats divers. La forte intensité de coupe a significativement ($P < 0,05$) produit plus que la faible. Comme dans plusieurs études antérieures, il sera cependant possible, à la fin de ce travail, de mieux cerner le problème. *Mots clés* : Pâturage naturel - Engrais azoté - Coupe - Cameroun.

INTRODUCTION

Rangelands represent a complex interaction of a multiplicity of plants and animals with the environment and each other. A rudimentary understanding of that interaction is necessary for manipulating the biotic or abiotic components of rangelands to obtain the desired outputs. The magnitude of interaction makes complete understanding impossible, but a knowledge of some relevant principles underlying these interactions render range management decision making much easier.

The vast land resources (more than 72,000 km^2) of the Adamawa Plateau occupy a unique position in the development of this region. Its efficient and sustained management is closely tied to the native vegetation that existed prior to extensive and generally poor manipulation by man. As the development of the region progresses, those areas suited for tillage agriculture are swallowed up leaving lands non-tillable and of inherently low productivity for grazing animals. Efficient management of those lands necessitated maintenance of healthy plant communities through the generation of wealth of sound data and management technique.

On these highlands (Adamawa plateau) most livestock feed comes from rangelands. These forage feeds are generally unsuitable for human consumption. The ruminants represent the only feasible way to convert this range resource into food for human consumption. With the increasing number of cattle and the decreasing size and importance of good rangeland, it is becoming increasingly necessary to seek ways and methods of improving the production of this range resources.

A few studies have been conducted in this environment on the rangelands response to fertilization and none on its response to grazing intensity. The studies by RIPPSTEIN (10), PAMO and YONKEU (8, 9) indicate that there is a highly significant response of rangeland to a high level of nitrogen fertilization alone and in the presence of phosphorus and potassium. However the economic status of the average herdsman and the problems of non availability of these products render the adoption of this technique very difficult. As a result, a two-year study (1985-1986) was carried out at the Wakwa Animal Research Station with a specific objective to investigate the response of rangeland to low levels of nitrogen fertilization and cutting intensity.

MATERIALS AND METHOD

The study area, Wakwa Animal Research Station, is located on the Adamawa Plateau, 7 km south of Ngaoundere the provincial capital, at an altitude of about 1,200 m. The climate of the region is a Sudano-Guinean type. The long term mean annual precipitation is 1,706.2 mm (7) ; however during the study

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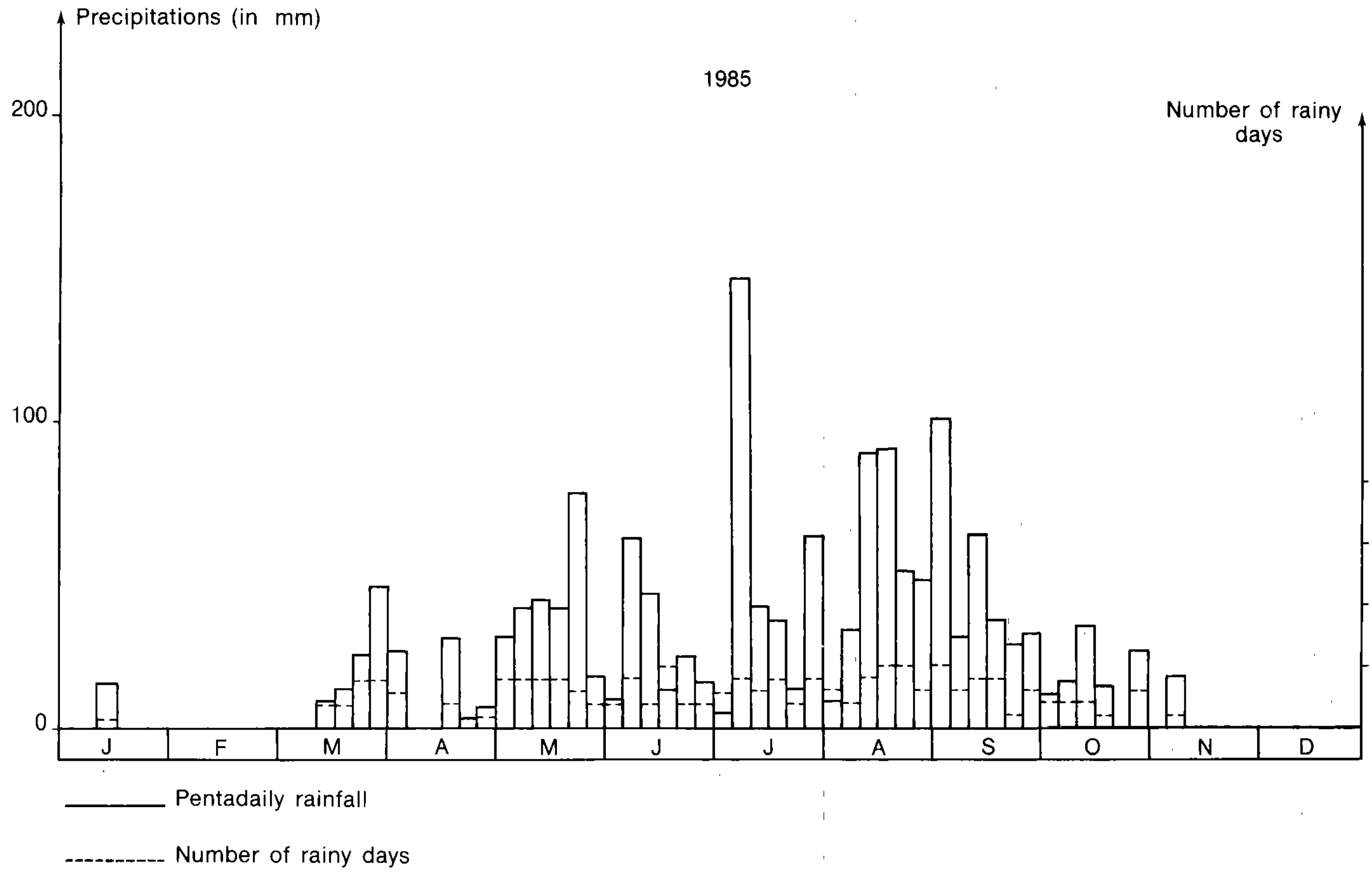

Fig 1a : Pentadaily rainfall and number of rainy days.

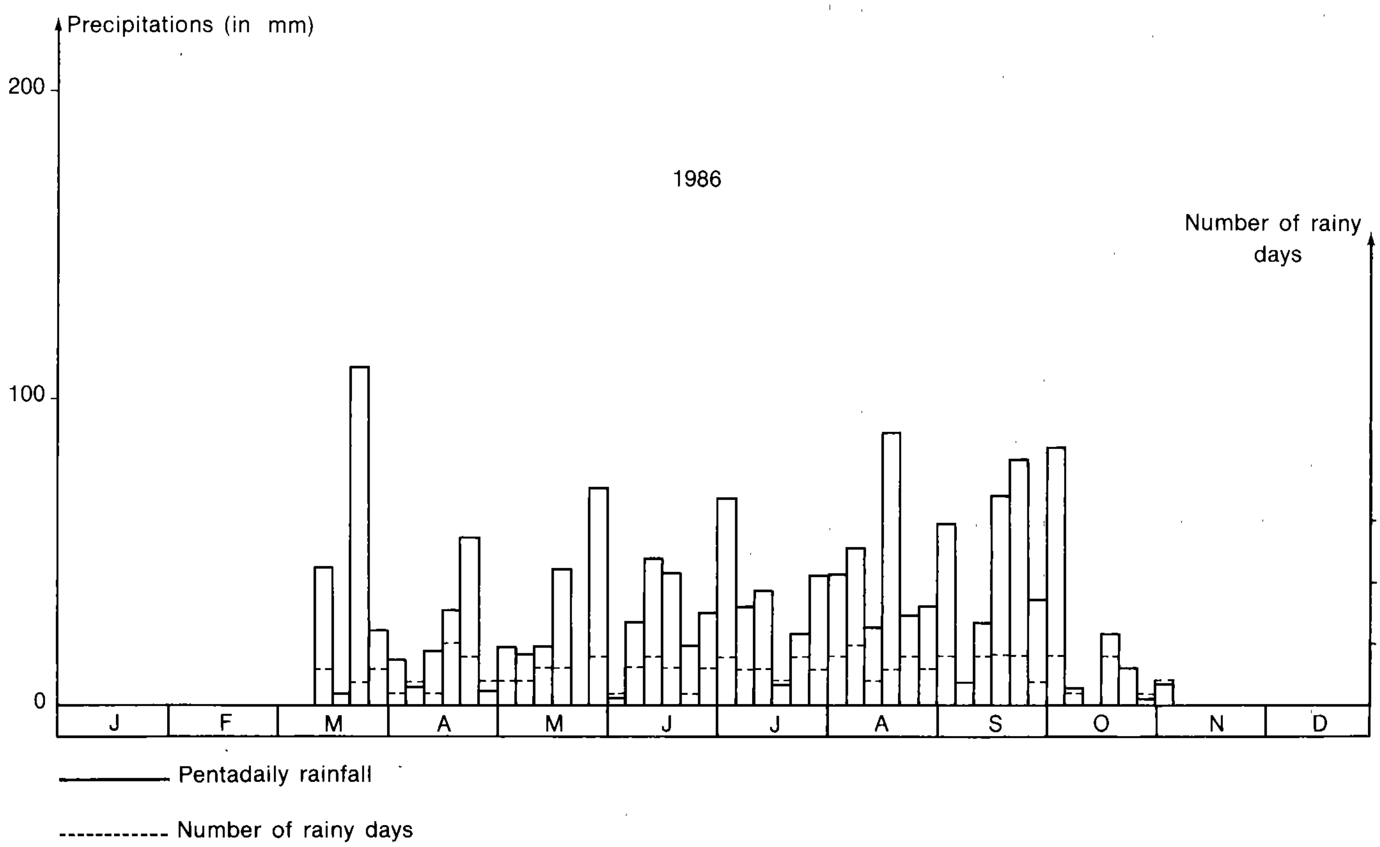

Fig. 1b : Pentadaily rainfall and number of rainy days.

period in 1985 and 1986 the annual precipitation was respectively 1,570 mm and 1,568 mm while the number of rainy days for a growing season of about 240 days were 133 and 138 days respectively. The pentadaily distribution of precipitation (Fig. 1a, b) appears variable in 1985 and regular in 1986. More than 80 per cent of this moisture falls between May and October.

The experimental site was paddock R7. Its soil is classified as ferralitic on basaltic sub-stratum. It is a relatively acidic soil (pH = 5.55) and is rich in organic matter with a good C/N ratio (17).

The grass cover of the experimental site was dominated by *Hyparrhenia rufa* (Nees) Stapf, *Hyparrhenia diplandra* (Hack) Stapf, *Hyparrhenia filipendula* (Hochst ex A. Rich.) Stapf, *Panicum phragmitoïdes* Stapf, *Brachiaria brizantha* (Hochst ex A. Rich) Stapf, *Sporobolus pyramidalis* P. Beauv. and various forage legumes (*Crotalaria sp., Desmodium sp., Indigofera sp., Trifolium sp.*) in a relatively small proportion.

The field study started in May 1985 (onset of rain). The design was completely randomized 7 x 3 factorial with four replicates. The treatments were seven levels of nitrogen in the form of ammonium sulfate at 21 per cent (0, 40, 50, 60, 70, 80, 90 units of nitrogen/ha) and three cutting intensities (I_1 = 5 cm, heavy ; I_2 = 10 cm, moderate ; I_3 = 15 cm, light above soil level) at monthly intervals.

The trial was conducted on 84 2 x 10 m plots demarcated with iron pegs. Plots were separated from each other by 1 m interval. More than three months after the first rains, the plots were zero timed by cutting back at the above mentioned levels, then fertilized at the above mentioned rates and later 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 weighed and recorded. Sub-samples of 500 g were randomly hand-picked after thorough mixing and furnace-dried at 90-95 °C until the dry weight became stable. These weights were used as a 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 tests or t-test (14).

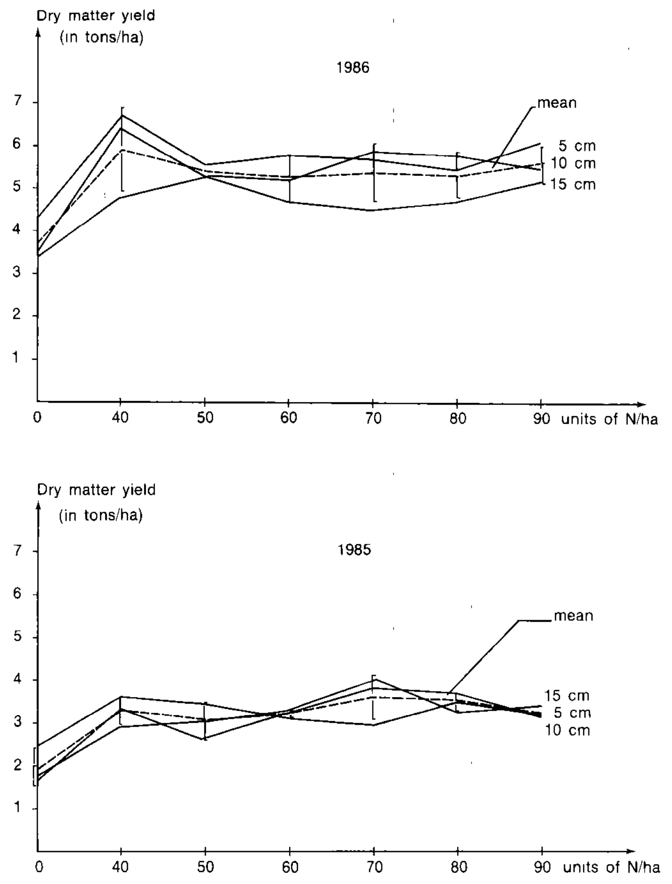

Fig. 2 : Dry matter yield in tons/ha under different fertilization rates in 1985 and 1986 at various cutting intensities.

RESULTS AND DISCUSSION

The application of nitrogen on this rangeland consistently improved its production both in 1985 and 1986 (Fig. 2). These results are basically in agreement with that of RIPPSTEIN (10), PAMO and YONKEU (8, 9) who worked with relatively high levels of fertilization. The response in 1986 however was greater than in 1985. This was due not only to the poor rainfall distribution in 1985 (Fig. 1a) but also to the fact that given the delay in plot establishment there were fewer cuttings in 1985 (four) than in 1986 (six). The analysis of variance carried out on the total dry matter of range forage indicates a significant difference ($P < 0.05$) due to fertilization but not of cutting intensity in 1985. In 1986 differences due to fertilization and cutting management were all significant ($P < 0.05$). For both years, there were no significant interactions indicating that both treatments reacted in the same way. The standard deviations of the various mean yield at different fertilization rates and cutting intensities are relatively consistent (Table I, Fig. 2).

During the two-years study period, there were significant increases in herbage yield between the control and the fertilized plots (Table I). Unfertilized plots produced on average 1.90 and 3.73 tons of dry matter herbage per hectare in 1985 and 1986 respectively.

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***TABLE I** Forage productions and their means in kg of dry matter per hectare under different fertilization rates and cutting intensities.*

Years	Cutting intensity \ Units of N/ha	0	40	50	60	70	80	90	Means**
1985	I_1 = 5 cm	2,404a	3,593.5a	3,450.5a	3,053.75a	2,944a	3,524.5a	3,167.5a	3,162.53 ± 415.26
	I_2 = 10 cm	1,617.5b	3,294a	2,643.5ab	3,191.5a	3,801.25a	3,639.25a	3,154a	2,648.71 ±1,231.21
	I_3 = 15 cm	1,680.25b	2,974.5a	2,974.5a	3,308.25a	4,000a	3,258.75a	3,446.75a	3,080.85 ± 714.85
	Means*	1,900.58 ± 437.09b	3,264.16 ± 345.21a	3,022.83 ± 405.66a	3,184.5 ± 127.39a	3,581.75 ± 561.17a	3,474.16 ± 195.17a	3,160.75 ± 9.54a	
1986	I_1 = 5 cm	4,282b	6,670.25a	5,532ab	5,808.75a	5,676a	ab 5,761.75	6,043a	5,639.1 ± 723.55a
	I_2 = 10 cm	3,463.5b	6,404.25a	5,275.75a	5.234.5a	5,865.75a	5,810.25a	5,537.75a	5,383.1 ± 929.32a
	I_3 = 15 cm	3,439.5b	4,756ab	5,304.75a	ab 4,672.25	4,528.5ab	4,698ab	5,155a	4,650.57 ± 602.47b
	Means*	3,728.33 ± 479.63b	5,943.50 ±1,036.9a	5,370.83 ± 140.32a	5,268.5 ± 570.31a	5,356.75 ± 723.53a	5,323.3 ± 568.89a	5,578.58 ± 445.4a	

* Means, in the same raw, bearing the same subscripts, are not significantly different $P < 0.05$.
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Fertilized plots yielded on average up to 3.60 and 5.94 tons with 70 and 40 units of nitrogen per hectare for the respective years. MADER (4) in true prairie and OWENSBY *et al.* (6) obtained similar results. The result of the work by MADER (4) was attributed only to nitrogen although nitrogen fertilization was realized in combination with phosphorus and potassium.

In 1985 herbage yields of 3.6, 3.8 and 4 tons of dry matter per hectare were obtained with a fertilization rate of 40, 70 and 70 units of nitrogen per hectare for heavy (5 cm) moderate (10 cm) and light (15 cm) cutting intensity respectively (Table I). There were however no significant differences ($P > 0.05$) between the yields at the various fertilization rates at the heavy cutting intensity. The moderate cutting intensity yielded a significant difference ($P < 0.05$) between the fertilized and unfertilized plots. This was equally observed on the light cutting intensity. This result indicates that heavy grazing or cutting intensity affected range plants such that even fertilizer could not stimulate growth. This happened because, as the season progressed (the first cutting occurred when the season was quite advanced) and the stems were elongating, pushing the apical meristem upwards, it was more susceptible to grazing or cutting ; removal at that time stopped production of new leaves until new apical meristem became active. Often, the plants did not initiate new growth late in the growing season even though the apical meristem had been removed. In order to maintain accelerated growth, it is then necessary that top removal should not be severe as to move the plant's growth rate back into the slow growth period. This was not the case as mowing of range plants removes leaf area necessary for energy production and reduce herbage yield. This agrees with the review by JAMESON (2) and WHITE (15) which indicated that severe defoliation affects plant food reserve and then their production.

Polynomial adjustment in 1985 (Fig. 3) of the yield under different fertilization rates for the three cutting intensities as indicated below gave variable results :

I_1 : $y = 2,476.27 + 30N - 0.25N^2$ $R^2 = 0.57$

I_2 : $y = 1,611.22 + 46.19N - 0.29N^2$ $R^2 = 0.79$

I_3 : $y = 1,648.30 + 44.21N - 0.26N^2$ $R^2 = 0.86$

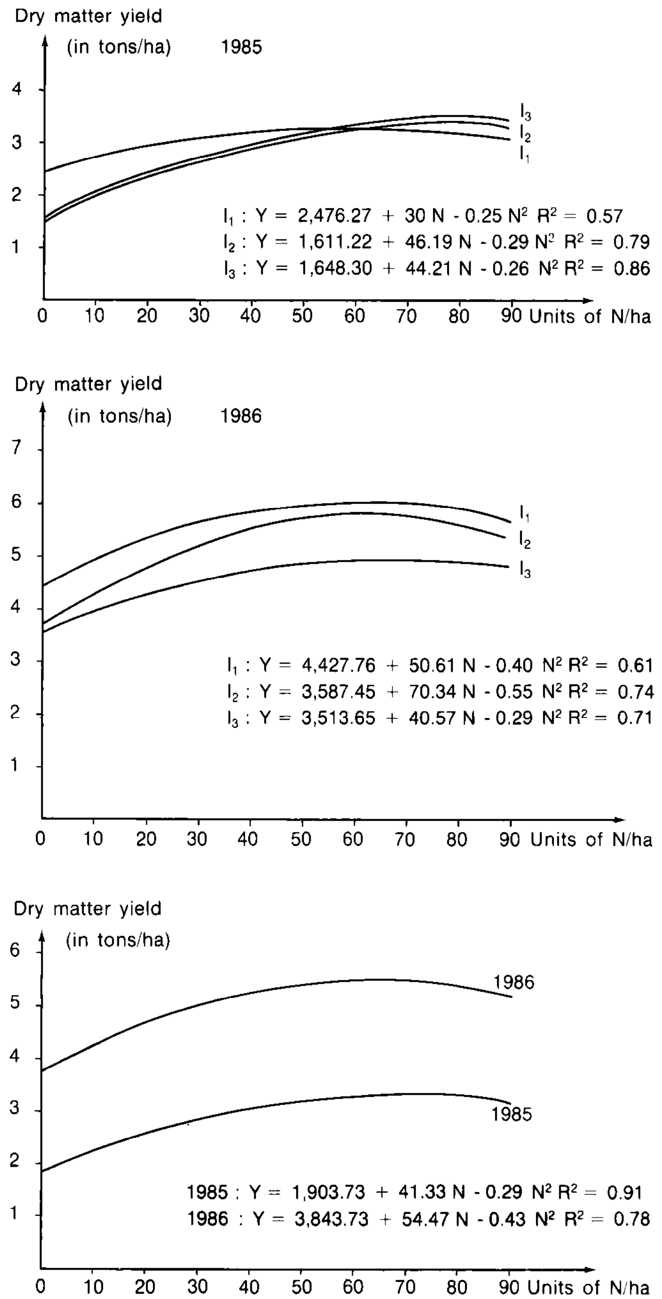

Fig. 3 : Adjusted dry matter yield in tons/ha under different fertilization rates in 1985 and 1986 at various cutting intensities and their average.

These adjustments were quite good for the light and moderate cutting intensities as shown by the relatively high coefficient of determination which indicate the proportion of total variation which can be explained by the regression curves. Optimum production (3.36 ; 3.42 and 3.50 tons of DM/ha obtained with 59, 79 and 84 units of nitrogen/ha under the heavy, moderate and light cutting intensities) derived from those curves were quite different from the field maximum production. These variations reflect the difference in the response of plants to the experimental treatments (fertilization rate and cutting intensity).

In 1986 there was a sizeable increase in herbage yield (85 per cent, 68 per cent and 32 per cent) at heavy, moderate and light cutting intensity as compared to the maximum production of the previous years. Although nitrogen fertilization increases moisture-use efficiency (6) because of greater root exploration of the soil mass, stimulated by added nitrogen (5), it could not have been the case in this study since both years had approximately the same amount of precipitation (1,570 and 1,568 mm in 1985 and 1986 respectively) distributed over the same number of months. This was certainly due to the poor rainfall distribution in 1985 and the increased number of cuttings in 1986 since the trial was already established and data collection resumed earlier. In all the three cutting intensities there were significant differences ($P < 0.05$) between the fertilized and unfertilized plots.

Adjusted data in 1986 (Fig. 3) are indicated by the equations below as well as the coefficient of determination (R^2) :

$I_1 : y = 4{,}427.76 + 50.61N - 0.40N^2 \quad R^2 = 0.61$

$I_2 : y = 3{,}587.45 + 70.34N - 0.55N^2 \quad R^2 = 0.74$

$I_3 : y = 3{,}513.65 + 40.37N - 0.29N^2 \quad R^2 = 0.71$

Although the production was higher the adjustment did not seem as good as in 1985 indicating that there were more variability which could not be explained by the regression equations. These data remain however more consistent. In 1986 the optimum production for heavy, moderate and light cutting intensities were 6.01, 5.82 and 4.93 tons of DM/ha obtained with 63, 64 and 70 units of nitrogen/ha respectively.

Regrowth of forage plants is influenced by frequency and intensity of previous grazing. Three cutting intensities were used in this study to simulate three grazing pressures at a month interval. In most instances, total herbage yield declines as grazing intensity increases. However this is not generally the case and some range areas appear to sustain high herbage yields even with heavy grazing intensity particularly in arid areas where short grass dominate.

During the first year of the study, there was no significant difference ($P > 0.05$) between the three cutting intensities (Table I). Although most works (11, 13) show reduced herbage yields with heavy grazing, some show differential herbage yield response to grazing intensity (1, 3). In fact in 1986 differential cutting intensities were observed. Significant differences ($P < 0.05$) were obtained between the three cutting intensities. However heavy cutting intensity significan-

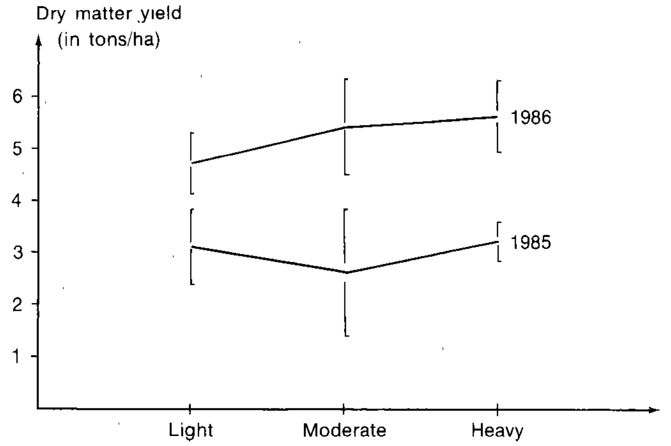

Fig. 4 : Dry matter yield in tons/ha under different cutting intensities in 1985 and 1986.

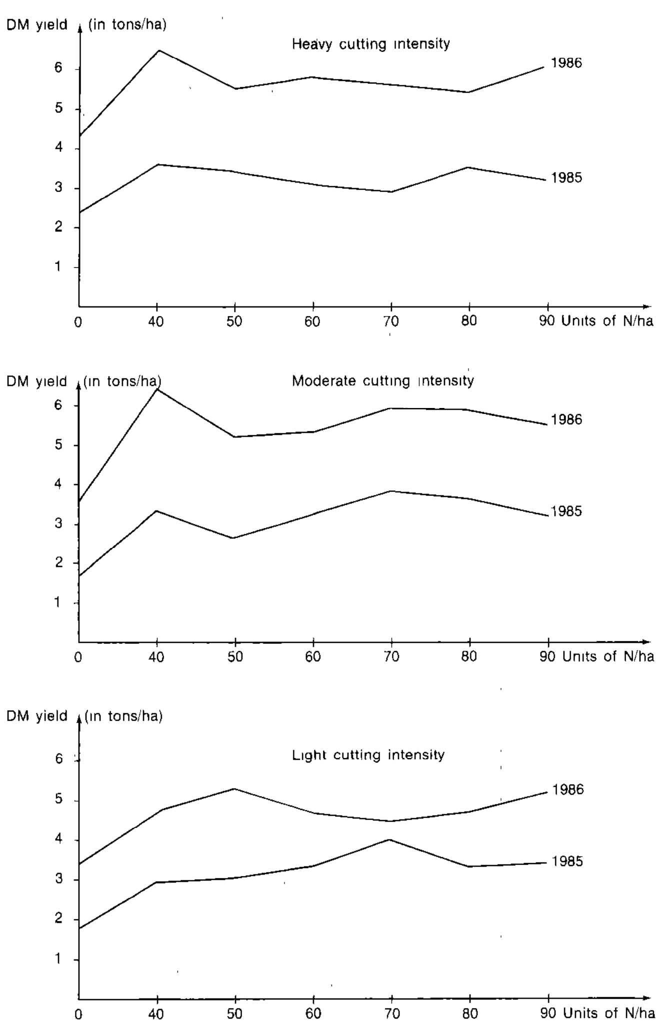

Fig. 5 : Comparison of dry matter yield under different fertilization rates at the same cutting intensities between 1985 and 1986.

tly ($P < 0.05$) outyielded light cutting intensity (Fig. 4) although there were no significant difference between moderate cutting intensity and the heavy or light intensities. This was probably due to the fact that after poor hand fertilization following some cutting, evidence of range forage burning by nitrogen was observed on certain parts of the moderate and light cutting intensity plots. This generally happened when rain did not fall one or two days after fertilization and the weather was very hot. This burning mostly affected plots which still had forage grasses with high proportion of leaves (light cutting intensity plots). Consequently growth resumption was delayed and then affected the production of the forage during the subsequent evaluation period.

The underlying reason for differential productivity under different grazing intensities is the differential utilization of various species. Palatable species have their production removed in direct proportion to grazing intensities. In this study however since grazing intensities were simulated by cutting, there was no selectivity hence all plants were under the same pressure and had to react according to their vigor. Therefore it could not be suprising to have differential herbage yield to cutting intensities.

Comparison of the range response to the cutting intensities between the years (Fig. 5) consistently indicates that the 1986 result significantly ($P < 0.001$) outyielded 1985 result.

CONCLUSION

This study has shown that even low rates of nitrogen fertilization influence the productivity of Adamawa ferralitic rangeland. On average the greatest yield (3.60 tons DM/ha) was obtained with a fertilization rate of 70 units of nitrogen per hectare in 1985. This indicates an increase of 88 per cent as compared to the control yield. However the optimum production (3.38 tons of DM/ha) provided by the adjusted means ($y = 1{,}903.73 + 41.33N - 0.29N^2$; $R^2 = 0.91$) with a fertilization rate of 71 units of nitrogen/ha was rather low. In 1986, 40 units of nitrogen per hectare yielded on average a maximum production of 5.94 tons DM/ha and the adjusted means, $y = 3{,}843.73 + 54.47N - 0.43N^2$ ($R^2 = 0.78$) gave an optimum production of 5.58 tons of DM/ha with a fertilization rate of 64 units of nitrogen/ha ; as compared to the control this was an increase of 59 per cent. Forage produced may be grazed in site at various grazing intensities, or cut and carted away for stall feeding or preserved as hay for subsequent feeding at times of grass shortages. In the case of field grazing animal may have the opportunity to select the more palatable portion of the grazeable species present on rangeland. Parts of plants such as stems are unlikely to be easily selected mainly because they are tough, fibrous and low in protein content. It seems therefore advantageous to graze at intervals and intensities yielding a maximum forage production of good quality and sustained maintenance of the rangeland. Among the myriad of ranch operator controlled factors, grazing intensity seems to be most important. The amount of phosphosynthetic tissue available for energy capture, determined in part by grazing intensity, will regulate productivity. Although in the early part of this study effect of cutting intensity on rangeland response was not clearly determined, at the end of the work, it would be possible to clearly address the question. Even SMITH reported (12) little difference in productivity of desirable species during the first year of grazing intensity study in Colorado, but 5 and 10 years later the desirable species under heavy grazing produced less and less compared to light or moderate grazing.

PAMO (E. T.). Rangeland response to low levels of nitrogen fertilization and cutting intensities on the Adamawa Plateau, Cameroon. *Revue Élev. Méd. vét. Pays trop.*, 1989, **42** (4) : 591-598.

Fertilizers and grazing or cutting intensity have been shown to affect the yield and quality of range grass in many areas but similar data are lacking for most of the Adamawa rangeland. A study was then conducted at the Wakwa Animal Research Station to evaluate Adamawa rangeland response on ferralitic soil to low levels of nitrogen fertilization and cutting intensity. A 7 x 3 factorial design was used. The treatments were seven levels of fertilizer (0, 40, 50, 60, 70, 80 and 90 units of nitrogen/ha) and three cutting intensities (heavy, 5 cm ; moderate, 10 cm ; and light, 15 cm above soil level) at monthly intervals. Nitrogen was applied after the zero timing of rangeland and after each cutting. In average, fertilization consistently increased the yield of rangeland as compared to non fertilized plots by as much as 88 % in 1985 and 59 % in 1986. Polynomial adjustment of the mean equally gave very good results as shown by the relatively high coefficient of determination R^2 (0.91 in 1985 and 0.78 in 1986). For the first year of the study there were no significant differences between the three cutting intensities. In 1986 due to various observed problems on the field differential yield response to cutting intensity was obtained with heavy cutting intensity significantly ($P < 0.05$) outyielding the light cutting. As in several previous studies it would be possible however at the end of the work to clearly address the question. *Key words* : Rangeland - Nitrogen fertilization - Cutting - Cameroon.

PAMO (E. T.). Influencia de tasas reducidas de fertilización nitrogenada y de cortas intensivas sobre los pastos naturales del Plateau de Adamaua en Camerún. *Revue Élev. Méd. vét. Pays trop.*, 1989, **42** (4) : 591-598.

En numerosas regiones, se demostró que la fertilización y la intensidad de pastoreo o de corta tienen influencia sobre el rendimiento y la calidad de las especies forrajeras ; datos similares sobre los pastos de Adamaua faltan. Así se estudió en el Centro de Investigaciones zootécnicas de Wakwa la influencia de intensidades de cortas sobre pastos naturales sobre suelo ferralitico con dosis reducidas de nitrogeno. Se hizo un ensayo factorial con siete dosis de nitrogeno (0, 40, 50, 60, 70, 80 y 90 unidades de nitrogeno/ha) y tres intensidades de corta (5 cm, elevada ; 10 cm, media y 15 cm más arriba del suelo, reducida) con un intervalo de un mes. Se esparcía el nitrogeno después de la corta de regularización y más tarde después de cada corta. Por termino medio, la fertilización aumentó regularmente la producción del pasto natural, comparado con los testigos de 88 p. 100 en 1985 y de 59 p. 100 en 1986. El ajuste polinomial de los datos medios dió también buenos resultados como lo indican los coeficientes de determinación R^2 (0,91 en 1985 y 0,78 en 1986) relativamente elevados. No hubo ninguna diferencia significativa entre las tres intensidades de corta durante el primer año de estudio. En 1986, las varias intensidades de corta producieron resultados diferentes a causa de problemas observados en el campo. La intensidad de corta elevada produzcó significativamente ($P<0,05$) más que la reducida. Como en estudios anteriores, sin embargo estos resultados permitirán delimitar este asunto. *Palabras claves* : Pasto natural - Abono nitrogenado - Corta - Camerún.

REFERENCES

1. BURZLAFF (D. F.), HARRIS (L.). Yearling steer gains and vegetation changes of Western Nebraska rangeland under three rates of stocking (a ten-year study). Nebraska, USA, Nebraska agricultural experimental station, 1969. 18 p. (Ref. SB 505).

2. JAMESON (D. A.). Responses of individual plants to harvesting. *Bot. Rev.*, 1963, **29** : 532-594.

3. LEWIS (J. K.), VAN DYNE (G.), ALBEE (L. R.), WHETZAL (F. W.). Intensity of grazing : its effect on livestock and forage production. *South Dakota agr. exp. Sta. Bull., 1956,* **459** : 44.

4. MADER (E. L.). The influence of certain fertilizer treatments on native vegetation of Kansas prairie. Ph. D. Dissertation, University of Nebraska, 1956. 116 p.

5. McKELL (C. M.), JONES (M. B.), PERRIER (E. R.). Root production and accumulation of root material on fertilized range. *Agron. J.*, 1962, **59** : 459-461.

6. OWENSBY (C. E.), HYDE (R. M.), ANDERSON (K. L.). Effects of clipping and supplemental nitrogen and wter on loamy upland bluestem range. *J. R. Mgmt*, 1969, **23** : 341-346.

7. PAMO (T. E.), YONKEU (S.). Étude de l'évolution de quelques paramètres climatiques de l'environnement pastoral de Wakwa, Adamaoua, Cameroun. *Revue sci. tech., Sér. Sci. zootech.*, 1986, **2** (3) : 19-35.

8. PAMO (T. E.), YONKEU (S.). Réponse du pâturage naturel à la fertilisation azotée sur sol basaltique en Adamaoua camerounais. XVIth int. Grass Cong., Nice, France, 1989. (sous presse).

9. PAMO (T. E.), YONKEU (S.). Réponse du pâturage naturel à la fertilisation sur sol basaltique en Adamaoua camerounais. *Revue sci. tech., Sér. Sci. zootech.*, 1989. (Soumis pour publication).

10. RIPPSTEIN (G.). Étude sur la végétation de l'Adamoua. Évolution, conservation, régénération et amélioration d'un écosystème pâturé. IRZ/CIRAD, 1985. (Publication spéciale n° 5).

11. SKOLVIN (J. M.), HARRIS (R. W.), STRICKLER (G. S.), GARRISON (G. A.). Effects of cattle grazing methods on ponderosa pine-bunchgrass range in the Pacific-Northwest. USDA, *Forest Ser. Tech. Bull.*, 1976. 40 p. (No 1531).

12. SMITH (D. R.). Effetcs of cattle grazing on a ponderosa pine-bunchgrass range in Colorado. USDA, *Forest Ser. Tech. Bull.*, 1967. 40 p. (No 1371).

13. SMOLIAK (S.). Range vegetation and sheep production at three stocking rates on Stipa-Bouteloua prairie. *J. R. Mgmt*, 1974, 27 (1) : 23-26.

14. STEEL (R. G.), TORRIE (J. H.). Principles and procedures of statistics. New York, McGraw-Hill Book Co Inc., 1980. 532 p.

15. WHITE (M. L.). Carbohydrate reserves of grasses : a review. *J. R. Mgmt*, 1973, **26** : 13-17.