



Growth and Biomass Yield of *Brachiaria ruziziensis* (Poaceae) under the Direct and Residual Effects of Fertilization with Hen Droppings at Flowering in West Cameroon

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Authors' contributions

This work was carried out in collaboration among all authors. Authors GJA, FT and DFW contributed to the setting up of the experimental device, the collection and processing of data and the drafting of the article. Author FVN contributed to the data processing and the writing of the article. Author ETP supervised all data collection activities and the writing of the article. All authors read and approved the final manuscript.

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ABSTRACT

Aim: A study was conducted at the Research and Experimental Farm (REF) of the University of Dschang with the aim of evaluating the direct and residual effects of fertilization with hen droppings on the growth and biomass yield of *Brachiaria ruziziensis* at flowering.

Methodology: A factorial design with five levels of fertilization in terms of nitrogen in hen droppings (0, 25, 50, 75 and 100 kg N/ha) on 6 m² (3 m x 2 m) plots in four replicates, i.e. a total of 20

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experimental plots was used. Fertilization with hen droppings was done one month after the placement of the stump chips, during the first year of cultivation (direct effects). In the second year of cultivation (residual effects), no fertilization was done. Measurements of plant heights and diameters were made on 40 plants per level of fertilization. Leaf, stem and whole-plant biomass assessments were made on all plots in relation to their fertilization levels.

Results: This study shows that the direct effect of fertilization in the form of hen droppings resulted in heights and diameters significantly greater than those obtained under the residual effect of fertilization. Biomasses of whole plants and their different compartments obtained under the residual effect of fertilization were significantly higher than those obtained under the direct effect of fertilization. Under the direct and residual effect of fertilization, the heights, diameters and biomasses of the fertilized plots were greater than those of the control plots. The level of fertilization corresponding to the dose of 100 kg N/ha gave the best results.

Conclusion: Fertilization with hen droppings at a dose of 100 kg N/ha would be recommended for the cultivation of *B. ruziziensis* over a two-year period, in order to limit the use of mineral fertilizers.

Keywords: Brachiaria ruziziensis; hen droppings; height; diameter; biomass; flowering.

1. INTRODUCTION

The need to feed a growing population in developing countries in particular is pushing farmers to exploit land at the expense of pastoral areas [1]. It then becomes important to set up sedentary livestock farms. This type of livestock farming would allow sustainable management of land resources and facilitate livestock breeding. However, the establishment of sedentary livestock farming requires the supply of good quality fodder within the sedentary zone [2,3,4]. The cultivation of fodder plants can be a solution that would make fodder available both in favorable periods (rainy season) and in unfavorable periods (dry season) [3,4,5,6]. Among the many fodder plants found in Cameroon, there is the *Brachiaria ruziziensis*. It is a perennial grass native to Central Africa that adapts well in different regions. It has good nutritional value and is well consumed by animals [7,8]. *Brachiaria ruziziensis* is recommended for the improvement of natural pastures, but also as green or preserved fodder [8,9]. Cultivation of *B. ruziziensis* can thus be an alternative to natural pastures [6]. However, Brachiarias are able to deplete the few nutrients remaining in poor soils. Consequently, their use as fodder requires fertilization, without which the soil will become infertile [10]. In addition, the key elements nitrogen, phosphorus, potassium and sulphur are often not available in sufficient quantities in the soil to allow optimal crop growth [11]. For these reasons, adequate fertilization must be applied to achieve good yields. Several authors have shown that chemical fertilizers have led to a quantitative and qualitative increase in forage production through nitrogen, which is the main limiting factor in tropical pastures [1,12,13].

However, although these fertilizers have a beneficial effect on plant growth, biomass production and chemical composition, their misuse increases the risk of environmental pollution due to nitrates from urea processing [14]. The use of chemical fertilizers is therefore not without effect on the environment because, in prolonged use, they lead to soil impoverishment, hence the need to find better alternatives that are cheaper, available and more environmentally friendly, such as compost and animal manure [15,16]. One of the organic fertilizers most used by farmers is hen droppings. Hen droppings are an excellent organic fertilizer rich in nitrogen, phosphorus, potassium and calcium. The use of hen droppings therefore represents an enormous potential for soil fertility management and for improving crop growth and yields [17]. A review of the literature has shown that few studies on the effects of hen droppings fertilization in plant production have been carried out so far beyond the first year of production. However, these fertilizers have significant effects up to the second year of production. This study aims to evaluate the direct and residual effects of fertilization with hen droppings on the growth and biomass yield of *Brachiaria ruziziensis* at flowering.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted at the Research and Experimental Farm (REF) of the University of Dschang between April 2015 and November 2016. The REF is located in the West Region of Cameroon, in the Menoua Division, at 05°20' north latitude and 10°03' east longitude [18]. The

climate of the West Cameroon Region is an equatorial Cameroonian climate with mountainous facies determined by the altitude which averages 1400 m. It is characterized by a rainy season from mid-March to mid-November and a dry season from mid-November to mid-March [19,20]. The average temperature of the hottest month (February) is 25°C and the average temperature of the coolest month is 19°C in July or August. Annual sunshine exposure is 1800 hours, with relative humidity varying between 33 and 98%. Precipitation varies between 1500 and 2000 mm per year [6,21].

2.2 Experimental Design

The experimental design is a factorial design with five levels of nitrogen fertilization in terms of hen droppings (0, 25, 50, 75 and 100 kg N/ha) on 6 m² (3 m x 2 m) plots in four replicates, for a total of 20 experimental plots.

2.3 Origin of the Fertilizer

Hen droppings were used as fertilizer in this study. It was obtained from a chicken farmer in the Menoua Division (Dschang). Its chemical composition was previously determined at the Laboratory of Soil Analysis and Environmental Chemistry of the University of Dschang, following the soil analysis method described by Pauwels et al. [22]. The result of the chemical composition made it possible to calculate the quantities of hen droppings to be applied in terms of nitrogen.

2.4 Soil Preparation, Plant Placement and Fertilization

During soil preparation, soil samples were collected at the test site in the 0 - 20 cm depth horizon. The chemical analysis of the soil was carried out at the Laboratory for Soil Analysis and Environmental Chemistry of the University of Dschang, following the method described by Pauwels et al. [22]. The 6 m² (3 m x 2 m) seedling blocks were laid by hand. *B. ruziziensis* stump chips were collected in the surroundings

of REF. These stump chips were dressed by reducing the size of leaves and roots, and cultured at a depth of 4 cm, with a spacing of 20 cm x 15 cm intra and inter rows, respectively.

The different levels of fertilization were quantified in terms of the nitrogen contained in the hens' droppings because nitrogen is an important nutrient involved in plant growth through its role in the synthesis of living matter [23,24]. Five levels of fertilization were defined (0, 25, 50, 75 and 100 kg of nitrogen per hectare) during this experiment. Each fertilization level corresponded to a quantity of hen droppings in kg, as shown in Table 1. Fertilization was carried out one month after the *B. ruziziensis* stump chips were grown. In the second year of cultivation, no fertilization was applied after the regulating mowing, which was done 5 cm above the ground.

2.5 Data Collection

2.5.1 Growth assessment

Growth was assessed by measuring the heights and diameters of the plants. Thus, 40 plants were sampled per fertilization level for height and diameter measurements. The heights were measured from the mowing point to the tip of the longest leaf with a tape measure graduated to the centimetre. The diameters were measured before the first internode with an electronic calliper graduated to the millimetre.

2.5.2 Biomass assessment

Biomasses were assessed for each level of fertilization. The seedlings were mowed with a cutting table and knives. The mowing was carried out at 5 cm from the ground, over an area of 2 m² in the centre of the seedling, to avoid edge effects. After mowing, the harvested forage was weighed. A sample of 0.5 kg of *B. ruziziensis* was taken per level of fertilization in each replication. Each sample was then separated into leaves and stems which were cut and dried at 60 °C in a Gallemkamp oven to constant weight for determination of dry biomass.

Table 1. Fertilizer levels (kg N/ha) and equivalent amounts of hen droppings applied (kg)

Fertilization levels (kg N/ha)	Quantity of droppings applied (kg / plot)
0	0
25	5.77
50	11.53
75	17.30
100	23.07

2.5.3 Statistical analysis

Data obtained on heights, diameters and dry biomass were analyzed using SPSS version 20.0 software. Where differences between direct and residual effects existed, the means were separated using the Student's test at the 5% significance level [25].

3. RESULTS AND DISCUSSION

3.1 Chemical Composition of Chicken Droppings

The Table 2 shows the results of the chemical composition of hen droppings.

3.2 Chemical Composition of Soil

The texture of the experimental soil was silty. It is a slightly acidic soil (average pH 5.5). Soil nitrogen content is low (0.6 g/kg soil). In an intensive production system, the nitrogen content must be increased to 2 g/kg. Nitrogen supplementation must therefore be provided. The percentage of organic matter (with a C/N ratio = 11.6) is in the ideal range, which implies good mineralization of organic matter [26]. This gives the soil a greater retention capacity, enabling it to

withstand massive fertilization. This soil has low levels of magnesium, phosphorus, calcium and potassium (respectively 0.43 Cmol/kg, 0.5 mg/kg, 2.06 Cmol/kg and 0.2 Cmol/kg). The cation exchange capacity of this soil is high (7.84 cmol/k of soil) due to the high organic matter content. All these soil characteristics make it possible to envisage fertilization with high doses.

3.3 Variations in Heights and Diameters of *Brachiaria ruziziensis* due to the Direct and Residual Effects of Fertilization with Hen Droppings at Flowering

The results show that the plant heights obtained under the direct effect of fertilization were significantly higher ($p < 0.05$) than those obtained under the residual effect of fertilization, regardless of the different levels of fertilization (Table 3). Furthermore, the heights obtained under the direct and residual effects of fertilization were higher than those obtained on the control plots. Plant heights increased with increasing levels of fertilization. Fertilization at the rate of 100 kg N/ha resulted in the highest heights under both direct and residual effects of fertilizer (222.75 and 218.75 cm, respectively).

Table 2. Content of the different mineral elements contained in hen droppings

Mineral Nutrients	N	K	P	Na	Ca	Mg
Quantity (g/kg)	2.6	20.438	0.809	1.015	6.960	73.046

Table 3. Variations in plant heights of *B. ruziziensis* (in cm) under the direct and residual effects of different levels of fertilization with hen droppings at flowering

Fertilization levels (kg N/ha)	Direct effect	Residual effect	SEM	p
0	207.63 ^a	201.28 ^b	0.92	0.0001
25	214.70 ^a	204.73 ^b	0.91	0.0001
50	217.20 ^a	210.45 ^b	1.92	0.0001
75	218.83 ^a	215.43 ^b	1.94	0.0001
100	222.75 ^a	218.75 ^b	1.21	0.0001

a, b: averages with the same letters on the same line are not significant at the 5% threshold.

SEM: standard error of means

Table 4. Variations in diameters of *B. ruziziensis* (in mm) under the direct and residual effects of the different levels of fertilization with hen droppings at flowering

Fertilization levels (kg N/ha)	Direct effect	Residual effect	SEM	p
0	3.43 ^a	2.95 ^b	0.05	0.0001
25	3.75 ^a	3.18 ^a	0.06	0.534
50	3.85 ^a	3.35 ^a	0.05	0.052
75	4.00 ^a	3.53 ^b	0.05	0.0001
100	4.08 ^a	3.55 ^b	0.05	0.0001

a, b: averages with the same letters on the same line are not significant at the 5% threshold.

SEM: standard error of means

Plant diameters obtained under the direct effect of fertilization were greater than those obtained under the residual effect of fertilization, regardless of fertilization levels (Table 4). The diameters obtained under the direct and residual effects of fertilizer were greater than those obtained on the control plots. Plant diameters increased with increasing levels of fertilization. The direct and residual effects of fertilization at the 100 kg N/ha rate resulted in the largest diameters (4.08 and 3.55 mm for the direct and residual effect of the fertilizer, respectively).

3.4 Biomass Variations of *B. ruziziensis* under the Direct and Residual Effects of Fertilization with Hen Droppings at Flowering

Leaf, stem and whole plant biomasses obtained under the residual effect of fertilization were significantly higher ($p < 0.05$) than those obtained under the direct effect of fertilization, regardless of the different levels of fertilization (Table 5). Leaf, stem and whole-plant biomasses obtained under direct and residual fertilizer were higher than those obtained on the control plots. In addition, leaf, stem and whole plant biomasses increased with increasing levels of fertilization.

3.5 Discussion

Fertilization with hen droppings resulted in higher plant heights and diameters in the fertilized plots than in the control plots. In addition, the heights of *Brachiaria ruziziensis* plants increased with increasing levels of fertilization. Indeed, it is the

high nutrient concentration of hen droppings, especially nitrogen (N) and phosphorus (P) that is responsible for the improvements in plant growth [17] observed in this study. This suggested that the timing of nutrient release from hen droppings during decomposition and uptake by plants was good. Indeed, Mulaji [27] and Kimuni et al. [28] demonstrated that the rate of decomposition of organic matter and plant growth was closely related to the timing of nutrient release and plant uptake.

Since nitrogen is the main factor limiting plant growth and production [5,29,30,31], the differences observed between the plant heights in the fertilized and control plots can be explained by the fact that the low nitrogen content (0.6 g/kg soil) in the soil of the control plots did not correspond to the amount needed for optimal plant growth. Thus, nitrogen inputs in the form of hen droppings resulted in significant differences in the plant heights of the fertilized plots. Moreover, the results of studies conducted by Yerima et al. [17] showed that hen droppings significantly improved soil properties, making them more productive. This demonstrates the role of hen droppings on plant growth and development. The results obtained from the effect of hen droppings fertilization levels on the evolution of heights and diameters of *Brachiaria ruziziensis* are in concordance with those obtained by Tendonkeng [6] and Azangue et al. [3,4]. Results according to which the heights and diameters of *Brachiaria ruziziensis* plants increased under the effects of increasing levels

Table 5. Variations in leaf, stem and whole plant biomass of *B. ruziziensis* (in t DM/ha) under the direct and residual effects of fertilization with hen droppings at flowering

	Fertilization levels (kg N/ha)	Direct effect	Residual effect	SEM	p
Leaves	0	6,08 ^b	12,20 ^a	0,201	0,0001
	25	9,31 ^b	12,68 ^a	0,170	0,0001
	50	9,34 ^b	13,91 ^a	0,195	0,0001
	75	8,77 ^b	14,46 ^a	0,390	0,0001
	100	10,63 ^b	14,94 ^a	0,246	0,0001
Stems	0	16,21 ^b	19,58 ^a	0,189	0,0001
	25	16,73 ^b	22,09 ^a	0,300	0,0001
	50	17,77 ^b	21,23 ^a	0,187	0,0001
	75	20,88 ^b	21,92 ^a	0,120	0,005
	100	19,44 ^b	21,43 ^a	0,198	0,003
Whole plants	0	22,30 ^b	31,79 ^a	0,106	0,0001
	25	26,04 ^b	34,77 ^a	0,383	0,0001
	50	27,12 ^b	35,14 ^a	0,270	0,0001
	75	29,65 ^b	36,39 ^a	0,445	0,0001
	100	30,07 ^b	36,38 ^a	0,206	0,0001

a,b: averages with the same letters on the same line are not significant at the 5% threshold
SEM: standard error of means

of nitrogen fertilization. On the other hand with those of Zamil et al. [32] and Yerima et al. [17] who demonstrated that hen dropping improve the availability of nutrients such as nitrogen, phosphorus and potassium, which promotes plant growth. Fertilization with hen droppings positively influenced the biomass production of leaves, stems and the whole plant of *Brachiaria ruziziensis* at flowering. In addition, each higher level of fertilization resulted in a higher biomass than that produced by lower levels of fertilization. The significant differences observed between the biomasses of the different levels of fertilization can be explained by the fact that the increasing levels of fertilization with hen droppings provided, in proportion to the amounts of hen droppings applied, the nutrients necessary for the production of plant biomass.

The significant differences observed between the biomasses of the different plant compartments in the fertilized and control plots can be explained by the fact that hen droppings are a fertilizer capable of adjusting the cation balance and the C/N ratio of the soil, as demonstrated by Yerima et al. [17]. On the one hand, the organic matter provided by hen droppings, which plays an important role in the soil, will prove favorable to the growth of micro-organisms that will induce nutrient solubilization activation. Nutrients that become sufficiently available in the soil over time are then efficiently used by cultivated plants [28,33]. Thus, hens' droppings provide the soil with sufficient amounts of nitrogen, phosphorus, potassium, calcium, magnesium and organic matter [34]. During the decomposition and mineralization of organic matter, the release of nutrients is beneficial to the study soil, which is low in organic matter, nitrogen, phosphorus and exchangeable bases [17]. Thus, the organic matter provided by chicken droppings will improve the physical properties of the soil. Apparent density and soil temperature are reduced with the addition of organic matter [34,35], while total porosity, moisture and water retention capacity are improved. The latter reduces the daily soil temperature, thus reducing water loss [36]. The increasing availability of soil nutrients due to the application of manure increases their uptake by plant roots [17]. The results obtained on the fertilization of *Brachiaria ruziziensis* plants with hen droppings corroborate those of previous studies carried out by Zamil et al. [32]; Agbede et al. [34]; Adeleye et al. [35] and Yerima et al. [17] which showed that hen droppings increase plant growth and yields. This is due to the improved chemical and physical

properties of the soil as a result of the hen droppings. The increase in biomass yield with the level of nitrogen fertilization in the form of hen droppings observed in this experiment is consistent with the observations of Pamo and Yonkeu [37] who observed in the Adamawa region of Cameroon that nitrogen fertilization in the presence of phosphorus and potassium significantly improved the production of forage grasses in natural pastures. Fertilization at the dose of 100 kg N/ha resulted in the best biomass yields. This suggests that fertilization at the 100 kg N/ha rate was the optimal fertilization for biomass production of *Brachiaria ruziziensis*. The variations in biomass obtained in this study are comparable to the observations of Bogdan [38] and Cook et al. [9] who showed that the biomass of *Brachiaria ruziziensis* varies from 5 to 36 t DM/ha depending on soil fertility, rainfall and level of fertilization. Fertilization increases the vegetation speed, which increases production for a given growth stage, or reduces the time needed to reach a defined yield [29,39,40,41]. The plant heights obtained under the direct effect of fertilization with hen droppings were higher than those obtained under the residual effect of fertilization. These results can be attributed on the one hand to the fertilization with hen droppings, which provided the nitrogen necessary for faster plant growth in the first year of cultivation, through its role in cell multiplication and thus elongation with intense growth activity [23,24]. On the other hand, it also contributed to soil impoverishment in the second year of cultivation in the absence of fertilization for the plots that had been fertilized in the first year of cultivation. The dry biomasses of leaves, stems and whole plants obtained in the second year of mowing were higher than those obtained in the first year of mowing. These differences in the dry biomasses of the different parts of the plant depending on the mowing year could be explained by the fact that the hen droppings introduced in the first mowing year improved the water retention capacity of the soil through the urea it contains. The water that became more available was absorbed in large quantities by the plants, which increased the fresh biomass of the plants, thus reducing the dry biomass in the first year of mowing.

4. CONCLUSION

The objective of this study was to evaluate the direct and residual effects of increasing levels of fertilization with hen droppings on the growth and biomass yield of *B. ruziziensis* at flowering. It

was found that fertilization positively influenced the heights, diameters and biomasses of leaves, stems and whole plants of *B. ruziziensis*. Fertilization at a dose of 100 kg N/ha gave the best results both on growth and biomass yield. This leads to the conclusion that fertilization at a rate of 100 kg N/ha would be recommended over a period of two years for the cultivation of *B. ruziziensis*.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Tendonkeng F, Boukila B, Pamo TE, Mboko AV, Tchoumboué J. Effect of different levels of nitrogen fertilization on the yield and chemical composition of *Brachiaria ruziziensis* during the run in West Cameroon. *Livestock Research for Rural Development*. 2010;223. (Retrieved December 13, 2010, from) Available:<http://www.lrrd.org/lrrd22/1/tend2019.htm>
2. JGRC (Japan Green Resources Corporation). Technical guide to animal husbandry: effective pastoral development through the production of grass. In *Technical documentation from the Japan Green Resources Corporation: Generating abundance in the Sahel by combating desertification*. 2001;7:68.
3. Azangue JG, Nguetsop VF, Tendonkeng F, Fokom WD, Tendonkeng PE. Effects of the different levels of fertilization with chicken droppings on the growth and production of biomass of *Brachiaria ruziziensis* (Poaceae) according to the phenological stages in West Cameroon. *International Journal of Biological and Chemical Sciences*. 2019;13(3):1762-1774. DOI:<http://dx.doi.org/10.4314/ijbcs.v13i3.44>
4. Azangue JG, Tendonkeng F, Nguetsop VF, Fokom WD, Tendonkeng PE. Direct and residual effects of different levels of chicken manure fertilization on the growth and biomass production of *Brachiaria ruziziensis* (Poaceae) at the bolting in West Cameroon. *Agricultural Sciences*. 2019;10:1113-1123. Available:<https://doi.org/10.4236/as.2019.108084>
5. Obulbiga MF, Kaboré-Zoungrana CY. Influence of nitrogen fertilization and exploitation rate on dry matter production and food value of *Andropogon gayanus* kunth in Burkina Faso. *Tropicicultura*. 2007; 25(3):161-167.
6. Tendonkeng F. Effect of nitrogen fertilization, phenological stage and mowing year on the growth, yield and nutritional value of *Brachiaria ruziziensis* Germain and Evrard. Doctoral / Ph.D. thesis, Faculty of Agronomy and Agricultural Sciences, University of Dschang, Cameroon. 2011;186.
7. Pamo TE, Boukila B, Fonteh FA, Tendonkeng F, Kana JR, Nanda AS. Nutritive values of some basic grasses and leguminous tree foliage of the Central region of Africa. *Animal Feed Science and Technology*. 2007;135:273-282. DOI: [http // doi.org / 10.1016 / J.anifeedsci.2006](http://doi.org/10.1016/J.anifeedsci.2006)
8. Tendonkeng F, Boukila B, Pamo TE, Mboko AV, Matumuini NEF. Direct and residual effect of different levels of nitrogen fertilization on the growth and yield of *Brachiaria ruziziensis* at different phenological stages. *Tropicicultura*. 2011;29 (4):197-204.
9. Cook BG, Pengelly BC, Brown SD, Donnelly JL, Eagles DA, Franco MA, Hanson J, Mullen BF, Partridge IJ, Peters M, Schultze-Kraft R. *Tropical Forages: an interactive selection tool*. [CD-ROM], CSIRO, DPI & F (Qld), CIAT and ILRI, Brisbane, Australia; 2005.
10. Husson O, Charpentier H, Razanamparany C, Moussa N, Michellon R, Naudin K, Razafintsalama H, Rakotoarinivo C, Rakotondramanana, Seguy L. *Brachiaria* sp., Practical no-till manual in Madagascar. 2008;3(4):20. Available:<http://www.supagro.fr/ress-pepites/PlantesdeCouverture/res/brachiaria.pdf>
11. Mériçout P. Study of the metabolism of the plant in response to the contribution of different fertilizers and crop aids. Influence of phytohormones on nitrogen metabolism. Doctoral thesis of the National Agronomic Institute Paris-Grignon. Paris, France. 2006;110.
12. Chesworth J. *Feeding ruminants*. Maisonneuve and Larose Edition. CTA. 1996;263.
13. Boddey RM, Macedo R, Tarré RM, Ferreira E, Oliveira OC, Rezende C,

- Cantarutti RB, Pereira JM, Alves BJR, Urquiaga S. Nitrogen cycling in *Brachiaria* pastures: The key to understanding the process of pasture decline. *Agriculture, Ecosystems and Environment*. 2004;103: 389-403.
14. Tendonkeng F, Boukila B, Pamo TE, Mboko AV, Zogang FB, Matumuini NEF. Direct and residual effects of different levels of nitrogen fertilization on the chemical composition of *Brachiaria ruziziensis* at flowering in West Cameroon. *International Journal of Biological and Chemical Sciences*. 2011;5(2):570-585.
 15. Mboko AV, Tendonkeng F, Matumuni FNE, Zougou GT, Miégoué E, Boukila B, Pamo TE. Comparative effect of two legumes fertilized with molybdenum on the growth and yield of *Brachiaria ruziziensis* at different mowing periods in West Cameroon. *International Journal of Biological and Chemical Sciences*. 2013;7(6):2513-2525.
Available:<http://dx.doi.org/10.4314/ijbcs.7i6.26>.
 16. Olanite J, Ewetola IA, Onifade OS, Oni OA, Dele PA, Sangodele OT. Comparative residual effects of some animal manure on the nutritive quality of three tropical grasses. *International Journal of Science, Environment and Technology*. 2014;3(3): 1132-1139.
 17. Yerima BPK, Tiamgne AY, Van Ranst E. Response of two varieties of sunflower (*Helianthus* sp.) To fertilization based on chicken droppings on a Hapli-Humic Ferrasol from the Yongka Western Highlands Research Garden Park (YWHRGP) Nkwen-Bamenda, Cameroon, Central Africa. *Tropicicultura*. 2014;32(4): 168-176.
 18. Suchel JB. The climatic privileges of the Bamiléké country. *The Overseas Notebooks*. 1989;165:29-52.
Available: [https // doi.org / 10.3406 / caoum.1989.3289](https://doi.org/10.3406/caoum.1989.3289)
 19. Sanmarco V. The Bamiléké of the district of Dschang. Example of the influence of the climate on indigenous life in Cameroon. *Annals of Geography, Bulletin of the Geographical Society*. 1945;295: 223-224.
Avaible:[https // doi.org / 103406 / geo.1945.12815](https://doi.org/10.3406/geo.1945.12815)
 20. Olivry JC. Hydrological regimes in Bamileke country (Cameroon). ORSTOM notebook, Hydrology series. 1976;XIII:37-71.
 21. Pamo TE, Boukila B, Fonteh FA, Tendonkeng F, Kana JR. Chemical composition and effect of supplementation with *Calliandra calothyrsus* and *Leucaena leucocephala* on milk production and the growth of baby dwarf goats. *Livestock Research for Rural Development*. 2005; 17.
Available:<http://www.lrrd.org/lrrd17/3/tedo17030.htm>
 22. Pauwels JM, Van Ranst E, Verloo M, Mvondo Ze A. Method of soil and plant analysis, stock management of glassware and chemicals. *Manual of Pedology Laboratory*. Agricultural publications. 1992; 28.
 23. Sys C, Van Ranst E, Debaveye J, Beernaert F. Land evaluation part II. *Methods for land evaluation*. Belgium, General Administration for Development Cooperation; 1991.
 24. Mihoub Adil. Effect of phosphate fertilization on nitrogen nutrition and productivity of a durum wheat crop (*Triticum durum* L. Var. Carioca) in the El-Goléa-Ghardaia region. Engineering thesis in agricultural sciences, University of Kasdi-Merbah Ouarla, Algeria. 2008;85.
 25. Soltner D. The basics of Plant Production. Volume 2: The soil and its improvement. 18th Edition, *Collection Sciences et Techniques Agricoles*. 2003;472.
 26. Steel RG, Torrie JH. Principles and procedures of statistics. New York, McGraw Hill Book C. 1980;633.
 27. Mulaji KC. Use of organic household waste composts to improve the fertility of acid soils in the province of Kinshasa (Democratic Republic of Congo). Doctoral thesis, University of Gembloux Agro Bio Tech. 2011;220.
 28. Kimuni NL, Mwali KM, Mulembo MT, Lwalaba LJ, Lubobo KA, Katombe NB, Mpundu MM, Baboy LL. Effects of increasing doses of hen manure composts on the yield of Chinese cabbage (*Brassica chinensis* L.) installed on an acid soil of Lubumbashi. *Journal of Applied Biosciences*. 2014;77:6509-6522.
 29. Morot-Gaudry JF. Nitrogen assimilation in plants: physiological, biochemical and molecular aspect. INRA Edition. 1997;422.
 30. Pamo TE, Boukila B, Meduke CN, Tendonkeng F. Effect of nitrogen fertilization and cutting frequency on the

- yield and regrowth of *Panicum maximum* Jacq. in West Cameroon. In: Xie Haining and Huang Jiehua (Eds). XXI International Grassland Congress / VIII International Rangeland Congress Hohhot, China. 2008;354.
31. Tendonkeng F, Boukila B, Pamo TE, Mboko AV, Matumuini NEF, Fogang ZB. Effect of different levels of nitrogen fertilization and the phenological stage on the growth and yield of *Brachiaria ruziziensis* in West Cameroon. International Journal of Biological and Chemical Sciences. 2009;3(4):725-735.
 32. Zamil SS, Quadir FQ, Chowdhury MAH, Al Wahid A. Effect of different animal manures on yield quality and nutrient uptake by mustard cv. Agrani. BRAC University Journal. 2004;1(2):56-66.
 33. Ojetayo AE, Olaniyi JO, Akanbi WB, Olabiyi TI. Effect of fertilizer types on nutritional quality of two cabbage varieties before and after storage. Journal of Applied Biosciences. 2011;48:3322-3330.
 34. Agbede TM, Ojeniyi SO, Adeyemo AJ. Effect of poultry manure on soil physical and chemical properties, growth and grain yield of sorghum in southwest, Nigeria. American-Eurasian Journal of Sustainable Agriculture. 2008;2(1):72-77.
 35. Adeleye EO, Ayeni LS, Ojeniyi SO. Effect of poultry manure on soil physico-chemical properties, leaf nutrient content and yield of Yam (*Dioscorea rotundata*) on alfisol in Southwestern Nigeria. Journal of American Science. 2010;6(10):871-878.
 36. Akanni DI. Response of nutrient composition and yield components of tomato livestock manure. Ph.D. Thesis, Department of Crop, Soil and Pest Management, Federal University of Technology, Akure. 2005;120.
 37. Pamo TE, Yonkeu S. Behavior of some forage species in the shallows of the SODEPA-Faro ranch, Adamaoua, Cameroon. In: Proceedings of the regional seminar on fodder and feed for ruminants. NGAoundéré Cameroon. Maison-Alfort, IEMVT, Yaoundé, MESRES. (Studies and Synthesis of the IEMVT n ° 30). 1987;413-425.
 38. Bogdan AV. Tropical pastures and fodder plants. Longman, London; 1977.
 39. Lemaire G, Salette J, Laissus R. Analysis of the growth of a natural Norman meadow in spring: II. The dynamics of nitrogen absorption and its efficiency. Fodder. 1982; 92:51-65.
 40. Peyraud JL, Astigarraga L. Review of effect of nitrogen fertilisation on the chemical composition, intake, digestion and nutritive value of fresh herbage: Consequences on animal nutrition and N balance. Animal Feed Science and Technology. 1998;72(3-4):235-259.
 41. Lemaire G, Pablo C, Jacque W. Ecophysiology of tropical fodder plants. In: Roberge G, Toutain B. Tropical forage crops. CIRAD. 1999;19-51.

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