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Association of *Aeschynomene histrix* with *Andropogon gayanus* or *Panicum maximun*: A Comparative Study of Pasture Quality

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Abstract: Forage crops are essential for developing ruminant livestock farming. The combination of grasses and legumes in the same pasture provides a forage with more balanced nutritional value which enhances animal performance. In sub-Saharan africa, forage crops are very rarely practiced. The objective of this study was to improve the quality of the forage given to ruminants, by growing together, grasses and legumes in the same pasture. A legume (*Aeschynomene histrix*) has been studied in association with two grasses (*Andropogon gayanus, Panicum maximum*). The study was carried out to evaluate the competitiveness of the legume forage according to different grass establishment densities in order to identify the mixture that offers a better compromise between productivity, forage quality and pasture stability. The evolution of the forage biomass and its nutritional value were evaluated over three years. The results obtained shown that the legume grows better in the presence of one of the two grasses studied. The forage from one grass had on average higher energy and nitrogen values that the other. However, the method of mowing used in this study was not sufficient to make a complete judgment on the stability of the two types of associations. The associations studied will have to be grazed by the cattle before concluding definitively.

Keywords: Aeschynomene Histrix, Andropogon Gayanus, Panicum Maximum, Forage Crops, Pasture, Forage Value

1. Introduction

Sub-Saharan Africa is one of the main meat importers in the world. Its meat consumption, fueled by rapid population growth and urbanization, is growing faster than in any other region of the world. Meat imports into sub-Saharan Africa account for 8% of world trade, but are expected to increase by around 6% per year over the 2015-2025 period [1]. To limit the share of imports in meat consumption of the countries of this part of the world, efforts should be made to develop the sector of herbivores breeding, whose feed is not competitive with that of human, unlike poultry or pigs. In fact, herbivorous animals (such as ruminants) are fed with fibrous feed, based on fodder and plant byproducts. Their feed may contain a very small proportion of cereals, which can be used directly for human consumption. Forage crops are essential for developing ruminant livestock farming in rural Africa, as has been the case in many other tropical regions [2].

For grassland specialists, the purpose of forage crops is usually to make mixtures. The combination of grasses and legumes in the same pasture provides a forage with more balanced nutritional value and increased digestibility. It provides livestock a feed richer in nitrogen [3], which has an impact on animal performance. However, the difficulty in managing the associations is to ensure a balance between the grass and the legume. In grass-legume association, competition between the two species is an important factor that strongly influences the stability of mixed pasture. Usually, the grass being more vigorous, it often ends up supplanting and eliminating the legume.

In this work, a legume was cultivated in combination with two grasses. The aim was to study the competitiveness of the legume according to different grass establishment densities and to identify the mixture that offers a better compromise between productivity, forage quality and pasture stability.

2. Material and Methods

2.1. Site of the Study

The experiment was carried out at the Parakou Integrated Normal School (9°30'N, 2°29'E) in the Borgou department of Benin. The altitude of this experimental site is about 350 m. The climate of the region is characterized by the alternation of a rainy season and a dry season. The rainy season runs from May to October and the dry season from November to April. The average annual rainfall is around 1200 mm. The average temperatures are quite constant and close to 26°C.

2.2. Experimental Treatments

In this study, *Aeschynomene histrix* was sown on plots of *Panicum maximum* and *Andropogon gayanus*. Five treatments representing the increasing densities of grass establishment were compared:

1. T1: plots with a pure culture of *Aeschynomene histrix*, no grass plant;
2. T2: sowing of *Aeschynomene histrix* on plots with a grass density of 5555 plants per ha, ie 5 plants per plot of 9 m²;
3. T3: *Aeschynomene histrix* seedlings on plots with a grass density of 11,111 plants per ha or 10 plants per plot of 9 m²;
4. T4: sowing of *Aeschynomene histrix* on plots with a grass density of 16666 plants per ha, ie 15 plants per plot of 9 m²;
5. T5: plots with a pure grass crop at a density of 22 222 plants / ha, ie 20 plants per plot of 9 m²; no *Aeschynomene histrix* plant.

This experience summarized in Table 1 therefore consisted of 5 treatments for each grass. Thus, for each grass, a complete random block was used. Each grass density was repeated four times. Thus, each block had 5 x 4 = 20 parcels of 9 m². The distance between the parcels was 1.5 m. The seeding rate of the legume was 10 g per plot, equivalent to 11 kg seed per ha for mixed and control crops. A germination test was carried out beforehand on the seed lot used. The germination rate was around 90%. The measurements made concerned the forage biomass and the chemical composition of the fodder.

Table 1. *Summary of the experimental protocol followed.*

Densities of grasses implantation [plants / ha]	0	5 555	11 111	16 666	22 222
Number of repetitions by species	4	4	4	4	4
Surface of each plot [m²]	9	9	9	9	9
Density of sowing of *Aeschynomene histrix* [kg of seeds/ha]	11	11	11	11	11

2.3. Measurements Made and Procedure

2.3.1. The Forage Biomass

For forage biomass estimation, the rate of cut was determined by grass growth. It was carried out when *Panicum maximum* was at the stage of 4-5 leaf or when *Andropogon gayanus* was at the stage of 5-6 leaf. Thus, there were 3 cuts per year during the first two years versus 4 cuts during the third year. The cutting height was 15 cm. It was made according to a square of density of 1 m² repeated 3 times per plot. For each cut, the grass was separated from the legume and the fresh weight of each species noted. The dry matter content was then determined by drying in an oven at a temperature of 60°C to constant weight.

2.3.2. Fodder Analysis Method

Harvested forage analyzes were performed using near-infrared spectrometry (NIRS). The samples to be analyzed were milled using a Cyclotec (Tecator) mill equipped with a 1 mm mesh screen. The milled material was then placed in a quartz window cup. These powders were scanned in a NIRSsystem 5000 and 2400 nm grating spectrophotometer and the scanning was done in increments of 8 nm. The absorbance levels of the powders thus obtained for the different wavelengths constituted the spectra of the samples which were treated using the IntraSoft International software.

Calibration is the crucial step in the analytical process [4]. It consists in measuring the spectra of a large number of samples of known chemical composition, to then establish linear models of prediction according to relations of the type:

$$y = b0 + b1x1 + b2x2 + ... + bixi + ... + bpxp$$

Where:

1. y is the predictor variable (total nitrogen content, raw Celullose,...);
2. bi are the regression coefficients;
3. xi are the optical densities at a specific wavelength (= logarithm of absorbance);
4. p is the number of different wavelengths taken into account in the model.

In this study, the prediction of the chemical composition of forage samples was based on calibration from tropical forage samples. The number of samples used to establish the prediction equations for the total nitrogen content (TN), crude fiber (CF) and total ash (TA) of the forage analyzed, as well as their accuracy are summarized in Table 2.

Table 2. *Accuracy of spectrophotometer calibration equations.*

	CF	TN	TA
Total number of samples	316	316	348
Average sample content [% of DM]	32,6	10,3	10,2
Number of samples	237	237	261
Calibration			
SSE	1,27	1,61	1,40
r^2	0,96	0,99	0,94
Number of samples	79	79	87
Validation			
SSE	1,5	0,74	1,68
R^2	0,95	0,98	0,91

2.4. Method for Calculating the Nutritive Value of Forage

To calculate the nutritional value of the forage, we used the crude fiber (CF), crude ash (CA) and total proteins (TP) contents obtained by NIRS method. The energy value expressed in Feed

Unit (FU) was determined using the Dijskstra formulas [5] established for grasses and legumes, namely:

- for grasses:

$$FU = (0.97 \times (100 - CA) - 0.3238\ CF - \frac{2.6577 \text{CF}^2}{100 - CA}) \times \frac{1.43}{100}$$

- for legumes:

$$FU = (0.7882 \times (100 - CA) - 0.1044 CF - \frac{2.551 CF^2}{100 - CA} \times \frac{1.43}{100}$$

The digestible nitrogen content (DN) of the forage was estimated from the Demarquilly formula recommended by Boudet [6]:

$$DN = 9.29 \times TN - 35.2$$

2.5. Statistical Analyzes of the Results

For each grass, the fixed factors considered for the analyzes were the year and the density of implantation of grasses. The analyzed variables concerned:

1. the total annual production of forage biomass;
2. the average nitrogen content of the forage harvested;
3. the average energy value of the fodder harvested.

For each variable studied, the two-way ANOVA was used to identify significant differences. The statistical model used was as follows:

$$Yijk = \alpha + Ai + Bj + A*B\ (ij) + ek\ (ijk).$$

Where:

1. α represents the average of the values of the measured variable;
2. Ai and Bj denote the main effects of the two factors;
3. A * B (ij) represents the theoretical value of the interaction of the two factors;
4. ek (ijk) represents the error.

For each variable studied, Minitab software was used to identify interactions using the Generalized Linear Model (GLM) and to compare the averages. When a significant interaction was identified between the two factors for a given variable, the one-way analysis of variance model was used. The factors were then studied separately. Thus, depending on the case, the averages were analyzed using the ANOVA with one or two classification criteria.

3. Results

3.1. Legume Contribution to Forage Biomass Production of Mixed Plots

The contribution of the legume to total forage biomass production in each plot was calculated. The results are shown in Tables 3 and 4. In the first and third year, the percentage of legume in forage production was greater in associations with *Andropogon gayanus* than in mixtures with *Panicum maximum*.

Table 3. *Percentage of legume in forage production of maximum Panicum block plots (n = 12).*

Year	Densities of *maximum Panicum* implantation [plants / ha]				
	0	5 555	11 111	16 666	22 222
1	100 ± 0.0 Aa	45.1 ± 20.1 Ab	31.10 ± 7.8 Ab	25.6 ± 9.1 Ab	-
2	100 ± 0.0 Aa	24.3 ± 08.8 Bb	16.35 ± 3.5 Bc	19.1 ± 6.6 Ac	-
3	100 ± 0.0 Aa	18.7 ± 05.1 Bb	14.10 ± 3.6 Bc	13.7 ± 4.5 Bc	-

For the same column, values followed by the same capital letter are not significantly different at the 5% probability level.
For the same row, the values followed by the same lowercase letter are not significantly different at the 5% threshold.

Table 4. *Percentage of legume in forage production of Andropogon gayanus block plots (n = 12).*

Year	Densities of *Andropogon gayanus* implantation [plants/ha]				
	0	5 555	11 111	16 666	22 222
1	100 ± 0.0 Aa	64.4 ± 19.6 Ab	63.7 ± 12.0 Ab 16.2 ±	50.40 ± 14.6 Ac	-
2	100 ± 0.0 Aa	34.9 ± 21.3 Bb	08.3 Bc	12.9 0± 4.3 Bc	-
3	100 ± 0.0 Aa	45.7 ± 18.7 Cb	38.6 ± 12.6 Cb	30.6 0± 13.9 Cb	-

For the same column, values followed by the same capital letter are not significantly different at the 5% probability level.
For the same row, the values followed by the same lowercase letter are not significantly different at the 5% threshold.

3.2. Fodder Biomass Production

The averages of forage biomass production for each treatment were calculated for each year and for each association. The results obtained are presented in Tables 5 and 6.

In the first year, the productions were similar in the two types of association. Forage biomass production increases with the seeding rate of grasses. The lowest biomass productivity was obtained with the legume in pure culture with 3.19 t / ha for the maximum Panicum block and 3.90 t / ha for the Andropogon gayanus block. The greatest production was obtained with grasses in pure culture. It was 8.73 t / ha for Panicum maximum and 8.27 t / ha for Andropogon gayanus.

In the second year, the density of 11111 grass plants per hectare showed a superiority of the Andropogon gayanus block averages compared to the maximum Panicum block. In addition, forage production increased as in the first year with the seeding rate of grasses. The best result was obtained with Andropogon gayanus in pure culture for a production of 8.55 t / ha of feed biomass against 6.62 t / ha for Panicum maximum.

In the third year, the productions of the two types of association in the mixed plots were close. However, in pure crop plots, the yields recorded for Andropogon gayanus were better than those recorded for Panicum maximum (6.18 t / ha vs. 4.30 t / ha respectively).

Overall, it appears that grasses are more productive than legumes. They generally produce twice as much as the legume. On the other hand, forage biomass production increased with the seeding density of grasses and forage biomass production of *Andropogon gayanus* association was greater than that of *Panicum maximum*. This superiority was remarkable especially in the second year

It is also worth noting the decline in crop productivity over the time. For most of treatments, the highest forage biomass productivity was obtained in the first year, with the exception of some of *Andropogon gayanus* combination treatments, which yielded their best yields in the second year. The lowest yields were obtained in the third year for all treatments.

Table 5. *Forage biomass production of Panicum maximum plots (t / ha), (n = 12).*

Year	Densities of *Panicum maximum* implantation [plants/ha]				
	0	5 555	11 111	16 666	22 222
1	3.19 ± 0.55 Ac	5.27 ± 1.27 Bb	6.43 ± 1.26 Ab	6.57 ± 1.66 Ab	8.73 ± 2.86 Aa
2	2.66 ± 0.45 Bb	6.18 ± 1.34 Aa	6.45 ± 0.86 Aa	5.73 ± 1.45 Ba	6.62 ± 1.39 Ba
3	2.46 ± 0.26 Bc	5.50 ± 1.05 Ba	5.29 ± 0.96 Ba	5.73 ± 1.45 Ba	4.30 ± 0.78 Cb

For the same column, values followed by the same capital letter are not significantly different at the 5% probability level.
For the same row, the values followed by the same lowercase letter are not significantly different at the 5% threshold.

Table 6. *Forage biomass production of plots of Andropogon gayanus (t / ha), (n = 12).*

Year	Densities of *Andropogon gayanus* implantation [plants/ha]				
	0	5 555	11 111	16 666	22 222
1	3.90 ± 0.60 Ac	6.20 ± 1.53 Ab	6.27 ± 0.80 Ab	6.64 ± 2.19 Ab	8.27 ± 2.72 Aa
2	2.62 ± 0.37 Bb	7.10 ± 3.24 Aa	7.98 ± 2.09 Aa	7.28 ± 1.95 Aa	8.55 ± 1.39 Aa
3	2.52 ± 0.47 Bc	4.44 ± 1.07 Bb	4.62 ± 1.00 Bb	5.43 ± 1.67 Aa	6.18 ± 1.39 Ba

For the same column, values followed by the same capital letter are not significantly different at the 5% probability level.
For the same row, the values followed by the same lowercase letter are not significantly different at the 5% threshold.

3.3. Nutritional Value of Forages

3.3.1. Digestible Crude Protein Content of Fodder

The digestible crude protein values of harvested forage are presented in Tables 7 and 8.

In the first year, the highest levels of digestible nitrogen (ND) were obtained with the legume in pure culture. They reached 165 and 151 g DN / kg MS respectively for blocks containing *Panicum maximum* and *Andropogon gayanus*. The lowest levels in ND were obtained with grasses in pure culture. They reached 36 g DN / kg DM for *Panicum maximum* and 47 g DN / kg DM for *Andropogon gayanus*. DM content of forage from mixed crops was intermediate to that of pure grass and legume crops. The averages recorded on the plots in pure culture were similar for both grasses. However, for treatments with mixtures, the *Andropogon gayanus* plots gave better results than that of *Panicum maximum*. Overall, in the first year, the level of digestible nitrogen content of the forage decreased as the density of grass seedlings in the association increased.

In the second year, the same trend was observed in the evolution of the DN content of the fodder. These decreased as the density of grass increased in the mixture. The highest values were obtained with the legume in pure culture (116 and 115 g ND / kg DM respectively for *Panicum* and *Andropogon* blocks). The lowest values were recorded for grasses in pure culture (34 and 32 g DN / kg DM respectively for the two blocks mentioned above). The DM content of forage from mixed crops was intermediate to that of pure grass and legume crops. However, during the second year, there was no great variation between the two types of associations. In addition, there was a large decrease in the levels of DN during this year. They decreased by half compared to those observed in the first year.

The observations in the third year were similar to those in the second year. However, the fodder derived from the *Andropogon* block associations gave higher DN contents than the fodder obtained from that of *Panicum*.

Table 7. *Levels of digestible crude protein of the fodder harvested in the Panicum maximum plots (g DN / kg DM), (n = 4).*

Year	Densities of *Panicum maximum* implantation [plants/ha]				
	0	5 555	11 111	16 666	22 222
1	165 ± 7 Aa	103 ± 6 Ab	86 ± 9 Ac	73 ± 3 Ad	36 ± 5 Ae
2	116 ± 8 Ca	59 ± 6 Bb	51 ± 2 Bb	53 ± 5 Bb	34 ± 4 Ac
3	135 ± 10 Ba	52 ± 4 Bb	47 ± 3 Cb	49 ± 4 Bb	32 ± 4 Ac

For the same column, values followed by the same capital letter are not significantly different at the 5% probability level.
For the same row, the values followed by the same lowercase letter are not significantly different at the 5% threshold.

Table 8. *Levels of digestible crude protein of the fodder harvested in the Andropogon gayanus plots (DN g / kg DM) (n = 4).*

Année	Densities of *Andropogon gayanus* implantation [plants/ha]				
	0	5 555	11 111	16 666	22 222
1	151± 9 Aa 115 ±	117 ± 17 Ab	112 ± 9 Ab	106 ± 6 Ab	47 ± 10 Ac
2	4 Ca	58 ± 14 Bb	54 ± 8 Bb	47 ± 4 Cb	32 ± 2 Bc
3	125 ± 6 Ba	74 ± 19 Bb	65 ± 13 Bb	58 ± 11 Bb	26 ± 2 Cc

For the same column, values followed by the same capital letter are not significantly different at the 5% probability level.
For the same row, the values followed by the same lowercase letter are not significantly different at the 5% threshold.

3.3.2. Energy Values of Harvested Forage

The energy values of harvested forage are presented in Tables 9 and 10. The highest energy values of forage were obtained with the legume in pure culture. They ranged from 0.69 to 0.81 FU / kg DM. Grasses in pure culture gave the lowest values, from 0.49 to 0.67 FU / kg DM. Fodder from mixed crops showed energy values intermediate to those of pure grass and legume crops. However, for the same year and for the same grass, there was no significant difference between plots in mixed culture (P> 0.05). On the other hand, the association with *Andropogon gayanus* gave higher energy values than those recorded for *Panicum maximum* associations during the three years of the experiment.

Table 9. *Energy value of forage harvested in the Panicum maximum block (FU / kg DM), (n = 4).*

Year	Densities of *Panicum maximum* implantation [plants/ha]				
	0	5 555	11 111	16 666	22 222
1	0.71 ± 0.0 Aa	0.58 ± 0.0 Ab	0.55 ± 0.0 Ab	0.53 ± 0.0 Ab	0.50 ± 0.0 Ac
2	0.70 ± 0.0 Aa	0.51 ± 0.0 Ab	0.49 ± 0.0 Bb	0.50 ± 0.0 Ab	0.49 ± 0.0 Ab
3	0.81 ± 0.0 Ba	0.56 ± 0.0 Bb	0.57 ± 0.0 Ab	0.57 ± 0.0 Bb	0.52 ± 0.0 Ac

For the same column, values followed by the same capital letter are not significantly different at the 5% probability level.
For the same row, the values followed by the same lowercase letter are not significantly different at the 5% threshold.

Table 10. *Energy value of forage harvested in the Andropogon gayanus block (FU / kg DM), (n = 4).*

Year	Densities of *Andropogon gayanus* implantation [plants/ha]				
	0	5 555	11 111	16 666	22 222
1	0.74 ± 0.0 Aa	0.70 ± 0.0 Ab	0.67 ± 0.0 Ab	0.66 ± 0.0 Ab	0.59 ± 0.0 Ac
2	0.69 ± 0.0 Aa	0.55 ± 0.0 Bb	0.55 ± 0.0 Bb	0.55 ± 0.0 Bb	0.51 ± 0.0 Bb
3	0.80 ± 0.0 Ba	0.73 ± 0.0 Ab	0.72 ± 0.0 Ab	0.71 ± 0.0 Cb	0.67 ± 0.0 Cc

For the same column, values followed by the same capital letter are not significantly different at the 5% probability level.
For the same row, the values followed by the same lowercase letter are not significantly different at the 5% threshold.

4. Discussion

4.1. Interspecific Competition and Consequences for Grazing Management

Based on the contribution of the legume in the forage biomass production of each plot in the associated crop, we realised that legume forage was dominant only in the first year, in the plots of *Andropogon*. Even in the third year, in this same block, the legume had percentages in forage production between 30 and 50%; values advocated by some authors [7] for legumes in associations. By cons, in the third year, and for the mixed plots of *Panicum maximum*, the proportion of the legume represented only 13 to 18% of the total dry matter of forage biomass. Based on the criterion of forage biomass of the species involved, it seems that the mixture involving *Andropogon gayanus* gave better forage in the third year. Legume percentages in the *Panicum maximum* plots were very low at risk of disappearing in the mixture.

4.1.1. Association with Panicum Maximum

The contributions of the legume to the weight of the forrage observed in the third year in this association reflects an insufficient development of *Aeschynomene histrix*. They were between 13 and 18%. This assumes that the association was not permanently installed. Grazing stability requires the establishment of a balance between grass and legume through appropriate pastoral practices and techniques. A high livestock load, but not excessive, can initially increase the proportion of the legume. Phosphate fertilization can also contribute to better growth of the legume [8]. But by raising the nitrogen content of the soil, the legume can also cause after a few years a contrary effect and favorable to the recovery of the grass.

In the long run, however, it seems that overexploitation is likely to kill the legume. However, the effect of a load deficit at the end of the rainy season can also be detrimental [9]. Indeed, towards the end of the rainy season, the growth of *Panicum maximum* is very fast and its nutritional value decreases very quickly. If the load is not sufficient, or if the interval between the periods of grazing is too long, the animals find themselves in front of a hard grass, rich in cellulose, unappetizing, that they will leave to overgraze the legume. Thus, the tufts of grass grow and legume regresses. Overall, a slight overload seems less harmful than a load deficit. In all cases, care must be taken to avoid the disappearance of *Aeschynomene histrix* from the pasture.

4.1.2. Association with Andropogon Gayanus

The contributions of the legume to the weight of the forage observed in the third year indicated a good development of *Aeschynomene histrix* in this association. They reached 30 to 45% in this block. We can consider that the association was well established. By cons, as we have previously reported, the associations with *Andropogon gayanus* are more fragile and less stable than the associations with *Panicum maximum*. It does not withstand severe pastoral exploitation and mismanagement. It has a higher forage production but requires a longer time to rest. If the association with *Panicum maximum* supports very well a 25-day cut interval, for the association with *Andropogon gayanus*, it is necessary to apply a longer interval of the order of 40 days [9].

4.2. Fodder Production

4.2.1. Plots in Pure Culture

Analysis of forage biomass production for each treatment showed that grasses were more productive than legumes ($P < 0.05$). The largest forage biomass production observed for the legume in pure culture was 3.90 t / ha compared to 8.73 and 8.27 t / ha, respectively for *Panicum maximum* and *Andropogon gayanus* in pure culture. This superiority of grasses in forage biomass production is one of the reasons for their association with legumes, which generally have lower productivity.

The forage biomass observed for *Aeschynomene histrix* in pure culture in the first year is similar to that observed by some authors [10]. These authors obtained, in the same zone of West Africa, a fodder production of 4.05 t / ha by practicing four cuts in the year. Forage production observed for *Andropogon gayanus* in first year is very high compared with that observed by other authors [11] in southern Benin. However, this difference would probably be due to the fact that the experiments were not conducted in the same environments.

The good yield of forage biomass obtained with *Andropogon gayanus* shows that the variety used for the trial is adapted to the Borgou region. It is a species that prefers sandy soils. The study of the soil granulometry of the experimental site revealed a proportion of sands of more than 76%.

The analysis of the evolution of fodder production on plots in pure culture from the first to the third year showed decreases in production of about 20% for the legume, 25% for *Andropogon gayanus* and more than 50% for *maximum Panicum*. These sharp declines in yields can probably be attributed to a decrease in soil fertility. Because, the biggest fall in productivity is recorded for *Panicum maximum* which is a demanding species in fertility. In addition, *Andropogon gayanus*, which is able to grow in sterile soils with few inputs, has a smaller decrease in productivity. Finally, the legume *Aeschynomene histrix*, which is able to fix atmospheric nitrogen to cover its nitrogen requirements, has recorded the lowest yield drop. These sharp decreases in fodder production recorded for these crops could be reduced by the mode of exploitation based on the direct grazing of fodder by livestock. This mode has the advantage of restoring three quarters of the phosphorus and potassium and more than half of the nitrogen ingested by animal waste [12].

4.2.2. Plots with Associated Crops

In the first year, fodder production obtained for plots with a grass / legume mixture were intermediate to those observed for pure crops. They were higher than the production of the legume and lower than those of the grasses. But by the second year, the productions of the associations and those of the grasses in pure culture were equal. Then, from the third year, the productions of the associated crops in the *Panicum* block surpassed those of the pure grass. This result is consistent with the observation of some authors who argue that the productivity of the association is generally better than that of the grass in pure culture without fertilization [13]. The superiority in forage production of associations compared to the pure cultures in the third-year can therefore partly be attributed to the improvement of the nitrogen content and the organic matter of the soil by the presence of the legume.

For plots with grass / legume mixtures, there was not a large variation between the averages of forage biomass production observed for each type of association and for each year. The seeding rate of grass has therefore had little effect on the productivity of mixed crops. On the other hand, it was difficult to conclude which of the grasses gave the best result in terms of fodder productivity in the associations since the production was very variable from one year to another. While mixtures with *Andropogon gayanus* gave the best results in the second year, those with *Panicum maximum* were the best performers in the third year. Therefore, other parameters such as stability and nutritional value of the pasture will have to intervene in the choice of the best association. However, it was found that association with *Andropogon gayanus* was more productive than association with *Panicum maximum* when the tow grasses were cultivated with *Stylosanthes hamata* [9].

The results we observed in terms of forage production for associations in our study seem satisfying, compared to those reported by other authors [9]. These authors associated *Stylosanthes hamata* with *Panicum maximum* and *Andropogon gayanus* in northern Ivory Coast, a region with a similar climate to that of northern Benin. The crops were grown without fertilization. They obtained 3.25 t / ha / year for the association *Andropogon gayanus / Stylosanthes hamata* and 2.29 t / ha / year for the association *Panicum maximum / Stylosanthes hamata*. On the other hand, the results of this experiment appear modest compared to those obtained by other authors. Ezenwa and Aken'ova [13] obtained 12.7 t / ha / yr with *Panicum maximum / Centrosema pubescens* and 13.7 t / ha / yr with *Panicum maximum / Stylosanthes hamata* in Nigeria. However, it should be noted that these high yields were obtained under different experimental conditions (appropriate fertilization of crops). Thus, to ensure greater productivity and best stability of mixed pastures, it is necessary to restore through fertilization the harvesting by mowing or to limit exports by direct grazing. In the current economic context of Sub-Saharan Africa, the second alternative appears to be the best solution for sustainable management of legume-improved pastures.

In any case, the yields obtained on the plots containing the grass / legume mixtures were satisfying compared to those obtained on the plots where these species were in pure culture. The results were even more remarkable in third year for *Panicum maximum*. It is a demanding plant in fertility, which has seen its production fall faster than that of *Andropogon gayanus*, over the years on plots in pure culture. The forage biomass yields were above 4.5 t / ha / yr for these mixed plots in the third year. Compared with natural fallow, which would allow an overall load of 0.7 TLU (Tropical Livestock Unit) / yr [9], the mixed pastures of this trial would allow an overall load of 2 to more than 2.5 TLU / yr.

4.3. Nutritional Value of Forages

4.3.1. Plots in Pure Culture

The legume has a digestible nitrogen content significantly higher than grasses. While the nitrogen value of grasses was around 30 g DN / kg DM, that of the legume was still greater than 100 g DN / kg DM. The energy levels observed for the legume were also higher than those observed for both grasses. While *Aeschynomene histrix* had energy contents between 0.69 FU / kg DM and 0.81 FU / kg DM, *Panicum maximum* and *Andropogon gayanus* had energy contents ranging from 0.49 FU / kg DM to 0.67 FU / kg MS. These results are consistent with the trends reported by other authors [14, 15]. These authors argue that tropical legumes generally have higher energy and nitrogen content than tropical grasses. The differences between grasses and tropical legumes in digestible nitrogen content are even more remarkable.

With the average nutritive values observed for the two grasses, they can be considered as medium fodder according to Boudet's classification [6]. This fodder could provide for the TLU (Tropical Livestock Unit) the coverage of its maintenance needs and a daily production around 1 l of milk or a gain in live weight of 100 g. For cons, the legume can be considered as excellent fodder. With the levels of energy and DN observed, the legume would allow the TLU to produce 5 liters of milk daily or to ensure a gain in live weight of more than 500 g. However, it is necessary to qualify these remarks. For, legumes very often have high levels of anti-nutritional factors that induce a reduction in the nutritional value of these fodder [16], although it has not been reported significant levels of anti-nutritional factors in the legume studied. Then the DN / FU ratio obtained for *Aeschynomene histrix* is excess, since it is greater than 130, the maximum value generally accepted for a ration of ruminants. Better use of legumes in ruminant feed demand their association with poorer grasses nitrogen.

4.3.2. Plots with Associated Crops

In this study, the energy and digestible nitrogen (DN) contents of the forage obtained with the associations were intermediate with those of the legume and grasses in pure culture. The highest levels of DN were obtained with parcels having the lowest grass implantation density (5555 plants / ha). However, the differences observed with the other mixed plots were not significant (P> 0.05). It was the same observation for the energy content. The energy values of the forage obtained with the associations were intermediate with those of the leguminous and grasses in pure culture. And, there was no significant difference between the averages of energy values observed. Forages obtained on plots involving grasses with legumes were of good quality. Their FU and DN values can be used to cover the daily production needs of TLU (Tropical Livestock Unit) from 1 to 3 liters of milk or 100 to 300 g of live weight gain [6]. In addition, it should be noted that associations with *Andropogon gayanus* had on average higher energy and nitrogen values than associations with *Panicum maximum*. This superiority of the nutritional value of forage derived from associations with *Andropogon gayanus* should not be attributed to a superior feed value of *Andropogon gayanus* compared to *Panicum maximum*, but to the abundance of legume in the plots of *Andropogon gayanus*. Indeed, the study of legume percentages in the associations has confirmed a greater abundance of the legume in *Andropogon gayanus* mixtures compared to those of *Panicum maximum.*

5. Conclusion

Our study compared *Panicum maximum* and *Andropogon gayanus*, two grasses, in association with *Aeschynomene histrix*, a legume. These crops were conducted without fertilizer, to adapt them to the socio-economic conditions of the study area unfavorable to mineral fertilization of forage crops. At the end of the study, it appears that the three forage plants are adapted to the pedoclimatic conditions of the Borgou region. On plots in pure culture acting as witnesses, they showed potential for forage production interesting despite the lack of fertilization. Thus, *Panicum maximum* ensures a production ranging from 4.30 to 8.73 t / ha, *Andropogon gayanus* a production of 6.18 to 8.73 t / ha and *Aeschynomene histrix* a production of 2.46 to 3.90 t / ha. The highest productions were recorded in the first year.

The persistence of the legume in the mixtures demonstrates the good competitiveness of *Aeschynomene histrix* against the two grasses grown. This legume, which has a higher nutritional value (0.69 to 0.81 FU / kg DM and 125 to 168 g DN / kg DM) improved the quality of the pasture. The grasses have indeed more modest values between 0.49 to 0.67 FU / kg DM and 26 to 47 g DN / kg DM. The associations thus gave forage of good quality, with energy values and nitrogen contents varying respectively from 0.49 to 0.73 FU / kg DM and 47 to 117 g DN / kg DM. The values of these fodder are acceptable and can cover the maintenance and production needs of animals raised in the department of Borgou.

All the results acquired during this experimentation have shown that *Aeschynomene histrix* seems to develop better in the presence of *Andropogon gayanus* than in association with *Panicum maximum*. However, the mowing method employed in this trial was not sufficient to make a complete judgment on the stability of the two types of associations. Indeed, if the assertion that *Aeschynomene histrix* has poor resistance to mowing is verified [17], the abundance of this legume in the *Andropogon* block in the third year should challenge us. For the operating mode used on-farm is pasture. In the tropics, during grazing, animals seem to prefer grasses over legumes. The selectivity of grazing animals may therefore be a factor influencing the evolution of forage species. Given the competitive strength of *Aeschynomene histrix* in the mixture with *Andropogon gayanus*, the exploitation method by pasture could lead to an even higher legume rate in the association. In contrast, increased selection of *Panicum* by livestock could lead to better legume development in association with *Panicum*. This is why the associations studied should be grazed by cattle before making a complete judgment on their behavior.

The decline in production observed for crops during the three years of experimentation is likely to be due to a decline in soil fertility. This hypothesis, which is followed by the method of exploitation used, must be verified by soil analysis at the end of the experiment. The grazing mode will reduce the effects of a possible soil depletion in this cropping system where the use of input is almost non-existent. This study will thus be able to evaluate the actual performance of cultivated fodder on animals.

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