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Influence of nitrogen fertilization (urea) and association with a legume (*Vigna unguiculata* L.) on the nutritional value of three potentially dual-purpose millet accessions and Thialack 2 and Souna 3 varieties in Senegal

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Abstract: The purpose of this study is to evaluate the combined effect of nitrogen fertilization with urea (46% N) and the association with a legume, cowpea (*Vigna unguiculata*) on fodder yield and feed value of 3 potential dual-purpose millet accessions (SL 423, SL 28 and SL 169), Souna 3 and Thialack 2 varieties. The study was conducted at the Agriculture Technical Application Center of the Higher National School of Agriculture of Thies (Senegal). An experimental device in completely randomized blocks comprising five treatments: a control; 3 doses of urea (0.5N, N and 1.5N with N = 150 kg of urea at 46% N) and an association with cowpea was used. Each type of treatment was repeated 3 times in the 5 millet populations, for a total of 75 experimental units of 8 m^2 each. At maturity, green forage samples were taken from each experimental unit immediately after mowing and subjected to bromatological analyzes. The application of urea on millet plots proved to be interesting in view of the important results obtained in terms of aerial biomass and its chemical composition. The analysis of the results showed that the nitrogen fertilization significantly influenced (P <0.001) the forage yield and the chemical composition of the millet stems. The combination of millet with cowpea did not have significant effects on aboveground biomass yield, but positively influenced the protein value of millet stalks. The SL 169 and the Thialack 2 variety gave the best fodder yields, while for the Total Nitrogenous Materials, the SL169 and the SL 423 show the best results at 225 kg urea per hectare.

Keywords: Millet stalks, nitrogen fertilization, dual-purpose millet, millet/cowpea association, Senegal.

1. INTRODUCTION

In the Sahel, livestock alone contributes between 5% and 10% of GDP, and pastoral systems provide more than 50% of milk production and meat for the various species[1]. In Senegal, the livestock sub-sector accounts for 28.8% of the GDP of the primary sector. It contributes to food and nutrition security and livelihoods for 30% of households in rural areas[2]. However, the harsh climatic conditions of recent decades, increasing demand for agricultural land, continued livestock pressure, inadequate management practices, have all significantly reduced the presence of trees, essential resources[3].

In fact, for the most part, feeding systems are based on the exploitation of rangelands whose low-quality limits the productivity of livestock. In agro-pastoral systems, farmers use crop residues to feed animals. For example, the use of cereal stalks and legume straws (groundnut and cowpea) has become a common practice in these systems. Legumes are known for their ability to improve soil fertility, including its nitrogen status for controlling weeds [4,5]. They can also favor the acquisition of phosphorus by cereals by rhizosphere processes[6]. Cowpeas and groundnuts, in particular, are of great nutritional and economic agronomic interest to small producers [7]. They are the main legumes grown intercropped with millet.

Nitrogen fertilization increases the rate of growth of vegetation and thus the production of dry matter for a defined regrow age or reduces the time required to reach a defined yield (maturity effect). The study of the effect of nitrogen fertilization and the association of millet and cowpea should make it possible to precisely define the interest of these cultivation practices in improving the nutritional value of millet fodder, especially their protein value. still weak. This study will identify options for improving the nutritional quality of fodder using cultural techniques.

2. MATERIELS AND METHODS

Site of study: The study took place at the level of the Application Center for Livestock Technology of the National School of Agriculture of Thies (14 ° 46'N and 16 ° 57'W). The millet was cultivated from July to September 2017, corresponding to the rainy season. The climate of the region is Sudano-Sahelian with alternating rainy seasons (July to October) and dries (November to June).

Experimental apparatus: The trial included two varieties of millet (Souna 3 and Thialack 2) and three potentially dual-use millet populations (SL 28, SL 169 and SL 423) grown in pure culture (with different doses of urea) and association with cowpea (*Vigna unguiculata*).

The experimental setup consists of 3 randomized blocks with five treatments and three replicates. A total of 75 elementary plots with an area of 8 m² separated by 1 m strips were obtained. The treatments consist of the application of different fertilizer doses (urea 46%) and the association with cowpea. Thus, in addition to the experimental control, 4 treatments were applied:

- Treatment 0 (T0): Control plots that received no treatment;
- Treatment 1 (T1): Plots treated with urea at the rate of 75 kg / ha;
- Treatment 2 (T2): Plots treated with urea at the rate of 150 kg / ha;
- Treatment 3 (T3): Plots treated with urea at the rate of 225 kg / ha;
- Treatment 4 (T4): Plots grown in association with cowpea

The cowpea was interplanted 15 days after sowing the millet at a distance of 50 cm on the lines.

Physico-chemical properties of the soil: In order to know the physical and chemical properties of the soil on which the mils were planted, samples were randomly taken from each block and sent to the National Higher School of Agriculture soil science laboratory. Samples were taken on the surface horizon, the first 10 centimeters.

The chemical analyzes focused on pH water, total nitrogen, total phosphorus and total carbon. While physical analyzes focused on grain size to determine soil texture through the proportions of borer, sand and silt.

Irrigation: Irrigation of the plots was done by rain. However, the latter was delayed in starting the crop, so a sprinkler was used thanks to the irrigation device of the agricultural application center (CATA). Rainfall data were collected from the Regional Directorate for Rural Development (RDRD) of Thies.

Conduct of the test: For the conduct of the culture, water supplies were brought at the beginning and then the plots were irrigated by the rain. A first weeding was carried out 15 days after sowing, then continuously throughout the crop to rid stoloniferous weeds. Phosphate manure (single phosphate) was introduced after millet removal at the rate of 150 kg / ha on all plots.

The stems were mown after the harvest of the mature ears. The mowing, done manually, was done by cutters at a height of 10 to 15 cm from the ground. The harvested stems were collected per millet population and processed, tagged and forwarded immediately to ENSA's Animal Husbandry Application Center (CATE).

Milled stalks of millet were cut small strands after being weighed. On each millet population, green forage samples were taken and taken to the laboratory for chemical analysis.

Chemical analyzes of green fodder: The chemical analyzes were carried out in the laboratory of bromatology of the ENSA of Thies according to the AOAC method, (1995). The Dry Matter (DM) evaluation used method 934.01; Organic Matter (Method N°. 942.05), Ash (Method N°. 942.05), Crude Cellulose (Method N°. 978.10) and Crude Protein, Kjeldahl Method using the content of N × 6.25 have been used. Dosage of NDF and ADF was done according to Van Soest's method.

Determination of the protein and energy values of green fodder: The nutritional and nutritive values of the green fodder were calculated from the results of the chemical analyzes carried out on the forage samples.

For the energy value, the calculation was carried out according to the new French systems of feed equivalents (Meat Forage Unit and Milk Forage Unit) from the results of digestibility of the different energies according to the equations of the INRA[8].

- ***Determination of the energy value*** **UFV =** $\frac{ENEV}{1855}$

Where :

ENEV: Net energy for maintenance and meat production = ME x kmf

kl, km, kf et kmf: coefficients of use of the Metabolizable Energy (ME)

kmf = $\frac{(kmf * kf * 1{,}5)}{(kf + 0{,}5km)}$; km = 0,287q + 0,554 ; kl = 0,60 + 0,24 (q – 0,57)

q: Metabolizable Energy concentration = $\frac{ME}{Raw\ Energy\ (RE)}$

Metabolizable Energy = RE x dE x $\frac{ME}{DE}$ (in kcal/kgP^{0,75})

RE (kcal/kg MO) = 4531 + 1,735MAT + Δ

TNM: Total nitrogen matter in g/kg of Organic matter

dE :digestibility of energy = 1,0087dOM – 0,0377

$\frac{EM}{ED}$= 0,8286 – 0,0000877 CB – 0,000174 TNM + 0,0243 FL

FL: Food Level = 1,7

CF : Crude fiber in g/kg of Dry Matter

Determination of digestible nitrogenous matter (DNM): The content of digestible nitrogenous matter (DM) for forage was determined according to the "Demarquilly formula": DNM (g/kg of DM) = 9.29 TNC - 35.2.

Data processing and analysis: The data was first entered on the Excel spreadsheet before being exported to the SAS software (Statistical Analysis System, 2000) for statistical processing via the following Generalized Linear Model (GLM):

Y = μ + αi + βj + αi βj + Ɛ

Where:

μ	:	Overall average
Ai	:	Effect of population or millet variety "i": SL28, SL169, SL423, Souna 3 and Thialack 2
Bj	:	Effect of treatment with the nitrogen dose used (0, 0.5 x N, N, 1.5 x N with N = 150 kg urea at 46% N) or the millet / cowpea combination
αiβj	:	Effect of interaction between population or variety of millet "i" and treatment "j"
Ɛ	:	Residual effect between population or variety of millet "i" and treatment "j"

3. RESULTS

Physico-chemical characteristics of the soil: Soil analyzes determined the nature and characteristics of the soil in which the mils were grown. The results showed that it is moderately basic sandy-clay soil (7.7 <pH <8.04). The average total nitrogen content is 5.9 g/kg of soil, which is sufficient for traditional agriculture but requires nitrogen supplementation for intensive agriculture[9]. In contrast, the average total phosphorus content was very low (2.6 g/kg soil), which required phosphate input[10].

Millet grain yield: The analysis of the results of the study shows a weak influence of the treatments on the grain yields of the different types of millet. Statistically, no significant difference was observed (P = 0.1153). However, millets having been treated with 150 kg of urea per hectare gave the best grain yields (1408.33 kg/ha); they are followed by mils who received no treatment (control plots) **(Table 1).** Mils grown in association with cowpea yielded the lowest yields (925 kg/ha) while those receiving 75 and 225 kg urea per hectare showed nearly similar intermediate yields (1100 kg/ha).

Table 1: Average grain yields of the five millet populations as a function of processing

Treatment	Souna 3	Thialack 2	SL 28	SL 169	SL 423	Average
T0	1166.67	1041.67	1083.33	1708.33	1083.33	1216.67
T1	791.67	1500.00	1333.33	875.00	1000.00	1100.00
T2	875.00	1041.67	2125.00	1875.00	1125.00	140833
T3	625.00	1583.33	1166.67	1708.33	500.00	1116.67
T4	750.00	833.33	1166.67	958.33	916.67	925.00
Average	**841.67b**	**1200.00ab**	**1375.00a**	**1425.00a**	**925.00ab**	

T0: Witness; T1: 75 kg / ha of urea; T2: 150 kg / ha of urea; T3: 225kg / ha of urea; T4: Association millet/cowpea. The averages which are followed by the same letter are not significantly different with the Duncan test (P ≤0.05).

However, the study shows a high variability of grain yields depending on the types of millet (varieties). In fact, very significant differences were observed in the grain yields of the different varieties cultivated (P=0.0059). Thus, we find that SL 169 and SL 28 gave the best yield (respectively 1425 kg/ha and 1375 kg/ha), followed by the variety Thialack 2 which has a yield of 1200 kg/ha.

Fodder yields: Fodder yields by type of millet per treatment are shown in Table 2. The analysis of the results shows that the treatments had a significant influence on forage yields (P = 0.0179). In fact, millets that received urea as treatment regardless of the dose gave the best fodder yields (on average 8698 kg of Dry matter/ha). The mils receiving 150 kg urea per hectare and those grown in combination with cowpea yielded the best and the lowest yield, respectively.

Like treatments, millet types also have a significant influence on forage yields (P = 0.0054). On this, the line SL 169 and the variety Thialack 2 are the best with a yield of 9190.27 kg of DM/ha and 8771.13 kg of DM/ha respectively.

Table 2: Average forage yields (in kg of DM/ha) of the five millet populations as a function of processing.

Treatments	Souna 3	Thialack 2	SL 28	SL 169	SL 423	Average
T0	8060.67	9278.67	7721.00	8364.00	7199.33	8124.73
T1	8063.67	10169.00	7624.00	10327.33	6440.00	8524.80
T2	7763.00	8701.33	9896.67	9115.00	8885.33	8872.27
T3	7893.67	9562.67	8759.33	10146.33	7126.00	8697.60
T4	7789.00	6144.00	7528.33	7998.67	6534.00	7198.80
Average	**7914.00ab**	**8771.13a**	**8305.87ab**	**9190.27a**	**7236.93b**	

T0: Witness; T1: 75 kg/ha of urea; T2: 150 kg/ha of urea; T3: 225kg/ha of urea; T4: Association millet/cowpea. The averages which are followed by the same letter are not significantly different with the Duncan test (P ≤0.05).

Chemical compositions of green fodder of different types of millet: Overall, the results of the study show a strong influence of nitrogen fertilization on the chemical composition of green fodder of different types of millet. Also, a high variability of the chemical composition is noted between the different types of millet. This means that the two parameters of treatment (fertilization) and the type of millet have significant effects on the chemical composition of forage, which influences their nutritional value (energy and protein).

In fact, the analysis in Table 3 shows that the crude protein content of millet fodder varies significantly depending on the type of treatment (fertilization) and the type of millet grown variety (P=0001). Mils from the treated plots (urea plus cowpea association) gave better results compared to millet grown on the control plots (having received no treatment) (6.04% for the control compared to 6.82% for T1; 7.14% for T2, 7.77% for T3, 6.43% for T4). It should be noted that millet fertilized with urea gave the best protein levels compared to those grown in association with cowpea. The latter gave results almost similar to those of the control plots.

With regard to millet types, lines SL 169 and SL 423 showed the best levels of protein (7.21% and 7.09% respectively). The other millets showed average contents of about 6%.

As for proteins, the fiber content of millet fodder was strongly influenced by both the treatments and the types of millet. In fact, the mils treated with the 75 kg dose of urea per hectare gave the highest fiber content; they are slightly followed by those who received no treatment (respectively 46.07% and 45.18%).

For the raw cellulose, significant differences were observed between the different types of millet and treatments. The Thialack 2 and Souna 3 varieties record the highest levels with respectively 47.56% DM and 46.90% DM. Regarding treatments, the highest fiber levels were noted in mils receiving 75 kg/ha of urea and those receiving no treatment (control) (respectively 46.07% and 45.18% of Dry Matter).

For NDFs, green fodder from different mills showed average values of more than 70%. While the average value of ADF is around 48%. For the total wall contents NDF and ADF), slight variations were observed between the different mils. However, for the NDF, the Thialack 2 and Souna 3 varieties showed high levels; they are slightly followed by the SL 28. This same trend is observed among the ADFs.

Table 3: Chemical compositions of millet fodder depending on the treatment and type of millet

	CP	CF	NDF	ADF	MM
T0	6.04e	46.07a	73.35a	48.14b	11.47c
T1	6.82c	45.18b	73.76ab	49.15a	10.87d
T2	7.15b	42.70d	72.70b	47.09cd	11.37c
T3	7.77a	43.78c	72.87b	47.40c	12.08b
T4	6.43d	42.20d	72.79b	46.66d	12.36a
Souna 3	6.64d	46.90b	73.37b	48.66b	10.61d
Thialack 2	6.54e	47.56a	75.24a	49.91a	11.72c
SL 28	6.75c	43.71c	73.85b	48.14c	11.45e
SL 169	7.21a	41.79d	72.18c	46.73d	12.09b
SL 423	7.09b	39.98e	70.82d	45.00e	12.27a

CF: crude fiber; MM: mineral matter; CP: crude protein; NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber. T0: witness; T1 :75 kg/ha urea; T2: 150 kg/ha urea; T3: 225kg/ha urea; T4: millet/cowpea association. The averages which are followed by the same letter are not significantly different with the Duncan test ($P \leq 0.05$).

Food value of fodder

- **Energetic value:** The results obtained show a very significant effect ($P < 0.001$) of nitrogen fertilization on the energy value of millet stems. Fodder derived from the millet-cowpea combination and those receiving the 150 kg dose of urea/ha showed the best energy values with respectively 0.540 MUF/kg DM and 0.537 MUF/kg of DM. Indeed, as shown in Figure 2, nitrogen fertilization strongly influenced the nitrogen content of millet forage. Thus, the higher the dose of urea, the higher the digestible nitrogenous matter (DNM) content in forages.

  Considering individually the types of millet, lines SL 423 and SL 169 gave the best energy contents with respectively 0.58 and 0.55 UFV/kg.MS.

- **Nitrogen values:** Variance analysis revealed a highly significant influence of nitrogen fertilization and millet/cowpea association on the DM content of millet forage. The maximum level was obtained with stems receiving 225 kg urea/ha (36.96 g DNM/kg of DM). Considering the treatments, forage derived from the millet/cowpea association gave the lowest levels in DNM (24.58 g DNM/kg of DM) compared to those from the parcels that received urea. Overall, forage from untreated plots (neither urea nor association with cowpea had the lowest yields (20.95 g/kg of DM).

Considering the types of millet, the lines SL 169, SL 423 and SL 28 have the best contents in DNM (respectively 31.74 g/kg of DM, 30.65 g/kg DM and 27.50 g/kg of DM) compared to certified varieties, Souna 3 and Thialack 2 (respectively 26.45 g/kg of DM and 25.54 g/kg of DM).

Figure 1: Levels of digestible nitrogenous matter (DNM) in millet stalks. The averages which are followed by the same letter are not significantly different with the Duncan test ($P \leq 0.05$).

Yield in Fodder Meat Unit and Digestible Nitrogenous Matter: The results presented above on the DNM and MFU contents of millet stalks show a highly significant influence of nitrogen fertilization on these two food and energy parameters. Indeed, as shown in Figure 2, there is an increase in the yield of DNM and MFU depending on the dose of urea applied to the millet plots. The superposition of the two graphs shows a quasi-synchronous evolution of the MAD and MFU contents, with a maximum provided by the dose of 150 kg/ha of urea (ie 70 kg N/ha). Beyond this dose, both parameters begin to fall. The dose of 150 kg / ha of urea provides yields of 837 MFU/ha and 109 kg of DNM/ha, which means that this dose seems to give the best compromise between the energy value and the nitrogen value of the millet stems.

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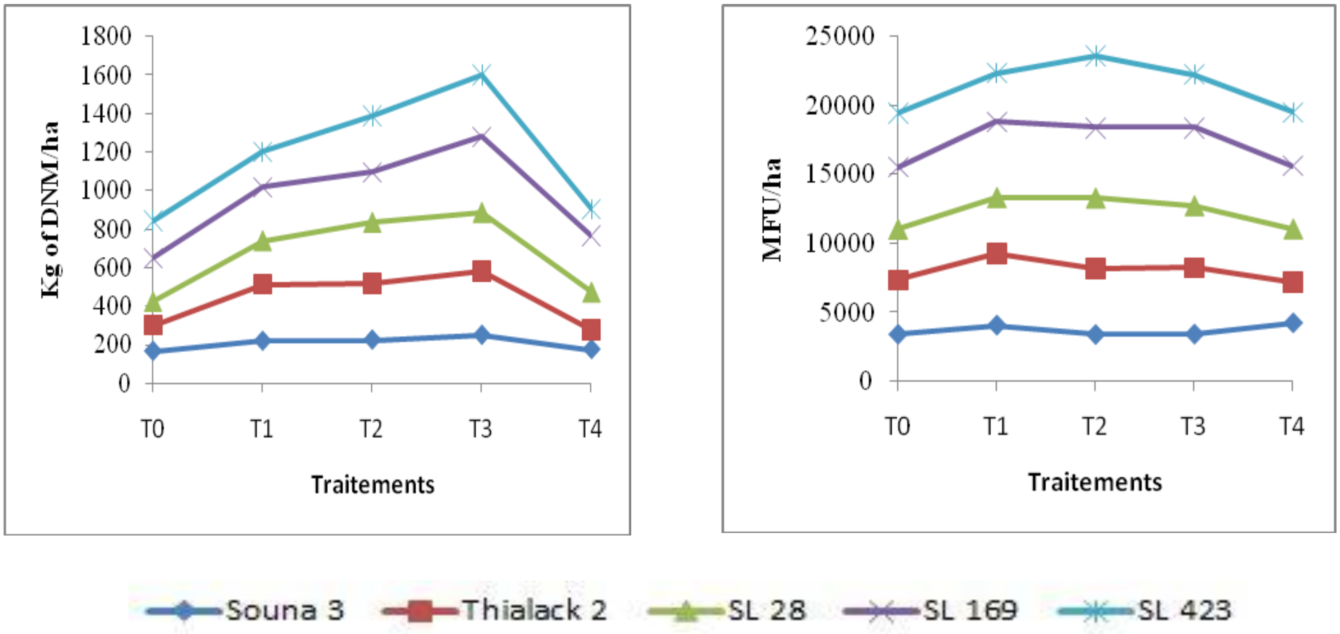
With regard to the types of millet, the line SL 423 presented the best energy yield (5229 MFU/ha), while SL 28 gives the best yield in nitrogenous matter (316 kg DNM/ha).



T0: Witness; T1: 75 kg / ha of urea; T2: 150 kg / ha of urea; T3: 225kg / ha of urea; T4: Association millet/cowpea

Figure 2: Energy and food values of millet stems according to treatments

4. DISCUSSION

Effects of nitrogen fertilization and association with cowpea on grain yield: The application of urea and the association of mi with cowpea did not have a major influence on millet grain yield. The results obtained show no significant differences with those obtained on the control plots, which received no treatment. This low effect of nitrogen on millet yield could be related to the water stress that plants faced during the month of September when rainfall was scarce on the plots. Indeed, according to Diouf [11], there is indeed an interaction between the water deficit and the nitrogen fertilization on the yield and its components and that in conditions of water deficit, the relative loss of grain yield increases with the nitrogen fertilization. According to Do and Winkel[12] the water deficit would have immediate consequences on the ears in the early phase of evolution (heading, flowering and fertilization), or on the grains at the beginning of filling.

Effects of nitrogen fertilization and association with cowpea on fodder yield: In contrast to grain yield, forage yield was strongly influenced by nitrogen fertilization. These results confirm those reported by Randhawa *and al.*, [13] and Sharma *et al.*[14]. Indeed, these authors concluded that the response of millet to nitrogen fertilization was positive up to a dose of 120 kg/ha N. According to Singh[15], this increase in forage yield following the nitrogen dose was due to an increase in the number of tillers per plant and the growth in length of the stems.

The combination of mils with cowpea yielded lower yields compared to urea intake. Indeed, the two cultures are in competition for the resources of the medium notably the water, the mineral elements and the light. The growth of two or more crops in combination often results in lower yields of both crops due to competition for limited essential resources[16 -18.] Mbaye *and al.*[19], working on different dates and seedling densities of cowpea associated with millet found no significant effect of cowpea on millet productivity and showed that the results differ by one year from other depending on dates and sowing densities.

According to Bengaly and Bagayogo[20], the legume can provide between 30% and 70% more fodder, but it provides a better forage, generally richer in nitrogen. What relativizes the negative effect of the legume on the grass and moreover the depressive effect on grain production of the cereal can be offset by a legume effect in the following years. According to the same authors, the previous corn-*Lablab purpureus* increases grain sorghum production by 400 kg / ha compared to previous pure corn.

Effect of nitrogen fertilization on the chemical composition of millet feed: Nitrogen input to the plots had a significant influence on the crude protein content of millet forage. The results obtained are similar to those reported by Randhawa *and al*.[21]. In fact, in the absence of nitrogen fertilization, the crude protein content of the grass depends first and foremost on the supply of nitrogen from the soil[22]. Similar effects have been reported by Halimat *and al.*[23], on wheat nitrogen nutrition. According to these authors, the contribution of nitrogen has a highly significant effect on the increase in the nitrogen content of the straws.

On the other hand, examination of the results shows that the nitrogen supply did not have much influence on the total wall and crude fiber content. These results are in line with those reported by Delaby[22]. According to the latter, fertilization has no or little effect on the crude fiber content and more broadly on the walls. The analysis of the results also shows that nitrogen input has had a significant influence on the mineral content of green fodder. Indeed, according to Salette and Huche[24], the absorption of minerals must adjust to the rate of elaboration of new plant tissues, that is to say, the dynamics of absorption and metabolism of nitrogen. and carbon. This general law is conditioned by the availability of soil mineral elements in relation to the biomass produced by nitrogen fertilization[22]

The combination of millet and cowpea has also had a favorable effect on the protein content of fodder. The protein results obtained on the fodder derived from the millet/cowpea combination are higher than those obtained on the forages resulting from the pure culture. This confirms the idea that a legume can improve the nitrogen balance of a grass with which it is associated. This improvement could be the consequence of the improvement of the leaf/stalk ratio of millet because any improvement of this ratio would have a positive impact on the protein value of the fodder. Similar effects have been reported by Togoï [25].

Food values of fodder: The contribution of urea to the plots had a significant influence on the feed values of millet fodder. These results confirm those reported by Obulbiga *and al*.[26]. According to these authors nitrogen fertilization positively influences the content of DNM, Milk Forage Unit and Meat Forage Unit irrespective of the organ of the plant. The improvement in the energy value of the forage resulting from the combination of millet with cowpeas could be due to the improvement of the leaf/stem ratio. In fact, the forages resulting from the combination of millet with cowpea have lower ADF contents than the others, hence their relatively higher energy value[27].

The energy values found in this study are higher than those reported by Ba *and al*.[28] who worked on the same varieties. This difference could be due to the harvest period of the millet stems, transport conditions but also and especially to the nitrogen supply on the plots and the association with the legume.

5. CONCLUSION

This study highlighted the effect of urea intake and the association of millet with a legume such as cowpea on fodder yield, chemical composition and feed value of millet stalks. The results show that the treatments applied have significant effects on the various parameters studied.

Feed biomass was positively influenced by urea intake. SL 169 and SL 28 showed the best forage yields. Nitrogen fertilization also significantly improved the chemical composition of millet stems, including the protein value. It is the same for the association millet/cowpea. The accessions SL 169 and SL 423 showed the best contents in Total Nitrogen Matter.

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