

Elephant grass genotypes for bioenergy production by direct biomass combustion

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Abstract – The objective of this work was to evaluate elephant grass (*Pennisetum purpureum* Schum.) genotypes for bioenergy production by direct biomass combustion. Five elephant grass genotypes grown in two different soil types, both of low fertility, were evaluated. The experiment was carried out at Embrapa Agrobiologia field station in Seropédica, RJ, Brazil. The design was in randomized complete blocks, with split plots and four replicates. The genotypes studied were Cameroon, Bag 02, Gramafante, Roxo and CNPGL F06-3. Evaluations were made for biomass production, total biomass nitrogen, biomass nitrogen from biological fixation, carbon/nitrogen and stem/leaf ratios, and contents of fiber, lignin, cellulose and ash. The dry matter yields ranged from 45 to 67 Mg ha⁻¹. Genotype Roxo had the lowest yield and genotypes Bag 02 and Cameroon had the highest ones. The biomass nitrogen accumulation varied from 240 to 343 kg ha⁻¹. The plant nitrogen from biological fixation was 51% in average. The carbon/nitrogen and stem/leaf ratios and the contents of fiber, lignin, cellulose and ash did not vary among the genotypes. The five genotypes are suitable for energy production through combustion.

Index terms: *Pennisetum purpureum*, ash, agroenergy, biological nitrogen fixation, genotype, lignin.

Genótipos de capim-elefante para produção de bioenergia por combustão direta da biomassa

Resumo – O objetivo deste trabalho foi avaliar genótipos de capim-elefante (*Pennisetum purpureum* Schum.) quanto ao potencial para a produção de bioenergia por combustão direta da biomassa. Avaliaram-se cinco genótipos de capim-elefante, em dois solos com baixa fertilidade. Os experimentos foram conduzidos na estação experimental da Embrapa Agrobiologia, em Seropédica, RJ. O delineamento experimental foi o de blocos ao acaso, em parcelas subdivididas, com quatro repetições. Os genótipos estudados foram Cameroon, Bag 02, Gramafante, Roxo e CNPGL F06-3. Determinaram-se a produção de biomassa, o acúmulo de nitrogênio na biomassa, o nitrogênio da biomassa proveniente da fixação biológica, as relações carbono/nitrogênio e talo/folha, e os teores de fibra, lignina, celulose e cinzas da biomassa. A produção de matéria seca variou de 45 a 67 Mg ha⁻¹. A menor produção foi do genótipo Roxo, e as maiores, dos genótipos Bag 02 e Cameroon. O nitrogênio total acumulado na matéria seca variou de 240 a 343 kg ha⁻¹. Em média, 51% do nitrogênio foram provenientes da fixação biológica. As relações carbono/nitrogênio e talo/folha e os conteúdos de fibra, lignina, celulose e cinzas não variaram entre os genótipos. Os cinco genótipos constituem materiais adequados para produção de energia pela queima.

Termos para indexação: *Pennisetum purpureum*, cinzas, agroenergia, fixação biológica do nitrogênio, genótipo, lignina.

Introduction

In recent decades, the search for alternatives to the use of fossil fuels is increasing globally. High international prices of oil and its derivatives and concerns about the environment motivate this process. Moreover, there is great expectation on the possible

economic benefits from the clean development mechanism projects coming from the use of renewable sources in the agricultural sector, such as bioethanol from sugarcane (Boddey et al., 2008) and eucalyptus timber for coal substitution (Kraxner et al., 2003). There is also a possibility of obtaining energy from plant biomass that could be transformed to charcoal

or even directly burned for heat production (Samson et al., 2005).

Elephant grass (*Pennisetum purpureum* Schum.) is highly efficient in fixing atmospheric CO₂, being capable of accumulating more than 60 Mg ha⁻¹ of dry matter per year, when under optimal conditions for growth, at high fertilization rates, especially with N, and good water availability (Andrade et al., 2005). Botrel et al. (2000) tested several clones of elephant grass, among which Cameroon, CNPGL 91 F27-01 and CNPGL 91 F06-3. These authors found an annual average productivity of 31, 43 and 37 Mg ha⁻¹ of dry matter per year, respectively. Traditionally, this crop has been managed for forage production for dairy cattle due to its high yield and protein content. However, for bioenergy purposes, apart from high dry matter production, the plant material should suit quality parameters for reaching the optimal energetic efficiency, which means high levels of fibre and lignin, and low levels of water, N and ash (Lemus et al., 2002; McKendry, 2002).

For elephant grass growing in poor N soils, the average of dry matter production after two cuts per year were about 30 Mg ha⁻¹, and fibre and lignin contents matched the desirable parameters for energy production from direct burning (Quesada, 2005). Protein content was remarkably reduced in comparison to common levels observed in elephant grass genotypes, destined for forage production. Biomass yield levels were not drastically reduced, in comparison to the ones in fertilised systems (Quesada, 2005). The suitability of the biomass for energy production, along with the possibility of two cuts a year, increases the potential of using this crop for energy production purposes (Samson et al., 2005).

The occurrence of diazotrophic bacteria associated with elephant grass, as reported in previous studies (Baldani et al., 1998; Kirchhof et al., 2001), indicates that biological nitrogen fixation (BNF) might play an important role in N supply to this crop in poor soils.

The objective of this study was to evaluate the production and quality of biomass and the biological nitrogen fixation in elephant grass genotypes, for energy production by direct combustion.

Materials and Methods

This study was performed in the experimental area of Embrapa Agrobiologia, in Seropédica, RJ, Brazil

(22°49'22"S, 43°38'42"W, at an altitude of 43 m). The experiment was composed of two factors in a split plot array. The main plot was the soil type and the subplot consisted of elephant grass genotypes, in randomized complete block design, with four replicates. The soils under evaluation were Argissolo Vermelho-Amarelo (Typic Hapludult – Acrisol) and a Planosolo Háplico (Typic Albaquilt – Planosolo) (Santos et al., 2006), both of low fertility and low plant N availability (Table 1). The following genotypes of elephant grass were evaluated: Cameroon, Bag 02, Gramafante, Roxo and CNPGL F06-3, all of them from the collection of Embrapa Gado de Leite. Plots were composed of 6 lines with 7-m length, with each row 1 m spaced apart, giving a total plot area of 42 m².

At planting, P and K fertilizer were applied in the furrows at a rate of 150 kg ha⁻¹ of K₂O (KCl) and 100 kg ha⁻¹ of P₂O₅ (single superphosphate), and 60 kg ha⁻¹ of FTE BR-12. The doses of P, K and micronutrients were applied based on a mean accumulation of these nutrients in elephant grass plants (Andrade et al., 2005; Moreira et al., 2006). No lime application was required (Table 1). Hence, in theory, N was the only factor limiting plant development in the experiment.

The experiment was set up in October 2005. The first cut was made in June 2006, the second in January 2007 and the third in July 2007. Manual weeding was performed as needed.

At harvesting, plant biomass of a 20 m² central area of each plot was cut at ground level and weighed fresh, without separating stem and leaves. Samples were taken to oven dry at 65°C, until constant weight, for the determination of accumulated dry matter. The proportion of stems and leaves, in each harvested plot, was calculated from ten plants taken at random within each plot, at the time of the cuts. Oven-dried plant samples were ground to 2 mm in a Wiley mill and, then, powdered in a roller mill similar to that of Smith & Myung (1990). The N content and the ¹⁵N natural abundance of each sample were analysed

Table 1. Soil chemical fertility parameters of the two soils.

Soil type	pH (H ₂ O)	Al ³⁺ --(cmol _c dm ⁻³)--	Ca ²⁺	Mg ²⁺	P -(mg kg ⁻¹)-	K ⁺	N ⁽¹⁾ (g kg ⁻¹)
Acrisol	6.0	0	3.0	1.55	5.2	33.7	0.95
Planosol	6.3	0	2.0	0.98	9.0	24.2	0.58

⁽¹⁾Semi-micro-Kjeldahl method.

according to Boddey et al. (2001). Total dry matter and N accumulated by the plants and the proportional BNF contribution were calculated. For the latter, the value of ^{15}N natural abundance of the whole plant (stems plus leaves) was considered (Yoneyama et al., 1997). Non- N_2 -fixing weeds were collected from the plots to serve as control plants for the BNF estimation based on the ^{15}N natural abundance technique (Unkovich et al., 2008). For the first and second biomass cuts the control species considered were *Emilia sonchifolia*, *Tradescantia fluminensis*, and *Arnica montana*, and for the third, *Tradescantia fluminensis*, *Richardia brasiliensis*, and *Arnica montana*. For these species, a composite sample per block for each species was taken, with single plant samples being collected randomly within the plots, along the lines of elephant grass.

The quality analysis of the elephant grass biomass consisted of the determination of fibre content (acid detergent fibre, ADF), cellulose, lignin and ash contents, following the procedure of Van Soest & Wine (1968). The C:N ratio was calculated considering 45% C in plant biomass. The stem/leaf ratio was also calculated considering the dry mass of each part.

The statistical procedures were those of the SAEG 9.1 (Universidade Federal de Viçosa, 2007). Normality and homogeneity of variance of errors were analysed using the Lilliefors and Cochran & Bartley tests, respectively. The required conditions were met in all cases. The analysis of variance was, then, performed with the application of the F test. Differences between means were separated by the use of Tukey's test at 5% probability.

Results and Discussion

A significant interaction between genotype and soil type was observed regarding total dry matter accumulation after the three cuts (Table 2). At the first cut, after 9 months from planting, dry matter accumulation by genotypes Roxo and Cameroon, when grown on the Acrisol, were 20.3 and 29.5 Mg ha^{-1} , respectively, and between 21.1 and 32.0 Mg ha^{-1} , when grown on Planosol. At the second cut, after further 7 months, the greatest dry matter accumulation were observed on the Acrisol, with a significant difference between genotypes Bag 02 and Gramafante, with a production of 18.1 Mg ha^{-1} and 27.9 Mg ha^{-1} , respectively. For the genotypes grown on the Planosol,

there was a significant difference between Roxo and CNPGL F 06-3, with total dry matter production of 18.8 and 22.8 Mg ha^{-1} , respectively. At the last cut, after the further 6 months of growth, the dry matter accumulation ranged from 6.7 to 14.5 Mg ha^{-1} on the Acrisol, with the lowest value observed for genotype Roxo and the largest for genotype Bag 02. On the Planosol, dry matter varied from 5.1 to 10.9 Mg ha^{-1} for the genotypes Cameroon and Roxo, respectively. The high productive potential for biomass production observed with elephant grass in the present study is consistent with those already reported in literature (Queiroz Filho et al., 2000; Magalhães et al., 2006). Still, the positive results hereby shown are of great relevance for the agroenergy sector, as no N fertilizer was applied and the soils studied were N depleted.

The high performance in dry matter accumulation was consequently accompanied by a high N accumulation by plants (Table 3). However, at the first cut, there were no statistical differences among genotypes, regarding N accumulation, when growing on the Acrisol, with values reaching over 100 kg ha^{-1} N. Nevertheless, when growing on the Planosol, differences between the genotypes Gramafante and Cameroon were observed, with values of 92 and 162 kg ha^{-1} of accumulated N, respectively. For the second cut, the genotypes Roxo and Gramafante showed the lowest N accumulation for the two soils, significantly lower than the other genotypes. At the

Table 2. Dry-matter production of elephant grass genotypes, grown in two soils and subjected to three cuts, over a 22-month period⁽¹⁾.

Genotype	1 st cut	2 nd cut	3 rd cut	Total
	-----(Mg ha^{-1})-----			
Acrisol				
CNPGL F06-3	26.6ab	22.1ab	10.7a	59.4b
Gramafante	23.6ab	8.1b	11.7a	53.4bc
Bag 02	24.3ab	27.9a	14.5a	66.6a
Roxo	20.3b	26.1ab	6.7b	53.0bc
Cameroon	29.5a	20.1ab	12.3a	61.9ab
Means	24.9	22.9	11.2	58.9
Planosol				
CNPGL F06-3	28.4ab	22.8a	7.0ab	58.2ab
Gramafante	28.9ab	15.0b	9.3a	53.1b
Bag 02	28.1ab	17.8ab	9.7a	55.6b
Roxo	21.1b	18.8ab	5.1b	45.0c
Cameroon	32.0a	20.1a	10.9a	63.1a
Means	27.7	18.9	8.4	55.0

⁽¹⁾Means followed by the same letters, in the columns, do not differ by Tukey's test at 5% probability.

third cut, there was no statistical significance between genotypes in either soil. Considering the three cuts, on average, 296 and 292 kg ha⁻¹ N were accumulated by the plants in 22 months, when grown in the Acrisol and Planosol, respectively. Cameroon, Bag 02 and CNPGL F06-3 accumulated more N after the three cuts, in both Acrisol and Planosol. Quesada (2005) worked with various genotypes of elephant grass, including those used in the present study, obtained similar results and recorded N accumulations of 270 kg ha⁻¹ N, in 15 months, without N fertilization.

These results are very promising, especially the high dry matter yield produced without the application of N fertilizer, which can represent more than 20% of all energy expenditure in biomass production of elephant grass, for direct burning purposes (Samson et al., 2005).

Table 3. Nitrogen accumulation of elephant grass genotypes, grown in two soils and subjected to three cuts, over a 22-month period⁽¹⁾.

Genotype	1 st cut	2 nd cut	3 rd cut	Total
	----- (kg ha ⁻¹) -----			
Acrisol				
CNPGL F06-3	105a	129a	68a	302ab
Gramafante	69a	82b	81a	232b
Bag02	98a	141a	96a	335a
Roxo	95a	125a	50a	270b
Cameroon	106a	134a	102a	343a
Means	95	122	79	296
Planosol				
CNPGL F06-3	116ab	135a	45a	296ab
Gramafante	92b	94b	55a	241b
Bag02	117ab	121a	77a	316a
Roxo	117ab	84b	39a	240b
Cameroon	162a	139a	41a	342a
Means	121	115	51	287

⁽¹⁾Means followed by the same letters, in the columns, do not differ by Tukey's test at 5% probability.

The high N accumulation indicates that BNF must be a key process for elephant grass cropping systems. The ¹⁵N abundance ($\delta^{15}\text{N}$) found in the elephant grass genotypes were lower than in non-N₂ fixing weeds, in all cases (Table 4), which confirms that the supply of N from BNF was appreciable. No significant differences between the ¹⁵N natural abundance of the different weed reference species were recorded. Thus, an average of the $\delta^{15}\text{N}$ values from the three control species sampled was considered to estimate the BNF to the elephant grass genotypes. The averaged $\delta^{15}\text{N}$ values of the reference species for the Acrisol were 6.53, 6.99 and 7.43 deltas for the 1st, 2nd and 3rd cuts, respectively. For the Planosol, the $\delta^{15}\text{N}$ values were 7.89, 7.85 and 6.25 for the three cuts, respectively.

For the three cuts, there were statistically significant differences in BNF contributions for the plants. On the Acrisol, at the first cut, Roxo genotype presented 21% of its total N derived from BNF, the lowest contribution when compared to the others (Table 5). On Planosol, the reliance on BNF by Roxo was 30%, again the lowest observed values, but only statistically different from CNPGL F06-3, which was of 52%. For the second cut, the results changed slightly on the Acrisol, where Roxo presented an increased BNF reliance (43%), compared to Bag 02 (29%), but not different from Cameroon (43%). However, on Planosol, which is usually more N deficient due to its sandy texture, genotype Roxo figured again among the genotypes with the lowest BNF reliance (35%), being significantly different from genotype Cameroon (47%). In the last cut, this same trend was observed for the two soils, with the lowest BNF reliance registered for genotype Roxo and the highest for genotype Cameroon.

Table 4. Nitrogen-15 natural abundance (%) of elephant grass genotypes and four weed species (non-N₂-fixing reference).

Genotype and reference plant species	Acrisol			Planosol		
	1 st cut	2 nd cut	3 rd cut	1 st cut	2 nd cut	3 rd cut
CNPGL F06-3	4.45b	4.09b	4.91b	3.81b	4.51b	4.02b
Gramafante	4.51b	4.19b	5.15b	4.83b	4.46b	3.78b
Bag 02	4.25b	4.93b	4.95b	5.06b	4.57b	3.82b
Roxo	5.14b	3.98b	5.69b	5.52b	5.02b	4.87b
Cameroon	4.55b	3.98b	4.61b	4.91b	4.08b	3.49b
<i>Emilia sonchifolia</i>	6.55a	7.06a	-	7.71a	7.71a	6.18a
<i>Tradescantia fluminensis</i>	6.71a	7.12a	6.88a	7.96a	7.96a	6.51a
<i>Arnica montana</i>	6.32a	6.80a	8.18a	7.89a	7.89a	6.06a
<i>Richardia brasiliensis</i>	-	-	7.23a	-	-	-

⁽¹⁾Means followed by the same letters, in the columns, do not differ by Tukey's test at 5% probability.

Considering the results of all the three cuts, genotype Roxo stood out as the one that was least benefited from BNF, and genotype Cameroon as the most. Bag 02 and CNPGL F06-3 genotypes were intermediate. The largest contributions of BNF were observed in the Acrisol. These results agree with Quesada (2005) and Samson et al. (2005), who found BNF contributions of 58, 70 and 68% for the genotypes Cameroon, Bag 02, and Gramafante, respectively. They concluded that BNF presented the lower potential in Roxo genotype. There are few field studies showing that BNF can contribute to the N nutrition of elephant grass. However, the presence of N₂ fixing bacteria of the genus *Herbaspirillum* inside this grass, detected by Kirchof et al. (2001), reinforces the possibility that BNF is an important process to the survival and productivity of this species. The importance of BNF to other grass species was already shown, with contributions of BNF of 30 to 40% registered for *Brachiaria* (Boddey & Victoria, 1986) and ecotypes of *Panicum maximum* (Miranda & Boddey, 1987), respectively. In sugarcane, Urquiaga et al. (1992) found BNF could contribute up to 70% of the plant N needs, but the expected contribution of this process for sugarcane growing in farmer fields are of the order of 30%, ranging from 0 to 60% (Boddey et al., 2001). The importance of this natural process must be highlighted as each 100 kg ha⁻¹ of N fertilizer that is substituted by BNF means a mitigation of about 450 kg ha⁻¹ CO₂, considering the phases of processing, transportation and fertiliser application (Robertson & Grace, 2004).

Significant interaction between elephant grass genotypes and soil types was also observed for the qualitative parameters C:N and stem:leaf ratios, and fibre, cellulose, lignin and ash contents (Table 6). All genotypes studied showed a high C:N ratio (above 70), especially the genotype Gramafante, which presented a C:N ratio 37% above average, which could be explained by its high stem:leaf ratio and low N tissue content. In both soils, the C:N ratio of genotype Gramafante (118 to 121) was significantly higher than in the other genotypes, except for genotype CNPGL F06-3. The stem:leaf ratio was not statistically different among genotypes, when plants were grown on the Acrisol, and the observed values ranged from 2.5, for genotype Gramafante, to 1.6, for genotype Roxo. Again, in the Planosol, the genotype Roxo presented the lowest stem:leaf ratio, on average 45% lower than that of the other genotypes. According to Ferrari Júnior & Lavezzo (2001) and Queiroz Filho (1998, 2000), the shorter the time between cuts, the greater is the proportion of leaves in the produced biomass. In the case of animal feeding forage, silage or grazing, the recommendation is the short-time cutting intervals (1 to 2 months), which also end up with a plant material with increased protein levels (Andrade et al., 2005; Fagundes et al., 2007). For energy purposes, however, the strategy should be the opposite, as fibrous and low protein plant materials promote the most efficient heat production.

Few studies have reported the biomass quality of elephant grass for energy purposes. Quesada (2005)

Table 5. Nitrogen-15 natural abundance and the estimates of the proportional contribution of the biological nitrogen fixation (BNF) to the nutrition of elephant grass genotypes grown in two soils and subjected to three cuts, over a 22-month period⁽¹⁾.

Genotype	1 st cut		2 nd cut		3 rd cut	
	δ ¹⁵ N	BNF (%)	δ ¹⁵ N	BNF (%)	δ ¹⁵ N	BNF (%)
	Acrisol					
PGL F06-3	4.45a	32a	4.09a	42ab	4.91a	34ab
Gramafante	4.51a	31a	4.19a	40ab	5.15a	31ab
Bag 02	4.25a	35a	4.93a	29b	4.95a	33ab
Roxo	5.14a	21b	3.98a	43a	5.69a	23b
Cameroon	4.55a	30a	3.98a	43a	4.61a	38a
Means	4.58	29.8	4.23	39.4	5.06	31.8
	Planosol					
PGL F06-3	3.81a	52a	4.51a	42ab	4.02a	36ab
Gramafante	4.83a	38ab	4.46a	42ab	3.78a	39ab
Bag 02	5.06a	36ab	4.57a	41ab	3.82a	39ab
Roxo	5.52a	30b	5.02a	35b	4.87a	22b
Cameroon	4.91a	37ab	4.08a	47a	3.49a	44a
Means	4.83	38.6	4.53	41.4	4.00	36.0

⁽¹⁾Means followed by the same letters, in the columns, do not differ by Tukey's test at 5% probability.

Table 6. Carbon:nitrogen (C:N) ratio, stem:leaf ratio, concentrations of acid detergent fibre (ADF), cellulose, lignin, and ash contents of elephant grass genotypes grown in two soils and subjected to three cuts, over a 22-month period⁽¹⁾.

Genotype	C:N	Stem:leaf	ADF (%)	Cellulose (%)	Lignin (%)	Ash (%)
Acrisol						
CNPGL F 06-3	98ab	2.0a	43.6a	28.4a	12.0ab	1.9ab
Gramafante	118a	2.5a	42.8a	27.3a	11.8ab	2.4ab
Bag 02	90b	1.9a	51.4a	33.9a	13.5a	2.2b
Roxo	87b	1.6a	37.7a	22.9a	12.6ab	2.2ab
Cameroon	84b	1.8a	42.8a	28.7a	9.7b	3.0a
Means	95	2.0	43.7	28.2	11.9	3.0
Planosol						
CNPGL F 06-3	107b	2.2a	40.3a	27.4ab	12.5a	3.0ab
Gramafante	121a	2.8a	41.9a	28.0ab	13.7a	2.8ab
Bag 02	82c	2.3a	41.0a	29.6a	12.6a	2.5b
Roxo	75c	1.1b	41.4a	26.1ab	12.6a	2.5ab
Cameroon	73c	2.1a	41.6a	26.8b	13.3a	3.3a
Means	93.3	2.0	42.4	27.9	12.4	2.6

⁽¹⁾Means followed by the same letters, in the columns, do not differ by Tukey's test at 5% probability.

found C:N ratio of about 95, when genotypes were grown on a Planosol, in the rainy season, and 55, when grown during the dry season.

The contents of acid detergent fibre (ADF) were not influenced by soil type, and all genotypes showed levels above 40% (Table 6). In studies with elephant grass grown for fodder purposes, the fibre content of the whole plant increases and protein content decreases, the longer the plant remains in the field (Andrade et al., 2005). The levels of fibre in the present study were similar to those reported by Savioli et al. (2000) and Campos et al. (2002), which recorded values close to 42%, and by Queiroz Filho et al. (2000), which reported values up to 48%, for plants growing for 100 days in the field. When grown on the Acrisol, all genotypes showed similar lignin content, except for genotype Cameroon, which was significantly lower (9.7%) in this parameter than the genotype Bag 02 (13.5%). When grown on the Planosol, no statistical difference was detected. According to McKendry et al. (2002), the levels of lignin and fibre observed in the genotypes used in the present study are considered satisfactory for energy production by direct combustion.

There was no statistically difference for cellulose contents in genotypes grown on the Acrisol, with values ranging from 22.9% (genotype Roxo) to 33% (genotype Bag 02). A small difference was detected on plants grown on the Planosol, with genotype Cameroon presenting the highest content (26.2%) and genotype BAG 02 (29.6%) the lowest. The contents of ash were more variable among genotypes, ranging from 1.9 to 3% when grown on Acrisol, the lowest value observed

in the genotype CNPGL F06-3 and the largest in genotype Cameroon. On Planosol, ash contents varied from 2%, for genotype Roxo, to 3.3%, measured in genotype Cameroon.

Although significant differences were observed among treatments, the levels of fibre, lignin, cellulose and ash were still adequate for heat production, since the maximum ash level considered critical for the calorific value of the biomass is 5% (McKendry, 2002; Kauter et al., 2003), high above the results found in the present work.

The results obtained so far, along with the work of Quesada (2001, 2005), indicate that this species has good adaptability to soils with low fertility, which is partially sustained by the significant contribution of BNF observed. Even though the BNF process could result in an apparent elephant grass independence of N fertilizer, more than 50% of the N required by the plant growth came from the soil. Thereby, the high CO₂ mitigation potential of elephant grass production systems, shown in the present study, is only sustainable, in the long term, if some other nitrogen source is introduced.

Conclusions

1. The genotypes Cameroon, CNPGL F 06-3 and Bag 02 are the most promising for bioenergy production purposes.

2. The genotypes present lignin, cellulose and ash contents suitable for use in direct burning.

3. The reliance in biological nitrogen fixation of *Pennisetum purpureum* varies with soil and genotypes, and can reach up to 50% of this species N needs.

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