DRY MATTER YIELD AND BROMATOLOGICAL CHARACTERISTICS OF ELEPHANT-GRASS

ABSTRACT

In the elephant-grass germplasm, there are genotypes that show a large genetic variability differentiated by morphological, reproductive, agronomic and biochemical characteristics. As such, there is a selection of new and more adapted elephant-grass genotypes, with greater productivity and nutritional quality, which can cause an increase in the forage offer, especially during the dry season. Thus, this work aimed at evaluating, throughout two years, the productive performance and nutritional value of 53 elephant-grass genotypes to produce forage in the edaphoclimatic conditions in Campos dos Goytacazes city, Rio de Janeiro state, Brazil. The experiment was composed of 53 elephant-grass accessions from *the Banco de Germoplasma da Embrapa Gado de Leite* (Germplasm Bank of Embrapa Gado de Leite), located in Coronel Pacheco city, Minas Gerais state, Brazil. It was applied the randomized block experimental design with two replications. Cuttings were performed every two months, throughout two years, totaling ten cuttings. The morpho-agronomic and bromatological characteristics were assessed, and the statistical analyses were carried out applying the Computational Applicative in Genetic and Statistics, Genes. Results indicated that there is a wide genetic variability among the elephant-grass genotypes concerning the characteristics under study. The Guaçu IZ-2, Gramafante Mineiro, Mole de Volta Grande, Pasto Panamá, and Taiwan A-25 genotypes were superior in all characteristics evaluated simultaneously and indicated to be the most productive and of the best nutritional quality. Therefore, they were the most suitable for forage production in the edaphoclimatic conditions in Campos dos Goytacazes city.

Keywords: *Pennisetum purpureum* Schum., crude protein, forage crop, vegetable genetic resources.

INTRODUCTION

The efficient use of forage and pasture as a staple food for animals represents one of the most secure ways to increase productivity, reducing production costs, given that animal feed represents the highest cost for livestock activity, mainly when applying additional sources of high nutritional quality. In this regard, the utilization of alternative foods at a lower cost that promote good results in animals is needed to improve the cost-benefit relation (Oliveira et al., 2010).

The elephant-grass (*Pennisetum purpureum* Shum.) is recognized as one of the most used forage grasses in Brazil, since it is well adapted as ration for animal feed in the form of cutting, grazing, silage and hay (Vale & Azevedo, 2013). It is a forage with a high potential of dry matter yield per area cultivated and is also an excellent low-cost alternative to high supplementation, with positive effects on the pasture stocking rates (Pereira et al., 2010).

Besides the high productive potential, the elephant-grass has a good nutritional value being its annual production of dry biomass higher than 50 t ha^{-1} in the Southeast Region of Brazil, provided that efficient genotypes are used according to the edaphoclimatic conditions favorable to the growth of the culture (Morais et al., 2009). That has increased the interest in this grass over the past years, owing to the

42 possibility of increasing productivity and reducing the area explored with its use for direct grazing in rotational
43 systems (Mota et al., 2010).
44   There are genotypes with a great genetic variability in the elephant-grass germplasm differentiated
45 by morphological, reproductive, agronomic and biochemical characteristics (Lima et al., 2011). Hence, the
46 selection of new elephant-grass genotypes with higher productivity, nutritional quality, and more adapted to
47 the edaphoclimatic conditions can cause an increase in the forage offer, especially during the dry season.
48 Consequently, that minimizes the effects of seasonality on production.
49   Given that, this work aims at evaluating the productive performance and the nutritional value of 53
50 elephant-grass genotypes in edaphoclimatic conditions in Campos dos Goytacazes city, Rio de Janeiro
51 state, Brazil over two years for forage production.

52
53 **MATERIAL AND METHODS**
54   The experiment was conducted at the *Centro Estadual de Pesquisa em Agroenergia e*
55 *Aproveitamento de Resíduos* (Agroenergy and Waste Management State Research Center) of
56 PESAGRO in Campos dos Goytacazes city. It was lying between 21° 19' 23'' south latitude and 41° 19'
57 40'' west longitude, and altitude varying between 20 and 30 m in the municipality.
58   The soil is classified as Yellow Latosol with the following characteristics: pH 5.5; phosphorus (mg
59 dm^{-3}) 18; potassium (mg dm^{-3}) 83; Ca (cmolc dm^{-3}) 4.6; Mg (cmolc dm^{-3}) 3.0; Al (cmolc dm^{-3}) 0.1; H + Al
60 (cmolc dm^{-3}) 4.5 and; C (%) 1.6.
61   The experiment was composed of 53 elephant-grass accessions from the *Banco de*
62 *Germoplasma da Embrapa Gado de Le*ite (Bank of Germplasm of Embrapa Milk Cattle), in Coronel
63 Pacheco, Minas Gerais state (Table 1).

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65

66 **Table 1. Identification of the elephant-grass accessions from the *Banco de Germoplasma de Capim-***
67 ***Elefante* (BAG-CE) of *Embrapa Gado de Leite* released in Campos dos Goytacazes city, Rio de**
68 **Janeiro state, Brazil.**

Genotype	Origin
Elefante de Colômbia	Colômbi
Mercker	IPEACO – Água Limpa – MG
Três Rios	Nova Odessa – SP
Napier Volta Grande	UFRRJ – Km 47
Mercker Santa Rita	UFRRJ – Km 47
Pusa Napier nº 2	Índia
Gigante de Pinda	Pindamonhangaba –SP
Napier Goiano	Goiás

Mercker S.E.A.	UFRRJ – Km 47
Taiwan A-148	UFRRJ – Km 47
Porto Rico 534-B	UFV – Viçosa – MG
Taiwan A-25	UFRRJ – Km 47
Albano	Colômbia
Híbrido Gigante da Colômbia	Colômbia
Pusa Gigante Napier	Índia
Elefante Híbrido 534-A	UFV – Viçosa – MG
Costa Rica	Turrialba
Cubano Pinda	UFRRJ – Km 47
Merckeron Pinda	UFRRJ – Km 47
Merckeron Pinda México	UFRRJ – Km 47
Mercker 86 – México	Colômbia
Taiwan A-144	UFRRJ – Km 47
Napier S.E.A.	UFRRJ – Km 47
Taiwan A-143	UFRRJ – Km 47
Pusa Napier nº 1	UFRRJ – Km 47
Elefante de Pinda	Colômbia
Mineiro	UFV – Viçosa – MG
Mole de Volta Grande	Volta Grande – SP
Porto Rico	CAMIG
Napier	Pedro Leopoldo – MG
Merckeron Comum	Pindamonhangada – SP
Teresópolis	UFRRJ – Km 47
Taiwan A-26	UFRRJ – Km 47
Duro de Volta Grande	UFRRJ – Km 47
Merckeron Comum Pinda	UFRRJ – Km 47
Turrialba	UFRRJ – Km 47
Taiwan A-146	UFRRJ – Km 47
Cameron – Piracicaba	UFRRJ – Km 47
Taiwan A-121	UFRRJ – Km 47

Vrukwona	Piracicaba – SP
P-241-Piracicaba nº 9	CNPGL
IAC – Campinas	UFRRJ – Km 47
Elef. Cachoeiro de Itapemirim	UFRRJ – Km 47
Capim-Cana D'África	EMCAPA – ES
Gramafante	-
Roxo	ESAL – Lavras – MG
Guaçu/IZ.2	Nova Odessa – SP
Acesso 62 – EMBRAPA	Embrapa Gado de Leite
Acesso 64 – EMBRAPA	Embrapa Gado de Leite
Acesso 67 – EMBRAPA	Embrapa Gado de Leite
Acesso 68 – EMBRAPA	Embrapa Gado de Leite
Acesso 77 – EMBRAPA	Embrapa Gado de Leite
Acesso 91 – EMBRAPA	Embrapa Gado de Leite

It was applied the randomized block experimental design with two replications. Planting was made in April 2008 after preparing the soil by plowing, harrowing, and opening 50-cm row spacing, through whole plants arranged with the base touching the apex of the next plant in furrows with 10-cm depth. Subsequently to opening of the furrows, 100 kg of P_2O_5 were incorporated to the bottom of the furrow. After 50-days planting, fertilization was complemented with top dressing application of 25 kg/ha of N. After each cutting, top dressing with 60 kg/ha of K_2O and 50 kg/ha of N was applied.

A standardization cutting was made in October 2008, and a first evaluation cutting, in December 2008. The other cuttings were made in February, April, July, October, and December 2009, also in February, April, July, and October 2010, which totalized ten cuttings, one cutting every two months throughout two years.

The following morpho-agronomic and bromatological characteristics were evaluated:

➢ **Morpho-agronomic:**

- Dry Matter Yield (DMY) – estimated by the product of the green matter weight of the whole plants (kg), weighed in suspended scale, from two square meters (2 m^2), by the

percentage of dry matter of the whole plant (% WDM) from the sampling of those plants. The final value (kg/m^2) is converted to t ha^{-1}.

➢ **Bromatological**

- Percentage of Crude Protein (%CP) – The determination of the crude protein was performed by

92   the Micro-Kjeldhal method, according to Silva & Queiroz (2002).

93   • Percentage of Neutral Detergent Fiber (%NDF) – the fiber contents in neutral detergent (%NDF)
94   were estimated in accordance with the methodology described by Silva & Queiroz (2002).

95   The analysis of variance was performed based on the mean of the plots considering the ten
96 cuttings for the DMY trait. For the %CP and %NDF, the analysis was performed on the basis of the mean
97 of two evaluations: one during water period and the other, in the dry period. All the effects were
98 considered random for the analysis of variance. The following statistical model was applied:

100     $Y_{ij} = \mu + G_i + B_i + \varepsilon_{ij}$, wherein

101 Y_{ij} = value of the i-th genotype in the j-th block;

102 μ = overall mean;

103 G_i = effect of the i-th genotype; B_i

104 = effect of the j-th block; and

105 ε_{ij} = experimental error.

106   Subsequently, the genotype means were grouped for each variable applying the Scott & Knott
107 test (1974) at 5% probability. Those statistical analyses were carried out using the Computational
108 Application in Genetic and Statistics, Genes (Cruz, 2013).

110 **RESULTS AND DISCUSSION**

112   The values of the mean squares of the analysis of variance and of the experimental coefficient of
113 variation for the morpho-agronomic (Dry Matter Yield) and bromatological (Percentage of Crude Protein
114 and Percentage of Neutral Detergent Fiber) characteristics are displayed in Table 2.

116 **Table 2. Summary of the analysis of variance of morpho-agronomic and bromatological**

117 **characteristics evaluated in 53 elephant-grass genotypes. Campos dos Goytacazes, Rio de**

118 **Janeiro state. 2008-2010.**

FV		Mean Squares		
	DF	DMY	%CP	%NDF
Block	1	3.6460	0,4972	71,8660
Treatment	52	1.6698 *	0,2946*	5,3084**
Waste	52	0,9743	0,1807	2,3692
Overall		6,55	5,40	69,69
CV(%)		15,07	7,88	2,21

119 ** and * significant at 1 and 5% probability, respectively, by the F test

120 Dry Matter Yield (DMY), Percentage of Crude Protein (%CP) and Percentage of Neutral Detergent Fiber (%NDF).

122   Results showed that there were significant differences for the dry matter yield (DMY) in t ha^{-1}
123 cutting^{-1} (average of ten cuttings) and percentage of crude protein (%CP) by the F test at 5% probability.
124 Nevertheless, for the percentage of neutral detergent fiber (%NDF) trait, it was significant at 1%
125 probability (average of two cuttings).
126   Among the elephant-grass accessions evaluated, the significant differences seen concerning
127 DMY, %CP, and %NDF prove the variability among the 53 genotypes evaluated, which enables to select
128 the best genotypes (Pereira et al., 2008; Oliveira et al., 2014).
129   The coefficients of variation of the traits evaluated are between 2.21 and 15,7%, which appears
130 to be suitable for the experimental evaluation. The variable dry matter yield (DMY) was the one that
131 presented the highest value for the coefficient of variation (CV). The percentage of crude protein (%CP)
132 and the percentage of neutral detergent fiber (%NDF) traits presented CV of 7.88 and 2.21%,
133 respectively; that was considered a low value. (Pimentel Gomes, 2009). In this way, the coefficients of
134 variations for the bromatological characteristics proved to be low, while, for the dry matter yield (DMY), it
135 was considered as medium.
136   The mean values of the dry matter yield (DMY), the percentage of crude protein (%CP), and the
137 percentage of neutral detergent fiber (%NDF) per genotype and the Skott-Knott cluster at 5% probability
138 are shown in Table 3.

139
140 **Table 3. Means referring to morpho-agronomic and bromatological characteristics evaluated in 53**

141 **elephant-grass genotypes.**

Genotypes	DMY	%CP	%NDF
Elefante de Colômbia	6.869 b	5.54 b	68.78 b
Mercker	5.047 b	5.77 a	68.68 b
Três Rios	4.704 b	5.94 a	66.92 b
Napier Volta Grande	6.489 b	5.74 a	72.19 a
Mercker Santa Rita	6.210 b	4.96 b	70.79 a
Pusa Napier nº 2	6.839 b	5.50 b	72.47 a
Gigante de Pinda	7.038 b	5.25 b	70.63 b
Napier Goiano	5.922 b	5.57 b	70.65 a
Mercker S.E.A.	5.451 b	5.29 b	67.56 b
Taiwan A-148	4.926 b	5.57 b	67.03 b
Porto Rico 534-B	6.632 b	5.26 b	69.10 b
Taiwan A-25	7.089 b	5.64 a	68.05 b
Albano	6.293 b	5.22 b	69.41 b
Híbrido Gigante da Colômbia	5.747 b	5.70 a	70.39 b

Pusa Gigante Napier	5.687 b	4.66 b	71.23 a
Elefante Híbrido 534-A	7.137 b	5.32 b	68.92 b
Costa Rica	7.366 a	5.25 b	70.20 b
Cubano Pinda	6.379 b	5.60 a	65.96 b
Merckeron Pinda	6.518 b	5.70 a	70.17 b
Merckeron Pinda México	5.689 b	5.37 b	65.22 b
Mercker 86 – México	5.128 b	4.96 b	69.43 b
Taiwan A-144	8.883 a	5.64 a	71.35 a
Napier S.E.A.	7.278 a	6.18 a	72.25 a
Taiwan A-143	6.808 b	4.76 b	68.67 b
Pusa Napier nº 1	6.424 b	5.69 b	69.22 b
Elefante de Pinda	5.678 b	4.87 b	69.23 b
Mineiro	7.364 a	5.90 a	69.53 b
Mole de Volta Grande	7.513 a	5.44 b	69.60 b
Porto Rico	8.718 a	4.59 b	67.40 b
Napier	6.557 b	6.22 a	69.40 b
Merckeron Comum	7.517 a	5.30 b	71.17 a
Teresópolis	5.908 b	4.96 b	70.91 a
Taiwan A-26	7.143 b	5.37 b	70.06 b
Duro de Volta Grande	6.013 b	4.66 b	69.55 b
Merckeron Comum Pinda	7.213 a	5.35 b	71.48 a
Turrialba	6.404 b	5.45 b	68.59 b
Taiwan A-146	6.714 b	5.25 b	68.13 b
Cameron – Piracicaba	6.722 b	5.59 b	70.12 b
Taiwan A-121	6.795 b	4.99 b	69.46 b
Vrukwona	6.442 b	5.42 b	71.89 a
P-241-Piracicaba nº 9	6.153 b	5.40 b	69.50 b
IAC – Campinas	5.988 b	5.15 b	71.86 a
Elef. Cachoeiro de Itapemirim	6.430 b	5.26 b	69.88 b
Capim-Cana D'África	6.048 b	5.19 b	70.23 b

Gramafante	7.485 a	5.43 b	70.13 b
Roxo	5.059 b	5.90 a	67.07 b
Guaçu/IZ.2	7.411 a	5.60 a	69.85 b
Acesso 62 – EMBRAPA	6.679 b	5.36 b	73.05 a
Acesso 64 – EMBRAPA	5.409 b	4.72 b	68.94 b
Acesso 67 – EMBRAPA	7.721 a	5.65 a	71.19 a
Acesso 68 –Gado de Leite	6.498 b	6.15 a	70.18 b
Acesso 77 – EMBRAPA	6.377 b	5.14 b	69.70 b
Acesso 91 – EMBRAPA	8.652 a	5.76 a	70.37 b

142   Dry Matter Yield (DMY) in t/ha, and Percentage of Crude Protein (%CP) and Percentage of Neutral Detergent Fiber (%NDF) in %.

143

144   Regarding the dry matter yield (DMY), the genotype means ranged from 4.704 to 8.883 t ha^{-1}, and
145   the mean was of 5.399 t ha^{-1}; the genotypes that most stood out were Costa Rica; Guaçu/IZ.2; Elefante
146   Híbrido 534-A; Gramafante; Mercker Comum; Mercker Comum Pinda; Mineiro; Mole de Volta Grande;
147   Napier S,E,A.; Pasto Panamá; Porto Rico; Taiwan A -144; Taiwan A-26; Taiwan A-26; and Vruckwona
148   Africano.
149   When assessing production and biomass quality characteristics of six elephant-grass genotypes
150   under five different production ages, Vidal et al. (2017) obtained dry matter yield ranging from 5.26 to 7.27
151   t ha^{-1} in eight-week age.
152   On the other hand, Leão et al. (2012) obtained as genotype mean 4.86 t ha^{-1} when evaluating the
153   forage production of inter-specific hybrids of elephant-grass and millet; however, the genotype that most
154   stood out produced 9.76 t ha^{-1}; thus, it was higher than the one found in this work.
155   With regard to the percentage of crude protein, the age in the harvest is the most important factor
156   that affects the crude protein content of the elephant-grass, because, as the ages of the plants increase,
157   the dry matter yield increases, but the crude protein decreases (Rusdy, 2016).
158   In this work, the crude protein contents ranged from 4.59 to 6.22%. The latter were lower than
159   the ones found by Silva et al. (2008), who obtained 7.20% of crude protein when evaluating the
160   percentage of crude protein of the elephant-grass in the 61-day age.
161   For the percentage of neutral detergent fiber (%NDF), percentages ranging from 68.78 to 73.05%
162   were found, and the overall mean was of 69.69%. Similar results were encountered by Garcia et al.
163   (2012). Lounglawan et al. (2013), when evaluating the percentage of neutral detergent fiber in 60-day
164   plants, discovered values between 73.71 and 76.49%; therefore they were higher than the ones found in
165   this paper.
166   The genotypes that showed the highest values of %NDF were Napier Goiano; Mercker Santa
167   Rita; Teresópolis; Mercker Comum; Acesso 67 – EMBRAPA Gado de Leite; Pusa Gigante Napier;
168   Taiwan A -144; Mercker Comum Pinda; Vrukwona; Napier Volta Grande; Napier S,E,A.; Pusa Napier n°2;
169   and Roxo. According to Van Soest (1994), the analysis of NDF is inversely related to the dry matter
170   digestibility. Thus, it can be noticed that, for this trait, the best performance was of the genotypes that

171   presented the lowest content percentages (Leão et al., 2012).

172
173   **CONCLUSIONS**

174   There is a large genetic variability among the elephant-grass genotypes on the characteristics

175   under study.

176   The Guaçu IZ-2; Gramafante Mineiro; Mole de Volta Grande; Pasto Panamá; and Taiwan A-25

177   genotypes were those that showed to be superior to all traits evaluated simultaneously. They proved to be

178   the most productive and with higher nutritional quality. Therefore, they are the most indicated to produce

179   forage in the edaphoclimatic conditions of Campos dos Goytacazes city, Rio de Janeiro state.

180

181   **REFERENCES**

182
183   Cruz, C.D. GENES - A software package for analysis in experimental statistics and quantitative
184   genetics. **Acta Scientiarum Agronomy**, v.35, p.271-276, 2013..

185
186   Garcia, C de S, Fernandes, A. M., Fontes, C. A. A.C, Vieira, R. A. M., Pimentel, V. A. P.
187   Desempenho de novilhos mantidos em pastagens de capim-elefante e capim-mombaça. **R. Bras.**
188   **Zootec**., v.40, n.2, p.403-410, 2012.

189
190   Leão, F. F., Cancellier, L. L., Pereira, A. V., Ledo, F. J. S., Afférr, F. S. Produção forrageira e
191   composição bromatológica de combinaçõesgenômicas de capim-elefante. **Revista Ciência**
192   **Agronômica,** v. 43, n. 2, p. 368-375, abr-jun, 2012.

193
194   Lima, R. S., Daher, R. F., Goncalves, L. S., Rossi, D. A., do Amaral Júnior, A. T., Pereira,
195   M. G., e Lédo, F. J. S. RAPD and ISSR markers in the evaluation of genetic divergence among
196   accessions of elephant grass. **Genetics Molecular Research**, *10*:1304- 1313, 2011.

197
198   Lounglawan P, Longlawan W and Sulesombat. Effect of cutting interval and cutting height on
199   yield and chemical composition of King Napier grass (*Penisetum purpureum* x *Pennisetum americanum*).
200   **APCBEE Procedia**, 8 : 27 – 31, 2013.

201
202   Morais, R. F.; Souza, B. J.; Leite, J. M.; Soares, L. H. B.; Alves, B. J. R.; Boddey, R. M.;
203   Urquiaga, S. Elephant grass genotypes for bioenergy production by direct biomass combustion.
204   **Pesquisa Agropecuária Brasileira***, 44(2):133-140, 2009.

205
206   Mota, V. J. G.; Reis, S. T.; Sales, E. C. J.; Rocha Júnior, V. R.; Oliveira, F. G.; Walker, S.
207   F.; Martins, C. E.; Cóser, A. C. Lâminas de irrigação e doses de nitrogênio em pastagem de
208   Capim-elefante no período seco do ano no norte de Minas Gerais. **Revista Brasileira de**
209   **Zootecnia**, Viçosa, v. 39, n. 6, p. 1191-1199, 2010.

210
211   Oliveira, J. B. Pires, A. J. V., Carvalho, G. G. P., Ribeiro, L. S. O., Cruz, J. F., Silva, F. F.
212   Subprodutos industriais na ensilagem de capim-elefante para cabras leiteiras: consumo,
213   digestibilidade de nutrientes e produção de leite. **Revista Brasileira de Zootecnia**, Viçosa, v. 39,
214   n. 2, p. 411-418, 2010.

215
216   Oliveira, M. L. F., Daher, R.F., Gravina, G. A., Silva, V. B., Viana, A. P., Rodrigues, E. V.,
217   Shimoya, A., Amaral Junior, A. T., Menezes, B. R. S., Rocha,S. Pre-breeding of elephant grass for
218   energy purposes and biomass analysis in Campos dos Goytacazes- RJ, Brazil.. **African Journal of**
219   **Agricultural Research**. , v.9, p.2743 - 2758, 2014.

220
221   Pereira, A. V.; Auad, A. M.; Ledo, F. J. S.; Barbosa, S. Pennisetum purpureum. In:
222   Fonseca, D. M. Da; Martuscello, J. A. (Org.). Plantas Forrageiras. Viçosa: Editora UFV, 2010. v. 1,
223   p. 197-219

224
225   Pereira, A. V.; Machado, M. A.; Azevedo, A. L. S.; Nascimento, S.; Campos, A. L.; Lédo, F. J. S.

Diversidade genética entre acessos de capim-elefante obtida com marcadores moleculares. **Revista Brasileira de Zootecnia**, v.37, p.1216-1221, 2008.

Pimentel-Gomes, F. **Curso de estatística experimental.** 15ª ed. Piracicaba: FEALQ, 451p, 2009.

Rusdy M: Elephant grass as forage for ruminant animals. Livestock Research for Rural Development. Volume 28, Article #49. **Retrieved** December 2, 2016.

Scott, A. J. A. & Knott, M. Cluster analysis method for grouping means in the analysis of variance. **Biometrics**, 30:507-512, 1974.

Silva, D.S. & Queiroz, A.C. **Análise de Alimentos: métodos químicos e biológicos**. 3ª Edição Viçosa. Editora UFV, 2002. p. 57-75

Silva, M. A.; Lira, M. A.; Santos, M. V. F.; Dubeux Junior, J. C. B.; Cunha, M. V.; Freitas, E. V. Análise de trilha em caracteres produtivos de Pennisetum sob corte em Itambé, Pernambuco. **Revista Brasileira de Zootecnia**, 37(7):1185-1191, 2008.

Vale, M. B.; Azevedo, P. V. Avaliação da produtividade e qualidade do capim elefante e do sorgo irrigados com água do lençol freático e do rejeito do dessalinizador. Holos, v. 29, p.181-195, 2013.

Van Soest, P. J. Nutritional ecology of the ruminant. **Cowallis**: O. & Books. 476p, 1994. Vidal, A.

K. F., Barbé, T. C., Daher, R. F., Filho, J. E. A., De Lima, R. S. N., Freitas, R. S., Rossi, D. A., Oliveira, É. S., Menezes, B. R. S., Entringer, G. C., Peixoto, W. F. S., & Cassaro, S. Production potential and chemical composition of elephant grass (Pennisetum purpureum Schum.) at different ages for energy purposes. **African Journal of Biotechnology** , 16(25), 1428-1433, 2017.