RESEARCH

Growth curve in elephant grass genotypes based on morpho-agronomic traits for energy production

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ABSTRACT

The elephant grass (*Cenchrus purpureus* (Schumach.) Morrone) is one of the species with great prominence for energy production because of its favorable traits, such as high yield and short cycle, combined with several biomass quality characteristics. Therefore, this study intended to evaluate the morpho-agronomic traits of eight elephant grass genotypes under different cutting ages. A randomized block design with three replicates was applied to the experiment, and plots were composed of a 12 m long line divided into six subplots for each of the bimonthly cuts. Eight genotypes were evaluated in the plots, and the cutting ages (2, 4, 6, 8, 10, and 12-mo) were analyzed in the subplots. The following traits were assessed: DM yield, (DMY) percentage of DM, and average plant height (HEI). All genetic-statistical analyses were conducted using the Genes Program. The evaluated genotypes showed nonsignificant differences, indicating that, for the evaluated traits, these genotypes are genetically similar. Most genotypes presented linear effect of 2nd degree in the two assessment cuts, pointing they did not reach their maximum capacity of DMY in the time interval of the evaluated cuts. The maximum %DM achieved for the most genotypes occurred at about 9-mo age, while genotypes Vruckwona and BAG-86 at about 10-mo age. The maximum points for HEI trait were between 8 and 10-mo age. Increasing the cutting interval leads to increases in DM yield, with the 10-mo cutting age being the most efficient, resulting in higher yields.

Key words: Bioenergy, *Cenchrus purpureus*, cutting age, dry matter yield.

INTRODUCTION

Biomass appears as a potential resource for energy production, showing economic and environmental advantages with significant relevance due to its low production cost, in addition to reducing CO_2 emissions, being able to be converted into chemical products, thermal/electrical energy, biofuels, among other essential material (Fontoura et al., 2015).

Within the feasible alternatives for energy production, plant biomass has stood out as a very promising source, being elephant grass (*Cenchrus purpureus* (Schumach.) Morrone) one of the species with great prominence for this purpose because of its favorable traits, such as high yield and short cycle, combined with several biomass quality characteristics, including high fiber content, more specifically the content of components rich in C and with high heating value, like cellulose and lignin (Silva et al., 2020).

In both Europe and Brazil, some steel plants and thermoelectric plants have already used elephant grass as an alternative source of energy, replacing mineral coal with charcoal (Mazzarella et al., 2015). Nevertheless, to make maximum use of the crop for this purpose, there is an essential need to conduct evaluation works of elephant grass genotypes focused exclusively on the production of energy biomass, since many genetically improved cultivars aimed at animal feed, in other words, genotypes with low levels of lignin and cellulose (Scheider et al., 2018).

Given the benefits of elephant grass, there is a need to develop improved varieties to meet the growing energy demand. Applying appropriate techniques for selection enables maximizing gains to be more efficiently managed by breeding programs, in addition to enabling inferences about gains to be achieved with the selection (Cruz et al., 2014). The focus of the desired traits is changed; first, grass with high levels of protein for animal feed was sought; now a plant with high fiber contents is sought, together with high biomass production and high calorific value, so that the energy produced from this material is of good quality to be mainly used in potteries in the north of Rio de Janeiro state. Considering that, there is a need for investigations to define the ideal time (age) for harvesting elephant grass for energy purposes.

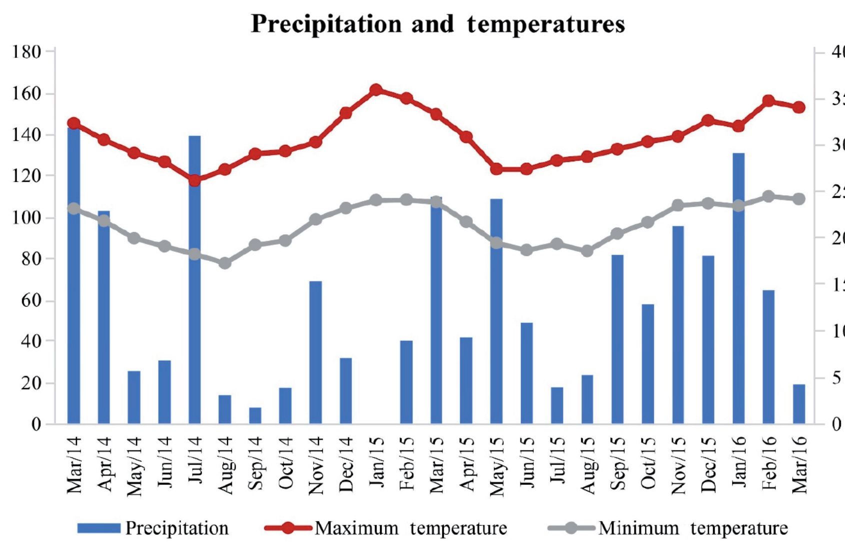
This paper was developed to evaluate the morpho-agronomic traits of eight elephant grass genotypes at different harvesting frequencies (2, 4, 6, 8, 10, and 12-mo), and also to identify elephant grass genotypes with high DM yield in edaphoclimatic conditions in the north of Rio de Janeiro state.

MATERIALS AND METHODS

The experiment was implemented in an experimental area within the Universidade Estadual do Norte Fluminense Darcy Ribeiro (UENF), located at the facilities of the Centro Estadual de Pesquisas em Agroenergia e Aproveitamento de Resíduos (CEPEAA), of the Experimental Station da Pesagro-Rio, in the municipality of Campos dos Goytacazes (21°44’47’’ S, 41°18’24’’ W; 11 m a.s.l.), Rio de Janeiro state, Brazil.

Under the Köppen classification system (Alvares et al., 2013), the climate in the north of Rio de Janeiro state is Aw type, tropical hot and humid, with a dry period in winter and rainy in summer, with an annual rainfall of around 1153 mm. Meteorological data were collected from the automatic agrometeorological station, located near the experimental area. Figure 1 depicts the monthly rainfall and temperature values for the period of the experiment (March 2014 to March 2016).

Figure 1. Rainfall and maximum and minimum temperatures during the conduction of the elephant grass experiment.



Source: Estação Evapotranspirométrica do Centro Estadual de Pesquisa em Agroenergia e Aproveitamento de Resíduos, Pesagro/Rio, Campos dos Goytacazes, Rio de Janeiro, Brazil.

The soil is classified as Yellow Latosol, with the following characteristics: pH 5.5, P = 18 mg dm^{-3}, K = 83 mg dm^{-3}, Ca = 4.6 cmol$_c$ dm^{-3}, Mg = 3.0 cmol$_c$ dm^{-3}, Al = 0.1 cmol$_c$ dm^{-3}, H + Al = 4.5 cmol$_c$ dm^{-3}, and C = 1.6%.

The experiment was carried out from 2014 to 2016, applying a conventional soil preparation system using a plowing harrow. After soil preparation, planting furrows were opened. Fertilization was determined in accordance with the results obtained in soil analysis, which consisted of 714 kg ha^{-1} of the chemical formula 4-14-8 (NPK).

The standardization cut was performed on 29 March 2014 (45 d after planting) with the aim of providing a uniform growth of sproutings. From this date on, cuts were executed in plots randomly chosen at 2, 4, 6, 8, 10, and 12-mo of age, respectively, when the evaluations were started. After 12-mo, a second standardization cut was carried out, and the procedure was fully repeated to perform the evaluations of the second year of evaluation.

The genotypes for the experiment were Cubano Pinda, Vruckwona, IAC-Campinas, Cameroon, CPAC, IJ 7139, BAG-86 and Capim Cana D'África from the Active Elephant Grass Germplasm Bank (BAGCE) of Embrapa Gado de Leite, located in the municipality of Coronel Pacheco, Minas Gerais state, Brazil, and were previously selected on the basis of studies for biomass production, adding some traits, such as late-flowering, DM yield, stem diameter, and number of tillers (Rossi et al., 2014).

It was used an experimental randomized block design with subdivided plots and three replicates. Plots were formed by a 12 m line divided into six subplots. Each one was referred to each of the bimonthly courts. The useful area was 1 m to the center of the subplot from which the sample was taken. In the plots, eight late-cycle genotypes were evaluated and harvesting frequency (2, 4, 6, 8, 10, and 12-mo) was assessed in the subplots. The following traits were evaluated.

Dry matter yield (DMY). A sample was taken from each plot at random and each part was chopped and placed in a labeled paper bag, weighed and oven-dried at 65 °C for 72 h. Then, the samples were weighed again to obtain the air-dried sample, following the methodology described by Silva and Queiroz (2002), and expressed as t ha^{-1}.

Dry matter percentage (%DM). The dried material was ground in a Wiley mill with a 1 mm sieve and packed in plastic bags to obtain the oven-dried sample. Two grams of each ground material were kept in an oven at 105 °C for 12 h and subsequently weighed again, following the methodology described by Silva and Queiroz (2002). Results were expressed in percentage (%).

Average plant height (HEI, m). Measured from the ground to the inflection of the last fully expanded leaf of each plant in the usable area. Analysis of regression and regression variance were conducted with the aid of the Computational Application in Genetics and Statistics - Genes Program (Cruz, 2013) of the Universidade Federal de Viçosa.

RESULTS AND DISCUSSION

Considering the source of variation Genotype × Harvesting frequency interaction in Table 1, nonsignificant effect (P > 0.05) was observed in each year of cultivation for all the traits analyzed, except by DMY trait in the second year of cultivation.

The Genotype × Environment interaction is disadvantageous in breeding programs insofar as a genotype performance can change from one environment to another, providing an alteration in the relative position of genotypes or even in the magnitude of their differences. This hinders the identification of superior genotypes for different environments.

Table 1. Summary of ANOVA of the morpho-agronomic traits of eight genotypes of grass in function of plant age (2, 4, 6, 8, 10, and 12-mo), during 2 yr cultivation for energy purposes.

		Year 1			Year 2		
SV	DL	DMY	%DM	HEI	DMY	%DM	HE[l]
Blocks	2	303.48	21.73	0.58	232.44	20.94	0.46
Genotypes (G)[a]	7	65.68[ns]	7.88[ns]	0.06[ns]	53.25[ns]	13.35[ns]	0.06[ns]
Error a	14	66.80	10.42	0.91	38.26	16.3	0.03
Cut (C)	5	2068.3**	1539.0**	6.4**	1267.9**	994.7**	9.8**
Interaction (G×C)	35	50.45[ns]	6.36[ns]	0.03[ns]	35.61**	8.77[ns]	0.02[ns]
Error b	80	39.25	5.41	4.79	15.04	11.87	0.03
Mean		20.92	32.22	2.58	19.65	30.52	27.12
CV, %		39.05	10.01	9.90	31.47	13.22	6.64

**, *, [ns]Significant at a level of 1%, 5%, and nonsignificant by the F test, respectively.
DMY: Dry matter yield (t ha^{-1}); %DM: percentage of DM; HEI: average plant height (m).
[a]Cubano Pinda, Vruckwona, IAC-Campinas, Capim Cana D'África, Cameroon, CPAC, IJ 7139, and BAG-86.

Significant effects (P < 0.01) were noticed for all the traits studied in the 2 yr of cultivation with respect to the source of variation cut. As for the source of variation genotype, all traits evaluated during the 2 yr of cultivation showed nonsignificant differences (P > 0.05). The lack of significant differences indicates that among the genotypes evaluated there is no phenotypic variability (Vidal et al., 2018). This is a result of the genetic proximity between these materials, as identified in studies developed by Lima et al. (2011). When evaluating the genetic divergence between elephant grass accessions via random amplified polymorphic DNA (RAPD) and inter simple sequence repeats (ISSR) markers, these authors found that the genotypes used in this work belong to the same group, which shows that these genotypes are probably genetically close.

The coefficient of variation (CV) for DMY, DM content (%DM) and plant height (HEI) traits found were, respectively, 39.05%, 10.01% and 9.90%, at the first year of cultivation, and 31.47%, 13.22% and 6.64%, at the second year of cultivation (Table 1). While some values of the coefficients of variation are classified as very high, these results support the results normally found in studies with culture under field conditions (Rossi et al., 2014; Oliveira et al., 2014; Rocha et al., 2015; Gravina et al., 2020).

The estimates of mean squares for the sources of variation (SV), due to regression and deviations of regression for the linear models of 1st and 2nd degrees applied to the mean values of DM yield for the six ages in 2 yr cultivation, are depicted in Table 2.

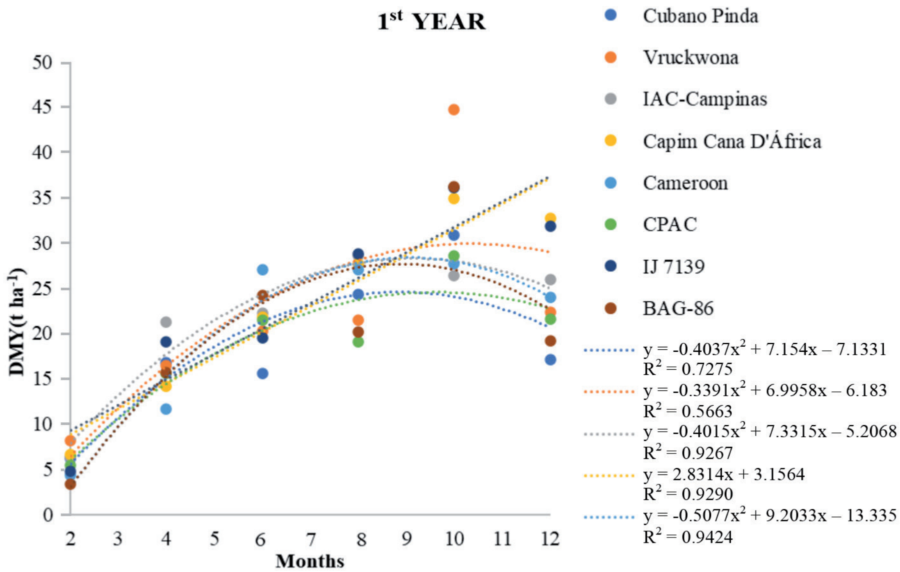
Concerning the first year of evaluation, all genotypes presented linear effect of 2nd degree, with the exception of genotypes Capim Cana D'África and IJ 7139, which had linear effect of first degree (P < 0.01), pointing they did not reach their maximum capacity of DMY in the time interval of the evaluated cuts (Figure 2).

Table 2. Estimates of mean squares for the sources of variation, due to regression (Reg.) and deviations of regression (Dev.) for linear models of 1st and 2nd degrees for dry matter yield (DMY) trait, in function of six cutting seasons including eight genotypes of elephant grass.

SV			DL	1st degree	R^2(%)	DL	2nd degree	R^2(%)	Model
Cubano Pinda	Year 1	Reg.	1	474.11**	45.02	2	292.01**	72.75	2
		Dev.	4	144.73**		3	95.63**		
	Year 2	Reg.	1	482.68**	87.19	2	50.48ns	96.31	1
		Dev.	4	17.71ns		3	6.79ns		
Vruckwona	Year 1	Reg.	1	1061.60**	47.42	2	206.06**	56.63	2
		Dev.	4	294.19**		3	323.56**		
	Year 2	Reg.	1	1046.70**	87.46	2	6.82ns	88.03	1
		Dev.	4	37.49*		3	47.71*		
IAC-Campinas	Year 1	Reg.	1	614.73**	63.04	2	288.83**	92.67	2
		Dev.	4	90.07**		3	23.81ns		
	Year 2	Reg.	1	731.12**	87.95	2	38.30ns	92.56	1
		Dev.	4	25.02ns		3	20.59ns		
Cameroon	Year 1	Reg.	1	1683.53**	92.89	2	91.70**	97.95	1
		Dev.	4	32.17ns		3	12.33ns		
	Year 2	Reg.	1	1260.36**	90.58	2	0.23ns	90.60	1
		Dev.	4	32.75ns		3	43.59*		
CPAC	Year 1	Reg.	1	922.51**	62.80	2	461.85**	94.24	2
		Dev.	4	136.60**		3	28.18ns		
	Year 2	Reg.	1	864.64**	93.66	2	28.015ns	96.69	1
		Dev.	4	14.62ns		3	10.16ns		
IJ 7139	Year 1	Reg.	1	586.94**	65.65	2	182.12**	86.03	2
		Dev.	4	76.74**		3	41.61ns		
	Year 2	Reg.	1	252.56**	66.31	2	25.93ns	73.12	1
		Dev.	4	32.06ns		3	34.11ns		
BAG-86	Year 1	Reg.	1	1645.53**	85.09	2	155.39ns	93.12	1
		Dev.	4	72.08ns		3	44.31ns		
	Year 2	Reg.	1	630.64**	67.75	2	127.61**	81.47	2
		Dev.	4	75.01**		3	57.48*		
Capim Cana D'África	Year 1	Reg.	1	801.84**	46.29	2	486.19**	74.35	2
		Dev.	4	232.58**		3	148.05*		
	Year 2	Reg.	1	1230.90**	89.30	2	17.85ns	90.59	1
		Dev.	4	36.86ns		3	43.20*		

**, *, nsSignificant at a level of 1%, 5%, and nonsignificant by the F test, respectively.

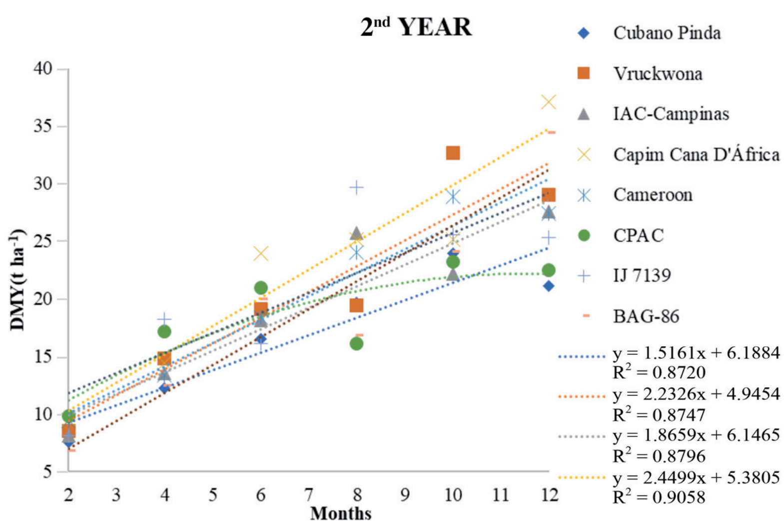
Figure 2. Adjusted lines and curves of regression for dry matter yield (DMY) trait in function of the cutting age, in the first year of cultivation.



The maximum DMY points for genotypes Cubano Pinda, Vruckwona, IAC-Campinas, Cameroon, CPAC, and BAG-86 were determined at 8.86, 10.31, 9.13, 9.06, 9.62, and 8.87-mo, respectively. The maximum yields estimated for these genotypes were Cubano Pinda 24.56 t ha^{-1}, Vruckwona 29.9 t ha^{-1}, IAC-Campinas 18.26 t ha^{-1}, Cameroon, 28.38 t ha^{-1}, CPAC 24.53 t ha^{-1}, and BAG-86 27.63 t ha^{-1} (Figure 2).

In the second year, most of the genotypes evaluated did not present maximum points, being observed an accumulation of DM during the 12-mo of yield. Only IJ 7139 displayed a linear effect of 2nd degree ($P < 0.01$). The maximum yield point for this genotype was achieved at 10.25-mo, with an estimated maximum DMY of 26.44 t ha^{-1} (Figure 3).

Figure 3. Adjusted lines and curves of regression for dry matter yield (DMY) trait in function of the cutting age, in the second year of cultivation.



The increasing tendency in DMY with the increase in the cutting age, evidenced in this experiment, is in line with the results found by Freitas et al. (2018) with elephant grass. It could also be noticed that cutting plants at more advanced stages of growth provides higher forage yields because of the longer period for DM accumulation (Vidal et al., 2017).

There are many works that support the findings of this study, for example, when evaluating the yield performance of 83 genotypes of elephant grass under the regime of annual cuts in the municipality of Campos dos Goytacazes, Araújo et al. (2017) obtained DMY ranging from 26.73 to 36.02 t ha^{-1} in four evaluation cuts. These results are similar to the ones found in this work.

The significance for the linear components of 1st and 2nd degrees, and the deviations of regression for %DM trait, which involves eight genotypes of elephant grass, are depicted in Table 3.

As can be seen, all eight genotypes evaluated had points of maximum %DM, in the 2 yr of cultivation, suggesting they did not accumulate DM within the 12-mo of cultivation because of the presentation of a maximum yield point (Figures 4 and 5).

The maximum %DM achieved for genotypes Cubano Pinda, IAC-Campinas, Cameroon, CPAC, IJ 7139, and Capim Cana D'África occurred at about 9-mo age, while genotypes Vruckwona and BAG-86 at about 10-mo age. The maximum %DM in the first year of cultivation ranged from 37.84% for genotype IJ 7139 at 9-mo age to 40.31% for genotype BAG-86 at 10-mo age (Figure 4).

For the second year of cultivation, genotypes IAC-Campinas, Cameroon and CPAC were at the maximum point at 8-mo age; genotypes Cubano Pinda, Vruckwona, IJ 7139, BAG-86 and Capim Cana D'África reached the maximum %DM at 9-mo age, with genotype 8 having the highest %DM (37.03%). The lowest %DM was obtained by genotype Vruckwona

Table 3. Estimates of mean squares for the sources of variation, due to regression (Reg.) and deviations of regression (Dev.) for linear models of 1st and 2nd degrees for the percentage of dry matter (%DM) trait, in function of six cutting seasons involving eight genotypes[a] of elephant grass.

SV			DL	1st degree	R^2(%)	DL	2nd degree	R^2(%)	Model
Cubano Pinda	Year 1	Reg.	1	615.92**	62.06	2	356.49**	97.97	2
		Dev.	4	94.14**		3	6.69**		
	Year 2	Reg.	1	361.26**	52.65	2	221.53**	84.93	2
		Dev.	4	81.22**		3	34.45**		
Vruckwona	Year 1	Reg.	1	553.37**	81.18	2	91.48**	94.60	2
		Dev.	4	32.07**		3	12.27**		
	Year 2	Reg.	1	284.02**	43.05	2	174.75**	69.53	2
		Dev.	4	93.94**		3	66.99**		
IAC-Campinas	Year 1	Reg.	1	675.38**	66.70	2	308.84**	97.20	2
		Dev.	4	84.29**		3	9.43ns		
	Year 2	Reg.	1	274.75**	45.41	2	289.32**	93.22	2
		Dev.	4	82.57**		3	13.66ns		
Cameroon	Year 1	Reg.	1	731.78**	63.42	2	387.49**	97.00	2
		Dev.	4	105.52**		3	11.52ns		
	Year 2	Reg.	1	134.22**	20.79	2	366.91**	77.62	2
		Dev.	4	127.84**		3	48.15**		
CPAC	Year 1	Reg.	1	659.13**	67.06	2	309.97**	98.60	2
		Dev.	4	80.94**		3	4.59ns		
	Year 2	Reg.	1	214.57**	36.48	2	328.61**	92.34	2
		Dev.	4	93.41**		3	15.01ns		
IJ 7139	Year 1	Reg.	1	540.82**	55.66	2	380.33**	94.80	2
		Dev.	4	107.72**		3	16.85*		
	Year 2	Reg.	1	412.00**	56.01	2	233.51**	87.75	2
		Dev.	4	80.91**		3	30.05ns		
BAG-86	Year 1	Reg.	1	879.76**	75.42	2	251.28**	96.96	2
		Dev.	4	71.70**		3	11.84ns		
	Year 2	Reg.	1	405.33**	67.25	2	163.36**	94.35	2
		Dev.	4	49.35**		3	11.34ns		
Capim Cana D'África	Year 1	Reg.	1	571.44**	59.77	2	332.69**	94.56	2
		Dev.	4	96.17**		3	17.32*		
	Year 2	Reg.	1	415.28**	54.83	2	235.14**	85.87	2
		Dev.	4	85.55**		3	35.68*		

**, *, nsSignificant at a level of 1%, 5%, and nonsignificant by the F test, respectively.
[a]Cubano Pinda, Vruckwona, IAC-Campinas, Capim Cana D'África, Cameroon, CPAC, IJ 7139, and BAG-86.

(34.63%), both at 9-mo age (Figure 4). When evaluating the %DM of 40 genotypes of elephant grass, in the municipality of Campos dos Goytacazes, Rossi et al. (2014) observed similar results, with an overall mean of 34.28% at 10-mo age.

The significance for the linear models of the 1st and 2nd degree, and the deviations of regression for plant height (HEI) traits, comprising eight genotypes of elephant grass, are depicted in Table 4. As observed for percentage of DM (%DM), all eight genotypes evaluated were significant for the source of variation regression of 2nd degree, displaying, therefore, maximum HEI points in 2 yr cultivation (Figures 6 and 7).

The maximum points for HEI trait were at 9.4, 9.7, 9.9, 10.6, 9.9, 8.8, 10.4, and 9.9-mo for genotypes Cubano Pinda, Vruckwona, IAC-Campinas, Cameroon, CPAC, IJ 7139, BAG-86 and Capim Cana D'África, respectively, in the first year of cultivation. Similar results were achieved in the second year of cultivation when the maximum points were between 8 and 10-mo age.

The estimated maximum HEI in the first year of cultivation was 3.10 m in Capim Cana D'África, and the lowest was 2.87 m in CPAC. In the second year of cultivation, higher estimated HEI were verified when compared to the first year, and the highest values were in Vruckwona, Cameroon, and IJ 7139, the latter being 3.26 m. The lowest estimated value in the second year of cultivation was 3.15 m for genotypes Cubano Pinda and BAG-86. Oliveira et al. (2015) reported similar results while evaluating six genotypes of elephant grass with an overall mean of 3.54 m.

Table 4. Estimates of mean squares for the sources of variation because of the regression and deviations of regression for the linear models of 1st and 2nd degrees for height (HEI) trait, involving eight genotypes of elephant grass.

SV			DL	1st degree	R^2 (%)	DL	2nd degree	R^2 (%)	Model
Cubano Pinda	Year 1	Reg.	1	2.46**	66.69	2	0.94**	92.15	2
		Dev.	4	0.31**		3	0.10**		
	Year 2	Reg.	1	4.94**	65.64	2	1.93**	91.29	2
		Dev.	4	0.65**		3	0.22**		
Vruckwona	Year 1	Reg.	1	2.39**	66.66	2	0.68**	85.66	2
		Dev.	4	0.30**		3	0.17*		
	Year 2	Reg.	1	3.77**	61.20	2	2.05**	94.37	2
		Dev.	4	0.60**		3	0.12*		
IAC-Campinas	Year 1	Reg.	1	2.86**	68.32	2	0.72**	85.62	2
		Dev.	4	0.33**		3	0.20*		
	Year 2	Reg.	1	3.65**	55.78	2	2.67**	96.58	2
		Dev.	4	0.72**		3	0.08^{ns}		
Cameroon	Year 1	Reg.	1	3.48**	79.65	2	0.57**	92.61	2
		Dev.	4	0.22**		3	0.11^{ns}		
	Year 2	Reg.	1	3.88**	67.87	2	1.57**	95.35	2
		Dev.	4	0.46**		3	0.09^{ns}		
CPAC	Year 1	Reg.	1	2.96**	71.91	2	0.67**	88.05	2
		Dev.	4	0.29**		3	0.16*		
	Year 2	Reg.	1	3.31**	54.61	2	2.56**	96.90	2
		Dev.	4	0.69**		3	0.06^{ns}		
IJ 7139	Year 1	Reg.	1	1.98**	56.81	2	1.31**	94.28	2
		Dev.	4	0.38**		3	0.07^{ns}		
	Year 2	Reg.	1	3.73**	65.56	2	1.71**	95.57	2
		Dev.	4	0.49**		3	0.08^{ns}		
BAG-86	Year 1	Reg.	1	3.76**	79.52	2	0.69**	94.15	2
		Dev.	4	0.24**		3	0.09^{ns}		
	Year 2	Reg.	1	4.10**	60.73	2	1.80**	87.38	2
		Dev.	4	0.66**		3	0.28**		
Capim Cana D'África	Year 1	Reg.	1	3.81**	71.13	2	0.98**	89.49	2
		Dev.	4	0.39**		3	0.19*		
	Year 2	Reg.	1	3.31**	60.56	2	1.74**	92.47	2
		Dev.	4	0.54**		3	0.14*		

**, *, ^{ns}Significant at a level of 1%, 5%, and nonsignificant by the F test, respectively.

Figure 4. Adjusted curves of regression for percentage of dry matter (%DM) trait in function of the cutting age, in the first year of cultivation.

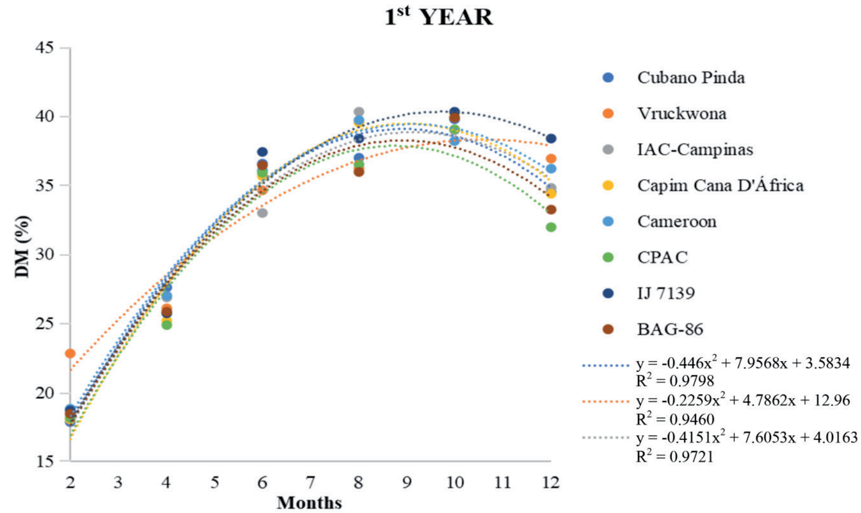


Figure 5. Adjusted curves of regression for percentage of dry matter (%DM) trait in function of the cutting age in the second year of cultivation.

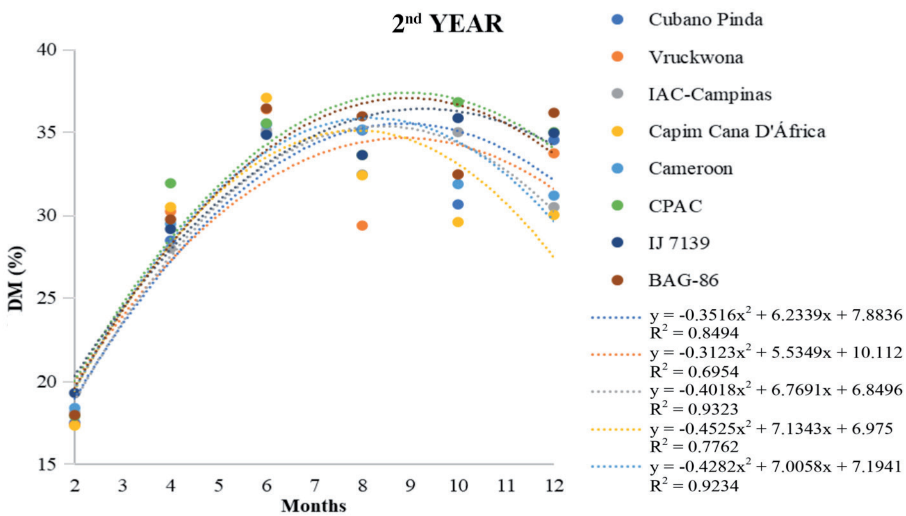


Figure 6. Adjusted curves of regression for plant height (HEI) trait in function of the cutting age in the first year of cultivation.

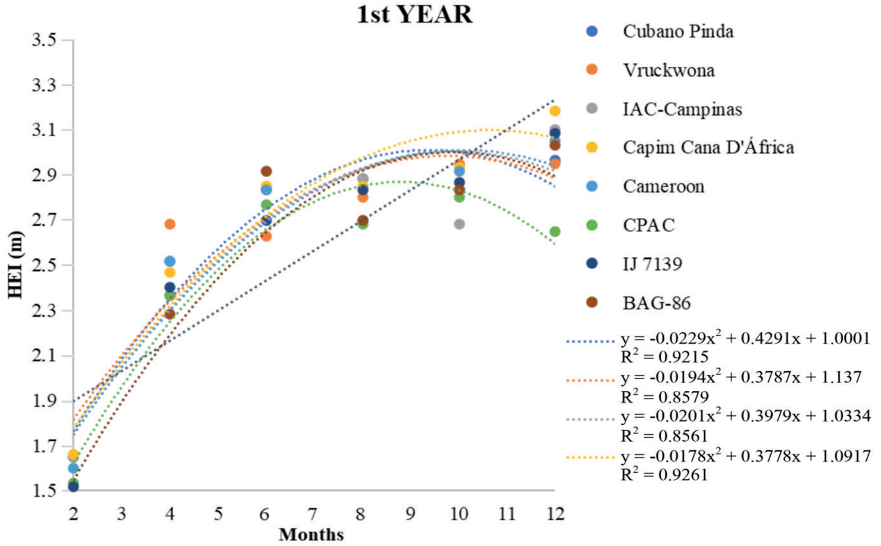
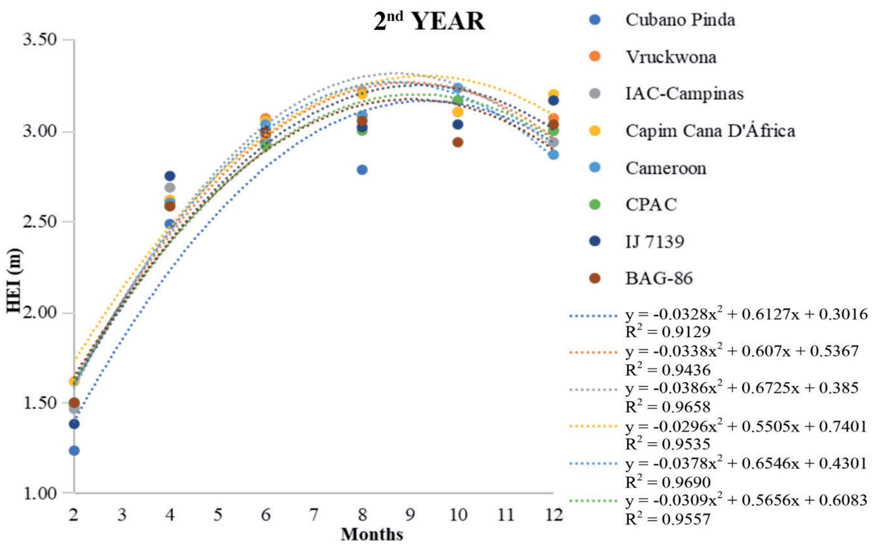


Figure 7. Adjusted curves of regression for plant height (HEI) trait in function of the cutting age in the second year of cultivation.



CONCLUSIONS

Nonsignificant differences were identified between the genotypes analyzed, proving that, for the traits under evaluation, these genotypes are genetically similar. The increase in the cutting interval results in gains in dry matter yield, being the cutting at 10-mo the most efficient, resulting in higher productivity of energy biomass.

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