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Pruning as a strategy to improve the nutritional value of the aerial parts of industry- purpose cassava clones

Poda como estratégia para melhorar o valor nutricional da parte aérea de clones de mandioca de indústria

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ABSTRACT

The present study aimed to assess the influence of pruning on the starch yield and nutritional value of the aerial parts of industry- purpose cassava clones adapted to the Cerrado region of Central Brazil. Four elite clones were submitted to either total shoot pruning or no pruning at 12 months after planting, in a randomized complete block design with three replications. Plants were evaluated eighteen months after planting. Clone 330/09 presented the highest root yield with and without pruning, and also higher starch yield, green and dry mass yields, and crude protein yield of aerial parts without pruning. In plants that were pruned, clones 117/09 and 359/09 stood out, with higher yields of the crude protein content of the aerial part and a higher *in vitro* digestibility of the dry matter. These clones are therefore an option when using the aerial parts of cassava in animal feed. Total pruning at 12 months of age significantly increased the crude protein content and *in vitro* digestibility of the dry matter of the aerial parts, improving its nutritional value. Pruning did, however, reduce the starch yield of the roots and the total yields of the roots and aerial parts.
Keywords: *Manihot esculenta* Crantz, animal feed, digestibility, cassava meal, starch.

RESUMO

O presente estudo objetivou determinar a influência da poda na produtividade de amido e no valor nutricional da parte aérea de mandioca de clones de mandioca de indústria adaptados ao Cerrado do Brasil Central. Quatro clones elite foram submetidos ou não à poda total da parte aérea aos 12 meses após o plantio, em delineamento experimental de blocos completos casualizados, com três repetições. As avaliações foram realizadas aos dezoito meses após o plantio, sendo os dados submetidos à análise de variância e as médias comparadas pelo teste de Tukey. O clone 330/09 se destacou por apresentar maior

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produtividade de raízes com e sem poda, e maiores rendimentos de amido, produtividade de massa verde e seca e produtividade de proteína bruta da parte aérea no manejo sem poda. No manejo com poda, se destacaram os clones 117/09 e 359/09, quanto os teores de proteína bruta da parte aérea e a digestibilidade *in vitro* da matéria seca da parte aérea, portanto, esses clones se constituem em opção visando o aproveitamento da parte aérea na alimentação animal. O manejo de poda total aos 12 meses de idade aumentou significativamente os teores de proteína bruta e a digestibilidade *in vitro* da matéria seca da parte aérea, melhorando o seu valor nutritivo, entretanto, reduziu o rendimento de amido das raízes e as produtividades de raízes e da parte aérea.
Palavras-chaves: *Manihot esculenta* Crantz, alimentação animal, digestibilidade, farinha, fécula.

INTRODUCTION

Cassava is cultivated mainly for to its starchy roots, which is used in human food (RINALDI et al., 2015; RINALDI et al., 2019), animal feed (OLIVEIRA et al., 2014; GONÇALVES et al., 2015; FERNANDES et al., 2016; SUDARMAN et al., 2016; OLIVEIRA et al., 2017), and as a raw material for various industrialized products (ZHU, 2015). This plant species displays drought tolerance and the ability to grow in acidic soils with low fertility, as well as flexibility in terms of planting and harvesting times, and in adapting very well to the climate and soil conditions of Brazil (FIALHO et al., 2013).

Cassava shoots are used in animal feed (FERNANDES et al., 2016), since they contain, on average, 21% crude protein, with a variation of 17 to 40% depending on the plant cultivar, stage of maturity, soil fertility, and climate (RAVINDRAN, 1993), and include characteristics required for use as roughage in animal feed.

A large portion of the aerial parts of the cassava plants is left in the field for nutrient cycling and is not used in animal feed. Active management of cassava crops is required to optimize the production of the roots for the flour and starch industry and that of the aerial parts for animal feed. Accordingly, Fialho & Vieira (2013) suggest the total pruning of the aerial parts of the cassava plant at 12 months after planting (at the end of the drought season and the beginning of the rainy season) as a management option for the Cerrado region of Central Brazil. This enables the utilization of the pruned branches for new plantings, and weed control, and the use of the excess aerial parts in animal feed. Thus, new aerial parts are formed until the time of harvest (18 months after planting), a period that coincides with the beginning of the drought season, and the food scarcity period in the region. This enables the aerial parts to be used in animal feed, along with the roots that the producer chooses to allocate to the formulation of the feed.

The pruning of the aerial parts of cassava plants is an efficient and viable strategy (OLIVEIRA et al., 2010). It is, however, important to study the interaction of this practice with agronomic characteristics and with the chemical-bromatological quality of the aerial parts. The present study aimed to determine the influence of pruning on the starch yield and nutritional value of cassava shoots in four industrial-purpose clones adapted to the conditions of the Cerrado of Central Brazil.

MATERIAL AND METHODS

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The field experiment was conducted between December 2013 and June 2015, in an experimental area of the State Agricultural School Juvêncio Martins Ferreira (Escola Agrícola Estadual Juvêncio Martins Ferreira), located in the municipality of Unaí, Minas Gerais (16º 32,401' S e 46º 50,680' W; 667 m altitude). The soil contained 70% clay, 25% silt, 5% sand, pH 5.15 in H_2O, 0.60 cmolc dm^{-3} of Al+++, 2.00 cmolc dm^{-3} of Ca++, 1.00 cmolc dm^{-3} of Mg++, 3.80 cmolc dm^{-3} H + Al, 1.80 mg dm^{-3} phosphorus, 252 mg dm^{-3} potassium, and 3.50% organic matter.

During the experiment, the average daily maximum, minimum, and mean temperatures were 31.93ºC, 19.52ºC, and 25.72ºC respectively, while the average relative humidity was 64.69%, the average wind speed was 1.57 m s^{-1}, the average hours of daily incident solar radiation was 7.46 h, the average daily radiation was 19.83 MJ m^{-2}, the accumulated precipitation was 1945 mm, and the mean potential evapotranspiration was 4.88 mm.

Four elite cassava clones for flour and starch production selected for the environmental conditions of the Cerrado of Central Brazil [clone 330/09, clone 117/09, clone 359/09 and clone 9 (which is registered in the Regional Germplasm Bank of the Cerrado as BGMC 996)] were evaluated for their response to pruning management of the aerial parts at 12 months after planting. We used randomized blocks with three replications; each of the eight treatments (the four clones with pruning of aerial parts at 12 months after planting and the four clones without pruning) were evaluated in plots composed of 4 rows of 10 plants, with 0.80 m spacing between plants, and 1.20 m between rows. The harvest area of each plot was represented by the 16 central plants. Crop treatment (fertilization and liming) was performed according to the technical recommendations for cassava crops for the Cerrado region (FIALHO et al., 2013; FIALHO & VIEIRA, 2013) and weed control was performed manually.

In the plots with pruning, the aerial parts of all plants was pruned at 10 cm above the soil at 12 months after planting. The plot was harvested at 18 months after planting, at which time the root yield in kg ha^{-1} (RY) and root starch (RS) were evaluated using a hydrostatic scale method. Approximately 800 g of the aerial parts were also collected, after each of the treatments, and crushed for further analysis.

The aerial samples were then identified, weighed, and placed in a forced ventilation oven at 55ºC to determine the pre-dried matter. After pre-drying, the samples were ground in a Wiley mill with a 1 mm sieve. Definitive drying was then carried out in an oven at a temperature of 105ºC for 16 hours. Crude protein content was determined based on total nitrogen content, dosed by the Kjeldahl method, using a conversion factor of 6.25 for crude protein. The procedure followed the methodology described by Silva & Queiroz (2002). The analyses of neutral detergent insoluble fiber (NDF) and acid detergent insoluble fiber (ADF) were determined according to the sequential method proposed by Van Soest et al. (1991). The *in vitro* digestibility of dry matter (IVDDM) was determined by the Tilley & Terry method.

We assessed analysis of variance according to the randomized block design in a factorial scheme. The Shapiro-Wilk's test was used to analyze the normality of the data at 5% significance. Data without a normal distribution were transformed (log x) before analysis of variance, and the

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original means were presented in tables. All statistical analyses were performed with the Software R, version 3.4.3 (R Core Team, 2017).

RESULTS AND DISCUSSION

There were significant differences (P < 0.05) between the means of the clone and management system factors for all evaluated traits (Table 1). This indicates that the phenotypic manifestations of characters related to root yield and the nutritional value of shoots could be altered by both genetic and agricultural practices (SILVA et al., 2014; PASTRANA et al., 2015; OLIVEIRA et al., 2016; FUHRMANN et al., 2019). This explains the importance of concomitantly taking into account factors related to genetics and management.

For all measured characters, except for dry matter (DM), acid detergent fiber (ADF) and IVDDM of aerial parts, there was a significant interaction (p < 0.05) between the clone and management system factors (Tables 1 and 2), indicating that the clones evaluated responded differently to pruning management. This indicates that there is a specificity between clones and management systems. When selecting clones to be used in animal feed production, it is important to consider their differential responses to the management system employed, in order to obtain the best production result.

Table 1. Summary of the analysis of variance and coefficients of variation (CV) of root yield variables and nutritional quality of aerial plant parts, evaluated in four cassava clones for the flour and starch industry (C), harvested at 18 months after planting, under two management systems (MS), with and without aerial part pruning at 12 months after planting

FV	DF	Mean squares										
		RY*	RSY	GMY	DMY	CPY	RS	DM	CP	NDF	ADF	IVDDM
C	3	717**	69**	631**	36**	0,3**	17**	37**	86**	198**	166**	99**
MS	1	937**	244**	7138**	757**	2,4**	207**	321**	661**	620**	468**	207**
C x MS	3	42**	14**	258**	20**	0,1**	11**	3	15**	74**	6	9
Residual	14	2	0,4	5	1	0,01	0,6	1	1	6	5	1
Total	23	-	-	-	-	-		-	-	-	-	-
CV (%)		3.7	5.4	7.3	8.8	10.7	2.4	3.51	8.97	3.92	6.5	6.5

*RY = root yield; RSY = root starch yield; GMY = green mass yield of aerial part; DMY = dry mass yield of aerial part; CPY = crude protein yield of aerial part; RS = root starch; MS = shoot dry matter; CP = crude protein; NDF = neutral detergent fiber of the aerial part; ADF = acid detergent fiber of the aerial part; IVDDM = In vitro digestibility of dry matter of the aerial part.
**p < 0.05 by the F test.

The coefficients of variation ranged from 2.4% for root starch (RS) to 10.7% for the yield of crude protein in the aerial parts (CPY), indicating a high experimental precision (Table 1), and consequently, confirming the reliability of the results.

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Table 2. Significance (p) by the F-test for the splitting of the interaction (clone x management system) of root production variables and nutritional quality of aerial parts, evaluated in four cassava clones for the flour and starch industry (C), harvested at 18 months after planting, in two management systems (MS), with and without pruning of the aerial part at 12 months after planting.

Factor	DF	RY*	RSY	GMY	DMY	CPY	RS	CP	NDF
Management system	1	0	0	0	0	0	0	0	0
Clones	3	0	0	0	0	0	0	0	0
Clones with pruning	3	0	0	0	0.03	0.09	0	0	0
Clones without pruning	3	0	0	0	0	0	0.02	0	0.01
Treatments within clone 117/9	1	0	0	0	0	0	0	0	0
Treatments within clone 330/09	1	0	0	0	0	0	0	0	0.01
Treatments within clone 359/09	1	0	0	0	0	0	0	0	0
Treatments within clone 09	1	0	0	0	0	0.01	0	0	0.04
Residual	14	-	-	-	-	-	-	-	-
Total	23	-	-	-	-	-	-	-	-

*RY = root yield; RSY = root starch yield; GMY = green mass yield of aerial part; DMY = dry mass yield of aerial part; CPY = crude protein yield of the aerial part; RS = root starch; CP = crude protein of aerial part; NDF = neutral detergent fiber of the aerial part.

Average root yields (RY) ranged from 19.3 to 42.4 t ha^{-1} in pruned plants and from 33.9 to 60.3 t ha^{-1} in unpruned plants (Table 3). Clone 330/09 presented the highest RY both among pruned plants and unpruned plants, followed by clone 09 in both management systems (Table 3). The average RY of 32.9 t ha^{-1} reported among the pruned clones in the present study was similar to that of 33.1 t ha^{-1} reported by Vieira et al. (2015b) in a study with 12 industrial cassava genotypes, evaluated by two harvests, submitted to the same pruning management in the same region. However, the average RY of 45.4 t ha^{-1} reported here for clones without pruning management, was much higher than the 30.3 t ha^{-1} reported by Viera et al., (2015a) when evaluating 17 industry cassava accessions in two harvests in the Cerrado area of Central Brazil.

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Table 3. Comparison of means of root and shoot production variables in t ha^{-1}, evaluated in four cassava clones for the flour and starch industry (C), harvested at 18 months after planting, in two management systems (MS), with (P) and without (WP) pruning at 12 months after planting (P).

Clone	RY*		RSY		GMY		DMY		CPY	
	P	WP	P	WP	P	WP	P	WP	P	WP
Clone 09	38.4 Bb**	50.6 Ab	10.8 Ba	17.8 Ab	15.4 Ba	45.0 Ab	3.4 Ba	12.6 Ab	0.4 Ba	0.7 Ac
Clone 117/09	19.3 Bd	33.9 Ac	5.4 Bb	11.2 Ad	8.3 Bb	36.4 Ac	2.1 Ba	12.3 Ab	0.5 Ba	1.2 Ab
Clone 330/09	42.4 Ba	60.3 Aa	11.1 Ba	21.1 Aa	17.1 Ba	71.2 Aa	3.8 Ba	20.4 Aa	0.6 Ba	1.6 Aa
Clone 359/09	31.5 Bc	36.9 Ac	10.4 Ba	13.1 Ac	9.4 Bb	35.5 Ac	2.1 Ba	11.1 Ab	0.5 Ba	1.1 Ab
Means	32.9 B	45.4 A	9.4 B	15.8 A	12.6 B	47.1 A	2.8 B	14.1 A	0.5 B	1.1 A

*RY = root yield; RSY = root starch yield; GMY = green mass yield of aerial parts; DMY = dry mass yield of aerial parts; CPY = crude protein yield of the aerial parts.
**Means followed by the same uppercase horizontally and lowercase vertically do not differ from each other, at 5 % significance, by the Tukey test.

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On average, pruning resulted in a root yield decrease of 12.5 t ha^{-1}, a slightly lower loss than reported by Andrade et al. (2011) in an experiment conducted with identical management systems. The reduction in root yield of pruned plants is a direct consequence of the consumption of root reserves by the plant during the regrowth of the aerial parts (OLIVEIRA et al., 2010; ANDRADE et al., 2011). This process consumes the accumulated reserve energy in the roots both for breaking the dormancy of the vegetative buds and for the recovery of the aerial parts (branches, petioles, and leaves).

The average root starch yield (RSY) ranged from 5.4 to 11.1 t ha^{-1} with an average of 9.4 t ha^{-1} in pruned plants, and from 11.2 to 21.1 t ha^{-1} with an average of 15.8 t ha^{-1} in unpruned plants. Pruning management led to an average RSY loss of 6.4 t ha^{-1} (Table 3). Among the clones evaluated, 330/09 presented a higher average RSY in both management systems. The mean, under pruning management, was statistically similar to those of clones 09 and 359/09 (Table 3).

The RSY obtained in the present study revealed that the clones evaluated for starch production, are good options for cultivation, with average yields higher than the 8.7 t ha^{-1} yield reported by Vieira et al. (2015a), but similar to the 10.1 t ha^{-1} yield reported by Vieira et al. (2015b) when evaluating industry cassava genotypes under similar management regimes in the same region. The reduction in RSY is caused by the expenditure of energy stored in the tuberous roots of cassava, during the regrowth and formation of new aerial parts (OLIVEIRA et al., 2010; ANDRADE et al., 2011).

The overall average green mass yield of aerial parts (GMY) was 12.6 t ha^{-1} with pruning (range: 8.3 to 17.1 t ha^{-1}) and 47.1 t ha^{-1} without pruning (range: 35.5 to 71.2 t ha^{-1}) (Table 3). Clone 330/09 presented the highest average GMY, both with and without pruning management. With pruning management, the GMY was statistically similar to clone 09 (Table 3). On average, a 73% reduction in GMY occurred due to pruning management, with the most significant reduction (77.2%) observed for clone 117/09. This reduction can be explained by the higher accumulation of cellulose in the stems of pruned plants compared to the stems of unpruned plants (OLIVEIRA et al., 2010).

In similar experiments with pruning at 12 months and harvesting at 18 months after planting, Vieira et al. (2015b) reported GMY ranging from 13.9 to 51.7 t ha^{-1} in 12 cassava genotypes and Fernandes et al. (2016) reported GMY ranging from 17.2 to 41.0 t ha^{-1} among eight clones studied, both higher than those reported in the present study. In turn, Vieira et al. (2015a) observed an average GMY ranging from 9.5 to 49.1 t ha^{-1} in unpruned cassava plants after 18 months, lower than those reported in the present study.

The overall average dry mass yield (DMY) of aerial parts was 2.8 t ha^{-1} (range: 2.1 to 3.8 t ha^{-1}) in pruned plants, and 14.1 t ha^{-1} (range: 11.1 to 20.4 t ha^{-1}) in unpruned plants (Table 3). Pruning resulted in a loss of 11.3 t ha^{-1} DMY of the aerial parts. The clones did not differ in terms of DMY with the pruning treatment, while without pruning clone 330/09 displayed the highest DMY (20.4 t ha^{-1}) compared to the others. The decrease in DMY after pruning is a direct result of the lower accumulation of lignin in the stems of pruned plants (OLIVEIRA et al., 2010), due to the short time between pruning and harvesting in pruned plots (6 months),

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compared to the period between planting and harvesting in unpruned plots (18 months). Fernandes et al. (2016) found DMY values ranging from 3.7 to 8.5 t ha^{-1} in pruned plants at 12 months after planting in crops at 18 months after planting. On the other hand, Hue et al. (2012) reported averages of 4.5 to 5.8 t ha^{-1} for DMY of aerial parts harvested at nine months after planting.

Average crude protein yields (CPY) of the aerial parts ranged from 0.4 to 0.6 t ha^{-1}, with an average of 0.5 t ha^{-1} in pruned plants, and from 0.7 to 1.6 t ha^{-1}, with an average of 1.1 t ha^{-1} in unpruned plants (Table 3). There was an average reduction of 0.6 t ha^{-1} in the CPY after the pruning treatment. This reduction was expected due to the marked decrease in the yield of the green mass of the aerial parts caused by pruning.

The clones did not differ in CPY among pruned plants, while among the unpruned plants the highest average CPY was found in the clone 330/09. The CPY values obtained in this study among non-pruned cassava plants were higher than those reported by Gómez et al. (2016) who obtained yields ranging from 0.44 to 0.9 t ha^{-1}, but were similar to those reported by Ventura & Pulgar (1990) with CPY ranging from 1.2 to 1.6 t ha^{-1}.

The percentage of root starch (RS) ranged from 26.2 to 32.9%, with an average of 28.8% among pruned plants, and from 33.1 to 35.4%, with an average of 34.6% among unpruned plants. Pruning resulted in a 5.8% reduction in RS (Table 4). RS was directly affected by the consumption of carbohydrates by the plant during the regrowth of the shoot after pruning management (OLIVEIRA et al., 2010) and also by the accumulation of gases in the cells of the cassava reserve roots in spaces generated by starch consumption during the development of new aerial parts (stems, petioles, and leaves) after pruning (MAEDA & DIP, 2000).

The RS content of clone 359/09 with pruning was significantly higher than that of the other clones. Without pruning, clone 359/09 showed statistically similar RS to clones 09 and 330/09 and a higher RS than clone 117/09. These results were similar to those obtained by Vieira et al. (2015b) in industrial cassava genotypes in the same region, with RS ranging from 27.5 to 33.1% with pruning, and higher than those obtained by Vieira et al. (2015a) in cassava accessions without pruning, ranging from 23.85 to 31.66%.

The average percentage of the dry matter of the aerial parts (DM) was 23.1% in pruned plants (range: 22.0 to 25.5%), and 30.4% (range: 27.9 to 33.8%) in unpruned plants. Pruning led to a reduction of 7.3% for DM (Table 4). This reduction is due to pruned plants presenting more green stems with a higher moisture content, and consequently lower percentages of dry matter. The mean DM of clone 117/09 was statistically higher than those of the other clones evaluated, both with (25.5%), and without (33.8 %) pruning.

The results obtained in this study are similar to those reported in other studies (FERNANDES et al., 2016; SALLES et al., 2016; HUE et al., 2012; MOREIRA et al., 2017; PEREIRA et al., 2017) for cassava DM, with values between 21.2 and 30%, and within the values suggested by Fluck et al. (2017) for good conservation of the aerial part of cassava in the form of silage.

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Table 4. Comparison of mean nutritional quality variables of the aerial parts in percentage (%), evaluated in four cassava clones for the flour and starch industry (C), harvested at 18 months after planting, in two management systems (MS), with (P) and without (WP) aerial part pruning at 12 months after planting.

Clone	RS*		DM		CP		NDF		ADF		IVDDM	
	P	WP	P	WP	P	WP	P	WP	P	WP	P	WP
Clone 9	28.0 Bb**	35.1 Aab	22.1 Bc	27.9 Ac	12.4 Ac	5.3 Bb	65.9 Aa	70.4 Aa	46.0 Ba	53.0 Aa	37.1 Ab	31.9 Bb
Clone 117/09	27.9 Bb	33.1 Ab	25.5 Ba	33.8 Aa	22.0 Aa	9.7 Ba	51.7 Ab	62.3 Ab	35.9 Bb	43.7 Ab	44.9 Aa	41.4 Aa
Clone 330/09	26.2 Bc	35.0 Aab	22.0 Bc	28.6 Ac	16.4 Ab	7.7 Bab	61.7 Aa	67.4 Aab	42.4 Ba	51.2 Aa	42.0 Ab	32.7 Bb
Clone 359/09	32.9 Ba	35.4 Aa	22.7 Bb	31.3 Ab	24.1 Aa	10.3 Ba	46.5 Ab	66.4 Aab	32.7 Bb	46.7 Ab	44.8 Aa	38.1 Ba
Means	28.8 B	34.6 A	23.1 B	30.4 A	18.7 A	8.2 B	56.5 B	66.6 A	39.3 B	48.6 A	42.2 A	36.0 B

*RS = root starch; DM = dry matter of aerial part; CP = crude protein of aerial part; NDF = neutral detergent fiber of the aerial part; ADF = acid detergent fiber of the aerial part; IVDDM = *In vitro* digestibility of dry matter of the aerial part.

***Means followed by the same uppercase horizontally and lowercase vertically belong to the same group, at 5 % significance, by the Tukey test.

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The average percentage of crude protein (CP) of aerial parts was 18.7% (range: 12.4 to 24.1%) in pruned plants, and 8.2 % (range: 5.3 to 10.3%) in unpruned plants (Table 4). A 10.5% increase was detected in the protein content in the total aerial parts of pruned plants, which is attractive as an option for animal feed. The higher mean CP was a direct result of the lower lignification of the stems of pruned plants, and of the higher retention of leaves and petioles compared to the unpruned plants.

The highest CP values were recorded in the aerial part of clones 117/09 and 359/09 in pruned plants. In unpruned plants the highest CP levels were recorded in clones 359/09, 117/09, and 330/09. In general, all clones presented CP above 7% in the aerial part, which is considered the minimum limit for the adequate development of rumen bacteria for good fermentation to occur (VAN SOEST, 1994). Moreover, the average values reported in the present study are much higher than those reported by Fernandes et al. (2016) when evaluating cassava genotypes under similar pruning management, and higher than those reported by Dantas et al. (2010), who evaluated only the upper third of the cassava shoot without pruning management. This suggests that both the proposed management and the tested accessions are promising for future use in animal feed. It is also important to highlight that the average CP under pruning management of clones 359/09, 117/09, and 330/09 were an order of magnitude higher than that reported for shoot silage by Fluck et al. (2017).

The overall average percentage of neutral detergent fiber (NDF) was 56.5% (range: 46.5 to 65.9%) in pruned plants, and 66.6% (range: 62.3 to 70.4%) in unpruned plants (Table 4). A 10.1% reduction in the NDF was observed after pruning. The ratio of NDF of a fodder is important because it is related to maximum dry matter intake (MERTENS, 1994). Thus, plants with higher NDF content would have lower consumption potential. This conferred a quality gain for the plants submitted to pruning. Clones 117/09 and 359/09 presented lower NDF values, both among pruned and unpruned plants. The average NDF of the clones submitted to pruning in the present study were lower than the average NDF reported for silage of the cassava shoot (FLUCK et al. 2017).

ADF values ranged from 32.7 to 46.0% in pruned plants (average: 39.3%), and from 43.7 to 53.0% in unpruned plants (average: 48.6%). A 9.3% reduction was observed in the ADF due to pruning (Table 4). The percentage of ADF in clones 117/09 and 359/09 was significantly lower than that of other clones tested, both with and without pruning, indicating that their aerial parts are potentially more digestible (VAN SOEST, 1994). The ADF values obtained in both management scenarios were lower than those reported in the literature in experiments under pruning conditions by Fernandes et al. (2016), and in conditions without pruning by Dantas et al. (2010), indicating the genetic superiority of the clones tested for use in animal feed. It also suggests that pruning management can improve the nutritional quality of the aerial part of cassava.

Clones 117/09 and 359/09 presented

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higher IVDDM values compared to clones 09 and 330/09, both with and without pruning. IVDDM values ranged from 37.1 to 44.9% in pruned plants and from 31.9 to 41.4% in unpruned plants. IVDDM is an important parameter in the evaluation of the nutritional value of ruminant feed, since it presents a high correlation with *in vivo* digestibility (TILLEY & TERRY, 1963), and consequently with the best use by the animals of the nutrients contained in the feed.

IVDDM decreased by 15% on average with pruning the plant. The IVDDM data obtained in the present study are close to those reported by Fernandes et al. (2016) who found values of 37.97, 42.27, 43.78, and 44.30% of IVDDM for cassava clones harvested at six months after pruning at twelve months of growth. Similar results were also reported by Ferreira et al. (2009) with 43.03% of IVDDM and by Salles et al. (2016), with 44.12% of IVDDM for the aerial part of cassava plants harvested at twelve months after planting. Note that the clones that presented the highest IVDDM values (117/09 and 359/09) also presented the lowest values of both NDF and ADF, and the highest CP. In general, the ADF is negatively correlated with food digestibility (VAN SOEST, 1994). As the physiological age of the plant progresses, the percentages of cellulose, hemicellulose, and lignin increase, reducing the proportion of potentially digestible nutrients (soluble carbohydrates, proteins, minerals, and vitamins), resulting in a sharp drop in digestibility (VAN SOEST, 1994).

The results indicate that the management of cassava by pruning at 12 months after planting is an important strategy which considerably improves the nutritional value of the aerial part of cassava for animal feed, despite the reduction in root yield. The improvement in nutritional quality can be verified by the increased protein in shoots (CP) and the decrease in NDF and ADF after pruning (Table 4). The improvement in the nutritional quality of the aerial parts with pruning, compared to without pruning, can be explained by the fact that the aerial parts without pruning are much more lignified (at 18 months) than the regrowth from the pruned parts which are younger (six months) and more herbaceous (OLIVEIRA et al., 2010). In addition, pruning management (total removal of the aerial part of the plant) stimulates a hormonal rearrangement that causes the breakdown of apical dominance. It also stimulates the simultaneous formation of several tender stems which are less lignified and have a large amount of leaves and petioles (OLIVEIRA et al., 2010).

Among the clones tested in the management with pruning, clones 117/09 and 359/09 performed the best in terms of CP and IVDDM and are therefore a viable option for cassava cultivation in the Cerrado region of Brazil for animal feed using the aerial parts.

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