CHEMICAL-BROMATOLOGICAL QUALITY AND PRODUCTIVITY OF PEANUT GENOTYPES (*ARACHIS HIPOGAEA* L.)

QUALIDADE QUÍMICO-BROMATOLÓGICA E PRODUTIVIDADE DE GENÓTIPOS DE AMENDOIM (ARACHIS HIPOGAEA L.)

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ABSTRACT: Peanuts (*Arachis hipogaea* L.) have a great potential for grain production for feed and forage production, being an alternative for producers, as it grows a double product. Grains have excellent quality and contain a greater amount of protein with which to feed the herd. The present study is a cut-off effect study with an application of Stimulate® phytostimulant to determine grain quality and peanut fodder genotype. In the first planting, the peanuts were cultivated under field conditions in a randomized block design in a 4 × 2 × 2 subplot scheme, with four cultivars and two cutting periods, with or without phytostimulant. The cultivars were IAC Tatu ST and Caiana (vertical growth), as well as non-flowering and harvesting seeds. For the second planting, a randomized block design was used with a subplot scheme of 3 × 2 × 2, with three cultivars and 2 cutting periods, with or without phytostimulant. The cultivars were IAC Tatu ST and Caiana (vertical growth) and IAC 503 (prostrate growth). All cultivars contained a high percentage of hay protein in the two plantings. The cultivar IAC 503 was efficient in the production of protein and fiber in the grains in both plantings, demonstrated the potential of protein for animal supplementation, and also presented high grain yield in the summer planting.

KEYWORDS: Forage: Cut. Protein. Fiber. Summer.

INTRODUCTION

Peanuts (*Arachis hipogaea* L.) are a world-class crop, being the world's largest producer of oil, as well as a raw material for the manufacture of chocolates, salads, sweets, and protein for the formulation of animal feed. Currently, Brazil has a peanut crop of approximately 129 thousand hectares, with a total estimated production of 411.3 thousand tons in the 2016/2017 harvest, an average of 1,800 kg ha^{-1}. In the northeast, peanut cultivation occupies a total area of approximately 6.4 thousand hectares, with an average of 700 kg ha^{-1} (CONAB, 2017).

The increase in the production of peanuts can be improved through the use of cultivars that have enhanced characteristics, such as drought tolerance, high yield in dense plantings, resistance to pests, and high production of flour and grains, such as cultivar IAC 886 that displays increased productivity in soil and disease resistance, and produces approximately 7,000 kg ha^{-1} of grains in the pod (ROMANINI JUNIOR, 2007). However, there are a limited number of studies on cultivated varieties and varieties of feed peanuts on the market that determine their nutritional value, and thus define potentialities for animal and human foods. Work done with forage peanuts (*Arachis pintoi* cv. Belmonte) by Paulino et al. (2008) revealed that an aerial population at 60 and 90 days of age had values of protein varying from 26.6% and 22.9% in dry forage matter, respectively. These values show the potential of peanuts as a protein source and demonstrate a relationship between the vegetative and reproductive period of the crop, because the latter can interfere with woody production and bromatological quality (GOBBI et al., 2012).

The use of new technologies can boost the growth and production of peanuts. The use of phytostimulants can improve growth and roots, as well as promote increased production of grains. Phytostimulants, dependent on the composition, concentration, and proportion of substances and nutrients (i.e., auxin, gibberellin, and cytokinin), increase plant growth and volume, stimulate cellular processing capacity, and increase water and nutrient production capacity by plants. The use of Stimulate® phytostimulant increased the efficiency

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of peanut plants, favoring the translocation of photoassimilates for the development of reproductive structures (CATO, 2006).

The research on the determination of cultivars, cut-off periods, and use of phytostimulants on the peanut crops under the edaphoclimatic conditions of Garanhuns-PE City, in a large dairy basin of the Southern Agreste of Pernambuco State, is important for the production of crude protein to improve herd milk and produce grains. Therefore, the present study aimed to evaluate the cut-off effect with an application of Stimulate® phytostimulant to determine grain quality and peanut fodder genotype.

MATERIAL AND METHODS

The experiment was conducted in the agricultural years 2016/2018. Two experiments were carried out in Garanhuns-Pernambuco (Southern Agreste), at 08°53′19″S, 36°37′34″W and 958 m above sea level. The soil of the experimental area is classified as Yellow-clay-sandy Argosol (EMBRAPA, 2013). In the region, the predominant climate is the As' type, which is equivalent to a tropical climate with a dry summer season and rainy winter, according to the Köeppen classification. The average annual precipitation is 1,038 mm, which is concentrated in the months of May and June, and the average annual temperature is 20 °C. Relative humidity ranges from 75 to 83% (INMET, 2017). The first experiment was implemented during the summer, crops were planted in November 2016 and removed from the field in March 2017. The second experiment was carried out in the winter, crops were planted in June 2017 and removed from the field in November 2017. The climatic data regarding the rainfall and temperature during the months of the experiment are presented in Figure 1-A and 1-B, respectively.

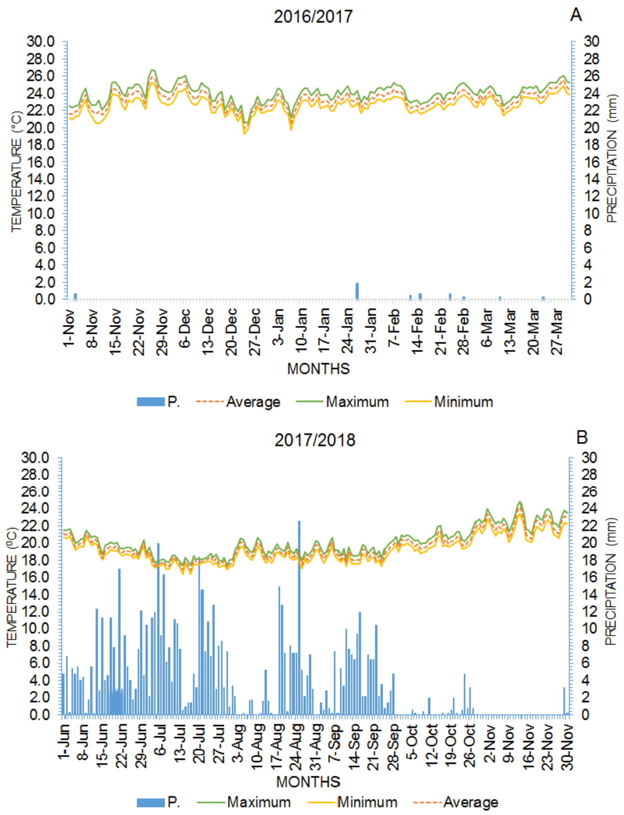

Figure 1. Climatic data from the 2016/2017 summer planting (A) and climatic data from the 2016/2017 winter planting (B).

Fertilization was conducted according to the recommendations of the state of Pernambuco, developed by the Institute Agronomic in Pernambuco (IPA). Fertilization was conducted before planting in the amount of 20 kg ha^{-1} nitrogen, 40 kg ha^{-1} phosphorus, and 20 kg ha^{-1} potassium (CAVALCANTI, 2008). Nitrogen was in the form of urea following the minimum recommendation for peanut culture.

For the first planting, a randomized block design was used with a 4 × 2 × 2 subplot scheme, with four cultivars, with and without phytostimulant, and two cutting periods. The cultivars were IAC Tatu ST and Caiana (vertical growth) and IAC 886 and IAC 503 (prostrate growth). Cutting times were at flowering and harvest and plots consisted of those with and without the commercially available *Stimulate* ® phytostimulant. The first experiment contained four blocks with an area of 44.8 m^2 each, totaling an area of 179.2 m^2. The cut to obtain phytomass of the aerial parts was also conducted during the flowering of the crop to 15 cm from the soil with aid of a 50 cm metric ruler and pruning shears. For the second planting, a randomized block design was used in a 3 × 2 × 2 subplot scheme, with three cultivars, with or without phytostimulant and two cutting periods. The cultivars were IAC Tatu ST and Caiana (vertical growth) and IAC 503 (prostrate growth), and the cutting times were at flowering and harvest, with and without use of commercial Stimulate® phytostimulant. The experiment consisted of four blocks with an area of 35.2 m^2 each, totaling an area of 140.8 m^2. The seeds were purchased from the Agronomic Institute of Campinas (IAC). The phytostimulant was applied to the seeds at a dosage of 750 mL ha^{-1} 16 hours before planting (in the afternoon of the day prior to planting) of the seeds. For the treatment without phytostimulant, distilled water was applied in the same amount at the same time.

The chemical analyses consisted of dry matter (DM), mineral matter (MM), and crude protein (CP) using the methodologies described by Detmann et al. (FLND), as well as acid detergent fiber (FAD) determined according to the recommendation of Van Soest (1994).

To determine the MM or ash, 2 g of dry hay and grain samples were placed in crucibles, oven dried at 105 °C for two hours, and then cooled for 30 minutes in a desiccator and weighed. Afterwards, they were taken to a muffle (600 °C) to burn the material for four hours and were then weighed (DETMANN et al., 2012).

For crude leaf protein (CLP), 0.1 g ground subsamples were analyzed from leaf samples of each replicate. Ground peanut hay samples were packed in micro Kjeldahl test tubes with 2 g of a 10: 1 catalytic mixture (sodium sulfate and copper sulfate) and 3 ml of pure sulfuric acid for analysis (PA). These tubes were heated in a digester block for the digestion phase of the organic matter. Heating was gradual and when the temperature reached 350 °C, it was held constant for 2 more hours. After obtaining the digested material, the distillation phase of the released ammonia was initiated and after the reaction with 500 g L^{-1} sodium hydroxide, it was collected in a 4% boric acid solution. The titration was performed in a standard solution of 0.02 N hydrochloric acid. A 99.7% nitrogen recovery was obtained for this procedure. For the calculation of the conversion of nitrogen to protein, the nitrogen content was multiplied by a factor of 6.25. Thus, the crude protein content of the leaf (PBF) and crude protein of grain were obtained on a dry matter basis according to the Kjeldahl method (984.13) as described in the analytical standards of Official Methods of Analysis (AOAC).

For the evaluation of FLND, a 1 g sample was weighed for each of two replicates, and the 1 g samples were packed in properly identified and subsequently sealed non-woven bags (TNT). The neutral detergent solution was added to packed TNT in specific pots for the procedure, which were then autoclaved at a temperature of 111 °C for 40 minutes. Subsequently, they were removed from the autoclave, and the bags were washed in distilled water at a temperature of 100 °C. This washing procedure was conducted until the neutral detergent solution was completely removed. To finish the samples, they were washed with acetone to remove any residue and were placed in a drying oven for 16 hours at 105 °C until they reached a constant weight. After drying, the bags were packed in a desiccator and weighed in an analytical balance to determine the residue and the calculated difference was the percentage of FLND (VAN SOEST, 1994). For the evaluation of fiber and acid detergent of the leaf (FLAD), the results were obtained using the same samples as for the FLN evaluation. The samples were conditioned in pots and subsequently added to the acid detergent solution, following the steps described for the previous evaluation (VAN SOEST, 1994). During the harvest, the grain yield (PROD) was evaluated through the average yield of the treatments and transformed into t ha^{-1}.

The experimental design was a randomized block with a 4 × 2 × 2 subplot scheme for the first planting, having four cultivars and two cutting seasons, with or without a phytostimulant. In the second planting, the same design was used in a 3 × 2 × 2 subplot scheme, using 3 cultivars and two cutting seasons, with or without phytostimulant. For statistical analysis, the phytostimulant factor was isolated. The data were analyzed statistically using an analysis of variance (ANOVA) to investigate the significance of the differences of effects on chemical analysis of the cut plants. Significant differences were compared using the Tukey test with a 5% probability using SISVAR software.

RESULTS AND DISCUSSION

For leaf dry matter (LDM), all cultivars presented acceptable values, ranging from 88% to 91.9% (GOES et al., 2004). However, it was observed that in the summer planting (Figure 2A) the cultivars IAC 886, IAC 503, and Caiana, which did not undergo cutting, differed statistically from those that were cut at flowering. Ramos et al. (2004) reported that shoot dry mass evaluations were of great importance in evaluating the development of plants, ensuring their establishment in the field. The ideal time for hay production was observed when there was the highest dry matter content; approximately 70 to 100 days of growth would be the ideal season (NASCIMENTO, 2006).

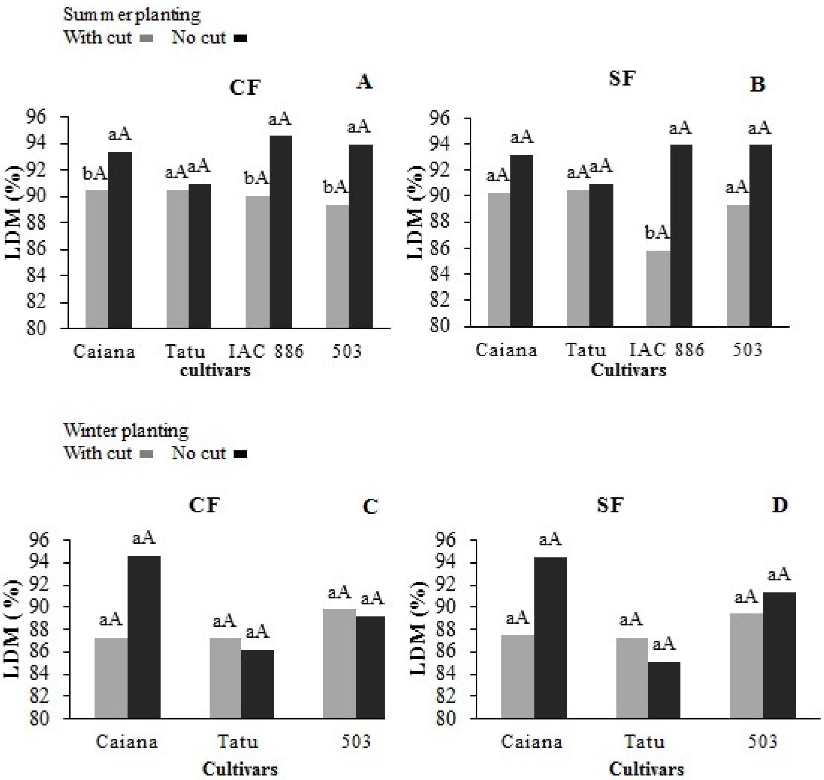

Figure 2. Leaf dry matter (LDM) of peanut cultivars submitted to the application of phytostimulant (A) and in the absence of phytostimulant (B) with cut and uncut in summer. Leaf dry matter (LDM) of peanut cultivars submitted to the application of phytostimulant (C) and in the absence of phytostimulant (D) with cut and uncut in winter.
Lowercase letters evaluate cuts within cultivars.
Capital letters evaluate cultivars within cuts.

The LDM content in both summer and winter averaged 90%, with no influence of climatic conditions; dry matter production decreased with the reduction of radiation levels. However, it is worth noting that the cultivar Caiana in the winter when the cut is not applied presented higher percentages in relation to the other cultivars, with the LDM content being around 94% and remaining stable when compared to the summer period. Silva (2011), when studying the nutritional potential of the peanut crop in Bahia, obtained a mean of 91.9% dry matter in the leaf. In this case, all the cultivars studied were good alternatives for use in regions where precipitation is above the expected normal means, as well as at times of rainfall occurrence in a given region. It should be noted that cultivars IAC 886 and IAC 503 are adapted to the southeast region, and in the present study they presented a percentage similar to that found by Fernandes et al. (2011) in the state of São Paulo, with an average of 90% LDM.

While investigating the percentage of leaf mineral matter (LMM) in the summer planting (Figure 3A and 3B), it was observed that the Caiana cultivar was statistically different ($P < 5\%$) when evaluating the cuts within the groups both with and without phytostimulant, where the cultivar Caiana that did not suffer a cut presented an average of 13.6%.

In the winter planting, the cultivars did not experience much influence from the phytostimulant, but the cultivar Caiana when undergoing the cut, stood out from the other cultivars. This result could be related to the fact that the Caiana cultivar during the two plantings did not suffer from the high temperature, high precipitation, or low solar irradiation. It presented vigorous growth and vegetative quality, without obvious effects of biotic and abiotic conditions, resulting in the subsequent increase in the concentration of the total mineral content. This result proves that fodder produced during the growing season had a lower percentage of mineral matter compared to that of the plant in full development. When the cultivars were cut in the summer there was a reduction in LMM, which may be related to the use of reserves of these minerals by the plant to regenerate and resume its growth.

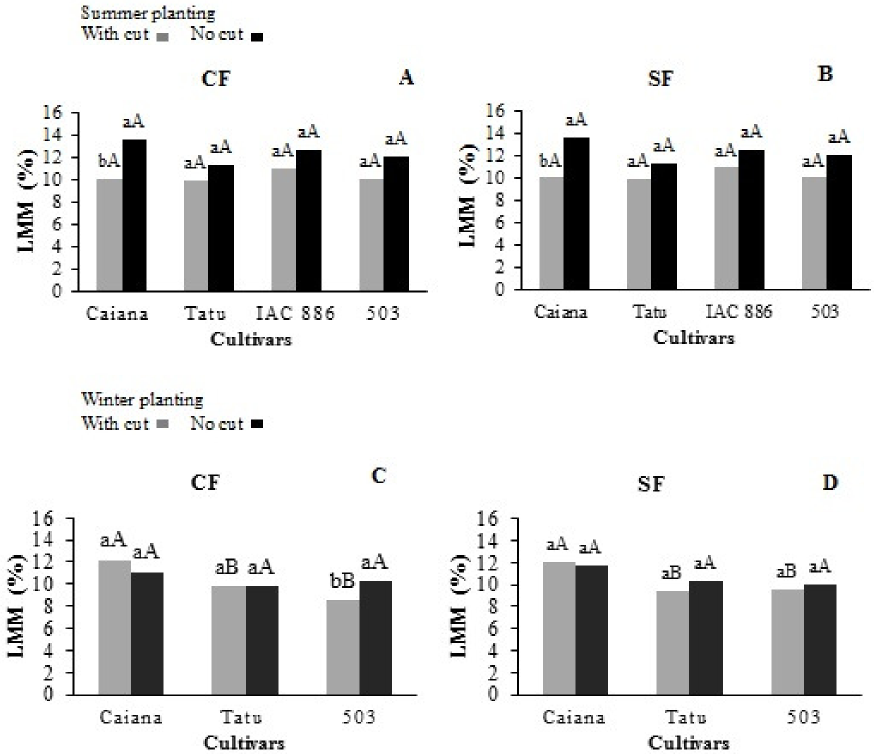

Figure 3. Leaf mineral matter (LMM) of peanut cultivars submitted to the application of phytostimulant (A) and in the absence of phytostimulant (B) with cut and uncut in the summer. Leaf mineral matter (LMM) of peanut cultivars submitted to the application of phytostimulant (C) and in the absence of phytostimulant (B) with cut and uncut in winter.
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Regarding leaf crude protein content (CLP) in the summer planting (Figure 4A and 4B) and winter (Figure 4C and 4D) all treatments obtained similar results, but there was a statistical difference for the cut, being approximately 50% greater than the treatment that did not receive the cut. These results were directly related to the values of dry matter (Figure 1), where values were inversely proportional to those of protein. Oliveira (1987) testing soybean cutting times at 60, 75, and 90 days after emergence for forage production, concluded that the later cut increased the yield of dry matter, but decreased its crude protein yield for soybean shoots. We observed that the crude protein content decreased with increasing forage age, according to Van Soest (1994), who cites the decline in plant nutrients as age increases. The values observed demonstrated the high protein content of this legume, characterizing it as a good choice for forage in ruminant feed, and it is an alternative to concentrated feed, having high energy value.

The low levels of CLP found in the plant at the end of the cycle were due to the fact that the plants were in advanced stages of development and had a low leaf: stem ratio with a mean of 10% of PB (CANTO et al., 998). In contrast, the high levels of CLP found in this research during the flowering cut were related to the high nitrogen content accumulated in this period.

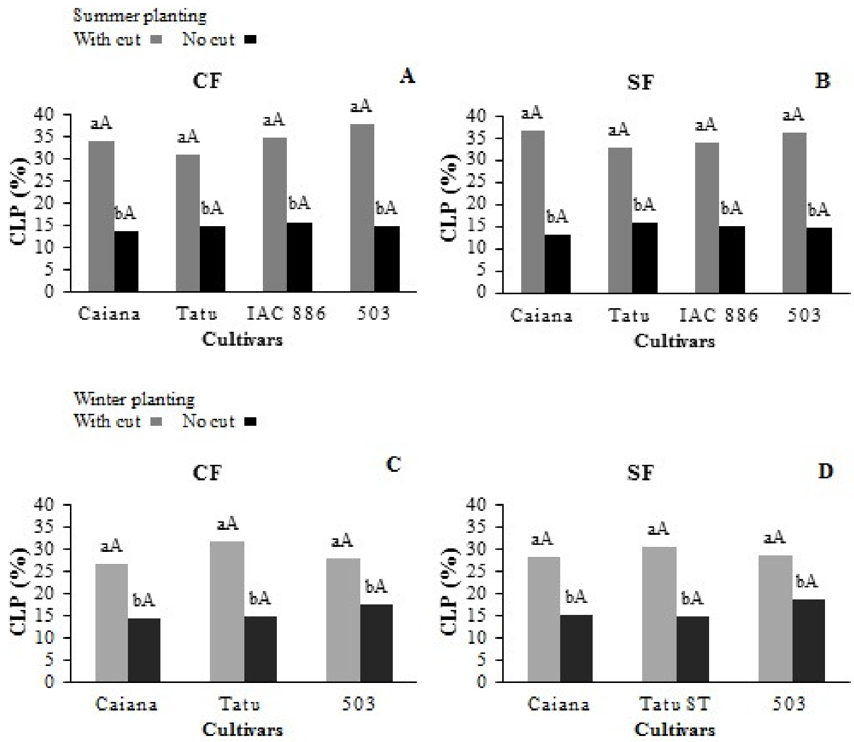

Figure 4. Crude leaf protein (CLP) of peanut cultivars submitted to phytostimulant application (A) and in the absence of phytostimulant (B) with cut and uncut in the summer. Crude leaf protein (CLP) of peanut cultivars submitted to the application of phytostimulant (C) and in the absence of phytostimulant (D) with cut and uncut in winter.

Lowercase letters evaluate cuts within cultivars.

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This research demonstrates the potential of the species *Arachis hypogaea*, having a mean of CLP 35% for all cultivars. These data corroborate the premise that this species produces grains but also is a good protein source when compared to forage peanuts *Arachis pintoi*, which were developed especially for animal feed. According to Teixeira et al. (2010), this species has an average protein content of 25%, lower than that obtained in this research. The recommendation of hay production for peanuts in the vegetative period has been researched in several studies, where cut intervals at flowering or in the middle of the crop cycle directly influenced the production of protein, as well as fiber.

Forage protein is a nutrient of fundamental importance in ruminant nutrition, because it provides the nitrogen necessary for reproduction of the bacteria responsible for the fermentative process that occurs in the rumen. Therefore, for proper breeding and bacterial activity in the rumen, it is necessary for the diet to contain a minimum of 8% crude protein. However, peanut cultivation has higher levels than the minimum required, obtaining a higher digestibility when compared to tropical grasses (DETMANN et al., 2012). Much experimental data highlight the improvement of animal production promoted by the presence of the legume either by direct participation of this plant in the diet of the animal or by the indirect effects related to its increased nitrogen contribution to the pasture ecosystem.

For FLND (Figures 5A and 5B), in the summer planting, the Caiana and IAC 503 cultivars showed statistical differences when they did not receive the cut, with a mean of 53% and 59%, respectively. The cultivar Caiana in the absence of phytostimulant, presenting an average of 60% (figure 5B). In the winter planting, the FLND content was reduced in relation to the summer planting. There was no influence of the phytostimulant, but the cultivars that were not cut, Caiana (Figure 5C) and Caiana and Tatu (Figure 5D), with a mean of 43, 41 and 46%, respectively, were statistically different in relative to those that were cut.

Fiber is an exclusively nutritional item comprising indigestible or slow indigestion compounds that occupy space in the gastrointestinal tract of animals (UNDERSANDER et al., 1993). These results are related to the content of phenolic compounds, such as lignin, which increase with plant age, making forage consumption and digestibility difficult, as they form part of the indigestible fraction contained in the plant cell wall (DETMANN, 2010). Values similar to those from this research are described in studies with peanuts, where 45% of NDF was found at 70 days of age (FERNANDES et al., 2011). The values of this study also corroborate an average percentage of 52.8% of NDN for the entire *Arachis pintoi* plant in different grazing strata (PARIS et al., 2008).

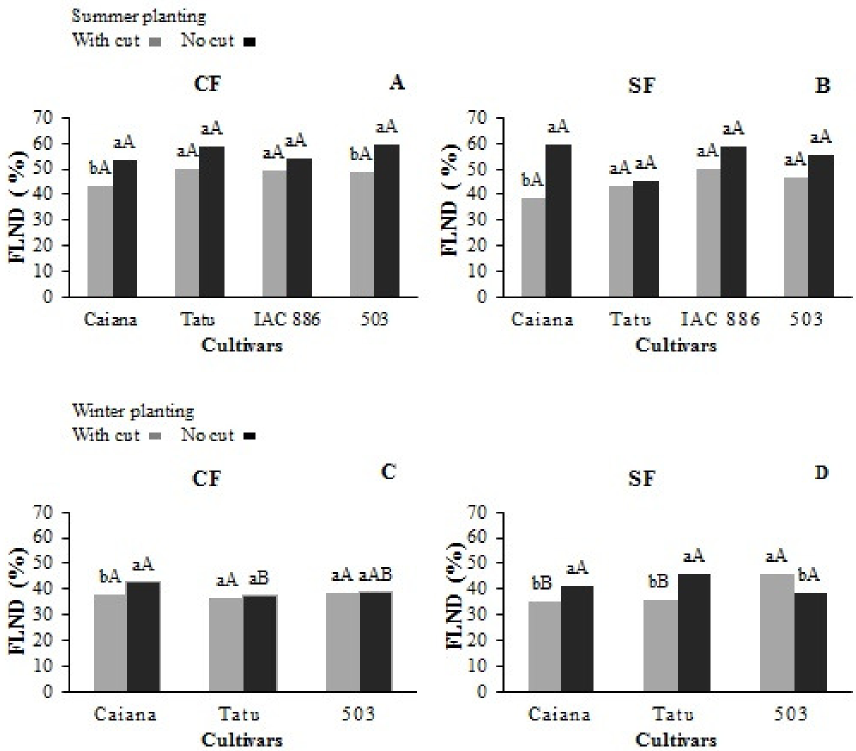

Figure 5. Fiber and leaf neutral detergent (FLND) of peanut cultivars submitted to the application of phytostimulant (A) and in the absence of phytostimulant (B) with cut and uncut in the summer. Fiber and leaf neutral detergent (FLND) of peanut cultivars submitted to the application of phytostimulant (C) and in the absence of phytostimulant (D) with cut and uncut in winter.
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Low fiber content in forage indicates higher consumption because of the lower physical filling of the rumen, and also higher digestibility because this fraction has most of the components that are not digested (LADEIRA et al., 2002). Therefore, it is necessary to know how to choose the best cutting age such that its supply to the animals does not limit consumption. The minimum level of NDF in the ruminant diet should be around 25% of dry matter for the normal functioning of the rumen. On the other hand, values higher than 60% are negatively correlated with forage intake, i.e., the higher the NDF concentration in the forage, the lower the DM intake (MERTENS, 1994).

In relation to the FLAD, there was no statistical difference between the cultivars in both the summer and winter planting, but when evaluating the effect of the cuts on each cultivar, it was observed that the cultivar IAC 503 when suffering the cut presented an average of 28% (Figure 6A), as well as the Caiana cultivar, but in an analogous result, it had a positive influence when not being cut, with an average of 27% FLAD. In general, in the summer planting the cultivars obtained an average of 26% for all the cultivars, and 20% in the winter.

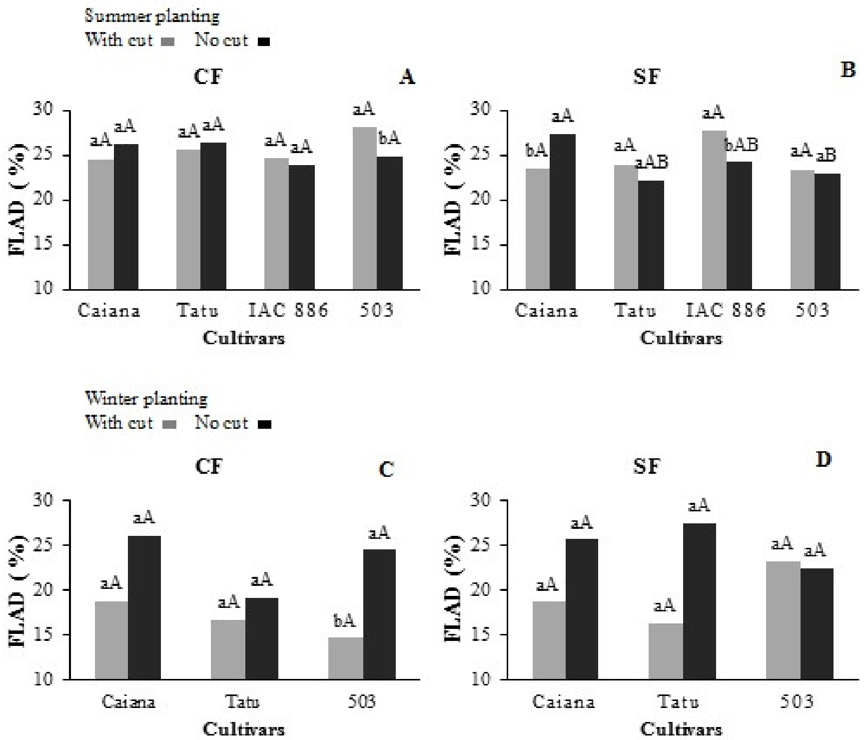

Figure 6. Fiber and leaf acid detergent (FLAD) of peanut cultivars submitted to the application of phytostimulant (A) and in the absence of phytostimulant (B) with cut and uncut in the summer. Fiber and leaf acid detergent (FLAD) of peanut cultivars submitted to the application of phytostimulant (C) and in the absence of phytostimulant (D) with cut and uncut in winter.
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The high percentage of FDA is a negative factor for the quality of forage, reducing its digestibility because the nutrients remain attached to the fiber and therefore little is available to the animals (VAN SOEST, 1994). Thus, the FDA indicates the percentage of highly indigestible material present in the forage. Low FDN values mean higher energy and high digestibility, i.e., higher forage energy, whereas low FDN forage has higher consumption rates than those with high FDA (MOURA et al., 2011).

The cultivars studied can be considered highly digestible when compared to values obtained by Teixeira et al. (2010), that when studying leguminous forage plants in northeastern Brazil verified that the peanut presents carbohydrates, celluloses, and hemicellulose contents around 16% and lignin at 9%, and in general presented 26% FDA, a value similar to averages obtained in this research. However, peanut cultivars were found to have an average of 58% (PARIS et al., 2008) and 45% (MOURA et al., 2011). It is important to note that the bromatological value of the crop may vary between regions and between cultivars.

While investigating the productivity (PROD) of peanut cultivars under phytostimulating, cutting effects, and different planting times, it was observed that for cuts within the cultivars, the IAC 886 and IAC 503 deferred significantly in the absence of cutting, with a means of 3.7 and 3.2 t ha^{-1}, respectively (Figure 7A). In the winter planting, the cultivars Caiana and Tatu presented higher values both in the absence and in the application of a phytostimulant with a mean of 1.3 t ha^{-1} (Figure 7C) and 1.3 t ha^{-1} (Figure 7D), respectively. Zanotto (1993), when evaluating the production of peanut-erect genotypes, found a mean of 3.3 t ha^{-1} and 2.8 t ha^{-1} for the cultivars Botutatu and Tatu in winter, and in the summer the production was reduced to 2.1 t ha^{-1} and 1.7 t ha^{-1} for Botutatu and Tatu, respectively, presenting similar results as ours.

The cultivars that were not cut showed higher productivity, both in summer and winter, but the high productivity in the summer and the reduction in the winter could be related to the climatic conditions that directly interfered with the development of the culture. It should be noted that, despite of this reduction in productivity in the winter period, the values obtained in this research, a mean of 1.3 t ha^{-1}, exceeded the average yield of 0.7 t ha^{-1} reported for the Northeast region (CONAB, 2017).

The high temperatures in the summer planting and the absence of the cut caused the cultivars to have more vigorous development, because when not receiving the cut they continued with their normal development, absorbing light energy and converting it at the photosynthetic rate, increasing the translocation of solutes to the production of grains (TAIZ and ZEIGER, 2006).

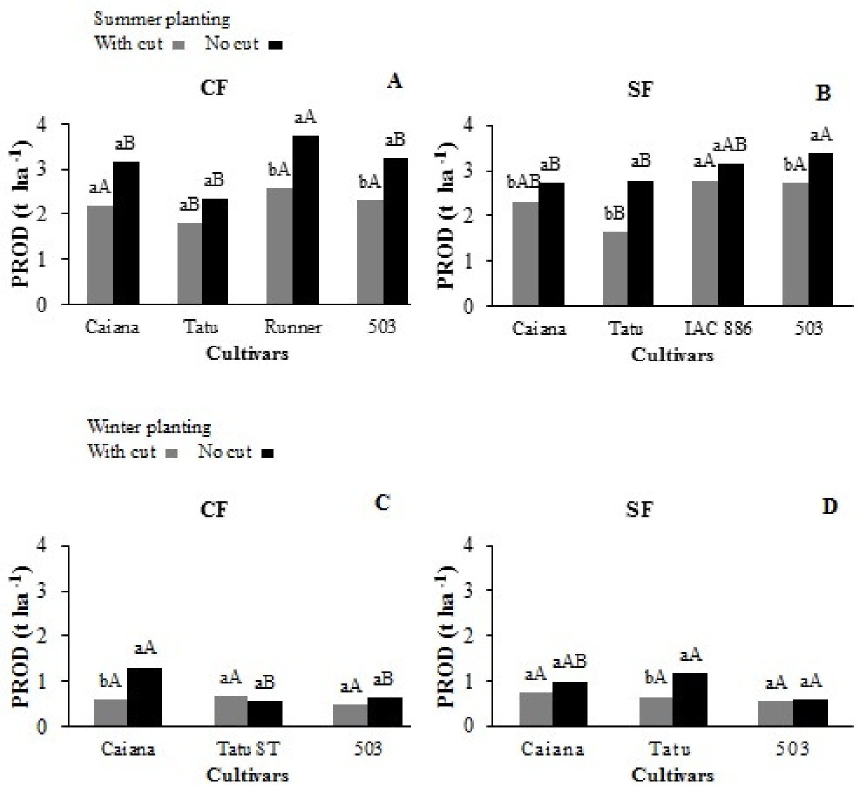

Figure 7. Productivity (PROD) of peanut cultivars submitted to the application of phytostimulant (A) and in the absence of phytostimulant (B) with cut and uncut in summer. Productivity (PROD) of peanut cultivars submitted to the application of phytostimulant (C) and in the absence of phytostimulant (D) with cut and uncut in winter.

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In agronomic terms, all the cultivars presented good productivity during the summer planting for the region but were below the average for the sowing season established by the agronomic institute of the field for the studied genotypes. The cultivars of low size had an average yield of 4 to 6 t ha^{-1} and cultivars of upright size around 3 to 4 t ha^{-1} for the State of São Paulo. Peixoto et al. (2008), when evaluating the production of the flat pod cultivar in the Bahia concave, presented an average of 1.6 t ha^{-1}. The values found in this research were lower than the 4.2 and 3.9 t ha^{-1} for the cultivars IAC 886 and IAC 503 (FACHIN et al., 2013). The values found in this research and the literature cited show that the productivity of the cultivars is influenced according to the region of Brazil, the purpose of the breeding program, the sowing season, and the management used.

CONCLUSIONS

The flowering cut is ideal for protein production in all cultivars

The levels of NDF and ADF were higher in plants that were not cut.

The cultivar IAC 503 is indicated for the production of protein, as well as fiber content in the two plantings, both with cutting, as well as in its absence, demonstrating that it can be an alternative item for feed in the northeast region. It also showed high productivity.

RESUMO: A cultura do amendoim (*Arachis hipogaea* L.) apresenta grande potencial para produção de grão para alimentação e produção de forragem, sendo uma alternativa para os produtores, produzindo a cultura com duplo propósito, grãos de excelente qualidade e significativa quantidade de feno para alimentação do rebanho. O objetivo desta pesquisa foi avaliar o efeito da época de corte com a aplicação do fitoestimulante *Stimulate*® sobre a qualidade do grão e forragem de genótipo de amendoim. No primeiro plantio o amendoim foi cultivado em condições de campo, em delineamento em blocos ao acaso, em esquema de subsubparcela de 4x2x2, sendo quatro cultivares, dois períodos de corte, com e sem fitoestimulante. As cultivares foram compostas de IAC Tatu ST e Caiana (crescimento vertical), IAC 886 e IAC 503 (crescimento prostrado) e as épocas de corte foram no florescimento e na colheita. Para o segundo plantio foi utilizado o delineamento em blocos ao acaso, em esquema de subsubparcela de 3x2x2 sendo três cultivares com e sem fitoestimulante e dois períodos de corte. As cultivares foram IAC Tatu ST e Caiana (crescimento vertical) e IAC 503 (crescimento prostrado). Todas as cultivares que receberam corte apresentaram alto percentual de proteína do feno nos dois plantios. A cultivar IAC 503, mostrou-se eficiente na produção de proteína e fibra nos grãos nos dois plantios, demonstraram potencial com fonte de proteína para suplementação animal, além de apresentar alta produtividade de grãos no plantio de verão.

PALAVRAS-CHAVE: Forragem. Corte. Proteína. Fibra. Verão.

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