Australian Journal of Basic and Applied Sciences, 10(8) April 2016, Pages: 97-105

AUSTRALIAN JOURNAL OF BASIC AND APPLIED SCIENCES

ISSN:1991-8178 EISSN: 2309-8414
Journal home page: www.ajbasweb.com

Agronomic Chemical and Anatomical Characteristics of Peanut Forage Submitted To Levels of Shade

[1]Freitas Nulciene Firmino de, [2]Medeiros Lucilene Tavares, [2]Sales Juliana de Fátima, [2]Vasconcelos Filho Sebastião Carvalho, [3]Rodrigues Arthur Almeida, [4]Rodrigues Douglas Almeida

[1]*Master in zootechnics, Federal Institute of Education, Science and technology Rio Verde, Goiás, Brazil*
[2]*Advisor, Course Professor Federal Institute of Education, Science and Technology Goiano - Campus Rio Verde, Brazil;*
[3]*Master in agricultural sciences, agronomy, Federal Institute of Education, Science and technology Goiano - campus Rio Verde, Brazil*
[4]*Environmental Engineer, University of Rio Verde – GO, Brazil*

Address For Correspondence:
Freitas Nulciene Firmino de, Master in zootechnics, Federal Institute of Education, Science and technology Rio Verde, Goiás, Brazil

ARTICLE INFO

Article history:
Received 12 February 2016
Accepted 18 March 2016
Available online 20 April 2016

Keywords:
Leaf anatomy, Arachis pintoi, epidermis, legumes, mesophyll

ABSTRACT

The agronomic, chemical, chemical detergent fiber (ADF) and anatomical charastics of forage *Arachis pintoi Amarillo* cultivar were evaluated. The plants were grown in pots and subjected to different levels of shade and two cut ages (60 and 120) days. The study was conducted the relatively recent introduction of *Arachis pintoi* cultivars in Brazilian pastures, as well as a certain lack of agronomic, bromatological and morphophysiological studies regarding the the nutritional quality of this forage. The DM levels linearly reduced with increasing shade levels, but increased due to the increase of the cut ages. There was a significant effects for interaction shade x cut age on thickness (μm) of the palisade parenchyma, spongy parenchyma and mesophyll, and there was linear reduction ($P < 0.01$), according to the shade levels, and a linear increase in thickness depending on the cut ages. The *in vitro* dry matter digestibility increased linearly with increasing shade levels.

INTRODUCTION

The effects of climate on the nutritional value of forage have been evaluated, as such climatic factors (light, humidity, and temperature) influence the nutritional quality of forage the most (VAN SOEST, 1994). Plants respond to irradiance levels through genetic adaptations and phenotypic plasticity, when plants are exposed to shade they can exert this plasticity, which occurs mainly during the growth and differentiation of assimilation organs, resulting in morphological, biochemical and histological alterations.

Generally these alterations are related to the increased uptake and utilization of incident light increasing the photosynthetic efficiency of the plant, a feature that limits growth in the shade (GOBBI *et al*., 2011).

Research evaluating the anatomical characteristics and their correlation with nutritional value has been developed over the years, but because they are scarce these demonstrate the importance of aggregating knowledge of plant anatomy to diverse nutritional assessments, correlating them (AKIN, *et al*., 1973; QUEIROZ *et al*., 2000).

The digestibility influences the use and the passage of food through the rumen, which in turn has a direct influence on voluntary feed intake and thus, in animal production. The leaf anatomy influences not only the fodder production, but also its nutritional value and animal performance. The plant tissues have potential for differentiated digestion, from which occurs the tissues proportion and nutritional value of forage grasses (BRITO *et al*., 1999).

To Cite This Article: Freitas Nulciene Firmino de, Medeiros Lucilene Tavares, Sales Juliana de Fátima, Vasconcelos Filho Sebastião Carvalho, Rodrigues Arthur Almeida, Rodrigues Douglas Almeida., Agronomic Chemical and Anatomical Characteristics of Peanut Forage Submitted To Levels of Shade. ***Aust. J. Basic & Appl. Sci.,*** *10(8): 97-105, 2016*

MATERIAL AND METHODS

The experiment was conducted in the field in an experimental area of the Beef Cattle Division of the Federal Institute of Goiás, Rio Verde Campus, at geographic coordinates 17º 47 '58' 'S and 50º 54' 28 " W, from February, 2012 to December, 2012. In this period soil collections were carried out in the 0 to 20 cm layer for chemical and physical characterization in conducted samples after air drying and sieving in a 4 mm sieve.

After the laboratory analyzes results, 5.0 dm³ soil were placed in each plastic pot with a 6.0 dm³ capacity after the correction of acidity with the application of limestone filler, which has total relative neutralization power (TRNP) of 100%, increasing the base saturation (v%) to 70%. Soil analysis was performed before and after incubation, to ensure proper soil correction.

The pots were organized on a wooden support, with a height of 0.70 cm and a width of 1.00 mm, and remained in incubation for 30 days after the addition of limestone filler, aiming to increase the base saturation (V%) 70%. After the incubation period, 20 Forage Peanut seeds were sown per pot, an average depth of 0.5 cm. After 15 days of seedling emergence thinning was carried out leaving only 10 plants. After a week of seedling emergence basic fertilization was done in the form of nutrient solution containing macro and micronutrients, the nutrient solution being reapplied after the first cutting. The cuts were performed at 60 and 120 days, this practice was carried out manually with the aid of shears, the height being between 3 and 5 cm above the soil surface in the pots.

The dry matter (DM) was measured by moisture lost by volatilization caused by heat. The percentage was calculated by weight difference of the sample before and after drying treatment in forced ventilation oven at 55° C for 72 hours, removing a sample for the determination according to the method described by SILVA & QUEIROZ, 2002.

The experimental design was completely randomized in a factorial 4 x 2, four shading levels (0, 30, 50 and 70%) and two cut ages (60 and 120 days), with eight repetitions, totaling 64 experimental units. During whole experimental period the pots were properly watered up to three times a day in order to maintain field conditions.

To determine the IVDMD, the technique described by Tilley & Terry (1963) was adopted, adapted to the artificial rumen developed by ANKON®, and using the "Daisy incubator instrument " from Ankom Technology (*in vitro true digestibility*- IVTD). The collection of ruminal fluid was done by using fistulated animals using two male animals with an average weight of 550 kg, the animals being maintained in the pasture in order to repeat that which occurred *in vitro* during 24 to 48 hours of fermentation.

For the species anatomical assessments five (5) fully developed leaves from each plot (pot) were collected and taken to the IF Plant Anatomy Laboratory - Goias Rio Verde Campus, where the samples were fixed in FAA_{70} and after 24 hours were removed from the fixative solution, washed and stored in 70% ethanol solution and subjected to analysis (Kraus & Arduin, 1997). To determine the stomatal density in the adaxial and abaxial sursurfaces of the leaf blade, the leaf clearing technique was used described by Kraus and Arduin, 1997. The cuts were made on an LPC type microtome table, allowing the observation of plant structures, and then transferred to a container with distilled water and stained with Safrablau.

All the material contained on the slides was photographed using an optical light microscope with an attached LEICA DM 500 camera, the variables were measured through software *Anatiquanti*.

The height and width of the leaves to calculate the total leaf area, and also the length of stolons, were determined using a graduated scale, measuring five leaves and stolons from each pot. After all the above mentioned analyzes, the soil from the of each pot was removed and the roots separated by washing under running water over a 0.5 mm mesh sieve. The counting of the total number of seeds per pot was then conducted and subsequently the average of the treatments.

RESULTS AND DISCUSSION

For the dry matter a significant linear decrease was observed due to the increased shade levels (Figure 1A), these results were similar to those of Gobbi *et al*., (2009), who evaluated shade levels (0, 50 and 70%) in intercropping with *Brachiaria decumbens* cv. Basilisk andh *Arachis pintoi* cv. *Amarillo* forage peanut and obtained similar results in their second cut.

Gobbi *et al*., (2010), evaluating the nutritional value of forage *Brachiaria decumbens* cv. Basilisk and *Arachis pintoi* cv. *Amarillo,* submitted to three artificial shade levels, reported similar results where the peanut showed a quadratic reduction on as a function of the artificial shade levels, the 50% shade resulted in lowest DM content. The same author reports that the lowest DM content can be attributed to lower transpiration rates, this behavior is very common in plants submitted to shade, resulting in a higher concentration of water present in the tissues.

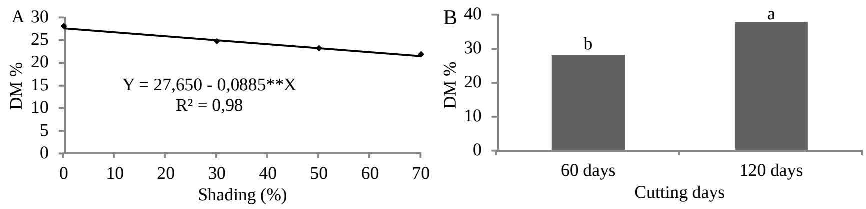

Fig. 1: Percentage of dry matter in relation to shade levels (A), percentage of dry matter with respect to ages cuts (B).

As for the cutting days, there was a growing linear increase in relation to the physiological age of the plants (Figure 1B), this is due to climatic environmental factors the plants are subjected, the factors that promote growth also accelerate plant maturity, thus compromising its nutritional value via the participation of structural components with the advancing age of the plant, thereby increasing the DM due to the increase in plant physiological age.

The DM reduction due to shading is related to lower plant development speed under shading conditions and also the microclimatic conditions of the shaded environment, predominantly mild temperatures and higher soil and air moisture (GOBBI, 2007). When determining the average length of stolons a linear increase (P <0.01) was observed due to the increase of the shade levels and the two cut ages, in relation to the average length of the stolons, recording the highest average lengths under the highest shade level (70%) (Figure 2).

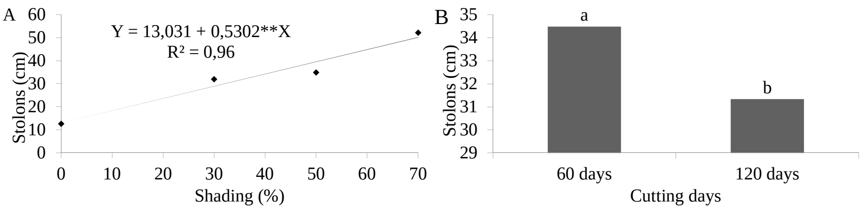

Fig. 2: Average length of stolons (cm) in relation to shade levels (A), in relation to cut ages (B).

The results were similar to those of Andrade & Valetim, (2004), who found that the height of the *A. pintoi* plants increased linearly and positively with the shade levels in January, February and March.

The legume *A. pintoi* has a stoloniferous growth habit, sending out stolons horizontally in all directions. At the 50 and 70% shade levels the *Amarillo* cultivar presented further growth both horizontally and vertically, this fact certainly can be explained by the etiolation formation mechanism that the plant used trying to seek light. As a function of the shade levels and cutting age, differences in leaf area were detected. A positive linear growth was observed (Figure 3A) and a 10% increase, approximately, also occurred in the leaf area as a function of the cut age (Figure 3B).

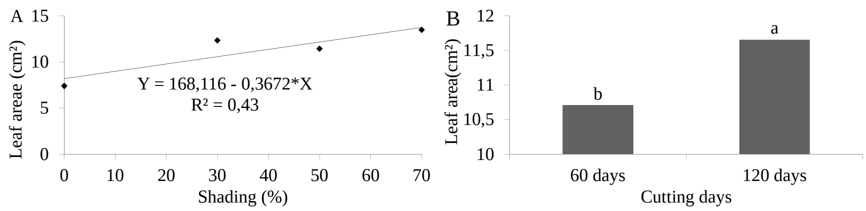

Fig. 3: Leaf area (cm²) as a function of shade levels (A), as a function of the cut ages (B).

Gobbi *et al*., (2011), evaluating the leaf specific area of the two species found similar results, the leaf area increase being linear due to the increase in the shade levels, but with the grass the increase in the leaf specific area was accompanied by a linear reduction in the leaf thickness, with increasing shade levels, and the leaf area of forage peanut leaves did not change significantly with increasing shade, unlike in the present work, which obtained opposite results. Gobbi, (2007), found similar results, there being a significant increase in a linear manner, due to the increase in the shade levels (0, 50 and 70%) in all evaluated cuts.

Environmental factors, in particular the intensity and distribution of the light, can have substantial effects on leaf development, size and thickness; increased leaf area of the forage, due to low irradiance, represents a strategic adaptive response to compensate for the lower photosynthetic rate per unit leaf area as a function of THE REDUCTION of light. (GOBBI *et al*, 2009). The increase in leaf area under shade conditions is linked to anatomical changes such as thinner epidermis, less thick mesophyll, palisade and spongy parenchyma, and even smaller proportion of support conductive tissues, and cell wall thickness, with higher proportions of intercellular spaces and lower stomata density (ALLARD *et al*., 1991). Plants subjected to shade invest relatively higher proportion of photoassimilates and other resources in order to increase leaf area, trying to improve the gathering of available light (GOBBI, 2007). The *Arachis pintoi* cv. *Amarillo* demonstrated significant effects, when given increasing levels of shade, as to the number of seeds, there being a linear increase, as can be seen in (Figure 4). Macedo *et al*., (2012), when evaluating different forms of uprooting the seeds of the forage peanut cv. *Amarillo*, found an increasing linear increase in the period from February to June.

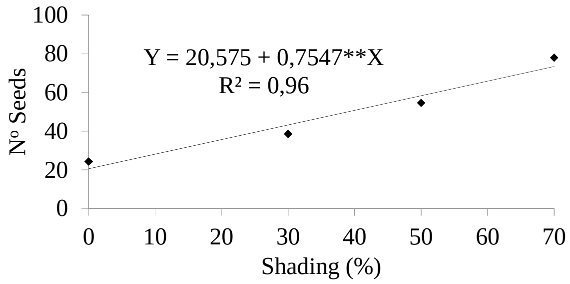

Fig. 4: Number of seeds depending on the shade levels.

It was observed that the forage peanut presented continuous flowering. This behavior was also observed by Ferguson *et al*, (1992), who reported that the *A. pintoi* species flowered constantly during the period of their evaluations. There was a significant interaction effect for shade x age on the number of seeds, and there was a linear increase as a function of the shade levels and the cut ages (Figure 5). Macedo *et al*., (2012), when evaluating the development of the number of flowers in forage peanut cv. *Amarillo* found an increasing linear increase in the period from February to June.

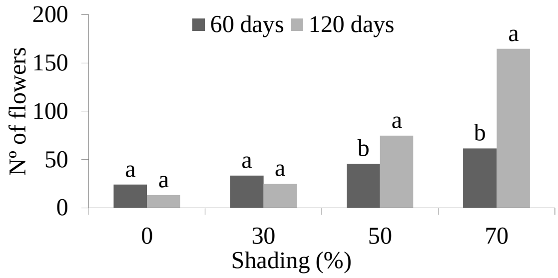

Fig. 5: Number of flowers of *Arachis pintoi* cv. *Amarillo*.

Differences were observed in stomatal density (stomata/mm²) on the abaxial leaf surface of *Arachis pintoi* cv. *Amarillo*, where a linear decrease can be observed in stomatal density due to the shade increase (Figure 6). Commonly, an increase in the number of stomata is observed with increasing irradiance (MORAIS *et al*., 2003). The stomatal density is related to the photosynthetic capacity of the leaves, since, the higher the number of stomata/mm^2, the lower the gas diffusion resistance of the leaf. Thus, the lower density may contribute to lower photosynthetic rate of leaves under shade (LIMA JUNIOR *et al*., 2006; GOBBI, 2007; MEDEIROS *et al*., 2011). However, the increased leaf area of the shaded plants can compensate for the lower density of stomata.

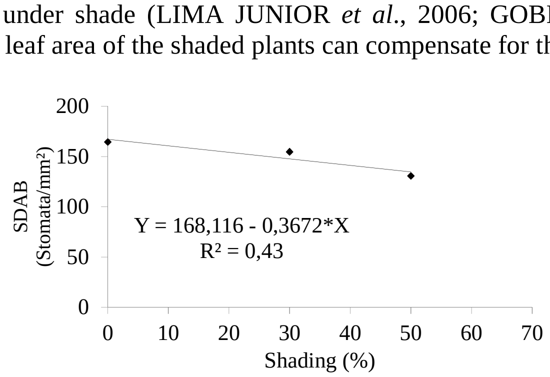

Fig. 6: Stomatal density of the abaxial surface (SDAF DEAB) (stomata / mm²) in relation to levels of shading.

Gobbi, (2007) obtained results similar to those of this research, wherein the stomatal density (stomata/mm²) on both sides of the forage peanut cv. *Amarillo* leaves decreased linearly with the increase in shade levels in all evaluated cuts, and the number of stomata was higher on the adaxial surface. Medeiros *et al*., (2011), reported that the stomatal density is a factor that directly influences the gas exchange process and the stomata are present according to the plant transpiration rate. This behavior has been observed in other species in which there was a greater stomatal density in plants subjected to high irradiance (LIMA JUNIOR *et al*., 2006). This increase in stomatal density can be related to higher irradiance to which the plants are submitted (LEE *et al*., 2000).

Comparing the average stomatal density as a function of cut days, it is observed that on both sides, the highest density was observed at 60 days compared with 120 days Figure (7 - A and B). The density and dynamics of the opening and closing of the stomata associated with reduced leaf area become productivity limiting mechanisms, since they cause a decrease in the CO_2 absorption and light interception, respectively (Medeiros *et al*., 2011). The stomatal density can be related to the age of the plants in various species (RICHARDSON *et al*., 2000; 2001).

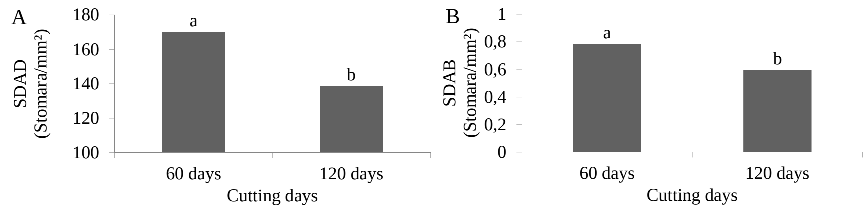

Fig. 7: Adaxial stomatal density (AdSD) (stomata/mm²), (A). Abaxial stomatal density (AbSD) (stomata/mm²), as a function of the cut days (B).

The ED/PD ratio (equatorial diameter and polar diameter (µm)) had no significance when submitted to the artificial shading treatments, but there was a significant difference regarding the cut ages (Figure 8).

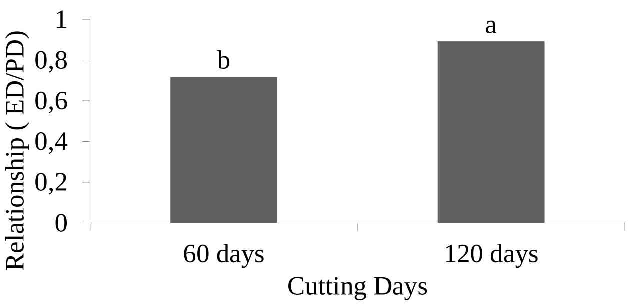

Fig. 8: Equatorial and polar diameter (µm) ratio (ED/PD), as a function of cut age.

More elliptical stomata can be more functional, reducing transpiration (CASTRO *et al*., 2009). To evaluate the functionality of the stomata the equatorial and polar diameters are usually measured and the closer their ratio is to 0.1 the more functional the stomatal opening and closing will be, since the elliptical shape results in a higher ratio of polar and equatorial diameters.

Khan *et al*. (2003), reported changes in shape of the stoma which directly affected their functionality; the more elliptical shape is characteristic of functional stomata, while the spherical form is more often associated with stomata of low functionality.

The thickness of the epidermis in both the adaxial and abaxial surfaces was influenced by the interaction of shade levels x cutting age. In Figure 9 it can be seen that there was a reduction in epidermal thickness on both sides as a function of shade levels. Gobbi (2007) in his study of the morphological and anatomical alterations of forage peanut (*Arachis pintoi* cv. *Amarillo*) in response to different shade levels, found that the shading promoted a linear reduction in leaf thickness, and consequently the thickness of the epidermis, a fact which corroborates the results obtained in the present research.

As s function of the cut ages, there was a significant difference of ($P > 0.01$) in relation to the two cut ages, on both surfaces; at 60 days the average thickness was less than that at 120 days (Figure 9 –B and D). This behavior was expected, because with the increase of the physiological age of the plants the replacement of the cell content by the cell wall occurs, and with it the onset of the secondary wall, there being an increase in the participation of cellulose and lignin. Furthermore, the senescence process begins, which accelerates the increase of fiber content in plant structure (Deschamps *et al.*, 2002).

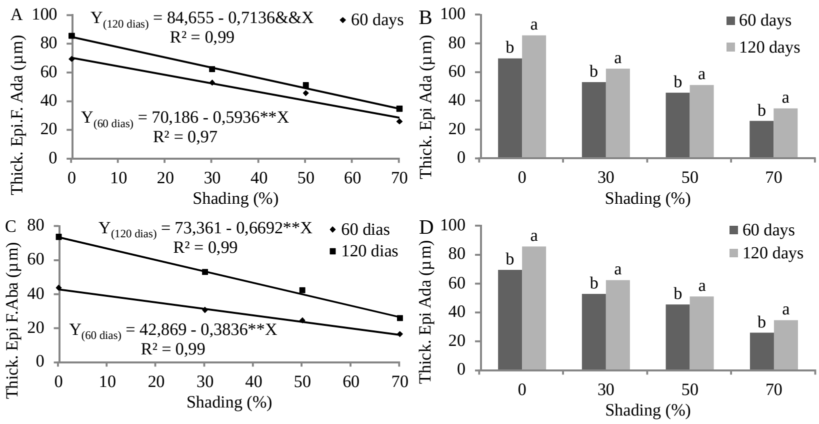

Fig. 9: Epidermal thickness (µm) in the adaxial surface as a function of shade levels, (A) Epidermal thickness (µm) in the adaxial surface as a function of the cut age, (B) Epidermal thickness (µm) in the abaxial surface as a function of shade levels (C) Epidermal thickness (µm) in the abaxial surface as a function of cut age (D)

Lima Junior *et al*., (2006) and Pinto *et al*., (2007), observed in leaves of *Cupania vernalis* and *Aloysia gratissima*, respectively, that the thickness of the epidermis of both surfaces altered under different shade conditions. Plants maintained under higher irradiance show a thicker epidermis on one or both sursurfaces. According to the author, the leaf plasticity is influenced, changing the thickness, area, and other characteristics of the plant body due to the higher or lower production of primary and secondary metabolites (Lee *et al*., 2000), in plants with thicker epidermis there is the possibility that bacteria do not have quick access to the cell wall to begin the digestion process.

Shade can cause a decrease in the proportion of vascular and support tissue, as well as reduction in cell wall thickness, this is due in part to the low rib density due to the expansion of the leaf area when the plants are subjected to shade (DICKSON, 2000;).

The plant cell wall thickness hinders plant digestion by reducing the accessibility of rumen microorganisms to the material. The digestibility of the cell wall can range from 0% to 100% according to the thickness and composition of plant tissues (SILVA *et al* 2012). A linear reduction in the thickness of the epidermis of both surfaces explains the high percentage of digestibility due to the shade level increase.

The above has been demonstrated in the work of Paciullo, (2008), who reported that low digestion of some tissues arises from dense arrangement of cells and their high cell wall thickness and also the presence of lignin. Therdigestibility shows a marked decrease with increasing physiological age of the plant showing that the developmental stage is one of the factors that influence the nutritional value of forage (PACIULLO, 2011).

There was an effectof the interaction shading x cut age on thickness (µm) of the palisade parenchyma, spongy parenchyma and mesophyll, where there was a linear reduction as a function of the shade levels, and a linear increase in thickness as a function of the cut ages (Figure 10).

The thickness of the palisade parenchyma (PP) decreased due to shading and cut ages. Results as that of Gobbi *et al*., (2011), are similar, in part; the reduction was in relation to shade levels due to the reduced thickness of palisade parenchyma subjected to shade which reduced the size and/or number of its cells, it may also have contributed to the decrease in the peanut-fodder leaf density.

In leaves subjected to shading, characteristics such as thin palisade parenchyma, the lower number and/or smaller size of the cells, as well as a higher proportion of intercellular spaces, may represent an attempt to decrease the resistance to diffusion of gases (CO_2) within inside the leaf, seeking to increase its photosynthetic efficiency (GOBBI *et al*.,2011).

The spongy parenchyma (SP) showed the same behavior as the palisade parenchyma, the thickness presenting significantly linear and negative as a function of the artificial shading levels and cut ages. The results were the opposite of the work of Gobbi *et al*., (2011), which did not present an alteration as a function of the treatment employed, however the lowest average thickness was presented at the 50% shade level, obtaining a thickness increase at the 70% level, unlike the present work where the reduction in the SP thickness was linear due to the increased shade levels, in the first cut.

In the second cut the results of Gobbi *et al*., (2011) were the opposite of those of the present work; they presented an increase in the SP thickness in relation to increased shade levels. Ivanova & P'yankov (2002) found a higher proportion of spongy parenchyma, which represents a form of photosynthetic acclimation to shading, since its cells promote better light dispersion, reaching results opposite to those of the present work.

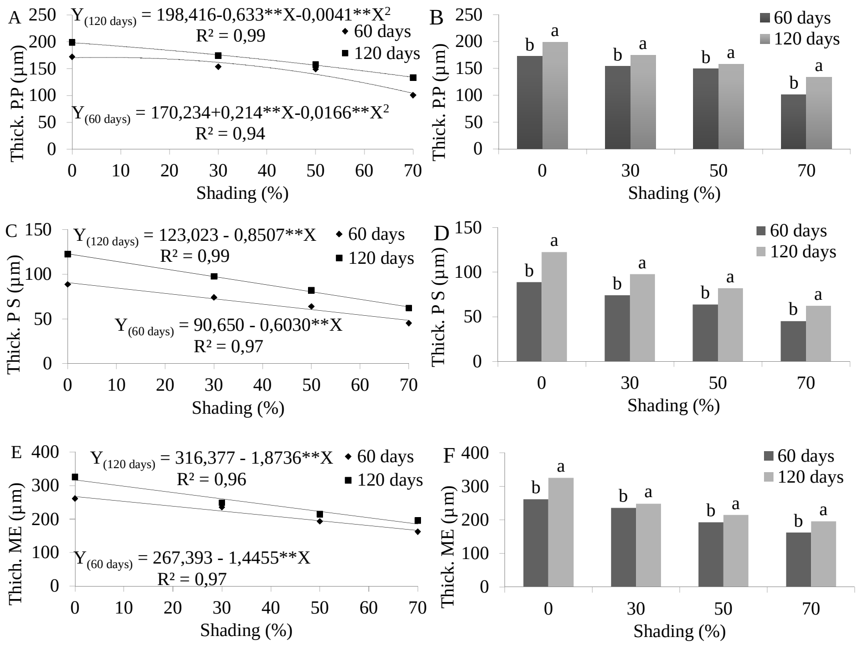

Fig. 10: Palisade parenchyma thickness as a function of shade levels (A); Palisade parenchyma thickness in relation to cut ages (B); Spongy parenchyma thickness as a function of shade levels (C); Spongy parenchyma thickness in relation to cut ages (D); Mesophyll thickness as a function of shade levels (E); Mesophyll thickness in relation to cut ages (M).

There were significant effects on the thickness of the mesophyll presenting a linear reduction in thickness due to the shade levels and cut ages, these data are the opposite of those of Gobbi *et al*., (2011), where there was no significant difference between the evaluated treatments. When evaluating the effects of three levels of shading (0, 40 and 70%) on leaf anatomy of fescue, it was found that the mesophyll in the cross section of the leaves also showed no significant difference between the treatments when submitted to different shade levels (Allard *et al*, 2007).

The coefficients of dry matter *in vitro* digestibility increased linearly in relation to shade levels (Figure 11). These results were similar to those obtained by Paciullo *et al*., (2007), who also found an increase in digestibility in plants subjected to shade.

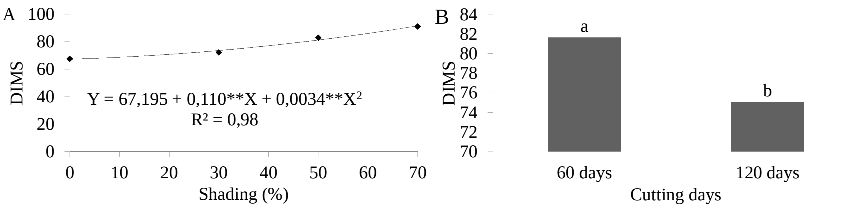

Fig. 11: Coefficients of dry matter *in vitro* digestibility, in relation to shade levels (A); Coefficients of dry matter *in vitro* digestibility, as a function of cut ages (B).

However, works evaluating shade levels are contradictory, since the lower cell wall thickness found in the present study explains the high digestibility coefficients in relation to the shade levels by the fact that a lower proportion of secondary walls, and therefore a linear increase, can increase the digestibility of plants subjected to shading (ANDRADE & VALETIM, 2004).

When working with forage peanut subjected to increasing shade levels (0, 50 and 70%), Gobbi *et al*., (2009) found that digestibility was not significantly affected in relation to shade levels. Peri *et al*, (2007) found similar results in which there were no significant effects of artificial shade levels on digestibility coefficients.

Regarding cut days coefficients, the dry matter *in vitro* digestibility decreased linearly as a function of increased plant physiological age (Figure 11 B), in general this happens because the plants lose their nutritional value with advancing age due to increased lignification. Paciullo *et al*. (2002) observed that the digestibility presents a sharp decline with increasing age, demonstrating that the stage of development is the most important factor influencing the nutritional value of forage plants.

The shade levels and cut ages influence the yield of dry matter, leaf area epidermis and mesophyll, thickness and also in flower production and consequently seed production. Leaves of *Arachis Pintoi* cv. *Amarillo* presented adaptational plasticity to the environment to which they were submitted, influencing the density and equatorial and polar diameter of the stomata. Higher digestibility coefficients were also observed due to the increased shade levels. It was aslo verified that at 60 days of age the plants showed lower dry matter coefficients, but demonstrated higher digestibility.

Conclusion:

The leaves of *A. pintoi* cv. *Amarillo* presented adaptational plasticity to the environment in which they were submitted, influencing the anatomical properties that result in higher or lower utilization by ruminant animals, in which we observed higher digestibility coefficients according to the shade levels.

With the data obtained in this study we observed that the forage in question presents good adaptation and tolerance to shade, its use being possible in agroforest and silvopastoral systems without developmental, production and nutritional value losses.

ACKNOWLEDGMENT

Federal Institute Goiano.

REFERENCES

Akin, D.E., H.E. Amos, F.E. Barton, 1973. Rumen microbial degradation of grass tissue by scanning electron microscopy. Agron J, 65(5): 825-828.

Andrade, C.M.S., J.F. Valentim, J.C. Carneiro, F.A. Vaz, 2004. Growth of tropical forage grasses and legumes under shade. Brazilian Agricultural Research, 39: 263-270.

Allard, V., J.F. Soussana, R. Falcimagne, P. Berbigier, E.C Onnefond, P. D´Hour, C. Hénault, P. Laville, C. Martin, C. Pinarès-Patino, 2007. The role of grazing management for the net biome productivity and greenhouse gas budget (CO2, N2O and CH4) of semi-natural grassland. Agriculture, Ecosystems and Environment, 121: 47-58.

Brito, C.J.F.A., R.A. Rodella, Deschamps, Y. Alquini, 1999. Quantitative anatomy and degradation *in vitro* tissue in elephant grass cultivars. Journal of Animal Science, 28(2): 223-229.

Deschamps, F.C., Ramos, L.P. 2002. Method for the determination of phenolic acids in the cell wall of fodder. Journal of Animal Science, 31(4): 1634-1639.

Castro, E.M., F.J. Pereira, R. Paiva, 2009. Plant histology: structure and function of vegetative organs. Lavras: UFLA, 234.

Dickson, W.C., 2000. Integrative plant anatomy. San Diego: Academic Press, 533.

Ferguson, J.E., C.I. Cardozo, M.S. Sánchez, 1992. Avances y perspectivas en La producción de semilla de *Arachis pintoi*. Pasturas Tropicales, 14(2): 14-22.

Goobi, K.F., 2007. Morpho-anatomical, nutritional and forage productivity subjected to shading. Thesis (Doctorate in Animal Science) - Federal University of Viçosa, 94p. Viçosa.

Gobbi, K.F., R. Garcia, A.F. Garcez Neto, 2009. Morphological, structural and productivity of signal grass and forage peanut submitted to shading. Journal of Animal Science, 38(9): 1645-1654.

Gobbi, K.F., A.F. Garcez Neto, O.G. Pereira, G.C. Rocha, 2010. Nutritive Value of signal grass and forage peanut submitted to shading. Archivos de Zootecnia, 59(227): 379-390.

Gobbi, K.F., R. Garcia, M.C. Ventrella, A.G. Neto, G.C. Rocha, 2011. Leaf area specific and quantitative leaf anatomy of signal grass and peanut-Forrageiro subjected to shading. Journal of Animal Science, 40(7): 1436-1444.

Ivanova, L.A., V.I. P’yankov, 2002. Structural adaptations of the leaf mesophyll to shading. Russian Journal of Plant Physiology, 49(3): 419-431.

Khan, S.V., 2003. Growth and water relations of *Paulownia fortunei* under photomixotrophic and photoautotrophic conditions. Biologia Plantarum, Copenhagen, 46(2): 161-166.

Kraus, J.E., A. Arduin, 1997. Basic manual methods in plant morphology. Rio de Janeiro, Seropédica.

Lee, D.W., F. Oberbauer, P. Johnson, K. Baskaran, M. Mansor, H. Mohamad, S.K. Yap, 2000. Effects of irradiance and spectral quality on leaf structure and function in seedlings of two Southeast Asian *Hopea* (Dipterocarpaceae) species. American Journal of Botany, 87: 447-455.

Lima Junior, E.C., A.A. Alvarenga, E.M. Castro, 2006. Fisioanatômicos aspects of young plants of Cupania vernalis Camb. Under different levels of shading. Tree magazine, 30(1): 33-41.

Macedo, G.A.R., H.M.A. Purcino, M.C. Viana, P. Oliveira, F.M. Freire, 2012. Effects, and withdrawal methods in Production and Seed Quality. *Arachis pintoi* – Pasturas tropicales, 27(1).

Medeiros, L.T., J.C. Pinto, E.M. Castro, A.V. Rezende, C.A. Lima, 2011. Nitrogen and anatomical characteristics, cultivars of Agricultural and Bromatological *Brachiaria brizantha*. Science and agro, Lavras, 35(3): 598-605.

Morais, Heverly, 2003. Physiological characteristics and shaded coffee growing with pigeonpea and unshaded. search. Agriculture. Brazilian, 38(10): 1131-1137.

Paciullo, D.S.C., J.A. Gomide, E.A.M. Silva, 2002. Anatomical characteristics of the leaf blade and the tropical forage grasses thatched, due to the insertion level tiller, age and the growing season. Journal of Animal Science, 31(2): 890-899.

Paciullo, D.S.C., C.A.B. Carvalho, L.J.M. Aroeira, M.J.F. Morenz, F.C.F. Lopes, R.O.P. Rossiello, 2007. Morphophysiology and nutritional value of signal grass under natural shade and full sun. Brazilian Agricultural Research, 42(4): 573- 579.

Paciullo, D.S.C., C.A.M. Gomide, C.R.T. Castro, de, P.B. Fernandes, M.D. Muller, M.F.A. Pires, E.N. Fernandes, D.F. Xavier, 2011. Productive and nutritional characteristics of pasture in agrosylvopastoral system as the distance from the trees. Brazilian Agricultural Research, 46(10): 1176-1183.

Peri, P.L., R.J. Lucas, D.J. Moot, 2007. Dry matter production, morphology and nutritive value of Dactylis glomerata growing under different light regimes. Agroforestry Systems, 70: 63-79.

Pinto, J.E.B.P., 2007. Morphophysiological aspects and content of essential oil of lavender the Brazil plant due to shading levels. Journal of Horticulture, 25(2): 210-4.

Queiroz, D.S., J.A. Gomide, J. Maria, 2000. Avaliação da folha e do colmo de topo e base de perfilhos de três gramíneas forrageiras. 2. Anatomia. Rev Bras Zootec, 29(1): 61-68.

Richardson, A.D., G.P. Berlyn, P.M.S. Ashton, R. Thadani, I.R. Cameron, 2000. Foliar plasticity of hybrid spruce in relation to crown position and stand age. Canadian Journal of Botany, 78(3): 305-317.

Richardson, A.D., P.M.S. Ashton, G.P. Berlyn, M.E. Mcgruddy, I.R. Cameron, 2001. Within-crown foliar plasticity of Western Hemlock, *Tsuga heterophylla*, in relation to stand age. Annals of Botany, 88(6): 1007-1015.

Silva, D.J., A.C. Queiroz, 2002. Food analysis (chemical and biological). 3ª Ed. Viçosa: University Press the UFV, 235.

Silva, N.S., H.S. Silva, E.M.G. Andrade, J.R. Sousa Júnior, G.F. Furtado, 2012. Anti-nutritional factors in forages Green Magazine of Agroecology and Sustainable Development, 7(4): 01-07.

Tilley, J.M.A., R.A. Terry, A two stage technique for the in vitro digestion of forage crops. Journal British Grassland Society, 104-111.

Van Soest, P.J., 1994. Nutritional ecology of the ruminant. New York, 476.