University of São Paulo
Luiz de Queiroz College of Agriculture
0111000 – Undergraduate monograph

Forage accumulation, root biomass, and canopy architecture of two species of perennial peanut managed under contrasting defoliation intensities

ROGÉRIO FURLAN JÚNIOR

Undergraduate monograph presented as a requirement to achieve Bachelor's degree in Agronomic Engineering

Piracicaba
2023

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Advisor:
Prof. Dr. CARLOS GUILHERME SILVEIRA PEDREIRA

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ACKNOWLEDGMENTS

I would like to thank,

God, Jesus, and all friendly spirits that have guided and protected me throughout my journey;

Luiz Vicente de Souza Queiroz and Ermelinda de Souza Queiroz for the idealization and legacy of this school of agronomy;

My parents, Cláudia E. F. Bis Furlan and Rogério Furlan, who supported me and made my dreams come true. Also, my extended family, especially Norisvaldo Furlan, Valdete Furlan, Maria Julia Bis Furlan, and Nicoli Bassi for the daily support and patience with me;

My advisor, Dr. Carlos Guilherme Silveira Pedreira, who always encouraged me to pursue a scientific career, and for all the learning opportunities, advices, and support he provided;

My co-advisor, Dr. Theyson Duarte Maranhão, for the help and support in writing reports, advice, and countless conversations about life, science or simply laughing with the other members of the "*Arachis team*";

My internship supervisor, Dr. Liliane Silva, that welcomed and hosted me at the Edisto Research and Education Station. Dr. Silva has provided me with an opportunity to work with research and extension in the United States and had a major contribution to my career and English knowledge necessary to write this Undergraduate monograph;

All the professors believed in and supported me, especially Drs. Bruno Carneiro e Pedreira, José Eurico Possebon Cyrino, Fernando Campos Mendonça and Francisco Antonio Monteiro;

All members from Grupo de Pesquisa em Pastagens (GP^2) and the "*Arachis team*", especially Lucas Prado Gomes dos Santos and Gabriel de Camargo Botechia, who

became my friends during the two and half years that we have been together in the field, laboratory, office, and day-offs.

EPIGRAPH

"A Luiz Vicente de Souza Queiroz, teu monumento é a tua escola"

SUMMARY

ABSTRACT

Warm-season forage legumes are a viable option to provide high nutritive value with high yield for forage systems. They can be a suitable option for horses, beef or dairy cow operations in Brazil. The objective of this study was to determine the agronomic and structural responses of rhizoma perennial peanut cv. Florigraze (AG; *Arachis glabrata* Benth) and pinto peanut cv. Belmonte (AP; *Arachis pintoi* Krapov. W. C & Greg) managed under two defoliation intensities (4 and 8 cm stubble height). The study was conducted in Piracicaba, São Paulo, Brazil from August 2021 to March 2022. The experimental design was a completely randomized block design with a split-plot arrangement, where the forage species were assigned to the whole plots and the stubble heights to the subplots. The response variables were forage accumulation (FA), canopy height (CH), root biomass (RM), and botanical and morphological composition and responses of the canopy. The FA was greater (P = 0.030) for AP than AG (10,633 *vs* 5,050 kg DM ha^{-1}). The CH had interaction between intensity × specie(P = 0.019), AG8 had the greatest height. The RM was affected by the intensity × specie interaction (P = 0.001), AP did not differ between treatments, but AG did, the greater value was 36,000 kg ha^{-1} in AG8. Based on results, AP managed under 4 cm stubble height is the most suitable management practice due to favorable forage production and canopy architecture.

Keywords: canopy architeture, forage legumes, forage production, root biomass

LIST OF ABBREVIATIONS AND ACRONYMS

AG	*Arachis glabrata* cv. Florigraze
AG4	AG defoliated at 4 cm of stubble height
AG8	AG defoliated at 8 cm of stubble height
AP	*Arachis pintoi* cv. Belmonte
AP4	AP defoliated at 4 cm of stubble height
AP8	AP defoliated at 8 cm of stubble height
CH	canopy height
CP	crude protein
DM	dry matter
FA	forage accumulation
IVDOM	in vitro digestible organic matter
LAI	leaf area index
RM	root biomass

1. INTRODUCTION

Pastures provide feed for ruminants that can convert indigestible plant fiber into meat, milk, and wool (RINEHART, 2008). In Brazil, the livestock industry is based on use of perennial forages. Pastures occupy 160 million hectares and are concentrated in marginal areas while the most fertile soils are allocated to row-crop production. The Brazilian beef cattle herd encompass around 210 million head and almost 90% of the Brazilian herd is raised exclusively on pastures. The country is also the third largest producer of milk, responsible for 34.8 billion liters in 2019.

The animal production under grazing in Brazil is based in warm-season grasses. These grasses evolved in African savannas, are often adapted to intense defoliation and abiotic stresses, and are able to withstand grazing and environment stresses. In contrast, many forage legumes originated in the American continent and were only exposed to small herbivores and some rodents as capybara (*Hydrocerus hydrochaeris*). Therefore, there were limited selection to species that tolerate heavy grazing (VALLE et al., 2009).

The increase in production cost due to high prices of inputs, and global inflation, has forced cattle producers to look for options to improve their efficiency of production and reduce costs associated with the activity. The incorporation of forage legumes in animal diets helps to improve nutritive value, especially protein concentration, which is one of most limitant nutrients and expensive. Legumes have greater digestibility compared to warm-season perennial grasses and can help balance the N availability in the rumen directly impacting the emissions of enteric methane (MONTENEGRO et al., 2000). In addition, legumes are able to fix nitrogen biologically through symbiosis with soil microorganisms which reduces the need to use inorganic nitrogen fertilizers and helps to decrease greenhouse gases emissions (MACEDO et al., 2014).

Due to the limitations to grow alfalfa (*Medicago sativa*) production in Central and Southeastern Brazil because of issues with persistence and pest pressure, the need to identify alternatives to provide high-quality forage legumes to high-performance animals, such as dairy cows and sports horses has increased. In the brazilian south, legumes such as clovers and alfalfa are used to feed these animal categories, especially during the winter, although there are some legume species of interest, such as the perennial peanut, native to Brazil. Perennial peanut forage has a nutritive value superior to that of most forage grasses with C4 metabolism and good adaptation to grazing and tropical climate.

Rhizhoma perennial peanut (*Arachis glabrata*) is native to South America, but has been widely used in subtropical regions of North America. It finds good acceptance among producers in forage systems where growing alfalfa is limiting. In a study, Rhizoma peanut was established in a well-established bermudagrass pasture (DUNAVIN, 1992) and the average daily gains obtained was 0.93 kg for beef heifers (SOLLENBERGER et al.,1989).

The defoliation intensity is an important parameter in the management of forage species since the stubble height directly impact on the production and qualitative responses of the pasture, including forage accumulation, the leaf-to-stem ratio, the nutritional value, in the subsequent cycles (Lemos et al., 2019). In addition, the defoliation intensity can also be a determinant of the persistence and vigor of stand regrowth (REZENDE et al., 2008), since it impacts the leaf area index (LAI).

Understanding the responses of perennial peanut species to defoliation intensities is important to establish management recommendations that favor improved productivity and stand longevity. The intensification of animal production systems based on pastures requires technical knowledge about the forage species in the system, in order to obtain profitability with sustainability. Knowing the responses of plants to the intensity of defoliation enables refinement in management and can generate information that will help in the planning of ruminant production systems, something that becomes increasingly necessary due to the constant increase in production costs and consequently in the level of production professionalization of the systems.

1.1 Objectives

The objective of this study was to determine forage accumulation, root biomass, botanical composition, and vertical canopy structure of rhizoma perennial peanut cv. Florigraze (AG; *Arachis glabrata* Benth) and pinto peanut cv. Belmonte (AP; *Arachis pintoi* Krapov. W. C & Greg) managed under two stubble heights (4 and 8 cm) in Piracicaba, São Paulo, Brazil.

2. LITERATURE REVIEW

2.1 Forage Legumes in Livestock Systems in Brazil

Forage legumes can be used in forage systems managed under grazing or harvested for hay, baleage or silage production. In addition to the nutritional importance of legumes, these plants also provide soil improvement, conservation, and nitrogen for other plants when used in mixture or in rotation due to the symbiotic relationship between *rhizobia* bacteria and legumes roots. Tropical forage legumes include numerous plant species that vary in growth form and have optimum growth temperatures slightly above 30ºC. The majority of tropical forage legumes' germplasm is original from the American tropics, with some occurring in Paraguay and Argentina. Many legumes can enhance intake, rate of passage dietary protein and animal performance when added to ruminant diets. Nevertheless, there is some resistance in adopting legumes in forage-based livestock systems in Brazil, mostly due to the lack of establishment and management recommendations, and poor stand persistence. (SHEAFFER et al., 2020; PITMAN and VENDRAMINI, 2020).

Legumes utilize the C3 pathway for carbon fixation, thus they contain less structural tissue than warm-season grasses and are more digestible (FRAME, 2005). Generally, forage legumes are used in systems targeting higher animal performance (e. g., horses, beef ,and dairy cattle), due to the higher nutritional value and digestibility when compared to grasses, including legumes into animal diet can also help to decrease methane emission (MONTENEGRO, et al., 2000).

Pasture production and animal performance are affected by nitrogen. Nitrogen supports growth dynamics (LEMAIRE et al., 2009) in processes such as forage accumulation and leaf area expansion, factors that support animal production (SILVA et al., 2016). Legumes help to decrease use of N fertilizer sources and reduce the production costs. Carvalho (2019) reported that *A. pintoi* managed under grazing can fix between 108 and 241 kg N ha^{-1}, Ledgard and Steele (1992) also compiled studies that reported N fixation by legumes between 13 to 373 kg N ha^{-1}, varying due to defoliation management, stand composition, and soil temperature and fertility.

2.2 Forage Production of *Perennial Peanut*

The genus *Arachis* is native to South America and comprises about 70 species, including annual and perennial species. The most well-known species are *A. hypogaea* (common peanut) and the perennial peanuts *A. glabrata* and *A. pintoi*. Research on perennial peanut species dates back to the 1970's with studies on pinto peanut (*A. pintoi*) and rhizoma peanut (*A. glabrata*) (KERRIDGE; HARDY, 1994). Due to its center of origin and breeding advances, perennial peanut species are well adapted to tropical and subtropical conditions, which allows them to be a substitute to alfalfa in some areas under warmer climates. They have been widely used in the horse industry of the southeastern USA as premium quality hay due to the high digestibility, crude protein levels, and climate adaptation (HOLLAND, 2017)

Plants from the *Arachis* genus are capable to fix atmospheric nitrogen through biological nitrogen fixation (BNF) due to a symbiotic relationship with *Rhizobium* bacteria. When grown in mixtures with grasses, the nitrogen added by the legumes helps reduce costs with N fertilization, which is the most limiting nutrient for grass production (ÅGREN; WETTERSTEDT; BILLBERGER, 2012).

2.2.1 Overview of Rhizoma perennial peanut and Pinto Peanut

Rhizoma perennial peanut is a warm-season perennial legume widely used in the southeastern United States. It was introduced from Brazil in the first half of twentieth century and most of the forage evaluation and research was conducted in Florida for this cultivar. In the USA, the first released cultivar was Florigraze in 1978.

Rhizoma peanut is established vegetatively by using root-rhizome material, with a planting rate around 5,400 kg ha^{-1} for pure stands (JARAMILLO et al., 2018). After planting, the establishment of a new pasture can require up to two years to provide proper ground coverage (BLOUNT, 2006). In mixed stands, it can be strip-planted into an established grass pasture. First the grass strips are sprayed with glyphosate, disked, and, then, the vegetative material is planted. This establishment method allows to continue using the area for hay production during the rhizoma peanut (AG) establishment (DUBEUX, 2015). Rhizoma peanut is considered drougth tolerant and it can persist in areas with 750 mm of annual rainfall. During harsh drougths, the above-ground portion may die, but the rhizomes can survive, providing proper regrowth at the beginning of the rainy season.

Rhizoma peanut can be managed under grazing or hay production, or used in mixtures with grasses. It has high forage yield and quality. Forage production can average 9,000 kg DM ha^{-1} year^{-1} (SILVA et al., 2021) and under frequent defoliation can reach up to 22% of crude protein, 77% digestibility and does not have antinutritional factors. Rhizoma peanut can be also used in pasture mixtures with bahiagrass (*Paspalum notatum Flugge*) and bermudagrass (*Cynodon dactylon*). On a bahiagrass-AG mixture, steer performance averaged 0.9 kg ADG (DUNAVIN, 1992). Thus, it can be a forage resource for many tropical and subtropical livestock production systems.

Pinto peanut is a warm-season perennial legume, native to the Cerrado vegetation region in Central Brazil. It, is considered persistent in pure stands and mixtures, due to its creeping habit with growing points close to the soil surface which are protected from grazing or mowing

(KERRIDGE; HARDY, 1994). It can also be established via stolons or seeds. Cultivar Belmonte is established via stolons (ANDRADE et al., 2006). In some mixtures with grasses, pinto peanut (AP) can be even established after the grass with no-tillage practices, as reported by Mamédio et al, (2020). Although is native to the Cerrado region of Brazil, this species has been studied and is well-adapted in several other locations in South america, such as Western Amazon in Brazilian Agricultural Research Corporation (EMBRAPA) in Acre state (ANDRADE, 1999; 2006; 2015), Southern parts of Minas Gerais state (PEREIRA et al, 2020) and Piracicaba (FERREIRA, 2014; AZEVEDO, 2020; PASSINI, 2020).

The AP growth can rate averages high 35 kg ha^{-1} d^{-1} and 12,800 kg ha^{-1} per year in monoculture in tropical and well managed systems, greater than other legumes, such as tropical kudzu (*Pueraria phaseoloides*). In addition, its crude protein levels average 17.5% (BAPTISTA et al., 2007) (CAVALI et al., 2004). This legume can be used in mixtures to provide nitrogen to the grass and enhance the nutritive value of the forage diet. Pereira et al (2019) reported that the mixture of AP with *Urochloa brizantha*, resulted in greater ADG when compared to the grass fertilized with 150 kg N ha^{-1} y^{-1}. In the same study, grazing management included adjusting stocking rate, maintaining a 40% legume participation in the mixture for a nine-year data collection period. In addition, there are successful cases in mixtures with African bermudagrass (*Cynodon nmefluensis*) with ADG of up to 0.85 kg (ANDRADE et al., 2015).

2.3 Defoliation management of forage systems

Defoliation management directly affects quality and quantity responses of forages. In addition, it is a determinant of plant regrowth and stand persistence. After defoliation, the residual leaf area, growing points and energy reserves are responsible for the regrowth. Therefore, the plant regrowth rate is directly impacted by the stubble height and mobilization of reserves at each defoliation event (DA SILVA E PEDREIRA, 1997).

When the forage is not harvested or a lenient management is applied, old plant tissue in the canopy impacts growth and compromises both quality and production. By not removing some of the plant parts, the renewal of plant tissue declines, leading to the accumulation and elongation of structural components of the canopy, such as stem. Also plant tissue is lost due to senescence, so inadequate defoliation reduces forage quality and increases the proportion of less digestible components (LASCANO, 1995).

On the other hand, excessive removal of tissue leaves insufficient leaf area to warrant fast regrowth and can result in opportunities for weed development, because producing new leaves from root reserves takes longer than from photosynthetically active tissue. As described by Gomide (1999), the pasture regrowth is directly proportional to residual leaf area.

Proper defoliation management has a vital role in forage systems, if growing points are removed that directly impacts production and stand persistence (ANDRADE et al., 2006). Therefore, the stand persistence ensured via proper establishment, defoliation management and maintenance of soil fertility are crucial for legume pastures (MARTEN et al., 1989). When harvesting forage for making hay, silage, or baleage, operations that export a lot of soil nutrients in form of plant material, not replacing soil fertility can exhaust plant reserves and result in stand degradation. (HECKMAN, 2018). Thus, soil fertility requirements need to be a top priority in forage conservation systems, especially for forage legumes, which have greater requirements of potassium, micronutrients, and soil pH than warm-season grasses.

3. MATERIAL AND METHODS

3.1 Experimental site description, treatments, and experimental design

The experimental area was located in the Animal Sciences Department of ESALQ in Piracicaba, state of São Paulo, Brazil (22°42'19" S 47°38'22" W, 520 m above sea level). The climate is classified as Aw under the Köppen climate classification (Dias, Alvares and Sentelhas ,2017). Weather data for the experimental period are shown in Fig. 1.

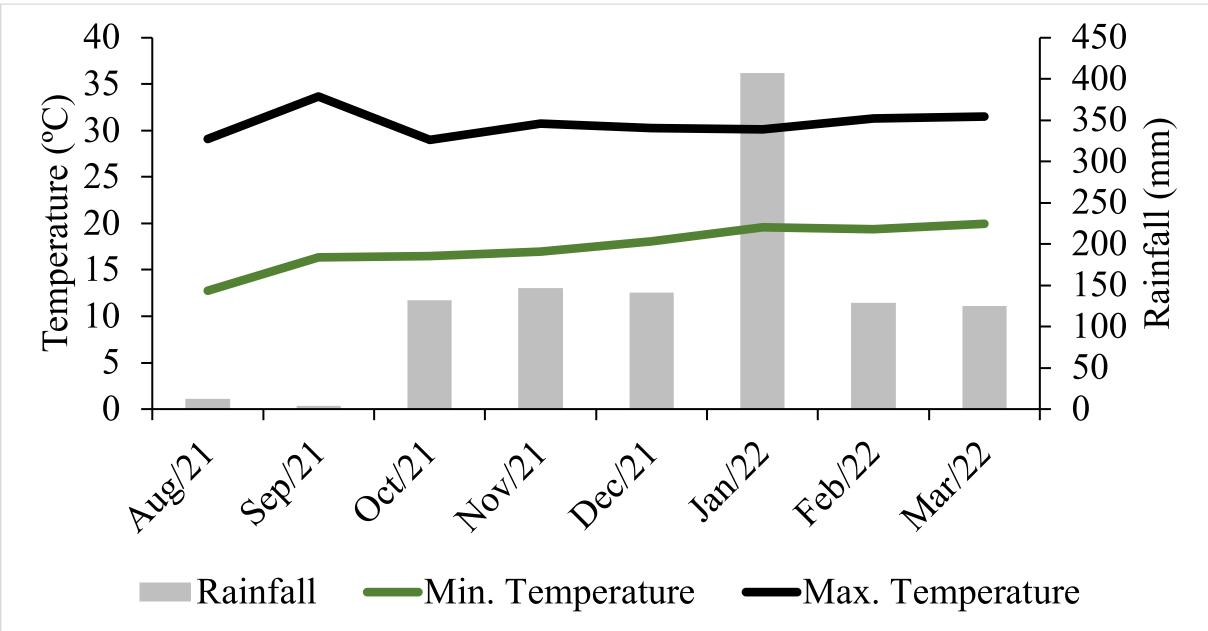

Figure 1. Monthly weather data during the experimental period in Piracicaba, SP, Brazil.

The soil is a highly fertile Kandiudalfic Eutrudox (ALMEIDA, 2022). Prior to the study initiation, soil was analyzed and the following results were obtained: pH (0.01 mol L^{-1} $CaCl_2$) = 4.9; organic matter = 33 g dm^{-3}; P (ion-exchange resin extraction method) = 47.8 mg dm^{-3}; K = 1.26 mmol dm^{-3}; Ca = 65.8 mmol dm^{-3}; Mg = 15.7 mmol dm^{-3}; Al = N. D; sum of bases = 82.8 mmol dm^{-3}; cation exchange capacity = 129.8 mmol dm^{-3}. Based on soil fertility, 50 kg ha^{-1} of K_2O; 30 kg ha^{-1} of P_2O_5; 1 Mg ha^{-1} of lime and 1 Mg ha^{-1} of gypsum were applied by surface broadcast.

The study was conducted from August 2021 to March 2022. The experimental design was completely randomized with a split-plot arrangement, where the species (AP and AG) were assigned to the whole plots and clipping heights (4 and 8 cm) to the subplots, with six replications. Each plot had 18 m^2 (4 x 4.5 m), and each sub-plot had 9 m^2 (2 x 4.5 m). The growing cycles were 42 days long, and every 42nd day all the forage mass above the clipping heights (4 and 8 cm) was mowed and raked.

The plots were established in March 2011 via vegetative propagation using stolons. The AP plots had forage mechanically harvested in intervals of 4 and 6 weeks, from 12/10/2012 to 04/18/2013 and 12/11/2014 to 06/04/2015 (FERREIRA, 2014; ALONSO, 2017). The establishment period of the AG plots was greater than AP, the plots were not harvested between 2012 to 2019. The AG plots were mowed just to stimulate regrowth from 2012 until 2019 as documented by Azevedo (2020).

The experimental area was irrigated with low-pressure sprinklers (Figure 2) and soil moisture was monitored by tensiometers installed in four plots, when the water potential reached values between 0.3 and 0.4 kPa, the irrigation system was turned on.

Figure 2. Overview of the experimental area.

3.2 Response variables

3.2.1 Forage Accumulation

The experimental period of the whole project was initiated in February 2020, when the forage of the experimental units was cut to their respective stubble heights (4 and 8 cm). This was considered the “day zero” of the experimental period. Data for this particular study were collected from August 2021 to March 2022. After forage samples were collected, the plot was staged to the assigned stubble height. Samples were collected in their respectives heights (4 and 8 cm) in visually representative points using scissors and 0.25 m^2 quadrats. Two samples were harvested in each subplot (Figure 3). Samples were oven-dried at 60 °C, until constant weight. Forage accumulation (FA) was calculated as the mean of the dry weight of samples.

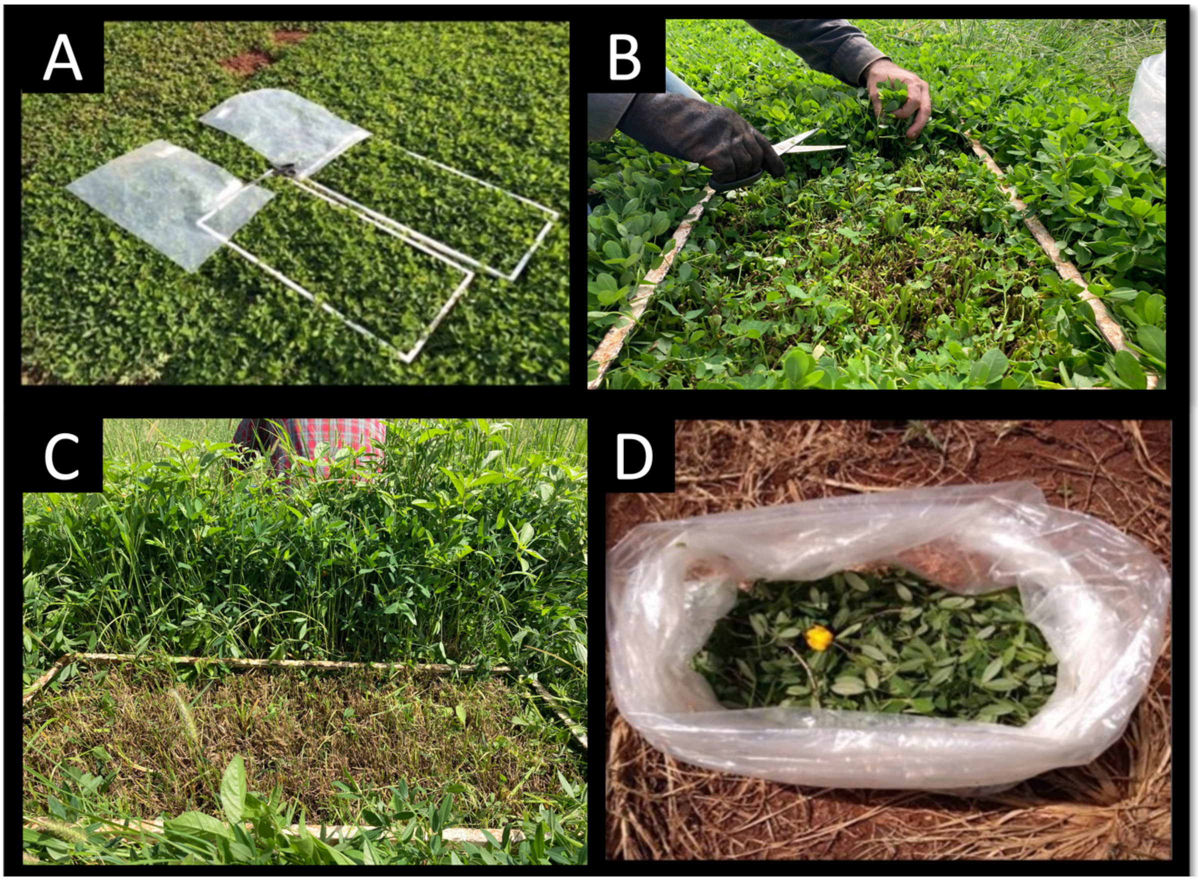

Figure 3. (A): Quadrats positioned for harvest in *A. pintoi* plot; (B): *A. pintoi* harvest; (C): *A. glabrata* stubble after harvest; (D): *A. glabrata* sample stored in plastic bag for transport.

3.2.2 Canopy height

The canopy height (CH) was measured at 10 representative sites of each sub-plot on day zero and on the 42nd day of each growing cycle before harvest. Measurements were taken using a ruler and an acetate sheet that did not compress the canopy structure (Figure 4).

Figure 4. (A): Evaluator measuring canopy height; (B): Detail of *A. pintoi* canopy height.

3.2.3 Vertical canopy architecture and botanical composition

The spatial distribution and arrangement of the canopy components was characterized once, with the inclined point quadrat (WILSON, 1960), at the end of the 17th regrowth cycle, before the harvest of forage mass. The inclined point quadrat was positioned at representative sites of average canopy height (visual assessment). The equipment rod was mounted at a 32.5º angle between the point of penetration into the canopy profile plane and the soil level. The rod was introduced into the canopy, and its tip touched different components (leaflet, petiole, stolon, dead material, and weeds), (Figure 3). Each touched component was identified and the height at which it occurred was recorded. This procedure was repeated until the tip of the rod touched the soil surface (the reference height). In each subplot, a minimum of 100 touched ponts were recorded.

Figure 5. (A): Operator using the “Inclined Point Quadrat”; (B): Touch in AP leaflet component

3.2.4 Root-rhizome biomass

The root-rhizome biomass was collected twice, at the first and last regrowth cycles. The root-rhizome biomass (RM) was collected using a spatula (20 cm wide) to 20 cm soil depth. Two samples were taken (soil volume of 8000 cm^3) in each sub-plot (Figure 6).

Figure 6. (A): Student using the sledgehammer to “cut” the soil with the spatula; (B): Student moving the spatula to “cut” the soil; (C): Students harvesting the final part of the sample.

The samples were washed in running water using a three sieves (8 x 15mm; 3 x 6 mm; 2 x 2 mm) to separate the root-rhizome material from the soil (Figure 7).

Figure 7. (A): Soil block containing root during the start of the washing process; (B): Root material during the process; (C): Material being transferred to the next sieve

The material obtained after the washing (Figure 7) was oven-dried at 100 ºC for one hour, then at 60 ºC until it reached constant weight. The sample separated than weighted on a digital scale (Figure 8) into root material and impurities (pebbles, dirt, and weed roots).

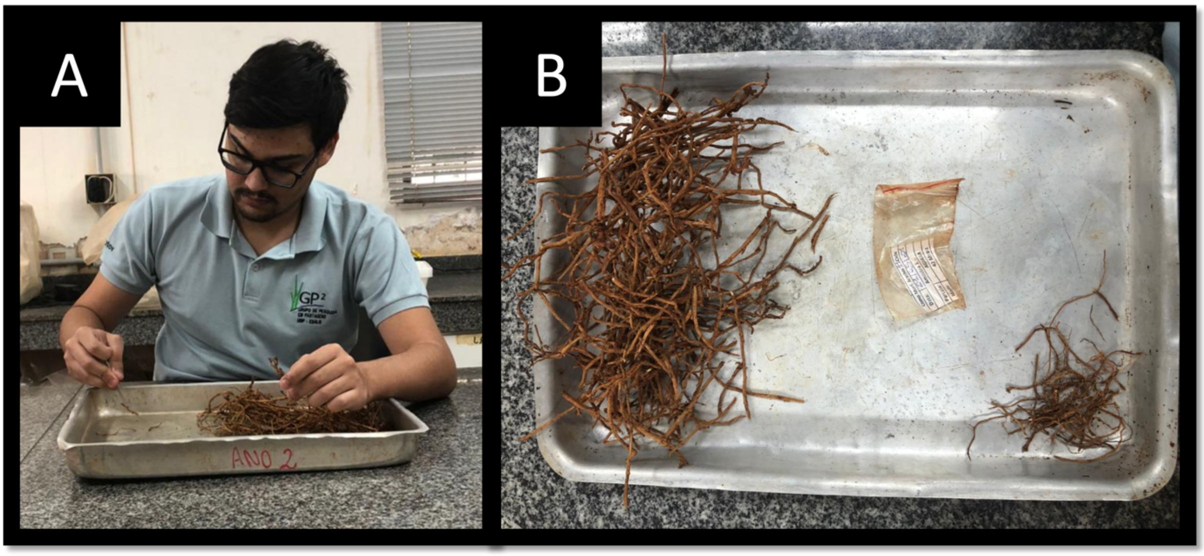

Figure 8. (A): Student sorting out root material from impurities; (B): Root material separated from weed roots and other impurities.

3.3 Statistical analysis

Data were analyzed using the PROC MIXED procedure of SAS®, with a model including the effects of species, defoliation intensity and their interaction as fixed effects and block as random effects. The covariance structure was chosen based on the Akaike's Information Criterion (AIC) (WOLFINGER, 1993). Treatment means were calculated using LSMEANS and compared by the probability of difference (PDIFF), with Student test ($P < .05$).

Vertical canopy architecture and botanical composition data, obtained with the "Inclined Point Quadrat", was used to obtain the percent of components (frequency of occurrence) by height interval along the vertical canopy profile. The botanical and morphological compositions were presented in graphics obtained in Microsoft Office Excel ® software.

4. RESULTS AND DISCUSSION

There was no intensity × species interaction for forage accumulation ($P = 0.452$). Forage accumulation was only affected by species ($P = 0.030$) (Table 1). Greater FA was observed for pinto peanut which is most likely due to differences on biomass proportion between aboveground and belowground (root-rhizhome) components for each species (OTERO, 1941; PRINE, 1964; KRAPOVICKAS, 1969).

Table 1. Forage accumulation of *Arachis glabrata* cv. Florigraze (AG) and *Arachis pintoi* cv. Belmonte (AP) affected by species in Piracicaba, São Paulo, Brazil.

Specie	Forage accumulation (kg DM ha^{-1})
AG	5,050
AP	10,633
P-value	0.030
SEM‡	672

†Species effect is indicated by P < .05.

‡SEM: standard error of the mean.

As reported in Cooley et al., (2020), in AG stands, defoliation frequency directly affects forage accumulation and rhizome biomass. The 42-d interval was shorter than the twice or once a year harvested conducted by Cooley et al., (2020) which resulted in double of FA for the most frequent intensity (COOLEY et al., 2020). Ortega-S. et al. (1992), reported that forage accumulation in AG increased in defoliation every 63 days when compared with 42 days. Cooley et al. (2020), evaluated defoliation frequency even more spaced, only twice per year targeting higher yield, but in Cooley et al., (2020) decrease in root biomass was still observed when harvesting with a short stubble height even with low frequence of defoliation (twice per year) (Table 3). These factors could also explain the smaller forage accumulation in AG when compared with AP (Table 1). Dubeux et al. (2017) reported AG forage accumulation as high as 13000 kg DM ha^{-1} yr^{-1}.

The canopy height was affected ($P = 0.018$) by the intensity × species interaction (Table 2). Rhizoma peanut greater height is related to the species growing habit, described as decumbent, different than Pinto peanut, whose growth habit is described as prostate (creeping) (COOK et al., 2020). Even though AP canopy was shorter than AG, resulting in almost twice of forage accumulation (Table 1). The species growing habit results in a denser canopy reinforcing the idea that the canopy height difference between species is connected by their different morphology. Furthermore, the taller canopy height in AG can be a response of the high percentage of weeds in its canopy (Figures 9 and 10); the competition for light may have caused AG plants to etiolate.

Table 2. Canopy height of *Arachis glabrata* cv. Florigraze (AG) and *Arachis pintoi* cv. Belmonte (AP) affected by the interaction intensity × specie in Piracicaba, São Paulo, Brazil.

Defoliation Intensity	AG	AP	*P-value*	SEM
cm	- - - - - - - - Canopy height (cm) - -			
4	13	12	0.057	0.41
8	18	15	<.001	
P-value	<.001	<.001		
SEM‡		0.41		

‡SEM: standard error of the mean,

The taller stubble resulted in taller canopies for both species at harvest. This is most likely due to the greater residual LAI for the 8-cm treatment, which supported faster regrowth (NASCIMENTO JUNIOR et al., 2002). These canopies could achieve the critical LAI (95% light interception) during the regrowth period, which forces the plants to elongate their stolons to enhance light penetration into the canopy. The 8 cm stubble resulted in greater percentage of leaves below the stubble height, and also more stolon and dead material (Figures 10 and 12) than the 4-cm treatment. Taller canopies did not result in greater FA, as there was no difference in defoliation intensity, reinforcing the assumption that in the 8 cm stubble height treatment, the plants may have achieved the critical LAI, growing in height and biomass, but growing the losses by senescence, as was not observed difference in the forage accumulation regarding the defoliation intensity.

Table 3. Root biomass of *Arachis glabrata* cv. Florigraze (AG) and *Arachis pintoi* cv. Belmonte (AP) affected by the interaction intensity × specie in Piracicaba, São Paulo, Brazil

Intensity	AG	AP	*P-value*	SEM
cm	- - - - - - - - Root biomass (kg ha^{-1})			
4	21000	15350	0.059	1970
8	36000	15000	<.001	
P-value	<.001	0.891		
SEM‡		1970		

‡SEM: standard error of the mean

There was an intensity × species interaction for RM (P = 0.001). Root biomass differences between species can be explained by the AG habit of allocating carbon into the root system and rhizomes, different than AP, which does not have these organs. (OTERO, 1941; PRINE, 1964; APEZZATO-DA-GLÓRIA, 2009; AZEVEDO, 2020). In this study, the different biomass allocation characteristics were observed in RM and FA as well. Rhizhoma peanut had twice the root biomass of AP in the 8cm stubble height treatment (Table 3), as a species intrinsic characteristic. In contrast, AP had twice the forage accumulation of the AG in these aboveground biomass (Table 1), even with a shorter canopy (Table 2).

The significant difference in root biomass between defoliation intensity in AG suggests that the 4 cm stubble height was too severe. Sollenberger and Collins, (2018), recommended stubble heights of 10 to 15 cm after 6 weeks of regrowth, similar to the present study. When comparing the defoliation intensity in this study with those author's recommendations, it is possible to associate the weed percentage to AG canopies (Figures 9 and 10). Thus, reinforcing that 4 and 8 cm of stubble height and the interval between defoliations used in this study could negatively impact AG stand persistence.

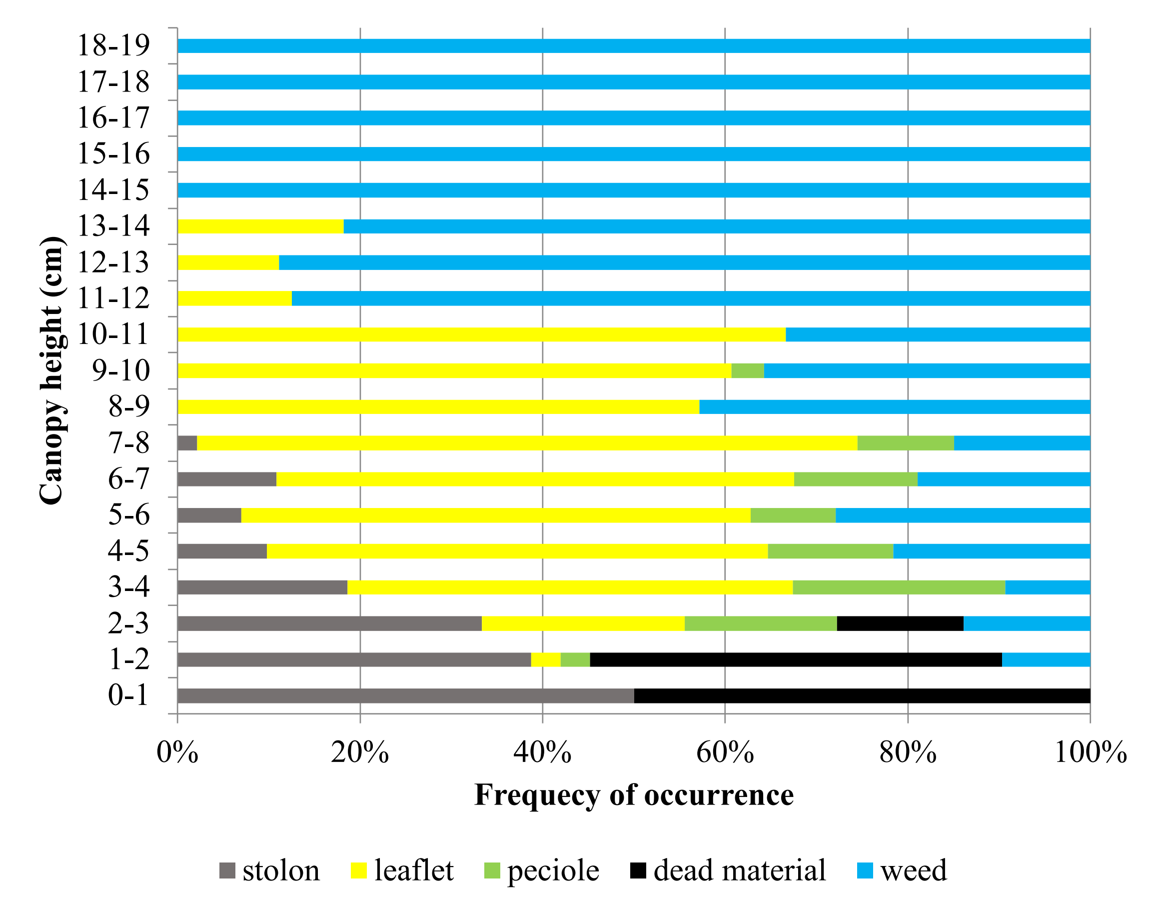

Figure 9. Vertical distribution of plant-part components of *A. glabrata cv. Florigraze managed under 4 cm of defoliation intesity (AG4)*.

The forage accumulation (Table 1) difference between species could be related to the greatar percentage of the leaflet component in AP canopy (Figures 11 and 12), when compared with AG (Figures 9 and 10) since this component is the major responsible for photoassimilates production.

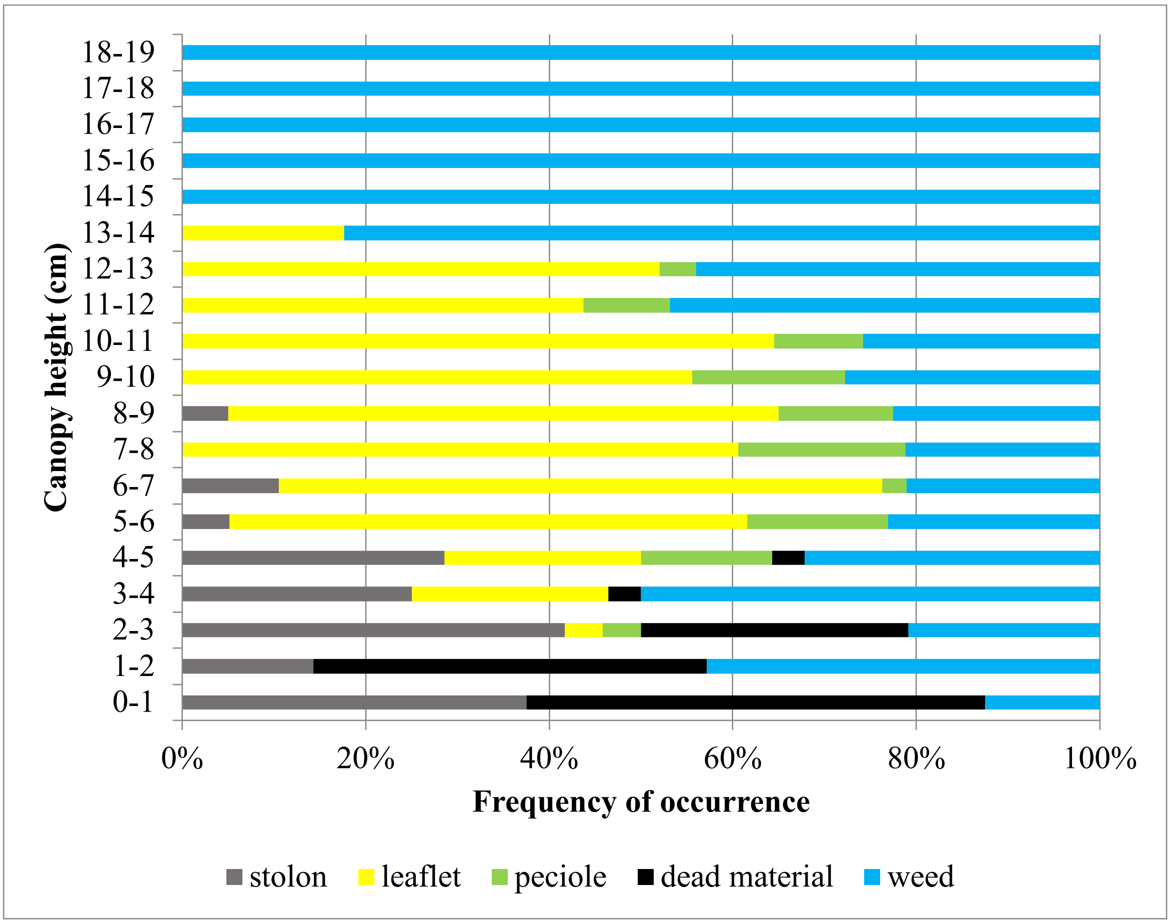

Figure 10. Vertical distribution of plant-part components of *A. glabrata cv. Florigraze managed under 8 cm of defoliation intensity (AG8).*

The similar frequency of occurrence of *A. glabrata* cv. Florigraze managed under 4 cm of defoliation intesity (AG4) and *A. glabrata* cv. Florigraze managed under 8 cm of defoliation intensity (AG8) canopy components of (Figures 9 and 10), especially the frequency of weed component, is most likely due to additional factor besides the defoliation intensity 4 cm affecting the AG stand. The vertical distribution of the rhizoma peanut (Figures 9 and 10) canopies, FA (Table 1), and RM (Table 3) responses indicate that the defoliation intensity and frequency used in this study may have impacted the AG stand development negatively. Sollenberger and Collins (2018) did not recommend stubble heights of less than 10 cm for the 6-week defoliation frequency in their study, while Ortega-S (1992) reported that AG stand persistence was greater in treatments that combined frequency of defoliation of 42 days or more and stubble height between 15 and 22 cm.

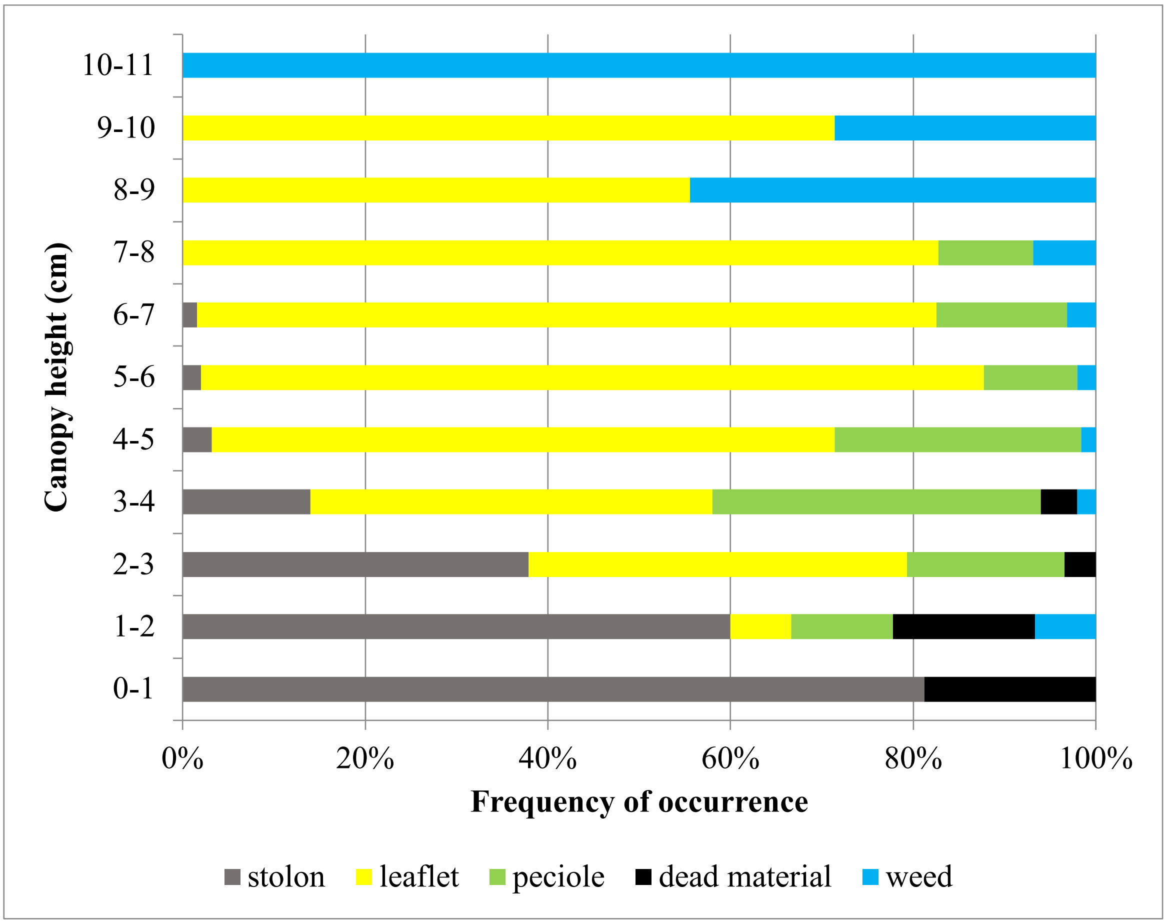

Figure 11. Vertical distribution of plant-part components of *A. pintoi* cv. Belmonte managed under 4 cm of defoliation intensity (AP4).

Pinto peanut canopy had less weeds than Rhizoma peanut, even managed under 4 cm of defoliation intensity (AP4), indicating that the management did not hinder stand persistence, different than what was observed in AG canopies (Figures 9 and 10) and root biomass (Table 3). The only weed occasionally observed in the field in AP canopies was nutgrass (*Cyperus rotundus*), the most problematic weed in the world (MONQUERO et al., 2014) in contrast with a great diversity of weeds seen in AG, highlighting the genus *Amaranthus*, *Cynodon*, *Trifolium*, *Cenchrus*, *Digitaria*, *Urochloa* and *Bidens*.

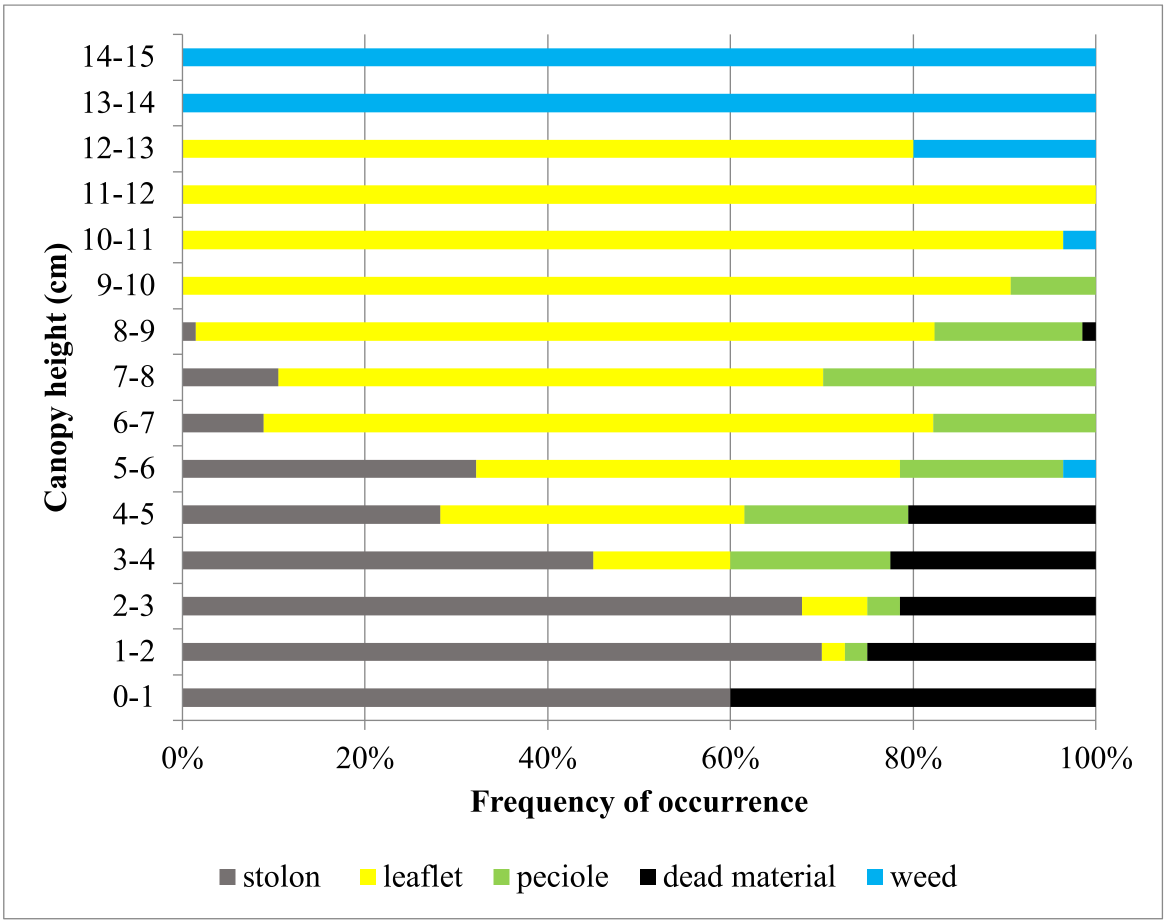

Figure 12. Vertical distribution of plant-part components of *A. pintoi* cv. Belmonte managed under 8 cm of defoliation intensity (AP8).

The greater frequency of occurrence of dead material, stolon, and petiole in *A. pintoi* cv. Belmonte managed under 8 cm of defoliation intensity (AP8) when compared with AP4 suggests that during the regrowth period, this treatment may reach the critical LAI index. This would cause the production of the components stolon and petiole increasing light penetration into the lower portions of the canopy, then causing the increase in dead material. There were no differences between the FA of the AP treatments (Table 1), corroborating this idea (ANDRADE, 2012).

Due to the greater percentage of leaflets, a smaller percent of weeds, and the absence of some weed genera such as *Cenchrus*, *Digitaria*, *Trifolium*, *Amaranthus,* and *Bidens* in AP canopies (Figures 11 and 12), the opposite was observed in AG canopies (Figures 9 and 10). These indicate that AP forage may have better nutritive value than AG, especially due to less weeds and the major occurrence of leaves (leaflet and petiole), the most important component for animal nutrition. The presence of some weed genera that were observed in AG would decrease the quality of the conserved forage and its commercial value.

Passini (2020), registered that AG had FA twice that of AP regardless of the defoliation intensity. Cooley et al., (2020) described that AG should be harvested twice a year for hay purposes or only once to avoid the decrease of root system biomass. According with Passini (2020) and Cooley et al., (2020), the lesser forage in AG in the present study after two years of imposed treatment suggests that the defoliation intensity (4 and 8 cm) and frequency (42d interval) impacted negatively the AG stand persistence.

Considering both species establishment challenges is very reasonable to choose a specie and management that presents high yield, stand persistence and longevity. Although the AP defoliated at 4 cm of stubble height (most intense defoliation management) should be preferred, longevity and stand persistence should be monitored over time by evaluating the participation of weeds and soil fertility, particularly when managing fields to produce hay. During the course if this experiment, the majority of weeds in AP canopy were nutgrass (*Cyperus rotundus*), a very persistent weed that can be propagated vegetatively and through seed (MONQUERO et al., 2014), not being an indication that the defoliation intensity used could impact negatively the stand during the experimental period.

5. CONCLUSIONS

Greater forage accumulation was observed for AP which also had less weed pressure than AG, regardless of the defoliation intensity treatment. Root biomass was greater in AG and was affected by defoliation intensity, indicating that the imposed defoliation intensity compromised the stand persistence.

Lesser dead material and stolon proportions were observed in AP4 than AP8 canopy. Furthermore after two years under this treatment AP4 showed no signs of stand degradation. Therefore, for the 42 days regrowth used in this study, the pinto peanut harvested at 4 cm had the best agronomical results.

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