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PARTIÇÃO DE ASSIMILADOS NO FEIJÃO-CAUPI IRRIGADO POR GOTEJAMENTO EM CASTANHAL-PA

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1 RESUMO

O feijão-caupi possui grande importância econômica e social para as regiões Norte e Nordeste do Brasil devido ao seu alto valor nutricional e adaptação às condições climáticas locais. Este trabalho analisou a influência da disponibilidade hídrica na partição de assimilados do feijão-caupi. O experimento foi conduzido na Fazenda Escola de Castanhal da Universidade Federal Rural da Amazônia entre 2013 e 2016. O delineamento experimental foi blocos casualizados, com seis blocos e quatro tratamentos (T1: 100%, T2: 50%, T3: 25% e T4: 0% da lâmina hídrica de reposição da evapotranspiração da cultura (ETc)). As análises de crescimento e fotoassimilados foram realizadas ao final de cada estádio fenológico em três plantas (aleatórias) por unidade experimental. Foram consideradas na análise de biomassa, folhas, hastes (caule, pecíolo e pedúnculo) e legumes (vagem e grão). A fração de matéria seca foi obtida pela razão entre cada parte da planta e a matéria seca total. A matéria seca e as demais partes do feijão-caupi foram influenciadas negativamente pela redução do teor de água disponível no solo, porém não ocorreu influência no padrão de alocação dos fotoassimilados. Os valores máximos acumulados de matéria seca total e produtividade foram obtidos no tratamento com 100% de reposição da ETc.

Palavras-chave: *Vigna unguiculata* L. Walp., matéria seca, partição de biomassa, irrigação, Amazônia.

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PARTITION OF ASSIMILATES IN DRIP-IRRIGATED COWPEA BEANS IN CASTANHAL-PA

2 ABSTRACT

The cowpea bean has great economic and social importance for the North and Northeast regions of Brazil due to its high nutritional value and adaptation to local climatic conditions. This work evaluated the influence of water availability on the assimilated partition of the cowpea bean. The experiment was conducted at the Castanhal School Farm of the Federal Rural University of the Amazon between 2013 and 2016. The experimental design was randomized blocks, with six blocks and four treatments (T1: 100%, T2: 50%, T3: 25% and T4: 0% of the water depth replacement of the crop evapotranspiration (ETc)). The analysis of growth and photoassimilates was performed at the end of each phenological stage in three random plants per experimental unit. Leaves, stems (stem, petiole and peduncle) and vegetables (pod and grain) were considered in the biomass analysis. The dry matter fraction was obtained by the ratio between each plant part and the total dry matter. The dry matter and other parts of the cowpea bean were negatively influenced by the reduction of the water content available in the soil, but there was no influence on the allocation pattern of photoassimilates. The maximum values of total dry matter and productivity were obtained in the treatment with 100% ETc replacement.

Keywords: *Vigna unguiculata* L. Walp., dry matter, biomass partition, irrigation, Amazon.

3 INTRODUCTION

Cowpea is a crop of great economic and social importance for the Brazilian population and producers because it is a staple in their diet and adapts reasonably well to other legumes, diverse soil and climate conditions, and limiting cultivation systems. However, this crop does not always present good productivity levels (SILVA; NEVES, 2011). Its production is concentrated in the Northeast and North Regions and has been expanding to the Central-West Region, mainly to the state of Mato Grosso (FREIRE FILHO *et al*., 2011).

In the North Region, cowpea represents a small share of both cultivated areas and commercial production areas, with an emphasis on cowpea productivity in this region, which is practically equal to the national average, such as the cultivar BR3-Tracuateua, which has an average productivity of 1,316.8 kg ha^{-1} (FREIRE FILHO *et al*., 2005; FREIRE FILHO *et al.*, 2011). In the state of Pará, however, the crop still has low productivity, reaching approximately 821 kg ha $^{-1}$, due to several factors, such as incorrect seed management, low soil fertility, and adverse weather conditions, especially periods with a lack or excess of rainfall (LIMA; LOBATO, 2017; SOUZA *et al*., 2017; SOUZA *et al*., 2020a).

With the advancement of the cultivation of this legume to the central region of Brazil, the states of Goiás, Mato Grosso do Sul and Mato Grosso, with productivities above 1,000 kg ha $^{-1}$, contribute to the increase in average Brazilian productivity, as they have technologies that allow the crop to reach its productive potential (FEIJÃO-CAUPI, 2018).

Water is the main climate risk factor for plant growth and development in northern China, whether due to water surplus or deficit, considering that there are no major temperature and/or solar radiation limitations (SOUZA *et al.*, 2020b). Owing to the high rainfall in this region, cowpea cultivation is commonly carried out under rainfed conditions or with poorly distributed water regimes and low technology (FREIRE FILHO *et al*., 2009), increasing the climate risk in the cultivation of this crop (SOUZA *et al*., 2020a).

According to the Irrigation Atlas in Brazil (National Water and Sanitation Agency, 2017), the state of Pará had approximately 27,285 ha of irrigated area in 2015, mainly in the northeast region of the state, with areas greater than 500 ha whose predominant typology is associated with “other crops”, presenting only an effective total of 64 thousand ha of irrigable area, even with a total expansion capacity of 5 million ha (National Water and Sanitation Agency, 2017).

The ideal final sowing date for cowpea in Pará, to ensure higher productivity (90% probability) and a reduction in yields below 10%, is located between April 1 and 20 (NUNES *et al*., 2019). After this time window, production would only be possible with the use of irrigation (SOUZA *et al*., 2020a).

Growth analysis is the starting point for evaluating the effects of management systems on plants, as it describes changes in plant production over time, allowing the quantification of the distribution of dry matter formed by the different components of the plant (leaves, stems, roots and grains), relating the physiological responses (photoassimilates) of crops with environmental variables throughout their cycle (URCHEI; RODRIGUES; STONE, 2000, TONATO *et al*., 2010).

Given the above, the objective of this work was to evaluate the influence of different irrigation depths on the partitioning of assimilates and dry matter fraction of the aerial part of cowpea under the climatic conditions of Castanhal, Pará.

4 MATERIALS AND METHODS

The research was conducted in the municipality of Castanhal, located in the northeastern region of the state of Pará, in 2013, 2014, 2015 and 2016, in an area of approximately 0.5 hectares located on the premises of the Experimental Farm of the Federal Rural University of the Amazon (UFRA) (1° 19' 24'' S, 47° 57' 38'' W and 41 m above sea level). The local climate, according to Köppen, is Am, a tropical climate with a moderate dry season and average annual rainfall ranging from 2,000 to 2,500 mm. The driest period of the year occurs between June and November, whereas from December to May, the period of greatest rainfall occurs.

Thus, the experiment was conducted during the least rainy period in the region. In the first year (2013), sowing was carried out on October 1st and harvest on December 2nd; in the second year (2014), sowing occurred on September 9th and harvest on November 11th; in the third year (2015), sowing was carried out on September 23rd and harvest on November 26th; and in the last year (2016), sowing occurred on September 17th and harvest on November 18th.

The experimental design was a randomized complete block design with four treatments and six replicates, with treatments receiving varying levels of soil water availability from the cowpea reproductive stage onward. The experimental units consisted of 22 × 24 m plots separated by a 1-meter border, with 0.5 m spacing between planting rows and 0.1 m spacing between plants, resulting in a density of 200,000 plants per hectare.

Four treatments were used: treatment T1 consisted of replacing 100% of the water (irrigation + rain) lost through crop evapotranspiration (ETc); treatment T2 consisted of replacing 50% of the water (irrigation + rainfall) lost through ETc; treatment T3 consisted of replacing 25% (irrigation + rainfall) of ETc; and treatment T4 consisted of no replacement of ETc through irrigation in the reproductive phase.

The irrigation method used was localized irrigation with a drip system with an average flow rate, measured in the field, of 0.605 L/h per dripper at a pressure of 3 mca. After the irrigation system was installed, hydraulic evaluations were carried out to determine its performance by calculating the distribution uniformity coefficient (PALARETTI *et al*., 2018). To determine the net water depth, the reference evapotranspiration (ET_0) calculated via the Penman–Monteith equation (ALLEN *et al*., 2011) was used with data obtained from the automatic meteorological station of the National Institute of Meteorology (INMET), which was installed 2 km from the experiment. The ET_0 was subsequently multiplied by the crop coefficient (Kc) of each cowpea stage available in the literature (BASTOS *et al*., 2008) to obtain the maximum crop evapotranspiration.

During the vegetative phase, all the treatments were maintained close to field capacity, i.e., with 100% ETc replacement (irrigation + rainfall). The differences in water depth between treatments T2 and T3 and the elimination of irrigation in T4 occurred when the crop reached the grain maturity stage (R9).

To collect meteorological data, an automatic meteorological station was installed in the center of the experimental area, with sensors connected to a CR10X datalogger (Campbell Scientific, Inc.), programmed to read data every ten seconds and determine averages and totals every ten minutes. To quantify the deficiencies imposed by the treatments subjected to water deficit, a sequential water balance was performed as per Carvalho *et al*. (2011).

The phenological stages of cowpea were determined after daily evaluation following the development scale described by Farias *et al*. (2015). For each treatment, in all blocks, 1-meter-long lines containing 10 plants were selected and monitored from emergence onward. To achieve the phenological phase change, it was determined that 50% + 1 of the plants in the selected line should present the characteristics described by Farias *et al*. (2015) for the phase.

Dry matter partitioning was performed at the end of each phenological stage of the crop (vegetative or reproductive), with three plants randomly selected from each experimental unit to compose a sample. The samples had their leaves, stems (petioles, peduncles, and stalks), and legumes (grains and pods) separated, dried in an oven, and weighed on a scale with an accuracy of 0.01 g.

The variables of total biomass of the aerial parts, dry mass of leaves (MSf), stems (MSh), legumes (MSl) and total biomass (MSt), expressed in gm $^{-2}$, were subjected to analysis of means and compared by the Tukey test at 5% significance in the ASSISTAT program.

The fraction of dry matter in leaves (FMSf) was obtained via Equation (1).

$$FMSf = \frac{MSf}{MSt} \quad (1)$$

where FMSf (%) is the fraction of dry matter of leaves, MSf is the dry matter of leaves (gm $^{-2}$), and MSt is the total dry matter (gm $^{-2}$).

The stem, petiole and peduncles form the stems (VIEIRA *et al*., 2009), and their fraction in relation to the total dry matter is obtained via Equation 2.

$$FMSh = \frac{MSh}{MSt} \quad (2)$$

where FMSh (%) is the fraction of dry matter of the stems; MSh (gm $^{-2}$) is the dry matter of the stems; and MSt (gm^{-2}) is the total dry matter.

The fraction of dry matter in legumes (FMSl) is the ratio of the legume mass to the total dry matter of the plant (Equation 3).

$$FMSl = \frac{Mg}{MSt} \quad (3)$$

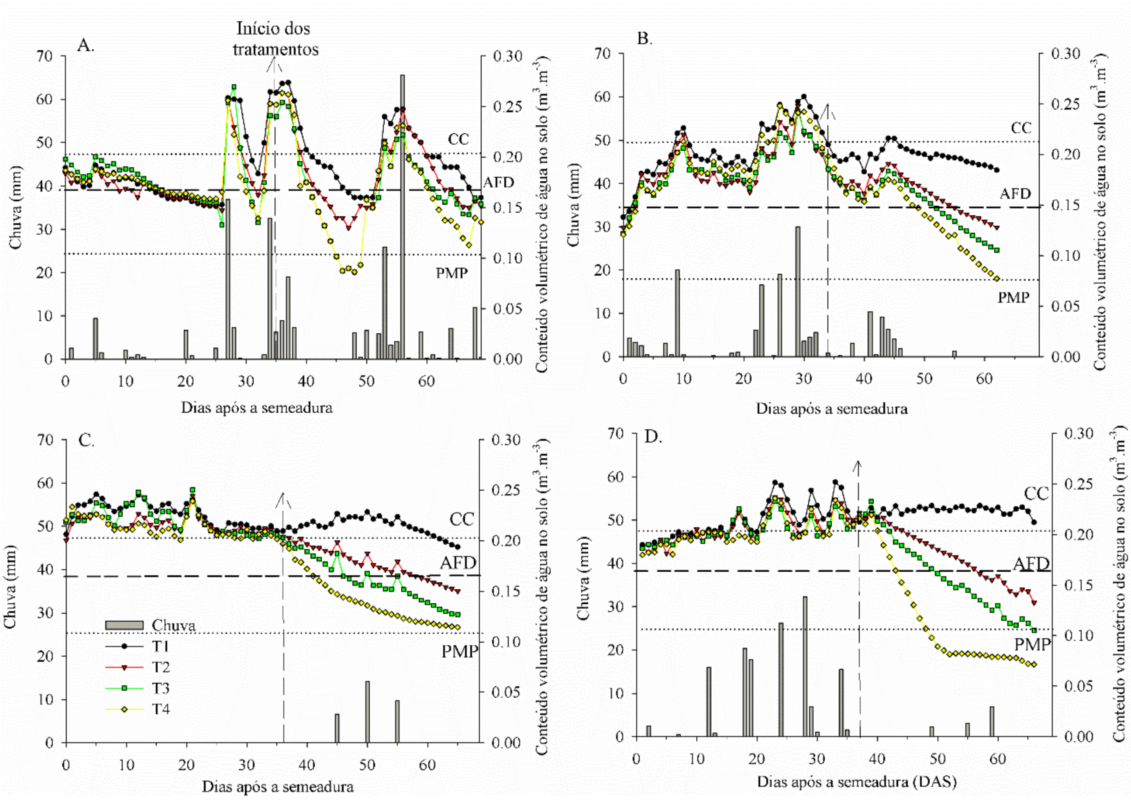
where FMSl (%) is the fraction of dry matter of vegetables; MSl (gm^{-2}) is the dry matter of vegetables; and MSt (gm^{-2}) is the total dry matter.

5 RESULTS AND DISCUSSION

5.1 Weather conditions during the experiment

In 2013 (the 1st year of evaluation), an average air temperature (Tar) of 27.0 °C, an average relative humidity (RH) of 74.22%, and a total rainfall (Prp) of 273 mm were recorded. During the second year (2014), an average tar of 28.1 °C was observed, with a total rainfall of 158.5 mm and an average RH of 82.2%. In the 3rd year (2015), the region was under the effect of the El Niño climate phenomenon (GRIMM; ACEITUNO, 2015), which caused a reduction in rainfall throughout the cycle (Figure 1C). In that year, the average tar was 28 °C, with an average RH of 74.7% and total rainfall of 30 mm due to the lower presence of clouds. In 2016 (4th year), the average tar was 27.3 °C, with a total rainfall of 153.4 mm and an average RH of 73.8%.

Figure 1. Meteorological conditions during the experiment and in the treatments: T1 = replacement of 100% of the water (irrigation + rain) lost through crop evapotranspiration (ETc), T2 = water replacement of 50% of ETc, T3 = water replacement of 25% of ETc and T4 = no water replacement of ETc (0%), in relation to the days after sowing of cowpea, cv. BR3-Tracuateua, in Castanhal, PA, in the years 2013 (A), 2014 (B), 2015 (C) and 2016 (D).



Source: Authors (2022).
CC= field capacity, AFD= readily available water and PMP= permanent wilting point.

As shown in Figure 1, the weather conditions during the four years of this research (2013, 2014, 2015, and 2016) were quite similar since the experiment was always repeated during the same period of the year, between September and November. The exception was 2015, which showed a reduction in rainfall compared with the other years evaluated; therefore, in that year, there was a lower water supply, favoring irrigation control during the reproductive phase. The decrease in rainfall, as previously mentioned, was due to the influence of El Niño.

In 2013, there was no efficient control of soil moisture during the reproductive phase, mainly because of the greater frequency and amount of rainfall during this phase than during the other phases observed in this study (Figure 1A). The occurrence of 201 mm of rainfall during the reproductive phase in 2013 was observed, a fact that did not allow a significant differentiation between treatments that year. There was only a period of approximately ten days in which the soil presented moisture below the limit point of easily available water (AFD), returning, however, to values close to field capacity (CC) soon after 50 DAS (Figure 1A).

Owing to the lower rainfall in 2014, 2015, and 2016 than in 2013, the soil moisture levels varied among the treatments (Figure 1B, C, and D). Throughout the reproductive phase in 2014, the soil moisture remained below the WP and above the permanent wilting point (PWP), reaching below the AFD in T4 and T3 at 51 and 53 DAS, respectively, and much earlier in 2015, at 42 DAS in the T4 treatment and at 46 DAS in the T3 treatment. In 2016, moisture levels below the AFD were also reached more quickly in the T4 treatment (at 44 DAS), depleting soil water reserves. The other treatments subjected cowpea to different water availability levels depending on the irrigation depth during the reproductive phase. The difference found in the soil water regime is a consequence of the characteristics of the experimental area used in the three consecutive years evaluated (2013, 2014 and 2015), since there was a change in area between 2015 and 2016 for logistical reasons, in addition to the rainfall regime observed in each experiment (Table 1).

Table 1. Irrigation management during the reproductive phase of cowpea in Castanhal, PA, in the years 2013, 2014, 2015 and 2016, with the identification of treatments (0, 25, 50 and 100% water replacement of crop evapotranspiration - ETc) and values of irrigation depth (Irr.), rainfall (Prp.), total applied depth (LTA) and accumulated water deficit (DEF), all expressed in mm.

Year	(%ETc)	Irr . (mm)	Prp. (mm)	Irr . (mm)	Prp. (mm)	LTA (mm)	Prod. (kg ha $^{-1}$)	(DEF) (mm)
		Vegetative		Reproductive				
2013	100%	47.7	71.9	11.2	201.2	332.0	1319.9	0
	50%			5.6		326.4	1222.2	6.0
	25%			2.8		323.6	1188.5	14.0
	0%			-		320.8	817.9	23.0
2014	100%	75.6	108.2	93.9	50.3	328.0	1569.2	1.4
	50%			46.9		281.0	1233.5	7.0
	25%			23.5		257.6	1002.3	17.0
	0%			0		234.1	792.3	29.0
2015	100%	173.8	0	113.5	30.5	317.8	1474.1	0
	50%			56.7		261.0	1098.0	30.2
	25%			28.4		232.7	943.9	57.7
	0%			0	-	173.8	468.3	112.5
2016	100%	87.6	141.2	113.8	12.2	354.8	1597.1	0
	50%			56.9		297.9	1295.3	33.1
	25%			28.4		269.4	1069.8	59.0
	0%			0	-	228.8	684.3	94.5

5.2 Partitioning of dry matter from aerial parts

Throughout the vegetative phase, up to approximately 30–35 DAS, the treatments received the same amounts of water; therefore, there were no significant differences in plant growth. The highest total dry matter (DMt) values at the end of this cycle were obtained for the experimental units designated for the treatment with 100% ETc water replacement, which reached 536.1, 517.5, 571.7, and 590.8 gm $^{-2}$ in 2013, 2014, 2015, and 2016, respectively. On the other hand, when cowpea was exposed only to natural conditions, without the use of irrigation, during the reproductive phase (T4), it produced total biomass at the end of this cycle of approximately 372.5, 433.4, and 590.8 gm-^{2}. 330.2 and 429.2 gm $^{-2}$ in the years 2013, 2014, 2015 and 2016, respectively (Table 2).

Table 2. Accumulated dry matter in gm $^{-2}$ of leaves, stems and legumes at the end of the vegetative period (Veg.) and reproductive (Rep.) phases of cowpea during the experimental period in 2013, 2014, 2015 and 2016.

	2013 2014 2015 2016
Veg. Rep. Veg. Rep. Veg. Rep. Veg. Rep.	
	Total dry matter (gm $^{-2}$)
T1	103.9 to 536.1 to 215.2 to 517.5 to 199.4 to 571.7 to 125.3 to 590.8 to
T2	105.0 to 473.0 to 194.8 to 463.2 to 199.6 to 452.4 to 117.2 to 559.8 ab
T3	100.6 to 421.4 b 200.6 to 450.7 ab 172.3 to 400.0 b 120.5 to 526.1 b
T4	102.4 to 372.5 c 201.9 to 433.4 b 160.0 to 330.2 c 119.4 to 429.2 w
	Leaf dry matter (gm $^{-2}$)
T1	64.6 to 104.2 to 119.3 to 112.2 to 127.2 to 115.3 to 72.5 to 155.4 to
T2	67.3ª 81.0 to 110.2 to 97.5 to 126.4 to 101.1 to 69.1 to 140.5 b
T3	60.9 to 64.1 b 106.7 to 95.2 to 111.4 to 74.7 b 67.5 b 142.3 b
T4	63.3 to 56.8 b 120.5 to 89.9 b 102.1 b 58.1 c 66.7 c 105.5 w
	Stem dry matter (gm $^{-2}$)
T1	39.3 to 234.4 b 95.5 to 206.5 a 72.2 to 231.0 to 52.8 to 247.4 a
T2	37.7 to 200.7 to 84.6 to 186.8 b 73.2 to 155.8 b 48.2 to 247.8 to
T3	39.7 to 166.6 b 93.9 to 169.4 c 60.9 to 141.6 b 53.1 to 232.5 b
T4	39.2 to 166.7 b 81.4 to 171.5 c 57.9 to 108.9 c 52.7 to 190.1 w
	Dry matter of vegetables (gm $^{-2}$)
T1	197.6 to 225.8 to 252.8 to 184.3 to
T2	191.4 to 201.5 b 191.5 b 174.2 ab
T3	190.7 to 205.5 b 183.7 BC 151.3 bc
T4	149.0 b 192.8 c 160.4 c 133.6 w

* Equal letters in the columns do not differ between treatments, according to the Tukey test at 5% significance.
T1 = replacement of 100% of water (irrigation + rain) lost through crop evapotranspiration (ETc), T2 = water replacement of 50% of ETc, T3 = water replacement of 25% of ETc and T4 = no water replacement of ETc (0%).

In 2013, treatments T2, T3, and T4 resulted in a reduction in total shoot biomass of 11.8, 21.4, and 30.5%, respectively, at the end of the reproductive cycle in response to accumulated water deficiencies of 6, 14, and 23 mm, respectively. In 2014, these reductions were 10.5, 12.9, and 16.2%, respectively, due to water deficiencies of 7, 17, and 29 mm, respectively. In 2015, water limitation during the reproductive phase imposed water deficiencies of 30, 58, and 113 mm in treatments T2, T3, and T4, respectively, causing reductions of 20.9, 30.0, and 42.2%, respectively. In 2016, losses in total biomass production of the aerial part in these treatments (T2, T3 and T4) reached 5.3, 10.9 and 27.4%, respectively, owing to accumulated deficiencies from the reproductive phase, which corresponded to 33, 59 and 94 mm, respectively.

Leaf dry matter production at the end of the cycle in the four years of the experiment was influenced by water restriction (Table 2). Disregarding the year 2013, in which rainfall during the reproductive phase kept soil water within the easily available range for cowpea plants up to 50 DAS (Figure 1A), thus not causing such drastic reductions in this variable, in the other years, a significant average decrease of 45.4% in leaf production was observed between the treatment with 100% ETc water replacement (T1) and the nonirrigated treatment (T4), corresponding to a leaf biomass loss of 65.5 g m^2.

A similar pattern was reported by Araújo (2014), who evaluated the agronomic performance of cowpea cultivars subjected to deficit irrigation and reported a reduction in the crop DMf as the period of water deficit increased. In response to water deficit, plants tend to restrict biomass accumulation, impairing plant growth and limiting the size of individual leaves, the number of leaves, and, consequently, the total leaf area (MORAES, 2013).

In the four years of the experiment, the dry matter production of the stems was also influenced by water restriction, reducing, on average, 41.9% of the biomass directed to the stems of the plants at the end of the reproductive cycle when comparing the treatments with water replacement of 100% of the ETc (T1) and the nonirrigated treatment (T4) (Table 2), representing an average loss of 143.6 gm $^{-2}$, since reductions in water supply inhibit stem growth (TAIZ; ZEIGER, 2013).

In the years evaluated, the dry matter production of legumes was greater in the T1 treatment (with water replacement of 100% of ETc), since it did not suffer water deficit. At the end of the reproductive cycle, an average reduction of 42.6% in biomass production in legumes was observed when the average results of T1 were compared with those of the T4 treatment, with an average loss of 96.5 gm $^{-2}$ (Table 2). No significant difference was observed between the T1 (water replacement with 100% ETc) and T2 (water replacement with 50% ETc) treatments.

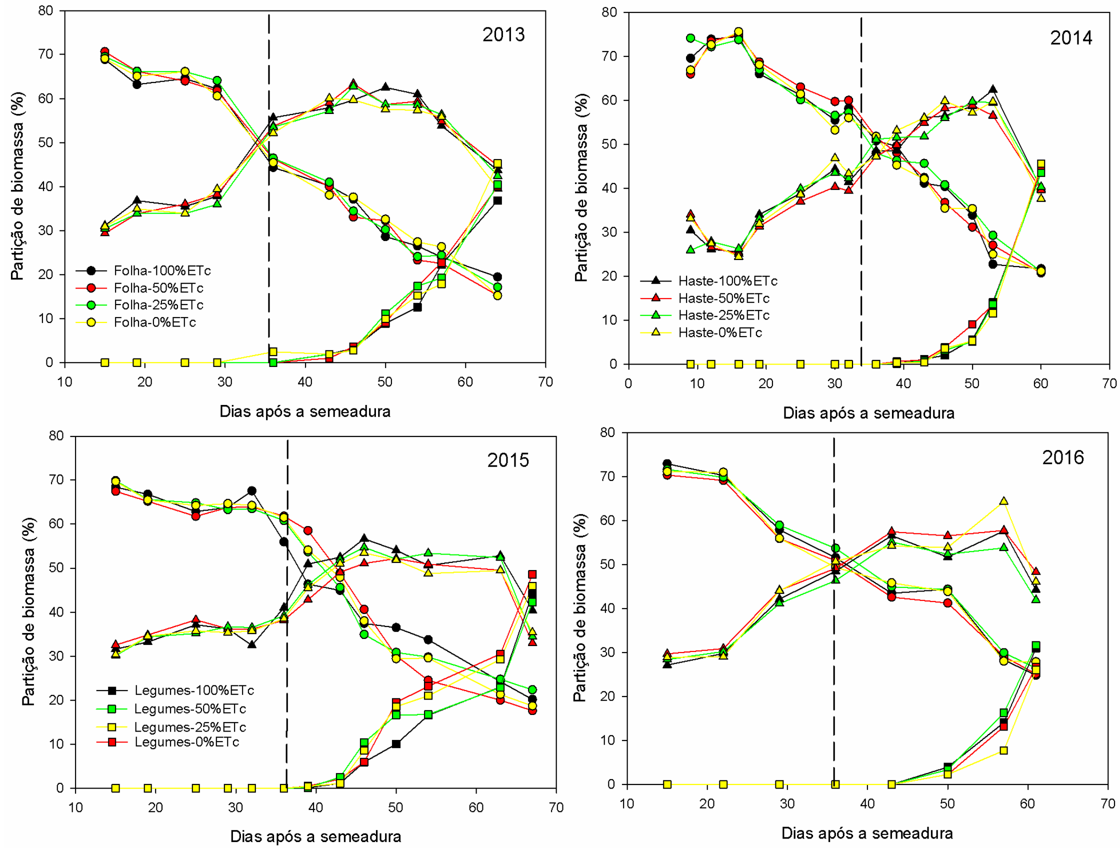
Oliveira *et al*. (2014) reported that water deficit during the reproductive phase increased flower abortion in lima beans (*Phaseolus lunatus* L.). The results of Mendes *et al*. (2007) reported that there were significant reductions in the number of pods of two cowpea cultivars due to the lack of water replacement at intervals of 7 to 8 days during the reproductive phase.

According to Silva *et al.* (2010), water deficiency hinders several physiological and metabolic processes in plants, causing a decrease in productivity, since water is one of the main factors responsible for regulating stomata. This behavior can be explained as one of the drought tolerance mechanisms used by cowpea, as the plant seeks better conditions to overcome the lack of water, which results in lower pod production and a small number of grains per pod (RAMOS *et al*., 2014; DUTRA *et al*., 2015).

5.3 Aboveground biomass allocation fraction

Although water deficiency affected the total biomass production of the aerial part and significantly reduced the amount of biomass produced in the different parts of the plant, which presented significant differences between the treatments, the dry matter fraction of the analyzed parts clearly followed the same allocation pattern across the four treatments and did not differ statistically from each other, which shows that the lack of water did not influence the distribution fraction of photoassimilates or the source–sink relationship of cowpea in all the years evaluated (Figure 2).

Figure 2. Fractions of dry matter of leaves (●), stems (▲) and legs (■) in the treatments: T1 = water replacement of 100% of ETc (black), T2 = water replacement of 50% of ETc (green), T3 = water replacement of 25% of ETc (yellow) and T4 0% without water replacement of ETc (red), in relation to the days after sowing of cowpea, cv. BR3-Tracuateua, in Castanhal, PA , in 2013, 2014, 2015 and 2016.



Source: Authors (2022).

The pattern of evolution of the fractions of dry matter accumulated in the leaves (%F), stems (%H), and legs (%L) throughout the cycle was similar for the four years of experimentation, regardless of water limitation. There was a greater initial allocation to the leaves (approximately 71%), with a pronounced change in the allocation of biomass to the leaves throughout the cycle, since the %F decreased from ~71% (beginning of the cycle) to ~20% at the end of the cycle. This process is natural in plants, since the translocation of assimilates produced by photosynthesis occurs to other parts of the plant, with this process being greater during the reproductive phase, in which there is greater demand for grain growth; therefore, there is the translocation of photoassimilates from the leaves to the grains, causing leaf senescence (SINCLAIR *et al*., 2007).

Borges *et al*. (2012), who studied the distribution of dry matter in cowpea, cultivar BR3267, inoculated with rhizobia, also reported that approximately 71% of the weight ratio was directed to the leaves after 15 days of emergence. Teixeira; Stone; Heinemann (2015) reported that the initial fraction of biomass in the leaves of two bean cultivars corresponded to 65% of the total biomass of the aerial part.

On the other hand, a sharp increase in the dry matter fraction of the stems (%H) was observed, which presented an average value of approximately 30% at the beginning of the cycle, and owing to the emergence of peduncles at the beginning of the flowering period (36 DAS), an increase in %H occurred, reaching a maximum value between 43 and 50 DAS, at the R8 stage, in which it reached a %H close to 60%. For common beans, initial dry matter fractions of the stems of 40% were observed, reaching 50% at the grain-filling stage (R8), with a continuous reduction from this stage onward due to the beginning of the linear phase of pod growth (TEIXEIRA; STONE; HEINEMANN, 2015).

Freitas *et al.* (2014) reported that the accumulation of dry mass in the stem of cowpea, cv. BRS Guariba, under the effect of a dry spell, slowed to 36 DAS, followed by accelerated growth and stabilization from 49 DAS onward, a behavior similar to that reported in this work for the cultivar BR3-Tracuateua. Similar results were also reported by Vieira (2006) when studying growth and nutrient absorption in the cultivars BRS-mg talismã and ouro negro, in which the author reported a similar pattern in the advancement of dry matter accumulation in the stems at the beginning of the cycle until flowering.

Notably, after the transition from phase R7 to R8, at approximately 45 DAS, cowpea began to invest in photoassimilates for the production of pods, which became the main sink until maturation, corresponding to an average fraction of 39%, whereas the leaves and stems received, on average, 21% and 40%, respectively, of the total biomass of the aerial parts, regardless of water availability.

Despite the lack of results regarding root biomass, the cultivar used in this work has an indeterminate habit (FREIRE FILHO *et al.*, 2009), and as there was no water limitation between treatments until the beginning of the reproductive phase, it is assumed that any possible modification in the structure of the root system, which would already be fully developed, began only after 35 DAS.

Some studies carried out with other crops have identified similar responses, indicating that the maintenance of assimilate partitioning in the presence of water deficiency can normally be associated with a significant increase in the amount of biomass allocated to the roots, which represents a form of plant compensation in response to water deficit (LIU; STUTZEL, 2004; WU *et al*., 2008), that is, an adaptation mechanism to water shortages (SHAO *et al.*, 2008). In the case of cowpea, Aquino *et al*. (2017) reported, however, that in the presence of saline water, there is a reduction in the allocation of assimilates to roots with increasing salinity.

Silva *et al* . (2017) analyzed the effects of water deficit on mangaba seedlings and reported a similar pattern in the fraction of biomass allocated to the roots, leaves and stems of seedlings that experienced moderate water deficit compared with those that experienced no deficit, with changes in partitioning only in situations of severe deficit, which corresponded to 20% moisture at field capacity.

The pattern of biomass allocation in different parts of a plant in response to soil water stress is characteristic of each plant type and species and depends on the level of water deficit. However, in general, under severe water deficit, roots become responsible for maintaining adequate water *status* in the plant, representing an adaptive strategy to explore deeper soil levels (SHAO *et al*., 2008; SILVA *et al.*, 2010). The redistribution of dry matter to the roots is characterized as a morphological adaptation of the plant to water stress to reduce its evapotranspiration surface area (ÁLVAREZ *et al*., 2011).

In the presence of water deficiency in the reproductive phase, the necessary increase in the root system in plants as an adaptation strategy to the lack of water will require the allocation of assimilates (SHAO *et al*., 2008), which are normally translocated for pod formation (TAIZ; ZEIGER, 2013). Therefore, competition begins between the lower and upper parts of the plant for assimilates, resulting in a reduction in its aerial biomass and an increase in its root biomass. According to Marcelis, Heuvelink, and Goudriaan (1998), this theory is explained by the theory of plant functional equilibrium, in which the distribution of assimilates between the root and aerial parts is regulated by a balance between the activities of both parts of the plant.

Although it was not possible to measure root biomass in this work, it is assumed that a possible reason for the lack of modification in the biomass distribution pattern (in percentage terms) in the presence of water deficiency is the need to reallocate assimilates to the root without altering the fraction directed to the different organs of the aerial part.

6 CONCLUSIONS

Under environmental conditions similar to those presented in this study, for high dry matter production and productivity, cowpea requires 100% of the ETc water replenishment during its reproductive phase. Notably, statistically similar results for these variables can be achieved with water replenishment of only 50% of the ETc.

The allocation pattern of assimilates (percentages of dry matter in leaves, stems and legumes) of cowpea does not change with water deficit; however, its magnitude can be severely reduced with the reduction in available soil water.

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