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Research Article

Brachiaria ruziziensis as a biomass producer in the coffee inter-row

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Brazilian agricultural production has been implementing sustainable production technologies that help producers achieve high productivity at reduced cost, in addition to reducing Green House Gas (GHG) emissions. The present work, faced with the demand for studies on this subject, aimed to quantify the production of shoot matter, carbon sequestration and nutrient flow of the cover plant *Brachiaria* ruziziensis (treatment 1) and spontaneous weeds (treatment 2) between the rows of the coffee tree and to identify the interference of the coffee tree and cultivar spacing. The experiment was carried out in the field in a completely randomized design with 15 replications. Treatment 1 was allocated in the Bourbon plot planted with the cultivar Bourbon Amarelo (IAC J10) at a spacing of 4.0 m between rows and 0. 66 m between plants where *Brachiaria* was mechanically sown in four rows spaced at 0.15 m using 8 kg of seeds/ha. Treatment 2 was installed in the Rubi plot with the cultivar Rubi (MG 1192) with a spacing of 0.60 m between plants and 3.90 m between the rows where weeds or weeds developed. The aerial part of both treatments was collected at 60 DAS (days after sowing) in an area of 2 m² for the extrapolation of the production of fresh and dry mass in kg ha^{-1}. These samples were also analyzed in the laboratory for the quantification of nutrients in dry matter. *Brachiaria* ruziziensis obtained higher fresh and dry mass and concentration of nutrients compared to spontaneous plants, however it did not differ in terms of carbon sequestration.

Key words: Cover plant, carbon sequestration, coffee

INTRODUCTION

Brazilian agricultural production, demand for large arable areas and implementation of technology to help producers achieve high productivity with reduced cost. In the past decades, the intensive and extractive use of production areas was carried out, causing wear of the system and greater emission of Green House Gases (GHG), climate change caused by GHG is considered a threat to sustainable production. Among the technologies adopted by the production system, there was the planting between the rows of perennial crops intercropped with cover crops, with carbon sequestration strategies. The largest sources of C (carbon) found on Earth are in the form of organic compounds, carbonates or CO_2 gas in the atmosphere (Rosendo et al. 2012).

Carbon sequestration is characterized as a process of assimilation and storage of CO_2 from the atmosphere, to reduce its impacts on the environment. Thus, carbon is absorbed by plants through photosynthetic synthesis, being retained in the plant cell wall. The reversal of this process occurs through biological decomposition, releasing CO_2 into the atmosphere.

The use of forage species between the rows of perennial crops, such as coffee, for example, is being widely adopted to perform nutrient recycling, soil protection, system balance, among other benefits, according to a study carried out with production in an organic system, there was recycling of nutrients and carbon fixation, which contributes considerably to the reduction of greenhouse gas emissions (Souza et al. 2012).

With the need to integrate sustainable practices in coffee production, there was an increase in the use of *Brachiaria* intercropped between the rows, due to its easy implementation and management. According to areas of pastures with *Brachiaria*, carbon is fixed in greater quantity in the soil and in the root system, and in forest areas this fixation occurs in greater volume in the aerial part (Salton, 2005).

Therefore, there is a need to carry out a survey and quantification of the increase in nutrient flow, carbon assimilated in the soil and benefits brought by the practice of carbon

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sequestration. This demand motivated the accomplishment of this work, which aimed to quantify the production of shoot matter, carbon sequestration and nutrient flow in the cover plant *Brachiaria* ruziziensis and in spontaneous weeds in the area.

MATERIAL AND METHODS

The experiment was carried out in the field in a completely randomized design, with two treatments and fifteen replications in Patrocínio-MG. According to the classification of macroclimates in Brazil, the municipality of Patrocínio is located in a region with a Cwa climate and has an average altitude of 960 m (Köeppen, 1928; Silva et al. 2005).

The treatments consisted of conducting two types of coverage *Brachiaria* ruziziensis (treatment 1) and weeds or weeds in the area (treatment 2) between the coffee lines. To also detect the interference of the coffee variety and spacing, these treatments were carried out in different stands. For this, treatment 1 was installed in the Bourbon plot and treatment 2 was installed in the Ruby plot. The stands are homogeneous in terms of soil and climate conditions (Figure 1).

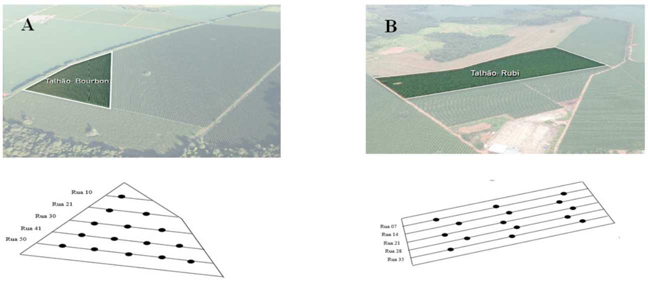

Figure 1. Scheme of distribution of sampling points in treatment 1 (A) and treatment 2 (B).

The Bourbon plot (treatment 1- with *Brachiaria* ruziziensis) is a 5-hectare triangular plot planted in December 2011 with the cultivar Bourbon Amarelo (IAC J10) at a spacing of 4.0 m between rows and 0.66 m between plants. The plot has an average yield of 34 bags/ha and is in full production for its seventh harvest. The planting of *Brachiaria* ruziziensis between the coffee lines was carried out on November 5, 2020 using 8 kg of seeds/ha. Sowing was carried out using a planter with 4 planting lines spaced at 0.15 m. To match the growing season of the plants of the two treatments, on the same day of planting *Brachiaria* ruziziensis, a brush was made on the spontaneous plants in the treatment area 2 (Figure 2).

Figure 2. Area carved in treatment 2.

The Rubi plot (treatment 2- with spontaneous plants) has 11 hectares of the Rubi cultivar (MG 1192), planted in January 2000 and is currently pruned (skeleton with neckline, eighteenth crop with zero crops). The spacing is 0.60 m between plants and 3.90 m between the rows where weeds or weeds have fully developed without mechanical or chemical control. The community of these plants was verified with the appearance of the species *caruru (Amaranthus viridis), corda de viola (Ipomoea sp.)*, bitter grass *(Digitaria insularis),* black woodpecker *(Bidens pilosa)* and chicken foot grass *(Poa annua).*

To survey the biomass production, quantification of carbon sequestration and nutrient flow, biomass was collected from the aerial part of the plants contained in the two treatments after using a brush set at 0.01 m above the ground. Fifteen points were collected in each field. The collection was carried out in the period of full vegetative growth, 60 days after the planting of *Brachiaria* and growth of spontaneous plants. After cutting with the implement, wooden screens were used to delimit the 2 m² area to collect the plant material from the plants (Figure 3).

Figure 2. Area carved in treatment 2.

After collection, the collected samples were immediately taken to the Safrar laboratory in Patrocínio-MG to be weighed on a precision balance to obtain fresh and dry mass after drying in a forced air circulation oven at 65°C until constant weight. The weight of fresh and dry plant material collected in an area of 2 m² was extrapolated to the unit of kg ha^{-1}.After sampling; the quantification of nutrients in the dry matter of the samples was performed according to the methodology of (Malavolta et al. 1997).

RESULTS AND DISCUSSION

Analysis of variance verified the difference in fresh mass between treatments (Table 1).

Table 1. Analysis of variance of fresh mass per area (kg.ha^{-1}).

PV	GL	QM
Treatment	1	162,801,766.5*
Score	14	3,220,385.9
Mistake	14	7,384,369.68
Total	29	23.05
CV (%).	23.05	

Note: * significant at 5% probability by the F test.

The fresh mass of the aerial part of the *Brachiaria* ruziziensis was significantly higher than the fresh mass of the aerial part of the wild plants (Table 2).

Table 2. Averages of fresh mass produced by *B. ruziziensis* and spontaneous plants.

Treatment	**Averages (kg.ha^{-1})**	
B. ruziziensis	14,117.70	A
Spontaneous plants	9,458.60	B

Note: Means followed by the same letter do not differ at 5% probability by the Tukey test.

B. ruziziensis produced, on average, about 4,660 kg ha^{-1} more than the community of weeds between the coffee lines in the same time interval; this represents 33% more fresh mass. This can be explained by the fast growth capacity and rusticity of this grass. As a cover plant, the *B. ruziziensis* is one of the species used in the management of coffee interrows, having numerous advantages (Ragassi et al. 2013). The species has a high production of dry matter in a short period of time, in addition to its adaptability to different types of soil and climate (Echer et al. 2012).

The greater spacing between the coffee rows (4 m) in the Bourbon plot planted with grass compared to the Ruby plot (3.9 m) with spontaneous plants was not a factor that helped the growth of *Brachiaria*. Also, the difference between the height and planting time of the cultivars was not a determining factor. This is because in both treatments there was a similar area of incidence of solar rays since the Rubi plot was skeletonized. There was also a difference in dry matter between treatments (Table 3). The *B. ruziziensis* obtained higher dry mass than spontaneous plants (Table 4). *B. ruziziensis* and weeds had the same average reduction of 30% in fresh mass after drying. The dry mass of *B. ruziziensis* was superior in relation to spontaneous plants in about 1,115 kg ha^{-1}, representing 28.22% more dry mass.

Table 3. Analysis of variance of dry mass per area (kg.ha^{-1}).

PV	**GL**	**QM**
Treatment	1	9,323,072.53*
Score	14	243,551.42
Mistake	14	57,082.03
Total	29	
CV (%)	22.27	

Note: * significant at 5% probability by the F test.

Table 4. Dry mass averages produced by *B. ruziziensis* and weeds.

Treat	**Averages (kg.ha^{-1})**	
B. ruziziensis	3,950.20	A
Spontaneous plants	2,835.27	B

Note: Means followed by the same letter do not differ at 5% probability by the Tukey test.

Regarding carbon sequestration, represented by the accumulation of total carbon transformed to total CO_2 equivalent in kg ha^{-1}, there was no difference between *B. ruziziensis* and weeds between the coffee lines (Tables 5 and 6).

Table 5. Analysis of variance of CO_2 eq. total (kg.ha^{-1}).

PV	**GL**	**QM**
Treatment	1	24.1293 ns
Score	14	523,670.26
Mistake	14	1,194,394.74
Total	29	
CV%	23.53	

Note: ns not significant at 5% probability by Tukey's test.

Table 6. Averages of CO_2 sequestered by *B. ruziziensis* and weeds.

Treat	**Averages (kg.ha^{-1})**	
B. ruziziensis	4,734.8	A
Spontaneous plants	4,555.4	A

Note: Means followed by the same letter do not differ at 5% probability by the Tukey test.

For the transformation of the carbon obtained in the dry matter of the plants to total CO_2 equivalent, it was considered that the plants sequester 3.66 kg of CO_2 from the atmosphere to produce 1 kg of total carbon in the dry matter by the photosynthetic process (CCAS, 2021). Although *B. ruziziensis* obtained higher fresh and dry mass, carbon sequestration was not higher than that of spontaneous plants. This can be explained because spontaneous plants produced less plant matter in their shoots, but accumulated 5% more total carbon in their biomass in relation to *B. ruziziensis* (Table 7).

Table 7. Nutrient composition in shoot dry matter.

Nutrients	***B. ruziziensis***	**Spontaneous plants**
Total number (%)	2.6	2.3
Total MO (%)	82.8	84.3
Total C (%)	30.0	35.0
Total mineral residue (%)	17.6	16.7
Insoluble mineral residue (%)	5.6	5.6
Soluble mineral residue (%)	12.0	11.1
C/N Ratio (%)	1/17	1/21
Phosphorus (total P2O5) (%)	0.7	0.7
Potassium (total K2O) (%)	3.8	3.9
Total Ca (%)	1.1	0.9
Total mg (%)	0.6	0.4
Total S (%)	0.2	0.1
Total B (mg.kg^{-1})	49.0	35.0
Total Cu (mg.kg^{-1})	46.0	31.0
Total Fe (mg.kg^{-1})	4205.0	4604.0
Total Mn (mg.kg^{-1})	95.0	53.0
Total Zn (mg.kg^{-1})	68.0	51.0
In total (mg.kg^{-1})	2.0	2.0
CTC (cmolc.kg^{-1})	57.0	36.0

Furthermore, it can be observed that the *B. ruziziensis* in its development it accumulated a greater amount of most macronutrients and micronutrients (except Fe) to the detriment of carbon accumulation. This fact corroborates the main objective of using this species for nutrient cycling in the soil (Silva, 2020). The capacity to produce biomass directly interferes with the capacity to absorb nutrients for cycling and this capacity responds to edaphoclimatic and phytotechnical factors (Kliemann et al. 2003; Amado et al. 2002).

CONCLUSION

It was concluded that the cover plant *Brachiaria* ruziziensis produced greater biomass in the aerial part, however it was not superior in terms of carbon sequestration when compared to spontaneous plants in the area. The grass had the greatest potential for nutrient cycling for the coffee crop because it has higher levels of macronutrients and micronutrients, with the exception of the iron element.

Carbon sequestration is an intrinsic capacity of plants that can be widely used to reduce the concentration of carbon dioxide (CO_2) in the atmosphere that causes the greenhouse effect and transform it into oxygen vital to life. Cover plants, in this sense, are allies within this strategy and for the better of the entire production system as a whole, bringing positive effects on the physical, chemical and biological attributes of the soil. The dynamics of the countryside linked to conservationist management's result in multiple economic gains such as carbon credit and cycling of nutritional resources in the soil, environmental by the conservation of the productive qualities of the soil and social by the implementation of practices that revitalize the sustainable development goals guided by the UN.

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