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Establishment of intercropping of beet and chicory depending on soil management[1]

Época de estabelecimento do consórcio de beterraba e chicória em função do manejo da palhada no solo

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ABSTRACT - This study aimed to evaluate the productivity and quality characteristics of beet and chicory based on management of straw and intercropping period of establishment. The experiment was conducted in the organic horticulture sector of Unioeste, in a design of randomized blocks with four replications, where the treatments were arranged in 2 x 5 and 2 x 8 factorial schemes. The first factorial consisted of the straw mulch management (with and without incorporation of the gray velvet bean straw) and the intercropping period of establishments and beet and chicory monocrops (0; 7; 14 and 21 days after transplanting beet). The second factorial was composed of the straw mulch management (with and without incorporation) and the cultivation of chicory intercropped with beet and in monocrop at the same periods. The chicory interfered in beet's productivity when the transplant occurred at the same period. The beet cultivation in a intercropping contributed positively to the better use of the area in the two management systems, influencing in a positive way the agronomic characteristics of the crop, but without compromising the commercial quality of the crops, that were agronomically viable, considering the UET index.

Key words: *Beta vulgaris*. *Cichorium endívi.* Vegetal cover. Yield. Post-harvest.

RESUMO - Objetivou-se avaliar as características produtivas e qualitativas de beterraba e chicória em função do manejo da palhada e da época de estabelecimento do consórcio. O experimento foi conduzido no setor de horticultura orgânica da UNIOESTE, em delineamento de blocos ao acaso, em esquema fatorial 2 x 5 e 2 x 8, com quatro repetições, sendo o primeiro fatorial constituído do manejo da palhada (sem e com incorporação da palhada de mucuna-cinza) e pelas épocas de estabelecimento do consórcio e do monocultivo de beterraba e chicória (0; 7; 14 e 21 dias após o transplante da beterraba). Sendo o segundo fatorial composto para avaliar as características da chicória com o manejo da palhada (com e sem incorporação) e pelo cultivo da mesma consorciada com beterraba e em monocultivo nas mesmas épocas. A chicória interferiu na produtividade da beterraba quando o transplante foi realizado na mesma época. A forma de cultivo da beterraba em consórcio contribuiu positivamente para o melhor aproveitamento da área nos dois sistemas de manejo, influenciando de forma positiva as características agronômicas da cultura, mas sem comprometer a qualidade comercial dos cultivos, sendo agronomicamente viáveis, considerando o índice de UET.

Palavras-chave: *Beta vulgaris*. *Cichorium endívia.* Cobertura vegetal. Rendimento. Pós-colheita.

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INTRODUCTION

Intercropping of leafy and tuberous vegetables has agro-economic and environmental advantages such as increased production per unit area in a given space and the optimization of water use, agricultural inputs and labor, contributing to supply diversification of food and raw materials, also promoting ecological balance to the production system (CECÍLIO FILHO *et al*., 2008; GRANGEIRO *et al*., 2011).

Crop intercropping consists of simultaneous growth of two or more crops, considered environmentally adequate because it allows biological diversity of species, making the agroecosystem more stable and with a lower risk of pests and diseases incidence (CECÍLIO FILHO; REZENDE; CANATO, 2007).

Some studies on vegetable intercropping report the use of tuberous crops with leafy crops, focusing mainly on the effect of fertilization, spatial arrangements and period of establishments (CECÍLIO FILHO; REZENDE; CANATO, 2007; GRANGEIRO *et al*., 2011; REIS; RODRIGUES; REIS, 2013). According to Grangeiro *et al.* (2007), the proper moment to intercropping has been considered a relevant factor, since the crops actually do not need be sown or transplanted in the same period, but during a part of their development, there will be interaction between them.

The same authors report in their work with beet and arugula intercropping that, regardless of the arugula sowing period, the fresh mass and root productivity of beet were smaller in the intercropping system, proving that beet was negatively influenced, when intercropped with arugula. The sowing or transplanting period in intercropping systems is an important management variable, since its delay can increase productivity and decrease the competition between growth factors.

Intercropping efficiency of vegetable depends basically on the capacity of minimizing the temporal competition of environmental resources and, thus, the aim is to develop crops with different types of architecture to favor the best use of light, water, pesticides and fertilizers (CECÍLIO FILHO; MAY, 2002). In order to assess whether or not intercropping is agronomically viable, the quantitative data the qualitative characteristics of the harvested product must be verified, such as its physical, chemical or aesthetic properties.

In vegetable production, in addition to intercropping, mulching is an important management technique used. This technique contributes to the decomposition of vegetal residues, which has benefits in soil structure improvement, erosion prevention (SMOLIKOWSKI; PUIG; ROOSE, 2001), maintenance of soil temperature and humidity, improvements in chemical, physical and biological properties of the soil, input of organic matter and nutrients (MULVANEY *et al*., 2010), in addition to weed control (SANTOS *et al*., 2011). Thus, planting on straw is a conservationist system, which stands out for having considerable contributions in the reduction of expenses, contributing to the economic viability and sustainability of agroecosystems (VOLK; COGO; STRECK, 2004).

In view of the above, this study aimed to evaluate the productive and qualitative characteristics of beet and chicory depending on the management of straw and the period of intercropping establishment.

MATERIAL AND METHODS

The experiment was carried out in the organic horticulture sector at the Experimental Station "Professor Antônio Carlos dos Santos Pessoa" (24°33'22'' S; 54º31'24'' W; 420 m altitude), at the Western Paraná State University, from December 2014 to July 2015.

The climate of the region, according to the Köppen classification, is Cfa - subtropical climate, with average temperature in the coldest month below 18 °C (mesothermic) and average temperature in the hottest month above 22 °C, with hot summers, infrequent frosts and tendency of rain concentration in the summer; however, without definite dry period. The annual precipitation varies from 1,800 to 2,000 mm, with average temperature between 22 and 23 °C (CAVIGLIONE *et al*., 2000).

For the soil chemical characterization, we collected samples throughout the experimental area, at a depth of 0 to 0.20 m, with pH results ($CaCl_2$) = 4.19; MO = 13.67 g dm^{-3}; P (Mehlich 1) = 214.39 mg dm^{-3}; K (Mehlich 1) = 0.72 $cmol_c$ dm^{-3}; Ca^{2+} = 4.92 $cmol_c$ dm^{-3}; Mg^{2+} = 2.84 $cmol_c$ dm^{-3}; Al^{3+} = 0 $cmol_c$ dm^{-3}; SB =8.48 $cmol_c$ dm^{-3}; CTC = 10.81 $cmol_c$ dm^{-3}; H + Al = 2.33 $cmol_c$ dm^{-3} and V = 78.45%. The soil of the experimental area is eutroferric Red Latosol, clay texture.

The experiment implementation consisted of two stages, the first was sowing and management of the cover plant, and the second was the transplanting and intercropping of beet and chicory. The crops predecessor to this experiment was tomato, lettuce and melon, in an organic system, with the removal of the crop remains of the area to avoid phytosanitary problems in the next crop.

In the first stage, we carried out the planting of gray velvet bean (*Mucuna pruriens*), spread and incorporated with a leveling grid. Sprinkler irrigation was carried out according to the need of the crop in December

2014. On March 31, 2015, when the plants reached their maximum development, at the beginning of flowering, the management occurred with a brushcutter and the incorporation of the green mass through plowing and harrowing.

Before the management, the biomass was determined using a 0.50 x 0.50 m frame, launched in five random points, where all the vegetal material found inside the frame was collected. The samples were packed in paper bags, weighed and then placed to dry in a forced circulation oven at 65 °C until reaching constant mass. The accumulated dry mass of the gray velvet bean was 9.4 t ha^{-1}.

The nutrients contents (macro and micronutrients) were determined in straw, indicating the following concentrations: N = 27.45 g kg^{-1}; P = 2.55 g kg^{-1}; K = 17.87 g kg^{-1}; Ca = 7.05 g kg^{-1}; Mg = 1.9 g kg^{-1}; S = 2.11 g Kg^{-1}; Cu = 13.5 mg kg^{-1}; Zn = 24.5 mg kg^{-1}; Mn = 18 mg kg^{-1}; B = 35.66 mg kg^{-1} and Fe = 185 mg kg^{-1}.

In the second stage, beet and chicory crops were cultivated with or without straw. The experimental design was randomized blocks, with treatments arranged in 2 x 5 and 2 x 8 factorial schemes, with four replications. The first factorial was composed of management of straw (with and without the incorporation of gray velvet bean straw), and by the intercropping period of establishments and beet monocrop of Tall Top Early Wonder and chicory crop Catalogna broadleaf, (0; 7; 14 and 21 days after transplant (DAT) of beet).

The second factorial was to analyze chicory, which was composed of management of straw (with and without incorporation) and chicory crop intercropped with beets in the same periods; chicory was also introduced in monocrop in the same periods in which the intercropping occurred, in order to isolate a possible effect of the planting period.

The experimental units consisted of 1.44 m^2 portions, comprising five rows of beet in intercropping, or in monocrop, with a useful area of 0.80 m^2. For chicory we considered five rows in monocrop and four rows in intercropping, with useful area 0.80 m^2 and 0.40 m^2 in monocrop and intercropping respectively, with spacing used for the two crops of 0.30 m between rows and 0.10 m between plants, totaling 60 beet and chicory plants in monocrop and, in a intercropping system, 60 beet and 44 chicory plants per experimental portion. The crop borders were represented by the side rows of each portion.

Seedlings were produced in 200-expanded cell polystyrene trays containing commercial vegetable substrate, with the composition based on pine bark, peat, charcoal and vermiculite. These were kept in a greenhouse until transplant period to the field, which occurred when they had 5 to 6 definitive leaves (29 days after sowing for both cultures). Irrigation occurred according to the need, with irrigators.

Planting fertilization occurred on the transplant day with 0.500 kg m^2 of humus with the following chemical characteristics: pH ($CaCl_2$) = 4.78; MO = 51.95 g dm^{-3}; P (Mehlich 1) = 361.15 mg dm^{-3}; K (Mehlich 1) = 2.94 $cmol_c$ dm^{-3}; Ca^{2+} = 6.76 $cmol_c$ dm^{-3}; Mg^{2+} = 4.49 $cmol_c$ dm^{-3}; A^{3+} = 0 $cmol_c$ dm^{-3}; SB = 14.19 $cmol_c$ dm^{-3}; CTC = 18.21 $cmol_c$ dm^{-3}; H + Al = 4.02 $cmol_c$ dm^{-3} and V = 82.47%.

The cover fertilization occurred weekly with the application of supermagro biofertilizer, a mixture of fermented micronutrients in an organic medium produced according to the methodology described by Burg and Mayer (2006). The chemical composition of the biofertilizer used in the experiment was: pH (H_2O) = : pH (H_2O) = 6.73; P = 0.70 g L^{-1}; N = 6.39 g L^{-1}; K = 4.82 g L^{-1}; Ca = 8.35 g L^{-1}; Mg = 8.55 g L^{-1}; S = 37.02 g L^{-1}; Cu = 1.50 mg L^{-1}; Zn = 24 mg L^{-1}; Mn = 1208.50 mg L^{-1}; B = 3124.49 mg L^{-1} and Fe = 1206.50 mg L^{-1}.

The concentration used in the experiment was 40 mL L^{-1} for the two crops, proposed by Burg and Mayer (2006) for use in beet, applied during the beet cycle 3.420 L m^{-1} and 1.400 L m^{-1} for chicory.

We carried out the cultural treatments according to the need of the crops and carried out the weed withdrawal manually, irrigation by aspersion, and there were no phytosanitary issues.

The beet and chicory harvest occurred at 106 and 41 DAT, respectively. In relation to beet, the evaluated characteristics were plant height, from the soil level to the highest leaf end, root diameter and length, root shape index (root diameter/root length ratio), root mean mass and commercial productivity (determined from the fresh mass of the total roots of ten central plants, free of cracks, bifurcations, nematodes, secondary roots and mechanical damages).

For the chicory crop the evaluated characteristics were plant height, crown projection per plant - calculated by the formula of the circle area $A = \pi.r^2$ (π is an irrational number whose approximate value is 3.1416 and *r* projection ratio), number of leaves, leaf area (using a leaf area integrator LI-COR 3100), and fresh mass of above-ground part of 10 random plants. After evaluating the chicory plants, the other plants were eliminated to avoid interference in the intercropping treatments.

Physicochemical characteristics of the beet were evaluated according to the soluble solids content (SS), titratable acidity (TA), ratio (SS/TA) and hydrogenionic potential (pH). Direct method determined soluble solids by using a WYA digital refractometer, model 2WA-J, with results expressed as °Brix. Titratable acidity was determined by titration with NaOH and 1N solution and phenolphthalein as indicator, with results expressed in g 100 g^{-1}, equivalent to citric acid (IAL, 2008).

We used the efficient land use (ELU) index to evaluate the intercropped systems. For this calculation we used the formula proposed by Willey (1979), equation 1.

$$ELU = (Yab/Yaa) + (Yba/Ybb) \quad (1)$$

where: *Yab* is the productivity of beets intercropped with chicory; *Yba* is the productivity of chicory intercropped with beet; *Yaa* is the productivity of beet in monocrop and *Ybb* is the productivity of chicory monocrop. For index calculation, the productivities expressed in t ha^{-1} were used.

The experimental data were submitted to normality tests by means of the Lilliefors test ($p \leq 0.05$) and homogeneity of variance by the Bartlett test and then subjected to analysis of variance by the F test, and the means compared by Student's *t*. All calculations were performed with the aid of statistical software SISVAR 5.3 (FERREIRA, 2011).

RESULTS AND DISCUSSION

There was no interaction for almost all assessed characteristics of the beet crop, such as plant height (PH), root diameter and length (RD and RL), root shape index (RSI), root mean mass (RMM), productivity (PROD) (Table 1), pH, soluble solids (SS) and ratio; thus the factors were studied separately for each factor.

For the beet crop, the management of straw did not influence the plant height, but by the period of chicory transplant; they presented the lowest height when they were intercropped with the chicory at 14 and 21 DAT, with heights of 39.29 and 37.77 cm, respectively (Table 1). In this period, the beet requires more nutrients for root formation, while chicory has its greatest demand at the beginning of its cycle. Thus, the intercropping in these periods reduced the height probably due to the competition of nutrients of gray velvet bean straw and the biofertilizer. The heights in this work were superior to those reported by Grangeiro *et al.* (2011), which working with beet and coriander intercropping obtained 31.05 cm height.

The diameter and length of beet roots did not differ statistically as a function of management of straw, only being significant for the period of establishment (Table 1). Thus, we observed a greater interspecific competition when the crops transplant occurred at the same period. Reis, Rodrigues and Reis (2013), worked with mineral fertilization in beet intercropping with lettuce and observed diameters of 68 mm for beet in single crop with the recommended fertilization for the crop. In this study, the largest diameters observed were 52.81 and 53.32 mm in intercropped crop at 14 and 21 DAT, respectively, with organic fertilization being in the commercial standard.

Table 1 - Plant height (PH), root diameter and length (RD and RL), root shape index (RSI), root mean mass (RM) and root productivity (PROD) of beet submitted to two managements of straw in monocrop and intercropping with chicory as a function of the transplant period

Treatments	PH (cm)	RD (mm)	RL (mm)	RSI	RM (g)	PROD (t ha^{-1})
			Management of straw			
Planting on straw	40.58	52.54	58.74	0.90	93.52	47.11
Incorporated straw	39.37	51.27	56.83	0.90	96.67	48.34
DMS	1.77	1.97	2.72	0.04	7.33	3.69
			Period of establishment			
Intercropping 0 DAT[1]	40.28 ab	49.70 b	55.82 b	0.88	78.10 c	39.05 c
Intercropping 7 DAT	42.38 a	51.36 ab	55.58 b	0.90	104.81 a	52.40 a
Intercropping 14 DAT	39.29 b	52.81 a	59.79 ab	0.89	99.81 ab	49.91 ab
Intercropping 21 DAT	37.77 b	53.32 a	57.42 ab	0.93	90.07 b	45.90 b
Single	40.15 ab	52.36 ab	60.32 a	0.88	102.69 a	51.34 ab
DMS	2.79	3.11	4.30	0.07	11.59	5.83
CVs (%)	6.81	5.84	7.26	7.40	11.89	11.92

[1]Days after transplant of beet; averages followed by the same lowercase letter in the columns did not differ statistically from each other, Student's t test, $p < 0.05$

Corrêa *et al*. (2014), who worked with different spacing and obtained diameter and length of 58.8 mm, observed similar results of beet diameter and length and 58.3 mm, respectively, when the transplant occurred with spacing between 10 cm plants.

There was no significant effect on management of straw nor at the intercropping period of establishment for the variable root shape index, which obtained an overall mean of 0.90. Thus, presenting a globular shape due to the difference between root diameter and length being small, in agreement with the information provided by the company.

There was a significant difference for root mean mass only at the period of intercropping establishment. The highest mean mass occurred when the intercroppings were established at 7 and 14 DAT, matching the single. This result can be explained because the beet plant absorbs the nutrients with more intensity from the 60 days (TIVELLI *et al*., 2011), thus, the 21 DAT with chicory entrance compromised this greater absorption. Corrêa *et al.* (2014) found similar result, which was a mean mass of beet roots of 101.3 g with the same plant spacing.

The highest productivity of beet occurred when the intercropping was carried out at 7 and 14 DAT. This variable was significantly influenced, presenting a reduction in the productivity in the intercropping at 0 DAT. This reduction in productivity can be attributed to the presence of chicory at the same period, as the source-drain relationship between crops and soil can be altered by crop condition, climate, physiological stage of intercropped crops and possible stresses that crops may experience. This behavior can be explained due to the greater competition for natural resources such as water, light, oxygen and nutrients, because chicory showed the highest crown projection at 0 DAT, causing a shading at the beginning of beet development and thus damaging the productivity.

The beet, when transplanted to the field, underwent an initial stress, which may have impaired its absorption of nutrients and, consequently, its productivity. The chicory, for having a more rustic root system, endured more after being transplanted and, therefore, was more vigorous than the beet. In this sense, the beet productivity was initially lower in relation to the other treatments, which were adjusting and increasing as the beet was adapting to the new environment and the existing competition.

Results obtained in this work for the beet crop differed from those found in intercropping with lettuce (SOUZA; MACEDO, 2007) and with coriander (GRANGEIRO *et al*., 2011), which did not observe differences in beet productivity. On the other hand, Grangeiro *et al.* (2007) worked with intercropping of beet and arugula depending to the intercropping period of establishment, and noticed a reduction in beet productivity when the arugula was sowed at the same period, similar to the results observed in this work. Arugula inclusion in the intercropping system in the other tested periods did not negatively influence the beet development.

There was interaction for the beet crop between management of straw and the intercropping establishment only for titratable acidity (TA) (Table 2). Planting on straw overcame the planting with incorporated straw to the titratable acidity (TA) of beet, presenting the highest acidity in the intercropping at 0 and 7 DAT. TA indicates how much the root is acidic, as it is represented by the presence of organic acids in the plant. The acidity difference between the treatments was small and low, thus in agreement with the value recommended for beet.

The results can be justified by the higher initial release of H^+ ions, which potentiated the soil acidity when the straw was over it, since crop tends to absorb this element that can acidify the root. In some times after chicory harvest in the first periods, the beet was in monocrop, so the highest values of acidity were for these periods when evaluated.

For the other beet physicochemical characteristics, the hydrogenionic potential (pH) did not differ in the management of straw, or in the time of establishment. For

Table 2 - Titratable acidity (TA) of beet roots submitted to two managements of straw in monocrop and intercropping with chicory as a function of the transplant period

TA	Management of straw	Period of establishment				
		0 DAT[1]	7 DAT	14 DAT	21 DAT	Single
	Planting on straw	0.24 aA	0.20 aAB	0.14 Ad	0.15 aCD	0.18 Abc
	Incorporated straw	0.14 bAB	0.13 bB	0.13 aB	0.15 aAB	0.18 aA
DMS	0.04				CVs (%)	18.11

[1]Days after transplant of beet; averages followed by the same lowercase letter in the columns and upper case in the row did not differ statistically from each other, Student t test, $p < 0.05$

soluble solids (SS), there was a difference only for period of establishment, and for *Ratio* there was a significant effect between management of straw and period of establishment (Table 3).

The average pH values of the beet are close to the values observed by Lima *et al*. (2010), who worked with organic and conventional systems and obtained pH = 6.06 in the organic system.

Soluble solids content is generally used as an indicator of the degree of maturity. The highest SS content was observed when the intercropping established at the same period. This can be explained by the experiment duration, which may have favored the increase of soluble solids contents and, therefore, the higher values for these variables. Marques *et al*. (2010), who evaluated beet under different doses of bovine manure, did not find significant differences, obtaining ranges from 10.26 to 11.10 °Brix.

The ratio highlighted when the culture was conducted on the straw incorporation and when the intercropping was established at 14 DAT, differing from the intercropping at 0 DAT and monocrop, which showed lower relationships. This can be attributed to the greater nutrient release in this type of management of straw and its greater absorption by the plant. The ratio represents the balance between sugars and organic acids, being related to the flavor, an important characteristic, since it will determine the consumption and the insertion of the product in the market. Higher results were found by Magro *et al.* (2015), who worked with effect of organic compounds and potassium adduction in beet crop.

In relation to chicory crop, interaction was verified for the characteristics of plant height, crown projection and number of leaves (Table 4); the other variables were analyzed separately.

There was interaction between the management of straw and period of establishments for plant height of chicory, and when the straw was incorporated, the intercropping at 14 DAT showed the lowest height (Table 4). This shows that multiple or intercalated crops formed by different species, which explore distinct spaces at different times, are capable of developing.

The crown projection and the fresh mass of chicory area were significantly influenced by the management of straw and period of establishment (Table 4), where the highest crown projection and the highest fresh mass were observed when the straw was incorporated where the monocrop at 0 and 7 DAT showed the highest projections and, consequently, the highest masses. When there is straw incorporation, there is greater release of organic compounds, mainly carbon, which directly influences the development of the plant and more specifically in its crown; therefore, the best results were in this way of management and in the first periods, when the releasing action of these elements is more intense.

The highest number of chicory leaves per plant was observed when intercropping was carried out at the same period of establishment with the beet in the planting on straw and in the monocrop when the straw was incorporated (Table 4), indicating that these characteristics were affected by intra and interspecific competition of

Table 3 - pH, soluble solids (SS) and root ratio of beet root submitted to two managements of straw in monocrop and intercropping with chicory as a function of the transplant period

Treatments	pH	SS (°Brix)	Ratio
		Management of straw	
Planting on straw	6.03	9.43	55.11 b
Incorporated straw	6.06	9.49	71.64 a
DMS	0.13	0.38	9.93
		Period of establishment	
Intercropping 0 DAT[1]	6.07	9.92 a	57.48 b
Intercropping 7 DAT	6.06	9.31 b	64.07 ab
Intercropping 14 DAT	6.00	9.28 b	73.26 a
Intercropping 21 DAT	6.05	9.46 ab	67.75 ab
Single	6.07	9.34 ab	54.31 b
DMS	0.21	0.60	15.71
CVs (%)	3.37	6.17	24.18

[1]Days after transplant of beet; averages followed by the same lowercase letter in the columns did not differ statistically from each other, Student's t test, $p < 0.05$

Table 4 - Plant height (PH), crown projection (CP) and number of leaves (NL) of chicory submitted to two managements of straw in monocrop and intercropping with beet, depending on the period of transplant

Period		PH (cm)		CP (cm²)		NL	
		AS	Inc[2]	AS	Inc	AS	Inc
Intc[3]	0 DAT[5]	40.25 aAB	45.29 aA	6904 aA	8386 aABC	21.79 aA	19.71 aAB
	7 DAT	39.08 aAB	42.81 aABC	5465 aA	7287 aBCD	16.50 aBC	11.71 bD
	14 DAT	42.78 aA	38.98 aC	6586 aA	5498 aD	17.22 aBC	13.29 aCD
	21 DAT	41.17 aAB	40.06 aABC	4603 aA	5046 aD	13.83 bC	18.21 aAB
S[4]	0 DAT	38.09 bAB	44.42 aAB	5934 bA	10049 aA	20.21 aAB	21.54 aA
	7 DAT	37.00 bB	43.94 aABC	6107 bA	9657 aAB	17.75 aABC	16.34 aBC
	14 DAT	40.58 aAB	39.58 aBC	6730 aA	5152 aD	18.46 aAB	17.38 aB
	21 DAT	41.33 aAB	39.88 aBC	4653 aA	6010 aCD	14.04 bC	19.87 aAB
DMS		5.34		2552.1		4.07	
CVs (%)		9.17		27.56		16.45	

[1]About the straw. [2]Incorporated. [3]Intercropping. [4]Single. [5]Days after transplant of beet; averages followed by the same lowercase letter in the uppercase rows and in the column did not differ statistically from each other, Student's t test, $p<0.05$

plants. The intercropping established at 14 and 21 DAT had the smallest leaf area (Table 5) because the beet used in the intercropping showed high size, causing an initial shading in the chicory crop and thus reducing the luminous intensity, photosynthetic process and consequently, the production.

The highest fresh mass of above-ground part of the chicory occurred when the straw was incorporated in the monocrop at 0 and 7 DAT (Table 5), and it can be explained due to the fragmentation and incorporation of the gray velvet bean in the soil where a rapid decomposition and release of nutrients occurred, thus

Table 5 - Leaf area (LA) and fresh mass of above-ground part (FWAG) of chicory submitted to two managements of straw in monocrop and intercropping with beet, as a function of the transplant period

Management of straw	WA (cm²)	FWAG (t ha⁻¹)
About the straw	69.80	33.98 b
Incorporated	70.83	42.72 a
DMS	8.33	5.88
Crop system		
Intercropping 0 DAT1	75.52 a	38.09 bc
Intercropping 7 DAT	76.83 a	29.44 c
Intercropping 14 DAT	64.19 ab	28.48 c
Intercropping 21 DAT	53.88 b	36.84 bc
Single 0 DAT	72.17 a	55.64 a
Single 7 DAT	78.65 a	46.19 ab
Single 14 DAT	74.19 a	38.97 bc
Single 21 DAT	67.09 ab	33.13 c
DMS	16.66	11.76
CVs (%)	23.53	30.47

[1]Days after transplant of beet; averages followed by the same lowercase letter in the uppercase rows and in the column did not differ statistically from each other, Student's t test, $p<0.05$

favoring the agronomic crop development. The fresh chicory mass was influenced when the intercropping occurred, regardless of the period established. This result corroborates Corrêa *et al*. (2014), who report that the plant population affects fresh leaf mass. In turn, Cecílio Filho *et al*. (2008) observed that, in an intercropping with chicory, arugula independently of the sowing season did not influence chicory productivity. On the contrary, for being the secondary culture, chicory influenced arugula in the same way observed in this study.

The efficient land use values, regardless of management of straw and the period of intercropping establishment were superior to the unit, indicating that the systems intercropped in the plantation with and without incorporation of straw used the available resources in relation to the monocrop (Table 6).

Chicory transplant at 21 DAT of beet provided the largest increase in ELU. These results show that 92 and 121% more soil area was necessary in the management in which the straw was incorporated and in planting on straw, respectively, so that the monocrop produced the equivalent to that obtained in the intercropping.

The results corroborate the studies that have been carried out with vegetable intercropping. Cecílio Filho and May (2002), worked with lettuce and radish intercropping according to the period of establishment and obtained a 60% efficiency in relation to monocrop at 7 DAT of lettuce. Camili *et al.* (2013) showed an advantage in the use of 65% of the area in the lettuce and taioba intercropping in relation to monocrop. Lima *et al.* (2014) worked with coriander, lettuce and arugula intercropping and obtained an efficiency of 80% of area in relation to monocrop. Vieira *et al.* (2014) reached 128% more of area in intercropping with taro and bean pod.

Table 6 - Productivity (t ha $^{-1}$) and efficient land use (ELU) according to the crop system of the transplant period

Treatments	Incorporated straw			Planting on straw		
	Productivity t ha^{-1}		ELU[1]	Productivity t ha^{-1}		ELU
	Beet	Chicory		Beet	Chicory	
Intercropping 0 DAT	38.39	44.81	1.48	41.26	31.36	1.49
Intercropping 7 DAT	56.91	27.81	1.51	49.92	31.06	2.08
Intercropping 14 DAT	50.71	23.88	1.54	50.90	33.08	1.93
Intercropping 21 DAT	45.19	45.56	1.92	46.56	28.13	2.21
Single Beet	55.50	-	1.00	48.96	-	1.00
Single Chicory 0 DAT	-	61.73	1.00	-	49.56	1.00
Single Chicory 7 DAT	-	58.94	1.00	-	33.44	1.00
Single Chicory 14 DAT	-	37.94	1.00	-	40.00	1.00
Single Chicory 21 DAT	-	41.06	1.00	-	25.19	1.00

[1]ELU = (Yab/Yaa) + (Yba/Ybb), Yab = production of crop “a” in intercropping with “b”; Yaa = production of crop “a” in single crop; Yba = production of crop “b” in intercropping with “a” and Ybb = production of crop “b” in single crop

CONCLUSION

Beet intercropping contributes positively to the better use of the area in the two management systems, positively influencing the agronomic characteristics of the crop, but without compromising the commercial quality of the crops, being agronomically viable considering the ELU index. Beet and chicory intercropping provides greater root production than monocrop when establishing intercropping from 7 DAT. For the assessed variables of chicory, the management with incorporated straw contributes to crop development.

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