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LEGUMINOUS COVER CROPS FOR BANANA PLANTATIONS IN SEMI-ARID REGIONS[1]

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ABSTRACT – High temperatures and low rainfall characterize the Brazilian semiarid regions. This regional climate demands the adoption of practices that increase the efficiency and sustainability of local farming. This study aimed to assess the ability of two perennial herbaceous leguminous species, calopo and tropical kudzu, to provide permanent soil cover in banana plantations in Jequitinhonha Valley, northeast Minas Gerais state, Brazil. To this end, we evaluated the differences of calopo and tropical kudzu in soil cover capacity and the amount of senescent phytomass deposited on the soil surface, nutrient content in senescent phytomass, as well as their effects on temperature and soil moisture, compared with bare soil in two experimental sites. The results showed that, compared with tropical kudzu, calopo had a higher soil cover capacity and was more effective at increasing organic material and nutrients in the soil owing to the relatively higher amount of senescent phytomass deposited on the soil surface. However, both calopo and tropical kudzu reduced soil temperature and increase soil moisture compared with bare soil. Overall, we concluded that these species can deposit high levels of senescence in the soil, providing several benefits to the cultivation system of banana plants in the semiarid regions.

Keywords: Sustainable agriculture. Green manure. Caatinga. *Pueraria phaseoloides*. *Calopogonium mucunoides*. *Musa* spp..

LEGUMINOSAS COMO PLANTAS DE COBERTURAS NO CULTIVO DE BANANEIRA EM REGIÃO SEMIÁRIDA

RESUMO – Altas temperaturas e baixa precipitação caracteriza a região do semiárido Brasileiro. Este clima regional exige a adoção de práticas que aumentem a eficiência e sustentabilidade da agricultura local. O objetivo deste trabalho foi verificar o comportamento de espécies leguminosas herbáceas perenes como cobertura permanente do solo sob pomar de bananeira, no Vale do Jequitinhonha, nordeste do estado de Minas Gerais, Brasil. Para esse fim, foi avaliado as diferenças entre as leguminosas, calopogônio e cudzu tropical na capacidade de cobertura do solo, quantidade de fitomassa senescentes depositada na superfície do solo, conteúdo de nutrientes na fitomassa senescentes, bem como seus efeitos sobre a temperatura e umidade do solo em comparação com solo sem cobertura. Os resultados demonstraram que, em comparação com o cudzu tropical o calopogônio obteve maior capacidade de cobertura do solo e, devido a maior quantidade de fitomassa senescente, foi mais eficaz no incremento de nutrientes. Além disso, ambas leguminosas reduziram a temperatura e mantiveram maior umidade do solo em comparação com o solo sem cobertura. Essas espécies podem depositar níveis elevados de material senescente sobre a superfície do solo, proporcionando várias vantagens para o sistema de cultivo de bananeiras em região semiárida.

Palavras-chave: Agricultura sustentável. Adubo verde. Caatinga. *Pueraria phaseoloides*. *Calopogonium mucunoides*. *Musa* spp..

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INTRODUCTION

The semiarid region of Minas Gerais and other Brazilian states in the Caatinga ecoregion are characterized by a poor rainfall distribution (400–800 mm on average), high temperature (27°C on average), and elevated annual evaporation (2,000 mm on average) throughout the year (INMET, 2016). Overall, the soil is shallow with outcrops of rock and stone ground (BRASIL, 2007). Due to the complexity and high heterogeneity of semi-arid regions in terms of rainfall, temperature, soil, vegetation, and applied farming practices, water and soil management in farming systems is challenging (LIMA; CAVALCANTE; PEREZ-MARIN, 2011).

In Brazil, semiarid regions are used mainly for the rainfed production of drought-tolerant forages and perennial crops; however, yields are relatively low (COELHO et al., 2014). Thus, the stabilization of farming systems and the maintenance of sustainable yields in these regions are of high importance.

To improve agricultural production in semiarid regions, farming systems need to be specifically designed for these areas, convenient for the local population, and well adapted to the local environment. If these factors occur, climatic risks will be reduced, and the production of food crops and forages will be stabilized through the efficient and rational management of the soil, water, and phytomass (MIRVAT et al., 2015).

The use of techniques that promote the permanent protection of soil is a promising method for semiarid regions. Among these techniques, the use of cover crops can increase water permanence, organic matter content, and biological activity, and decrease soil temperature, thereby improving the productive efficiency of agricultural systems (ESPINDOLA et al., 2006). However, the selection of appropriate cover crop species depends on the crop system and related management practices (PERIN et al., 2004). Therefore, it is necessary to investigate the effects of different cover crop species in different regions and under different cultivation management systems.

Here, we aimed to study the differences of two cover crops, tropical kudzu and calopo, in soil cover capacity, the amount of senescent phytomass deposited on the soil surface, nutrient content in senescent phytomass, as well as soil moisture and temperature compared with bare soil in semiarid regions of Brazil.

MATERIAL AND METHODS

2.1. Experimental sites

The experiment was conducted from October 2010 to November 2011 in Itaobim and Virgem da Lapa, which are located in the Caatinga ecoregion of Jequitinhonha Valley (S16º42' W41º50'), northeast Minas Gerais state, Brazil. The climate in this region is characterized as semi-arid (BSh), according to the Köppen climate classification, with an annual average rainfall of 708 mm (Figure 1), which is highly accumulated during the summer months (SILVA; TRINCA; NERY, 2009; INMET, 2016).

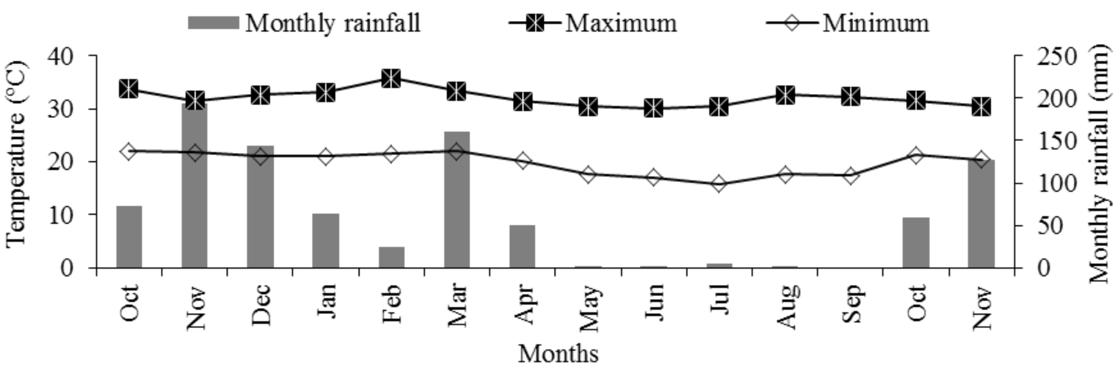

Figure 1. Maximum and minimum temperature (°C) and monthly rainfall (mm) in Itaobim and Virgem da Lapa region from October 2010 to November 2011 (INMET, 2016).

In Itaobim, the experimental site (S16º36'12" W41º33'1"; 287 m altitude) was a banana (*Musa* spp. cv. Nanicão) plantation with paludal, dystrophic Red-Yellow Argisol soil. In October 2010, a soil sample was collected from the 0–20 cm layer, and analysis results were as follows: 27% clay, 12% silt, 61% sand, 68% base saturation, pH-H_2O 6.4, 0.3 $cmol_c\ dm^{-3}$ Al (extracted by 1 mol L^{-1} KCl), 1.9 $cmol_c\ dm^{-3}$ Ca (extracted by 1 mol L^{-1} KCl), 1.1 $cmol_c\ dm^{-3}$ Mg (extracted by 1 mol L^{-1} KCl), 24.1 mg dm^{-3} P (extracted by Mehlich 1; 0.05 mol L^{-1} HCl and 0.0125 mol L^{-1} H2SO4), and 181.3 mg dm^{-3} K (extracted by Mehlich 1).

In Virgem da Lapa, the experimental site (S16º52'4" W42º19'35"; 337 m altitude) was also a banana (cv. Nanica) plantation with typical haplic, Orthic Luvisol soil. In October 2010, a soil sample was collected from the 0–20 cm layer, and analysis results were as follows: 21% clay, 35% silt, 44% sand, 79% base saturation, pH-H_2O 6.1, 0.1 $cmol_c$ dm^{-3} Al, 5.0 $cmol_c$ dm^{-3} Ca, 1.7 $cmol_c$ dm^{-3} Mg, 6.7 mg dm^{-3} P, and 189.1 mg dm^{-3} K.

2.2 Experimental design and treatments

We used a split-plot arrangement randomized as a complete block design with four replications (n = 4) in each experimental site (Itaobim and Virgem da Lapa). Management strategy (two perennial leguminous cover crops, calopo and tropical kudzu, and bare soil with monthly weeding that used as a control) was the main factor, whereas time of data collection was the sub-factor.

The total area in both experimental sites was 648 m^2, the experimental plot area at each site was 162 m^2 (18 × 9 m), the subplot area was 54 m^2 (6 × 9 m), and the central area was 12 m². Each plot area included 27 clumps of banana plants with three plants of different growth stages at 3 × 2-m spacing, whereas the central area included two clumps of banana plants (i.e., six banana plants).

Banana plants were fertilized only in October 2009 during the sowing of mother plants (previous year the experimental implementation) using the minimum recommended rates in this region, i.e., 120 g P_2O_5 (superphosphate), 30 g K_2O (potassium sulfate), 20 g dolomitic limestone, and 15 L cattle manure per plant (BORGES; OLIVEIRA; SOUZA, 1995). Manual weeding was conducted throughout the experimental area prior to sowing of calopo and tropical kudzu. Sowing was performed in October 2010 at 2 cm depth with 30 cm spacing between furrows and a mean density of 20 seeds m^{-1} in each furrow. Seeds were not subjected to any type of treatments to promote seed germination.

2.3 Data collection and statistical analysis

In this study, the response variables were soil cover, the amount of senescent phytomass deposited on the soil surface, macro- and micro-nutrient content in senescent phytomass, soil temperature, and maintenance of soil moisture.

Soil cover was assessed at 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330, 360, and 390 d after sowing (DAS) based on the number of intersections. The intersection of two perpendicular strings defined a point that represented a specific area. The sum of areas that included vegetation in relation to the total area was used to estimate the total soil cover (FÁVERO et al., 2001).

Senescent phytomass deposited on the soil surface was measured, harvested, and weighed in three random samples of 1 m^2 per subplot and estimated in t ha^{-1}. Samples were collected at 90, 150, 210, 270, and 330 DAS and dried in a forced air ventilation oven at 65°C to constant weight. The macro- and micro-nutrient content was measured in senescent phytomass deposited on the soil surface. Nitrogen (N) levels were determined using sulfuric acid digestion and Kjeldahl distillation, whereas all other nutrients using nitric-perchloric digestion. Phosphorus (P) levels were determined using a spectrophotometer (UV-VIS), potassium (K) levels using a flame photometer, and calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), zinc (Zn), sodium (Na), and copper (Cu) levels using an atomic absorption spectrophotometer (EMBRAPA, 2000). The macro- and micro-nutrient content accumulation was calculated by multiplying the shoot nutrient content by the shoot dry matter.

Soil temperature was measured using a Solo Term 1200 digital thermometer (Solotest, Sao Paulo, Brazil) with a metal probe at 5-, 10-, and 15-cm depth at 90, 120, 150, 180, 210, 240, 270, 300, 330, and 360 DAS between 1 and 2 pm. The volumetric soil moisture was indirectly determined based on the soil bulk density at 90, 120, 150, 180, 210, 240, and 270 DAS in the 0–10-cm soil layer using the standard oven method as described by Bernardo, Soares and Mantovani (2006).

Data were tested for normality using the Shapiro-Wilk test and for equality of variances using Levene's test. The visual inspection of residuals did not reveal any deviations from homoscedasticity or normality. Analysis of variance in conjunction with Tukey's test was carried out to identify differences at $P < 0.05$.

RESULTS AND DISCUSSION

Treatments were compared at each measurement date, regardless the experimental site, since the only significant interaction was between treatments over time. All other variables showed a triple significant interaction; therefore, treatments were compared at each measurement date and location (Table 1).

Table 1. Resumed analysis of variance of soil cover, the amount of senescent phytomass deposited on the soil surface, macro- and micro-nutrient content in senescent phytomass, soil temperature, and maintenance of soil moisture of two perennial leguminous species (calopo and tropical kudzu) in a banana plantation in Itaobim and Virgem da Lapa.

		Source of variation (F values)					CV
Variables		Soil management (M)	Location (L)	M*L	Time (T)	T*L*C	(%)
Soil cover		1.01^{*}	5.41^{ns}	8.11^{ns}	2.34^{*}	7.48^{ns}	8.7
Senescent phytomass		1.15^{*}	1.03^{*}	0.01^{**}	1.72^{*}	2.03^{*}	11.6
Nutrient – Macro	N	1.02^{*}	2.04^{*}	1.29^{*}	--	--	13.6
Nutrient – Macro	P	0.67^{**}	4.03^{*}	7.14^{ns}	--	--	14.9
Nutrient – Macro	K	0.17^{**}	0.80^{**}	0.40^{**}	--	--	17.3
Nutrient – Macro	Ca	4.02^{*}	0.41^{**}	5.11^{ns}	--	--	11.3
Nutrient – Macro	Mg	0.74^{**}	0.60^{**}	8.09^{ns}	--	--	15.3
Nutrient – Micro	Cu	2.24^{*}	4.64^{*}	2.27^{*}	--	--	17.9
Nutrient – Micro	Fe	2.85^{*}	0.07^{**}	1.03^{*}	--	--	18.4
Nutrient – Micro	Mn	2.41^{*}	0.46^{**}	5.21^{ns}	--	--	13.9
Nutrient – Micro	Zn	0.82^{**}	0.44^{**}	7.60^{ns}	--	--	17.6
Temperature	5 cm	0.77^{**}	3.27^{*}	0.13^{ns}	0.04^{**}	0.01^{**}	9.4
Temperature	10 cm	0.74^{**}	4.83^{*}	5.20^{ns}	0.61^{**}	0.71^{**}	4.8
Temperature	15 cm	0.66^{**}	2.49^{*}	7.41^{ns}	3.87^{*}	4.97^{*}	4.4
Soil moisture		0.41^{**}	5.00^{*}	0.82^{**}	0.12^{**}	1.31^{**}	12.4

**Significant at 0.01 probability; *significant at 0.05 probability; ^{ns}no significant difference by the F test, respectively.

Significant differences were observed between calopo and tropical kudzu in soil cover capacity; calopo had a gradual growth, and soil cover was 47%, 75%, and 99% at 30, 60, and 90 DAS, respectively, whereas tropical kudzu had a slower initial establishment, and soil cover was 20%, 29%, and 78% at 30, 60, and 90 DAS, respectively (Figure 2).

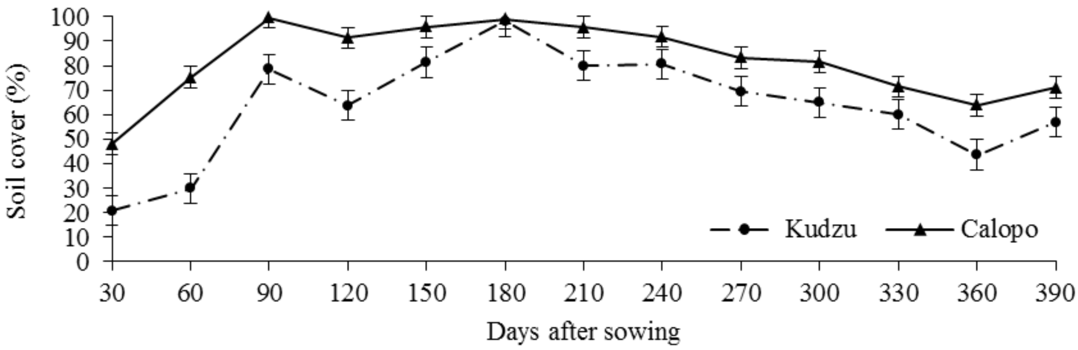

Figure 2. Average soil cover (%) of two perennial leguminous species (calopo and tropical kudzu) in two banana plantations (Itaobim and Virgem da Lapa) over a period of 360 d (30–390 d after sowing). Vertical lines indicate the least significant difference at each time at $P < 0.05$.

Soil cover decreased at 90–120 DAS, reaching 91% for calopo and 63% for tropical kudzu. This decrease was probably a result of drought between January and early March, which frequently occurs in this region and is known as “Indian summer”.

In the occurrence of occasional rain from the first half of March to early April 2011, soil cover was 95% for calopo and 81% for tropical kudzu at 150 DAS and approximately 97% for both species at 180 DAS. After 180 DAS, the leguminous species increased the deposition of senescent phytomass, and thus, soil cover gradually reduced at 63% for calopo and 43% for tropical kudzu at 360 DAS (Figure 2).

Soil cover reduced the force of runoff water by reducing its volume through the increase of infiltration. It has been reported that cover crops prevent surface sealing, increase storage capacity, and improve soil structure through the deposition of organic material to the soil, (LONGO; ESPINDOLA, 2000; KÄTTERER et al., 2011).

The senescent phytomass of both species was deposited on the soil surface at both experimental sites starting at 90 DAS. Calopo showed higher values of senescent phytomass, except for that at 330 DAS that tropical kudzu had greater values (Figure 3).

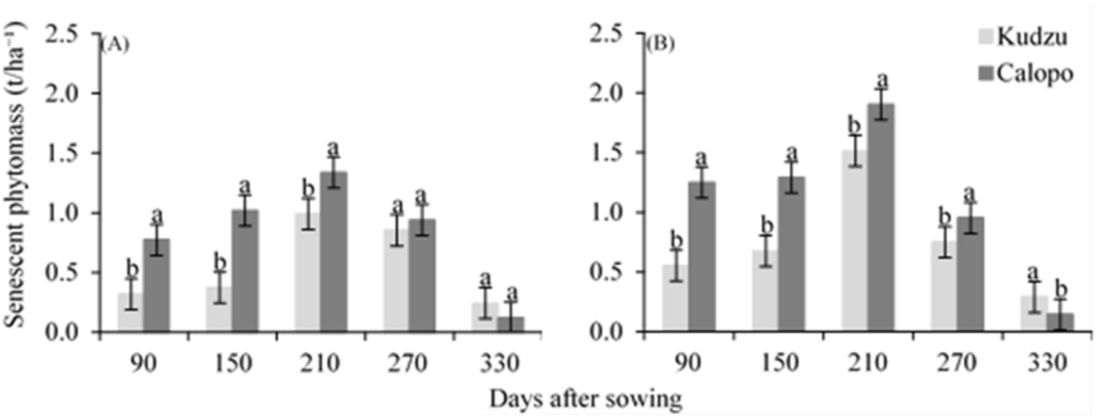

Figure 3. Senescent phytomass of two perennial leguminous species (calopo and tropical kudzu) deposited on the soil surface of two banana plantations in Itaobim (A) and Virgem da Lapa (B) over a period of 300 d (90–330 d after sowing). Different letters at the top of the bars show significant differences at each time at $P < 0.05$.

The highest deposition of senescent phytomass occurred at 210 DAS; 1.98 and 1.55 t ha^{-1} for calopo and tropical kudzu, respectively, in Virgem da Lapa, and 1.62 and 1.25 t ha^{-1} for calopo and tropical kudzu, respectively, in Itaobim (Figure 3). At 330 DAS, a small amount of senescent phytomass was deposited on the soil surface because of the low number of viable leaves in both species (Figure 3).

In Itaobim, the total phytomass deposited on the soil surface by calopo and tropical kudzu was 4.10 and 2.60 t ha^{-1}, respectively (Figure 3), whereas in Virgem da Lapa, 5.56 and 3.72 t ha^{-1}, respectively (Figure 3). These values of senescent phytomass were higher than those observed by Teodoro et al. (2011) in a similar semi-arid region. These differences could be attributed to several factors, such as soil fertility, rainfall distribution, plant spacing, agronomic treatments, and interactions with banana plants.

Calopo and tropical kudzu also differed in their nutrient cycling ability, which was related to the amount of nutrient content and senescent phytomass deposited on the soil surface. In both sites, macro-and micro-nutrient accumulation was higher in the senescent phytomass of calopo than of tropical kudzu, except for Mn that the average values did not differ between the two species in Itaobim, whereas in Virgem da Lapa, Mn accumulation was higher in the senescent phytomass of tropical kudzu than of calopo (Table 2).

Table 2. Macronutrient (N, P, K, Ca, and Mg) and micronutrient (Cu, Fe, Mn, and Zn) accumulation in senescent phytomass of two perennial leguminous species (calopo and tropical kudzu) over a period of 240 d (90–330 d after sowing) in a banana plantation in Itaobim and Virgem da Lapa.

Management	Macronutrients					Micronutrients			
	N	P	K	Ca	Mg	Cu	Fe	Mn	Zn
	(kg ha^{-1})					(g ha^{-1})			
	Itaobim								
Kudzu	58.1 b	3.7 b	14.6 b	27.8 b	9.4 b	64.1 b	543.6 b	517.8 a	107.4 b
Calopo	86.9 a[1]	7.1 a	21.1 a	41.9 a	13.4 a	68.1 a	645.4 a	522.2 a	162.3 a
CV (%)	13.6	14.9	17.3	11.3	15.3	17.9	18.4	13.9	17.6
	Virgem da Lapa								
Kudzu	75.5 b	4.8 b	25.9 b	37.7 b	16.2 b	124.1 b	1004 b	871.7 a	145.9 b
Calopo	121.6 a	9.0 a	41.4 a	55.4 a	18.9 a	131.4 a	1040 a	847.7 b	206.2 a
CV (%)	13.6	14.9	17.3	11.3	15.3	17.9	18.4	13.9	17.6

[1]Means followed by different letters within a column differ significantly at $P < 0.05$.

Overall, the highest nutrient concentrations were measured for calopo, probably because of the higher amount of senescent phytomass deposited on the soil surface compared with tropical kudzu (Figure 3). These findings demonstrated that calopo had a greater ability to recycle nutrients and supply N to the system than tropical kudzu.

Leguminous cover crops in cropping systems change the annual patterns of N uptake and mineralization, reduce downward movement of NO_3, retrieve NO_3 from deep soil layers, and fix atmospheric N_2 (DABNEY; DELGADO; REEVES, 2001). The deposition and liberation of nutrients by senescent phytomass occurred periodically, which might result in the most efficient absorption of nutrients, especially of N, by banana plants, due to the low initial demand, rapid leaching (especially in sandy soils), and high salt content (MALAVOLTA, 2006).

Phytomass production and nutrient extraction by leguminous plants can be beneficial for intercropping or subsequent crops, since the increase in N availability, combined with the efficient nutrient cycling, can increase yield and reduce production costs by minimizing the demand for external nutrient inputs.

Moreover, soil cover and deposited senescent phytomass reduce the thermal amplitude of the soil, which is important in regions that are characterized by high annual temperatures. In Itaobim, soil temperatures averaged 26.6°C and 27.1°C at 5-cm depth, 26.2°C and 26.6°C at 10-cm depth, and 25.7°C and 26.0°C at 15-cm depth, when the soil surface was covered by calopo and tropical kudzu, respectively. These soil temperatures were lower than those of bare soil that were 31.0°C, 29.6°C, and 28.2°C at 5-, 10-, and 15-cm depth, respectively (Table 3).

Table 3. Soil temperature at 5-, 10-, and 15-cm depth in a banana plantation in Itaobim and Virgem da Lapa covered by two perennial leguminous species (calopo and tropical kudzu) compared with bare soil over a period of 270 d (90–360 d after sowing).

Management	Days after sowing									
	90	120	150	180	210	240	270	300	330	360
	Itaobim									
	5 cm (ºC)									
Kudzu	32.4 b[1]	33.4 a	27.8 ab	25.8 a	23.4 a	20.6 a	26.9 a	29.8 a	25.9 a	24.5 ab
Calopo	29.1 a	32.3 a	26.7 a	25.7 a	23.1 a	20.7 a	27.0 a	28.7 a	28.0 b	23.8 a
Bare soil	40.9 c	37.5 b	29.7 b	29.9 b	26.7 b	21.7 a	30.2 b	35.1 b	32.6 c	26.7 b
CV (%)	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
	10 cm (ºC)									
Kudzu	30.7 b	32.0 a	27.2 ab	25.6 a	23.3 a	21.1 a	27.4 a	29.3 a	25.7 a	24.0 a
Calopo	28.0 a	31.5 a	26.4 a	25.5 a	23.0 a	21.2 a	26.6 a	28.5 a	27.7 b	23.4 a
Bare soil	35.3 c	35.6 b	28.2 b	28.3 b	25.8 b	21.8 a	29.9 b	34.1 b	31.6 c	25.2 a
CV (%)	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
	15 cm (ºC)									
Kudzu	29.4 b	31.5 a	26.5 a	25.3 a	22.9 a	21.1 a	26.1 a	27.9 a	25.4 a	23.7 a
Calopo	27.3 a	30.9 a	25.9 a	25.1 a	22.4 a	21.6 a	26.1 a	27.9 a	26.4 a	23.1 a
Bare soil	32.5 c	33.9 b	27.2 a	27.1 b	25.4 b	21.7 a	28.6 b	31.2 b	29.7 b	24.3 a
CV (%)	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
	Virgem da Lapa									
	5 cm (ºC)									
Kudzu	30.1 a	30.7 b	29.0 b	25.3 a	27.3 b	24.3 a	22.9 a	26.2 ab	22.6 a	26.4 a
Calopo	29.7 a	27.9 a	26.7 a	25.1 a	24.5 a	23.5 a	22.1 a	26.1 a	22.7 a	26.0 a
Bare soil	39.1 b	33.1 c	35.2 c	28.7 b	31.6 c	27.8 b	26.2 b	28.2 b	28.2 b	30.0 b
CV (%)	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
	10 cm (ºC)									
Kudzu	28.5 a	29.9 b	28.6 b	25.1 a	25.6 b	23.1 a	21.8 a	25.3 ab	22.0 a	25.9 a
Calopo	28.0 a	27.1 a	26.3 a	24.9 a	23.7 a	22.2 a	20.9 a	24.6 a	21.1 a	25.5 a
Bare soil	30.6 b	32.0 c	31.6 c	27.1 b	28.6 c	26.0 b	25.0 b	26.6 b	26.1 b	28.1 b
CV (%)	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
	15 cm (ºC)									
Kudzu	26.3 a	28.5 b	27.3 b	24.9 a	24.4 a	21.9 a	21.1 a	23.7 a	21.5 a	25.5 ab
Calopo	26.0 a	26.8 a	25.7 a	24.7 a	23.3 a	21.6 a	20.8 a	23.6 a	20.2 a	25.0 a
Bare soil	28.3 b	31.1 c	31.1 c	26.5 b	27.5 b	23.1 a	23.4 b	24.4 a	24.0 b	26.8 b
CV (%)	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4

[1]Means followed by different letters within a column differ significantly at $P < 0.05$.

In Virgem da Lapa, soil temperatures averaged 25.5°C and 26.5°C at 5-cm depth, 24.4°C and 25.6°C at 10-cm depth, and 23.8°C and 24.5°C at 15-cm depth, when the soil surface was covered by calopo and tropical kudzu, respectively. These soil temperatures were lower than those of bare soil, which were 30.9°C, 28.2°C, and 26.7°C at 5-, 10-, and 15-cm depth, respectively (Table 3).

Temperature is important in many microbial processes, including N mineralization, nitrification, and denitrification, and directly influences the soil water evaporation (CHAUHAN et al., 2007). In the present study, the lower soil temperature and greater deposition of senescent phytomass under the leguminous cover crops increased the capacity of soil moisture retention (Tables 3 and 4; Figures 2 and 3).

Table 4. Volumetric moisture content in the 0–10 cm soil layer in a banana plantation in Itaobim and in Virgem da Lapa covered by two perennial leguminous species (calopo and tropical kudzu) compared with bare soil over a period of 180 d (90–270 d after sowing).

Management	Days after sowing						
	90	120	150	180	210	240	270
	Volumetric moisture ($cm^3.cm^{-3}$)						
	Itaobim						
Kudzu	0.062 ab	0.021 ab	0.032 b	0.091 b	0.067 a	0.032 a	0.037 a
Calopo	0.068 a	0.032 a	0.054 a	0.124 a	0.072 a	0.050 a	0.038 a
Bare soil	0.051 b	0.015 b	0.028 b	0.054 c	0.037 b	0.025 b	0.018 b
CV (%)	12.4	12.4	12.4	12.4	12.4	12.4	12.4
	Virgem da Lapa						
Kudzu	0.131 a	0.030 b	0.134 a	0.090 b	0.056 b	0.037 a	0.038 a
Calopo	0.132 a	0.051 a	0.104 b	0.117 a	0.085 a	0.041 a	0.036 a
Bare soil	0.095 b	0.021 b	0.050 c	0.061 c	0.032 c	0.020 b	0.018 b
CV (%)	12.4	12.4	12.4	12.4	12.4	12.4	12.4

[1]Means followed by different letters within a column differ significantly at $P < 0.05$.

Cover crops have a positive effect on soil water storage at 0–10 cm depth throughout the growing season compared with bare soil (Table 4), demonstrating an effective management practice for reducing the temperature and increasing the water retention in the soil. These results are in agreement with those reported by Silva et al. (2016), who studied the effect of soil cover with calopo and kudzu on temperature and soil moisture in the semiarid region of Jequitinhonha Valley and reported a significant positive correlation of soil cover and soil moisture.

Mohammed (2013), reported that cover crops significantly increase water infiltration inside the soil, and hence, facilitate root penetration, conserve soil moisture, and reduce evaporative losses. The absorption of water by organic matter in the soil and the porosity of the soil increase the capacity for water retention and reduce evapotranspiration. However, the relative benefit of incorporating cover crops into a cropping system depends to some extent on the quantity, duration, and distribution of residues in the cropping system throughout the year (KASPAR; SINGER, 2011).

In the present study, calopo and tropical kudzu exhibited a good soil cover capacity. At 90–120 and 210–360 DAS that were the periods of water scarcity, calopo and tropical kudzu showed a slower growth and lower production of leaves, which suggested a relatively low competition with banana plants. After the onset of the rainy season at 360 DAS, we observed the regrowth of tropical kudzu and the emergence of new calopo seedlings.

Our results demonstrated that these leguminous species can persist over time and promote continuous incorporation of organic material into the soil through senescence during drought periods and subsequent regrowth. Therefore, both species could be used in perennial cultivation systems in semiarid regions.

CONCLUSION

Calopo and tropical kudzu are both suitable as permanent ground cover crops, since they increased senescent phytomass, soil water retention, and nutrient concentrations in the soil and decreased soil temperature in two banana plantations in the semiarid region of Jequitinhonha Valley, northeast Minas Gerais state, Brazil. Calopo showed a higher ability to cover soil and deposited more senescent phytomass than tropical kudzu, highlighting its potential use as green manure and permanent mulch.

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