Maize (*Zea mays*) intercropping in a silvopastoral system with *Brachiaria hybrid* cv. Mulato and *Leucaena leucocephala* cv. Peru

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The effect of maize (*Zea mays*) intercropping on the establishment of a simultaneous silvopastoril grass-leucaena sowing was studied. A completely randomized design with two treatments was used: A) *Leucaena leucocephala* cv Peru and *Brachiaria hybrid* cv. Mulato plus maize and B) leucaena plus mulato grass. Sowings were made at the beginning of June, 2007 in the rainy season, on a carbonated brown soil. Indicators studied were: number of plants, number of stalks plant^{-1}, height and yield in leucaena and height, number of plants and yield in mulato grass. Botanical composition, availability and bromatological composition of the grassland were determined. SAS 9.1 software was used for the statistical analysis of the evaluated indicators. In treatment A, leucaena showed higher height values ($P < 0.01$) (108.67 cm vs. 93.73 cm), yield ($P < 0.01$) (90.20 vs. 75.10 g DM plants^{-1}), number of stalks plant^{-1} ($P < 0.001$) (12.91 vs. 10.61) and number of plants ($P < 0.001$) (4.96 vs. 3.83). In this treatment, mulato grass showed higher number of plants ($P < 0.01$) (8.50 vs. 6.10) and yield ($P < 0.001$) (300.15 vs. 250.02 g DM plants.1). Percentage of mulato grass was also higher (66% vs. 50%) with this treatment. The remaining grasses did not differ. There was a higher availability ($P < 0.05$) in the treatment with maize (7.8 vs. 5.8 t DM ha^{-1}). It is concluded that maize intercropping in a simultaneous sowing of leucaena and mulato grass favors leucaena establishment and does not affect the grass. Results indicate the possibility of establishing silvopatoral systems with leucaena and mulato grass of recent introduction in our country through maize intercropping in the sowings, with the advantage of grain harvesting and possible sale to cover the establishment expenses.

Key words: *leucaena, grass, simultaneous sowing*, *silvopastoril system*

Since the 80's studies have been carried out on the establishment and management of silvopastoral systems with *Leucaena leucocephala* (Pérez 2000 and Iglesias *et al* 2007). In this period it was possible to establish approximately 13% of the grasslands with leucaena (Anon 2000). Years later, the percentage decreased in cattle rearing areas reaching values around 9% (Soto 2004). Presently, this practice should be reconsidered, since it is a practical feeding alternative for bovine cattle, especially in the poor rainy period (Miltra and Mitra 2000 and Guevara *et al*. 2009). Also, it could contribute to improve grassland ecosystems and biodiversity, as well as their sustainability in time (Milera 2010 and Senra *et al* 2010).

In general, different studies indicate that for leucaena establishment, hand, chemical or mechanized cleaning practices (Ruiz *et al*. 1998, Ruiz and Febles 1999 and Ruiz *et al* 2008) are necessary. These labors are important mainly during the first ten weeks after sowing, if the establishment of leucaena silvopastoral systems associated with different grasses is required. With the initial intercropping of seasonal cultures, as maize, bean, sorghum and others, these cultural cleaning labors can be disregarded during leucaena establishment, which is a more feasible option for farmers (Guevara *et al*. 2003, Altieri 2004 and Ruiz *et al*. 2006b).

For this study the *Brachiaria hybrid* cv. Mulato of recent introduction in Cuba was used to test the effect of maize intercropping on the establishment of this grass associated with leucaena.

Materials and Methods

Localization and edaphoclimatic conditions. The study was developed in areas of the fattening farm Ayala of the Institute of Animal Science in Cuba (ICA). This facility is located at 47 ½ km of the Central Highway, at 22º 53' North latitude and at 82º 02' West longitude, at 92 m.a.s.l. Its soil is dark carbonated (Hernández *et al*. 1999) with neutral pH and 4.5% of organic matter, with good drainage and plain topography. According to data recorded in 2011 by the meteorological station of ICA, average temperature in the last 30 years has been approximately 24.16º C. The warmest month has been June, with 26.3ºC. January and February behaved as the coldest, with 20.4ºC and 20.2ºC, respectively. Maximum temperature has reached up to 33ºC in August and the minimum 5ºC. Annual rainfalls are in the order of 1300 mm, with the highest values in July (244.6 mm).

Treatment and design. Two paddocks of one hectare each of similar soil type, without flooding or slopes were taken. A completely randomized design with two treatments was used: A) *Leucaena leucocephala* and *Brachiaria hybrid* cv. Mulato associated with maize and B) leucaena and mulato grass without maize (figures 1 and 2). The experimental unit was the sampling point. From the two systems, 100 points of 1 m^2 in the leucaena rows were randomly selected. Replications using similar amounts were made in the brachiaria grass rows to perform the measurements in both plants.

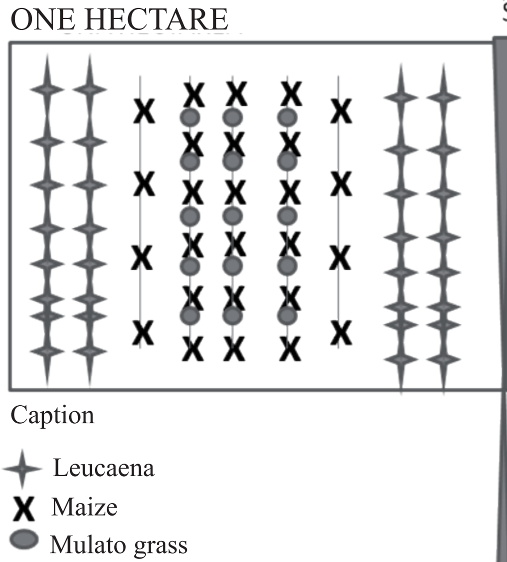

Figure 1. Treatment leucaena-mulato grass and maize

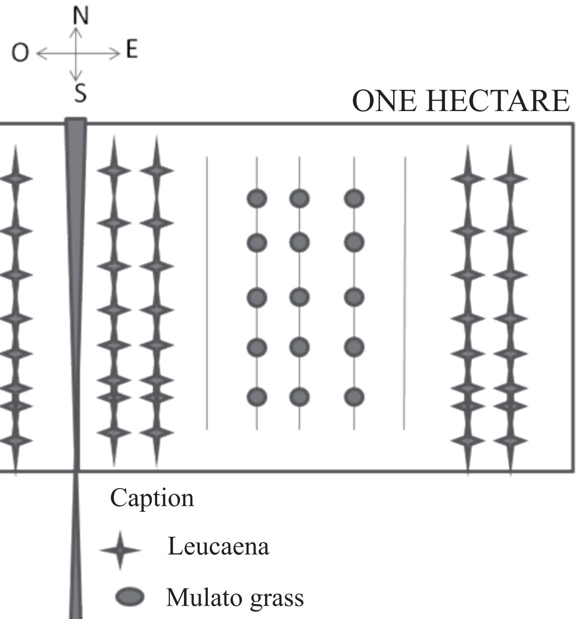

Figure 2. Treatment leucaena-mulato grass without maize

Procedure. A conventional soil preparation was made ploughing every 0.80 m in both treatments. All sowings were simultaneously carried out the same day, in June, 2007. Double rows of leucaena 4.20 m apart were sown. Distance between plants was of 0.50 m and the sowing dosage of 3 kg ha^{-1} of total seed, for an approximate density of 5 000 plants ha^{-1}. There were five rows between the double rows of leucaena. In the three central rows, botanical seeds of mulato grass were sown while ploughing, with dosages of 4 kg ha^{-1} of total seed. In treatment A, maize was sown in the five central rows, with a dosage of 13 kg ha^{-1} of total seed. In this case, in the three central rows, distance between plants was of 0.80 m and 1.20 m in the rows near the Leucaena.

Measurements were taken 150 days after sowing. Indicators studied were: number of plants, number of stalks $plant^{-1}$, height and yield in leucaena and number of plants, height and yield in mulato grass. Botanical composition, availability and bromatological composition of the grassland were determined.

In treatment A, maize yield was estimated for which 10 points were randomly taken of 10 linear m. All cobs were harvested, grains were separated and weighed. Later, yield in t DM ha^{-1} was established.

For the botanical composition of the main pasture, the method of t'Mannetje and Haydock (1963) was employed and the availability was determined according to Haydock and Shaw (1975). A 0.25 m^2 frame was used and 80 visual observations were performed. Availability estimation was developed with the CALRAC program (Roche *et al*. 1999).

Leucaena availability was determined applying the method proposed by Mahecha *et al*. (2000). For that, five shrubs per paddock, availability representatives, were selected. Each was ranked between one and five (1 = lower amount of foliage, 5 = higher amount of foliage), according to real samples. All usable material (leaves and thin stalks) was selected and harvested. Once known the availability equivalent in each ranking, each tree was ranked in the 100 points randomly selected. In both treatments, the chemical composition of leucaena and brachiaria (AOAC 1995) was studied.

For the economical analysis in Cuban pesos (CUP) sowing expenses were considered and a cost card per treatment was prepared indicating: fuel and lubricant expenses for soil preparation and labor force. Also, seed, cleaning labors and harvest expenses were considered. Maize grains sale was also stated.

Data of the number of plants of leucaena and mulato grass, as well as the number of stalks per plant in leucaena were transformed according to $\sqrt{x}$. Data were processed by the statistical package SAS 9.1, Windows (2007) version.

Results and Discussion

In treatment A, the number of stalks $plant^{-1}$, number of plants and Leucaena height and yield were higher when maize was intercropped (table 1).

Results obtained in leucaena with maize

Table 1. Effect of intercropping maize in leucaena on the studied indicators.

Indicator	Units	Treatment		SE(±)	Sig.
		A with maize	B without maize		
Leucaena plants	Number/m^2	2.191 (4.96)	1.911 (3.83)	0.064	***
Branches plant^{-1}	Number	3.581 (12.91)	3.151 (10.61)	0.031	***
Height	cm	108.67	93.73	0.94	**
Yield	g DM plant^{-1}	90.20	75.10	0.46	**

*** (P < 0.001) and **(P < 0.01)
1Data transformed according to √x
( ) original data

intercropping could be due to the sowing distances used, mainly in the two rows close to leucaena (1.20 between plants), which were 0.40 m higher than the three in the center. This made possible a decrease in the shade effect and the competition that maize leaves could have provoked, without compromising leucena establishment. This result agrees with Padilla *et al*. (2001) and Ruiz *et al*. (2006a), who found the best results in leucaena establishment with maize intercropping. Ruiz (1988), Ruiz *et al* (1999) y Ruiz (2005) pointed out that the best sowing time of an erect seasonal culture, as maize, is after the germination of the legume, mainly because the shade provoked by the maize could establish the competition and, therefore, affect leucaena germination and growth. However, in this study there was a simultaneous sowing of leucaena-mulato grass associated with maize, where leucaena indicators studied were not affected.

Another aspect to be considered in treatment A was the maize control over other grasses considered weeds, as in the case of leucaena. This agrees with results reported by Ruiz (1988), Liebman (2004), Pound (2004) and Ruiz *et al*. (2006a). In treatment B, 35 days after sowing, a cultural labor of hand cleaning in the double leucaena rows was necessary. In this way, it was prevented that spontaneous growth grasses complicate leucaena survival. Thus, this cleaning labor raised the establishment cost. This confirms that the use of seasonal culture, in this case maize, associated with other cultures as protective plant, could be beneficial for agricultural systems. It is a feasible practice in Cuban cattle rearing for the development of silvopastoral systems with leucaena.

In table 2 is shown the effect of intercropping maize in mulato grass. The number of plants and yield were higher in treatment A. However, in treatment B plants were taller.

Mulato grass during its establishment tolerated the maize shadow and its growth was not compromised. Nonetheless, to a certain extent, it limited the height. This could be associated to the fact that mulato grass was sown in the three central rows, precisely where the sowing distance between maize plants was shortened, which could have limited sunlight penetration.

In treatment A, this result favored the good performance of this grass and a lower competition of other spontaneous growth grasses. In B, the presence of other grasses affected the number of plants by 28% regarding treatment A. This coincides with the findings of Ruiz and Febles (1986), Sistachs *et al*. (1990), Moreno *et al*. (1993), Pino *et al*. (1993), Muñoz *et al*. (2001) and ANON (2005) on the beneficial effects of associating cultures with maize to obtain positive results in the production.

Regarding the botanical composition, there were

Table 2. Effect of intercropping maize in *Brachiaria híbrido* vc. Mulato on the indicators studied

Indicator	Units	Treatment		SE(±)	Sig.
		A with maize	B without maize		
Brachiaria plants	Número m^2	2.891 (8.50)	2.451 (6.10)	0.06	**
Height	cm	81.78	85.73	0.50	*
Yield	g MS.planta^{-1}	300.15	250.02	0.46	**

*** (P < 0.001) and **(P < 0.01)
1Data transformed according to √x
( ) original data

no differences between treatments (figure 3), except ($P < 0.05$) for the percentage of mulato grass which was in favor of treatment A. However, in spite that there were no differences between treatments, the presence of native grasses could establish competition with mulato grass. Moreover, the spontaneous sprout of these grasses could have been the main cause affecting the number of plants of mulato grass in the sampled places and its percentage in the total area.

Yield of edible available biomass was higher ($P < 0.05$) in treatment A, (7.8 vs. 5.8 t DM ha^{-1}). Values of metabolizable energy ranged in both treatments from 11.0 – 11.2 MJ kg DM^{-1} for leucaena and from 9.95 – 10.1 MJ kg DM^{-1} for mulato grass, respectively. In leucaena, crude protein (CP) values and neutral detergent fiber (NDF) were of 265.5 – 265.7 g kg DM^{-1} and of 443.5 – 445.3 g kg DM^{-1}, respectively, and in mulato grass of 82.4-83.1 g kg DM^{-1} and of 713.5 – 715.5 g kg DM^{-1}, respectively.

Harvesting and sale of maize grains generated 2 500 CUP, yielding 1.6 t/ha in non-irrigated areas without fertilization. This yield is attributed to the soil fertility conditions, the adequate rainfall regime, poor damage of pests and diseases affecting maize quality. This made possible to meet the sowing expenses according to the cost card (table 3).

It is concluded that maize intercropping in a simultaneous leucaena and mulato grass sowing favors leucaena establishment without affecting the grass. This allows the establishment of silvopastoral systems with leucaena and mulato grass recently introduced in Cuba, intercropped with maize. Also, harvesting and sale of grain makes possible to cover sowing expenses.

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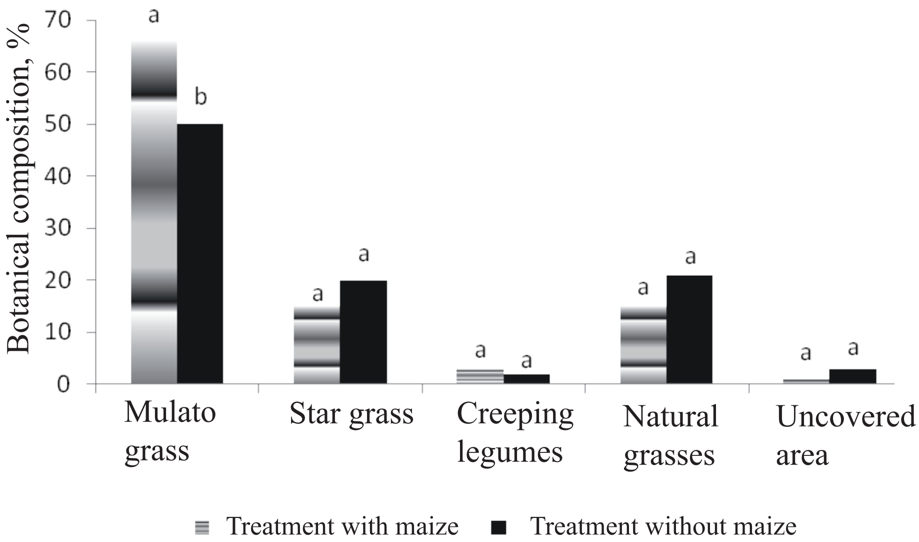

Figure 3. Botanical composition for both treatments five months after sowing

Table 3. Cost card per treatment in Cuban pesos (CUP)

Indicators	Treatments	
	A with maize, (CUP)	B without maize (CUP)
Soil preparation	41.8	41.8
Seeds	146.0	68.0
Manual sowing	100.0	83.0
Manual cleaning	--	73.3
Maize harvest	140.5	--
Total of expenses	428.3	266.1
Maize sale estimate	2500.0	--

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