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Evaluation of dead leaf and soil creatures associated to *Gliricidia sepium* (Jacq) Kunth ex Walp, used as live fences in savannahs

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ABSTRACT

The contribution of decayed dry leaves and edaphic fauna to soil by using *Gliricidia sepium* (Jacq) Kunth ex Walp as living fences on savannas with a predominant serpentine stratum was determined in Camagüey municipality, Cuba. Results showed *G. sepium* beneficial environmental impact due to its high contribution of decayed dry leaves to soil, i.e., 332 kg/ha per month equivalent of 3,98 t/ha per year. Development of edaphic fauna —earthworms and beetles mostly— was enhanced, showing the benefits of this ecosystem environment, as well.

Key Words: Gliricidia sepium, *living fences, decayed dry leaves, edaphic fauna*

INTRODUCTION

The growing increase in population has created a need to step up agricultural productions, thus the soils with the best physical and productive features have been saved for grain and vegetable production. As a consequence, livestock management has been left with the least qualifying lands, including savannahs or lowlands in the American continent tropics. They are the ecosystems with the greatest possibilities for livestock (Paretas, 2001 and Ibrahim, and Mora-Delgado, 2003).

Live fences are an alternative to agroforestry systems, based on the in-line plantation of trees and shrubs on the inner and outer borders of farms (Otaróla, 1995; Villanueva *et al.*, 2005 and Sánchez, 2007).

The use of live fences in Cuba is common practice, especially in the countryside, because of the low implementation costs and durability, and not for its potential use (Pedraza, 2000). In ecological terms live fence plantation is a way to acquire wood without felling the forests. The live fences are also associated to the protection and improvement of soils by fixing nitrogen and improving the neighboring pasture. Air quality is also improved (carbon sequestration), and contribute with the presence of more wild animals (birds, amphibian, reptiles, bats), and insects (butterflies) in the farms (Villanueva *et al.*, 2005).

G. sepium is probably the most widely multipurpose tree spread in tropical areas, only after *Leucaena leucocephala. Cuban scholars* (Pedraza and Gálvez, 2000) have shown the forage potential of live fences. Edible biomass productions have been produced in this species, which may contribute with 4.4 kg of DM/tree, 120 after reshoot from strategic trimming. Digestibility of dry matter is 58 to 69 % (Arcos, 2000 and Pedraza *et al.*, 2003).

Current intensification of cattle raising has significantly effected on the social and economic development of countries that develop it; however a striking deterioration of environmental conditions is observed. Forest-grazing systems significantly contribute soil recovery from livestock exploitation, without negative effects to the environment.

Nowadays, countries in Central America and the Caribbean, especially Costa Rica and Cuba, the use of forest-grazing systems has aroused the interest of researchers, planners and producers. This program has had a remarkable effect on cattle production increases.

Crespo (2001) cited by Crespo (2008) found that the inclusion of arborescent forage species in native grazing lands used for cattle fattening, had a favorable contribution to dead leaf accumulation and nitrogen balance in the systems studied. Fernández (2006) affirmed that its inclusion is very important because it makes possible the developments of a wide range of soil creatures that favor soil structure, by digging galleries through which air and water flow, thus helping other taxonomic groups in the soil.

The aim of this research is to determine the contribution made by dead leaves and soil creatures associated to G*liricidia sepium* (Jacq) Kunth ex Walp, used as live fences in ultramafic savannahs in Camagüey.

MATERIALS AND METHODS

The study lasted two years (November 2010 to November 2012). It was carried out in areas of Noel Fernández State Farm, in Minas, province of Camagüey, Cuba, located at 21º28'50"-21º29'15" north latitude and 77º39'50"-77º40'20" west longitude, 40 m above sea level. Grown up pinion trees (*Gliricidia sepium* (Jacq) Kunth ex Walp) from a 15-year old bordering fence, planted at a distance of 1 m from each other, were used.

The experiment was performed on red-brownish ferromagnesian ferro-lithic soil, (Hernández *et al*., 1999a). Internationally, these soils are classified as Inceptisole, according to Soil Taxonomy (1994) and Cambisole, according to FAO-UNESCO (1990), cited by Hernández *et al*. (1999b).

The local climate is humid tropical interior plain, with seasonal humidity and high evaporation (Díaz, 1989); the air temperature is high, ranging between 23.0 and 24 ^{o}C; mean rainfall values were between 245.1 and 1 424.5 mm in the low-rain period (PPLL) and rainy period (PLL), respectively, according to data given by the weather station at the Cuban Hydraulics Dam, pluviometer 835, located at 21º31'50" north latitude, and 77º41'30" west longitude.

Twenty lots of 0.50 x 0.50 m were cleared from weeds and any organic matter under the trees. All matter piled was collected every fifteen days, until it was weighed and scaled to the overall area (Crespo y Rodríguez, 2000).

Twenty sampling sites of 0.5 x 0.5 m under the trees and the neighboring pasture were cleared and dug 10 cm deep. All individuals from different species were counted.

Statistical analysis

Mean and standard deviation for dead leaves and soil creature deposition were determined using SPSS, version 15.0.1 (2006).

RESULTS AND DISCUSSION

Monthly dead leaf deposition (kg/ha) is 332.0 ± 0.05 kg/ha, equal to 3.98 t/ha, 35 kg/ha higher than reports by Toscano (2012) in the same scenario, but using *Bursera simaruba*

Biomass availability generated by the system caused senescent material detachment and a slow continuous pile of dead leaves on the surface, eventually became part of the soil as organic matter. The plant material deposited favored humidity retention and might form an important barrier to prevent soil erosion (Navia and Dávila, 1999).

Similar dead leaf depositions have been achieved by Gómez (1991), cited by Hernández and Hernández (2005), with the inclusion of *G. sepium* in Colombian regions, and by Febles, Ruiz and Simón (1995) in fruit, legume and pasture plantations, in studies carried out in Cuba.

The volume of dead leaves and the nitrogen incorporated to the soil may also be visibly incremented. According to results by Skerman *et al.* (1991), Leucaena contributed with 1,2 t MS/ha of dead leaves in two years, whereas Hernández and Hernández (2005) found that *G. sepium* may produce 2.6 t DM/ha/year of dead leaves, and 51 kg of N/ha/year. The results of this research are higher than those previously cited, except the study by Hernández and Simón (1994) and Simón (1995), who determined that *A. lebbeck* dead leaf deposition on the soil ranged from 10 to 13,6 t/ha in the rainy and low-rain seasons, respectively.

In the soil-pasture system, soil enrichment caused by trees is mainly produced by the gradual intake of nutrients in the soil, from tree biomass and herb-level dead leaves (Crespo y Fraga, 2006).

Dead leaf canopy not only provides organic matter, but also regulates the temperature of the soil; therefore, organic matter decomposition and nutrient supply take place slowly and continuously.

Dead leaf layers work as sponges; they keep humidity conditions that favor the action of microorganisms in a regulated manner. Thus, a balance is created between the canopy, the dead leaves, decomposers and nutrients; creating a basic balance so ecosystems and tropical forests endure time (Arango, 1991 and Hernández and Hernández, 2005).

According to Hernández and Hernández (2005), tree contribution to nutrient recycling is also linked to the fact that depending on the soil conditions and species, they are able to go deeper into the soil, intake nutrients and bring them back to the surface with natural foliage, stems and fruit demise and fall, or by trimming. Nutrients like Ca, K, Mg and S can be recycled.

Knowledge of the amount and chemical composition of dead leaves produced by plants are of great interest, as it sheds light on nutrient return to systems (González and Gallardo, 1995).

Crespo and Fraga (2006) compared the production of dead leaves and its contribution of N, P y K in two pasture lands with different species. In the second pasture land arborescent species *L. leucocephala and Cajanus cajan, and tree species A. lebbeck, encompassing* 65 % of the area, were studied. However, the first pasture land studied was characterized by the absence of trees. Generally, total dead leaf production was 60 % greater in the second pasture land, which corroborates the reports on the advantages of tree systems.

In the defoliation process, the leaves from the trees gradually fall onto the soil; they work as coverage first, then significant amounts of nitrogen are incorporated, enriching the pasture along the live fence.

In Cuba and other areas of the continent reinstating trees and shrubs in pasture lands (forest-grazing system) is an appealing alternative to recover soil fertility (Simón, 2000; Ruiz and Febles, 2001; Acosta *et al*., 2006; Ibrahim *et al*., 2006 and Crespo, 2008). In that sense, Noval (2000) using three-eight year old leucaena in pasture lands, was able to prove the significant increase of phosphorous in the soil.

Other authors, like Machecha *et al.* (1999) assessed the chemical composition of the soil in Star pasture prairies, alone and associated to leucaena; N, C and OM contents were greater in the associated areas, which may be explained by contributions from trimming, feces, dead leaves and grazing residues from all botanical components of the prairie. Consequently, in the sites where this research took place similar benefits may be expected.

Table 1 shows the behavior of soil creatures in the system studied. Both in the rainy and low-rain seasons, soil worms and coleoptera were the main groups found in the ecosystem studied, similar to findings by Rodríguez *et al*. (2002) and Rodríguez *et al*. (2008), in different pasture land systems with singleand associated crops. The amount of coleoptera was remarkably significant in tree systems, with striking differences in the rainy season. The remaining organisms showed no significant differences between systems, but were more numerous in the tree systems in both seasons.

According to Simón (1998), some of these organisms, especially coprophages (coleoptera), may favor feces intake by the soil in 24 h . Digging by coleoptera helps decrease fecal infestation in the land; meaning more pasture is available and more water retention in the soil is produced, along with soil horizon removal.

An increase in soil life and in the number of coprolites on the soil must occur, considering increases in vegetation and the ensuing dead leaf contribution, which is favorable to the ecosystem. Crespo and Rodríguez (2000) and Rodríguez *et al.* (2003) have reported remarkable increases in biotic components of the soil as more trees are planted in grazing lands, due to dead leaves and the beneficial effects of trees on soil micro-climate.

Moreover, trees have been taken to pasture lands, increasing organic matter contents and improving the micro-climate. It also favors the biological activity of micro-fauna (Sánchez *et al.*, 2003), especially of bacteria and micorhyzogenic fungi (Sadeghian *et al.*, 1998 and Machucha, 2002), which produces more mineralization, mobilization and availability of some nutrients (P and K) in the soil Generally speaking, within the agro-forestry techniques used, the use of *G. sepium* as live fence means lower costs and more income, in comparison with other types (Pérez, 1995). The introduction of trees and shrubs in traditional livestock systems improve their structure and reduces soil erosion. These results are supported by greater nutrient recycling and nitrogen fixation, as well as tree root deepening, more macro and meso fauna activity, and erosion control.

In six months of live fences, around 4,0 t/km of dry biomass have been produced, whereas increases up to 5,3 t/km have been observed in nine months.

Shade is an important aspect too, as it not only brings about animal comfort, but also soil fertility and improved nutrition of some plant species under their canopy (Wilson, 1991; Pedraza, 2000 and Simón, 2000).

Until very recently, these resources had been overlooked by scientists, due to inappropriate knowledge of potential use and poor initiatives to develop more innovating nutritional systems (Ørskov, 2005).

In the tree systems, organic matter keeps adequate levels of fertility. Residue recycling at tree foundations may reduce or halt acidification and help in erosion control and organic matter losses. The advantage brought by woody-forage species, like legumes as a diet for ruminants is grounded on their capacity to grow and develop in marginal areas, using very simple techniques that protect the soil. Moreover, biomass production from trees and shrubs is more viable than pasture alone, with no fertilizers (Benavides, 1995 and Benavides *et al*., 2005).

CONCLUSIONS

G. sepium puede aportar altos niveles de hojarasca al suelo. Las cercas vivas de *G. sepium* benefician el buen desarrollo de la fauna edáfica demostrado en los altos niveles de presencia y la diversidad de esta.

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Table 1. Behavior of soil fauna in the system studied (individuals/m^2)

Animal species	PLL			PPLL		
	With piñon	Without piñon	+ES	With piñon	Without piñon	+ES
Millipedes	22	22	0.19	81	121	0.31
Annelids	198	227	0.53	173	74	0.48
Coleoptera (larvae)	227	110	0.53	300	167	0.63
Spiders	0	0	-	3	0	-
Centipede	42	29	0.27	12	5	0.74
Total (individuals /m^2)	489	388		569	367	

PLL: rainy season; PPLL: low-rain season