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Leucaena feeding systems in Paraguay

Sistemas de alimentación con leucaena en Paraguay

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Abstract

Leucaena leucocephala became naturalized in Paraguay long ago. However, due to cases of toxicity in horses and cattle, now identified as mimosine toxicity, leucaena was considered a weed until the beginning of this millennium. At this time the mimosine toxicity problem was overcome by the introduction of ruminal fluid from Australia containing the mimosine-degrading and -detoxifying bacterium *Synergistes jonesii*. As long as an internationally funded technical assistance project was operating (offering technical advice, provision of seed, seed scarification service and transmission of ruminal fluid containing *Synergistes*), the area sown to leucaena (either in twin rows into grass pastures or as fodder banks) increased rapidly in Paraguay, particularly in the Chaco area. However, the powdery fluvisols of the drier parts of the Chaco were not well suited to growth of leucaena, as persistence was restricted due to the impact of rodents, termites and also leaf-cutting ants, which prosper particularly well in this part of the Chaco. In more humid areas with usually heavier soils, currently leucaena represents an integral part of the feeding systems in hundreds of Paraguayan farms (large-scale as well as smallholders), mainly for steer fattening and dairy cow supplementation. After taking into account the above-mentioned setbacks, the total area of leucaena is currently estimated at about 10,000 ha.

Keywords: Chaco, fodder bank, mimosine toxicity, row seeding, shrub legumes, steer fattening.

Resumen

Leucaena leucocephala ha sido naturalizada en Paraguay desde hace mucho tiempo. Sin embargo, debido a casos de intoxicación en caballos y bovinos, ahora identificada como toxicidad por mimosina, la leucaena fue considerada una maleza hasta principios de este milenio. El problema de la intoxicación se ha podido solucionar mediante la introducción, en 2003 desde Australia, de fluido ruminal con la bacteria *Synergistes jonesii* que degrada y desintoxica la mimosina. Mientras estuvo en funcionamiento un proyecto de asistencia técnica financiado con fondos internacionales, el cual ofrecía asesoría técnica, suministro de semilla, servicio de escarificación de semilla y provisión de fluido ruminal con *Synergistes*, el área sembrada con leucaena (ya sea en forma de doble-hileras en pasturas o como bancos de forraje) aumentó rápidamente en Paraguay, particularmente en la región del Chaco. Sin embargo, los fluvisoles de las partes más secas del Chaco resultaron no ser aptos para el cultivo de la leucaena, ya que su persistencia estuvo afectada por roedores, termitas y también hormigas cortadoras de hojas. Estas plagas prosperan particularmente bien en esta parte del Chaco. En áreas más húmedas, con suelos generalmente más pesados, la leucaena representa actualmente una parte integral de los sistemas de alimentación animal en centenares de granjas paraguayas (tanto propiedades grandes como pequeñas fincas), principalmente para novillos de engorde y suplementación de vacas lecheras, abarcando una superficie de aproximadamente 10,000 ha.

Palabras clave: Bancos de forraje, cebs de novillos, Chaco, hileras dobles, leguminosas arbustivas, toxicidad por mimosina.

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Introduction

The leguminous forage shrub *Leucaena leucocephala* is not native to Paraguay; having been introduced a long time ago it has been partly naturalized. Anecdotally, there was a major effort during the 1970s to grow leucaena on a broad scale for grazing and feeding purposes and to integrate this excellent forage, also named 'tropical alfalfa', into local feeding systems. Clearly, these efforts failed and farmers had a generally poor image of leucaena. Although it was used occasionally by smallholders as a source of forage, it was considered primarily a weed, as cases of hair loss, particularly among horses, were observed.

In the 1990s, a German-financed agricultural R&D project commenced in the Paraguayan Chaco. Initial small-scale, short-term grazing trials demonstrated leucaena's high potential to increase growth of steers, even when both grass and leucaena leaves were dry but abundant after being frosted in winter (Glatzle 1999; Cabrera et al. 1999). In studies over longer grazing periods, however, monthly bodyweight gains in steers decreased progressively, with weight losses being experienced after animals grazed leucaena for approximately 6 months (Klassen 2005) (Figure 1). The cause of this phenomenon was identified as mimosine toxicity. It became obvious that a solution to this problem was crucial if wider acceptance of leucaena as a forage crop at farm level was to be achieved.

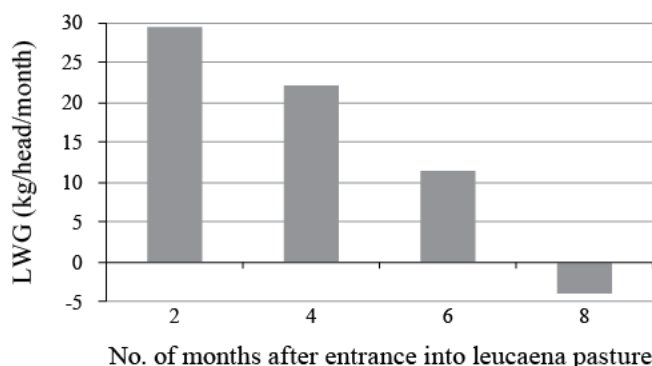


Figure 1. Monthly liveweight gains (LWG) of steers (without mimosine-degrading bacteria) as a function of the time spent grazing on leucaena.

Dealing with the mimosine toxicity problem

In early 2003, INTTAS (Iniciativa para la Investigación y Transferencia de Tecnología Agraria Sostenible) contacted Dr Raymond Jones, the discoverer of the mimosine-degrading rumen bacterium *Synergistes jonesii* (Jones 1986), a retired senior scientist from the CSIRO

Davies Laboratory in Townsville, Australia and invited him to Paraguay. After extended zoo-sanitary clearing procedures in Australia and Paraguay, Dr Jones managed to bring a thermos of ruminal fluid from Australian steers grazing leucaena, which contained the appropriate bacteria. Immediately on arrival at the Central Chaco Research Station (it was after midnight) we inoculated 2 rumen-fistulated steers with this fluid, about 72 hours after it had been extracted from steers in Queensland. The recipient animals had been prepared by feeding abundant leucaena for several days. By 5 days after inoculation a urine coloration test demonstrated that these steers were effectively degrading mimosine in their rumens (Jones and Megarritty 1986).

After some animal-to-animal transmission tests of the mimosine-degrading capability of the rumen fluid we offered a service for ruminal fluid transmission to farm animals grazing on leucaena. This service was soon taken over by a local agricultural extension program that maintained fistulated steers on leucaena as rumen fluid donors. Between 2003 and 2017 an estimated 800 farmers were provided with the mimosine-degrading microflora in order to prevent mimosine toxicity from developing in stock grazing leucaena. Even leucaena growers from neighboring Argentina came to collect a thermos of rumen fluid for dosing their animals.

Initially the ruminal fluid (10 mL/animal) was injected with a rumen injection gun to about 20% of the animals in the target herds grazing leucaena. The ruminal fluid was transported in a flexible rubber bottle (Figure 2) to avoid suction of air into the container as the fluid volume was reduced with each injection. Oxygen is lethal for the obligate anaerobic *Synergistes* bacterium. When injection into the rumen was not properly executed, isolated cases of infections happened (resulting in subsequent animal mortality in one case). Therefore we changed to an oral application system (Figure 3), and doubled the dose to 20 mL/animal. This method has proven quite effective.

When considering some basic rules, it is necessary to inoculate only a single group of animals per farm, as the ruminal bugs are readily transmitted from one animal to another within the same herd. Jones (1986) suggested that, as *Synergistes* needs mimosine (or its metabolite 2,3-DHP) as its major carbon and energy source, these organisms are lost from the rumen within 6–9 months, after the delivery of substrate ceases when animals are no longer fed on leucaena. However, we observed mimosine toxicity symptoms in a group of dairy cows when they re-entered a leucaena fodder bank after a break of only 4 months without access to leucaena. We assumed that the diet of the dairy cows, which was primarily silage and concentrate feed, reduced the survival time of *Synergistes* in the rumen

in the absence of mimosine. On commercial beef ranches some steers are usually kept as donor animals on leucaena pasture for most of the year. These animals are mixed with groups of 'naïve' steers to provide a source of inoculum when these groups enter leucaena for fattening. When fattened animals are sold, the lightest ones are usually held back and mixed with the next group for fattening.



Figure 2. Transmission of ruminal fluid with a rumen injection gun supplied from a flexible rubber bottle to avoid suction of air.



Figure 3. Oral application of ruminal fluid is less risky for the recipient animal but requires more restraint.

Large-scale adoption of leucaena feeding systems on farms

The solution to the mimosine problem in 2003 was the 'launching pad' for a rapid expansion of the area sown with leucaena in the semi-arid and subhumid Chaco region (600–1,200 mm of annual, summer-dominant rainfall) with geologically young, mostly neutral to alkaline soils, as well as the more humid ecosystems in Eastern Paraguay (1,200–1,700 mm annual rainfall) with

ferralitic and slightly more acidic soils. This expansion was supported and driven by the active promotion of a technology package for leucaena establishment and management made public through numerous field days, active participation in agricultural expositions with exhibition stands, pamphlets, extension videos (which were even broadcast on television) and a well-attended leucaena congress with international (including Australian) participation organized in the Chaco in 2005.

The disseminated technology package covered all relevant aspects of leucaena establishment, including seedbed preparation, sowing methods, initial weed and pest (leaf-cutter ants) control and leucaena management under grazing. Acceptance of the technology was supported by the offer of a number of services provided by the R&D project INTTAS: general technical assistance to leucaena growers; provision of ruminal fluid containing *Synergistes* bacteria; and supply of leucaena seed, both the common Peru type and the new cultivar Tarramba (tree type, fast-growing and more frost-tolerant). By signing a contract with the Australian license holder, Leucseeds, INTTAS acquired the right to multiply and commercialize Tarramba seed in Paraguay (Figure 4) and was equipped with a prototype of a patented seed-scarification device. Naegele (2005) summarized the crucial points in leucaena management, while this information is also accessible on the INTTAS website [Glatzle et al. (2004, 2006, 2007); Klassen et al. (2007); Naegele et al. (2007)].

As a consequence of the active technology promotion, the area sown with leucaena in the Paraguayan Chaco increased rapidly to an estimated 10,000 ha within a few years, almost all of which (99%) was sown in twin rows at a distance of 5–10 m into existing grass pastures (mostly Gatton panic). This was achieved after either total soil tillage or tillage of strips within the pasture (Figure 5), or, in more humid regions, sowing in combination with a crop (Figures 6 and 7). Animal production (finishing steers or bulls) per unit area and per head increased remarkably with the incorporation of leucaena (Table 1; Figure 8). The responses in productivity to sowing of leucaena are generally smaller in summer than in winter, when grass quality is low (Figure 9). About 5% of the total area sown with leucaena is represented by high density stands, used as fodder banks, mostly in smallholder dairy farms in the Chaco and in Eastern Paraguay. These are either directly grazed on an hourly basis or used by cut-and-carry, partly offered as chopped fodder while milking (Cabrera 2005). Dairy cows that had access to leucaena produced up to 2 liters more milk per day than those from the control group that grazed on Gatton panic pasture only (Klassen et al. 2007).



Figure 4. Label of a bucket of Tarramba seed, harvested, processed and marketed in Paraguay under Australian license.



Figure 5. Leucaena sown in twin rows into Gatton panic pasture, previously tilled in strips.



Figure 6. Leucaena establishment in twin rows accompanied by a sorghum crop in the first year.



Figure 7. Leucaena establishment with zero-tillage in strips in a soybean crop in humid Eastern Paraguay.

Table 1. Carrying capacity and liveweight production per ha of steers grazing Gatton panic alone and Gatton panic with leucaena sown in twin rows (Glatzle and Klassen 2004). AU = Animal Unit = 450 kg live weight.

Pasture	Stocking density (AU/ha)	Liveweight gain (kg/ha)
Gatton panic	1.1	211
Gatton & leucaena	1.7	476

Grazing period: 15.7.2003 to 15.4.2004, at Rio Verde, Chaco. Steers had been inoculated with *Synergistes* ruminal microflora.



Figure 8. Brahman bulls grazing leucaena sown in twin rows in Gatton panic pasture.



Figure 9. The presence of leucaena in pastures boosts animal performance, particularly in winter, when grass is dry and of low quality.

The present situation and leucaena persistence

When external funding of the R&D project INTTAS ended in 2007, the services provided to farmers could no longer be maintained. Seed production became virtually a matter of farmers' own initiatives (which presented few concerns in Paraguay as labor costs are low and minimal seed is required per hectare). Mechanical seed scarification is available nowadays from a private seed grower, and ruminal fluid containing *Synergistes* from a local cooperative in the Chaco. However, the absence of active promotion and associated services offered from a single entity has considerably reduced the rate of expansion of leucaena feeding systems during the past 10 years. Furthermore, major areas of well-established leucaena pastures have been progressively lost, particularly in zones with an average annual rainfall of <800 mm and with silty, powdery soils (fluvisols and

others, very common in the dryer parts of the Chaco), where termites and rodents (tucu tucu, *Ctenomys* spp.) killed increasing numbers of leucaena plants, thinning out the stands. This is certainly due to the fact that these rodents and certain species of termites prosper particularly well on these light-textured soils in the dryer areas of the Chaco. In more humid zones, however, on clay soils and coarse sands, leucaena has usually persisted very well for at least a decade, even when a high saline ground water table was present (which apparently does not affect deep-rooting leucaena). In some years with particularly heavy frosts, leucaena not only lost its leaves but also died back to the base, from where plants resprouted vigorously in the next spring. Today, we consider that the total area sown to leucaena in Paraguay has found an equilibrium slightly below the 10,000 ha level, with a balance between newly established leucaena pastures and those lost due to rodents and ants.

However, particularly among smallholders, leucaena has been well adopted as a source of forage and firewood, and is very common in fodder banks in the home gardens of small-scale producers.

Conclusions

Leucaena is a highly productive and valued tropical/subtropical forage legume, well adapted to most regions of Paraguay. While the mimosine toxicity problem prevented earlier integration into the country's feeding systems, introduction of the mimosine-degrading bacteria in 2003 removed this impediment. From that time, the area sown to leucaena (either in twin rows into grass pastures or as high-plant-density fodder banks) increased rapidly until it found a new equilibrium between new establishments and die-offs, mainly due to pests. Today, on hundreds of Paraguayan farms (large-scale as well as smallholders) leucaena represents an integral part of the feeding systems, mainly for steer fattening and dairy cow supplementation. Although the initial dynamics of leucaena expansion have slowed down considerably, the past decade can be considered as a consolidation phase, which allowed the documentation of where leucaena is well adapted and persistent. Hundreds of thousands of hectares of country in Paraguay are suitable for leucaena, the respective technology packages are available and improved animal performance has been demonstrated. If another promotional campaign (which would require some funding and considerable enthusiasm) could be mounted, it might trigger renewed interest in leucaena with another increase in area sown and corresponding increases in animal production.

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(Note of the editors: All hyperlinks were verified 16 August 2019.)

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