Leucaena in Latin American Farming Systems: Challenges for Development

P. J. Argel, C.E. Lascano[1] and L. Ramírez[2]

Abstract

Different species of *Leucaena* have been used traditionally by indigenous people of Mexico and Central America, as part of their subsistence activities that take advantages of all plant resources available in the natural environment; however, this does not implies an intensive use of leucaena in their farming systems. *L. leucocephala* is the species more widely used, but it has limitations such as slow growth during establishment, deficient cold tolerance, poor growth on acid soils and susceptibility to defoliating psyllid. These inherent problems of leucaena added to deficient transfer programs, poor diffusion of technical information and farmers tradition, are some of the reasons for the poor farmer adoption in a wide scale. With the present technology available on *L. leucocephala* productivity of large areas of the region can be improved either by incorporating leucaena in grazing systems or into crop lands, however, to realize this potential technical and transfer problems must be solved.

The genus *Leucaena* is native to the New World and extends from Southern United States through middle South America. Presently, there are 22 species identified (Bray et al. 1997); however *L. leucocephala* (Lam) de Wit is the species more investigated and utilized (Casas and Caballero 1996), followed by *L. diversifolia* (Schlecht) Benth (Salazar 1986).
For centuries indigenous people of the American tropics, have used *Leucaena* species as a source of edible pods, as forage for domestic animals, as poles for construction, as firewood and as shade in permanent plantations. But despite the diverse uses of leucaena, and the convinced research results that show significant increases in animal products, improvement of the soil through nitrogen fixation and the possibilities of using this legume in alley cropping systems, there is not an intensive use of leucaena in the region.
In this review we discuss the present status of leucaena in the region and comment on some of the reasons for the poor adoption of the legume in a wide and intensive scale; the potential and recommendations for future developments is also presented.

Traditional use of Leucaena

The species presently recognize of *Leucaena* have a long history of human use by indigenous communities of Mexico and Central America. Usually the *Leucaena* species are protected in traditional agroforestry systems (Hughes 1993), for example five taxa are reported to be utilized by Indian groups of Mexico, these are *L. lanceolata, L. confertiflora* subsp. *adenotheloidea, L. esculenta* subsp. *paniculata, L. esculenta* subsp. *esculenta, L. leucocephala* subs. *leucocephala* and *L. leucecephala* subsp. *glabrata* (Casas and Caballero 1996).

[1] Centro Internacional de Agricultura Tropical (CIAT), Apdo 6713, Cali, Colombia.
[2] Universidad de Yucatán, Mérida, México.
Paper presented at the Workshop: Leucaena - Adaptation, Quality and Farming Systems, held in Hanoi (Vietnam) from 9 - 14 february, 1998.

The more widely cultivated species of *Leucaena* in Mexico by indigenous people are *L. esculenta* subsp. *esculenta* and *L. leucocephala* subsp. *glabrata.* The former is called guaje rojo (red guaje) and local people, mainly of the Mixtec group, gather pods, seeds and young leaves for human consumption. The seeds are eaten raw, roasted, cooked in stews or milled and added to traditional chilli sauces (Casas and Caballero 1996). The cultivation of leucaena is not intensive; edible parts are gathered from individuals planted in home gardens, from wild populations or from selected individuals spared in crop lands.

L. leucocephala is widely distributed in the region; the subsp. *glabrata* has naturalized in Honduras. Other species native to this country are *L. salvadorensis*, *L. diversifolia*, *L. shannonii* subsp. *shannonii* and *L. lempirana* (Ponce 1995). Indigenous people of Honduras have also managed the leucaena trees for a long time and use them as a source of edible pods, as forage for pigs, rabbits and cattle, for firewood, for construction, as living fences, as shade and as green manure. Similar use of leucaena is practiced by small farmers of Guatemala (Arias 1994), Costa Rica (Camacho 1989) and in other countries of the region. A more detailed used of *Leucaena* species by local people is presented in Table 1.

However, it needs to be clarified that this use of leucaena is part of a diversified practice for family subsistence of indigenous people that take advantages of all available plant resources in the local environment to fill particular needs, it does not mean that presently exists an intensive use of leucaena in the region.

Table 1. Main use of native *Leucaena* species by indigenous people of Mexico and Central America (Adapted from Hughes 1993).

Species	*Main use*
L. collinsii subsp. *collinsii* subsp. *zacapana*	Firewood, fence posts, wood for construction, unripe pods consumed
L. confertiflora	Unripe pods consumed
L. cuspidata	Unripe pods consumed
L. diversifolia	Shade tree, fodder for domestic animals, wood for construction
L. gregii	Firewood, fodder for goats
L. lanceolata	Firewood (prefered over L. *leucecephala*), fodder for pigs
L. leuc. subsp. *leucocephala* subsp. *glabrata*	Unripe pods consumed (has occurred for milenia), fodder for livestock, green manure, firewood, wood for construction
L. macrophylla	Unripe pods consumed
L. multicapitulata	Wood for construction, firewood
L. pulverulenta	Firewood, wood for construction, shade tree
L. salvadorensis	Firewood, fence posts, living fences
L. shannonii	High value as bee forage, firewood, fence posts
L. trichodes	Firewood, livestock food -mainly for goats-, it is toxic to horses

Present status of Leucaena in the Region

Research

Considerable research on leucaena has been carried out in the region, including the humid subtropics, during the last 10 to 15 years, particularly by agronomists whose primary interest has been production of livestock feed (Hughes 1993). In this regard the contribution of leucaena, mainly *L. leucocephala,* to improve animal products (beef and milk) is well documented (Faría-Marmol 1996; Ruíz et al. 1996; Dávila and Urbano 1996; Suárez et al. 1987; Goldfarb and Casco 1995).

Lascano et al.(1995) reviewed leucaena research results in countries of Central and South America and the Caribbean, and concluded that there is sufficient germplasm and experimental information available in the region for different environments. Based on soil and environmental data (soil pH (H_2O)>5.5, Al saturation > 40%, altitude <1500 m.a.s.l. and dry periods of 3 to 6 months) described macro-regions and agricultural production systems that could benefit from leucaena. Much of the research has been conducted on *L. leucocephala,* particularly the 'K' varieties from Hawaii (Viquez 1995), the cvs. Perú and Cunningham and germplasm supplied by RIEPT (CIAT's supported pasture network).

From 1986 to 1991 the Proyecto Madeleña (CATIE - ROCAP) studied the adaptation and the potential use of *L. leucocephala* and of *L. diversifolia* as firewood, charcoal and forage in several sites of Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica and Panamá (Salazar 1986; Camacho 1989). The sites varied from 0 to 1200 m.a.s.l., mean temperature from 20 ºC to 29,9 ºC and total rainfall from 1635 to 3433 mm; the soils had a pH > 5.0 and no aluminum toxicity. *L. leucocephala* adapted well to soils well drained with little compaction and in sites with a well defined wet season, meanwhile that *L. diversifolia* adapted better over 800 m.a.s.l.

Based on DM yields under different plant densities of trials conducted in Costa Rica, Salazar et al. (1987) developed preliminary predictive model equations to estimate DM yields of foliage, firewood and total biomass of *L. leucocephala* and *L. diversifolia*. The equations are based in the natural logarithm of the dbh (diameter breast height of the main stem) and the plant total height. For instance for *L. diversifolia*, firewood (kg/tree) could be estimated by the equation LnY = - 1.7544 + 2.4039 Ln dbh (Y= firewood DM).

L. diversifolia is a tree of medium size and easier to manage as shade for coffee than the traditional species used such as *Inga densiflora* and *Gliricidia sepium.* This species is suitable for the production of posts (the wood is hard and heavy) and has a high calorific value as firewood (approximately 4,400 kcal/kg). Table 2 indicates that in one site in Costa Rica (La Garita) it produced in a period of 4.4 years 45.9 metric ton/ha of firewood and 89.0 metric ton/ha of total biomass in three harvests (Salazar et al. 1989). It also has potential as forage plant since the mimosine content is low (CATIE 1986).

More recently, lesser known *Leucaena* spp. have been under evaluation and the results show great variation in vigor, forage and wood biomass production, branching habits, drought and psyllid tolerance (CONIF 1986; Viques 1995; Argel and Pérez 1996). Among the more promising species are worth to mention *L. collinsii, L. diversifolia* subspp. *stenocarpa* and *diversifolia, L. pallida, L. salvadorensis, L. macrophylla* subsp. *nelsonii* and *L. esculenta* subsp. *esculenta.* However, the new lines must find a place in crop production and agroforestry systems, to have a chance for wide adoption.

Table 2. Growth and regrowth yields of *L. diversifolia* in La Garita de Alajuela, Costa Rica (Adapted form Salazar et al. 1987).

Variables	First harvest* (2.6 years)	Regrowth harvests 1st (0.8 yrs)	Regrowth harvests 2nd (1 yr)**	Total production (4.4 years)
Total height (m)	6.0	5.3	5.3	-
dbh (cm) of main stem	4.7	2.9	2.8	-
Foliar DW (mton/ha)	13.9	10.3	18.9	43.1
Firewood DW (mton/ha)	23.4	14.9	7.6	45.9
DW standing biomass (mton/ha)	37.3	25.2	26.5	89.0
Specific gravity (g/cm3)	0.54	0.54	-	-

* Harvest of the original stand
** Harvest of regrowth at 10 to 12 month intervals

The interspecific crosses between *L. leucocephala* and *L. diversifolia*, to obtain hybrids tolerant to acid soils, continues in Brazil (Schifino-Wittmann et al. 1995); however, although superior acidity-tolerant phenotypes have been selected, no cultivar has been released up to date (Hutton 1995).

Utilization in production systems

Leucaena - particularly *L. leucocephala* - has the potential to be used in a diversity of production systems of the region, either leucaena-based pastures (Faría-Mármol and Morillo 1997) or in crop production activities such as shade in perennial crops, for erosion control planted as hedges in hillsides, as mulch and green manure, for wood, firewood and fence posts.

However, the reality is that despite positive research findings that show the potential that leucaena has to improve different agropastoral production systems of the region, its use by farmers is limited. In Brazil, Venezuela, Colombia, Mexico and countries of Central America and the Caribbean, *L. leucocephala* is planted in small scale as forage plant (protein banks or associated with grasses) mainly as part of a research or development project, and in few cases planted by the own initiative of the farmer; figures of the total area planted are not available.

L. leucocephala planted on strips into existing grasses in Campo Grande (Brazil) has increased beef production threefold (P. Rayman pers. comm.); however, no more than 500 ha are presently planted and farmers show little interest in this technology for reasons listed below. In the Cerrados and Northwest of Brazil leucaena has been promoted to be used as windbreak and protein bank among small farmers, but it is use only in small scale (M. Soter and C. T. Karia pers. comm.). Similarly occurs around the Maracaibo Lake in Venezuela with the use *L. leucocephala* (D. Urbano pers. comm.), in the Cauca Valley of Colombia (Shultze - Kraft 1994) and in the State of Chiapas in Mexico (I. Carmona pers. comm.).

L. diversifolia is used and prefered over other species by local farmers of Guatemala as firewood, because it splits easily, burns slowly and produces little smoke. The hardwood is used to make axe handles and to built attics for drying tabacco. Also *L. leucocephala* is used in a small scale by farmers of Nicaragua as windbreak planted together with *Tecoma stands* and *Eucalyptus camaldulensis*, thus offering a better foliar surface for wind control (CATIE 1986).

Regional projects, such as Madeleña (CATIE - ROCAP) and COHDEFORD in Honduras have encouraged during the last years the use of leucaena (mainly native lines) in agroforestry systems and as live fences among indigenous people (Ponce 1995); however, statistics on the degree of success are not available. Similarly, CATIE has researched the use of leucaena in ally cropping systems in Nicaragua and Costa Rica (Viques 1995), but the utility and advantages of the system are not known nor it is a popular practice among farmers.

Limitations to Adoption

Research and promotion in the region have centered on *L. leucocephala*, which is known by its deficient cold tolerance, heavy defoliation during prolonged dry periods, poor growth on acid soils, heavy pod production, low wood durability and susceptibility to a defoliating psyllid (Hughes 1993), although its high forage quality is well recognized. Therefore, there are inherent factors to the species that limit its adoption, but there are additional ones that merit to be mentioned:

- There are not well supported transfer programs to promote the utilization of leucaena in the region.
- Farmers do not understand or are not fully aware of the benefits of using leucaena as a fodder plant or in agroforestry systems.
- Traditionally for a cattle farmer a pasture is formed by pure grass only and has difficulties accepting a pasture formed by trees.
- Technical information on establishment at low cost and management methods to regenerate plantations is scarce.
- Leucaena-based pastures need intensive management under rotation, a practice that is not generalized among cattle farmers of the region.
- Ants and termites are a problem during the establishment phase of *L. leucocephala* in areas like the Cerrados of Brazil.
- There are not studies that show the economic impact of using leucaena at the farm and community level, and the contribution of the legume to the cycling of nutrients and improvement of the soil.

Potential and Recommendations for Development

With the present technology available, large areas of the Latin American tropics could be planted with *L. leucocephala*, particularly areas of the region with medium to good fertility soils and a well defined dry season. According to Lascano et al. (1995), these areas are present in the southern part of Mexico, in some island of the Caribbean, along the Pacific coast of Central America, parts of Colombia, Venezuela, Guyana, Ecuador, Bolivia,

Paraguay, northern Argentina and east and northeast of Brazil. Generally, these areas hold already a high population of beef and dual purpose cattle.
To this areas we need to add millions of hectareas of very acid oxisol and ultisols with pH < 5 and Al saturation of 47-87 percent that cover around 55 percent of South America and 68 percent of Brazil (Hutton 1995). These areas could be planted with acid-tolerant hybrids of *L. leucocephala* x *L. diversifolia* that are well advanced in Brazil (Schifino-Wittmann et al. 1995), or with newly identified species presently under evaluation (Argel and Pérez 1996).
However, for this potential to be realized a series of problems and limitations need to be overcome with relation to the present available lines of leucaena:

- Improve the growing methods, focusing on establishment and soil nutritional requirements of *L. leucocephala.* Farmers have to wait too long from planting to the first grazing. Appropriate planting techniques are needed, together with the selection of robust genotypes of faster growth.
- Organize and establish transfer programs that incentive farmers participation in the planting, growing and management of leucaena. A government incentive may be considered such as one that is presently in place in Mexico, where the state covers to a farmer around 60 percent of the cost of establishment of a new pasture (usually the seed cost of a grass).
- Improve the dissemination of technical information on the potential and limitations of leucaena-based systems to farmers, extension agents and policy makers. This can be assisted by establishing a regional network to share germplasm, experimental results and experiences with farmers. The present chain of experiments already underway in Latin America with new species of leucaena supported by the Oxford Forestry Institute in collaboration with CIAT, may be the base for a future regional network.
- Incentive programs to identify new lines tolerant to high Al saturation and low Ca soil concentration either by breeding or selection from new species of leucaena.

Conclusions

Leucaena species are utilized for different uses by indigenous people of Latin America as part of a diversified practice that takes into account all plant resources available for subsistence in the local environment.
L. leucocephala is the species more widely distributed and researched, however there is no wide utilization of this species in agropastoral system of the region. New species of leucaena are still in an early phase of evaluation.
The potential of leucaena to increase animal production, as well as to contribute to more sustainable crop practices, is enormous, but there are several factors that limit adoption (lack of effective transfer programs, farmers traditions, slow establishment, poor growth in acid soils), that need to be resolved if an intensive use in different production systems of this important legume, is to be achieved in the near future.

References

Argel, P. J. and Pérez, G. 1997. LEUCNET *Leucaena* trials in Mexico, Central and South America, and early results from Costa Rica. LEUCNET News, Issue No. 4, July 1997, 13-14.

Arias, R. 1994. Arboles nativos de uso múltiple utilizados por pequeños productores de Guatemala. Revista Forestal Centroamericana. No. 7, Año 3, 10-15.

Bray, R. A., Hughes, C. E., Brewbaker, J. L., Hanson, J., Thomas, B. D. and Ortiz, Amanda. 1997. The World Leucaena Catalog. Department of Agriculture, the University of Queensland, Brisbane, Australia, 48 pp + PC diskete.

Camacho, P. 1989. Consideraciones de sitio y manejo para predicción de crecimiento de *Leucaena leucocephala.* In: Salazar, R. ed., Manejo y aprovechamiento de plantaciones forestales con especies de uso múltiple. Actas Reunión IUFRO, Guatemala, Abril 1989, 387-407.

Casas, A. and Caballero, J. 1996. Traditional management and morphological variation in *Leucaena esculenta* (Fabacea: Mimosoideae) in the Mixtec region of Guerrero, Mexico. Economic Botany 50(2), 167-181.

CATIE. 1986. Silvicultura de especies promisorias para producción de leña en América Central. Resultados de 5 años de investigación. Serie Técnica, Informe Técnico No. 86, 177-200.

CONIF INFORMA. 1986. Resultados preliminares de la producción de biomasa de *Leucaena* spp. en Urabá, Antioquia, Colombia. No 5, 16 pp.

Dávila, C. and Urbano, D. 1996. Leguminosas arbóreas en la zona sur del Lago de Maracaibo. In: Tyrone, C., ed., Leguminosas forrajeras arbóreas en la agricultura tropical. Centro de Transferencia de Tecnología en pastos y forrajes. Universidad del Zulia (Venezuela), 101-113.

Faría-Mármol, J. and Morillo, D. E. 1997. Leucaena: Cultivo y Utilización en la Ganadería Bovina Tropical. Convenio Corpozulia-Fonaiap-Luz (Venezuela), 152 pp.

Faría-Mármol, J. 1996. Evaluación de accesiones de *Leucaena leucocephala* a pastoreo en el bosque seco tropical. I. Disponibilidad de forraje. Rev. Fac. Agron. (LUZ), Venezuela, 13, 169-178

Golfard, M. C. and Casco, J. 1995. Leucaena in the Northwest Region of Corrientes Province, Argentine. In: Shelton, H. M., Piggin, C. M. and Brewbaker, J. L., ed., Leucaena - Oportunities and Limitations. Proceedings of a Workshop held in Bogor, Indonesia, 24-29 January 1994. ACIAR Proceedings No. 57, 159-161.

Hughes, C. E. 1993. Leucaena Genetic Resources. The OFI Leucaena Seed Collection and a Synopsis of Species Characteristics. Oxford Forest Institute, Department of Plant Sciences, University of Oxford, 117 pp.

Hutton, E. M. 1995. Very acid soil constraints for tree legumes like *Leucaena* and selection and breeding to overcome them. In: Evans, D. O. and Szoot, L. T., ed., Nitrogen Fixing Trees for Acid Soils. Nitrogen Fixing Tree Research Report (Special Issue). Winrock International and NAFTA, Morrilton, Arkansas, USA, 258-264.

Lascano, C. E., Maass, B. L., Argel, P. J. and Viquez, E. 1995. Leucaena in Central and South America. In: Shelton, H. M., Piggin, C. M. and Brewbaker, J. L., ed., Leucaena - Oportunities and Limitations. Proceedings of a Workshop held in Bogor, Indonesia, 24 - 29 January 1994. ACIAR Proceedings No. 57, 152-158.

Ponce, E. 1995. Leucaena in Honduras. In: Shelton, H. M., Piggin, C. M. and Brewbaker, J. L., ed., Leucaena-Oportunities and Limitations. Proceedings of a Workshop held in Bogor, Indonesia, 24 - 29 January 1994. ACIAR Proceedings No. 57, 162-166.

Ruiz, T. E., Febles, G., Jordán, H. and Castillo, E. 1996. El género *Leucaena* para el mejoramiento de la ganadería en el trópico y subtrópico. In: Tyrone, C., ed., Leguminosas forrajeras arbóreas en la agricultura tropical. Centro de Transferencia de Tecnología en pastos y forrajes. Universidad del Zulia (Venezuela), 11-16.

Salazar, 1986. *Leucaena diversifolia* y *L. leucocephala* en Costa Rica. Silvoenergía (Costa Rica) No. 18, Julio 1986, 4 pp.

Salazar, R., Picado, W. and Ugalde, L. 1987. Comportamiento de *Leucaena* en Costa Rica.

CATIE, Serie Técnica, Informe Técnico No. 115, 41 pp.
Schifino-Wittmann, M. T., Paim, N. R., Freitas, L. H. C. and Simoni, C. 1995. Leucaena in Rio Grande do Sul (Southern Brazil). In: Shelton, H. M., Piggin, C. M. and Brewbaker, J. L., ed., Leucaena-Oportunities and Limitations. Proceedings of a Workshop held in Bogor, Indonesia, 24 - 29 January 1994. ACIAR Proceedings No. 57, 167-168.
Schultze-Kraft, R. 1994. El 'psyllid' de *Leucaena* también puede ser un problema en América tropical. Pasturas Tropicales 16(2), 48-50.
Suárez, S., Rubio, J., Franco, C., Vera, R., Pizarro, E. A. and Amézquita, M. C. 1987. *Leucaena leucocephala:* producción y composición de leche y selección de ecotipos con animales en pastoreo. Pasturas Tropicales- boletín 9(2), 11-17.
Viquez, E. 1995. Leucaena in Central America. In: Shelton, H. M., Piggin, C. M. and Brewbaker, J. L., ed., Leucaena-Oportunities and Limitations. Proceedings of a Workshop held in Bogor, Indonesia, 24 - 29 January 1994. ACIAR Proceedings No. 57, 169-173.