Multipurpose leguminous trees for the lowland tropics in CIAT's genebank

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Abstract: The genebank at the International Center for Tropical Agriculture (CIAT for its Spanish acronym) conserves and distributes globally one of the world's largest collections of tropical forages. While most accessions are herbaceous legumes, the collection also includes several leguminous-tree genera such as *Acacia*, *Albizia*, *Bauhinia*, *Calliandra*, *Clitoria*, *Erythrina*, *Gliricidia*, *Leucaena*, *Prosopis*, *Senna*, *Sesbania* and *Zapoteca*. These trees have been used for a variety of purposes, including cut-and-carry feed, green manure, fences and hedgerows, wood for fuel and tools, shade and erosion control. Distribution of accessions has been relatively modest, but climate-change mitigation and restauration of tropical lowlands may increase demand for these multipurpose legume trees in the future.

Key words: feed, germplasm, soil erosion, tropical legumes

History of the collection

When CIAT was created in 1967, demand for meat and dairy products was anticipated to increase in the tropics, not only because of population growth but also urbanization and rising incomes. History confirmed these expectations (1). However, the swine and beef-production programs CIAT had established early on were dismantled by the mid-1970s when the organization decided to focus its limited resources on forages and feed for domestic animals (2). The decision was strategic for several reasons. First, quantity and quality of feed was and continues to be a limiting factor in many animal-production systems in the tropics, although not all farmers are yet convinced that nutrition and health of livestock are a foundation of productive and sustainable animal production. Second, in the American tropics, pasture degradation and soil erosion were already apparent in the 1970s and continue to be a threat to long-term productivity of pastures. Third, emissions of greenhouse gases such as methane, though not a public concern in the early 1970s, have since then found their way to the front pages (3).

Because of the Old-World origin of most livestock such as cattle, goats, sheep and horses, plants that have co-evolved with them and can withstand grazing were logical forage options. Therefore, African grasses such as *Andropogon, Brachiaria, Hyparrhenia* and *Panicum*, which had been introduced into the American tropics two centuries ago (4), were introduced into the CIAT collection starting in 1974. Permanent pastures based on these species set the challenge of continuing productivity on low fertility often acid soils. So, neotropical legumes such as *Arachis, Centrosema, Desmodium, Macroptilium* and *Stylosanthes* in association with *Rhizobium* and other nitrogen-fixing local bacteria were called upon, given the costs and poor availability of nitrogen fertilizers in the region. Grass-legume association were the principal pasture option proposed for vast swaths of lowland savannas of South America (5).

For smallholders in regions such as Central America and Southeast Asia, livestock often is only part of the total farm production (2). So, when CIAT moved beyond its mandate crops to work on agricultural systems such as hillsides, savannahs and forest margins, the topic of land restoration came into focus. This is where leguminous trees came in. In the tropics, where light does not limit growth, productivity per hectare can be increased through vertical dimension by adding one or several arboreal layers. *Inga* trees providing shade to coffee plantations have long been part of the traditional landscape in Central America and Colombia. Many smallholder farmers need wood for fuel, fences, and tools; hence the interest in genera such as *Albizia, Calliandra, Gliricidia* and *Sesbania*. They also need forages for cut-and-carry feed, green manure, or ways to control erosion.

Germplasm distribution

The distribution of leguminous-tree seeds from CIAT genebank (Figure 1) is relatively modest (Table 1) for several reasons. First, many farmers and researchers may not know that such a collection exists. Second, not all accessions are currently available for distribution because of the difficulty to produce seed free of all quarantinable pathogens. For example, CIAT genebank conserves 31 accessions of *Gliricidia sepium*

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Table 1: The most significant genera of leguminous trees in CIAT's tropical-forage collection (source: CIAT's genebank database queried in Feb 2019; a full list can be obtained, and germplasm requests can be made at https://genebank.ciat.cgiar.org/genebank/foragecollection.do; taxonomy according to (6)).

Genus	*Acacia*	*Albizia*	*Bauhinia*	*Calliandra*	*Clitoria*	*Erythrina*	*Gliricidia*	*Leucaena*	*Prosopis*	*Senna*	*Sesbania*	*Zapoteca*
No. species	7	2	1	3	1	8	1	15	1	10	14	2
No. accessions	18	6	8	28	2	41	31	196	11	26	62	5
No. accessions currently available	11	0	2	14	0	3	0	125	7	12	54	2
Times distributed within CIAT	40	6	2	80	15	23	14	762	9	28	194	11
Times distributed outside CIAT	96	18	12	180	75	72	54	3308	41	66	468	19
Times distributed internationally	25	9	8	52	29	13	25	1843	17	20	128	5
Times distributed within Colombia	71	9	4	128	46	59	29	1965	24	46	340	14

Figure 1. CIAT field collection of legume trees (photo: Gonzalez-Guzman 2019).

but none of them can be distributed currently. Nevertheless, CIAT has distributed 76 samples of 15 *Calliandra calothyrsus,* 189 samples of 19 *Sesbania sesban* and 2,675 samples of 106 *Leucaena leucocephala* accessions (Table 1). *Leucaena leucocephala* is particularly valued as ruminant forage and fuelwood by farmers throughout Southeast Asia and parts of central Asia and Africa (7). It is also planted in hedgerow systems with grass for cattle production in northern Australia, as a hedgerow species in parts of Southeast Asia and Africa, and as a shade tree over coffee and cocoa in the Americas. In Colombia, the accession CIAT 21888 was released as cultivar 'Romelia' (8).

There are other tree species conserved in CIAT's genebank which have not been widely distributed, yet they could occupy niches that are not covered by herbaceous-legume and grass species. For example, feeding goats and cattle with supplements made of *Erythrina poeppigiana* or *Gliricidia sepium* increased productivity by 20%

compared to urea supplementation (9, 10). Another case worth noting is *Calliandra calothyrsus*, a high-protein forage used not only as a supplement on nutrient-poor pastures, but also for erosion control and land rehabilitation. It provides green manure and is a source of nectar for beekeeping and is planted for shade in coffee and tea plantations (11).

To withstand grazing, many forage species are aggressive colonizers of open spaces with a capacity for quick re-growth. Not surprisingly, CIAT's collection also includes species listed in the Global Invasive Species Database (12), such as *Acacia farnesiana, Acacia mangium, Adenanthera pavonina, Albizia lebbeck, Albizia saman, Leucaena leucocephala* and *Prosopis juliflora*. Before requesting germplasm, the degree of invasiveness of a species should therefore be considered.

Funding for research into tropical forages has substantially declined over the past two decades. Climate-change mitigation and the restauration of degraded agricultural land, however, are critical research topics of growing importance to which tropical-forage collections such as that at CIAT can contribute solutions.

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Figure 2: *Leucaena leucocephala* being regenerated on the border of *Brachiaria* spp. Field collection at CIAT headquarters in Palmira, Colombia (photo: Gonzalez-Guzman 2019).