



Worldwide, 3.4 billion hectares of grazing land plus a quarter of the world crop production area are utilized for livestock feeding. This amounts to more than two thirds of total agricultural land area. Forage species are, thus, a prominent feature of agricultural landscapes around the world. Moreover, forages themselves rank among the highest value crops in many countries and contribute to sustainability of crop-livestock systems. Hence, improved forages provide an unprecedented opportunity for many small farmers in the tropics to improve their livelihoods. But feeding animals in a sustainable, cost-effective way is challenging. A high proportion of smallholder crop-livestock systems in the tropics are located in vulnerable areas with low fertility, acid soils, prolonged dry seasons, exposure to waterlogging, and land in different stages of degradation. CIAT¹ aims to help farmers by developing and utilizing a range of eco-efficient forage options that can be grown under a range of favorable to marginal environments in the tropics.

In view of the Center's expertise across different production systems, CIAT's tropical forage research has an explicit **global focus**, with strategic research capacity in South America, Central America and the Caribbean, Eastern Africa, and Southeast Asia. We recognize that the strongest interaction between research disciplines, partners, and clients happens in the context of agricultural systems and markets in the countries. **Capacity building, strong partnerships, and knowledge sharing** are, therefore, integral parts of the research outlined below.

Outputs and impact

- CIAT uses an integrated approach towards its research, encompassing germplasm evaluation, participatory research and extension, and livestock systems analysis. This approach has been highly successful. More than 40,000 small farmers in Southeast Asia adopted forages because they were benefiting from increased income as well as higher returns to labor.
- Since 1970, national programs have released 64 tropical forage grass and legume cultivars, based on 30 CIAT germplasm accessions that were provided by the Genetic Resources Unit of CIAT.
- Superior *Brachiaria* bred cultivars (Mulato and Mulato II—both developed at CIAT), combine high nutritional quality, drought tolerance, resistance to spittlebug, and adaptation to acid soils. Their release by the Mexican seed company Papalotla contributed to improved rural livelihoods through increased efficiency of livestock production. In addition, smallholder farmers also benefited from the sales of seed, vegetative planting material, and fodder.
- More efficient and reliable screening methods were developed to assess adaptation to biotic and abiotic stresses. These high throughput phenotyping protocols facilitate evaluation of hundreds of forage genotypes over very short periods, thus enhancing the efficiency of *Brachiaria* improvement.
- *Canavalia brasiliensis* was selected by CIAT as a climate-hardy adapted forage legume that readily fixes nitrogen and improves soil fertility. CIAT was able to harness its high potential for marginal environments to increase livestock and crop production.

- “Selection of Forages for the Tropics” (SoFT; www.tropicalforages.info) is a knowledge system developed by CIAT and its partners to bring together information on the ecological adaptation of tropical forage species, their use, and management.

Main activities

Forage germplasm developed through collection, selection, and breeding

Forage grasses and multipurpose herbaceous and shrub legumes of high quality that are adapted to major biotic and abiotic constraints are developed. **Adaptation to climate change** as a dynamic response is an integral part of the work on improving stress tolerance. Addressing forage conservation technologies that are suitable to smallholder systems and attention to emerging diseases and pests will further enhance the sustainability of forage-based smallholder systems. Main research products are:

- Mechanisms of adaptation to abiotic and biotic stresses defined and forage quality and seed production potential assessed.
- Genes responsible for stress tolerance discovered.
- Superior forage grass and legume genotypes developed.

Forages as high value products developed and forage options integrated into smallholder crop-livestock systems to realize livelihood and environment benefits

Development of improved forages is intimately linked with research to employ these forages to sustainably diversify and intensify crop-livestock systems, enhancing productivity while minimizing the environmental footprint.

Research emphasizes the **high value opportunities** of forages, leading to improved **market competitiveness** of forages (e.g., hay, silage, and forage meal) and derived ruminant (e.g.,

1. For an explanation of acronyms and abbreviations see www.ciat.cgiar.org/newsroom/pdf/acronyms_syntheses.pdf

cattle, goats, sheep) and monogastric (e.g., swine, poultry, fish) livestock products such as milk, meat, and eggs. We work in a market-oriented value chain approach targeted at smallholder systems and involving the private sector, NGOs, and governmental institutions.

We aim to balance between economic and environmental—and implicitly social—sustainability of tropical agricultural production systems through **an increase in system performance**. The major challenge is combining higher agricultural output (through higher forage productivity and quality) with greater use efficiency of inputs (nutrients, water, land, and labor), sustained crop productivity (e.g., through legumes as green manures providing nitrogen) while, at the same time, contributing to **mitigate the effects of climate change**. Main research products are:

- The suitability of forage-based protein feeds for monogastric and ruminant animals assessed and improved.
- Optimal partnership approaches developed to connect farmers with superior and diverse forage grass and legume options and associated management practices.
- Linkage of farmers to market-oriented forage based crop-livestock systems.
- Mitigation of climate change (improved carbon sequestration and reduced greenhouse gas emissions).
- Development of decision support tools and facilitation of sustainable seed supply systems.

Main partners and collaborators

Australia: Australian Centre for International Agricultural Research (ACIAR); Queensland Department of Primary Industries and Fisheries; University of New England • **Austria:** BOKU • **Brazil:** Embrapa • **Cambodia:** Department of Agriculture-Kampong Cham; Department of Animal Health and Production; Royal University of Agriculture • **Colombia:** CARSUCRE; CORPOICA; FEDEGAN; FEGASUCRE; Fondo Ganadero del Cauca; Organismo de Inspección Ganacor; Universidad de Caldas; Universidad de la Amazonia; Universidad del Cauca; Universidad del Valle; Universidad Nacional de Colombia • **DR Congo:** Consortium for Improving Agriculture-based Livelihoods in Central Africa (CIALCA); Université Catholique de Bukavu; Université Evangélique en Afrique • **Germany:** Friedrich-Löffler-Institute; FU Berlin; Julius Kühn Institute; University of Hannover; University of Hohenheim; University of Rostock; VDLÜFA;

Von-Thünen Institute • **Honduras:** DICTA; Sertedeso • **Japan:** JIRCAS • **Lao PDR:** National Agriculture and Forestry Research Institute • **Mexico:** Papalotla Seed Company • **Nicaragua:** INTA; UNA • **Rwanda:** ISAR • **Switzerland:** ETH-Zürich • **Thailand:** Khon Kaen University; Ubon Ratchathani University; World Vision • **Vietnam:** National Institute of Animal Husbandry; Tay Nguyen University • **Regional and international:** CATIE; CIALCA

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