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Tropical grasses cut greenhouse gas

Dr. Myles J. Fisher has discovered that deep-rooted grasses in the South American savannas are removing billions of tons of CO_2 from the atmosphere.

Pasture grasses planted to increase beef production in the South American savannas are countering the doomsday predictions of global warming, announced CIAT scientists in an article published in the 15 September issue of *Nature*.

The deep-rooted grasses may remove as much as 2 billion tons of carbon dioxide—a "greenhouse gas"—from the atmosphere yearly, says Dr. Myles Fisher, CIAT ecophysiologist.

"Green plants are small factories that use carbon dioxide, or CO_2, and sunlight to produce organic matter. The perennial grasses *Andropogon gayanus* and *Brachiaria humidicola* convert as much as 53 tons of CO_2 per hectare yearly to organic matter," Fisher says. "That's as much CO_2 as a gas-guzzling car emits in 133,000 miles, or 213,000 kilometers."

Deep root action

The storage of organic matter was not noticed earlier because the extensive roots of these grasses deposit it as deep as a meter in the savanna soil, Fisher explains.

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CIAT is dedicated to the alleviation of hunger and poverty in developing countries of the tropics by applying science to agriculture to increase production while sustaining the natural resource base.

CIAT is one of the 16 international centers sponsored by the Consultative Group on International Agricultural Research (CGIAR), a group of 40 nations and international agencies that fund research for development. The Centers focus on the crops and livestock that provide 75% of the food for the developing world.

Editing and Production

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Scientists at CIAT and in national programs introduced Andropogon and Brachiaria, originally from Africa, to the grassy savannas of South America in the 1970s.

CO_2 emissions contribute to global warming because the CO_2 acts as a "blanket" around the earth, Fisher explains. The sun's rays penetrate the CO_2 blanket, which traps their heat within the atmosphere. The resulting "greenhouse effect" is predicted to raise average global temperatures by at least 2°C (3.6°F) in the next century.

Vanishing CO_2

The burning of fossil fuels and tropical forests pumps between 26 and 31.5 billion tons of CO_2 into the atmosphere yearly, scientists estimate. But the annual increase of atmospheric CO_2 is only 18 to 24 billion tons. Oceans, tropical wetlands, and green plants absorb some of the missing amount, but scientists had not been able to account for the rest.

"Improved savanna grasses must explain part of this difference," Fisher says. "Brazil alone has at least 35 million hectares of introduced pastures—enough to fix 2 billion tons of CO_2 per year."

The pasture grasses fix more CO_2 when planted with the legumes *Arachis pintoi* or *Stylosanthes capitata*, both from South America.

One cow grazed on the grass-legume associations gains up to 200 kg yearly, versus 70 kg for a cow grazed on native savanna. So the cattle business prospers as CO_2 levels drop.

Because Andropogon and Brachiaria adapt well to acid soils, national programs have released one or both of the grasses to farmers in at least 12 Latin American countries.

Savannas—the last frontier

The South American savannas, almost five times the size of France, are the world's last frontier for agriculture. They produce more than US$15 billion worth of meat, milk, and grains annually, despite fragile, infertile soils. But less than a quarter of their area is farmed.

"Planting improved pastures on the savannas slows the chain-saw invasion of the rain forests, preserving precious biodiversity," Fisher says.

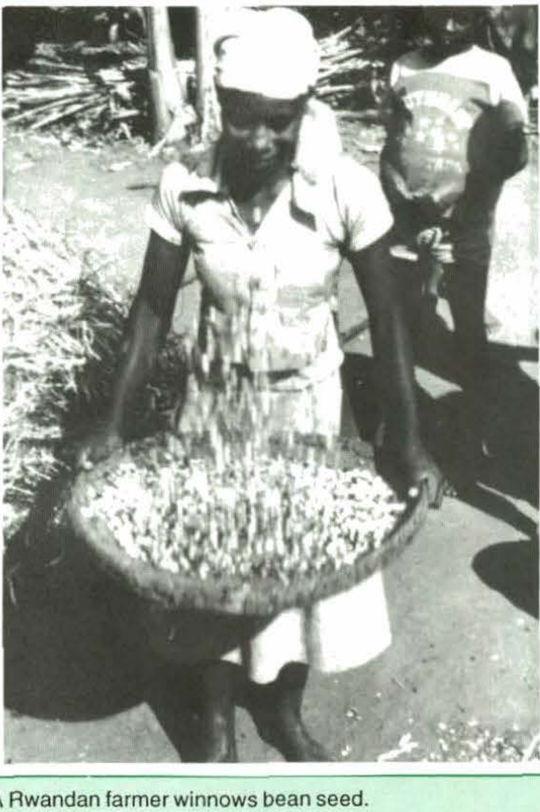
Fisher, an Australian, joined CIAT in 1985. He was previously a research physiologist with Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO). He holds a doctorate from the University of Queensland.

The *Nature* paper is titled "Carbon storage by introduced deep-rooted grasses in the South American savannas." Coauthors, all CIAT scientists, are: Drs. I. M. Rao, M. A. Ayarza, C. E. Lascano, J. I. Sanz, R. J. Thomas, and R. R. Vera.

by **Gail Pennington**
photo by **Luis Fernando Pino**

"Seeds of Hope" to save Rwanda's food crops, avert famine

In a field where the Uganda National Agricultural Research Organization is multiplying 35 Rwandan bean varieties to return to the war-torn country are (left to right) Dr. Charles Wortmann, CIAT agronomist in Uganda; Dr. Robin Buruchara, CIAT plant pathologist; and Dr. Israel Kibirige-Sebunya, director of Uganda's Kawanda Research Station.



A Rwandan farmer winnows bean seed.

The war in Rwanda halted agricultural production, and famine is imminent unless domestic food production is restored rapidly, says Dr. William Scowcroft, CIAT deputy director general.

That's why eight International Agricultural Research Centers are launching "Seeds of Hope," a crash program to rescue, multiply, and distribute seeds of Rwanda's six most important food crops before they disappear forever.

"When the war in Uganda ended in 1986, all our breeding materials had been looted, and farmers had eaten their seeds. We requested replacement seeds that had been preserved at CIAT and by cooperators in other national programs. Now we must do the same for Rwanda."

—Dr. Israel Kibirige-Sebunya.

"Seeds of Hope" for planting, not eating

"The seeds aren't for eating, they're to plant," Scowcroft explains. "Seeds of Hope" is a post-war program—started before fighting ceased—to restore Rwanda's agriculture and preserve as much of its genetic diversity as possible. "That's never been done. At least, not on this scale."

Most Rwandans are subsistence farmers who will return to tiny, hillside farms that they planted, then abandoned, in April, Scowcroft explains. Surviving Rwandans will glean what meager crops are left in the weed-choked fields. They'll eat the seeds they would save, in normal times, to plant the next crop.

"Farmers eating their seeds...that means more than human starvation, it's also the genetic death knell for hundreds of rugged, traditional crop varieties that feed Rwanda," Scowcroft says.

Seeds mean survival—for farmers and for crop varieties

Nature and farmers have selected, over centuries, varieties of crops like beans, sorghum, maize, and potato with the genetic potential to resist local pests and grow in specific ecological niches. If those varieties disappear, so will their potential to help future generations.

The six crops comprise 73% of the total food consumed in Rwanda before the war, and contribute 80% of both calories and protein to the Rwandan diet.

The seeds are mostly of Rwandan varieties that had been preserved in Center and national gene banks, says Dr. Julia Kornegay, leader of CIAT's Bean Program. CIAT had stationed bean scientists in Rwanda, with support from the Swiss Development Cooperation (SDC), from 1983 until their evacuation last April.

The seeds are being multiplied jointly with national agricultural programs in Burundi, Kenya, Tanzania, Zaire, Ethiopia, and even in Colombia.

Aid agencies and non-government relief groups will distribute packets of seeds along with food aid. "Otherwise, farmers would eat the seeds, not plant them," Kornegay says.

Diversity assures survival

Sustainable food production in Rwanda depends on biodiversity, Kornegay points out. Rwandan farmers always mix the beans that they plant so a single pest or disease can't wipe out an entire crop. For example, CIAT scientists have identified more than 2,000 different mixtures of some 500 bean varieties in Rwandan fields.

Rwanda is Africa's most densely populated country. As many as 700 people per square kilometer were packed onto her cultivated land before the war.

CIAT, which coordinates Seeds of Hope, began to multiply bean seeds for Rwanda in May—the forerunner to the eight-Center initiative.

Sponsors have pledged US$1.07 million to finance the seed rescue program through 1995, Scowcroft says. The U.S. Agency for International Development, through its office of Foreign Disaster Assistance, pledged an initial $200,000 to catalyze the project. Other sponsors include the UK's Overseas Development Agency, SDC, International Development Research Centre (Canada), AIDAB (Australia), and World Vision Australia. The International Centers will provide in-kind resources worth $800,000.

Organizations that distribute seeds include World Vision, CARE, Doctors Without Borders, Catholic Relief Service, Austrian Relief, Belgian Administration for Development Cooperation (BADC), CARITAS, U.N. High Commission for Refugees, International Commission for the Red Cross, CONCERN, and UNICEF.

Crops, and Centers with primary responsibility for their multiplication, are: *beans*, CIAT; *sorghum*, ICRISAT, or the International Crops Research Institute for the Semi-Arid Tropics, based in India; *potato* and *sweet potato*, CIP, the International Potato Center, in Peru; *maize* or *corn*, CIMMYT, the International Center for Maize and Wheat Improvement, Mexico; *cassava*, IITA, the International Institute of Tropical Agriculture, Nigeria; and *overall genetic resources*, IPGRI, the International Plant Genetic Resources Institute, based in Rome. ICRAF, the International Centre for Research in Agroforestry, Kenya, offers *tree genetic resources*. ILCA, the Ethiopia-based International Livestock Centre for Africa, has volunteered to multiply seeds for the project.

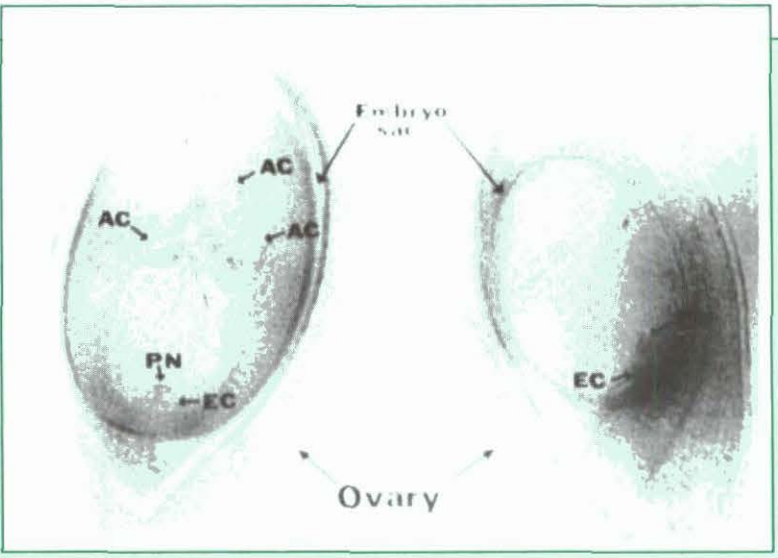
by **Thomas Hargrove**
photos by **Thomas Hargrove, Julia Kornegay**

Apomixis gene may allow farmers to plant their own hybrid seed

Dr. John Miles (left) and Dr. Joe Tohmé examine an apomictic brachiaria grass with molecular biologist Natalia Palacios (center).

Scientists are hot on the trail of an "apomixis gene" that lets plants reproduce vegetatively, but through seeds rather than plant parts such as stolons. Breeding that gene into crops means that farmers may someday plant seed from their own harvests of high-yielding hybrids, year after year, without buying new seed, says Dr. John Miles, CIAT geneticist.

"That could transform agriculture in both developing and industrialized countries," Miles says. "It could give farmers in developing countries access to the same



The ovaries of a sexual and an apomictic brachiaria.

types of hybrid seed that modernized agriculture in industrialized countries."

Commercial production of hybrid seed is expensive because it requires the controlled crossing of parents for each crop, Miles explains. First-generation hybrids are usually more vigorous than the parents, but that vigor is lost in later generations. Seeds harvested from a hybrid crop cannot be re-sown: their yields are too low and variable.

"But if we breed an apomixis gene into a hybrid, and it expresses itself, the seeds would exactly reproduce the vigor, and other useful traits such as disease resistance," says Dr. Joe Tohmé, CIAT plant geneticist. "The problem is to find that gene—it's a bit like looking for a needle in a hay stack."

CIAT scientists have identified, in a brachiaria grass, 'molecular markers' that will help them find this gene. "That means we've limited our search to a small part of the haystack," Tohmé says.

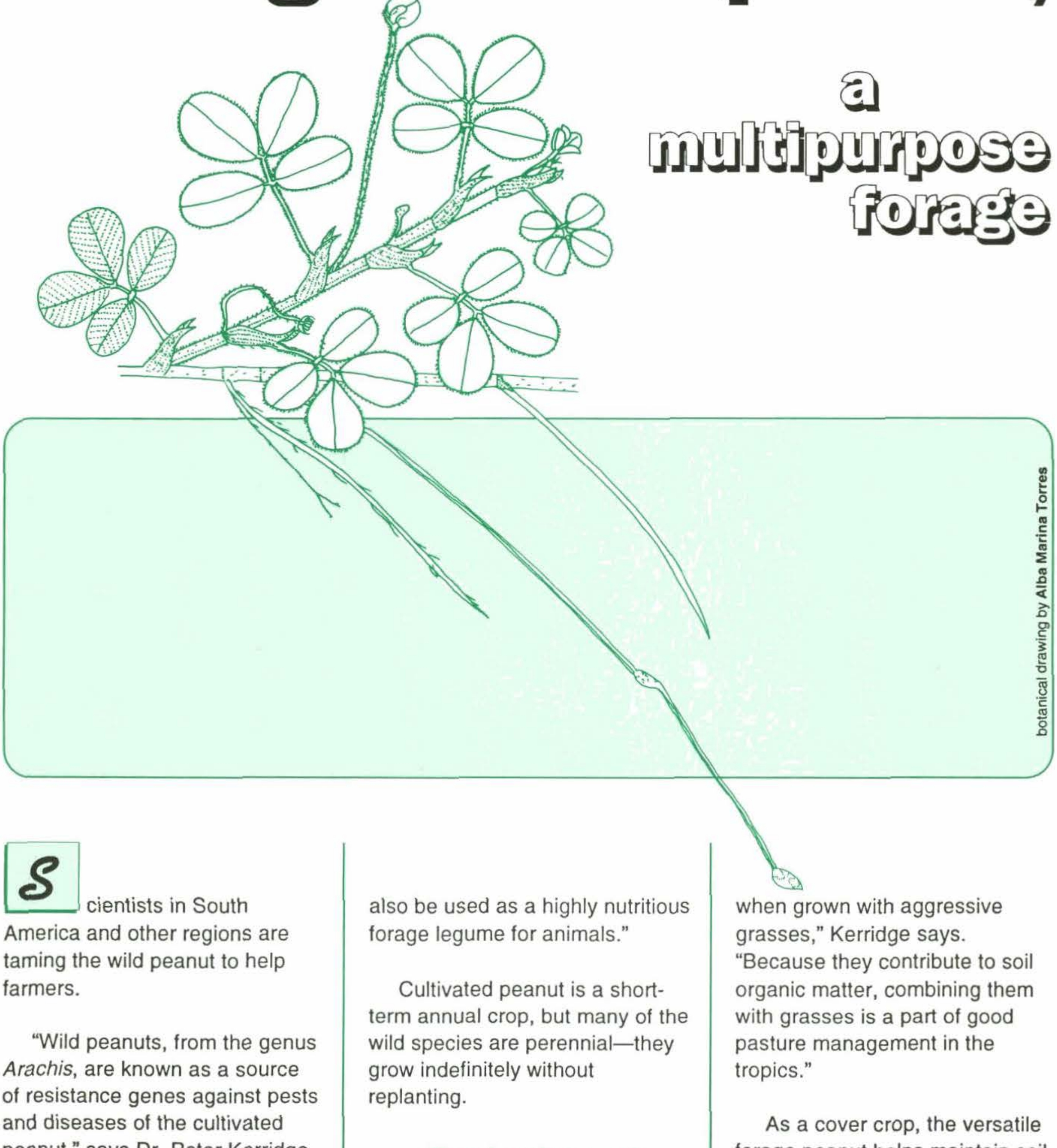
CIAT scientists have identified, in a *brachiaria* grass, 'molecular markers' that will help them find this gene. "That means we've limited our search to a small part of the haystack," Tohmé says.

Once found, the next step is to clone the gene into unrelated crops such as rice, which feeds 2.5 billion people. The markers confirm that a single dominant gene controls apomixis in brachiaria. Cloning may take 3 to 5 years. "But then we will be able to develop true-breeding hybrids that could yield 30% more than current varieties," Tohmé says.

Except for citrus, apomixis is rare in crops of economic importance, Miles says. Most apomictic genes are found in wild relatives of crops. "But the wild plants are so different that scientists have had little success in transferring their genes into domesticated crops through conventional breeding."

by **Elizabeth de Páez**
photo by **Mauricio Antorveza**

Taming the wild peanut, a multipurpose forage



botanical drawing by Alba Marina Torres

Scientists in South America and other regions are taming the wild peanut to help farmers.

"Wild peanuts, from the genus *Arachis*, are known as a source of resistance genes against pests and diseases of the cultivated peanut," says Dr. Peter Kerridge, leader of CIAT's Tropical Forages Program. "Wild perennial peanut plants, because of their high protein content, can also be used as a highly nutritious forage legume for animals."

Cultivated peanut is a short-term annual crop, but many of the wild species are perennial—they grow indefinitely without replanting.

Productive and persistent

"These perennial peanuts are highly productive and persist when grown with aggressive grasses," Kerridge says. "Because they contribute to soil organic matter, combining them with grasses is a part of good pasture management in the tropics."

As a cover crop, the versatile forage peanut helps maintain soil productivity, prevent erosion, and control weeds in commercial crops of coffee, citrus, African oil palm, coconut, and rubber. It improves the soil by "fixing" nitrogen. Soil bacteria in nodules on the roots of the legume convert atmospheric nitrogen into nitrogenous compounds that are used by the plant.

Wild forage peanuts are found naturally only in Brazil, Argentina, Uruguay, Paraguay, and Bolivia. Of the 80 known species, 63 are native to Brazil.

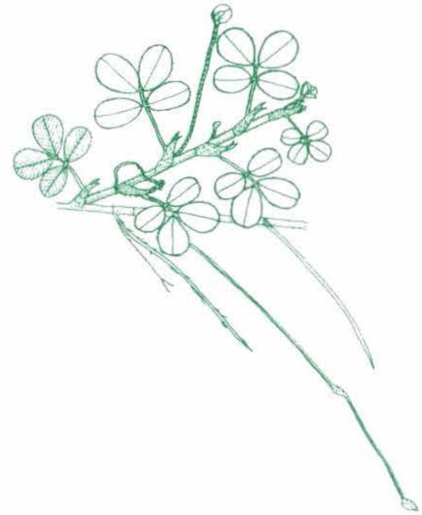
"We must explore areas where wild *Arachis* occurs and conserve the germplasm for future generations," says Dr. José Valls, curator of wild *Arachis* species at CENARGEN, Brazil's Genetic Resources Center. "Because the species occur in several countries, collection and conservation require an international effort."

Forage scientists are identifying good species for forage, and determining where and how they can be integrated into farmers' practices.

Peanut "pioneers"

"Vigorous stolons and high underground seed production help forage peanuts tolerate heavy grazing," says Dr. John Ferguson, CIAT forage agronomist. "They're like 'pioneers'—they invade open spaces, overcome competition, and produce lots of seed."

In Colombia's Eastern Plains, steers grazed on a perennial peanut-grass pasture gain more than half a kilogram per day. "This grass-legume pasture is more productive and persistent than any other combination we have tried," says Dr. Carlos Lascano, CIAT ruminant nutritionist. "Cattle gain more than 400 kg/ha yearly compared with 20 kg/ha on native savanna pastures."



"We must explore areas where wild *Arachis* occurs and conserve the germplasm for future generations. Because the species occur in several countries, collection and conservation require an international effort."

"In Florida, the perennial peanut *Arachis glabrata*, introduced from Brazil in 1936, is nicknamed 'Florida's alfalfa,' as it can replace the expensive hay brought in from far-away New Mexico and Utah," says Professor E. C. French, University of Florida.

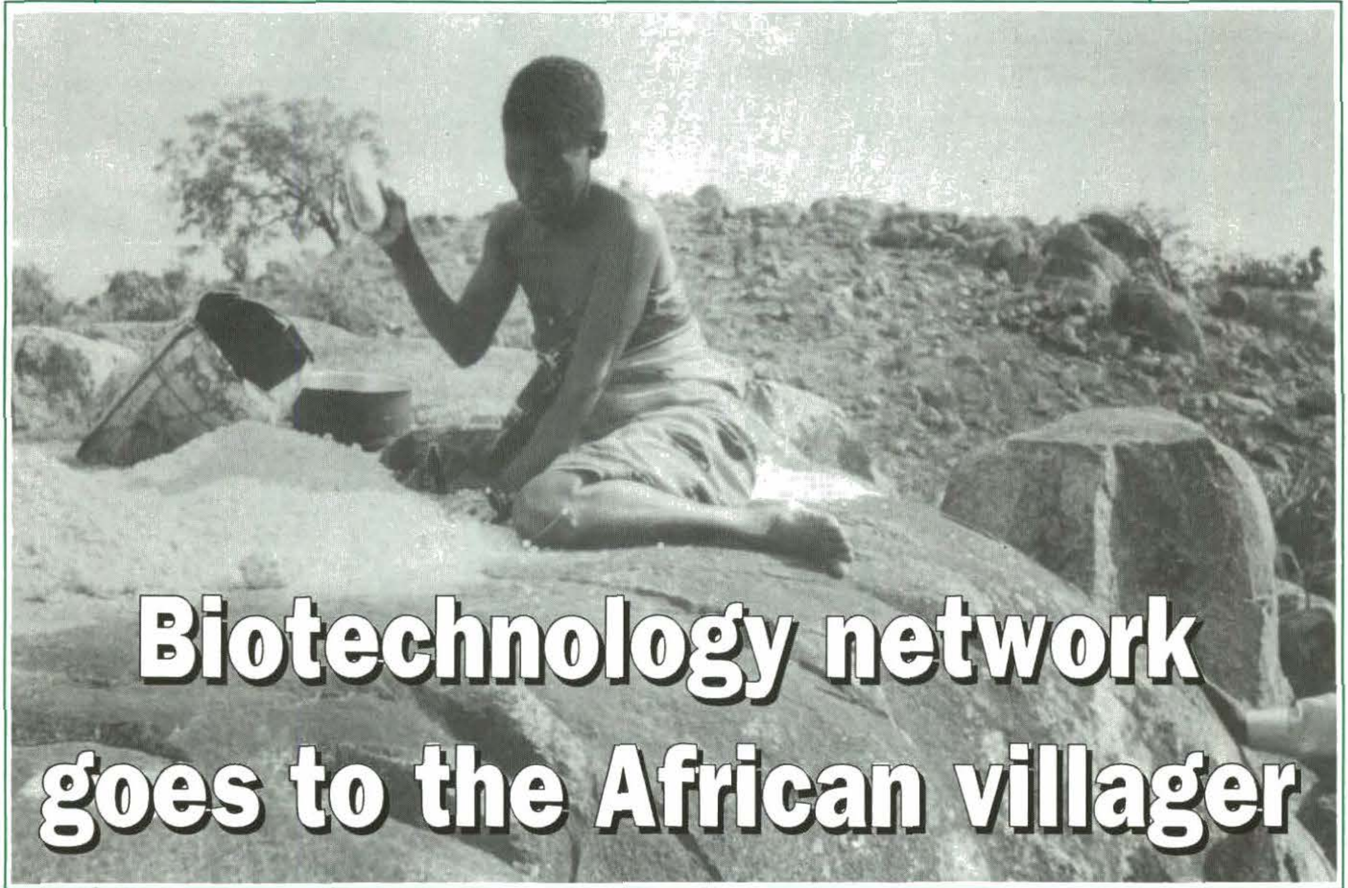
"*Arachis pintoi*, or perennial forage peanut, cuts fertilizer costs and improves weed control as a ground cover in coffee plantations on the Colombian hillsides," says Senén Suárez of CENICAFE, Colombia's Coffee Research Center.

The legume tolerates infertile acid soils and grows well from sea level to as high as 1,800 m. "It grows best with continuous moisture," says Kerridge, "but can survive 4 months of drought."

"Extensive use of a single variety leaves it susceptible to devastation by diseases or pests, so we need to widen the genetic base to make sure we have the natural resistance genes to control possible outbreaks," Kerridge says. "We also need to know more about the biology and management of forage peanuts."

Scientists plan to collect a wider range of wild *Arachis* species and to promote those that can be useful in agriculture.

by **Bill Hardy** ❑



Biotechnology network goes to the African villager

This Tanzanian woman pounds fermented and dried cassava to prepare flour. She will cook it as a porridge called *ugali*, a staple of her diet.

Ugali, the word for cassava porridge, also means 'food' in some Tanzanian villages. "That's how vital cassava is during food shortages," says Dr. Ann Marie Thro, of the international Cassava Biotechnology Network (CBN), coordinated by CIAT.

Cassava often means the difference between eating and starving to farmers in drought-stricken northern Tanzania. That's why two teams of CBN biotechnologists travelled across northern Tanzania in October 1993. They interviewed some of the world's poorest farmers on how biotechnology could help cope with harsh growing conditions.

Typical north Tanzanian farmers grow from 5 to 10 cassava varieties, which they use from root to leaf tip, Thro says. They eat not only the fresh or processed roots but also the cassava leaves as a green vegetable. They plant the stems or use them as firewood, and feed root peelings to livestock.

Farmers seek improvements

"We need cassava varieties that tolerate drought and poor soils even better than those we grow now," farmers in Sarawe village told the biotechnologists. They also wanted plants that mature early, giving food soon after planting.

"The farmers asked for roots that, once mature, could be left in the ground for long periods," Thro says. "That provides greater food security. Cassava spoils in 3 to 4 days after harvest."

Farmers need cassava that can resist the major dry-season pests: mealybug, scale, and green spider mite. "The mealybug wiped out the crop 2 years in a row in some areas," Thro says. Wild pigs, rats, and monkeys are also pests.

Ensuring a supply of healthy planting materials, especially for new varieties, is difficult. Cassava propagates from stem cuttings, but few strong stems remain after drought or pests weaken a crop.

Better processing methods

Women, who harvest and process most cassava, want processing methods that improve nutritional quality, and that increase the variety of cassava products they can market.

IPRA HANDBOOKS: The Voice of Experience in Participatory Agricultural Research

Farmers have taken agricultural research into their own hands in Cauca, Colombia. And now they speak for themselves, in a set of nine handbooks published by IPRA, CIAT's Participatory Research Project, with a grant from the W. K. Kellogg Foundation.

The books share the first-hand knowledge of six Local Agricultural Research Committees (known as CIALs from the Spanish acronym). These small-scale farmers, pioneers of participatory research, have worked with IPRA researchers since 1990.

The CIALs select their own research objectives, carry out experiments, and act on the results, integrating their local knowledge with modern technology.

Each handbook introduces a step in the process of forming or operating CIAL research groups and describes the research done for that stage. The books are designed for hands-on use by farmers, extension workers, and researchers interested in participatory research.

Specific examples explain each procedure. For example, Handbook 5, *Planning the Experiment,* describes how a CIAL chooses where to test new maize varieties for the area. It lists questions, such as "Should the plots be in lowlands or in the hills?" Then it justifies each alternative. "If we're testing new varieties of a crop we know, we choose a place that we would normally use. If it's a new crop, we choose a place where we plan to plant in the future," the text explains.

Scientific concepts in the farmers' terms

"The handbooks introduce scientific concepts, terms, and procedures to the farmers in their own terms," says Teresa Gracia, CIAT rural sociologist. "Through examples, the books lead the farmers from the abstract to the practical. In the first handbook, the text defines **experiment**. It explains different kinds of experiments, then describes specific cases."

The CBN team members on the field study were from CIAT, the U.K.'s Natural Resources Institute, the Tanzanian Ministry of Agriculture, the Tanzania Food and Nutrition Center, and the Tanzania Home Economics Association (a nongovernmental organization).

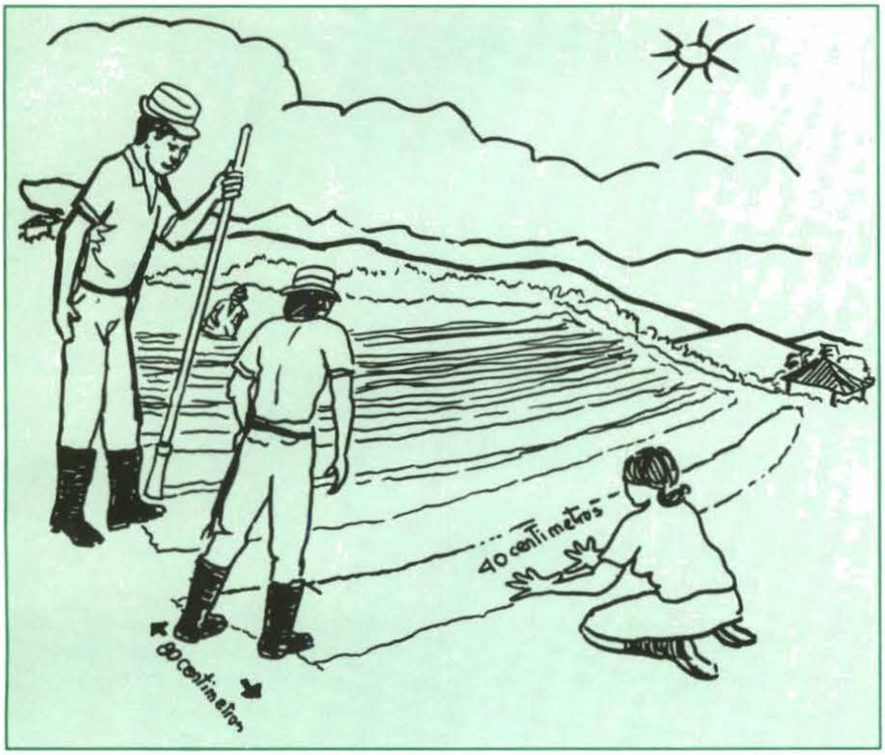
The field study was inspired and funded by the Special Programme for Biotechnology and Development Cooperation, of the Directorate General for International Cooperation (DGIS), part of the Netherlands Ministry of Foreign Affairs. DGIS joined CBN coordination in 1992.

CBN selected the villages with data provided by the Collaborative Study of Cassava in Africa, a project led by the International Institute of Tropical Agriculture (IITA).

CBN was formed in 1988 to apply biotechnology to cassava research, particularly to develop better small-scale technology for farmers and processors.

by **Gail Pennington**
photo by **Ann Marie Thro**

CBN



The simple Spanish text is written in the language of farmers. Large drawings reinforce the text for those who cannot read. More than 100 of the farmers involved in the original research edited both the texts and drawings. The farmers' attention to detail in the drawings impressed the researchers. "We don't plant that kind of tree near bean fields," is a typical comment.

In the Cauca region alone, farming communities have formed about 50 CIAL groups, involving at least 1000 farm families. CIALs have mushroomed outside the pilot project area in Colombia. Another 20 CIALs exist in Latin America.

In UNDP and Swiss Development Cooperation projects, IPRA has used the texts to train more than 100 national researchers from Latin America and Africa to organize CIALS.

The handbooks have been translated into English for release in 1995; they are being tested in Africa. A Portuguese version is also planned. A training program is planned for Asian countries in 1996, with translations to local languages.

The nine volumes are *The Experiment, Local Agricultural Research Committees, The Diagnosis, The Objective of the Experiment, Planning the Experiment, Evaluating the Experiment, Things That Can Go Wrong, Sharing the Results of our Experiment,* and *A True Case.*

The handbooks are available singly or in complete sets. In Colombia, each volume costs Col$3,400. For other developing countries, they are US$5 each; for developed countries, US$8. Write to the Distribution Section, CIAT, A.A. 6713, Cali, Colombia.

by **Gail Pennington**
drawing by **Oscar Vargas**

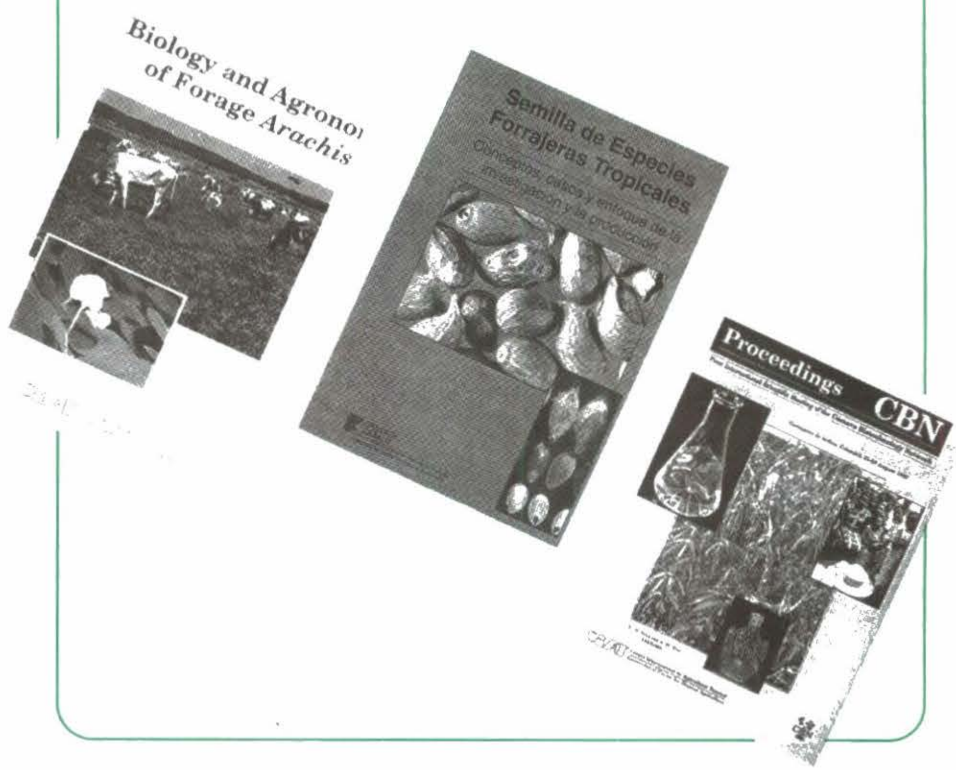
Recent Publications

Proceedings of the First International Scientific Meeting, Cassava Biotechnology Network, Cartagena, Colombia (1994)

(Available in English only)
Roca, W. M.; Thro, A. M. (editors)
496 pages. 21.5 x 28 cm.
Perfect bound, paperback.
Price: Colombia, Col$14,500;
other developing countries, US$21;
developed countries, US$25.
This book presents over 70 papers and working group reports given at the 1992 meeting of the Cassava Biotechnology Network. It includes methodologies for applying biotechnology to conserve and characterize germplasm. Molecular genetics research will lead to delineation of relationships between species, characterization of major genes to manipulate desired traits, and molecular mapping to increase the efficiency of crop improvement.

Uso de la Tierra e Impacto Ambiental en las Sabanas de América Tropical: Selección Bibliográfica, 1948-1993 (1994)

(Available in Spanish only)
Cadena, Zeneire; Mejía, Mariano; Vera, Raúl
101 pages. 21.5 x 28 cm.
Price: Colombia, Col$4,100;
other developing countries, US$6;
developed countries, US$16.
Contains 611 references organized under the topics ecology, soils, land use, and agricultural production systems. Includes key words and an author index.



Semilla de Especies Forrajeras Tropicales: Conceptos, casos y enfoque de la investigación y la producción (1994)

(Available in Spanish only)
Ferguson, John E. (editor)
370 pages. 15 x 22 cm.
Perfect bound, paperback.
ISBN 958-9183-70-0
Price: Colombia, Col$7,400;
other developing countries, US$11;
developed countries, US$30.
This book contains the proceedings of the eighth meeting of the Assessment Committee of the International Network of Tropical Pastures Evaluation (RIEPT). Its major topic was seed production and supply of tropical forage species for research and pasture development.

Biology and Agronomy of Forage *Arachis* (1994)

(Available in English only)
Kerridge, Peter C.; Hardy, Bill (editors)
209 pages. 17 x 24 cm.
Perfect bound, paperback.
ISBN 958-9183-96-4
Price: Colombia, Col$11,700;
other developing countries, US$16;
developed countries, US$44.
This book contains the proceedings of a workshop on forage *Arachis* held at CIAT. It includes 17 presentations, on topics related to taxonomy, germplasm resources, plant physiology, diseases and pests, nutritive value, and agronomic use. They include previously unpublished data.