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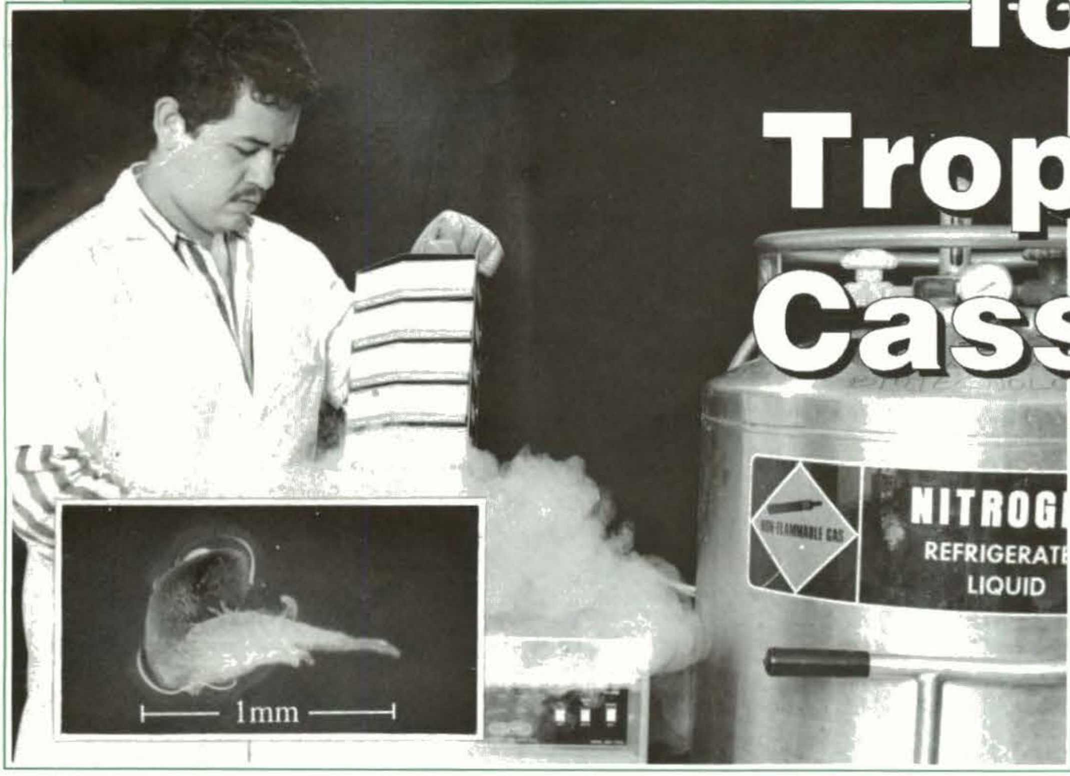
The Freeze Is on for Tropical Cassava



Roosevelt Escobar demonstrates cryopreservation or "deep-freezing" of cassava in CIAT's biotechnology laboratory. The storage tank, from which frost is rising, has the capacity to store samples of the entire world cassava collection—at least 6,000 cassava shoot tips, 1 mm each.

Cryopreservation will soon help the CIAT gene bank conserve and distribute cassava varieties worldwide. Cassava feeds about 500 million people, or 1 of every 10 living persons.

Tissues of tropical cassava plants will soon be stored in the coldest temperatures on earth—and approaching the deep cold of outer space—at CIAT. Cryopreservation, or protection of living plants by deep-freezing, is being tested as a way to conserve the genetic diversity of the root crop in CIAT's gene bank.

"Deep-freezing in liquid nitrogen stops all cell functions, so plants can be conserved indefinitely," says Dr. William Roca, head of CIAT's Biotechnology Research Unit.

"Gene banks are the basis for tomorrow's food supply," says Rigoberto Hidalgo, CIAT research associate. Cryopreservation will

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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 18 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.

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CIAT Graphic Arts	Production

soon help the CIAT gene bank conserve and distribute cassava varieties worldwide. Cassava feeds about 500 million people, or 1 of every 10 living persons.

World collection in 1 cubic meter

Shoot tips (1 mm) of as many as 6,000 cassava varieties—samples of the entire world collection—can be cryopreserved in a 1-cubic-meter tank of liquid nitrogen at -196 °C (-321 °F). (The coldest natural temperature recorded on earth was at Vostok, Antarctica, in 1960: -88.3 °C; the atmosphere of Neptune is about -205 °C.)

CIAT now maintains cassava varieties by planting in the field and by growing clones of shoot tips *in vitro*, in test tubes. CIAT stores more than 5,000 clones in vitro in a laboratory of 50 sq m.

"But test-tube clones must be transferred to a fresh medium every 12 to 18 months," Roca adds. "Deep-freezing prevents cell deterioration, greatly reducing the risk of genetic mutations, losses from contamination, or other hazards."

In the field, a similar collection occupies more than 5 hectares of land. But field cultivation often exposes the collection to insect and disease attacks and climatic and soil stresses. Labor costs of both methods are high.

"A cryopreserved collection would require minimal maintenance—mostly keeping a constant ultra-low temperature," Roca says. The deep-frozen plants would back up an active collection in the field or in vitro.

Freezing in stages

"CIAT freezes cassava in stages because sudden drops in temperature can form ice crystals that kill cells," explains Roosevelt Escobar, CIAT research assistant in the cryopreservation project.

Before freezing, the plant parts are treated to remove some of the freezable cell water. Then, fast-penetrating, protective chemicals are added to further protect the cells from freezing damage.

Cell dehydration continues as freezing starts at a slow rate: 0.5 °C/minute. After reaching -20 °C, the freezing rate increases to 1 °C/minute, until reaching -40 °C. "By then, the cell has released almost all of its freezable water," Escobar says. "We then increase the freezing rate to 500 °C/minute. Step-freezing takes only 1 hour."

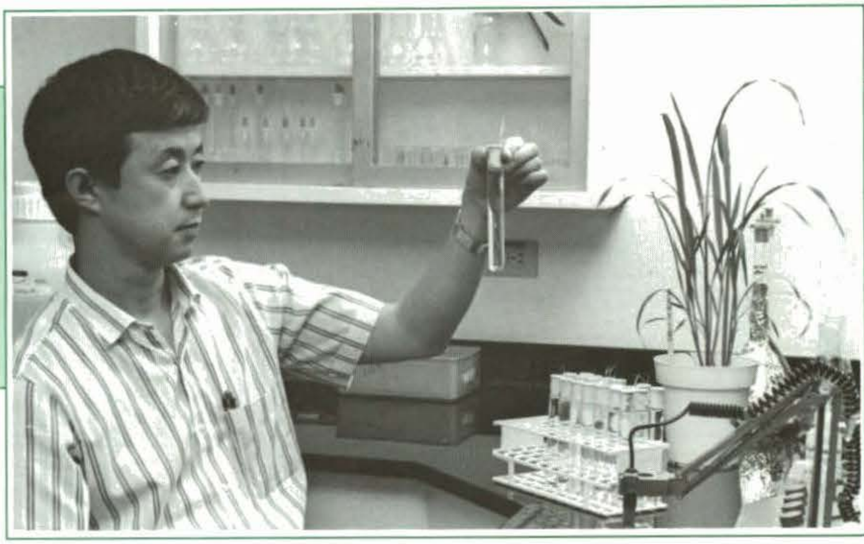
Potential for other crops

CIAT is refining its cryopreservation technology. Only in 1991 were scientists able to freeze plant parts in liquid nitrogen, recover them, and make them grow again into whole plants. The initial research was conducted jointly with the International Board for Plant Genetic Resources (IBPGR).

"Although CIAT is developing cryopreservation only for cassava, the technique might also be used for other tropical species that are propagated vegetatively, such as potatoes, sweet potatoes, and bananas," Roca adds, "or even for seed-propagated plants such as forages."

by **Bill Hardy**
photo by **Mauricio Antorveza**

Why Can Some Rice Grow in Acid Soils?



Rice seedlings are first grown in test tubes containing a liquid, acidic medium. Checking their tolerance for acidity is Dr. Kensuke Okada, TARC plant physiologist assigned to CIAT's Rice Program. In front of him, an example of acid-tolerant dryland rice is growing in a pot filled with acid soil.

A dryland rice variety, *Oryzica Sabana 6*, can tolerate the acid, infertile soils of South American savannas. But how? To find the answer, CIAT and the Tropical Agriculture Research Center (TARC), in Japan, have begun collaborative research.

Released in 1991 by the Colombian Institute of Agriculture (ICA), Oryzica Sabana 6 was selected by Dr. Surapong Sarkarung, CIAT rice breeder, and colleagues. It is the first high-yielding, deep-rooted dryland rice variety to tolerate acid soils. Sabana 6 (Spanish for "savanna") matures quickly (in 105-108 days) and resists lodging. It also resists diseases such as rice blast and leaf scald and the sogata planthopper—a pest that also spreads "hoja blanca" ("white leaf"), a viral disease prevalent in Latin America.

"Acid soils usually have high levels of aluminum, which is toxic to crops," says Dr. Kensuke Okada, TARC plant physiologist assigned to CIAT's Rice Program.

Exudates may hold key

"Chemical compounds, or exudate, may ooze out of the roots of Oryzica Sabana 6 into the surrounding soil," explains Dr. Jorge Mayer, biochemist at CIAT's Biotechnology Research Unit. "If so, the exudate may be composed of organic acids such as citric acid. These acids would 'bind' with the aluminum, preventing it from poisoning the plant and, simultaneously, free phosphorus—an essential plant nutrient that is usually bound with aluminum in savanna soils."

"If we can identify the chemical makeup of the exudate, we can test, in the laboratory, the acid-soil tolerance of each new rice line by its ability to produce the chemical," Okada says. "This would speed the breeding and eventual release of new varieties to farmers."

Scientists also hope to identify the genes that control acid-soil tolerance. "Once found, we can breed them into other rice types, thus making them tolerant," Mayer says. "We could even transfer such genes through molecular techniques to other plants that, potentially, could use this mechanism of acid-soil tolerance."

Environmental payoffs

"There could be an environmental payoff," says Dr. Daniel Robison, soil scientist in CIAT's Land Use Program. "Rice varieties that tolerate poor soils allow farmers in marginal areas such as the savannas surrounding the Amazon Forest to produce more acceptable yields for longer periods. This may reduce the need for more land, thus slowing deforestation."

Acid-tolerant rice varieties can also help open up the acid savannas of Africa and parts of Asia.

Japan and CIAT

TARC's relationship with CIAT began in 1975 with pastures. Based in Tsukuba Science City, TARC is affiliated with the Japanese Ministry of Agriculture, Forestry and Fisheries. The 106 TARC scientists research agriculture in tropical, subtropical, and temperate zones, emphasizing collaboration with national programs and other agricultural institutions. TARC also acts as an information service center.

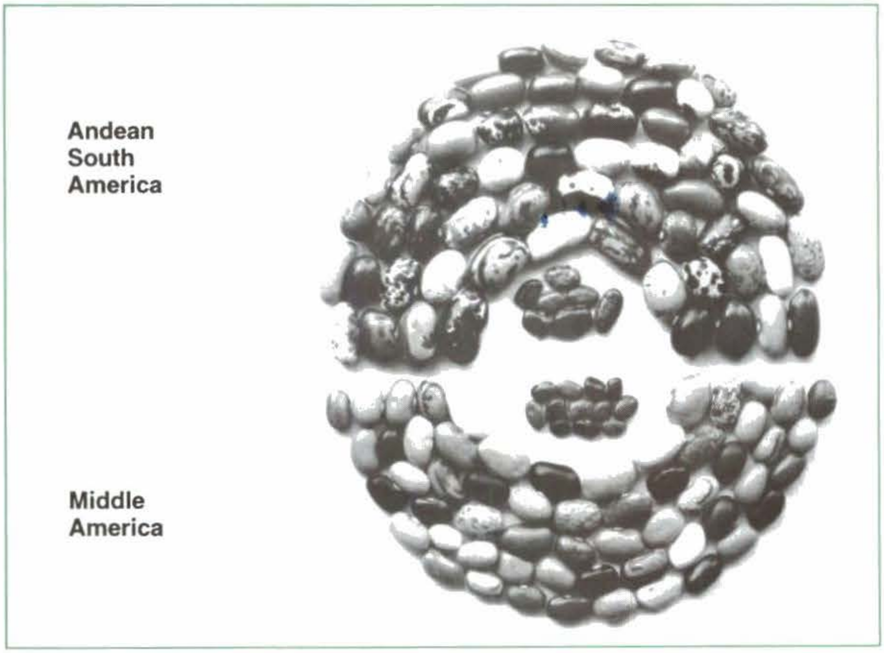
In addition to TARC's scientific cooperation, the Japanese Government, CIAT's third largest donor, channels more than US$3 million to CIAT through the Japanese Ministry of Foreign Affairs and the Consultative Group on International Agricultural Research (CGIAR).

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

Moving Genes to Confuse Bean Pathogens

Latin Americans are choosy about beans. So are some local diseases that prey on beans. CIAT scientists are turning this choosiness into a weapon for environmentally friendly pest control.

"Two major types of beans evolved over 10,000 years," says Dr. Shree Singh, CIAT bean geneticist. The large-seeded beans that are popular in Colombia, Ecuador, Peru, Argentina, and Chile originated in the Andes Mountains. The small beans preferred in Central America and Mexico originated in that region.



Common, or dry, beans are either large-seeded, originating in Andean South America, or small-seeded, from Central America and Mexico. Beans vary greatly in color, shape, and ability to resist diseases, pests, and soil and climatic stresses. CIAT scientists use this variation to improve crop productivity, thus improving food supplies and incomes, and helping to protect the environment.

"Local disease pathogens 'coevolved' to attack each type," explains Dr. Marcial Pastor Corrales, CIAT bean pathologist. "Thus, the anthracnose pathogen from the Andes, which can destroy entire crops, can easily overcome resistance in the large-bean varieties that originated there. But those pathogens didn't coevolve with the small beans from Central America. Therefore, some varieties of small beans resist the anthracnose pathogen that attacks large beans. And vice versa."

Andean genes into Central American beans

CIAT is breeding genes from Andean beans into Central

American beans to make them resistant to Central American pathogens. Likewise, resistance genes from Central America should make Andean beans resistant to local pathogens.

"We are introducing resistance genes that are not recognized by the local pathogens," Pastor Corrales says.

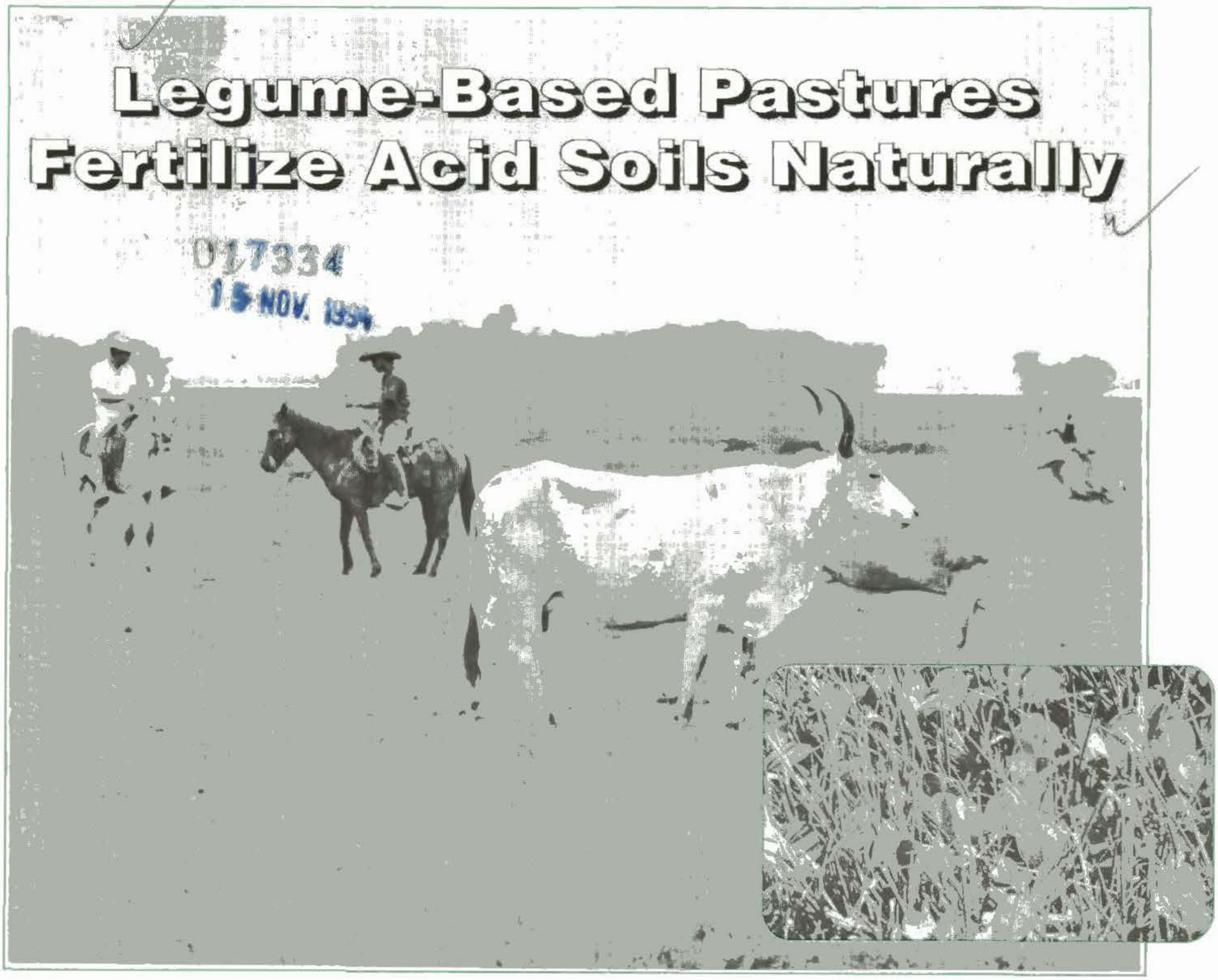
"After combining resistance from the Central American and Andean beans, we bring in resistance from wild beans and related species," Singh explains. "The idea is to take advantage of all resistance available."

Resistant plants are fundamental to any sustainable, nonchemical strategy of pest management, Pastor Corrales says. "We need to use the wide genetic diversity found in all kinds of beans to manage pathogens that are themselves genetically variable."

CIAT beans that resist Fusarium wilt are being crossbred in the USA to develop resistant varieties for farmers in Colorado. Genes found in wild Mexican beans help control the Mexican bean weevil, a pest that devours 25% of beans stored in Africa, and 15% in Latin America. That resistance can save farmers millions of dollars annually. Environmental returns may be even greater.

by **Bill Hardy**
photo by **Shree Singh**

Legume-Based Pastures Fertilize Acid Soils Naturally



A grass-legume pasture (inset) improves acid soils such as those of native savannas. Better forage means more milk and meat to feed a growing world.

"Tropical forage legumes—nitrogen-fixing plants similar to temperate legumes such as clover and alfalfa—recycle nutrients through plant and animal residues and thus build soil fertility, improve soil structure, and increase its biological activity," says Dr. I. M. Rao, CIAT plant nutrition physiologist.

Pasture legumes improve infertile and acid soils—the main constraint to farm productivity across Latin America.

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CIAT's strategy is to develop forages and technology to establish, manage, and use pastures to increase the productivity of nutrient-poor acid soils.

"Plants have evolved mechanisms by which they adapt to survive and produce offspring in these soils," Rao explains.

Root growth and nutrients

"Shoots fix carbon and roots draw water and nutrients from the soil," Rao adds. "Both plant parts interact to make growth possible. CIAT research shows that when nutrients are adequate, growth of shoots—the above-ground portion of the plants on which animals graze—is relatively greater than root growth. But with insufficient nutrients, the plants produce more roots, and less forage, of lower quality."

Animals will eat less of a low-quality forage, so CIAT studies how roots acquire limited nutrients, whether natural or applied as fertilizer, and how much root system is needed to use them. Plants must balance the uptake and use of nutrients to produce good forage.

Among the essential nutrients for plant growth, phosphorus (P) is particularly problematic. P deficiency affects 96% of all acid, infertile soils of tropical America—1 billion hectares. CIAT research indicates that legumes, even with a smaller root system, acquire more P than grasses in acid soils. "In these soils, most of the total P is 'fixed,' so plants can't use it," Rao says. "This makes P fertilization less effective, and limits pasture productivity."

Animals retain only about 20% of the nutrients they ingest. The rest are returned to the soil through excreta. "In grazed pastures, nutrients cycle from the soil to plants and then back to the soil, either through the death of plant tissue or via grazing animals," says Dr. M. A. Ayarza, CIAT soil scientist. "Rainfall and fertilizers add nutrients to the cycle. Nutrients leave the cycle when animals are sold, and through leaching and gaseous emissions."

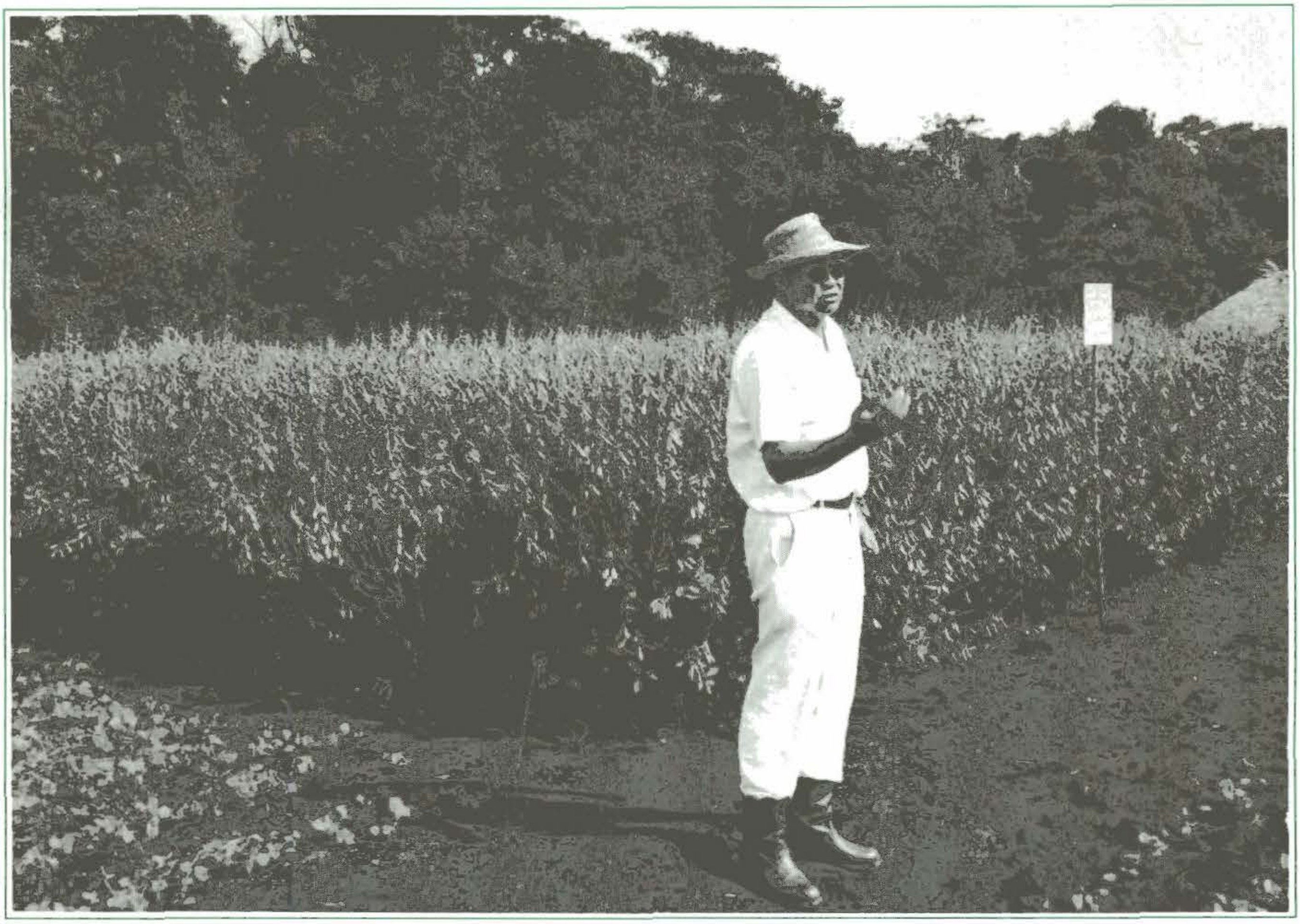
Grazed grass-legume pastures can build soil fertility through more nutrients available to plants and their more rapid cycling, Ayarza adds.

"Earthworms also help cycle nutrients by building the soil structure," Ayarza says. "Earthworm activity triples in legume-based pastures, increasing mineralization, texture, porosity, and water infiltration and retention."

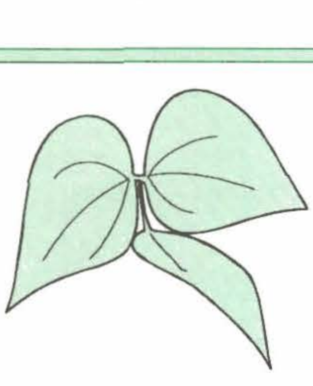
Legume-based pastures have the potential to increase farm production in the vast savannas of South America that cover an area four times the size of France, he adds.

by **Bill Hardy**
photo by **Mauricio Antorveza**

Fields Sown with Gold: Gold Beans for Brazil's Poor



CIAT agronomist Dr. Michael Thung is surrounded by gold—improved bean varieties for Brazil's poor consumers.



Farmers in Brazil have shifted production of dry beans, the country's most important food, to their poorest land over the past two decades. But improved bean varieties have kept production on that land high enough to maintain constant prices.

"Poor consumers, who spend 13% of their food budget on beans, have benefited most," says Dr. Michael Thung, a CIAT agronomist who works with Brazil's Centro Nacional de Pesquisa em Arroz e Feijão (CNPAF).

One key bean variety is *EMGOPA 201-Ouro* ("Gold"), a CIAT line that Brazilian scientists released as a variety in 1984. Ouro is now recommended in 12 states.

"Ouro was the first improved variety for which a separate market class was created," Thung says. "Ouro is called ENGOPA on the

Brazil is the world's largest producer and consumer of dry beans, growing 25% of the world's production of roughly 9 million tons. Per capita consumption in Brazil in the mid-1980s was about 14 kg. Both the rich and poor may eat beans twice a day.

São Paulo commodity market, Latin America's largest.

"The yield potential of Ouro isn't as high as that of other improved varieties—but its production is stable, and it resists four destructive diseases—anthracnose, angular leaf spot, rust, and bean common mosaic virus," Thung adds.

Improved varieties are now planted on 25% (more than 200,000 hectares) of the bean land of four states—Espírito Santo, Goiás, Minas Gerais, and Rio de Janeiro. These varieties, often grown on small farms, were developed by CNPAF and state agricultural research institutions, in cooperation with CIAT.

Brazil, the world's largest bean producer

Brazil is the world's largest producer and consumer of dry beans, growing 25% of the world's production of roughly 9 million tons. Per capita consumption in Brazil in the mid-1980s was about 14 kg. Both the rich and poor may eat beans twice a day.

"Bean production in Brazil was highly unstable from 1970 to 1985," Thung explains. "Brazil managed to keep production stable, at about 2.5 million tons, by planting more land in beans."

The area planted to beans grew at a rate of 1.9% per year—the same rate at which yields fell. "Farmers shifted beans to poor, marginal soils so they could plant more profitable crops such as soybeans—an export crop—and wheat for local consumption on the best land," Thung explains. Settlers from southern Brazil brought beans to forest margins to grow for home consumption.

Stagnant production, an irregular supply, and decreased purchasing power drove down domestic consumption of beans rapidly, by almost 2.4% per year, even though the wholesale price remained relatively stable.

"More than 70% of the area in Goiás is planted to the traditional variety Carioca, or to Ouro," Thung says. "Carioca is grown more in irrigated areas, and Ouro, in mixed cropping systems. Ouro is less vigorous and easier to harvest than Carioca and does not affect maize yields. Farmers in Bolivia now also grow Ouro, known locally as Mantequilla Mairana."

CIAT-developed varieties in the states of Espírito Santo, Goiás, and Rio de Janeiro add an annual value of US$12.1-15.5 million to bean production. Those varieties add another $3.1-7.2 million in Minas Gerais.

23 CIAT lines are Brazilian varieties

By late 1992, 23 improved CIAT lines had been released as varieties through Brazil's national bean evaluation network. "Improved varieties are a clean, cheap, and sustainable way to improve yields," Thung adds.

"Without the improved varieties, the supply of beans in Brazil would have fallen further, prices would have increased, and beans would have lost some importance in the diet of the poor," Thung says. "This shows that new technology is useful even when demand is not increasing."

by **Bill Hardy**
photo by **Alexandra Walter**

Pasture Technology Helps Protect Forest Margins of the Peruvian Amazon

Peruvian national agencies and the CIAT Tropical Forages Program are developing new pastures for forest margins. In the photo, *Brachiaria dictyoneura* with *Desmodium ovalifolium* at the experimental station in Pucallpa.

Peru's Amazonian forests cover 56 million hectares—43% of the nation's land. "But social changes and governmental policies are causing much of the population of Peru's high plateaus and coastal areas to migrate toward the Amazon forest margins," says Kenneth Reátegui, CIAT tropical pastures agronomist stationed in Pucallpa, Peru.

"The ecosystem has infertile soils and heavy rainfall," Reátegui explains. "It is easily degraded by poor cropping practices and improper cattle management. A lack of good pasture varieties worsens the problem."

In 1985, Peruvian agencies and CIAT began a project to evaluate and select better pasture varieties in local farmers' fields. Cooperating with CIAT are the Instituto Nacional de Investigación Agraria y Agroindustrial and the Instituto Veterinario de Investigaciones Tropicales y de Altura.

"We are developing stable and profitable management practices, plus local systems for production and marketing of pasture seeds for deforested areas," Reátegui says. "In no way do we promote the clearing of forests for agricultural production."

New pasture cultivars

Through the project, Peruvian institutions have released the pasture cultivars San Martín (*Andropogon gayanus*) and Pucallpa (*Stylosanthes guianensis*). Cattlemen have also widely accepted *Brachiaria dictyoneura*, *Arachis pintoi*, and *Desmodium ovalifolium*.

"These species are not only good forage, they also improve the soil's condition," Reátegui explains. "They recycle large quantities of nutrients between plants and soil, thus contributing to sustainability."

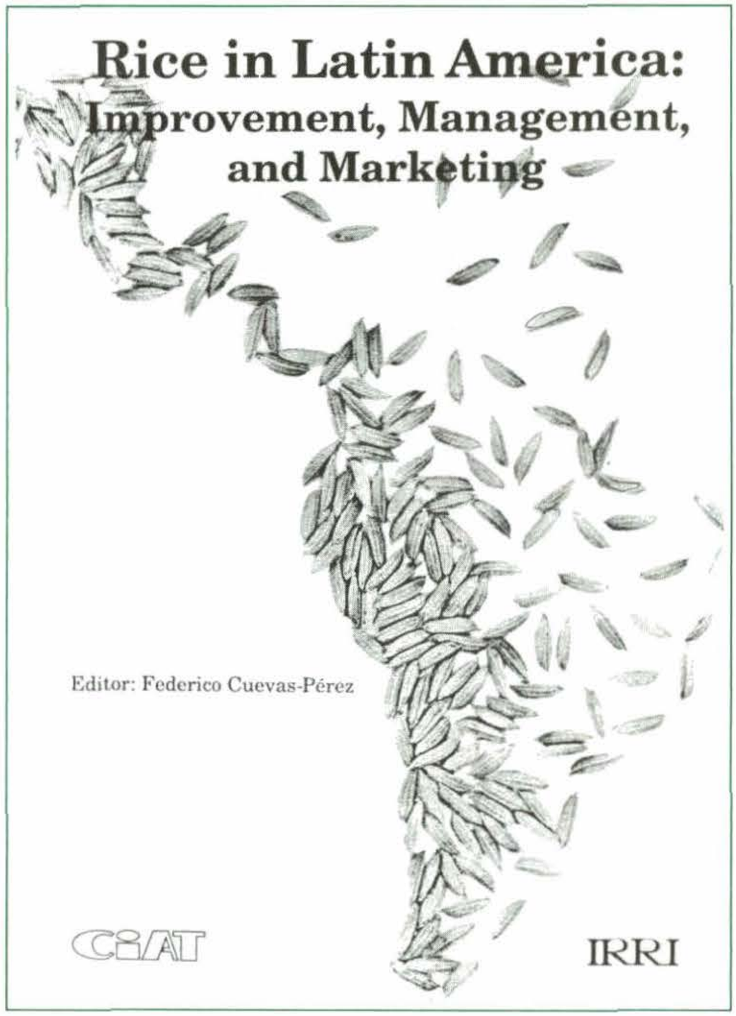
"Agricultural products are hard to market in this region, so annual crops for family consumption—plantain, maize, and beans—are possible alternatives for survival," says Dr. William Loker, former project consultant. "In these conditions, cattle raising, especially beef-milk systems with improved pastures, requires little labor and few inputs. A high demand for beef and milk assures farmers of markets and a constant cash flow.

"But improved pastures cannot solve the problems of forest degradation," Loker comments. "Farmers in forest margins must manage their farms with systems that increase their incomes while recycling nutrients."

"These species are not only good forage, they also improve the soil's condition," Reátegui explains. "They recycle large quantities of nutrients between plants and soil, thus contributing to sustainability."

by **Alberto Ramírez**
photo by **Alberto Ramírez**

Pioneer Book on Rice in Latin America Released at Cali Book Fair



The first book in 20 years to examine the role of rice in Latin America and the Caribbean was launched at the National Book Fair in Cali in November, 1992. **Rice in Latin America: Improvement, Management, and Marketing** was published in Spanish and English by CIAT and the International Rice Research Institute (IRRI) in the Philippines. It was presented by Dr. Manuel Rosero, head, Cereals Section, Colombian Institute of Agriculture (ICA).

In 297 pages, **Rice in Latin America** brings together 12 papers, with commentaries, and 50 posters that were presented at a 1991 international rice conference held in Mexico. It interweaves four themes that affect the rice industry's present status and are critical to its future: genetic improvement—modern rice varieties are already yielding at their full potential but the world's population keeps growing; water management—water is increasingly scarce and rice cultivation appears to be a wasteful user; red rice—a noxious weed that is rapidly invading many rice-producing regions; and marketing—Latin American and Caribbean countries are opening up their markets and consequently changing politico-economic policies. The book's technical editor was Dr. Federico Cuevas-Pérez, IRRI's liaison scientist for Latin America and coordinator of the Latin American operations of the International Network for Genetic Evaluation of Rice.

Rice in Latin America sells for US$12 in developing countries; US$33 in developed countries; and Col$7000 in Colombia (includes air mail postage). Send orders to the Publications Distribution Office, CIAT, A. A. 6713, Cali, Colombia.

by **Elizabeth de Páez**
cover design by **Julio Martínez**

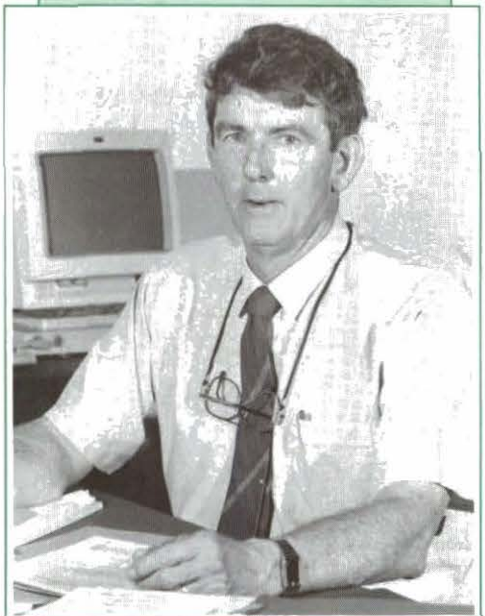
CIAT Names New Deputy Director General

Dr. William Robert Scowcroft is the new deputy director general for Germplasm Development Research at CIAT.

Before coming to CIAT, Scowcroft, an Australian, was director of the Victorian Institute for Dryland Agriculture, Horsham, Australia. He has held senior agricultural research and management positions in the state and federal governments of Australia, including the Commonwealth Scientific and Industrial Research Organisation (CSIRO). He also has worked for the private sector in Canada and advised the Canadian government.

Scowcroft received his Ph.D. in genetics from the University of California, Davis, and his B.S. in agriculture from the University of Sydney, Australia.

"Dr. Scowcroft's strong background in plant cell genetics and biotechnology makes him a valuable addition to CIAT," says Dr. Gustavo Nores, CIAT director general. "He combines impressive research experience with extensive management experience in the private sector."



Dr. William Scowcroft, the new deputy director general for Germplasm Development Research at CIAT.

"To protect the future of their agriculture, developing countries must share in the 'ownership' of technology and research outcomes," Scowcroft says. "Our research must merge its existing strength in germplasm development with developments in sustainable agriculture and resource protection. And CIAT's partnership must include the private sector and nongovernment organizations."

Scowcroft replaces Dr. Douglas Laing, who held the position for almost 13 years. Laing is now director general of CAB International of the United Kingdom.

Scowcroft's wife Caroline and their children will be joining him in Cali.

by **Gail Pennington**
photo by **Mauricio Antorveza**

Correction

CIAT International Vol. 12 No. 1, June 1993, p. 12, included an incorrect statement: "Dr. Lucia Pearson de Vaccaro is the new chairperson of the CIAT Board of Trustees...Vaccaro is the first woman to serve as chairperson of the board of any Center sponsored by the Consultative Group on International Agricultural Research."

Dr. Gelia Castillo of the University of the Philippines at Los Baños served as chairperson of the board of the International Potato Center (CIP) in 1983-1984.

We apologize for this error.

The Editors
CIAT International