

The Collaborative Research Support Programs (CRSPs)

Scientific Accomplishments and Social Impacts Through Joint Research and Training



A Worldwide Community of Active Research Partnerships
of U.S. and Developing Country Scientists, Governmental Departments/Ministries of Agriculture,
Public and Private Research Institutions and Organizations, Small-Scale Farm Families,
Local Entrepreneurs and Rural and Urban Consumers.



The Collaborative Research Support Programs (CRSPs) were created in response to Title XII of the U.S. Foreign Assistance Act legislated in 1975.

The main thrust of Title XII was to strengthen the role of Land-Grant and other U.S. universities in programs of sustainable agriculture and natural resource management that help developing countries produce adequate food, fiber, fuel and shelter materials. CRSPs were also to contribute to U.S. agriculture.

The U.S. Congress provides funding to the CRSPs through the Agency for International Development. The more than 25 U.S. institutions and 27 developing countries also make major financial and in-kind contributions.

The CRSP model has received widespread commendation and is recognized for its success in developing mutually beneficial collaborative research between U.S. and overseas institutions. The programs have been able to attract the most capable U.S. faculty into collaborative research for development because of the unique scientific challenge, mutual interests, long-term commitment and global benefits derived through this model.

The 1990s are significant for the CRSPs as they enter their second decade of planned, long-term research. The purpose of this publication is to present examples of the collective impact of the CRSPs to date in order to encourage their maximum application in international development and U.S. agriculture.

The CRSP Council, producer of this document, is comprised of officials from the individual CRSPs:

- Bean/Cowpea CRSP
- Fisheries Stock Assessment CRSP
- Nutrition CRSP
- Peanut CRSP
- Pond Dynamics/Aquaculture CRSP
- Small Ruminant CRSP
- Soil Management CRSP (TROPISOILS)
- Sorghum/Millet CRSP (INTSORMIL).

IMPACT

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

AFLATOXIN DECONTAMINATION

Aflatoxin, a carcinogenic compound, is a major problem affecting peanuts and other food-and-feed grains worldwide.

Two clays found in SENEGAL (one of which is regularly consumed by people there) have been confirmed by PEANUT CRSP researchers in TEXAS and SENEGAL to be very effective in removing aflatoxin from contaminated peanut products.

THE VALUE OF THIS NEW, EFFECTIVE AND COST-EFFICIENT TECHNOLOGY FOR MANAGING AFLATOXIN CONTAMINATION IN PEANUTS, AND OTHER GRAINS SUCH AS CORN, IS INCALCULABLE.

The use of this technology in detoxifying animal rations can provide a stronger outlet for peanut production worldwide and contribute substantially to the livestock industry.

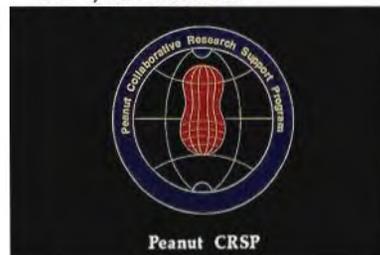
Highly adsorptive clays (toxins held on surface of clay particles), when mixed with aflatoxin-contaminated peanut oil, removed essentially 100 percent of the aflatoxin as the clay settled out of the oil.



Aspergillus flavus-contaminated peanuts, the producer of the highly carcinogenic aflatoxin.

Collaborators:

PRAIRIE VIEW A&M UNIVERSITY
TEXAS A&M UNIVERSITY
ITA, SENEGAL



Animal-feeding trials in Texas showed that the clay, mixed with a feed containing aflatoxin-contaminated peanut meal, bound with the aflatoxin and carried it out of the animal in the feces.

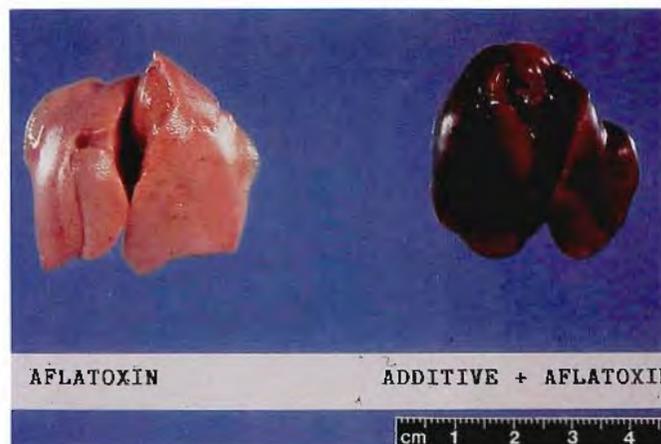
Although livers are primary accumulation sites of toxins in animals, researchers found little or no aflatoxin in the livers of chickens fed the contaminated, clay-fortified meal. As yet, however, there is no FDA clearance in the UNITED STATES for its use.

In SENEGAL, projected population increases suggest that by the year 2000 the country will not be able to meet domestic oil needs from domestic production. Improved decontamination technology using indigenous clays can help address this problem.

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Chicken livers showing effects of clay adsorption of aflatoxin from peanut meal.

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ALTERNATIVES FOR COCA GROWERS

During the 1980s, international demand fueled a boom in the production of coca leaves. In Bolivia, production increased from 20,000 to 160,000 tons annually. Between 50,000 and 70,000 families migrated from the highlands to the tropical forests, where they now depend on coca for their livelihood. In Peru, production levels are even higher than those in Bolivia, and illicit revenues support both institutional corruption and terrorism.

Land clearing for coca cultivation has caused massive deforestation in Bolivia and Peru. Hundreds of thousands of hectares of virgin rainforest have been cleared, degrading the environment and diverting resources from food production. Coca production also exhausts soil nutrients, further degrading the land.

Government strategies to control coca production by force have had limited impact. Without viable alternatives, farmers desperately persist in growing coca. Attempts to discourage migration to coca-producing areas by withholding transportation, health, and educational services have also been ineffective. Such tactics further marginalize coca producers and diminish their access to alternative technologies.

SOIL-MANAGEMENT RESEARCH GIVES FARMERS A WAY OUT. BY COMBINING ANNUAL FOOD CROPS WITH PERENNIALS, CONTINUOUS CULTIVATION PROVIDES AN ORDERLY TRANSITION FROM COCA PRODUCTION TO SUSTAINABLE AGRICULTURE (FIGURE 1). PRODUCERS DIVERSIFY THEIR

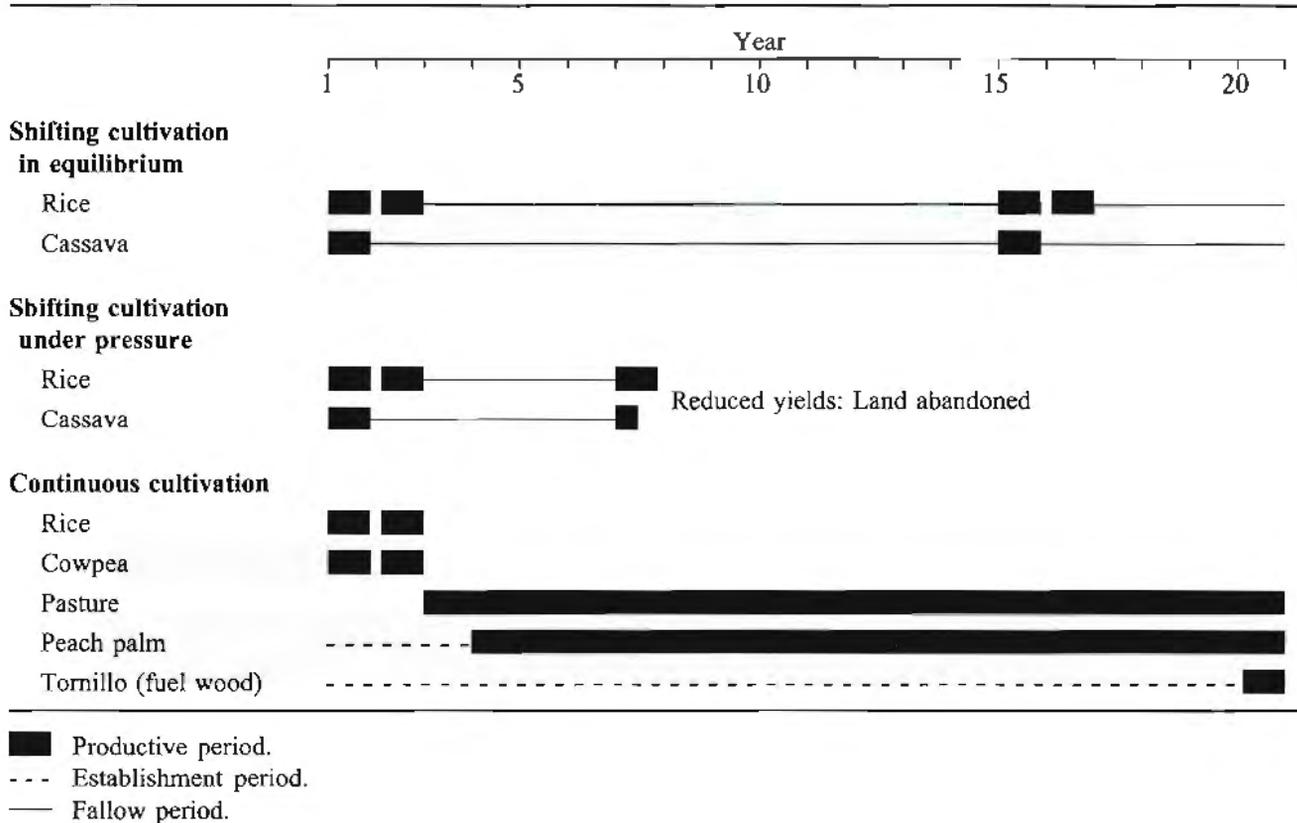


Without alternatives, farmers will continue to grow coca. Here, coca leaves dry along the roadside.

Cornell University
North Carolina State University
Texas A&M University
University of Hawaii
United States Department of Agriculture



Figure 1. A comparison of land productivity for shifting cultivation and for a continuous system that combines annual food crops with perennials.



CROPS, ESTABLISH LINKS WITH LEGITIMATE MARKETS, INCREASE PRODUCTION OF AGRICULTURAL COMMODITIES, REDUCE DEFORESTATION, AND IMPROVE THEIR SOCIOECONOMIC STANDARD OF LIVING.

Initial reactions to multistrata and low-input systems have been enthusiastic. In addition to the crops listed in Figure 1, pineapple, banana, macadamia nut, tea, citrus, and other tropical fruits are also being tested. The nutrient requirements for production that is both sustain-

able and profitable will be the focus of TROPISOILS' collaborations. These new technologies are offering viable alternatives to illegal coca production.

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COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

CHILDHOOD NUTRITION-MONITORING TECHNOLOGY

During the past decade, the NUTRITION CRSP has described the real human costs of mild to moderate malnutrition expressed in terms of impaired individual performance as well as household and community function.

Household studies conducted in rural and semi-rural communities in EGYPT, KENYA, and MEXICO show clearly that not only reduced quantity of food but especially poor quality food results in stunted growth, impaired cognitive and behavioral development, and poor school performance of children.

RESEARCHERS OF THE NUTRITION CRSP HAVE DEVELOPED DATA BASE TECHNOLOGY FOR EXAMINING FOOD NUTRIENT COMPOSITION IN ORDER TO RECOMMEND FOODS, FROM AMONG THOSE LOCALLY AVAILABLE IN THE REGION, THAT CAN BETTER ASSURE OPTIMAL GROWTH AND DEVELOPMENTAL OUTCOMES.

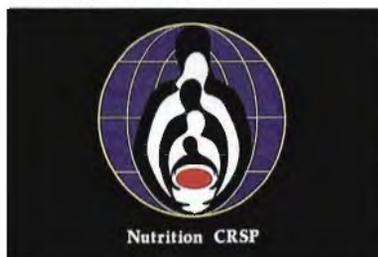
The problems are compounded by food insufficiency of mothers and resultant malnutrition, which is linked to poor-quality child caregiving.



Weighing infant in Nutrition CRSP Kenya research.

Collaborators:

PURDUE UNIVERSITY
UNIVERSITY OF ARIZONA
UNIVERSITY OF CALIFORNIA-BERKELEY
UNIVERSITY OF CALIFORNIA-LOS ANGELES
UNIVERSITY OF CONNECTICUT
UNIVERSITY OF KANSAS
NI, EGYPT
UN, KENYA
INN, MEXICO



The NUTRITION CRSP findings indicate that governmental policies which support continuing tolerance of malnutrition in children will seriously erode the quality of human resources available to these countries for 25–50 years.

This information and relevant recommendations are made available to governmental administrators interested in policy decisions which can have positive impacts on developmental outcomes of children.



Measurement of cognitive development in Kenya child.

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COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

DEGREE TRAINING

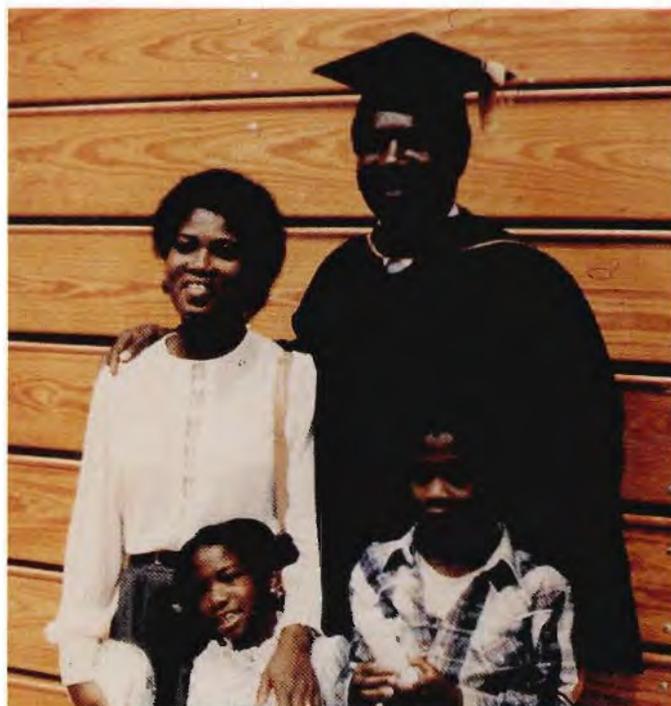
A MAJOR GOAL OF THE BEAN/COWPEA CRSP IS BUILDING AGRICULTURAL RESEARCH AND TEACHING CAPACITY. A TOTAL OF 219 GRADUATE DEGREES HAVE BEEN AWARDED.

Several surveys have been administered to CRSP students and graduates. Assessments of individual returns-to-training and personal impact indicate a positive return from the investment.

Among West African respondents, a rate of return of 31 percent is anticipated from the monetary and non-monetary benefits. These have been calculated over a thirty-year benefit/cost stream to reflect the projected lifetime earnings of the researchers.

Respondents were very positive about CRSP training, highlighting the relevance of the content of their programs to their current professions, the amount of material covered in their academic programs and the specific skills learned.

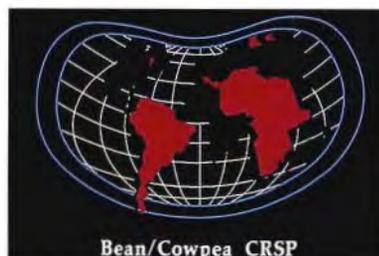
Assistantships with CRSP professors were the most highly rated practical experiences. Field trips and contact with extension personnel were also valued experiences.



African scientist, new recipient of CRSP-sponsored Ph.D., with proud and happy family

Collaborators:

BOYCE THOMPSON INSTITUTE	UNIVERSITY OF MINNESOTA
COLORADO STATE UNIVERSITY	UNIVERSITY OF NEBRASKA
CORNELL UNIVERSITY	UNIVERSITY OF PUERTO RICO
KANSAS STATE UNIVERSITY	UNIVERSITY OF WISCONSIN
MICHIGAN STATE UNIVERSITY	WASHINGTON STATE UNIVERSITY
PURDUE UNIVERSITY	BUNDA COLLEGE, MALAWI
UNIVERSITY OF CALIFORNIA-DAVIS	CNPAF/EMBRAPA, BRAZIL
UNIVERSITY OF CALIFORNIA-RIVERSIDE	EAP, HONDURAS
UNIVERSITY OF GEORGIA	INCAP, GUATEMALA
UNIVERSITY OF ILLINOIS	SOKOINE UNIVERSITY, TANZANIA
	UNIVERSITY OF NIGERIA, NIGERIA



Significant monetary benefits did follow training, with or without promotions, although salaries did not keep pace with inflation.

Personal benefits cited were increased family health care, access to education for the children and improved quality of housing.

Professionally, the respondents cited the following benefits derived from their training:

- increased prestige
- intellectual satisfaction
- increase in level of job-related responsibilities
- opportunities for travel to workshops and conferences
- communication with other researchers
- availability of increased support staff
- opportunities for secondary income through contracting, consulting, etc.
- availability of job-related transport
- greater access to books and other professional material

There was a clear indication that CRSP training strengthened linkages between farmers and researchers, researchers and policy makers, and among the researchers themselves.



CRSP students studying plants in the field.

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COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

ENVIRONMENTAL POLICY

Poverty and natural-resource degradation are linked to negative environmental impacts in the tropics. Population growth creates food, fiber, and fuel needs that lead to deforestation, decreased fallows, abandoned lands, and a general degradation of the natural-resource base. Such degradation limits future production and perpetuates poverty.

Without new sustainable-production technologies and appropriate development policies, tropical populations are condemned to deprivation. Shifting cultivation—whether by slash and burn or bulldozer clearing—must end.

THE GOOD NEWS IS THAT TROPISOILS AND ITS COLLABORATIVE RESEARCHERS HAVE DEVELOPED SUSTAINABLE SOIL AND WATER MANAGEMENT TECHNOLOGIES THAT PROVIDE SOCIAL AND ECONOMIC BENEFITS TO FARMERS WHILE PRESERVING ENVIRONMENTAL QUALITY.

Our research trials have demonstrated that, with appropriate inputs, 43 consecutive crops can be grown without yield reduction on low-fertility soils of the humid tropics (Figure 1). Deforestation reductions based on improved management options are presented in Table 1. Each option is suited for a particular socioeconomic and natural-resource setting.

Our work on the environmental consequences of such soil management practices as land clearing, liming, and fertilizing provides clear implications for policy-



TropSoils provides alternatives to slash-and-burn systems.

Table 1. Sustainable management options developed in Yurimaguas, Peru.

One ha under the sustainable management options	Saves from deforestation (ha/year)
Irrigated rice	11.0
Low-input	4.6
Continuous cropping	8.8
Legume-based pastures	10.5
Agroforestry	Insufficient data

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North Carolina State University
Texas A&M University
University of Hawaii
United States Department of Agriculture



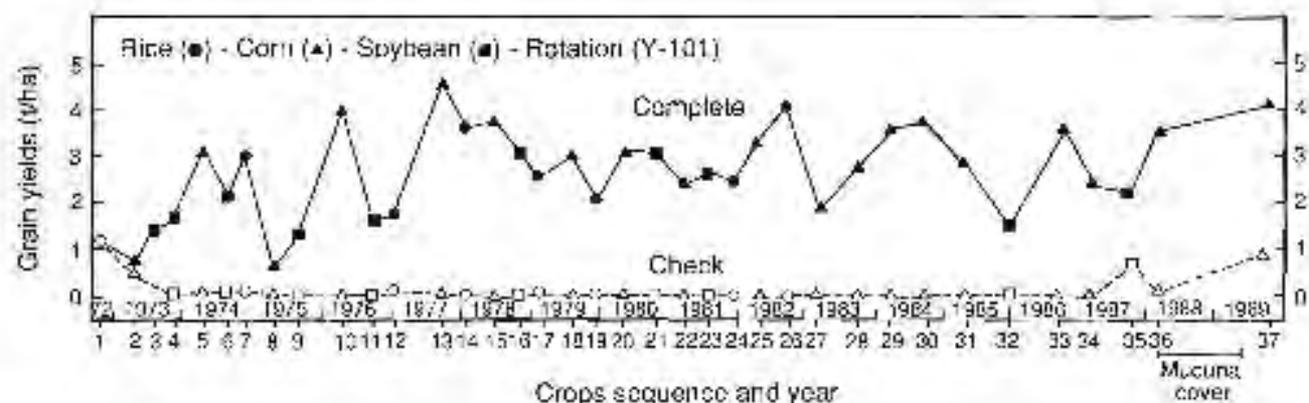


Figure 1. Forty-three consecutive crops in Yurimaguas, Peru.

makers. The potential social and economic benefits of these alternative technologies will depend on government policies regarding matters like terms of trade, taxes, credits, and land tenure.

In Paraguay, a shift from low-input to commercial production, combined with favorable terms of trade for imported fertilizer, has increased national wealth and reduced deforestation and environmental problems.

Reformed tax and credit policies in Brazil and Indonesia have improved soil management practices and discouraged bulldozer clearing. Landsat photography shows that over 72% of the deforestation in Brazil prior to 1980 was done to establish pastures. With generous incentives, investors bulldozed forests and expanded the Amazon cattle population to almost 9 million head. New tax and credit policies have greatly reduced incentives to clear virgin rainforest. Large portions of future food, fiber, and fuel needs could be supplied by applying improved management options to these abandoned and degraded pastures, provided appropriate policies are in place.

In Indonesia, transmigration from highly populated Java to settlements in forested and less populated regions resulted in rainforest destruction and land degradation. From 1971-1980, approximately one million people were moved at a cost of several thousand dollars per family. Located on acid, infertile soils, these settlers could not sustain basic food crop production. Since 1983, policy reforms along with new and appropriate soil management technologies are laying the foundation for sustainable agriculture and environmentally sound resource management.

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IMPACT

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

ENVIRONMENTAL RESTORATION

Recent research by the FISHERIES STOCK ASSESSMENT CRSP is providing methodologies which substantially assist in measuring and quantifying the impact of environmental changes on marine resources.

These methods quantify changes in congregations of fish species and, in conjunction with other methods, aid in more exactly quantifying estimates of how many there are.

INFORMATION FROM THESE METHODS GENERATED BY THE FISHERIES STOCK ASSESSMENT CRSP IS NECESSARY FOR RESTORATION OF VALUABLE LIVING WATER RESOURCES IN AREAS WHERE THERE HAS BEEN SEVERE ENVIRONMENTAL DAMAGE, e.g., LARGE OIL SPILLS.

Environmental insults to living marine resources can have a profound impact on the livelihood and health of the people who rely on them.

For example, shrimp are one of the most commercially valuable natural resources. KUWAIT alone harvested about 1,000 tons last year, which were valued at more than \$10 million. Total fish yield from the Persian Gulf exceeded 300,000 tons annually.



Marine shrimp are very valuable.

Collaborators:

UNIVERSITY OF MARYLAND
UNIVERSITY OF RHODE ISLAND
UNIVERSITY OF WASHINGTON
OMANI-AMERICAN JOINT COMMISSION



The FISHERIES STOCK ASSESSMENT CRSP methods can help measure the impact of the war in the Persian Gulf and provide crucial monitoring data important for marine resource recovery.

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Shallow-water fisheries are environmentally fragile.

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COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

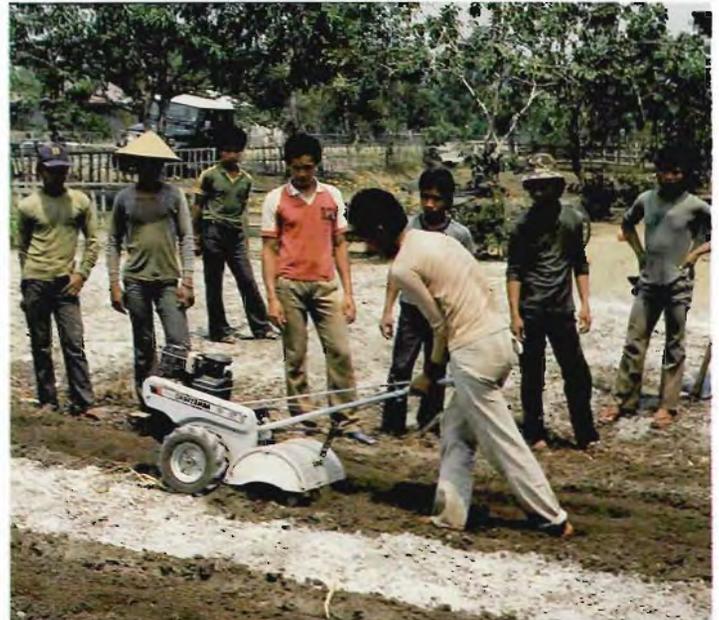
EXPERTISE ON A DISK

Unless we translate scientific knowledge into sound agricultural practices and environmental policies, sustainability cannot be achieved. Applying current technologies to specific management problems is one of the principal challenges developing countries must face.

SOIL MANAGEMENT INFORMATION INCREASES DAILY, BUT RESOURCE-POOR FARMERS OFTEN CANNOT AVAIL THEMSELVES OF IT. IF WE ARE TO OVERCOME THAT PROBLEM, SCIENTIFIC DATA MUST BE ORGANIZED IN FORMS THAT EXTENSION AGENTS AND POLICY-MAKERS CAN USE. TROPISOILS' ACIDITY DECISION SUPPORT SYSTEM (ADSS) DOES JUST THAT: IT TURNS RAW INFORMATION INTO USEFUL KNOWLEDGE.

ADSS is a menu-driven computer program that enables extension agents to diagnose and correct soil-acidity problems. Like the Phosphorus Decision Support System also being developed by TROPISOILS, ADSS belongs to a new generation of computer programs called *expert systems*. Using symbolic logic and heuristics (rules of thumb), these systems help nonexperts solve problems that would normally require a specialist. In a relatively quick, consistent, and inexpensive manner, the knowledge gained through years of research can be available to local populations and adapted to local problems.

ADSS asks a series of questions about soil, crops, liming materials, input-output prices, and climate. The



ADSS helps farmers estimate profits for various liming rates. Here, transmigrants in Indonesia attend a liming demonstration.

Cornell University
North Carolina State University
Texas A&M University
University of Hawaii
United States Department of Agriculture



program makes calculations and recommends efficient soil-management strategies (Figure 1). For example, once you have tapped the appropriate database and selected a crop, ADSS calculates aluminum tolerance and estimates profits for various liming rates.

For each soil management option you select, the software also projects costs and returns on investment. Instead of relying on guesswork or trial and error, users can make informed decisions based on the same logic and problem-solving methods an experienced soil scientist might use. ADSS is especially helpful where soils have been surveyed and described according to Soil Taxonomy, and where the results of a soil analysis are available.

The advantages of expert systems are legion. Valuable information need no longer be confined to the research site or circumscribed by the movement of a specialist. By forcing us to organize what we know into a problem-solving product, expert systems also expose knowledge gaps and guide research priorities in ways that encourage efficient use of limited funds. They help us to avoid doing what has already been done and rediscovering what is already known.

Who can benefit from ADSS? Everyone from agronomists, to the salespeople who advise farmers, to the policy-makers responsible for land use planning, land tenure, agribusiness investments, and natural-resource management.

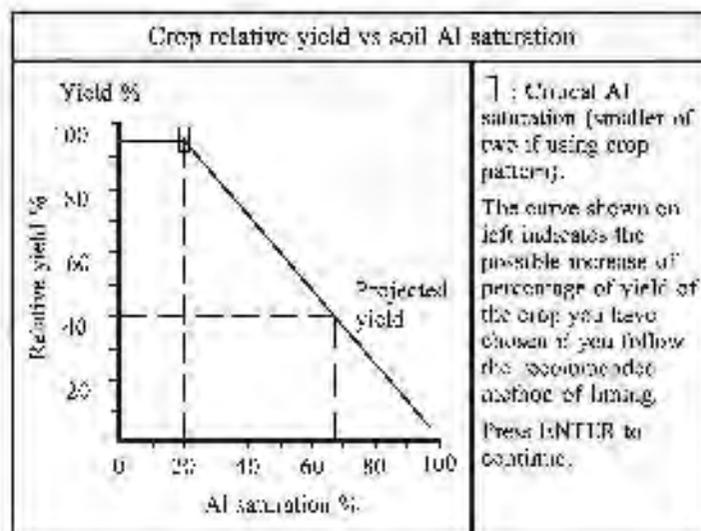


Figure 1. A sample yield chart generated by ADSS.

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COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

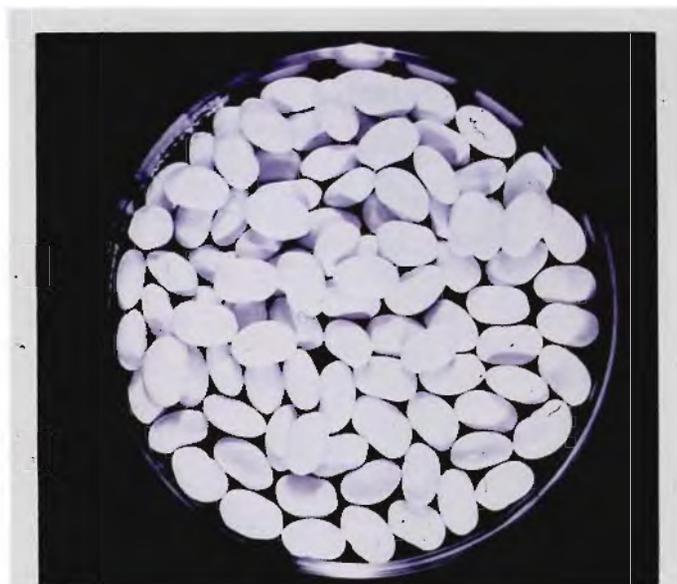
IMPROVED BEAN VARIETIES

NEBRASKA, WISCONSIN, MICHIGAN, and NEW YORK are among the states that have benefitted from the germplasm enhancement work of the BEAN/COWPEA CRSP.

THE EXCHANGE OF GERMPLASM AND PRODUCTION TECHNOLOGIES THROUGH MUTUALLY BENEFICIAL RESEARCH IS ONE OF THE MOST VALUABLE CONTRIBUTIONS OF THE BEAN/COWPEA CRSP. THE U.S. IS ONE RECIPIENT OF SIGNIFICANT FINANCIAL AND ENVIRONMENTAL GAINS.

The NEBRASKA researchers have released *Starlight*, a Great Northern bean larger and a brighter white than any others grown currently. It is expected to give NEBRASKA the competitive edge in foreign markets (e.g., European) where these qualities are important. *Starlight* has resistance to bacterial diseases (halo and common blight) and fungal diseases (white mold and rust).

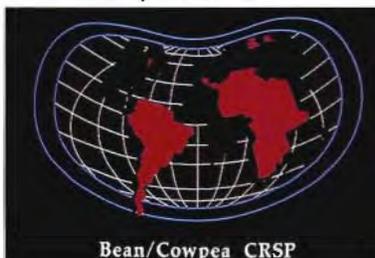
WISCONSIN researchers have released two snap bean lines with enhanced biological nitrogen fixation (BNF) capacity. This BNF capacity reduces the need for high nitrogen application levels thus reducing groundwater nitrate pollution from the run-off. WISCONSIN farmers' costs are expected to be decreased by \$15-20 per acre by the reduced requirement for chemical fertilizer.



Starlight, a new release from Nebraska research (high yielding, large, bright white Great Northern) with disease resistance.

Collaborators:

CORNELL UNIVERSITY
MICHIGAN STATE UNIVERSITY
UNIVERSITY OF NEBRASKA-LINCOLN
UNIVERSITY OF PUERTO RICO
UNIVERSITY OF WISCONSIN-MADISON
WASHINGTON STATE UNIVERSITY
USDA, PROSSER
SEA, DOMINICAN REPUBLIC
ICTA, GUATEMALA
EAP, HONDURAS
BUNDA COLLEGE, MALAWI
INIFAP, MEXICO



In MICHIGAN, new cultivars developed by Bean/Cowpea CRSP scientists are being planted on over 80,000 acres per year. These new cultivars give a 20–25 percent increase in yield. In a normal year, the increase means over \$3.7 million extra dollars for MICHIGAN growers.

In NEW YORK, a new red kidney cultivar was developed which has a yield advantage of 30 percent over former cultivars and has shown superior canning quality. Planted on 2,000 acres per year, with a 5 bushel (300 lb.) increase per acre, this cultivar can mean \$150,000/year extra income for NEW YORK growers.



Nebraska research plots showing full large-seed Starlight Great Northern plants compared with much smaller plants of another Great Northern which has small seed size.

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Caption 19A

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COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

IMPROVED BEAN VARIETY

Through BEAN/COWPEA CRSP training (nine advanced degrees), improvements at the Arroyo Loro Experiment Station, and increased support from the government of the DOMINICAN REPUBLIC (DR), there is an enthusiastic bean research team in place.

One of the newest products of this collaboration is the new improved *PC-50* bean cultivar which has high yield, a fine-quality grain preferred by DR consumers, and high resistance to rust (a wide-spread and highly destructive fungal disease).

About 60 percent of the dry bean crop in the DR was planted to this cultivar in 1990.

AMONG SURVEYED GROWERS, MEAN YIELD FROM *PC-50* WAS 987 KG/HA IN THE DR, WHILE MEAN YIELD FOR THE COUNTRY OVER THE LAST TEN YEARS WAS 505 KG/HA.

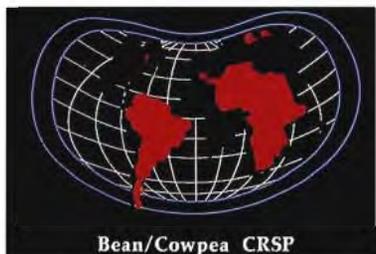
The BEAN/COWPEA CRSP scientists from the DR and their U.S. counterparts have evolved an unusually well-integrated research effort that is both basic and applied. They have collaborated with the Seed Department of the DR Ministry of Agriculture, which increased and distributed the seed of *PC-50* to farmers.



PC-50, a new release by the Ministry of Agriculture in the Dominican Republic, high-yielding, disease-resistant seed of the locally preferred type.

Collaborators:

UNIVERSITY OF NEBRASKA-LINCOLN
UNIVERSITY OF PUERTO RICO
UNIVERSITY OF WISCONSIN-MADISON
SEA, DOMINICAN REPUBLIC



The strong acceptance of *PC-50* will make a major contribution to increased and more stable yields in the DR. Because it is of the preferred type, increases in plantings and consumption are expected.

In the study of grower acceptance, the top reasons given for growing *PC-50* were the high quality of the seed, its market-ability, and productivity. The most significant qualities were color of the grain (red mottled), yield and size (large).

Of the farmers surveyed, 92 percent said they wanted to continue growing *PC-50* because the seed quality is good, it is profitable, they could get credit easily by growing it, and they personally like the variety. Some pointed out that it is a widely adapted variety and the weight and uniformity of the seed are good.

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PC-50 seed production field in the Dominican Republic.

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COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

IMPROVED COWPEA TECHNOLOGY

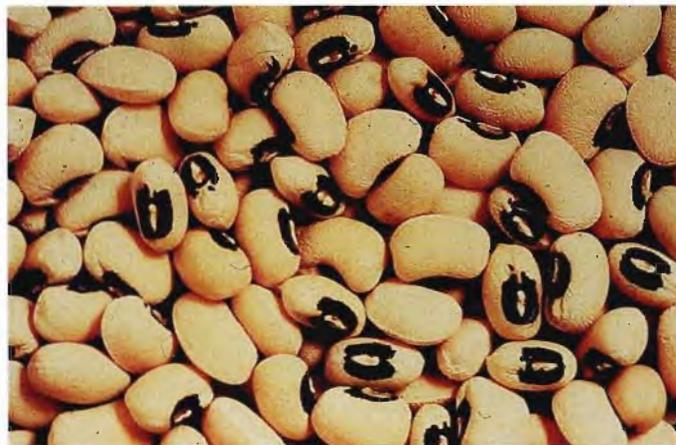
In northern SENEGAL, droughts had reduced food supplies to near-famine levels but BEAN/COWPEA CRSP research demonstrated that cowpeas can produce substantial amounts of food when all other crops fail.

WITH A MAJOR CALIFORNIA VARIETY AUGMENTING LOCAL LANDRACES, COWPEA PRODUCTION INCREASED FROM 16,000 TONS IN 1984 TO ABOUT 80,000 TONS IN 1985. IN SPITE OF THE CONTINUED DROUGHT THAT YEAR, THE ADDITIONAL SUPPLIES OF COWPEAS PROVIDED A MILLION HUNGRY PEOPLE WITH IMPORTANT QUANTITIES OF FOOD.

A rate of return analysis indicated the BEAN/COWPEA CRSP research in SENEGAL had generated a return of 63 percent per dollar invested.

The research had determined that early-maturing cowpeas, e.g., *California Blackeye #5*, could be effective in the driest parts of northern SENEGAL.

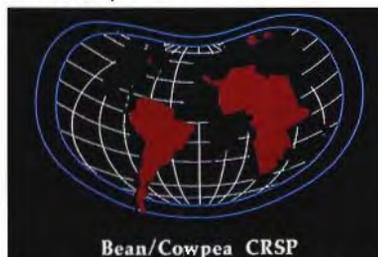
The rate of return analysis assessed the effectiveness of this and other cowpea varieties and new production technologies developed.



California Blackeye #5 seed which responded to emergency conditions in Senegal.

Collaborators:

UNIVERSITY OF CALIFORNIA-RIVERSIDE
ISRA, SENEGAL



With 1 million people threatened with starvation in 1985, the European Economic Community, USAID and the Government of Senegal purchased from CALIFORNIA farmers 700 tons of this seed for emergency distribution. This seed was distributed to Senegalese farmers together with advice from BEAN/COWPEA CRSP researchers on the most effective methods for growing the crop.

Since 1985, expanded production in northern SENEGAL has continued to avert famine in this extremely harsh environment.



On-station tests of seed germination under stress conditions.

For more information, contact:

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IMPACT

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

INCREASED FISH PRODUCTION

Fish farming in HONDURAS is experiencing rapid growth as indicated by a 600 percent increase in demand for tilapia fingerlings from 1986 to 1990. Under the guidance of the POND DYNAMICS/AQUACULTURE CRSP, Honduran fish farmers are using new technologies to meet this growing demand.

DURING THE 5.5-MONTH TILAPIA PRODUCTION CYCLE, NET RETURNS TO LAND, LABOR AND MANAGEMENT FROM THESE TECHNOLOGIES RANGED FROM \$642 TO \$174/HA FOR THE LOW TO HIGH FERTILIZATION RATES, RESPECTIVELY.

A study of tilapia production in HONDURAS established, first, the profitability of using chicken litter as an organic fertilizer. Gross yield of tilapia increased significantly, with applications of 1,000 kg total solids/ha/wk yielding the greatest estimated profit.

Second, to fertilize ponds more efficiently, scientists recommended supplementing chicken manure with urea as an alternative to using the manure alone. Their research showed that to support the same yield, the amount of manure needed was nearly ten times greater when used alone than when mixed with urea. Each week this information saves the Honduran fish farmer \$30 in fertilizer costs.



Chicken litter being used to fertilize fish pond.

Collaborators:

AUBURN UNIVERSITY
UNIVERSITY OF HAWAII
RENARE, HONDURAS



Additional research found corn gluten, a by-product of the corn starch process, to be a cost-effective feed in tilapia and carp polyculture. This feed is much cheaper than the pelleted fish feed traditionally used. Corn gluten generates roughly 80 percent of the regular fish yield but does so at 50 percent of the cost.



Harvesting tilapia in Honduras.

Finally, because tilapia males grow much larger than females, the scientists used a synthetic male hormone to cause young fry to develop as males. The treatment is 97 percent effective and is recommended for use at the government hatcheries as well as for qualified fish culture operations.

Through the recommendations generated by this research, new technologies enable the fish farmers of HONDURAS to meet the high demand for fingerlings every year.

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IMPACT

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

IMPROVED GOAT FOR MILK AND MEAT

A dual-purpose goat that produces both milk and high-quality meat has been developed by the SMALL RUMINANT CRSP. Without incurring additional capital expense, farmers have been able to double their net return per animal.

EXPRESSED ON A PER HECTARE BASIS, EACH DUAL-PURPOSE GOAT GENERATES AN AVERAGE OF \$52 ADDITIONAL INCOME FOR THE GOAT PRODUCERS. FOR THE 200,000 FARMERS WHO ARE THE BENEFICIARIES OF SMALL RUMINANT CRSP RESEARCH TO DATE, THIS REPRESENTS A POTENTIAL ADDITIONAL NET INCOME OF \$10 MILLION.

The introduction of dual-purpose goats with the improved forage production practices has resulted in a 66 percent increase in food yield from goats for the small-scale farm families.

Conservatively, if only 10 percent of the humid and sub-humid areas in KENYA were available for food crops and fallow, the potential annual benefits to small-scale farmers would amount to \$2.5 million.

Dual-purpose goat production is integrated with maize production to meet does' requirements for nutrition and lactation. Two lactating does can thrive on the



Kenyan technician milking dual-purpose goat at research station.

Collaborators:

TEXAS A&M UNIVERSITY
UNIVERSITY OF MISSOURI-COLUMBIA
WASHINGTON STATE UNIVERSITY
WINROCK INTERNATIONAL
KARI, KENYA



by-products of a quarter-hectare of maize for five months, with the last trimester of pregnancy planned to coincide with the thinning stage of the corn crop.

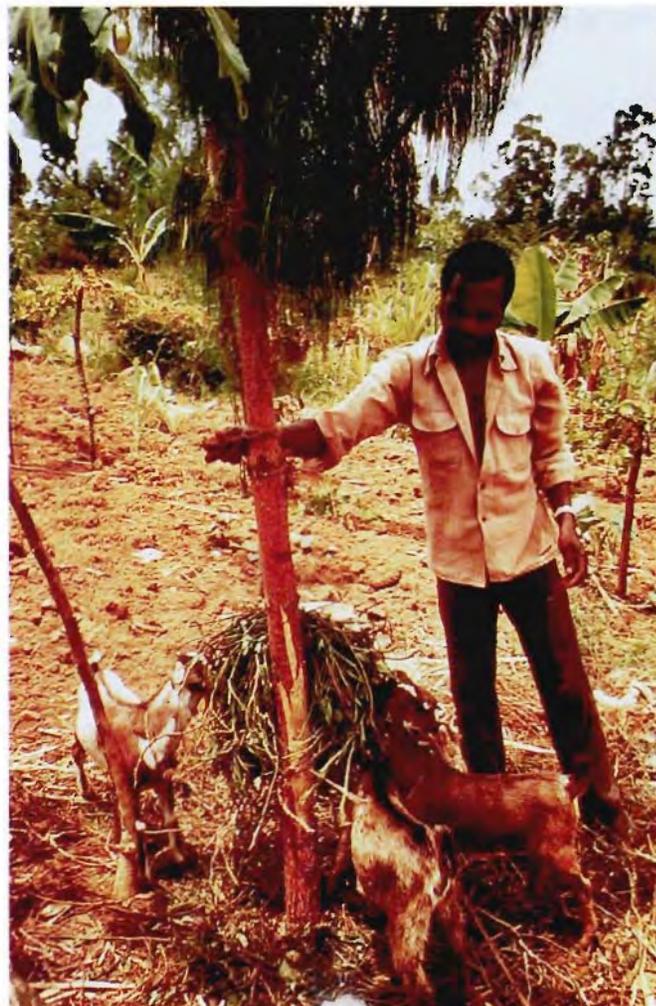
Further profitable integration of goat and crop production has been demonstrated by the SMALL RUMINANT CRSP through the use of sweet potatoes. After the tubers are taken for human consumption, sweet potato vines and leaves have been found to be an ideal milk substitute for goat kids.

With the feeding strategy developed, goat kids can be weaned by one month of age, allowing the farmer to realize maximum milk off-take from does without injuring the welfare of the progeny.

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Small-scale farmer in Kenya feeding sweet potato vines and leaves to goat kid, replacing doe's milk.

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IMPACT

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

IMPROVED LAMB PRODUCTION

In Indonesia, the demand for sheep and goat meat far exceeds the supply. The growing population compounds this problem.

To meet this challenge, the scientists of the SMALL RUMINANT CRSP have focused on developing sheep that produce two or more lambs per year. They have also given attention to expanding and better utilizing local feed resources.

A HIGHLY PROLIFIC STRAIN OF JAVANESE THIN TAIL SHEEP AVERAGES 2.8 LAMBS PER LITTER, NEARLY DOUBLE THE AVERAGE IN WEST JAVA. THIS MEANS A POTENTIAL ANNUAL INCREASE, IN SHEEP PRODUCED IN THIS PROVINCE, OF 1.5 MILLION HEAD, WHICH ADDS \$18 MILLION PER YEAR TO FARMERS' INCOMES.

Further, the integration of crop and animal systems through the utilization of crop residues (e.g., rubber and coconuts) as feed for sheep provides new sources of nutrition.

Sheep also consume vast amounts of weeds, thus reducing the need for chemical measures to control for weeds.



Javanese Thin Tail Ewe with four lambs, a product of prolific-sheep research applying nutrition and breeding principles to small-scale enterprises.

Collaborators:

UNIVERSITY OF CALIFORNIA–DAVIS
UNIVERSITY OF MISSOURI–COLUMBIA
NORTH CAROLINA STATE UNIVERSITY
WINROCK INTERNATIONAL
AARD, INDONESIA
RUBBER RESEARCH INSTITUTE, INDONESIA



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North Sumatran sheep feeding on improved forages in small-scale farming enterprise.

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COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

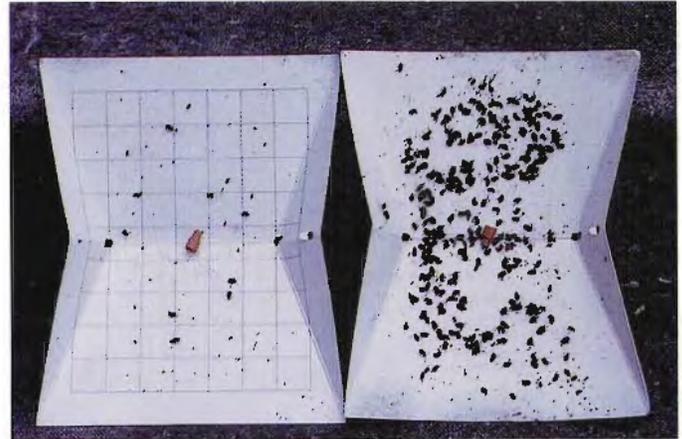
IMPROVED PEANUT PRODUCTION

The NORTH CAROLINA–VIRGINIA peanut production area covers about 250,000 acres or 15 percent of the 1.7 million acres of peanuts in the United States. Gross value of the crop to farmers averages over \$200 million annually.

Extensive Integrated Pest Management (IPM) research has been underway by the PEANUT CRSP to decrease chemical use to control southern corn rootworm. The result is monetary savings to the farmer and a reduction in potential chemical damage to the environment.

UNDER CURRENT PRODUCTION COSTS, MONETARY SAVINGS FROM PEANUT CRSP IPM TECHNOLOGY IN THE NORTH CAROLINA–VIRGINIA AREA FOR THE CONTROL OF SOUTHERN CORN ROOTWORM IS EXPECTED TO REACH \$1.5 MILLION ANNUALLY.

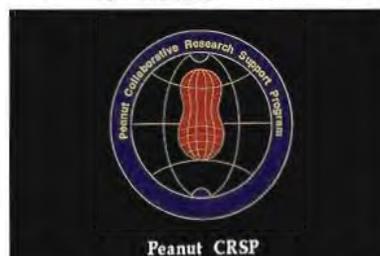
Southern corn rootworm causes extensive damage to peanuts in the area and much work has been done to develop IPM strategies, e.g., pest-tolerant cultivars, cultural control and application of chemicals based on when insect numbers reach threshold damage levels.



Pheromone traps monitor seasonal build-up of southern corn rootworm beetle (adult stage).

Collaborators:

NORTH CAROLINA STATE UNIVERSITY
UPLB, PHILIPPINES
DEPARTMENT OF AGRICULTURE, THAILAND
KHON KAEN UNIVERSITY, THAILAND



For example, use of the cultivar *NC-6*, identified as tolerant in conjunction with the PEANUT CRSP, can cut in half the chemicals needed (and thus the cost) for southern corn rootworm control.

Further, early season build-up of the southern corn rootworm, monitored by numbers caught in pheromone traps, reveals when the early season populations reach economic threshold levels for pod damage later in the season. Control based on economic thresholds can bring additional savings and reductions in chemical use.



Pheromone trap mounted in peanut field.

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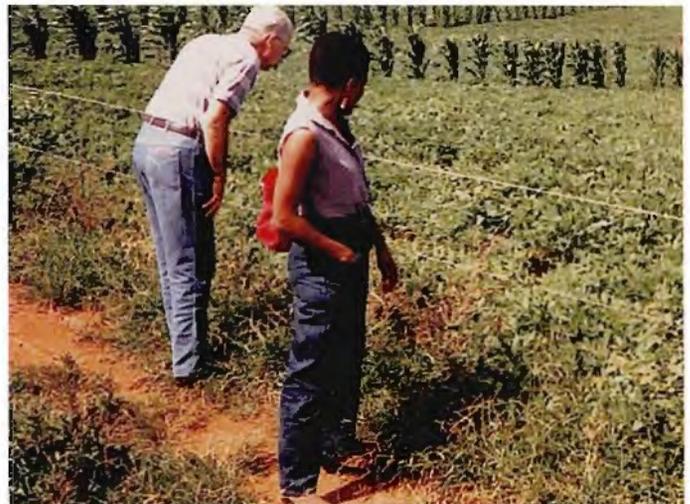
IMPROVED PEANUT VARIETY

JAMAICA is a net importer of peanut and peanut products. The level of production is small and has little impact on the domestic price. Indeed, all output can be sold at international market prices. Thus, increases in peanut yield can substantially benefit the small-scale farmer.

WITH NO INCREASE IN THE 5,000 ACRES PLANTED, A NEW PEANUT CULTIVAR, *CARDI-PAYNE*, CAN POTENTIALLY INCREASE PEANUT PRODUCTION IN JAMAICA BY 1 TO 3 MILLION POUNDS ANNUALLY. THE ANNUAL VALUE TO THE ECONOMY FROM THE INCREASED YIELD OF *CARDI-PAYNE* IS IN THE RANGE OF \$600,000, TEN TIMES THE RESEARCH INVESTMENT MADE TO DEVELOP IT.

CARDI-Payne yields 42 percent over the traditional peanut cultivar and is acceptable to consumers, especially for peanut butter production.

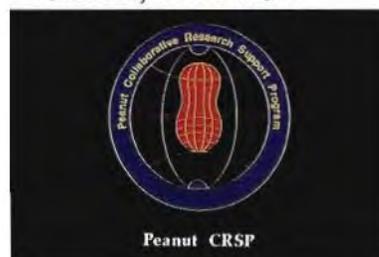
There has been early adoption of this cultivar by some Jamaican farmers. With a strong extension group aiding in its diffusion, *CARDI-Payne* will prove of substantial benefit in the country.



The new *CARDI-Payne* peanut cultivar growing in farmers' fields, Jamaica.

Collaborators:

UNIVERSITY OF GEORGIA
MINISTRY OF AGRICULTURE, JAMAICA
CARDI, JAMAICA

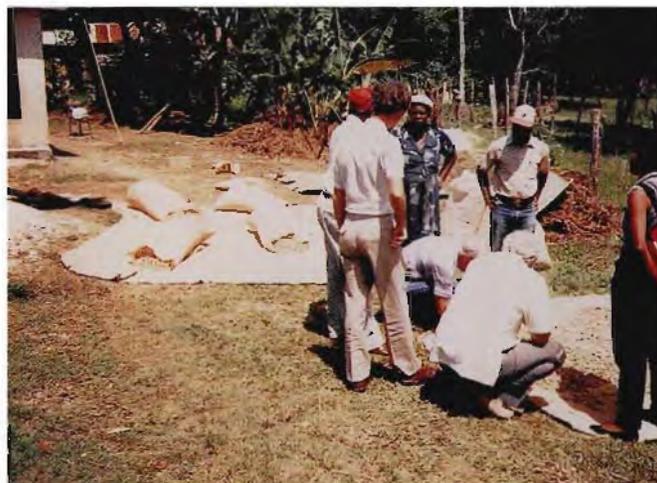


CARDI-Payne was developed through the collaboration of the PEANUT CRSP and the Caribbean Agricultural Research and Development Institute (CARDI).

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The new *CARDI-Payne* peanut cultivar harvested from farmers' fields, Jamaica.

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IMPACT

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

IMPROVED PRODUCTION FOR ACID SOILS

There are almost 2 million acres of low pH, low fertility, and aluminum toxic soils in the eastern plains of COLOMBIA. Acid soils and aluminum toxicity have limited the establishment of crops in this region. The area is so remote it is not economically feasible to move soil amendments into the area, e.g., calcium and phosphorous.

In response, SORGHUM/MILLET CRSP (INTSORMIL) scientists are generating improved sorghum varieties for the region.

On January 21, 1991, ICA announced the release of two sorghum varieties, *Sorghica Real 60* and *Sorghica Real 40* for planting in the Colombian acid soils areas.

IT IS ANTICIPATED THAT 50,000 ACRES WILL BE PLANTED TO THESE NEW VARIETIES IN 1991 WITH A MARKET VALUE OF ABOUT \$5 MILLION.

The program was started in 1983 and focused on the selection and evaluation of sorghum genotypes tolerant to acid soils and aluminum toxicity.

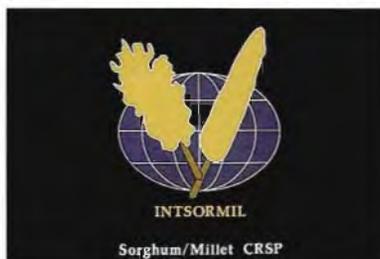
To date, six private seed companies have requested 100 MT of foundation seed which will be increased and sold to farmers.



Colombian researchers and commercial sorghum producer examine new acid-tolerant sorghum varieties.

Collaborators:

MISSISSIPPI STATE UNIVERSITY
UNIVERSITY OF NEBRASKA
TEXAS A&M UNIVERSITY
CIAT
ICA, COLOMBIA
FEDEARROZ, COLOMBIA
FENALCE, COLOMBIA
OCCIDENTAL, COLOMBIA



Three private seed companies from PERU, VENEZUELA and BRAZIL also have requested breeders' seed of these new releases. The varieties have potential for the acid soil regions of AFRICA as well.

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Telex: 438087 UN INTPRG LCN



Colombian INTSORMIL investigator shows differences among sorghum cultivars for tolerance to acid soils.

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IMPACT

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

IMPROVED SHEEP PRODUCTION

COLORADO, CALIFORNIA, MONTANA, TEXAS, UTAH, WYOMING and NEW MEXICO are among the states benefitting from sheep production research conducted by the SMALL RUMINANT CRSP.

U.S. rangelands management, forage production, and genetic resistance to internal parasites have been important topics of research for these areas.

SMALL RUMINANT CRSP GENETICS AND PARASITE RESEARCH HAVE IDENTIFIED PARASITE-RESISTANCE IN SHEEP THAT IS ESTIMATED TO SAVE U.S. SHEEP PRODUCERS NEARLY \$40 MILLION PER YEAR.

Further, validated computer simulation models are available to help the U.S. sheep industry evaluate the potential for leaner lamb meat production.

Simulations indicate that traditional U.S. lamb producers can increase net profits by \$3 to \$6 per head.

These profits, applied to the 1 million head fed annually in COLORADO, TEXAS, OREGON, WYOMING, KANSAS and CALIFORNIA, are projected to increase net returns each year by \$3 to \$6 million.



Typical U.S. rangeland enterprise grazed by meat- and wool-producing breed of sheep in Wyoming.

Collaborators:

COLORADO STATE UNIVERSITY
MONTANA STATE UNIVERSITY
TEXAS A&M UNIVERSITY
TEXAS TECH UNIVERSITY
UNIVERSITY OF CALIFORNIA-DAVIS
UNIVERSITY OF MISSOURI-COLUMBIA
UTAH STATE UNIVERSITY
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Large lamb feeding operation in Colorado.

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IMPACT

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

IMPROVED SHRIMP PRODUCTION

Researchers from the POND DYNAMICS/ AQUACULTURE CRSP collaborated with the private sector in HONDURAS to develop technologies that would reduce operating costs. Because commercial rations are a major expense in shrimp farming, attention was paid to developing alternative, cost-effective feeds. The behavior of juvenile shrimp was also studied.

BIOLOGICAL STUDIES OF FEEDING BEHAVIOR IN MARINE SHRIMP, CONDUCTED BY THE POND DYNAMICS/ AQUACULTURE CRSP, LED TO SAVINGS OF NEARLY \$1 MILLION A YEAR FOR SHRIMP GROWING IN HONDURAS.

The research determined that young shrimp do not feed until four weeks after hatching. This single finding saved shrimp farmers one month of feed costs per growing cycle, generating a savings of \$975,000 in the first year the delayed feeding strategy was recommended.

Additional savings came from recommendations to decrease direct feeding of shrimp by using fertilizers less expensive than feed (e.g., chicken litter) to enrich the pond environment and thereby indirectly feed the shrimp. It was determined that chicken litter at 250 kg/ha/wk can substitute for feed during the first 4 to 8 weeks of cultivation.



Shrimp harvesting in Honduras.

Collaborators:

AUBURN UNIVERSITY
UNIVERSITY OF HAWAII
RENARE, HONDURAS



This production technology is important in HONDURAS, the second poorest country in the western hemisphere, where shrimp is the fourth largest export commodity and an important source of foreign exchange.

Together, these findings are producing considerable savings for shrimp farmers—in Honduras, the U.S., or wherever shrimp are cultivated.

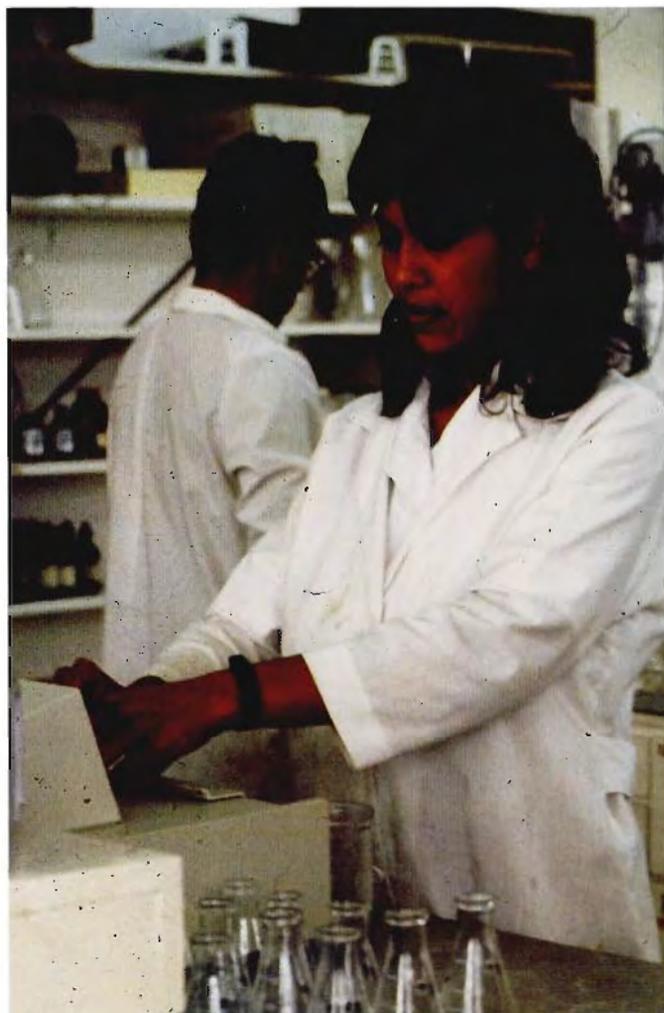
As worldwide demand for shrimp grows and estuarine habitats deteriorate, wild shrimp stocks are becoming depleted. Improvements in hatchery technologies can reduce some of the pressures placed on native, wild stocks of shrimp.

Using locally available ingredients, the scientists generated yields exceeding that obtained with commercial rations. They recommended that, for best survival, growth, and feed efficiency, juvenile shrimp be fed a 25 percent protein diet and stocked at low densities in an environment containing substrate.

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Technician conducting pond water-quality experiments.

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IMPACT

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

IMPROVED SORGHUM PRODUCTION

Nearly all U.S. sorghum production is from hybrid varieties grown under dryland conditions and is used as feed and for export (e.g., MEXICO). Two-thirds of the cattle in the Southwest U.S. and one-third of the cattle in the Midwest, who are on feed, are fed sorghum. The U.S. value of sorghum at the farm gate is about \$840 million.

U.S. losses from greenbug are estimated at \$248 million annually when irrigated grains must be substituted for the dryland sorghum damaged by this pest.

ECONOMIC GAINS TO THE U.S. FROM GREENBUG RESISTANT (TYPE e) SORGHUM DEVELOPED BY THE SORGHUM/MILLET CRSP (INTSORMIL) WAS \$389 MILLION UNDER CURRENT FARM PROGRAM PROVISIONS.

In the period 1979–1989, total funding for INTSORMIL programs (including non-federal funds) for KANSAS, NEBRASKA and TEXAS was \$21.7 million, with \$14.7 million of this used to fund research in sustainable plant protection systems, germplasm enhancement and conservation, and sustainable production systems.



Adult and juvenile stages of greenbugs damage sorghum plant by piercing leaf.

Collaborators:

KANSAS STATE UNIVERSITY
MISSISSIPPI STATE UNIVERSITY
PURDUE UNIVERSITY
TEXAS A&M UNIVERSITY
UNIVERSITY OF ARIZONA
UNIVERSITY OF KENTUCKY
UNIVERSITY OF NEBRASKA



The annual rate of return to the research investment in the U.S. is 49.2 percent. When impacts of sorghum exports are considered, worldwide net gain is \$113 million and the global annual rate of return on the research investment is 33.4 percent.

Worldwide production of sorghum, the fifth most important cereal globally, is 60-70 million MT from 40-50 million ha. In 1988, the U.S. share, 24 percent of world production (14.670 million MT), was produced on 8 percent of the sorghum area (3.663 million ha).



Healthy greenbug-resistant sorghum variety compared with susceptible varieties.

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COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

IMPROVED SORGHUM VARIETY

Hageen-Dura I (HD-I), a high food-quality sorghum hybrid, is a joint product of the SORGHUM/MILLET CRSP (INTSORMIL), the Sudan Agriculture Research Corporation (ARC) and ICRISAT. It was released in SUDAN in 1983.

THE RATES OF RETURN TO RESEARCH ON *HD-I* WITHOUT FURTHER EXPANSION OF THE AREA PLANTED IN *HD-I* IS 22 PERCENT AND 31 PERCENT FOR LOW AND HIGH FERTILIZATION LEVELS RESPECTIVELY.

HD-I has found a niche in the Gezira Irrigation Scheme of SUDAN, one of the largest irrigation projects in the world.

Over the period of 1983–1990, Gezira sorghum production ranged from 164,000 to 243,000 hectares and was 6 percent to 24 percent of total sorghum production in SUDAN. The 24 percent was the contribution of the irrigated sector during the major drought year 1984–85.

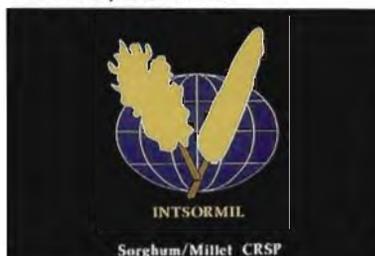
The introduction of *HD-I* is changing the sorghum marketing situation in the irrigated sector. From farm surveys in 1990, farmers producing local sorghum cultivars purchased 12 to 26 percent of their sorghum for home consumption.



Sudanese scientists and farmers examine field of HD-I.

Collaborators:

PURDUE UNIVERSITY
TEXAS A&M UNIVERSITY
ICRISAT
ARC, SUDAN



In contrast, farmers producing *HD-I* sold 25 to 33 percent of their production over this same period. The availability of this marketed surplus gave these farmers another income source, as well as consumption benefits.

Farmers growing *HD-I* with moderate fertilization and other recommended practices produced 3.28 MT/ha as compared with 1.13 MT/ha for the traditional varieties without fertilizer. The introduction of *HD-I* is convincing farmers to invest in fertilizer with their own resources.



Sudanese scientists and farmers in HD-I field ready for harvest.

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IMPACT

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

IMPROVED STORAGE TECHNOLOGY

The cowpea weevil is a very serious post-harvest pest in many parts of the world, especially WEST AFRICA. In just three months, high infestations in storage can destroy over 50 percent of stored grain.

IN WEST AFRICA ALONE, COWPEA WEEVIL LOSSES ARE ESTIMATED IN THE LITERATURE TO BE IN EXCESS OF \$50 MILLION. USING NEW SOLAR TECHNOLOGY DESIGNED BY BEAN/COWPEA CRSP SCIENTISTS, THESE LOSSES CAN BE ELIMINATED.

The low-technology solar heater designed by these scientists is effective, yet cheap and easy to build from locally available materials. The solar heater, continually being improved and expanded, is fabricated using insulating plant material (e.g., dry grasses or other plant residue) and large squares of both black and translucent plastic sheeting.

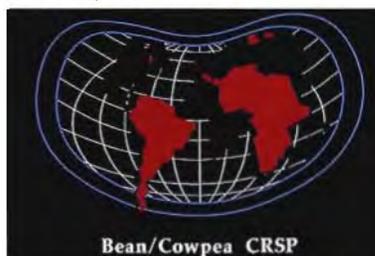
The BEAN/COWPEA CRSP scientists found that exposing cowpeas to temperatures around 65°C for a few minutes killed all of the stages of the weevil in and on the seed. Germination and cooking time, in the varieties studied, are little affected by this technology.



Solar heater composed of four layers: insulating material (not visible), black plastic (heat absorbing), infested cowpeas, clear plastic (greenhouse effect).

Collaborators:

PURDUE UNIVERSITY
IRA, CAMEROON



The new solar disinfestation technology for cowpea stocks will have a dramatic impact on low-resource farmers in developing nations.

This technology is also adaptable to beans and other crops with insect storage problems and is able to reduce the use of hazardous chemicals currently used for storage purposes.



On-station experiments using solar heaters for disinfesting cowpeas. Traditional granaries visible in background.

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COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

INTEGRATED SOIL & WATER MANAGEMENT

In semiarid Africa, population pressure and climatic change destroy vegetation, increase water and wind erosion, and degrade the land.

TO COMBAT THESE PROBLEMS, TROPISOILS' LONG-TERM RESEARCH IN NIGER HAS DEVELOPED LAND-REJUVENATION TECHNOLOGIES THAT COMBINE AGROFORESTRY WITH ENVIRONMENTALLY SOUND SOIL, WATER, AND CROP-PRODUCTION PRACTICES.

Transferring sustainable systems to this region requires the following: an understanding of indigenous technologies; an inventory of available soil, water, and vegetative resources; and an ability to integrate new technologies into local farming systems.

Our research site is a model watershed near Niamey, Niger. A biodiversity survey identified 119 plant species, 65% of which are annuals. About 30 species are used for forage, food, fuel, shelter, and medicine. Villagers have expressed concern, however, that this number may be decreasing. TROPISOILS' technologies are now preserving these species, which, in turn, rejuvenate the soil, control water and wind erosion, and contribute to agroforestry projects.

TROPISOILS' researchers found that micro-highs in the soil surface could significantly improve millet and cowpea growth and also influence tree and shrub distribution. Micro-highs form when nutrient-rich dust collects in twigs and other plant residues. Nutrient



New technologies can reduce erosion across the Sahel.

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North Carolina State University
Texas A&M University
University of Hawaii
United States Department of Agriculture



harvesting via dust collection has now become standard practice in agroforestry and revegetation efforts. Native grasses grow amongst the residues, thus providing biomass for animals. If this simple practice were adopted across the Sahel, wind erosion could be greatly reduced, as could the environmental and health problems caused by dust.

When farmers reported that decreasing soil fertility and low yields were reducing fallows and increasing nonproductive lands, TROPISOILS' research demonstrated that a sustainable system could be established by applying small amounts of phosphorus—either from animal manure or inorganic fertilizer - to interplantings of millet and cowpea. Millet and cowpea grains provide foods, cowpea foliage provides marketable animal fodder, and millet stalks provide construction material, animal fodder, and dust-collecting mulch.

Seventy percent of the local rainfall is estimated to be lost by surface runoff. Recognizing that *effective* rainfall not *total* rainfall is the key to crop production, TROPISOILS has installed diguettes and syrup-pan systems as water catchments to slow runoff, increase infiltration, and reduce erosion. Natural revegetation in these catchments collects nutrient-rich dust, increasing the biomass that can be used for fuel and forage.

By integrating new and indigenous technologies, TROPISOILS has begun to rejuvenate degraded lands, produce sustainable yields, increase earnings, and improve the quality of life.



Diguettes slow runoff, increase infiltration, and reduce erosion.

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IMPACT

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

LIME—A RESOURCE FOR AGRIBUSINESS

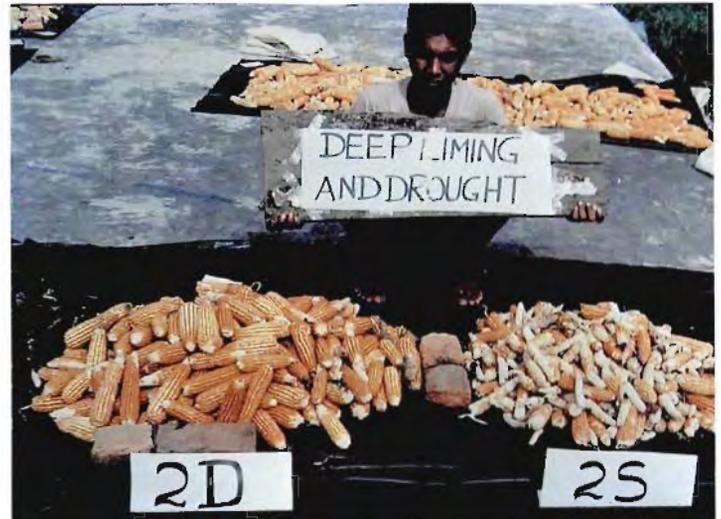
Because tropical Oxisols and Ultisols are acid and highly saturated with aluminum, they are toxic to many plant roots. Low in nutrients, these soils sustain crops for no more than a few years. Erosion then further degrades the soil.

To expand agricultural production and reduce land pressure on Java, over 12,000 transmigrant families were moved into this kind of environment at Sitiung, Sumatra, Indonesia. These resource-poor farmers considered lime amendments too expensive, too difficult to incorporate. They resigned themselves to growing a few acid-tolerant crops low in nutritional value.

ONCE TROPISOILS AND ITS COLLABORATORS ESTABLISHED LIME'S RESIDUAL EFFECT, HOWEVER, FARMERS' VIEWS CHANGED. SO DID THEIR YIELDS: FARMERS NOW GROW MANY MARKETABLE CROPS, COMBAT DROUGHT EFFECTIVELY, APPLY FERTILIZERS AND CHEMICAL INPUTS EFFICIENTLY, AND PRODUCE LARGER VOLUMES ON SMALLER PLOTS.

Agricultural lime is nothing more than finely ground natural limestone. When mixed with the soil, however, lime neutralizes acidity, detoxifies aluminum, and supplies plants with calcium and magnesium. Lime is found in abundance within 50 km of Sitiung.

Recognizing lime as a key to reclaiming marginal land, TROPISOILS began collaborative research to



Note the difference in yield for corn that received lime at 2 tons/ha to a 50-cm depth (2D) as compared with corn that received lime at 2 tons/ha to a 10-cm depth (2S).

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United States Department of Agriculture



determine the immediate and long-term benefits of a single, carefully calibrated application. Previously, cost-effectiveness could not be established because lime's residual effect was unknown, the optimum depth of incorporation was undetermined, the leaching rate was unmeasured, and the role of organic matter as a lime substitute was unquantified.

Field research established lime responses for Indonesia's most important foods. In the first year, liming at 3 tons/ha produced the following yield increases: SOYBEAN 1279%, MUNGBEAN 482%, CORN 138%, and COWPEA 37%. Liming at 2 tons/ha improved RICE yield 100%, while 1 ton/ha improved PEANUT yield 88%.

These results stimulated research on whether lime PLACEMENT might reduce drought risks. We now know that deep placement helps corn roots extract water from greater depths, thus preventing moisture stress. Over a three-harvest period, liming at 1 ton/ha to a 10-cm (4-in) depth improved yields 117%; liming to 20-cm (8-in) and 50-cm (20-in) depths improved yields 239% and 330%, respectively. Liming at 2 tons/ha to a 10-cm depth raised yields 213%; 2 tons/ha to a 20-cm depth raised them 269%; and 2 tons/ha to a 50-cm depth raised them 357%. Depth of incorporation or volume of soil amended proved more important than application rates. Indeed, deep placement can prevent moisture stress during rainless periods of up to three weeks.

These results suggest that lime can act as an inexpensive substitute for irrigation systems. Research continues to

measure the residual effects (SUSTAINABILITY) of these lime treatments. On-farm research has stimulated interest and given farmers hope that their land can produce sustainable yields.

If producing agricultural limestone is to be a viable AGRIBUSINESS, credit policies must be determined by lime's residual value, rather than its immediate value. Once research is complete and production technologies available, agricultural policies can be formed on such matters as quality standards, marketing, storage, supportive agribusinesses, prices, land values, cadastre policies, and loan ceilings.

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IMPACT

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

MALNUTRITION SCREENING PROCEDURES

The research of the NUTRITION CRSP has determined that the quality, not just the quantity, of the nutrient intake affects cognitive development and school performance of children.

Based on these findings, a major policy decision, instituting a malnutrition-screening program, was made by the state of CALIFORNIA.

AN INTEGRATED SET OF TECHNIQUES FOR ASSESSING SIGNS OF CHRONIC MALNUTRITION WERE ADAPTED OR DEVELOPED AND TESTED BY INTER-DISCIPLINARY TEAMS OF NUTRITIONISTS, PHYSICIANS, PSYCHOLOGISTS AND ECONOMISTS OF THE NUTRITION CRSP.

The Child Health Disabilities Program of the Department of Health Services, Health and Welfare Agency of California has implemented a rigorous screening program for malnutrition and an intervention referral system based on the work of the NUTRITION CRSP.

This set of techniques is available to nutrition programs throughout the U.S., especially those serving children from disadvantaged homes.

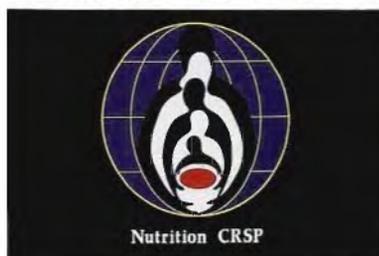


Height measurement as part of a screening program for chronic malnutrition.

Collaborators:

UNIVERSITY OF CALIFORNIA-BERKELEY

UNIVERSITY OF CALIFORNIA-LOS ANGELES

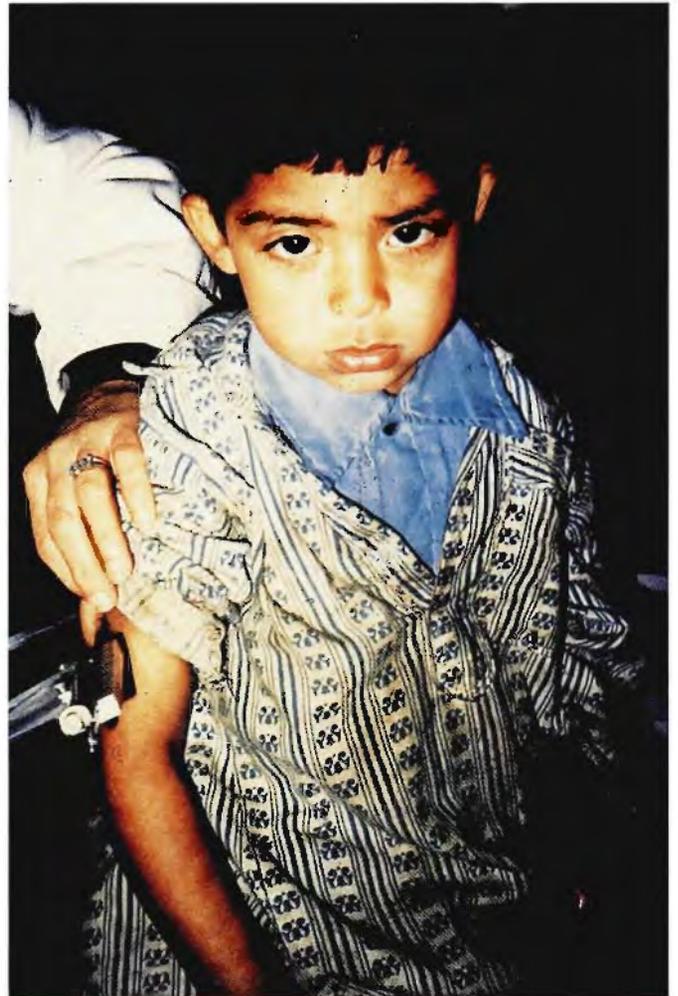


The research of the NUTRITION CRSP supports the charting of new directions in nutrition programming and is providing a sound basis for policy decision-making both in developing countries and the U.S.

For more information, contact:

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Skinfold thickness measured by calipers as part of nutrition screening program.

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IMPACT

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

NEW TECHNOLOGY PRODUCES TRANSGENIC BEANS

The lack of a reliable method to introduce useful genes into beans has been a major factor limiting the application of biotechnology for bean improvement. This problem now has been overcome through collaborative research fostered by the BEAN/COWPEA CRSP between the University of WISCONSIN-Madison and a biotechnology company, Agracetus, Inc. of Middleton, WI.

FOR THE FIRST TIME, TRANSGENIC BEANS CONTAINING FOREIGN GENES HAVE BEEN DEVELOPED. THE NEW TECHNOLOGY PRODUCING THIS BREAKTHROUGH PROMISES TO HAVE A MAJOR IMPACT ON PLANT IMPROVEMENT RESEARCH FOR MANY CROPS WORLDWIDE.

The technology is being used to solve a major viral disease problem in beans (bean golden mosaic) in Latin America. Beans will be transformed with mutated, non-functional viral genetic material (DNA), which is expected to block replication of naturally occurring virus and, thus, render the beans resistant to a major virus disease.

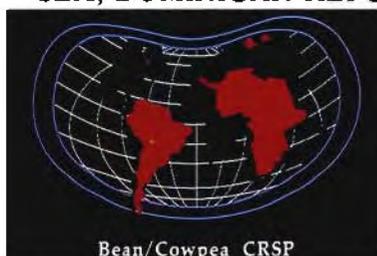
By application of electric discharge particle acceleration technology (the electric discharge particle gun), developed by Agracetus, Inc., the DNA of a foreign gene is coated on gold particles and "shot"



Transgenic beans were produced containing a marker gene which gives a blue color when treated with a chemical substrate. The seed on the left was from a non-transformed bean plant and does not have the marker gene whereas the seed on the right was from a transformed bean plant which has the marker gene. Current research is developing transgenic beans with viral resistance.

Collaborators:

UNIVERSITY OF WISCONSIN-MADISON
AGRACETUS, INC., MIDDLETON, WI
CIAT
SEA, DOMINICAN REPUBLIC



into bean tissue. These foreign genes are then integrated into the genetic material of the bean. The transformed beans then produce seeds carrying the foreign genes.

Through the BEAN/COWPEA CRSP, collaborating with the Ministry of Agriculture of the Dominican Republic and the International Agricultural Research Center CIAT, the genetic material (DNA) of the bean golden mosaic virus was isolated and characterized by molecular techniques. It is this viral DNA which is being used with the particle gun technology to impart viral resistance.

The particle gun technology for generating transgenic plants opens up many new exciting opportunities for increasing pest and disease resistance and for improving the nutritional quality of beans and other crops in developing countries and the United States.



Bean golden mosaic is the main viral disease of beans in Latin America and causes losses up to 100 percent in certain areas. Biotechnological methods are being used to develop new control strategies for this disease.

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IMPACT

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

PEANUT SUPPLEMENT

Chinese-type wheat flour noodles are important as a basic food source in Thailand, especially in the urban areas. Although high in energy, the crude protein content of these noodles is no more than 10 percent. The daily protein intake of many people is marginal.

IN COOPERATION WITH THE PEANUT CRSP, 6,000 INDIVIDUAL PACKAGES OF PEANUT-FLOUR-ENRICHED WHEAT NOODLES WERE PRODUCED THAT HAD AN AVERAGE CRUDE PROTEIN CONTENT OF 17 PERCENT. SENSORY QUALITY OF THE ENRICHED NOODLES WAS ACCEPTABLE TO THAI CONSUMERS. THE PRIVATE SECTOR IS EXPECTED TO PRODUCE AND DISTRIBUTE THIS PRODUCT.

Laboratory research had shown that defatted peanut flour can be added to wheat flour to increase protein content of noodles up to 20 percent, without reducing sensory quality.

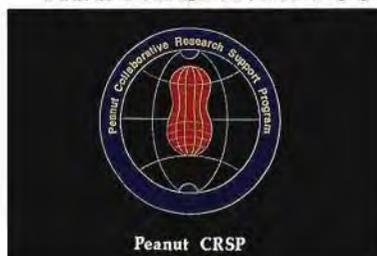
Pilot-scale research was conducted in THAILAND to expand the production and market potential of high-protein peanut-flour-supplemented noodles. In addition to heightened nutrition, the expanded food use of peanut will also increase the market demand and, therefore, the income potential for peanut farmers.



Commercially produced package of peanut-flour-enriched noodles (17 percent protein).

Collaborators:

UNIVERSITY OF GEORGIA
KASETSART UNIVERSITY, THAILAND
THAI PRESERVED FOODS, THAILAND



Expanded consumer tests followed using 200 panelists from the general public and 120 secondary school students. Both groups of consumers found the peanut-flour-supplemented noodles acceptable.

Thai consumers in the study recognized the nutritive value of the peanut-supplemented noodles and indicated they would consider it positively in deciding to buy the noodles in the future, if they were commercially available.



Typical Thai dish using high protein noodles.

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COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

POND MANAGEMENT STRATEGIES

Aquaculture is an important resource for THAILAND's poorest regions. Of the 20,000 small-scale producers in the impoverished rural northeast region, most rely on livestock manures of varying quantity and quality. Fish yields have therefore averaged only 1,500–1,800 kg/ha annually.

SCIENTISTS FROM THE POND DYNAMICS/ AQUACULTURE CRSP HAVE DEVELOPED ECONOMICALLY-EFFICIENT FERTILIZER STRATEGIES (A COMBINATION OF ORGANIC AND INORGANIC FERTILIZERS) WHICH CAN PRODUCE YIELDS OF 18,000 KG/HA PER YEAR, THE HIGHEST ANNUAL TILAPIA PRODUCTION EVER ACHIEVED WITHOUT SUPPLEMENTAL FEEDS.

The new strategies are currently being adopted by 500 small-scale fish pond operators in Udon Thani province. In Nong Khai province, adoption of the fertilizer techniques by the 100 small-to-medium operations there could result in increased net income of approximately \$2,500/ha.

Indeed, small-scale aquaculture production describes the majority of Thai fish production for non-export use. This level of enterprise also has parallels in small-scale fish farming in the U.S.



Researchers stripping fish eggs.

Collaborators:

MICHIGAN STATE UNIVERSITY
UNIVERSITY OF HAWAII
UNIVERSITY OF MICHIGAN
AIT, THAILAND
NIFI, THAILAND



Whether Thai or American, farmers producing at this level must emphasize efficiency if their enterprise is to remain viable. Therefore, the U.S. and Thai researchers have concentrated on the chemical and biological aspects of fish pond management. Fish yields increased as a result of the recommendations.

Over the past five years, new fertilization technologies developed by the scientists have been readily accepted. Major attention has been paid to better understanding precisely how ponds which are properly fertilized can further increase fish yields.



A fish catch in Thailand.

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IMPACT

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

PRODUCTION TECHNOLOGY FOR FRAGILE ENVIRONMENTS

A USAID and German-financed HONDURAS project adapted and promoted a soil-conservation technique. The SORGHUM/MILLET CRSP (INTSORMIL), with other organizations, then evolved a package of sustainable production practices including soil conservation techniques (SCT) and improved sorghum varieties suited to fragile hillsides.

The combination of improved sorghum varieties and production practices has been shown to increase the farm income by 15 percent. When combined with policies to prevent price collapse in good rainfall years, the income increase is estimated to be 58 percent.

IF ONLY THE PRESENT AREA IS CULTIVATED WITH THE NEW SORGHUMS, THE CURRENT VALUE OF THE RETURNS IS \$4.6 MILLION. CONSERVATIVELY, IF THIS AREA ONLY IS PLANTED TO THE NEW CULTIVARS UNTIL 2012, THE INTERNAL RATE OF RETURN IS PROJECTED AT 32 PERCENT.

This return rate requires the combined technologies of seed treatment, low fertilization and SCT (e.g., stone walls).



Sustainable agriculture emphasizing soil conservation for small-scale farming on hillsides: corn and sorghum planted behind rock walls.

Collaborators:

MISSISSIPPI STATE UNIVERSITY
PURDUE UNIVERSITY
TEXAS A&M UNIVERSITY
EAP, HONDURAS
SRN, HONDURAS
LUPE, HONDURAS



Traditionally, corn is the major food and feed staple in HONDURAS. However, sorghum serves as an important substitute feed source as well as an emergency food supply for the small-scale, hillside farmers in the southern part of the country.

From 1983 to 1988, approximately 52 percent of the total sorghum produced in the country came from these farms, over one-half of which possess slopes greater than 50 percent. Farming on these fragile lands is expected to continue over the next decades.

The diffusion of the new sorghum cultivars is just in the beginning stages and, therefore, the returns are expected to become higher over the next few years.



Improved **Maicillo** variety sorghum on-farm trials for hilly lands.

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Lincoln, Nebraska 68583-0948

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Fax: (402) 472-7978
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IMPACT

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

SOIL MANAGEMENT

In the African semiarid tropics, increased population pressure and recent climatic changes have resulted in severe land degradation, water and wind erosion, and loss of abundance and diversity of natural vegetation.

TROPSOILS' systematic, long-term research in NIGER is resulting in effective land rejuvenation from agroforestry-related practices.

THE FOUNDATION FOR INCREASED, SUSTAINABLE AGRICULTURAL PRODUCTION IN THE REGION IS THE NEW HEIGHTENED UNDERSTANDING OF THE (A) MECHANICS OF LOCAL ECOLOGY AND (B) BIODIVERSITY OF THE SOILS AND NATURAL VEGETATION.

Surveys of biodiversity in a typical watershed in western NIGER identified, among the two distinct types of vegetation, 119 species, 65 percent of which were annuals. Almost 30 species were found frequently to be used by the local population as forage, for human consumption, for construction, to stabilize soils from wind erosion or as medicine. These species are being exploited further for more effective soil management intervention strategies.

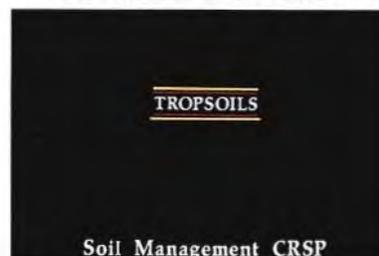
TROPSOILS research related millet growth and tree distribution to micro-topographic variation and the presence of eroded surfaces. Micro-high (surface mounding) areas were highly correlated with the



TROPSOILS is utilizing CRSP component technology to reverse desertification by synthesizing new soil management technology with indigenous technology for effective management of natural resource base.

Collaborators:

CORNELL UNIVERSITY
NORTH CAROLINA STATE UNIVERSITY
TEXAS A&M UNIVERSITY
UNIVERSITY OF HAWAII

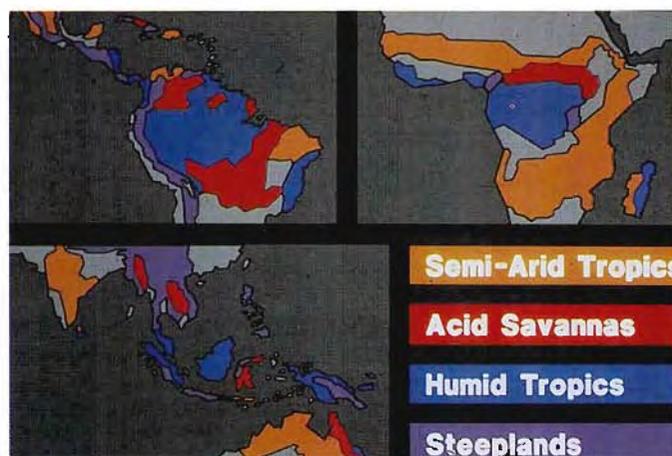


presence of trees and adjacent wind-eroded surfaces, indicating the effect of small trees in trapping wind-eroded materials airborne from adjacent soils.

Millet yield in fields with micro-highs were significantly higher than the yields in fields without micro-highs. The wind-blown materials that accumulate on the micro-highs were found to be higher in available nutrients, especially bases, and a primary reason for the enhanced plant growth. This work is the basis for agroforestry recommendations.

More efficient seedling placement was developed from TROPISOILS research, replacing the current method of planting acacia trees on a grid pattern. The findings elucidate the strong association between acacia growth and pre-existing soil chemical and physical properties, i.e., the presence of old termite mounds, soil micro-topographic differences, and soil variability.

More efficient multiple-use windbreaks (e.g., fodder and food production, house and mat construction materials, surface mulches) were designed to fit the local ecology and are ready for on-farm trials.



Major ecologies of Asia, Africa and Latin America/Caribbean.

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COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

SOIL RESTORATION AND SUSTAINABILITY IN THE SAHEL

Across the Sahel, increasing population and declining soil fertility threaten environmental stability and long-range food security. “There is no point in talking about natural-resource management and sustainability unless we are prepared to invest in long-term soil-management research,” says Oumar Niangado, Director General of Mali’s Institute of Rural Economy (IER). “We need a natural-resource program that emphasizes soil restoration and crop diversity. The CRSPs can play an important role in helping us to develop that kind of program.”

Niangado explains that the need for such programs will become more and more acute in the years ahead: “If we receive an average amount of rainfall, we can feed our current population without too much difficulty,” he says. “But that may not be true for our children. We need to take good care of our soil resources if we are to meet the needs of future generations.”

That kind of stewardship has been the focus of an ongoing collaboration between the Soil Management CRSP/Texas A&M University and the IER. The goal of that collaboration is to maximize the productivity of the region’s sorghum-producing soils. Recognizing that appropriate tillage practices and nutrient inputs are crucial to the efficient use of the region’s limited water resources, researchers have compared seedbed preparation techniques—with and without fertilization—for their impact on the growth, yield, and water-use efficiency of grain sorghum and cowpeas.



Improved management of soil and water resources is the key to meeting the needs of future generations.

Cornell University
North Carolina State University
Texas A&M University
University of Hawaii
United States Department of Agriculture



Soil Management CRSP
Collaborative Research Support Program

THE FOUR-YEAR RESULTS ARE ENCOURAGING: FERTILIZATION COMBINED WITH VARIOUS RIDGED TILLING PRACTICES INCREASED SORGHUM GRAIN YIELDS FROM 897 TO 2310 KG/HA, A GAIN OF 157%; STOVER YIELDS INCREASED FROM 2912 TO 6725 KG/HA, A GAIN OF 131%. COWPEA GRAIN YIELDS INCREASED FROM 412 TO 921 KG/HA, A GAIN OF 123%; COWPEA HAY YIELDS WENT FROM 1379 TO 2580 KG/HA, A GAIN OF 87%.

Appropriate soil preparation techniques combined with improved plant nutrient management would greatly increase water- and nutrient-use efficiency and help sustain production on the 17-million hectares of clay-loam soils Africans use to grow sorghum.

Having demonstrated the efficacy of various fertilizing and tilling strategies, Soil Management CRSP and IER researchers are conducting further studies to evaluate the effectiveness of green-manure crops in recycling mineral nutrients and improving soil physical properties. The Soil Management CRSP, the INTSORMIL CRSP, and the IER are also working to overcome four constraints to sorghum production in Sahelian soils: soil acidity, nutrient deficiencies, spatially variable soil toxicity, and drought stress. Particular attention will be focused on determining soil amendment requirements and on identifying sorghum genotypes capable of tolerating drought and chemical stress.

Researchers hope that by increasing yields on soils best suited to the continuous cropping of sorghum and



Research conducted at Cinzana, Mali, could help sustain sorghum production across the Sahel.

cowpeas, they can reduce the need for such cropping on the less productive and easily degraded soils that dominate the region.

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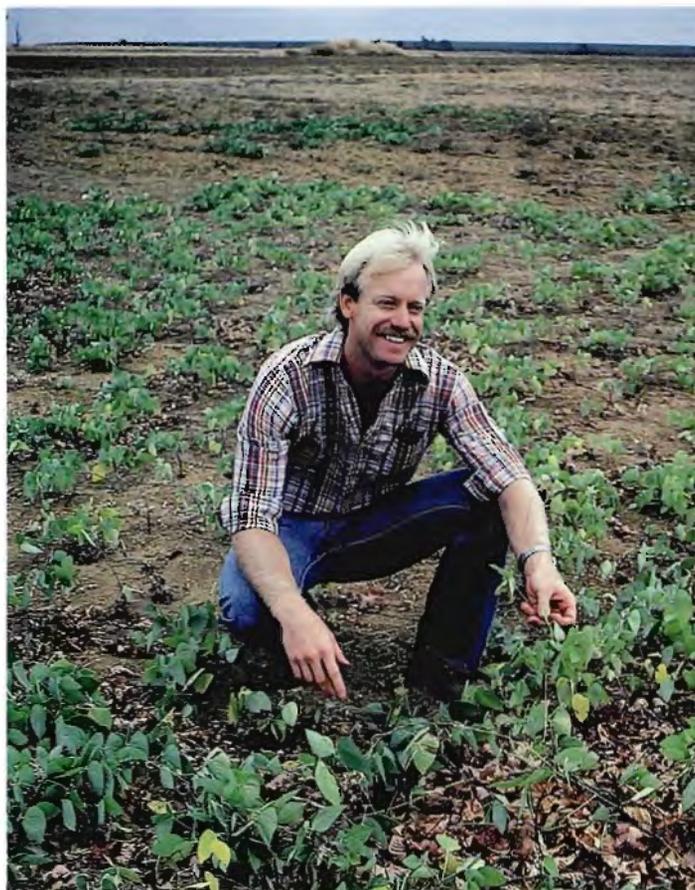
COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

SUSTAINABLE SAVANNAS: A NEW ROLE FOR LEGUME GREEN MANURES

On tropical savannas, long dry seasons constrain green-manure use. As a result, many producers have been unable to take advantage of the legumes' nitrogen-supplying properties, a serious drawback in areas where fertilizer N is either unavailable or too costly. Equally serious is the progressive land degradation that occurs when neither crops nor legumes stabilize the dry-season landscape.

Researchers from the Soil Management CRSP* and the Centro de Pesquisa Agropecuária dos Cerrados (CPAC)/EMBRAPA reasoned that if drought-resistant legumes planted at the end of the wet season could survive the dry season and continue to grow in the following wet season, they might provide a viable (and valuable) management system for sustaining long-term crop production. Without displacing food or cash crops, such legumes would increase the N in the agricultural system through biological nitrogen fixation, and they might also recycle nutrients and control soil erosion, weeds, and nematodes.

EXPERIMENTS SUGGEST THAT THOSE SPECULATIONS WERE WELL-FOUNDED: OF THE 52 LEGUMES SCREENED BY RESEARCHERS, 37 SURVIVED A SEVERE DRY SEASON, AND 12 PRODUCED BIOMASSES AND N LEVELS SUFFICIENT TO CONTRIBUTE TO CROP YIELDS. UNDER FAVORABLE CONDITIONS, THE BEST LEGUMES CAN PRODUCE OVER 5000 KG/HA OF DRY MATTER AND OVER 100 KG/HA OF N FOR THE FOLLOW-



Legumes like mucuna that survive dry season and grow rapidly at the onset of the rainy season can be important additions to savanna cropping systems.

Centro de Pesquisa Agropecuária dos Cerrados (CPAC)/
EMBRAPA (Brazil)
Cornell University
North Carolina State University
Texas A&M University
University of Hawaii
United States Department of Agriculture

* Research supported in part by a special USDA grant to Cornell University, 87-CRSP-2-3084: Screening legumes for dry-season survival in acid savanna tropics.



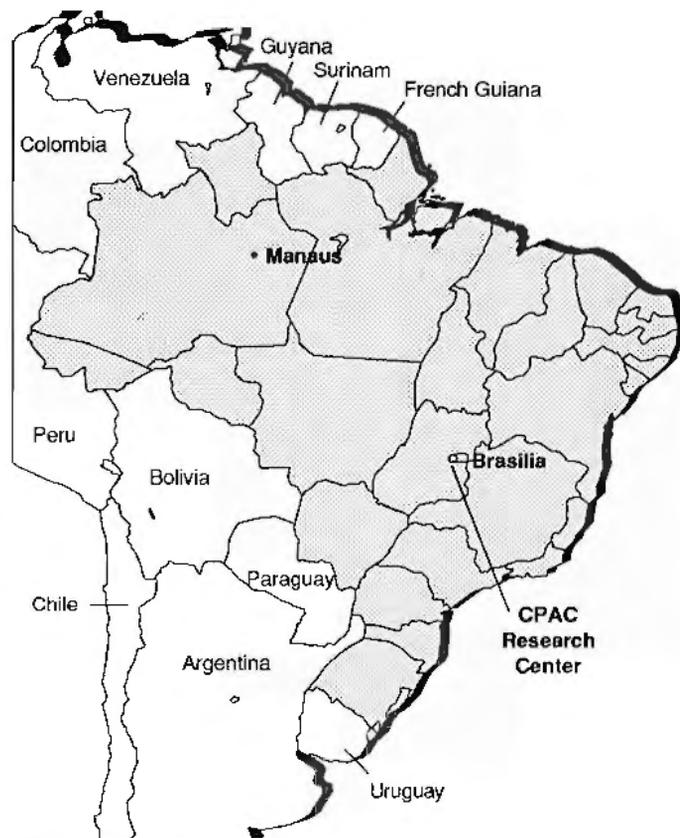
Soil Management CRSP
Collaborative Research Support Program

ING MAIZE CROP. THESE RESULTS SUGGEST THAT LEGUMES CAN BE MATCHED TO ALMOST ANY SAVANNA CROPPING SYSTEM. *CANAVALIA BRASILIENSIS* AND *MUCUNA ATERRIMA* APPEAR ESPECIALLY PROMISING, PERFORMING WELL OVER A WIDE RANGE OF DRY-SEASON CONDITIONS.

Because these legumes survive the dry season by extending their roots deep enough to extract subsoil water, researchers conjectured that the plants might also recycle N from depths below the rooting zone of the wet-season crop. Results have confirmed this conjecture: fallow plots contained more subsoil N than did plots planted to legumes, an indication that N is being recycled. Such recycling not only benefits the subsequent crop, but it also reduces the risk of groundwater pollution.

Because savanna cropping systems typically leave the soil surface exposed during the dry season, the soil is highly vulnerable to wind erosion—and to water erosion should rain happen to fall. Water erosion is also likely to occur at the onset of the rainy season because the soil remains exposed until the wet-season crop is well-established. Legumes which grow during the dry season can provide soil cover and thus reduce the risk of wind erosion. In addition, renewed growth can occur as soon as the first rain falls, providing additional ground cover until the legumes are incorporated into the soil.

These findings suggest that the potential contribution of legumes to savanna cropping systems has been underestimated. Properly managed and selected, legumes have



Research sites at Brasilia and Manaus

the potential to replace much of the fossil-fuel fertilizer N now being used and to increase yields where such fertilizer is unavailable. Combined with reduced land degradation, such benefits suggest that legume green manures are a key to the environmentally responsible management of the savanna.

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IMPACT

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

TUNA MANAGEMENT

An evaluation of the potential for tuna resources in the waters of INDONESIA recently was done in order to assess the level of tuna fishing which could be sustained without overexploiting the stocks and endangering the viability of the region's industry.

RECENT APPLICATIONS OF A STOCK ASSESSMENT MODEL, NEWLY DEVELOPED BY THE FISHERIES STOCK ASSESSMENT CRSP, INDICATED THAT THERE IS CONSIDERABLE NATURAL VARIABILITY IN TUNA STOCKS BUT CAREFUL MANAGEMENT CAN SUSTAIN PROFITABILITY.

Prior estimates of the magnitude of the tuna resources were very optimistic. The new methodology, however, shows that the resource potential is substantially less than that which had been previously estimated with less robust techniques.

The details of this information are being used to manage a recent fishery development loan which is in excess of \$250 million.

Tuna contributed over 22,000 metric tons in 1983 to the Indonesian fishery. This quantity was valued at \$19 million in that year. By 1990, the fishery value generated had increased to nearly 57,000 metric tons worth \$103 million.



Small-scale fishermen and their boats: Tuna fishing involves small- and large-scale technologies.

Collaborators:

UNIVERSITY OF RHODE ISLAND
DEPARTMENT OF FISHERIES, INDONESIA



The total increase represents an increase in value of over 32 percent per year. Clearly, very rapid development of this resource is possible. However, it is important to monitor how far such development can go without over-fishing and over-capitalizing.



Skipjack tuna sorted for market, Jakarta, Indonesia.

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IMPACT

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPS)

WEED CONTROL

Worldwide sorghum losses to *Striga* have been projected to be 5 to 15 percent, the equivalent of 845,000 MT per year for SUB-SAHELIAN AFRICA alone. In some cases there is a crop loss from *Striga* of 100 percent.

TWO NEW RESEARCH OUTCOMES ARE EXPECTED TO MAKE IT POSSIBLE FOR GROWERS TO HAVE *STRIGA*-FREE SORGHUM PRODUCTION: THE DEVELOPMENT OF A RAPID, NON-DESTRUCTIVE BIOASSAY FOR ASSESSING *STRIGA* RESISTANCE AND NEW GENES FOUND TO HAVE STABLE *STRIGA* RESISTANCE CURRENTLY BEING BRED INTO IMPROVED SORGHUM VARIETIES.

SORGHUM/MILLET CRSP (INTSORMIL) researchers in INDIANA have developed a simple and rapid laboratory assay for screening sorghum varieties for *Striga* resistance.

In addition, the scientists have identified a sorghum with strong and broadly expressed resistance, a major find because of the paucity of *Striga*-resistant genotypes.

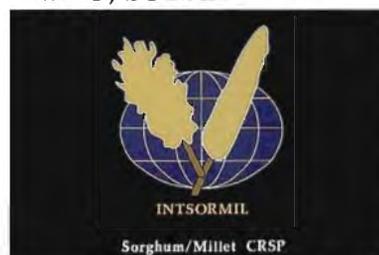
Striga species (witchweeds) are parasitic flowering plants which grow only by attaching their roots to the roots of host



Sorghum field severely infested with purple flowering parasitic weed *Striga*.

Collaborators:

PURDUE UNIVERSITY
INRAN, NIGER
ARC, SUDAN



plants such as sorghum. They draw all of their nutrition from the host plant and, in addition, cause toxic, growth-regulatory effects on the sorghum before emerging from the soil. The damage cannot be prevented by pulling the weed after emergence.

The new assay measures the capacity of a sorghum variety to stimulate germination of the *Striga* seed; a negative reaction indicates strong resistance.

The impact will be especially significant for sorghum production in AFRICA.

The validity of the new assay technology has been confirmed in field studies in SUDAN, NIGER and the UNITED STATES.

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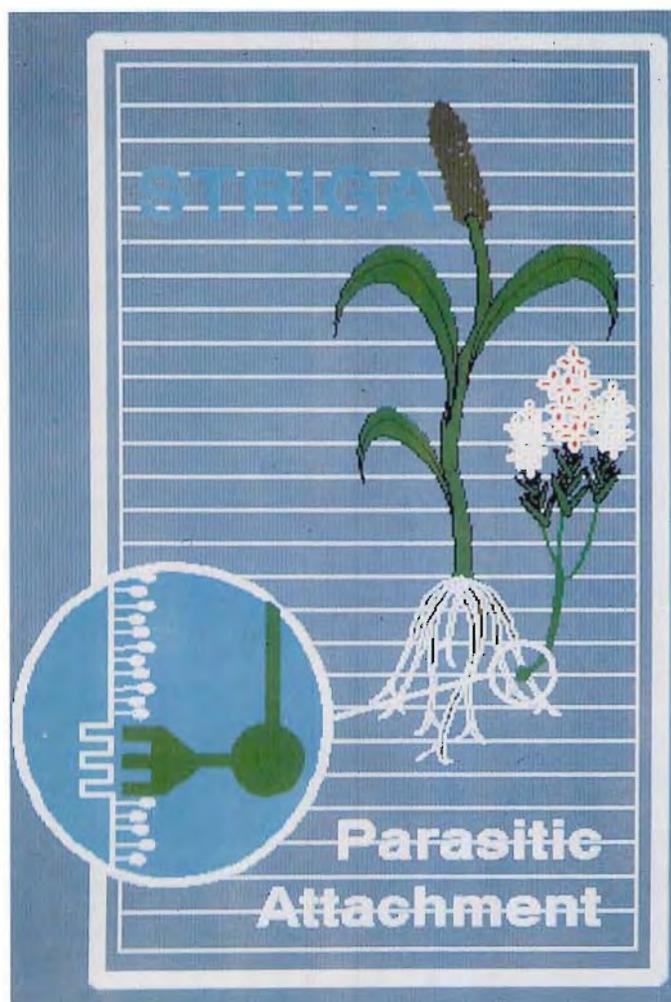


Illustration of sorghum host-*Striga* parasitic attachment mechanism.

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