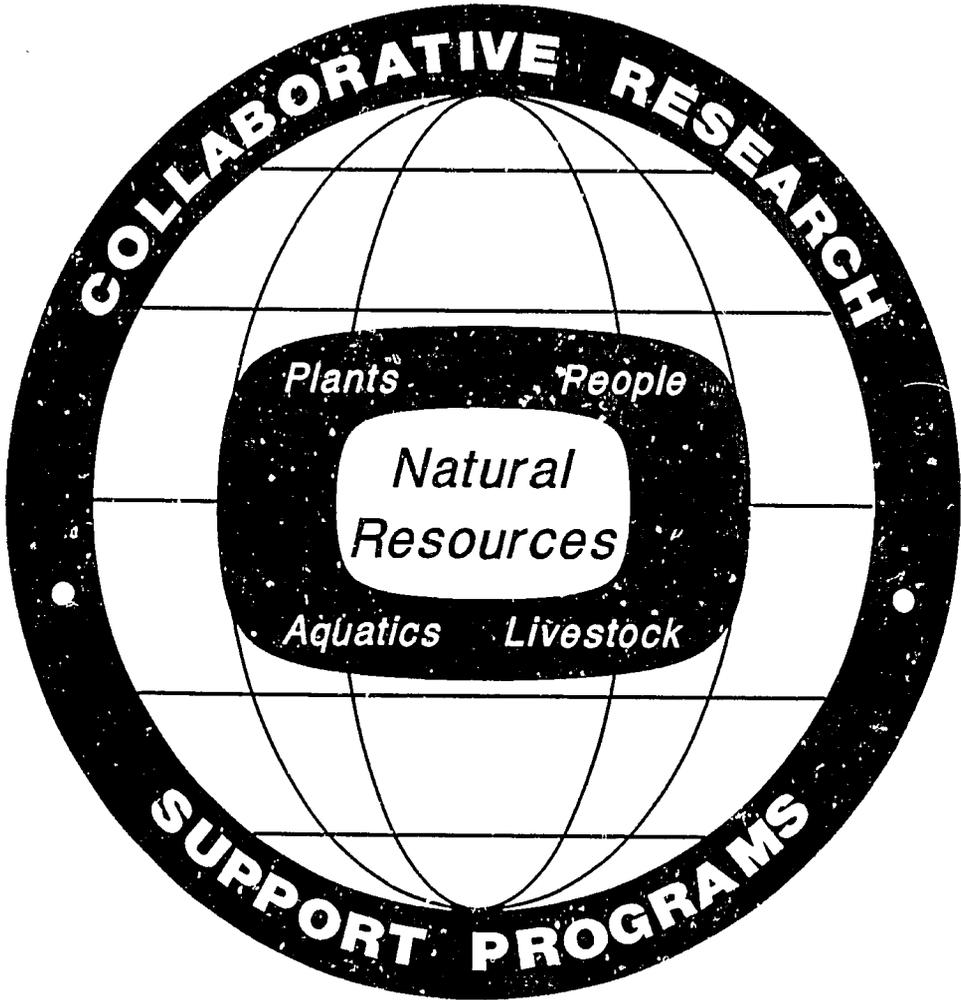


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# Global Research for Sustainable Food Production



CRSP Council  
1991

United States Agency For International Development  
Bureau for Science and Technology  
Board of International Food and Agricultural Development

# GLOBAL RESEARCH FOR SUSTAINABLE FOOD PRODUCTION

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## □ PREFACE

The Collaborative Research Support Programs (CRSPs) were created in response to Title XII of the Foreign Assistance Act legislated in 1975. The main thrust of Title XII was to strengthen the capacities of Land-Grant and other U.S. universities to participate in programs of sustainable agriculture and natural resource management that help developing countries to produce adequate food, fiber, fuel, and shelter materials.

The United States Congress funds the CRSPs through the Title XII program. Participating U.S. and host-country institutions provide support for the programs as well. The CRSPs are implemented by the U.S. Agency for International Development.

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, 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 the collective strengths and accomplishments of the CRSPs in order to encourage their maximum application in international development.

We invite you to call upon the CRSP Council to collaborate in areas of common interest in our quest for sustainable food production.

## □ INTRODUCTION

Innovative technologies are an important key to Third World development. When such technological advances result from collaborative activities between U.S. and developing country scientists, institutional growth and human resource development also occur.

Collaborative research of this kind is carried out by the Agency for International Development (A.I.D.) in many of the scientific disciplines that contribute to development. The most important efforts are those which improve the sustainability of food production systems in the developing countries with an emphasis on enhancing the quality of life for small-scale crop, animal, and fish farmers and their families. The Agency's Collaborative Research Support Programs (CRSPs) are a long-term, multidisciplinary research and training initiative that capitalizes on the vast U.S. Land-Grant University and College of Agriculture system that works with developing country research programs. The currently functioning CRSPs are:

- the Bean/Cowpea CRSP
- the Fisheries Stock Assessment CRSP (FSA-CRSP)
- the Nutrition CRSP
- the Peanut CRSP
- the Pond Dynamics/Aquaculture CRSP (PD/A CRSP)
- the Small Ruminant CRSP (SR-CRSP)
- the Sorghum/Millet CRSP (INTSORMIL)
- the Soil Management CRSP (TropSoils).

The productive activities of these eight programs directly support A.I.D.'s three-part agricultural goal of helping smallholders in developing countries to improve their incomes, alleviate hunger, and maintain and improve the natural resource base upon which they depend for food, fuel, fiber, and shelter.

The various CRSPs use similar methods to pursue this goal. All of the CRSPs carry out research that leads to the development of ecologically and environmentally sound technologies. The knowledge they disclose and the innovations they devise help developing country farmers manage their food-producing resources for sustainable agricultural yields. Each CRSP has created collaborative linkages between the U.S. and developing country research communities that foster institutional growth and encourage the education and training of scientists and technicians. CRSP innovations are being shared with international agricultural research centers, private industry, private voluntary organizations, and other

nations beyond the developing countries and regions directly involved in the original research, including the agricultural community in the United States.

The over 70 Missions and Regional Offices through which A.I.D. directly assists developing countries are vital partners in the generation and distribution of these technologies. By means of basic ordering agreements, cooperative agreements, grants, contracts, and other collaborative arrangements, the A.I.D. Missions and Regional Offices involve themselves in the research, technical assistance, and educational activities of the CRSPs. These collaborations enhance the CRSP efforts and give them a broader base from which to share their findings and technical expertise.

At a recent meeting, representatives of the CRSPs reached two important decisions that will help them to more comprehensively meet the needs of A.I.D.'s Missions and Regional Offices. First, they established a CRSP Council, which will increase their ability to coordinate the activities of the individual programs and will make the CRSPs accessible as a group. Second, they are developing several inter-CRSP initiatives that will make available a greater breadth of scientific knowledge, combine and synergize new technology; and encourage the exchange of information, resources, and other inputs among the CRSP programs and countries.

The following chapters delineate the **Purpose, Program, and Accomplishments** of the individual CRSPs. A complete list of each program's participants appears at the end of each chapter under **Resources** and information on how to reach key individuals is given at the beginning of each chapter.

A.I.D. Missions and Regional Offices are encouraged to continue and expand their CRSP contacts as they envision, plan, and expand their agricultural programs.

## □ BEAN/COWPEA CRSP

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Year of Inception: 1980

**Purpose:** To overcome constraints to the production, distribution, storage, utilization, and marketing of bean and cowpeas, important sources of dietary protein.

**Program:** In general, the Bean/Cowpea CRSP works to:

- Identify, maintain, and improve available bean and cowpea germplasm.
- Employ human and physical resources across institutions and ecological zones to solve common problems associated with bean and cowpea availability.
- Integrate traditional resources with biotechnology in ways that are mutually reinforcing.
- Support and encourage multidisciplinary investigations.
- Sponsor integrated research and training in which U.S. and non-U.S. students work together to solve research problems.
- Focus on the needs of small-scale farmers, especially women.

This CRSP particularly addresses limitations caused by insects and diseases, and plant response to stress such as environmental extremes, e.g., heat and drought. CRSP researchers also study constraints that result from particular farming systems, socio-cultural factors, and the economics of the production-to-consumption cycle, as well as problems related to food storage and preparation, nutrition, and health regimens commonly practiced. The education, training, and research resources of the countries and regions are assessed to determine how they may be strengthened.

With a major concern for sustainability, research in traditional settings is emphasized, as is the integration of basic (especially biotechnology) and applied research to promote more rapid and appropriate response to critical agricultural problems. The research designers demonstrate particular sensitivity to the needs of small-scale farmers, especially women, who produce and handle the crops. The CRSP coordinates its work with other international research programs that have mutual interests and other countries that have common needs.

In the case of beans, the CRSP is working on the following projects with the collaborators indicated:

- **Biology, Epidemiology, Genetics, and Breeding for Resistance to Pathogens of Beans with Emphasis on Those Causing Bacterial Blight, Rust, and Bean Golden Mosaic Virus -- Dominican Republic**
- **Molecular Approaches to Control of Bean Golden Mosaic Virus -- Dominican Republic**
- **Improving the Productivity of *Phaseolus* Beans under Conditions of Low-Input Agriculture Through Genetic Selection of Host Cultivars and *Rhizobium* Strains for Enhanced Symbiotic Efficiency -- Ecuador**
- **Agronomic and Genetic Aspects of Bean Adaptation and Yield -- Guatemala**
- **Development and Implementation of Strategies for Breeding Beans with Enhanced Disease Resistance and Greater Tolerance to Drought -- Honduras**
- **Improvement of Dry Bean Nutritional Quality and Acceptability -- Instituto de Nutricion de Centroamerica y Panama (INCAP)**
- **Biological and Social Aspects of Bean Improvement and Host Pathogen Co-Adaptation in Malawi, a Secondary Center of Diversity -- Malawi**
- **Breeding Beans for Yield, Adaptation, and Nitrogen-Fixation Capability under Conditions of Limited Moisture -- Mexico**

- Breeding High-Yielding Disease and Insect Resistant Beans Adapted to Minimum Input Conditions and Assessing Socio-Economic Impact of New Cultivars and Production Practices on Smallholder Families, Especially Women -- Tanzania

For cowpeas, the program focuses and collaborators are as follows:

- Insect Pathogens in Cowpea Pest Management Systems for Developing Nations -- Brazil
- Preservation of Postharvest Cowpeas by Subsistence Farmers in Cameroon -- Cameroon
- Appropriate Technology for Cowpea Preservation and Processing and a Study of Its Socio-Economic Impact on Rural Populations in Nigeria -- Nigeria
- A Program to Develop Improved Cowpea Varieties, Management Methods, and Storage Practices for Semiarid Zones -- Senegal

In keeping with the CRSP's emphasis on multi-disciplinary research, efforts are expanding to increase contributions from non-production fields such as agricultural economics, socio-cultural perspectives, and food science.

Both short-term and degree training offered by the program involve the participation of CRSP personnel and make available all relevant biological, social, and food science disciplines. To date, 192 graduate degrees have been earned through the CRSP and nearly 1,000 scientists have participated in short-term training in such areas as computer technology, on-farm testing, research management, and pest control. MSTAT, a computer program for agricultural research, has attracted particular worldwide interest.

The CRSP's substantial investments in host country equipment, facilities, and long- and short-term training of personnel have been cited by host country administrators as especially important contributions to their research programs.

### **Accomplishments:**

- Using California Blackeye #5 seed (CB5), cowpea production in Senegal was increased four-fold in 1985 and 1986. This unusually abundant harvest fed over a million people affected by a multi-year drought. It generated an average yearly gross-value increase of about \$35 million representing a 63% return on the dollar investment.

- Four causal agents of bean golden mosaic virus (BGMV) have been cloned and three have been totally sequenced. In cooperation with private industry, these cloned DNA have been blasted into beans with a particle gun causing disease expression. For the very first time, transformed bean plants have been produced. Bean landraces from the Dominican Republic identified to have BGMV resistance are expected to provide the resistant genes for this new technology.
- Diverse bean and cowpea germplasm has been collected and is serving as a source of material for plant improvement programs in developing countries and the United States.
- Bean varieties that fix up to 60 kilograms of nitrogen per hectare have been identified and are being used by farmers and plant breeders. Already effective in Wisconsin, these varieties are reducing the need for applied fertilizers, thus helping prevent nitrate water pollution and reducing costs.
- Bean and cowpea lines identified to have drought and heat tolerance are strengthening production in semi-arid areas of developing countries. The bean selections also are being used by U.S. bean growers whose productivity is increasingly affected by climatological changes (e.g., the "greenhouse effect").
- Strains of microbes pathogenic to cowpea insects have been isolated and are now available to the scientific community for biological insect control. Preliminary tests in Illinois and New York show that several insects can be controlled by this method which will reduce the use of toxic and costly insecticides.
- Bean cultivars have been identified showing resistance to bean fly, a major problem in Africa and Asia. This genetic material is being used by breeders.
- Selections have been made from a wild species of cowpea which has resistance to storage insects. In addition, simple solar heating and double-bagging technology is dramatically reducing insect losses during storage.
- New multiple-disease-resistant bean varieties have been developed and released to farmers and breeding programs. Bean lines combining resistance to common blight, rust, white mold, and bean common mosaic virus along with improved architecture and seed quality have been developed. These varieties reduce the need for farmers to use environmentally hazardous pesticides and fungicides.

- Development and use of bean common mosaic virus antisera and serodetection protocols have reduced the risk of transmitting viral diseases in imported beans and have enabled farmers to plant disease-free seed.
- Information gathered on farming systems in developing countries provides a firm basis for the introduction of new or improved sustainable agricultural technologies and methods.
- In 1988, bean harvest in Tanzania was up 70% from the previous year as a result of higher bean prices encouraged by CRSP socio-economic research, increased rain, release by CRSP researchers of NITROSUA--a newly developed dry inoculant for biological nitrogen fixation, and CRSP collaboration with the CIAT/SADCC variety improvement team.

## **CRSP Resources:**

### **Collaborating U.S. Institutions**

Boyce Thompson Institute  
 Cornell University  
 Michigan State University  
 Purdue University  
 University of California, Davis  
 University of California, Riverside  
 University of Georgia  
 University of Minnesota  
 University of Nebraska-Lincoln  
 University of Wisconsin  
 University of Puerto Rico  
 Washington State University

### **Overseas Collaborating Institutions**

Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA), Brazil  
 Instituto de Ciencias y Tecnología Agrícola (ICTA), Guatemala  
 Bunda College of Agriculture, Malawi  
 Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias (INIFAP), Mexico  
 Institut de Recherche Agronomique au Cameroun (IRA), Cameroon  
 Institut Senegalais de Recherches Agricoles (ISRA), Senegal  
 University of Nigeria, Nsukka, Nigeria  
 Instituto Nacional de Investigaciones Agropecuarias (INIA), Ecuador  
 Secretaria de Estado de Agricultura (SEDA), Dominican Republic

**Escuela Agrícola Panamericana (EAP), Honduras**  
**Instituto de Nutrición de Centroamérica y Panamá (INCAP), Guatemala**  
**Sokoine University of Agriculture (SUA), Tanzania**

## □ SORGHUM/MILLET CRSP (INTSORMIL)

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Year of Inception: 1979

**Purpose:** To improve the production, marketing, and utilization of grain sorghum and pearl millet in less-developed countries, and to strengthen the capabilities of LDC institutions to generate, adapt, and apply improved technology to local conditions.

**Program:** In general, INTSORMIL works to:

- Address universal constraints to the production, availability, and improved utilization of sorghum and pearl millet. Research constraints addressed by the program fall within the general disciplinary areas of breeding, pathology, entomology, cultural practices, physiology, utilization, economics, and sociology.
- Improve research capability through collaboration between U.S. and host country counterparts, through exchange of professional visits between the U.S. and the host country scientists, and by supporting LDC national research programs in terms of equipment, supplies, travel, and personnel.

- Provide both short-term and degree training programs for host country staff at U.S. institutions. On-site technical assistance and training is provided by U.S. scientists.
- Disseminate the technologies developed by the INTSORMIL program through host country organizations to the farmer information chain. These technologies can be shared with all A.I.D. missions and countries where sorghum and millet are important food crops.

Ways to resolve constraints that continue to thwart the development of sustainable sorghum and millet agricultural production and utilization systems are categorized by the CRSP under five global technical thrusts. These thrusts, oriented toward natural resource conservation and development, environmental protection, and sustainable agricultural production systems, are as follows:

Germplasm Enhancement & Conservation - 9 projects  
 Bio-Intensive Plant Protection Systems - 6 projects  
 Sustainable Production Systems - 7 projects  
 Crop Utilization and Marketing - 2 projects  
 Host Country Program Enhancement - 8 countries

### **Accomplishments:**

- Genetic materials from INTSORMIL have made a significant contribution to millet research efforts at ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) and elsewhere in India. A significant portion of the ICRISAT male-sterile breeding project now consists of selections derived from crosses of ICRISAT and INTSORMIL breeding lines. Commercial seed companies in India are using the INTSORMIL/Kansas 2221 line as a female parent in large-scale hybrid seed production.
- INTSORMIL scientists developed the sorghum breeding lines that ICRISAT/UNDP used in developing the hybrid "Hageen Dura 1" in Sudan. This hybrid is now used exclusively in the irrigated areas of Sudan where it produces 150% more than traditional varieties. It also is demonstrably superior to varieties traditionally planted in the dryland, rainfed areas of that country. In 1989, 70,000 acres of the new hybrid were grown in Sudan.
- INTSORMIL/Texas A&M Scientists and Honduran collaborating scientists have developed two new sorghum varieties and one new sorghum hybrid for Central America. Forty-seven on-farm trials in 1988 demonstrated that the improved cultivars increased yield over traditional cultivars by 23% to 38% on the steep hillsides of southern Honduras. When seed insecticide

treatments and 60 kg/ha nitrogen were applied as inputs, yields were boosted 68% to 113% on farmers fields. The participating farmers admire the productivity of the new cultivars and plan to continue using this new technology.

- INTSORMIL research in Niger demonstrated that an altered cowpea arrangement increased the light available to cowpea in the millet/cowpea canopy. This altered planting arrangement, which increased cowpea yields by 25% while maintaining millet yields, has been adopted by the Nigerian extension service and is being promoted to farmers.
- Sorghum researchers at INTSORMIL/Purdue University have identified an important striga seed germination stimulant exuded by plant rootlets. Striga is the major biological impediment to yield throughout Africa and Asia. Continued research building on this technological breakthrough will lead to more effective control measures and will benefit all areas where striga occurs. This research should also contribute to final elimination of the striga infestation in North and South Carolina and will lessen the threat of other striga infestations in the United States.
- Collaborative research between INTSORMIL scientists and Food Research Center scientists in Sudan has yielded the technology for making bread from 20% sorghum/80% wheat composite flour. Effective January 1, 1990, the Government of Sudan has issued a policy directive which requires all millers and bakers in Sudan to make and use composite flour for bread. This technology will create new internal markets for sorghum and ease foreign exchange losses from wheat imports.
- The process of implementing collaborative research with host country institutions has annually increased and improved the cadre of LDC scientists and technicians available to conduct research on these two priority crops. As of mid-1989, the CRSP had trained 178 non-U.S. and 106 U.S. students with A.I.D. grant funds, and another 213 non-U.S. and 90 U.S. students received training in INTSORMIL projects with funds from other sources. Since the CRSP's inception, 587 students have been trained under its auspices including 257 Ph.D's., 227 M.S's., 26 B.S's., and 46 short-term and 29 post-doctoral scholar/visiting scientist recipients.
- Three of the LDC sites where INTSORMIL collaborates now have the technical capability to implement full multi-disciplinary research programs to improve the production and utilization of sorghum and millet. The result of these commitments is a network of strong collaborative linkages that has long-term potential for solving agricultural development problems

involving sorghum and millet in each of the regions where INTSORMIL is involved.

## **CRSP Resources:**

### **Collaborating U.S. Institutions**

Kansas State University  
University of Kentucky  
Mississippi State University  
University of Nebraska  
Purdue University  
Texas A&M University

### **Collaborating Host-Country Institutions**

Department of Agricultural Research (DAR), Botswana  
Instituto Colombiano Agropecuario (ICA), Colombia  
Ministerio de Recursos Naturales (MRN), Honduras  
Institut Economie Rurale (IER), Mali  
Institut Nigerien du Recherche Agronomic, (INRAN), Niger  
Agriculture Research Corporation (ARC), Sudan  
Institut Senegalais de Recherches Agricoles, (ISRA), Senegal  
Institut de Technologie Alimentaire (ITA), Senegal  
Kenya Agricultural Research Institute (KARI), Kenya

### **INTSORMIL collaborates with the following networks:**

Consejo Latin Americana de Investigadores in Sorgo (CLAIS)  
SAFGRAD/East Africa  
SAFGRAD/West Africa  
SADCC/ICRISAT, Southern Africa  
EARSOM/ICRISAT, East Africa

## □ PEANUT CRSP

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Year of Inception: 1982

**Purpose:** To enhance and coordinate the resources of U.S. and less-developed country institutions in a long-term research program to resolve common constraints on the production and utilization of the peanut in an environmentally sound system.

**Program:** In general, the Peanut CRSP works to:

- Develop cultivars, cultural and pest management practices, and utilization processes that would lower costs and stimulate peanut utilization as a primary food resource.
- Support research programs in terms of equipment, supplies, travel, and personnel.
- Offer short-term and degree-oriented training programs for host country staff at U.S. institutions, and degree training for select U.S. students.
- Provide host countries with on-site consultations and research collaboration with U.S. scientists, which combined with training and program support improves research capability of host country scientists and institutions.

- Increase the flow of technological information from the Peanut CRSP to the potential beneficiaries: small-scale farmers, processors, and rural and urban consumers.

The Peanut CRSP research focuses specifically on developing alternatives to low-yield cultivars that lack stress tolerance, ameliorating yield losses due to pests, reducing mycotoxin hazards, overcoming inadequate food supplies, and improving resource management schemes that prevent efficient production and utilization.

### **Accomplishments:**

- The improvement of genetic resources through the incorporation of disease resistance and tolerance to insects and abiotic stresses has led to the development and release of thirteen improved peanut cultivars and several advanced experimental cultivars for west Africa, southeast Asia, the Caribbean, and the United States.
- Integrated pest management (IPM) strategies to reduce insect damage and to reduce aflatoxin development caused by *Aspergillus* sp. invasion through insect-damaged pods was developed in Burkina Faso. IPM strategies also decreased losses to rosette virus in west Africa (Nigeria).
- Identified a highly adsorbent clay (Senegal and Texas) that binds and removes aflatoxin from village-processed peanut oil and peanut meal fed to animals (the clay has potential as a food additive). This discovery has incalculable potential to control aflatoxin, a carcinogenic compound.
- In Sudan, nutritionally enriched "kisira" (thin bread) is being produced by blending sorghum and peanut flour. This product reduces the incidence of sorghum-induced niacin and protein deficiency.
- Developed a peanut-based cheese spread in the Philippines and peanut-enriched noodles in Thailand. These products, which have the potential to increase protein intake, are being tested.
- Sponsored or co-sponsored 35 workshops to plan research and disseminate technology.
- Trained 105 M.S. and Ph.D. graduate students and provided short-term, non-degree training for 160 individuals. U.S. scientists annually provided over 200 days of in-country consultations with host country scientists.

## **CRSP Resources:**

### **Collaborating U.S. Institutions**

Alabama A&M University  
University of Georgia  
North Carolina State University  
Texas A&M University

### **Collaborating Host Country Institutions**

Institut Senegalais de Recherches Agricoles (ISRA), Senegal  
Institut de Technologie Alimentaire (ITA), Senegal  
University of Ouagadougou Institut Superior Polytechnique, Burkina Faso  
Institut Nationale de Recherches Agronomiques du Niger (INRAN), Niger  
Institute for Agricultural Research (IAR), Nigeria  
Ministry of Agriculture, Institut d'Economie Rurale (IER), Mali  
University of the Philippines at Los Banos (UPLB), Philippines  
Institute of Plant Breeding (IPB), Philippines  
Philippine Council for Agriculture and Resources Research Development  
(PCARRD), Philippines  
Department of Agriculture (DOA), Thailand  
Kasetsart University (KU), Thailand  
Khon Kaen University (KKU), Thailand  
Caribbean Agricultural Research and Development Institute (CARDI),  
Caribbean  
University of the West Indies, Trinidad, Caribbean

### **The Peanut CRSP collaborates with the following networks:**

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT),  
India  
ICRISAT Sahelian Center (ISC), Niger  
French Oilseeds Research Institute (IRHO), France  
Caribbean Agricultural Research and Development Institute (CARDI),  
Trinidad  
International Development Research Centre (IDRC), Canada  
Australian Centre for International Agricultural Research (ACIAR)  
Conférence des Responsables Africains et Français de la Recherche  
Agronomique (CORAF), France  
International Service for National Agricultural Research (ISNAR),  
Netherlands

## □ SMALL RUMINANT CRSP (SR-CRSP)

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Year of Inception: 1978

**Purpose:** To improve meat, milk, and fiber production from sheep and goats, and more recently from alpacas.

**Program:** In general, the Small Ruminant CRSP works to:

- Broaden the genetic base and gene pool available for improving small ruminant species.
- Develop reliable, economical vaccines with which farmers can control the most constraining small ruminant diseases.
- Apply biotechnology to animal health management systems.
- Develop more productive mixed-farming systems, especially those combining ruminants and tree crops.
- Develop sustainable agropastoral systems for marginal lands.
- Document and analyze the roles played by women and men in small ruminant production in order to ensure that research results are relevant and applicable, particularly to women.

- Increase the incomes and food supplies of subsistence-level small ruminant producers.
- Strengthen the research capacity of overseas and U.S. agricultural institutions through collaboration and training.

### **Accomplishments:**

- In Kenya, the CRSP developed a composite breed dual-purpose goat (DPG) for milk and meat production in higher potential farming areas. While another three years are needed to "set" the breed genetically, the work has successfully combined into a single stock two locally adapted meat breeds and two imported dairy breeds. The introduction of dual-purpose goats and of improved forage production practices has resulted in a 66% increase in food yield from goats for smallholder families. Raising DPGs on marginal land generates an annual average of U.S. \$52 additional income per hectare. If only about 10% of the humid and subhumid area in Kenya was available for food crops and fallow, the potential annual benefits to farmers would amount to \$2.5 million.
- In Indonesia, the CRSP developed a highly prolific strain of Javanese Thin Tail sheep. This strain yields an average of 2.8 lambs per litter, nearly double the usual litter size in West Java. The producers of 3 million sheep in this province will annually gain 1.5 million sheep and \$18 million in revenue.
- In Morocco, the CRSP found that the D'Man breed of sheep readily transmits its high prolificacy. It is thus possible to use these local genetic resources to increase prolificacy in Moroccan sheep as needed to suit different management and feeding systems. If just 10% of Morocco's 10 million ewes are replaced with D'Man crosses, producers would earn an estimated \$5 million in additional income per year.
- In Kenya, the CRSP developed a new vaccine against contagious caprine pleuropneumonia (CCPP). This epidemic disease affects at least 48 million goats in Africa and Asia and, if untreated, has a mortality rate greater than 80%. The vaccine is safe, easily stored, economical to produce, and highly efficacious. When this vaccine is widely available, it will prevent an average of 82 annual local outbreaks involving an estimated 300,000 goats in Kenya alone.
- On Peruvian highland ranges, the CRSP documented the competitive and interactive grazing behavior of sheep, llamas, and alpacas. Llamas and sheep can be grazed together. Alpacas have the most opportunistic feeding strategy,

compete directly with other grazing animals when range conditions vary, and are best managed alone.

- The CRSP verified that rural women in many countries play significant and often primary roles in the care, feeding, and management of small ruminants as well as in making major consumption and distribution decisions.
- In Indonesia, the CRSP developed a successful pilot network in which 100 smallholder farmers are following recommended methods for improved hair sheep production. The demand already is already so great for SR-CRSP improved hair sheep that not enough sheep can be produced for the farmers who want them at the present.
- Many of the program's substantive results have been documented in more than 1,900 technical reports, journal articles, books, and abstracts, and in 210 verbal presentations. Many of these have been translated into the principal language of the host country. A summary of this documentation is available from the office of the Management Entity, the University of California, Davis.
- In 1986, the CRSP co-hosted a world conference on sheep genetics and reproduction and published a new, comprehensive reference book, *Genetics of Reproduction in Sheep*, with contributions from 50 scientists from 17 countries.
- The CRSP developed and validated computer simulation models for small ruminants that can have wide application in the United States and abroad. Social scientists also have designed a model for communicating SR-CRSP project results.
- More than 300 individuals from 28 countries have completed university training in fields related to small ruminant research, about 20% being women. More than 1,000 host country participants attended more than 20 short-term training programs.
- SR-CRSP scientists have moved into major research, education, or government positions (e.g., an SR-CRSP trained scientist working in Peru was appointed Dean of Veterinary Science at the National Veterinary Institute).

## **CRSP Resources:**

### **Collaborating U.S. Institutions**

University of California, Davis  
Colorado State University  
University of Missouri  
Montana State University  
North Carolina State University  
Texas A&M University  
Texas Tech University  
Utah State University  
Washington State University  
Winrock International Institute for Agricultural Development

### **Collaborating Overseas Institutions**

Ministerio de Agricultura Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA), Brazil  
Instituto Nacional de Investigacion Agraria y Agroindustrial (INIAA), Peru  
Agency for Agricultural Research and Development (AARD), Indonesia  
Kenya Agricultural Research Institute (KARI), Kenya  
Institut Agronomique et Veterinaire (IAV), Hassan II University, Morocco

### **Networks**

*Asia:* The Indonesian Small Ruminant Network, established in 1988, is planning for SR-CRSP participation in a Small Ruminant Regional Network to be initiated in 1990.

*Latin America:* The Andean Small Ruminant Network was formed in 1990 with Lima, Peru, as the headquarters.

*Africa:* Preliminary discussions have taken place with respect to SR-CRSP participation in a small ruminant network with leadership coming from the International Livestock Center for Africa (ILCA).

## □ SOIL MANAGEMENT CRSP (TROPISOILS)

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CGNET: 157:CGI901

Year of Inception: 1981

**Purpose:** To develop and adapt improved soil-management technologies that are agronomically, ecologically, and economically sound for tropical developing countries.

**Program:** In general, TropSoils works to:

- Conduct collaborative soil-management research that will contribute to sustainable agriculture, improve the natural resource base, and minimize environmental degradation.
- Formulate new technology into usable knowledge for diverse user groups, primarily our peers in the developing countries.
- Provide training in the principles and practices of soil management to developing country personnel through collaborative research, workshops, and research networks.

The TropSoils Global Plan focuses on researchable constraints and problems related to:

- The management, conservation, and enhancement of natural resources that are most critical to meeting food, fiber, fuel, and shelter requirements, as well as to preserving genetic diversity and attenuating climatic change. Specific constraints addressed include:

- land-clearing pressure on soils resources to produce more food for increasing populations;
  - restrictions that landscapes impose on soil-use options;
  - climate variability effects on soil properties, cropping systems, and production sustainability;
  - complete soil resource inventories for land-use planning and resource enhancement activities;
  - production-demand pressure on soil resources by industrial development and desire to increase export earnings.
- The successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the natural-resource base and avoiding environmental degradation. The soil-related constraints dealt with include:
    - acidity and toxicity of many tropical soils limit crop yields and crop selection;
    - plant nutrient deficiency, nutrient removal, soil losses by erosion as causal factors to soil degradation, abandonment, rainforest destruction, and encroachment onto less productive soils;
    - soil properties and management practices that degrade soil physical properties or render the soil non-productive;
    - topographic limitations;
    - plant water stresses that reduce productivity and restrict crop options.
- Outreach that includes extrapolation, communication, training, networking, and decision-support activities that translate research into useful knowledge. The constraints on successful outreach that are dealt with include:
    - the number and diversity of potential users;
    - the range of physical, biological, climatic, topographical, social and economic conditions;
    - the often rudimentary extension and communication channels;
    - the lack of trained scientists, educators, and communicators in developing countries;
    - the gap between new information and usable knowledge.

### **Accomplishments:**

- Research on high-input systems in the humid tropics of Peru has shown that yields can be sustained through 40 successive crops while also conserving the soil and enhancing soil fertility.
- A newly developed low-input system can extend the slash-and-burn cycle from two or three crops with quickly declining yield to five or six acceptable

crops. Following this cycle with a tropical kudzu cover crop promises to provide essential weed control, supply nitrogen, and permit further cropping without an extended natural fallow. For every hectare of previously cleared land placed under a sustainable system, five to ten hectares of tropical rainforest will be preserved by reducing the need to clear new land.

- Agroforestry has been used to improve soil management and enhance natural resources in both the humid and semiarid tropics.
- TropSoils programs have identified species available in the biodiversity of the tropical rainforest that are well suited to low-input sustainable agriculture systems.
- The potential role of perennial crops is becoming very well established for both agronomic and social reasons. Tree crops, which maximize the output of human effort, provide security and a variety of readily marketable commodities.
- Pastures based on acid-tolerant legumes and compatible grasses increase the area that can be farmed, thus raising income and food quality without the heavy labor associated with cultivated crops.
- Research has revealed that liming is essential for high yields and full exploitation of soil water. Even in the humid tropics of Indonesia, drought may be a problem when roots cannot penetrate acid subsoils and the plant is dependent on the small amount of water in the thin topsoil.
- Rapid screening techniques have been developed to test the release pattern of nitrogen-fixing legumes. One legume, mucuna, can fix up to 170 kg of nitrogen per hectare, enough for an excellent corn crop.
- Soil acidity and active aluminum have been identified as primary constraints to crop production at Niamey, Niger. Evidence suggests that this is a serious problem throughout the country, as well as in much of the Sahel. New techniques are being devised to assess the extent of the problem and measure the impact on farm and national food production.
- The value of mulching has been demonstrated in natural forest reseedling, weed control, and plant nutrient conservation. The return of plant residues can be equivalent to a generous application of fertilizer. Soilage harvested from fallow areas can substantially augment intercrops and cover crops grown in cultivated fields.

- TropSoils has trained 51 PH.D.'s, 31 M.S.'s, and 2 B.S.'s. Non-degree formal training has been provided for 1,249 individuals including 536 women.

## **CRSP Resources:**

### **Colaborating U.S. Institutions**

Cornell University  
 North Carolina State University  
 Texas A&M University  
 University of Hawaii

### **Collaborating Host-Country Institutions**

Instituto Nacional de Investigacion Agraria y Agroindustrial (INIAA), Peru  
 Centre for Soils Research (CSR), Indonesia  
 Institut National de Recherches Agronomiques du Niger (INRAN), Niger  
 Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA), Brazil  
 Institut d'Economie Rurale (IER), Mali  
 Institut de Recherches Agronomiques (IRA), Cameroon

### **Collaborating International Institutions**

International Institute of Tropical Agriculture (IITA), Nigeria  
 International Crops Research Institute for the Semi-Arid Tropics, (ICRISAT),  
 West Africa  
 International Board for Soil Research and Management (IBSRAM), Thailand  
 International Rice Research Institute (IRRI), Philippines  
 Potash and Phosphate Institute (PPI), U.S.  
 Centro Internacional de la Papa (CIP), Peru  
 Centro Internacional de Agricultura Tropical (CIAT), Colombia  
 Sorghum/Millet CRSP (INTSORMIL), U.S.  
 Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), Mexico  
 Centro Agricultura Tropical de Investigacion y Entrenamiento (CATIE),  
 Costa Rica  
 International Council for Research in Agroforestry (ICRAF), Kenya

### **Networks**

Red de Investigacion en Suelos Tropicales (RISTROP), a tropical soil management research network of scientists from 12 Central and South American countries.

## □ FISHERIES STOCK ASSESSMENT CRSP (FSA-CRSP)

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Year of Inception: 1985

**Purpose:** To promote the sustainability of small-scale multispecies tropical marine capture fisheries through development of new methodologies for stock assessment and management.

The FSA-CRSP's final product will be a Stock Assessment Manual for fisheries managers in the developing countries. Associated microcomputer software will explain specific models, methods, techniques, and approaches to stock assessment and management of small-scale multispecies tropical marine capture fisheries.

Law of the Sea ratification by most nations gives them jurisdiction over living marine resources within 200 miles of their coasts. Development of methods for accurate assessment of fish stocks in these so-called Exclusive Economic Zones (EEZ) is extremely important, especially for the developing countries, which typically exhibit a tropical multispecies condition addressed only by this CRSP.

**Program:** In general, the FSA-CRSP addresses:

- Population dynamics of multispecies fish stocks.
- Stochastic properties of tropical fisheries.

- Relationships among yield, fishing effort, species composition, and stability of multispecies fisheries.
- Appropriate sampling designs for small-scale fisheries.
- Aging of tropical fish.
- Age and size relationships of tropical fish.
- Hydroacoustic techniques for estimating fish abundance in shallow-water estuaries.
- Tropical fish reproduction and recruitment, particularly in mangrove and coral reef areas.
- Assessing biological productivity of coral reef fishery systems.
- Decision support systems for managing small-scale multispecies tropical fisheries.

CRSP researchers are:

- Applying artificial intelligence, expert systems, and decision support systems to the study of population dynamics and management of multispecies tropical fisheries.
- Developing, testing, and validating modifications and extensions of standard fisheries models to account for the multispecies nature of tropical fisheries, the stochastic properties of these fisheries, and the relation of species composition to the economic value of the fish catch.
- Developing new sampling designs and field monitoring programs that take into account the realities of artisanal fisheries in order to provide local scientists and managers with catch and effort data needed for fisheries management.
- Developing and validating a general framework and methodology for understanding and predicting the abundance and growth of selected fish and invertebrate species in tropical environments.
- Developing methods of determining the age of tropical fish species and constructing age-size keys to draw inferences about recruitment, growth, and mortality.

- Developing hydroacoustic techniques for rapidly assessing the population size of fish stocks in shallow-water multispecies environments through field studies.
- Developing ways to obtain more and better management information from existing data; and constructing multispecies stock assessment models among yield, fishing effort, species composition, and stability data.
- Using visual, trap, and shoreline sampling techniques to assess the composition and variability of fish communities to monitor and assess recruitment dynamics through field experiments, and to estimate the productivity in reef and shoreline fisheries.

The relatively new field of fishery science involves scientists from a variety of fields including marine biologists, statisticians, oceanographers, ecologists, limnologists, economists, and others. Host country researchers are intimately involved in developing the new methodologies and techniques for small-scale multispecies tropical fisheries stock assessment and management.

FSA-CRSP investments in host country equipment and facilities have been substantial. Personnel from the Department of Fisheries in Costa Rica and from the Bureau for Fisheries and Aquatic Resources in the Philippines are actively involved in the research projects, facilitating direct transfer of new methodologies and techniques, as well as data analysis, to host country governmental institutions responsible for fishery management. Through FSA-CRSP efforts a regional fish aging laboratory is being established in Costa Rica, and the FSA-CRSP has made substantial contributions to the establishment of an extensive marine research laboratory in the Philippines.

Annual, short-term training workshops on specific techniques are being conducted in Costa Rica and the Philippines. Two lengthy regional workshops--one each in the Philippines and Costa Rica--on new methods of stock assessment and management of small-scale multispecies tropical fisheries are being planned for the spring of 1993.

### **Accomplishments:**

- Developed the first stage of an expert system for analyzing fishery data, predicting future harvests, and providing advice to fishery managers on optimal management strategies.

- Extended standard fishery models to give advice to fishery managers even when fishery data and information are limited.
- Developed new and innovative statistical methods for stock assessment sampling in small-scale fisheries.
- Developed improved length-based stock assessment analyses.
- Advanced the techniques for aging tropical fish.
- Demonstrated new techniques using hydroacoustics for fish detection in shallow waters.
- Developed methods of predicting changes in multispecies fish assemblages.
- Developed new techniques for studying fish community structures.
- Initiated the most extensive coral reef fishery productivity and ecological studies ever attempted.
- Conducted numerous short-term training workshops in the Philippines and Costa Rica on various aspects of the developing research.
- Conducted two regional workshops in the Philippines on the management of tropical fisheries. Eight countries participated.
- Conducted a two-week workshop in Costa Rica on new methods of aging tropical fish.
- FSA-CRSP collaborators have conducted several semester-long courses at the University of the Philippines on community structure analysis and fishery models.

## **CRSP Resources:**

### **Collaborating U.S. Institutions**

University of Maryland - Center for Environmental and Estuarine Studies  
 University of Rhode Island  
 University of Washington  
 University of Miami  
 University of Delaware

## **Collaborating Overseas Institutions**

University of Costa Rica-Centro de Investigacion en Ciencias del Mar y  
Limnologia

University of the Philippines-Marine Science Institute

University of the Philippines in the Visayas-College of Fisheries

International Center for Living Aquatic Resources Management (ICLARM)

Research Institute for Marine Fisheries, Indonesia

Department of Fisheries, Thailand

## **The FSA-CRSP collaborates with the following networks:**

AID/Association of Southeast Asian Nations (AID/ASEAN) Coastal  
Resources Management Project

Argentine National Council for Scientific and Technical Research

Costa Rican Department of Fisheries

Los Angeles County Library

National Marine Fisheries Service

Philippines Bureau for Fisheries and Aquatic Resources

Smithsonian Institute

Tinker Foundation

United Nations Food and Agriculture Organization (FAO)

## □ POND DYNAMICS/AQUACULTURE CRSP

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CGNET: 157:CGI901

Year of Inception: 1982

**Purpose:** To define the principles underlying sound aquaculture management and improve practices that will provide increased employment and a dependable, inexpensive source of animal protein.

**Program:** The Pond Dynamics CRSP bases its work on a global concept and carries out the same experimental protocol at each site. The information thus obtained is compiled at Oregon State University into the world's largest standardized database on tropical aquaculture, which will be used to develop aquacultural "expert systems." In each host country, U.S. researchers go beyond the global experiment, collaborating with host country researchers and educators on site-specific research.

General areas of related activity:

- Multidisciplinary research.
- Institution building and curriculum development.
- Dissemination of information.
- Creation and maintenance of sustainable aquacultural systems.

### Specific endeavors:

- Aquaculture research is by nature multi-disciplinary and involves experts in resources economics, limnology, aquatic ecology, fisheries, computer science, fish culture, agricultural engineering, statistics, and genetics. Because of this diversity of knowledge, the CRSP has developed professional linkages with many national and international groups.
- The CRSP builds on existing infrastructure in the host countries to enhance institutional support and training curricula that are needed to conduct scientific experiments in aquaculture.
- U.S. researchers in the host countries arrange (mostly graduate) university training, mainly through networking with other programs, and on-the-job training of junior scientists and technicians. They also provide educational advisory services, teach short courses, and work with extension agents and the Peace Corps.
- The CRSP publishes a wide array of information on its research activities and distributes these materials to over 500 people in the United States and overseas. CRSP researchers create and nurture professional contacts with scientists in many developing countries through scientific conferences and workshops.
- The CRSP recognizes that fish farming is an effective and sustainable way for women to earn income and produce food, and supports efforts to develop women-owned and operated fish ponds.
- By studying highly eutrophic (highly productive and in some cases polluted) ponds, CRSP researchers have gained a better understanding of complex aquatic environments. Experiments on the use of locally available inputs (such as composts and green grass) help researchers to offer sound advice on safer (or sustainable) management of pond systems and by extension, aquatic systems. In every country where the CRSP works, it has opportunities to advise on ecologically sound sites for aquaculture development to prevent the further loss of fragile or sensitive environments.

### Accomplishments:

- CRSP researchers demonstrated that low-cost agricultural products (such as soybean meal) and by-products (like corn gluten) can be used as successful substitutes for expensive pelleted fish feed, thus helping fish farmers to expand production and save money. This information had immediate

practical application in Honduras where the rapid growth in aquaculture (evident from the 600% increase in demand for fingerlings in 1986) led fish farmers to seek cost-effective inputs. Other studies on feeding behavior led to the conclusion that juvenile marine shrimp do not need to be fed until four weeks after hatching. This finding resulted in annual savings of \$975,000 for a single marine shrimp facility in Honduras.

- In Rwanda, CRSP researchers set out to find alternatives to high-priced inorganic fertilizers and scarce organic fertilizers. They found that compost can provide a sustainable fertilizing input to fish ponds. In a study of the effects of four types of organic fertilizer on fish production, the treatment using green grass resulted in greater pond productivity and fish growth than treatments using more energy-intensive materials.
- In Thailand, where acidic soils make fish ponds hard to manage, CRSP research led to the recommendation that ponds be constructed by diking rather than the conventional method of digging and that organic fertilizers be used. Using these recommendations alone, 13 million hectares of acid-sulfate soils around the world can be made more useful for aquaculture.
- In Rwanda, U.S. field scientists introduced fish culture and statistics courses into the National University curriculum, wrote a biometry textbook in French, and cooperated with Host Country administrators in reorganizing the national plan for aquaculture development. The laboratory built by the CRSP in Rwanda is the premier water quality laboratory in that country and one of the best in East Central Africa.
- In Indonesia, CRSP researchers played a major role in curriculum development at the Institut Pertanian Bogor and in Honduras, the CRSP served as a catalyst in linking together various groups involved in aquaculture such as government agencies, private and state universities, and the Peace Corps, as well as the CRSP itself.
- In Indonesia and Thailand, tilapia harvest from CRSP ponds has quadrupled, reaching levels that previously were attainable only with expensive supplemental feed.
- The CRSP is collaborating with ICLARM (The International Center for Living Aquatic Resources Management--an IARC) on a handbook of aquaculture research techniques. The handbook is an outgrowth of the CRSP's work plans, which scientists in developing countries find extremely useful, particularly because they have limited access to expensive texts on aquaculture techniques.

## **CRSP Resources:**

### **Collaborating U.S. Institutions**

Auburn University  
University of California, Davis  
The Consortium for International Fisheries and Aquaculture Development  
(CIFAD):

- University of Michigan
- Michigan State University
- University of Arkansas at Pine Bluff
- University of Hawaii
- Oregon State University

### **Collaborating Host-Country Institutions**

Royal Thai Department of Fisheries  
Asian Institute of Technology, Thailand  
National University of Rwanda  
Department of Renewable Natural Resources, Honduras

### **The PD/A CRSP collaborates with the following networks and organizations:**

The International Center for Living Aquatic Resources Management  
(ICLARM), Philippines  
Zamorano, Honduras  
The Peace Corps, Honduras and Thailand  
University of the Philippines in the Visayas  
Department of Aquaculture (DINAAC), Panama  
United Nations Food and Agriculture Organization (UN FAO), Rome, Italy  
International Center for Aquaculture, Auburn, Alabama  
Institut Pertanian Bogor, Indonesia  
Western Regional Aquaculture Consortium, Seattle, Washington  
Midwestern Regional Aquaculture Center, Michigan  
International Rice Research Institute (IRRI), Philippines

## □ NUTRITION CRSP

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CGNET 157:CG1901

Year of Inception: 1982

**Purpose:** To measure the effects of marginal malnutrition on human function in rural and semi-rural areas of Egypt, Kenya, and Mexico.

**Program:** In general, the goals of the Nutrition CRSP are to:

- Employ a multidisciplinary approach to study the etiology and consequences of marginal malnutrition in the context of the household and community.
- Achieve similar research protocols in Egypt, Kenya, and Mexico so that the research findings can be compared across countries that differ in their staple crops, agricultural systems, environment, and culture.
- Measure the effects of marginal malnutrition on growth, cognitive development, reproduction, lactation, and morbidity experience of individuals.
- Estimate food intakes of individuals and households and identify which foods and nutrients have the greatest impact on human function.

This CRSP was implemented to study whether and how marginal malnutrition affects the ability of individuals to function in their households and in their community. Marginal malnutrition was initially defined as a shortage of energy intake, and this concept has been expanded to include either a shortage of dietary

energy or of foods that affect the quality of the diet. The latter include animal products.

This CRSP was conceived, designed and implemented somewhat differently from the other CRSPs. Up to this point in time, its main purpose has been the study of marginal malnutrition in its natural context, rather than the planning of appropriate intervention strategies. A great deal of effort was invested in implementing the research design to be as similar as possible in Kenya, Egypt, and Mexico - countries that differ in their food supply, agricultural systems and culture but that a majority of the population in each country suffers from marginal malnutrition.

### **Accomplishments:**

- Developed a model for conducting highly comparable investigations of the causes and consequences of marginal malnutrition in different countries, using an interdisciplinary team.
- Established that growth failure of individuals in marginally malnourished communities starts a few months after birth and is most severe during the first year of life. Most children do not recover from this early growth failure. This is of great significance since the features of life experience that lead to small size also lead to delays in cognitive development.
- Found that the main predictor of infant growth is maternal size (body weight for height), pointing to the importance of adequate maternal nutrition prior to and during pregnancy.
- Showed that in situations of food shortage or famine, inadequate intakes of dietary energy have adverse effects on human growth and body size, reproductive outcomes, cognitive development, behavior, and activity. There is no metabolic adjustment that allows individuals to "adapt" to low energy intake.
- Observed that the more common problem in Egypt, Mexico, and Kenya is that the quality of the diet is inadequate to support optimal development and function of individuals. Dietary quality was associated with low intake of animal and fish products which are good sources of available vitamins, minerals, and essential amino acids.
- Initiated new projects concerned with child survival, micronutrient deficiencies and human function, long-term effects of marginal malnutrition on function, and applied nutrition programs for mothers and children under the age of five years.

- Improved data management and analysis capabilities in both host country and U.S. institutions.
- Held workshops with appropriate representatives from governments and academia in each host country to present the research findings and discuss the policy implications.
- Trained 25 M.S., 20 Ph.D., and 14 B.S. students and provided non-degree training for 530 individuals.

### **CRSP Resources:**

#### **Collaborating U.S. Institutions**

Purdue University  
University of Arizona  
University of California, Berkeley  
University of California, Los Angeles  
University of Connecticut  
University of Kansas

#### **Overseas Collaborating Institutions**

Instituto Nacional de la Nutricion, Mexico (INN)  
Nutrition Institute, Egypt  
University of Nairobi, Kenya